Electronics World

FEBRUARY, 1968
60 CENTS

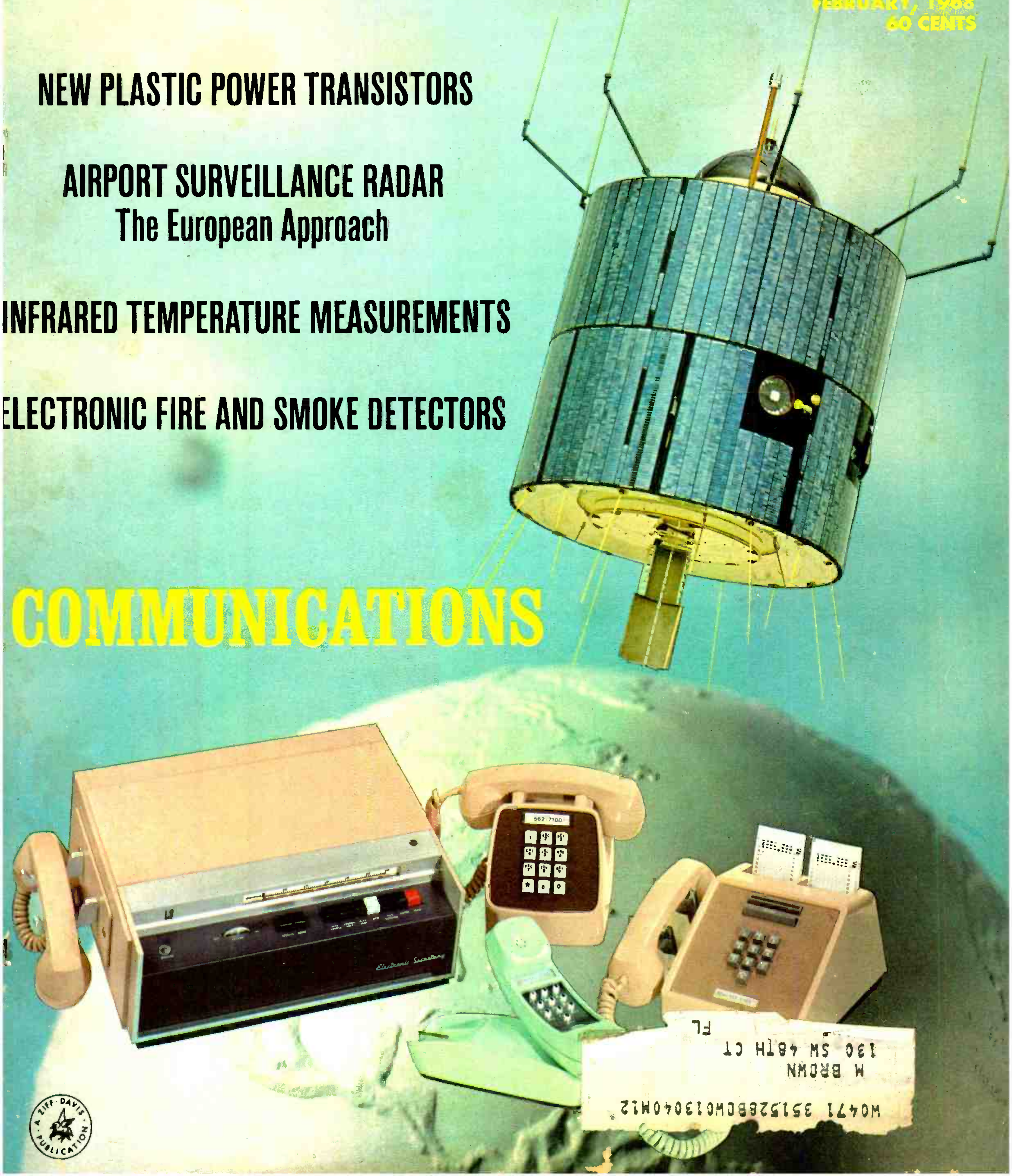
NEW PLASTIC POWER TRANSISTORS

AIRPORT SURVEILLANCE RADAR
The European Approach

INFRARED TEMPERATURE MEASUREMENTS

ELECTRONIC FIRE AND SMOKE DETECTORS

COMMUNICATIONS



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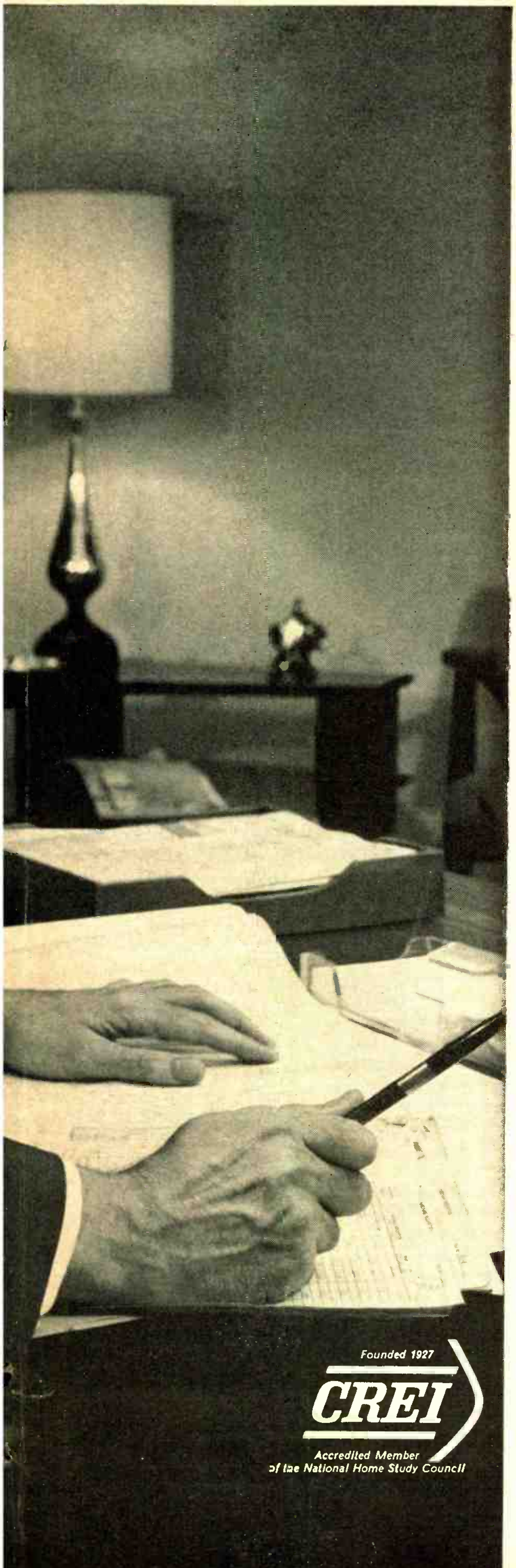

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THIS MONTH'S COVER focuses on the new scenes in communications technology. Everyone is familiar with the telephone, but few people know how the new systems work. Fewer understand how hundreds of people can talk over a single wire pair simultaneously; and how a synchronous satellite, like the one on the cover, will enable hundreds of business men, and housewives too, to talk around the world easily. New telephones are available too. General Telephone & Electronics developed the electronic secretary and the Type 80 "Touch Calling" phone for the busy executive. For home use, New Jersey Bell Telephone Co. can provide the Trimline unit and card-insert set for invalids or frequently called numbers. In addition to relaying calls from phones like these, the Hughes Aircraft Co.'s Applications Technology Satellite takes pictures of cloud cover with a camera that looks out from its side.

Photograph: Dirone-Denner.

Electronics World

FEBRUARY 1968 VOL. 79, No. 2

CONTENTS

MONTHLY FEATURES

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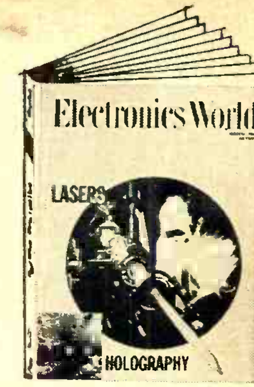
COMING NEXT MONTH



SPECIAL FEATURE ARTICLES ON: LASER TECHNOLOGY

Don't miss the facts on the "laser revolution" as revealed in our next issue. More and more reasons are being found for using the coherent light device in industry. E. Allan Haley of the Perkin-Elmer Corp. discusses some of the new applications. Holography, too, is coming into its own. In the March issue, Dr. Ben Pernick of The Grumman Aircraft Engineering Corp. explains the dynamics of the three-dimensional laser process and cites certain industrial applications.

SUBMINIATURE INTEGRATED ANTENNAS
Very small antennas for communications frequencies below 30 MHz may soon be available, but don't expect the TV roof antenna to disappear. Paul Mayes of JFD Electronics evaluates the performance of small antennas and tells us why rooftops will look like a multiquilled porcupine for some time.

RADIC—A LOW-FREQUENCY MULTIPLEX INTERCOM
Single-sideband suppressed carrier and frequency-division multiplexing techniques are used in a Collins Radio Co. developed intercom to reliably tie together the hundreds of stations which service the Apollo rockets. The 112-channel communications system was used during the Saturn V launch.

D.C. POWER TRANSMISSION
The value of extremely high voltage d.c. transmission is debatable among American engineers. Meanwhile, new EHV systems are being installed in Los Angeles and the Northwest. Russia is also installing the system.

LINEAR POTS & STRAIGHT LINES
Everyone needs them, but few know how to ask for or develop the specifications for linear potentiometers. John Doering of Helipot tells you how. The four most common definitions of potentiometer linearity are discussed.

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

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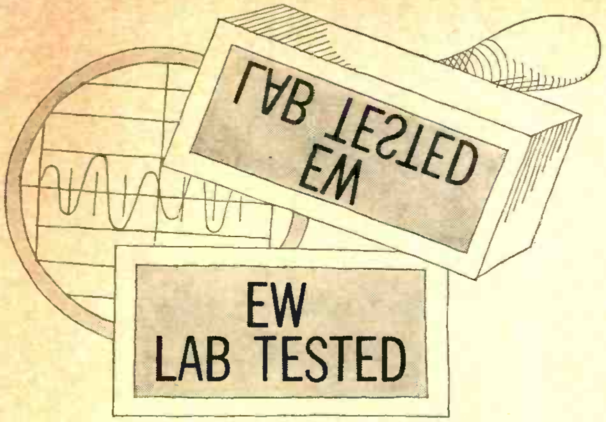


HI-FI PRODUCT REPORT

TESTED BY HIRSCH-HOUCK LABS

Allied TD-1030 Tape Deck/Preamp
Empire 4000 "Cavalier" Speaker System

Allied TD-1030 Tape Deck/Preamp

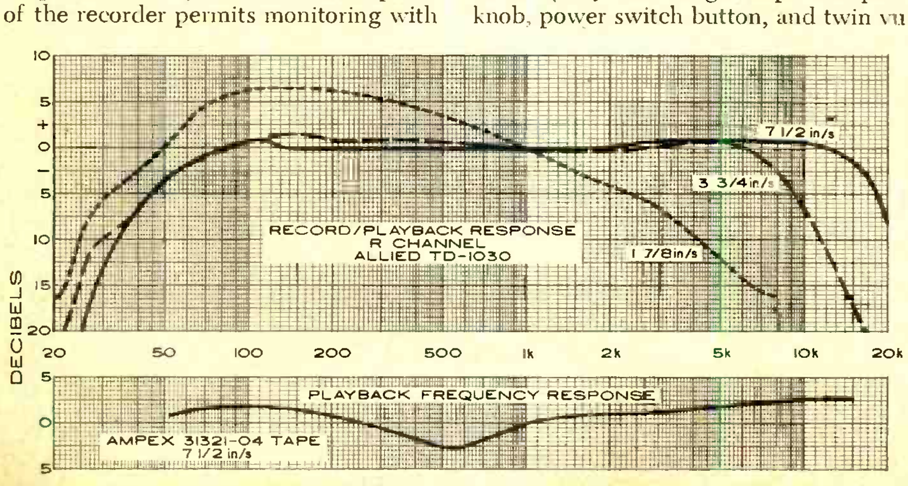
For copy of manufacturer's brochure, circle No. 19 on Reader Service Card

ALTHOUGH most tape recorders are designed as portable packages complete with low-powered playback amplifiers and miniature speaker systems, there is a real need for instruments which can be wired into a home-music system and played back through the larger amplifiers and speakers of the average high-fidelity system. Virtually all portable recorders provide for such interconnection, but it makes little sense to pay for amplifiers and speakers which will not be used. Furthermore, they are generally aesthetically at odds with home decor.

The *Allied* TD-1030 is a stereo tape deck/preamp designed specifically for use with a fixed, home-music system. It is a three-speed, four-track stereo unit furnished in a wooden enclosure with an attractive wood-grain finish. The compact unit, measuring 15⅝ inches by 13⅝ inches by 6¾ inches, may be installed in a vertical or horizontal position. A fitted dust cover is supplied, as well as two pairs of molded input and output cables.

The all-solid-state electronics includes a playback preamplifier delivering a nominal line output of 0 dBm (0.78 volt) from a signal recorded at the same input level. There are no playback volume or balance controls, but we found an almost exact equality between input and output levels. A jack on the front panel of the recorder permits monitoring with stereo headphones during recording, and a three-position headphone-level adjustment is located underneath the recorder. Being a two-head machine, the TD-1030 does not permit monitoring off the tape while recording.

All controls associated with the recording process are concealed behind a hinged door on the panel of the deck. These include two microphone input jacks, recording-level controls, and a red interlock lever which must be operated together with the tape-transport knob to enter the record mode. Not only does this layout keep the appearance of the TD-1030 extremely simple and uncluttered (only the single tape-transport knob, power switch button, and twin vu meters are visible in normal operation), but it reduces the possibility of accidental tape erasure to near zero.



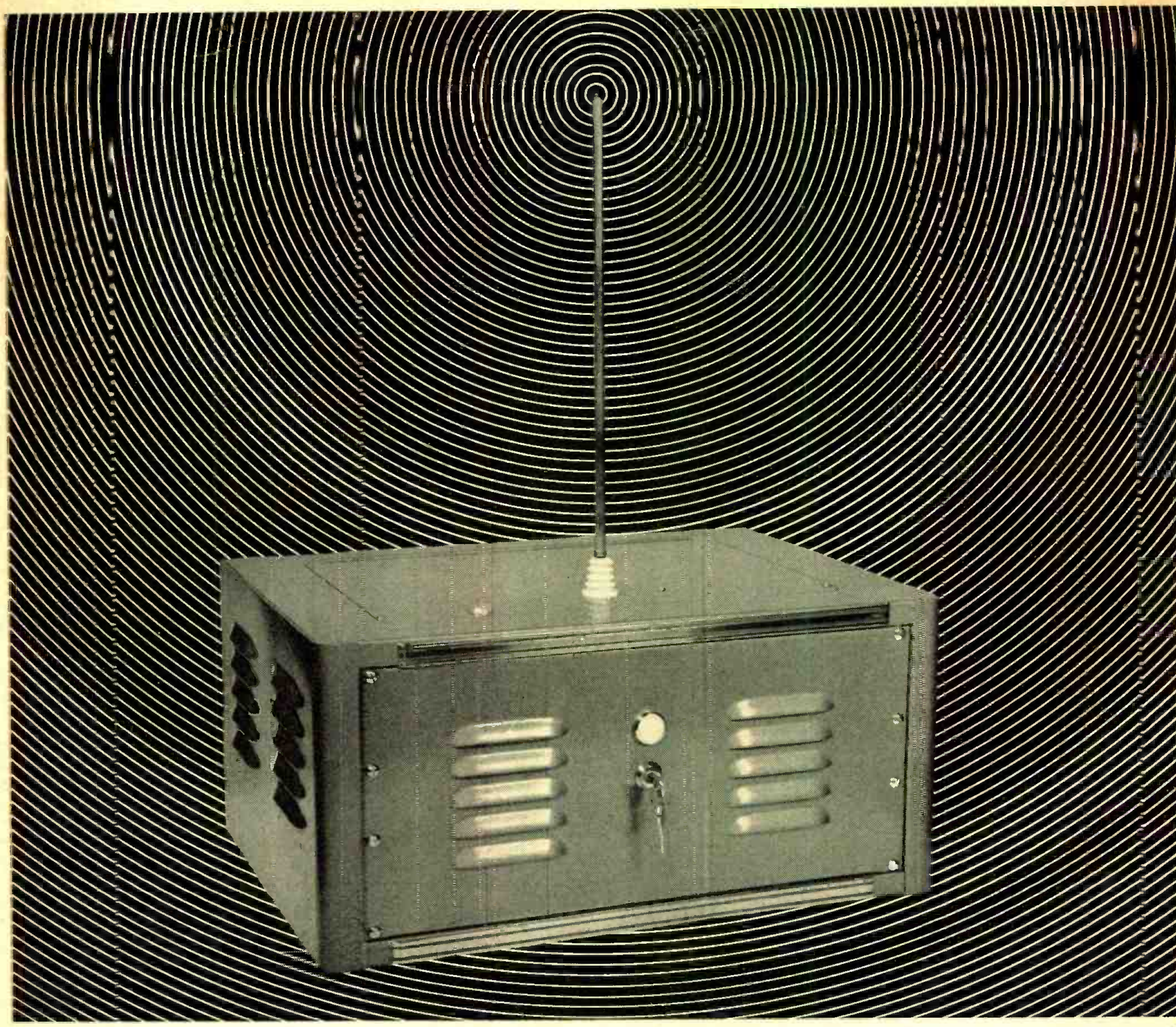
The two illuminated meters monitor recording levels and playback line output levels, reading the same amount during either process. A bright red bar between the meters lights up when recording. The high-level inputs do not have to be disconnected when recording from microphones, since plugging in a microphone automatically disconnects the other input source.

The tape-transport knob is detented at "Rewind", "Stop", "Play/Rec", "Pause", and "Forward". The "Pause" position is convenient for eliminating unwanted announcements when recording from the air, since it does not drop out the recording interlock. It is important to let the tape stop between either of the fast speeds and normal speed, since tape breakage is possible if the control is operated too rapidly. The instruction manual warns of this, and we confirmed the importance of the cautionary note by breaking some tapes when the recommended procedure was not followed.

A small knob between the tape reels changes speed from 7½ in/s to 3¾ in/s, together with the appropriate equalization changes. To go to 1⅞ in/s, the 3¾ in/s position of the knob is used, and a removable portion of the drive capstan is unscrewed and stored on a post provided for this purpose. Obviously, the same equalization is used for both 1⅞ and 3¾ in/s operation.

When playing the *Ampex* 31321-04 alignment tape, the 7½ in/s frequency response of the *Allied* TD-1030 was within ±2.5 dB from 50 to 15,000 Hz. The over-all record/playback response at 7½ in/s was ±1.5 dB from 60 Hz to 16,000 Hz. At 3¾ in/s there was an expected loss of highs, but the performance was nonetheless quite adequate for moderate-quality music recording with ±1.5 dB from 60 Hz to 7500 Hz. The lowest speed was of little value except for voice recording, for which it was obviously intended. At 1⅞ in/s the response fell off smoothly above 200 Hz, to −6.5 dB at 1000 Hz and −15 dB at 3500 Hz, with respect to the maximum value.

(*Continued on page* 84)



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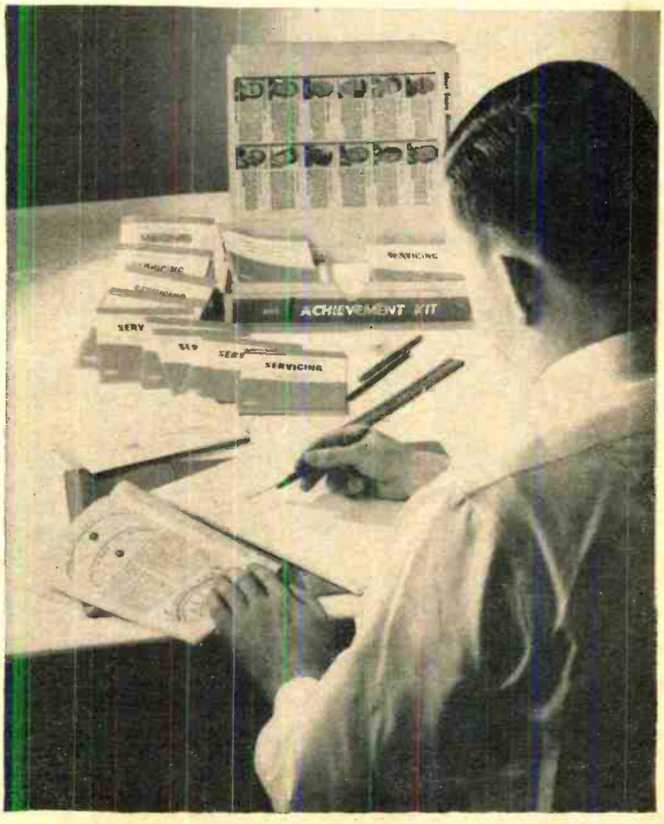

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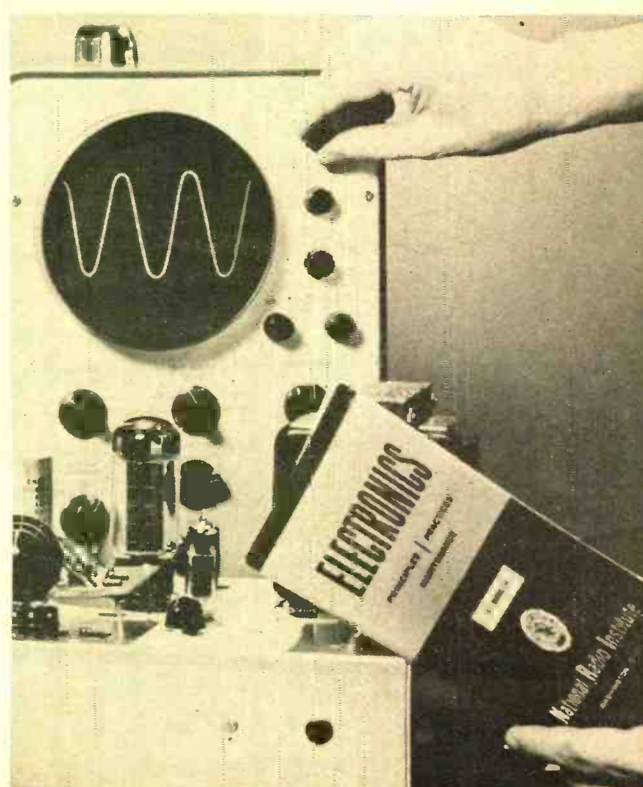

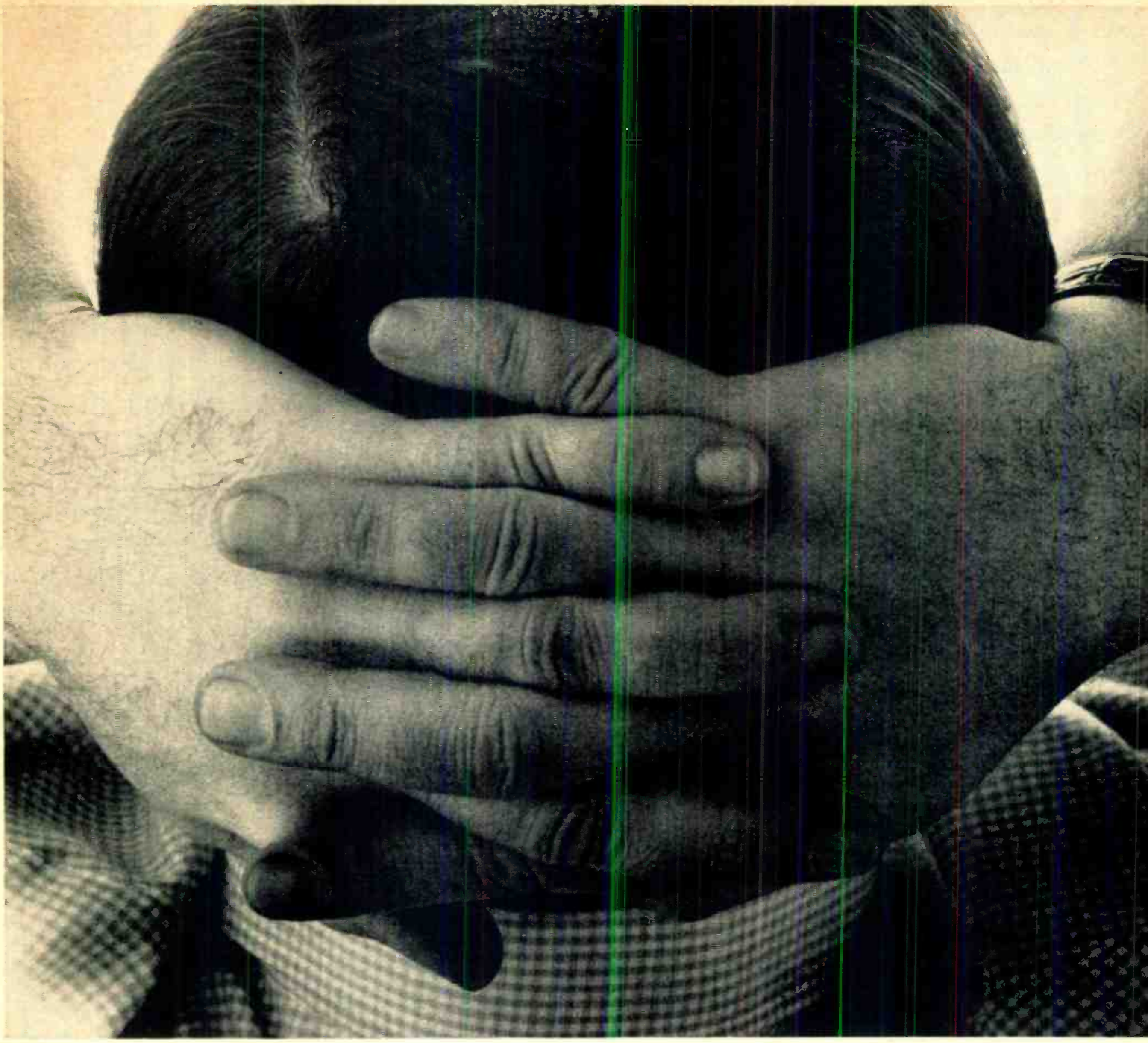

Reflections on the news

By WALTER H. BUCHSBAUM/Contributing Editor

Car 54 Where Are You?

The whereabouts of Car 54 was funny on television, but in actual police work the exact location of each patrol car is an essential element in any efficient, fast-response operation. Police departments in many U.S. cities, among them New York and Los Angeles, are evaluating schemes that automatically and instantaneously locate every police vehicle. One such scheme depends on call boxes which pick up very weak radio-frequency signals from passing police cars. The call boxes relay the identity of the passing patrol car to a central computer which stores this information and displays it on a map overlay. In another scheme, a transponder in each car is interrogated by a search radar at a central station. The car's position is pinpointed by radar range and azimuth. A third scheme utilizes loran techniques. The time delay between transmitted and received signals from two master stations and a transponder in the car, fix the car's position. New York is studying the loran scheme and Los Angeles is investigating call-box technique.

Each system has merits and each has drawbacks, depending on local conditions such as the terrain, high buildings, call-box availability, etc. And each system can be expanded to receive emergency signals from buses or taxis. When an emergency vehicle uses the system, the computer will receive and locate the alarm and dispatch the nearest patrol car to the scene.

New Mercury Switch

The novel combination of capillary action, a flexible plastic tube, and column of mercury; with terminals at each end make up the new Mercury All Position (MAP) switch. Developed by *Beltone Electronics Corporation*, the new switching elements provide the first truly bounceless mechanical switch. When the plastic tube is squeezed or bent, the solid mercury column connecting the two axial terminals breaks suddenly, opening the switch. Because of the configuration of the visco-elastic tubing, the surface tension of the mercury, and the presence of a tiny amount of inert gas, the opening and closing of the switch is instantaneous and without any contact bounce. In a typical application, the MAP elements, which measure 1 inch in length and ⅛ inch in diameter, are activated by a lever arm driver and by a solenoid, just like the spring contacts of a relay.

With a minimum life of 50 million operations, a temperature range from −30°C to +85°C, and a maximum activating speed of 200 times a second, the new MAP switching elements can replace reed relays and even solid-state switching devices in many applications. Manual switches often use a diode and an *RC* network to eliminate noise caused by contact bounce, but when the new MAP elements are incorporated in the mechanical switch, contact bounce is no longer a problem.

Zinc-Air Penlight Battery

Early this year, *Leesona Moos Laboratories* expects to announce a miniature version of the zinc-air battery which they have been producing for military and space applications. The new batteries will be penlight size and will weigh half as much but provide eight (8) times as much power as present carbon-zinc batteries. Zinc-air or zinc-oxygen cells use a high-rate oxygen cathode with a porous zinc anode in a potassium-hydroxide solution electrolyte. Oxygen from the ambient air (or from a stored oxygen supply in space applications) passes through the cathode and corrodes the zinc anode into zinc-oxide and forms hydroxyl ions, in combination with the electrolyte. The zinc anode is consumed in the process. In the larger versions of this cell, the anode can be mechanically replaced. This effectively recharges the battery.

Although not strictly a fuel cell, zinc-air or oxygen batteries approach the economy and efficiency of fuel cells without requiring a pump or liquid fuel injection. The introduction of zinc-air penlight cells is only the first step in what promises to be a whole new series of high-efficiency batteries for small electronic devices. One limitation must be kept in mind, however, and that is the need for free access to the ambient air. When the zinc-air batteries are used in air-flow-restricted containers, such as plastic flashlights, their efficiency will be severely impaired.

Ultra-Sound in Color

In the November 1961 issue of EW, we described the technique of using ultrasonic signals to provide a cross-sectional picture of portions of the human body. Since then, this method has been perfected and ultrasonic TV displays and photographs of internal organs, arms, and legs are used in many hospitals.

The x-ray-like picture is based on the absorption characteristics of 3.5-MHz sound signals by the various tissues. In a cross-sectional view of a leg, for example, veins, bones, tendons, and muscles can be clearly distinguished.

Dr. J. E. Jacobs of Northwestern University refined the technique by adding a color-TV type of display. Different tissue types appear in various distinct colors, although not necessarily the colors of actual tissues. Veins and arteries may be blue, bones green, and muscles orange. This results in an extremely vivid picture in which each tissue type is identified by its distinctive color. Since the picture appears on a TV screen, continuous study of living tissue is possible. The refined system is being manufactured by *James Electronics Inc.* of Chicago. It will cost $10,000 to $20,000, depending on the complexity of the associated equipment.

While developed primarily for medical diagnosis, the new ultrasound color system can also be used for non-destructive inspection of metal structures such as welds and stress points.

It is encouraging to see color-TV so directly and ingeniously applied to a vital medical service. The next step might be the development of a color conversion device which would produce the actual colors with a 3-D effect, to permit doctors to "look into" their patients without need for exploratory surgery.

A Surplus of Surplus Electronics Equipment

During the past year all of the military services have weeded out many types of surplus equipment. In particular, electronics equipment such as oscilloscopes, various test sets, radio communications gear, and radar sets have been retired in unusually large numbers. As a result, the surplus market is glutted. To stimulate sales of this surplus electronics equipment, the Defense Supply Agency has recently exhibited a large variety of this equipment in Washington and, although sales were good, there are still many good buys available at various locations all over the country.

Those of our readers interested in buying electronics equipment at bargain-basement prices should write to: Commander, Defense Logistics Services Center, Attention, DLSC-MSB. Federal Center, Battle Creek, Michigan 49016, for information and details. You must be over 21, a citizen, and not connected with the disposal of surplus equipment. Catalogues of available items are at every sales center. They may also be obtained through the mail. Equipment is sold on a cash basis only.

The Crowded Air Space

When you read these lines a major air collision may have already occurred. The probability of it happening grows every day. After all the investigations and reports of the increasing danger of mid-air collisions, nothing has been done to prevent such catastrophies. For this fiscal year (1968), the Federal Aviation Administration was allotted $54 million for facilities and equipment, more than their original budget request. According to the FAA, they expect to spend $14.3 million for automation equipment and $1.23 million for terminal area radar.

A number of anti-collision schemes and actual equipment have been discussed, and one, the EROS system described in the December 1967 issue of EW, demonstrated. Some time this spring, a huge new centralized air-traffic-control center goes into operation in the New York terminal area, but it won't have a complete automatic altitude decoding system working until late in 1968 or early 1969. However, most commercial airliners will be equipped with altitude-reporting transponders by 1969. This will help, but nothing at all is planned for the increasing numbers of private planes. What is even more discouraging is that ground-controlled collision warning systems will be limited to areas near the major airports. True collision-avoidance radar, which would work anywhere, is technically feasible, but the airlines wait for the FAA to do something about it and the FAA—well they are thinking it over.

Why does it always take a major disaster at the cost of human lives to alert us to the dangers so clearly pointed out by all the experts? Ask any commercial pilot when his last near-hit was. See "Airport Surveillance Radar" on page 27 of this issue.

After the Electric Rifle?

Uncased rifle ammunition has been demonstrated before, but now the *Smith and Wesson Company* has announced the development of a .22 caliber rifle which uses a caseless cartridge, ignited by electric current from a battery. The key part of the electric rifle is a bolt made of insulation material. Two electrodes are embedded in the bolt so that they contact the solid propellant each time the bolt is closed. A special insulation material is used which can withstand both the heat and the shock of each shot without deforming.

Following the electrically fired rifle we can foresee the development of a machine gun using the same principle. For that application, an electronic pulse generator, synchronized to produce the desired firing rate, may be used. This would place electronics directly into the deadly weapon. ▲

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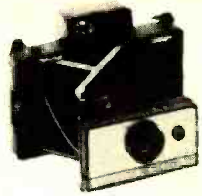

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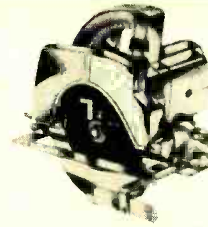

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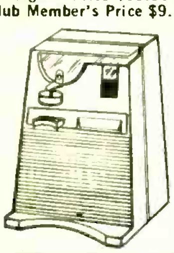

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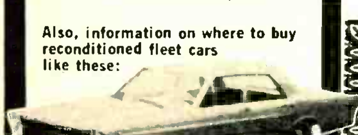

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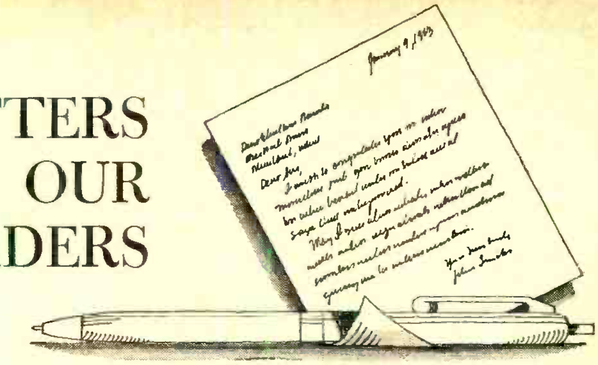
LETTERS FROM OUR READERS



TUNGSTEN-HALOGEN LAMPS

To the Editors:

Some of the lasers shown in your interesting "Recent Developments" feature use as their pumping light what is referred to as a "tungsten-halogen" lamp. Just what kind of light is this and what are its advantages?

ALLAN S. MCGRAW
Houston, Tex.

The tungsten-halogen lamp is used as a high-intensity light source for professional photography and for theater and television lighting. The main advantages are the high light output plus the fact that the lamp retains its brightness and color temperature for several times longer than conventional incandescent lamps.

Tungsten-halogen lamps (also called quartz-iodine or quartz lamps) use tungsten filaments like conventional lamps, but halogen gases (related to iodine) are added to the normal gas mix in the envelope. These gases combine with the tungsten that is evaporated from the filament; it is this evaporated tungsten that in ordinary incandescent lamps is deposited on the inside of the envelope, causing blackening and a reduction in light output along with a change in color temperature. The high-temperature requirements for these lamps mean that quartz, or other high-temperature glasses, must be used for the envelopes.—Editors

* * *

LOW-COST C-D IGNITION

To the Editors:

With due respect to the author of the article "Low-Cost Capacitive-Discharge Ignition System" in your November number, I take issue with his statement in the third paragraph wherein he says, "The total cost will not be much more than about $20 at mail-order prices."

Actually, the total cost of the system is well over $35 and this price is at the dealer level. This is assuming that it is possible to buy or substitute for any of the special *TI* semiconductors that are specified.

I have tried without success to obtain either the *TI* devices or substitutes from many distributors here in the state of Florida, and they have no records of such *TI* numbers or any cross-references.

I am bewildered as to where Mr. Cawlfield made his purchases. I am positive he didn't find most of the items in his junk box. I have been in the electronics game for more than 35 years and I have been unable to find a 6-ampere filament transformer in my own junk box, even though I have taken filament transformers from TV sets which have had as many as 35 tubes.

In any event, thanks for your magazine. I enjoy it.

JOSEPH T. BECK
Beck Radio-TV
Tampa, Fla.

All the TI *semiconductors used can be found in the latest* Allied Radio *industrial catalogue. The most expensive one is the SCR which sells for a little over $5. The two transistors cost $1.35 each, while the various diodes all sell for under $1 apiece. This means that the total semiconductor cost is around $12.*

If your junk box does not contain the filament transformer described, you can buy a brand-new one for around $4.50. Hence, I think you will agree that the total cost of the system as described should be, as the author says in his article, "not much more than about $20 at mail-order prices."—Editors

* * *

SEMICONDUCTOR TEST SET

To the Editors:

In the November, 1967 issue of ELECTRONICS WORLD there appeared a "Semiconductor Test Set" construction article by M. Gross.

Mr. Gross stated that two checks possible with the test set were the I_{CES} and I_{CBO} tests. What has been ignored is that I_{CBO}, a value determined by the manufacturer, requires a finite V_{CB} setting. The test set had no adjustable V_{CB} setting, thus limiting the use of the I_{CBO} test mode.

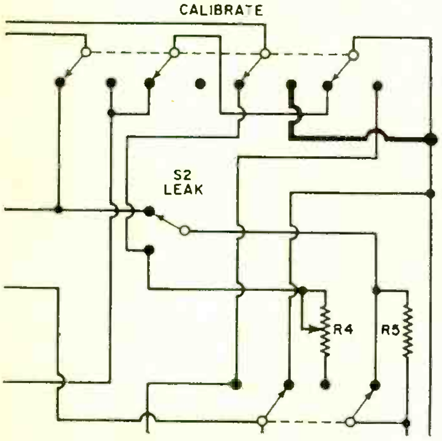
Incidentally, many popular transistors require a V_{CE} setting higher than the source available in the set. Moreover, I_{CES} is a value seldom listed in most semiconductor literature.

EDWARD S. MEDINA
Albuquerque, N. M.

To the Editors:

I have been one of your regular readers for over ten years now, and I want to congratulate you on the continued excellence of the magazine. As a technical writer, I consider it a "must" among my sources of up-to-date information on the state of the art in all the different fields of electronics. I have frequently found that within a few months of reading one of your articles, I have been called on to prepare a technical manual for equipment using the principles you had outlined so that I have had a head start on the job. However, it is not only your general articles that interest me; I enjoy the construction articles as well.

I would like to draw your attention to two errors in the schematic of the "Semiconductor Test Set" on page 74 of the November issue. The meter polarity was reversed, and "Calibrate" switch S4 disconnects the meter altogether in the "Calibrate" position so



that the second calibration procedure on page 76 cannot be performed. I enclose a marked-up copy of the schematic, showing what I believe to be the correct connections.

Normally your schematics are excellent—however, I feel that this one could have benefited either from supplemental simplified schematics, or from a more functional layout along the lines of the examples I enclose, which I made up for myself while constructing the unit.

CHRISTOPHER TERRY
Dir. of Publications
COMPAT Corp.
Hicksville, N. Y.

Just about all the transistor testers we have seen and used do have some limitations. However, even those devices with limitations still permit valid comparisons to be made and allow rough qualitative checks of a large number of transistors.

With regard to Reader Terry's letter, we thank him for his comments as well as for pointing out the circuit errors mentioned above. (The corrected diagram is shown above with the proper wiring indicated by a heavy line.)—Editors ▲

You can earn more money if you get an FCC License

...and here's our famous CIE warranty that you will get your license if you study with us at home

NOT SATISFIED with your present income? The most practical thing you can do about it is "bone up" on your electronics, pass the FCC exam, and get your Government license.

The demand for licensed men is enormous. Ten years ago there were about 100,000 licensed communications stations, including those for police and fire departments, airlines, the merchant marine, pipelines, telephone companies, taxicabs, railroads, trucking firms, delivery services, and so on.

Today there are over a million such stations on the air, and the number is growing constantly. And according to Federal law, no one is permitted to operate or service such equipment without a Commercial FCC License or without being under the direct supervision of a licensed operator.

This has resulted in a gold mine of new business for licensed service technicians. A typical mobile radio service contract pays an average of about $100 a month. It's possible for one trained technician to maintain eight to ten such mobile systems. Some men cover as many as fifteen systems, each with perhaps a dozen units.

Coming Impact of UHF

This demand for licensed operators and service technicians will be boosted again in the next 5 years by the mushrooming of UHF television. To the 500 or so VHF television stations now in operation, several times that many UHF stations may be added by the licensing of UHF channels and the sale of 10 million all-channel sets per year.

Opportunities in Plants

And there are other exciting opportunities in aerospace industries, electronics manufacturers, telephone companies, and plants operated by electronic automation. Inside industrial plants like these, it's the licensed technician who is always considered first for promotion and in-plant training programs. The reason is simple. Passing the Federal government's FCC exam and getting your license is widely accepted proof that you know the fundamentals of electronics.

So why doesn't everybody who "tinkers" with electronic components get an FCC License and start cleaning up?

The answer: it's not that simple. The government's licensing exam is tough. In fact, an average of two out of every three men who take the FCC exam fail.

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

CIE courses are so effective that better than 9 out of every 10 CIE-trained men who take the exam pass it...on their very first try! That's why we can afford to back our courses with the iron-clad Warranty shown on the facing page: you get your FCC License or your money back.

There's a reason for this remarkable record. From the beginning, CIE has specialized in electronics courses designed for home study. We have developed techniques that make learning at home easy, even if you've had trouble studying before.

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Your CIE instructor gives his undivided personal attention to the lessons and questions you send in. It's like being the only student in his "class." He not only grades your work, he analyzes it. Even your correct answers can reveal misunderstandings he will help you clear up. And he mails back his corrections and comments the same day he receives your assignment, so you can read his notations while everything is still fresh in your mind.

It Really Works

Our files are crammed with success stories of men whose CIE training has gained them their FCC "tickets" and admission to a higher income bracket.

Mark Newland of Santa Maria, Calif., boosted his earnings by $120 a month after getting his FCC License. He says: "Of 11 different correspondence courses I've taken, CIE's was the best prepared, most interesting, and easiest to understand."

Once he could show his FCC License, CIE graduate Calvin Smith of Salinas, California, landed the mobile phone job he'd been after for over a year.

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THESE CIE MEN PASSED... NOW THEY HAVE GOOD JOBS

Matt Stuczynski, Senior Transmitter Operator, Radio Station WBOE

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Chuck Hawkins, Chief Radio Technician, Division 12, Ohio Dept. of Highways

"My CIE Course enabled me to pass both the 2nd and 1st Class License Exams on my first attempt...I had no prior electronics training either. I'm now in charge of Division Communications. We service 119 mobile units and six base stations. It's an interesting, challenging and rewarding job. And incidentally, I got it through CIE's Job Placement Service."

Glenn Horning, Local Equipment Supervisor, Western Reserve Telephone Company

"There's no doubt about it. I owe my 2nd Class FCC License to Cleveland Institute. Their FCC License Course really teaches you theory and fundamentals and is particularly strong on transistors, mobile radio, troubleshooting and math. Do I use this knowledge? You bet. We're installing more sophisticated electronic gear all the time; what I learned from CIE sure helps."

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The United States of America

NUMBER P1-20-6490

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PLACE AND DATE OF ISSUANCE BUFFALO, NEW YORK SEPTEMBER 11, 1963

DATE AND TIME OF EXPIRATION SEPTEMBER 11, 1968 AT THREE O'CLOCK A.M. EASTERN STANDARD TIME

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President

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So you shouldn't have much trouble moving a lot of our tubes, week in and week out.

When you use our tubes, you get our Sylvania Bright Guys award certificates as a bonus. They're not quite the same as money. But they will get you the kinds of things only money can buy.

Your distributor is the man to contact for details. He'll give you a Sylvania Bright Guys award kit (which includes a catalogue listing the good things we offer—about 1500 in all).

Naturally, the more tubes you buy from him, the more certificates he'll give to you.

It's a pretty fair way to work, wouldn't you say?

SYLVANIA
A SUBSIDIARY OF GENERAL TELEPHONE & ELECTRONICS

Radio & Television news

By FOREST H. BELT /Contributing Editor

Still Chasing X-Rays

The Public Health Service (PHS) continues to measure x-rays emitted by color-TV receivers. The "big scare" is past with the modification of most of the *G-E* sets that were emitting excessive radiation below the receivers. However, PHS is still finding some *G-E* and other sets with radiation slightly in excess of 0.5 milliroentgen per hour at 5 cm from the surface of the set, the maximum recommended by the National Council on Radiation Protection and Measurement. A recent survey of 131 *G-E* sets conducted for PHS by the Pinellas County, Fla. health department showed that 27 of the sets produced radiation between 0.5 to under 1.25 mR/hr, 5 sets radiated between 1.25 to under 2.50 mR/hr, 3 sets radiated between 2.50 to under 6.25 mR/hr, and 3 radiated in excess of 6.25 mR/hr. This radiation was measured at the sides and rear of the sets rather than below as was formerly the case.

Even with this amount of radiation, the danger of biological damage is quite low. And this can be minimized by viewing the set at a distance of 6 to 10 feet and by avoiding prolonged exposure to the sides and rear of such receivers. However, service technicians should be aware of this radiation and should keep the high voltage on all color-TV receivers no higher than the values recommended by the manufacturers.

There has also been some talk, mainly by makers of glass for picture tubes, that color CRT's without safety plates were allowing x-radiation from the screen in front. PHS field measurements failed to turn up even one case of such forward radiation, even with bare-faced picture tubes, and even with misadjusted high voltage. Measurements will continue in several areas of the country; the PHS has asked the Electronic Industries Association to cooperate in this regard.

More and More in Less and Less

Why not an AM radio on a single integrated-circuit chip? *Philco* came pretty close last year with its two-chip prototype, which may go into production this summer. A British semiconductor manufacturer is on the verge of producing the integrated circuit that will make possible the single-chip AM receiver. *Plessey Co.* has developed a linear IC that has oscillator, mixer, i.f., detector, and all audio stages (including output) on one chip. The company expects to supply the unit in production quantities soon.

Meanwhile, *Mullard Ltd.*, another British company, has accomplished essentially the same thing. The *Mullard* IC doesn't include the audio output stage, though, and requires an outboard transistor. A ceramic filter, also outboard, is used for i.f. selectivity. The same chip can be used in communications receivers, or as a TV sound i.f. amplifier. Just a few more steps and Dick Tracy's wrist radio will be an oversized antique; a communications set will fit neatly into any ring.

Radio-TV Tuned With Potentiometer

In the past 8 or 9 months, several semiconductor manufacturers have come up with voltage-variable capacitive diodes that have a capacitance range wide enough to tune the entire television band. At least one company has a unit that can cover the AM broadcast band—the toughest to accomplish. *ITT Semiconductors* revived the excitement lately by unveiling an entire kit of semiconductors for making solid-state TV tuners without mechanical parts. In addition, suggests *ITT*, the new design will make remote control much simpler. A diode with very low forward resistance is used for bandswitching, and two tuning diodes are tuned by voltage from a potentiometer. The kit even includes a temperature-stabilized zener diode for absolute voltage control. *Telefunken*, of Germany, showed a prototype design last year in which the entire v.h.f.-u.h.f. television bands could be tuned with a five-button switch and a potentiometer.

The AM-tuning diode introduced by *ITT* purports to simplify broadcast-band tuning. Sorry, but until the price is lower, the old coil-and-capacitor setup isn't likely to disappear suddenly.

Solid Approach for Test Instruments

Among instruments for servicing home-entertainment electronic products, you seldom hear of a new instrument that isn't solid-state. Color-bar generators and stereo-multiplex generators were among the first to reflect the trend, because they came into importance just about the time solid-state technology experienced a price break which put it into the range of service-type equipment. It's no surprise, then, that almost any new test instrument nowadays is transistorized.

The big step forward has been in portability. With the minuscule power requirements of transistor stages, battery operation of all but the largest instruments is practical; without the limitation of a power cord, portability is a cinch. *RCA* recently added a transistor tester, sine/square generator, and volt-ohmmeter to the long list of portable instruments for home servicing and industrial use. "Knight-Kit" (*Allied Radio*) also has a complete new line of solid-state test equipment which is a.c.-operated.

Most glamorous of recent developments along this line is the incorporation of the field-effect transistor into voltmeters. Equipment makers weren't long in taking advantage of the high input impedance of the FET. Among early manufacturers in this area are *Heath*, *Triplett*, and *Amphenol*; and more recently *Sencore*.

Pay-TV . . . A Waiting Game

The on-again, off-again character of subscription television continues. Congress finally asked the Federal Communications Commission (FCC) to withhold any decision until at least the end of 1968. This will give Congress time to hold more hearings and perhaps come up with legislation that spells out exactly what pay-TV can or cannot do. An attempt may even be made to decide on one standard system; there are several possible—some wired, some aired.

The National Association of Broadcasters (NAB) strongly opposes pay-TV. So do movie-theater owners. They've been fighting it for more than a dozen years. Their biggest win came a couple of years ago when they ousted a large subscription-TV operation that almost got started in southern California, defeating it through a referendum of voters.

Whether the FCC heeds the Congressional suggestion or not, pay-TV proponents seem both patient and optimistic. They insist pay-TV is inevitable. The argument they use most is that pay-TV will offer the public commercial-free programs of high quality. That may turn out to be a poor argument. For one thing, there may not be that many "high-quality" programs to be had for viewing anywhere, pay or otherwise. For another thing, a survey last year revealed that only about half the viewing audience are actually that annoyed with commercials. (In fact, nearly 40% like them.) Besides, a new NAB Television Code soon to go into effect will limit commercial interruptions to four per 60-minute program which should be some improvement.

This One's Available

Last month, this column reported that *Amperex* and *Matsushita* had both introduced high-voltage power transistors (1500-volt base-collector rating) for the horizontal-deflection stage of solid-state TV sets. As is often true of new developments, there was this catch: neither transistor is available in quantity until late this year, for one reason and another. *Delco Radio* has one with a lower rating (1200 volts), but it, too, is not yet available in production lots.

To the rescue comes *Toshiba* (*Tokyo Shibaura Electric Co.*) offering its 2SC643, rated at 1500 volts and available for delivery now. The firm will soon have a version rated at 1800 volts, plenty for large-screen solid-state TV. The price of the *Toshiba* unit is competitive, too, less than $2.50. There is a companion vertical-deflection transistor, the 2SC642—and it's available.

Dummy Transistors in Radios

Some manufacturers and importers of tiny transistor portable radios are apparently still counting "dummy" transistors in their labeling and advertising. At least the Federal Trade Commission (FTC) continues to express concern about the practice. A so-called 10-transistor radio may have only 6 or 7 working; the rest are just stuck in the board and not hooked up. Overseas manufacturers blame the importers, who (they complain) keep asking for "extra" non-functioning transistors in sets they order. The cheap reject transistors are an inexpensive way of making a radio seem (in the ads) more sensitive and powerful.

The FTC solution, which is okay with the Electronic Industries Associations of both the U.S. and Japan, is a new rule to prohibit counting transistors that are not active. An early proposal specified that the transistor, to be counted, must detect, amplify, or receive radio signals. A more liberal consideration of auxiliary functions (a.v.c. and the like) is expected to shape final wording of the new rule. Japan furnishes more than half the transistor portables imported into the U.S. Hong Kong supplies a significant percentage, too, and has been chief target for complaints.

All-Solid-State CB

A pair of new silicon r.f. power transistors are contributing to the end of hybrid CB units (those which still use tubes in the transmitter output stages). The *RCA* 40581 and 40582 are triple-diffused silicon planar *n-p-n* types, in TO-39 packages. They round out a full complement of *RCA* transistors for making an entire 27-MHz transmitter solid-state. They can develop 3.5 watts of unmodulated r.f. power output at Citizens-Band frequencies, comparable with tube performance in the usual 5-watt-input power stage. ▲

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MASSAINO: Canzona XXXV à 16 (complete) DGG Archive • Performed on old instruments, and recorded with techniques that combine directionality with depth and ambiance, this band reproduces the sound of the music in its original environment, a large and reverberant cathedral.

CORRETTE: Concerto Comique Op. 8, No. 6, "Le Plaisir des Dames" (third movement) Connoisseur Society • Recording demonstrates the sound and special layout of a small performing group (harpsichord, cello and flutes) in fairly resonant surroundings.

KHAN: Raga Chandranandan (excerpt) Connoisseur Society • This classical Indian music provides some of the most exciting musical experiences imaginable. Directionality between vastly different instruments is the point here as well as the sheer sound of the instruments themselves.

RODRIGO: Concert—Serenade for Harp and Orchestra (excerpt from the first movement) Deutsche Grammophon Gesellschaft • This excerpt provides a wealth of instrumental color behind a harp solo. The music is clear, colorful, rather classical, and immensely entertaining.

MANITAS DE PLATA: Gypsy Rhumba (complete) Connoisseur Society • The recording puts the listener in the center of a flamenco party by precisely transmitting the directionality, depth and ambiance of this completely impromptu recording session.

MARCELLO: (arr. King): Psalm XVII "The Heavens are Telling" (complete) Connoisseur Society • This arrangement of the brief Marcello Psalm is for brass choir and organ, who answer one another antiphonally.

PRAETORIUS: Terpsichore: La Bourrée XXXII (complete) DGG Archive • A musical gem played by a raft of renaissance instruments including recorders, viols, lutes, harpsichord, small kettle drums, chimes, bells, and triangle.

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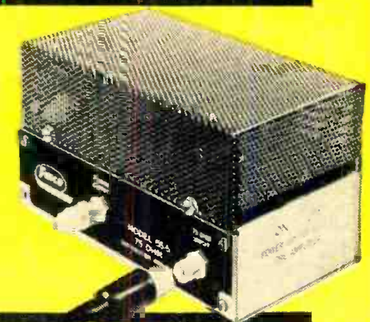

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CIRCLE NO. 78 ON READER SERVICE CARD

AIRPORT SURVEILLANCE RADAR: *The European Approach*

By RICHARD HUMPHREY

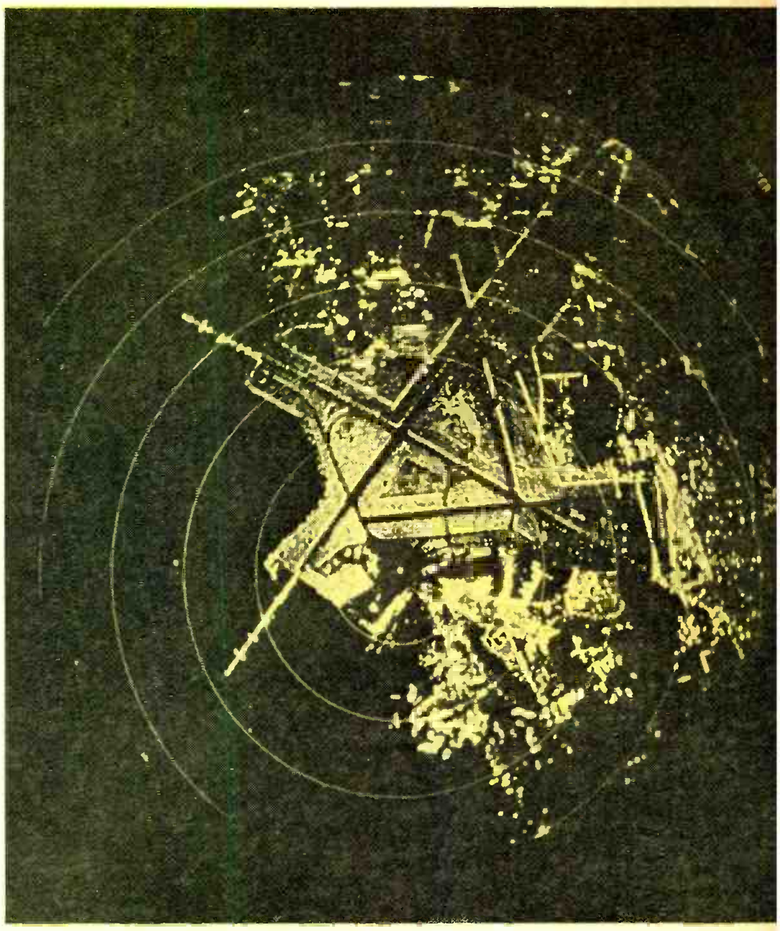


Photo of radar scope shows plane taking off in upper-left runway and another plane landing in lower-left runway. The original radar display shows clearly the wings of the two planes along with a ladder-like trace indicating motion.

High-speed scanning rates and higher operating frequencies are used by radars at several major European airports to produce detailed pictures of aircraft landings and take-offs and to monitor traffic on the ground.

FEW service industries can match the growth of the nation's air-travel business. In 1960, 9784 control-tower operators manned 153 control towers at 2780 airports to supervise aircraft which flew at an average speed of 235 mi/h (domestic) and 307 mi/h (international).

In 1965, 14,875 control-tower operators manned 292 control towers at 3570 airports to supervise aircraft which flew at an average speed of 315 mi/h (domestic) and 451 mi/h (international). Figures for the first half of 1967 show an increase in most of these categories.

Radar is absolutely necessary to the safe and efficient handling of this ever-increasing flow of air traffic. As proof, witness the result of a radar failure at Kennedy International on July 28th, 1967: only 20 planes could be landed in one hour at this airport which normally handles a hundred or more hourly.

Radar solves with ease and safety most of the problems created by more and more airplanes flying at faster and faster speeds. But where it may fall short is during the two most dangerous times of an airliner's flight: landing and take-off.

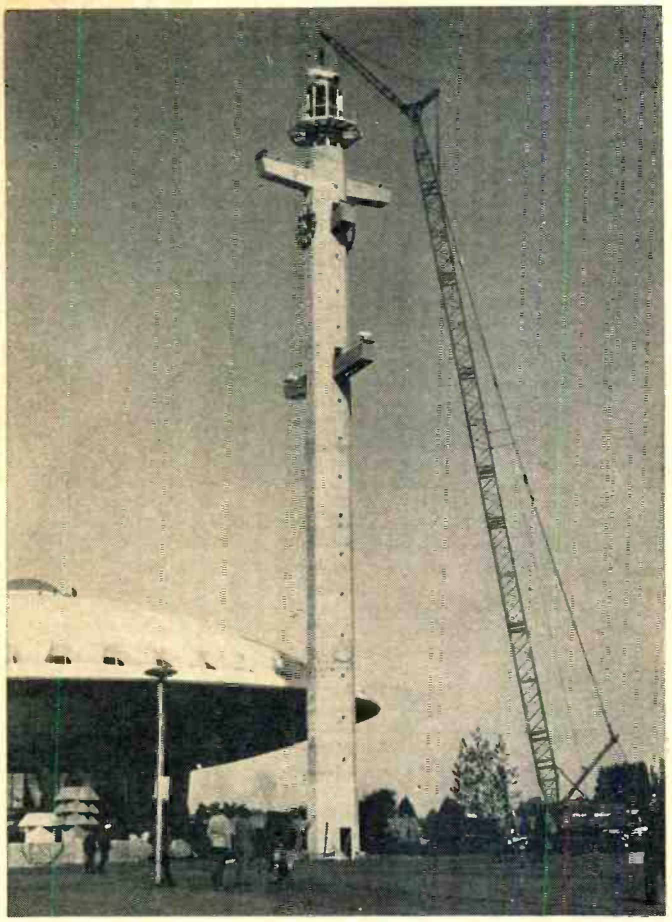
Many major airports in Europe are giving considerable attention to these two vital times. At London, Schiphol, and Eindhoven in Holland, and at Frankfort and other air terminals, they are using a special type of radar called ASDE—airfield surface detection equipment—to track not only landings and take-offs but also to keep an eye on the swelling ground traffic which is a necessary part of today's high-volume air-travel industry.

On the other hand, the only major airport in the New York area which has ASDE radar is Kennedy International. Newark airport had it at one time but it was discontinued a few years ago on what one FAA official termed a "cost *versus* benefit" basis. Even the ground collision at LaGuardia on May 2nd of last year between a *Yankee Airlines* DeHavilland and a privately owned *Piper* Cherokee in which three people lost their lives has not changed American thinking as far as ASDE radar is concerned. (LaGuardia does not have ASDE.)

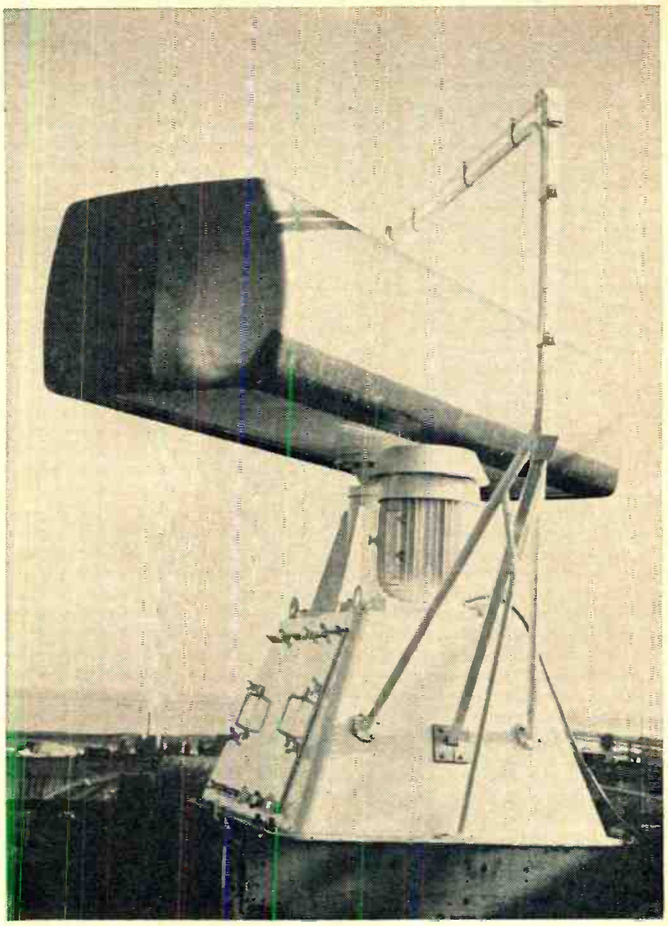
Comparison Between Equipment

To get a comparison between the type of equipment used here and that in general use in Europe, this author talked to FAA radar specialist Harrison Longmate about the Kennedy unit.

"The equipment at Kennedy," Longmate said, "is made by the *Airborne Instruments Laboratory* and operates at 24,000 MHz (the 1.25-cm band) with a pulse length of



Radar tower at Holland's Eindhoven airport is shown here with a crane installing the ASDE-500 antenna and transceiver unit.



A closeup view of the 92-inch radar antenna (enclosed in its fiberglass radome) which is used with the Philips equipment.

0.02 microsecond, a PRF (pulse recurrence frequency) of 14,400, and a peak power of 36 to 50 kW.

"Polarization of the *AIL* ASDE radar is either circular or linear, average power is 11 to 14 watts, the scan rate (antenna r/min) is 60 and you can tilt the antenna ±3°. The beamwidth is 1° vertical and it has a 16-inch display tube. On the scope, an aircraft looks something like a 'T'. In fact," he concluded enthusiastically, "you can even pick out three fins on a Connie!"

This ability to delineate the actual shape of the observed target is common to all ASDE radar. A moment's thought will tell you that ASDE radar *must* be able to do this (how else to sort out aircraft, tank trucks, baggage trailers, "follow-me" cars, etc.).

The European counterpart of the *AIL* unit is the ASDE-500 made by *Philips*, with a slightly higher operating frequency (33,000 MHz) and a markedly faster antenna rotation speed (500 effective r/min). Its maker claims these two characteristics give its ASDE radar a better picture of what's taking place on the ground.

While this is a moot point (33 GHz and 24 GHz would seem to have the same advantages and disadvantages), many feel the increased scan rate of 500 pictures-per-minute (8⅓ per second) is the feature which puts the European unit ahead in this respect.

The advent of jet-aircraft-lengthened runways gave us higher landing and take-off speeds, brought about an increase in the number of ground-support vehicles and, in general, increased the work and responsibilities of the control-tower operator. To ease this situation, an increased scan rate would seem to be desirable.

A direct comparison between the two ASDE units and their scan rates is interesting. Suppose we have an aircraft landing at 120 mi/h. This plane will be traveling 10,560 feet each minute, 176 feet per second. The Kennedy *AIL* ASDE radar (with a scan rate of 60 r/min) takes one look-per-second, which means the observed aircraft travels 176 feet between each picture renewal. The *Philips* ASDE-500 with its 500-per-minute scan rate lets this target progress only about 21 feet between looks.

Other Special Capabilities

Good ASDE radar must also have other special capabilities. To give control-tower personnel quicker and more accurate at-a-glance information, the definition must be much higher than 1300-MHz, 2700-MHz, or 9000-MHz radar with comparably sized antennas. This definition is, of course, a direct result of using frequencies whose wavelengths are in the millimeter range (the shorter the wavelength, the longer *electrically* an antenna can be made while still remaining within modest *physical* length) plus extremely short pulse lengths and relatively fast PRF's (pulse recurrence frequency, the number of times-per-second the radar's blast of signal power is triggered).

In PRF, pulse length, and operating frequency *AIL's* ASDE radar and the *Philips* ASDE-500 are pretty much neck-and-neck. They both have pulse lengths of 0.02 microsecond while operating frequency (33 GHz for the ASDE-500 and 24 GHz for the *AIL*) and the PRF's (12,000 in the *Philips* and 14,400 in the *AIL*) are, if not identical, in the same neighborhood.

Additionally, ASDE radar should have a "daylight" viewing screen. While optical viewing of a target held on long-medium-, and short-range radar is not only usually impossible but seldom desirable, in ASDE work there might be many times when control-tower personnel will find it highly advantageous to switch swiftly from radar-view to eyeball-view. Here the quick transition while still retaining relatively good visual clarity almost demands the daylight-type of CRT viewer.

Also, reliability and ease of maintenance rate very high on the "must" list for ASDE radar. (LaGuardia, which has only conventional radar, once experienced two-hour landing delays during a radar failure.)

But by far the most remarkable thing about the European ASDE radar is the effective antenna rotation speed of 500 r/min. What the manufacturer did was to build *two* complete radar units back-to-back—two cosecant-squared antennas enclosed in a fiberglass cylinder, two transmitters, two receivers, and two power supplies (Fig. 1). The resultant signals are then fed to one central control console. There, the two signals are flip-flopped and phased to *double* the actual *physical* antenna rotation speed of 250 r/min to an effective r/min of 500. The picture, with its now-500 scan rate, is delivered to as many as five display consoles.

Explaining "from the top down", we start with an antenna r/min of 250 which is remarkable enough in itself. Each of the two radars has a PRF of 6000. This means (dividing the 6000 PRF into one second) that each radar fires at intervals of 166.66 microseconds.

Since it would serve no useful purpose to have these two sets merely duplicate one another, we synchronize them (in the central control console) so that radar #2 fires 83.33 microseconds later than radar #1. This produces two results: with each radar being triggered every 166.66 microseconds and then being meshed like two combs into each other, we end up with a firing interval from the *two* sets of one-half of 166.66 microseconds, or 83.33 microseconds, and a *total* PRF of 2 × 6000 or 12,000.

However, this will bring up a problem. Visualize the following: radar #1 fires when its antenna is facing, say, 000° (due North). Radar #2 fires 83.33 microseconds later. Since radar #2's antenna is aimed (back-to-back remember) 180° from radar #1's, it would fire at 180° *plus the number of degrees (or parts of degrees) which the antenna (at 250 r/min) has turned through.* Then, 83.33 microseconds later, radar #1 will fire at 000° plus the number of degrees it has turned in 166.66 (2 × 83.33) microseconds.

If we place a target at 000° the problem raised by this displacement, which takes place each time the antenna unit revolves, becomes readily apparent. The physical rotation of 250 r/min of the ASDE-500 antenna is just too fast! Our target at 000° would be hit just *once per revolution.* It certainly won't be a very good idea to have a high picture renewal rate if we don't have a comparable—and necessary—solid target return.

Here's where the delay phasing of the ASDE-500 double-ended signal steps in. From a code wheel in the rotating unit, a signal is obtained and used to delay the sync pulse *for each set* approximately 5 minutes of one degree (1/12th of a degree). Here's why that interval was chosen: taking radar #1 we see that its antenna will make 4⅙ revolutions per second (250 r/min ÷ 60). 4⅙ r/s is equivalent to (360° × 4⅙) or 1500°. We see that with a PRF of 6000 being fired through 1500°, each time radar #1 fires, its beam will have rotated through 15′ (0.25°). Now, if we can delay that firing 5′ on each revolution, we would shift the scan pattern 5′ on the second firing, 10′ on the third, and on the fourth we would return to our original state of 15′ and the sequence would start all over again. This particular technique is applied to both radar #1 and radar #2.

The target at 000° now gets a scatter-gun type of coverage. The scanning density is only slightly increased by this but we do get a better picture as far as total saturation is concerned.

This "better" picture is easily discernible in the photos taken of the ASDE-500 scope. The clarity and definition are in marked contrast to radar operating at the lower frequencies. What these photographs *don't* show is the almost total lack of distraction caused by the slow- "sweep" of the radar beam around and around the fac the CRT in conventional radar. In the ASDE-500 the beam races around 8⅓ times a second. It doesn't have the hypnotic effect that many radar operators find annoying.

Effects of Precipitation

The increased return from small targets which is another advantage of the millimeter wavelengths involved in ASDE radar gives rise, paradoxically, to a disadvantage.

"One trouble we have," said the FAA's Harrison Longmate in speaking of the Kennedy *AIL* equipment, "is saturation of the radome in a heavy rain which affects the signal. Of course," he added, "there's a certain amount of interference to our lower frequency radar in extremely heavy precipitation."

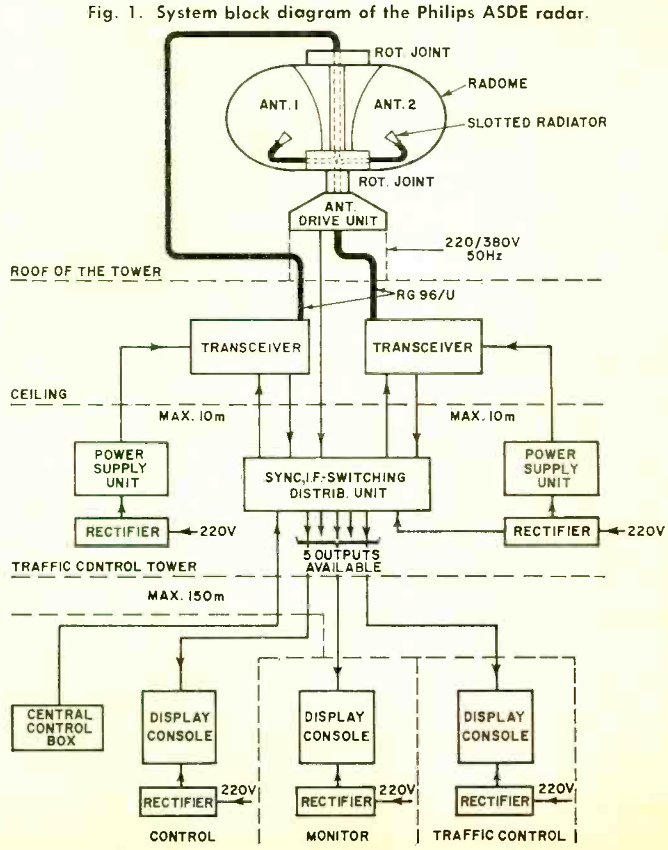
Longmate's remarks were echoed by Lt. Cmdr. Glass of the U.S. Coast Guard's Electronic Engineering Center at Wildwood, N.J. where the only 33,000-MHz radar (a marine navigation unit, not the ASDE-500) in the country is presently being evaluated (see "New Q-Band Marine Radar" in the April 1967 issue).

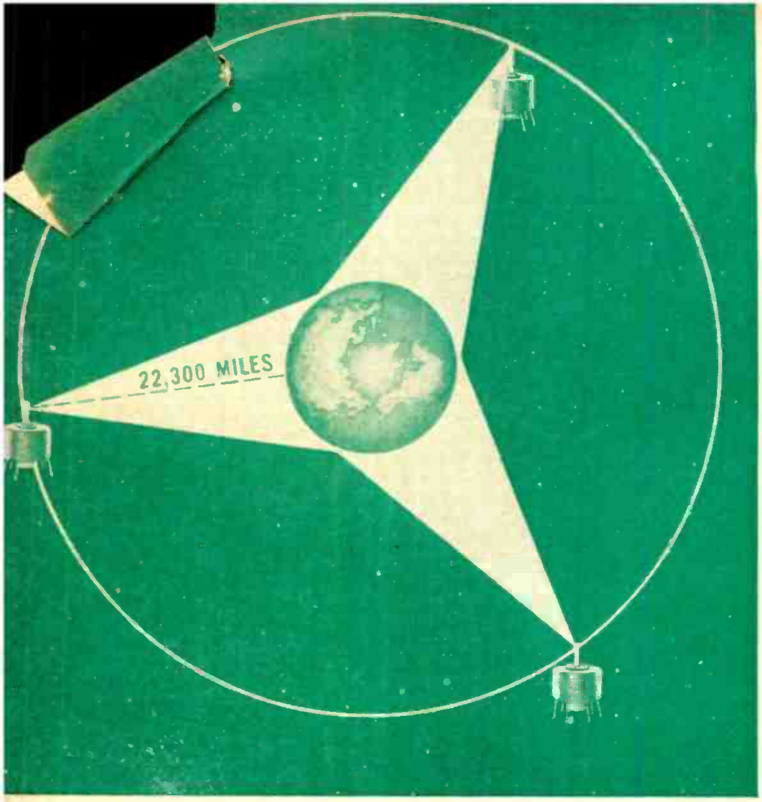
"We had a very interesting day down here early in February," Glass said. "Light rain, then sleet and rain, fine snow, heavy snow, and then changing in the reverse order. The *Philips* radar," he observed, "was affected more by the weather than the X-band (9000-MHz) equipment."

In addition to the millimeter (33-GHz) radar, the Coast Guard has 18- to 20-centimeter (9-GHz) units undergoing testing. Antennas are almost identical in placement so this unique weather panorama was ideal for comparison purposes.

Schiphol airport's ASDE radar was installed before the field was fully operational. The American point of view—despite the fact that collisions and near-misses involving two aircraft or an airplane and a ground vehicle occur with an interesting regularity—is that ASDE radar "hasn't proven itself". That Europe should find so much that is good in this equipment while we have a lessening interest in it is rather hard to understand. ▲

Fig. 1. System block diagram of the Philips ASDE radar.





At an altitude of 22,300 miles, synchronous satellites in an equatorial orbit circle the earth once a day and thus remain in a fixed position relative to the earth. Their signals can cover more than one-third the earth, or an area as small as the U.S.

GLOBAL tête-à-têtes: a satellite repeating system

By SIEGFRIED H. REIGER/Vice-President, Technical, Communications Satellite Corp.

Four communications satellites are in synchronous equatorial orbit over the Atlantic and Pacific oceans. Comsat, as operations manager, can use their services to tie Europe and Africa, and Asia and Australia to North America.

Editor's Note: A legal skirmish may be building up between the Communications Satellite Corp. *and the* American Telephone & Telegraph Co. Comsat *is looking for FCC approval to launch a pilot domestic satellite system to bring satellite-distributed color television and overseas communications to the Pacific and Rocky Mountain time zones. Meanwhile,* AT&T *wants FCC permission to lay a new $80-million communications cable across the Atlantic—it would carry 720 circuits to Spain and Portugal, doubling the present capacity.*

Comsat *is unhappy because only half of its Early Bird facility is being used and they have a second, more powerful satellite, the Atlantic II, in the same general ocean area. Thus the new cable, they say, could retard* Comsat's *growth. If approved by the FCC, the new cable, called TAT-5, should be completed in less than two years.*

Most of the other carriers, International Telephone and Telegraph Co., RCA Communications, Inc., *and* Western Union International, Inc., *believe we need more satellites as well as cables. Meanwhile AT&T will urge FCC approval on the grounds that the cable will serve as a backup for existing facilities and would permit a reduction in the transatlantic tariff rates.*

COMMERCIAL satellite communications are now available to more than two thirds of the world and new satellites to be launched, beginning this year, will make such service available to any country that has an earth station.

The satellites in this developing global system are synchronous satellites. They orbit the earth over the equator at an altitude of 22,300 miles. At this altitude, they circle the earth once a day and thus remain in a fixed position relative to the earth's surface. Such satellites serve an area greater than one-third of the earth's surface by relaying all forms of communications between the various earth stations within their line-of-sight.

Early Bird (International Telecommunications Consortium—Intelsat I), the world's first commercial communications satellite, was launched on April 6, 1965. It links North America and Europe with 240 high-quality, two-way voice channels or one color-TV channel. Weighing only 85 pounds, this one small satellite increased transatlantic communications capacity by nearly 50 percent and made possible the live transmission of commercial television across an ocean for the first time.

Early in 1967, three larger satellites of the Intelsat II series were orbited. Two of these are stationed over the Pacific Ocean while the third is over the Atlantic. These satellites, along with Early Bird, comprise the space segment of the evolving global communications satellite system. The Pacific satellites transmit communications between North America and the Far East, including Australia. The latest Atlantic satellite makes similar service available between North America, Latin America, Europe, Africa, and the Middle East. Like Early Bird, the Intelsat II satellites transmit signals over 240 communications channels, but with much more power. Signals are beamed from ground stations to the satellites (uplink) at 6.0 GHz and are broadcast (downlink) at 4.0 GHz. One satellite of the Intelsat III series is expected to be launched and orbited over the Indian Ocean early this year. It will have either 1200 voice circuits or a mixture of voice and color-TV channels. It will link Japan with England and all countries in between.

The Operators

The four satellites now in operation are owned by the International Telecommunications Satellite Consortium. This is a growing group of countries cooperating in the development of a global communications system. At the present time, 60 countries are members and the *Communications Satellite Corporation (Comsat)* represents the U.S.

Intelsat is a unique concept in international cooperation and participation. It is the largest international joint venture of its kind ever undertaken. The member companies own the satellites on an investment-use basis, *i.e.*, each country's investment is based on the projected use it will make of the available satellite circuits. To date, member countries have invested a total of about $70 million and have received a return of some $14 million in revenue.

Comsat acts as manager for Intelsat and, as such, is responsible for the design, development, operation, and maintenance of the satellites.

Intelsat is an outgrowth of two interim agreements which thirteen countries signed in August 1964. These and subsequent agreements are being reviewed preparatory to setting up a more permanent arrangement by January 1, 1970.

In contrast with the joint ownership of the satellites, earth stations in the global communications system are owned and operated by national agencies or designated entities in the countries where they are located. Three earth stations are operating in the United States with single stations in Canada, the United Kingdom, France, Germany, Italy, Spain, the Ascension and Canary Islands, Japan, Thailand, the Philippines, and Australia. A number of other earth stations are being constructed, six of them in the United States and many more planned. By the end of 1969, there may be more than 40 earth stations in operation.

A communications satellite system consists of the satellites and their associated earth stations. Thus, the satellite system is combined with the terrestrial facilities in various countries to relay communications from one customer to another.

In most cases, government-owned entities operate telecommunications in foreign countries—satellite and/or terrestrial. In the United States, *Comsat* is a publically held communications carrier, regulated by the FCC, as are other common-carrier companies.

The Carriers' Carrier

The FCC has ruled that *Comsat*, in effect a carriers' carrier, is permitted to sell international satellite services only to *AT&T*, *RCA Communications*, *ITT*, and *Western Union International*. *Comsat* can, however, sell services directly to other private entities in "unique and exceptional" circumstances and to the U.S. Government when such services are in "the national interest". Thus, *Comsat* has little or no direct business relationship with the ultimate customer in the United States at this time and no such relationship in other countries.

On the other hand, the economic advantages of satellites have already been instrumental in reducing transoceanic communications costs. This has been done within the framework of a composite pricing system in which the international carriers use a part of the satellite earnings to carry the higher cost of existing telephone cables. For example, after *Comsat* had reduced its transatlantic monthly charge a second time for a voice-grade half-circuit between the Continental United States and Great Britain to $3800, the carriers' equivalent monthly charge was also reduced a second time to $6500. After *Comsat* established a rate of $6500 for similar service between the United States and Japan, the carriers reduced their equivalent charges to $10,000.

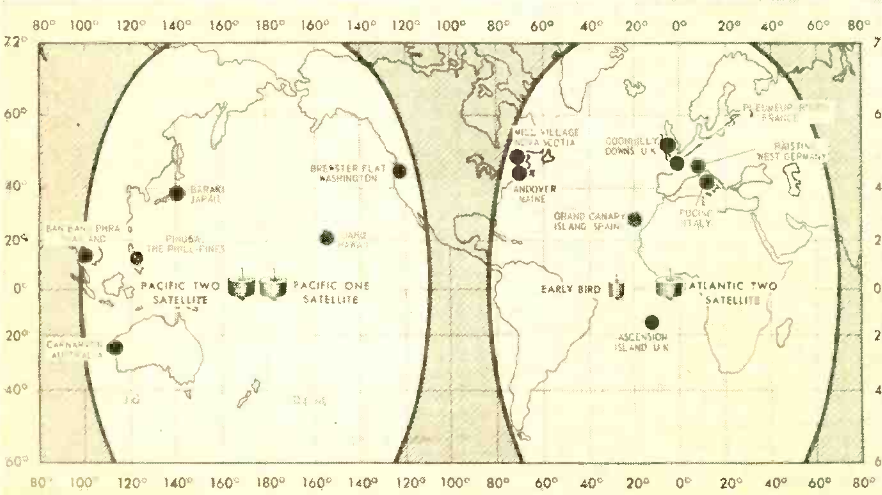
Overseas carriers must be allowed to recover their investment in transoceanic cables. However, if the composite rate approach provides incentives for the carriers to install new cables and if the earnings of satellites are used to subsidize facilities which are not now economically competitive, then developing countries as well as developed countries would not receive the full benefit from satellite technology.

Modern satellites have a number of distinct communications advantages. First, they make available high communications capacities at low cost. For example, the 1200-circuit satellites to be launched this year represent an average orbital cost of only $9 million. Future satellites, now only in the design stages, will provide more than a hundred times the capability of present satellites at a relatively small incremental increase in orbital cost. Second, satellites are capable of transmitting all forms of communications simultaneously—telephone, television, teletypewriter, data, and facsimile. And they have a multiple-point, multiple-access capability. That is, all earth stations within a satellite's line-of-sight can communicate with each other at the same time, in pairs or in groups. Presently, no other form of transmission is capable of providing this facility.

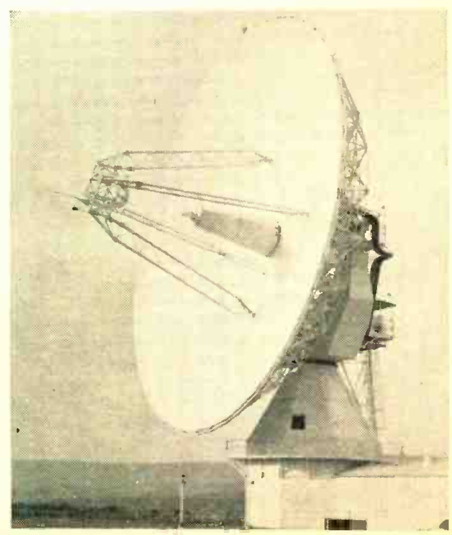
New Horizons

In the short period of time since June 1965 when Early Bird went into commercial service, international television has become commonplace and the potentials of satellite communications have been demonstrated in many ways. Television has been used to transmit medical information between the U.S. and Europe and is helping make possible world-wide medical education and practice. Future satellites may also help solve air-traffic control and management problems as well as help navigate and communicate with ships at sea.

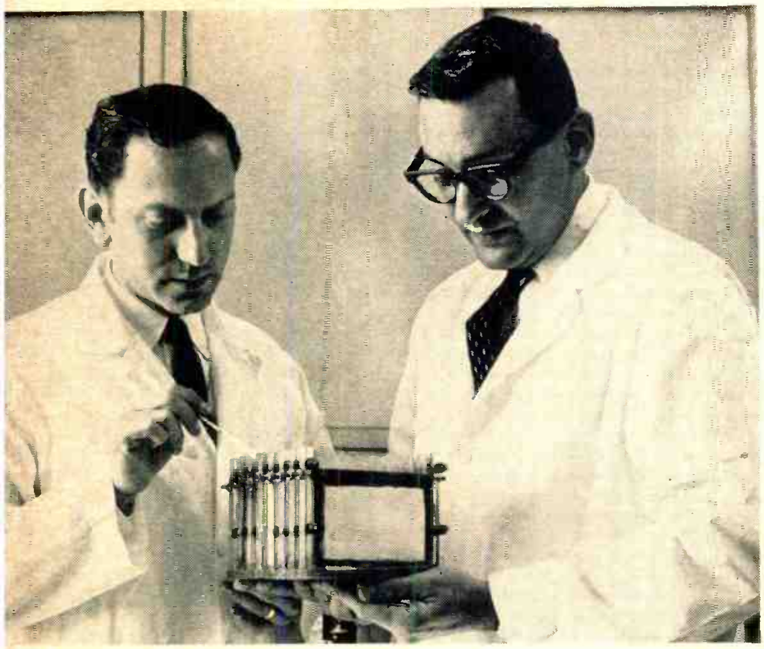
The telecommunications (*Continued on page* 78)

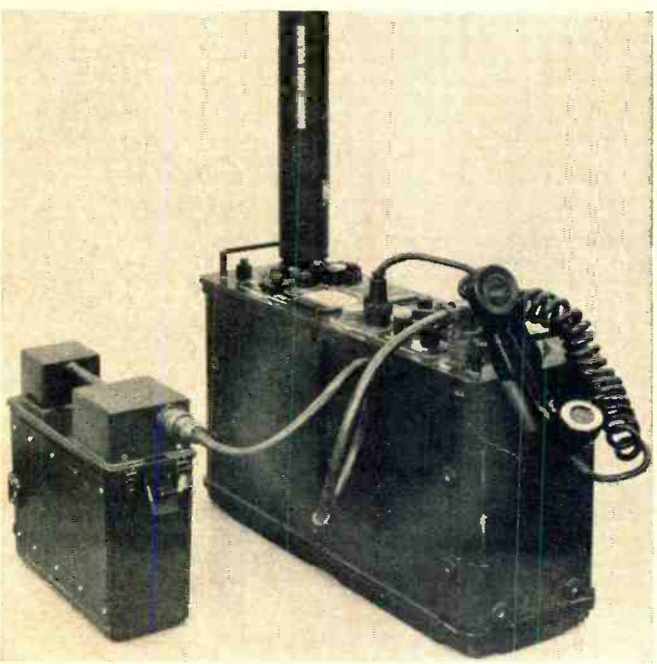


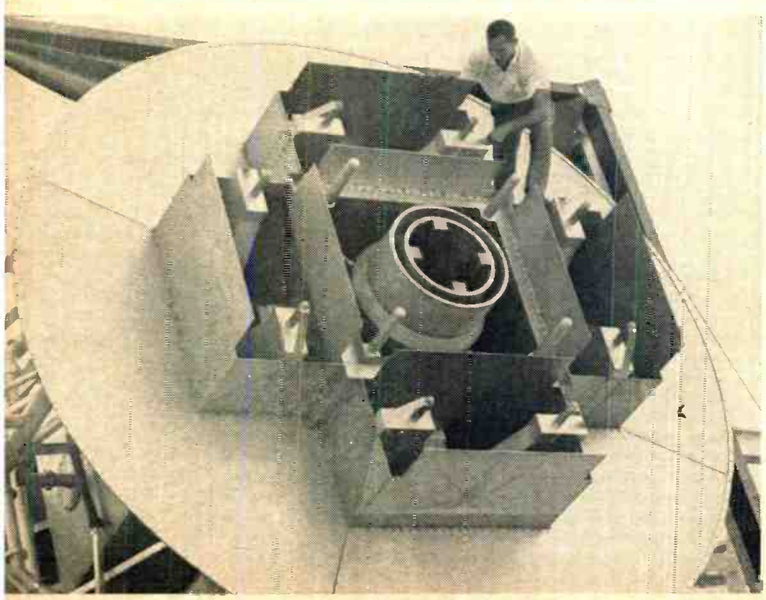
Two satellites over the Atlantic ocean and two over the Pacific already make commercial satellite communications available to more than two-thirds of the world. More powerful satellites will be orbited during this year to expand system to a global scale.



There are 15 earth stations like this one at Brewster Flat, Wash., operating in 11 countries around world. By 1969, 40 stations should be in operation, 6 in U.S.







RECENT DEVELOPMENTS IN ELECTRONICS

New Iron-Air Battery. (Top left) An experimental iron-air cell stack that can be used in an "air-breathing" battery that produces six times more electric energy than a conventional lead-acid auto battery is shown here. The new battery, developed at GT&E Laboratories, is rechargeable and has produced 60 to 70 watt-hours per pound of battery in laboratory tests. Further improvements in power output are anticipated. In comparison, a conventional lead-acid battery operating in an automobile produces energy at the rate of 10 to 12 watt-hours per pound of battery. The new cell uses a porous iron anode along with an air cathode which is an oxygen (air) permeable hydrophobic structure on a nickel grid containing platinum black as electrocatalyst. A potassium hydroxide electrolyte is used. Output voltage during discharge is between 0.80 and 0.96 volt. Iron-air cells having capacities between 5 and 20 ampere-hours have been fabricated. These cells have been operated for more than 200 charge-discharge cycles, and are said to surpass the new zinc-air batteries that are described just below in cycle life.

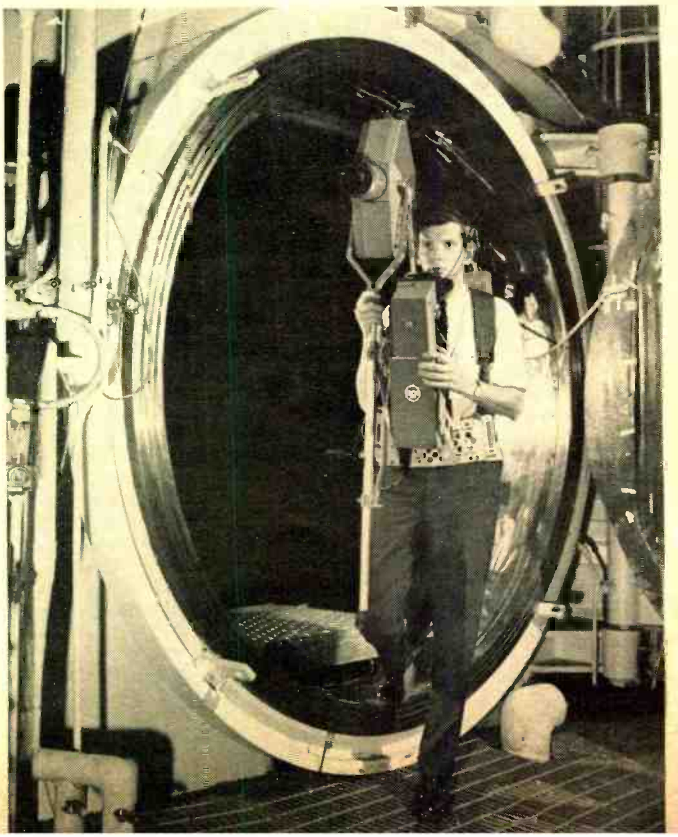
Rechargeable Zinc-Air Battery. (Center) Another new type of storage battery, but one that has advanced beyond the experimental laboratory stage is the zinc-air battery. A 28-volt, 25-ampere-hour version of this battery is at the extreme left in the photo where it is shown operating a standard military communications unit. Light weight, field rechargeable in ten minutes or less, and superior low-temperature performance are outstanding characteristics. The new battery has been developed by Leesona Corp. for use with U.S. Marine Corps radios. Preliminary qualification tests have been successfully performed and field service testing is now in progress. This cell uses a porous zinc anode, while the cathode uses oxygen from the air. As with the iron-air battery described above, the cathode is made from a hydrophobic material which allows the passage of air into the cell but is impervious to the potassium hydroxide electrolyte. Again a special catalyst is used to improve the rate of reduction of the atmospheric oxygen. The cell provides energy densities of about 50 to 80 watt-hours per pound as a rechargeable cell depending upon application. Open-circuit voltage is about 1.4 V per cell.

Largest Antenna Feed. (Bottom left) The antenna feed for the world's largest and most powerful missile-tracking radar is shown on its test stand. The feed is a five-horn monopulse radar radiator which can provide four different types of polarization—vertical, horizontal, left and right circular. It is designed to gather maximum target information from the radar echo. The 150-foot diameter antenna, built by Radiation Inc., is part of the Advanced Research Projects Agency's Project Defender for the nation's anti-missile defense program. When tests are complete, this feed will be shipped to the South Pacific for installation as a major part of ARPA's Long/Range Tracking and Instrumentation Radar (ALTAIR) System.

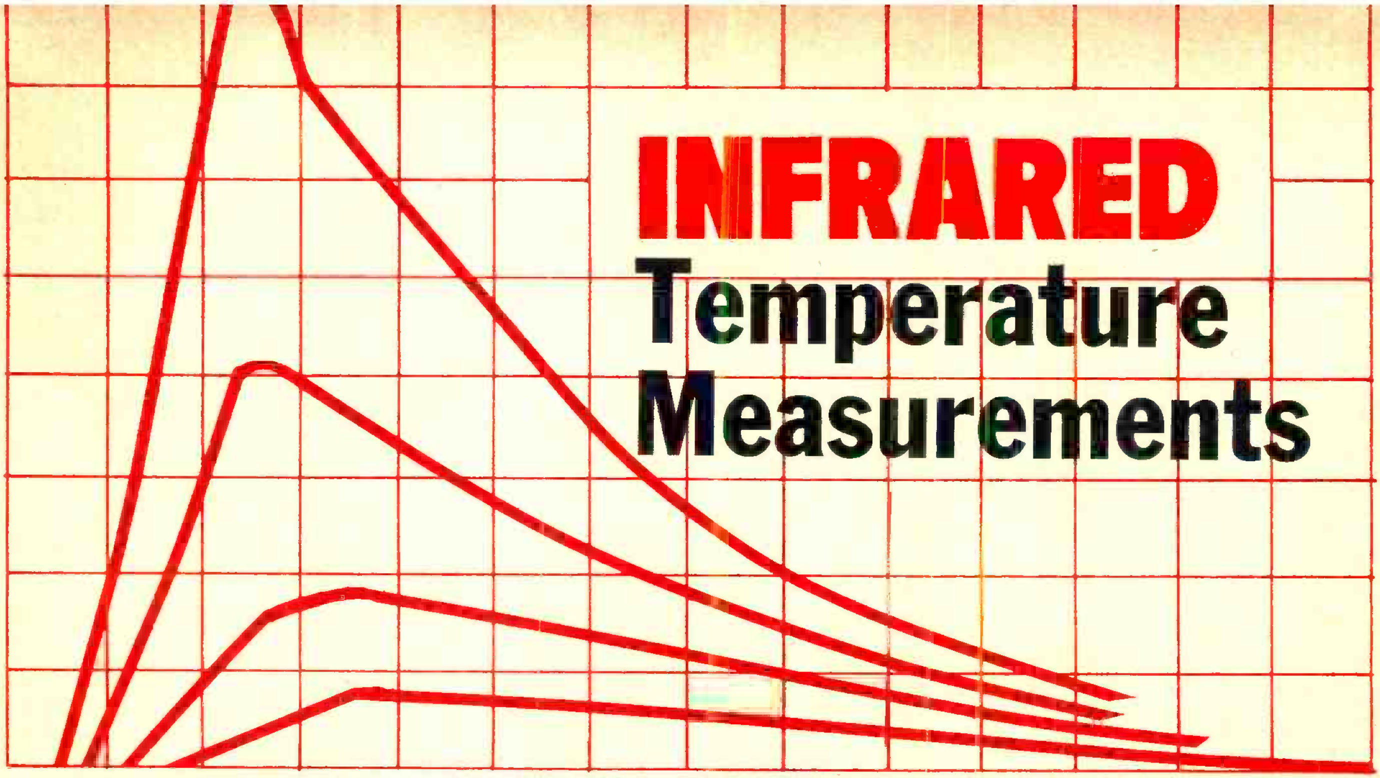
Automatic Rainfall Detector. (Top left) The technician in the photo is inspecting the connections linking an automatic rain gage to the data transmission telephone equipment housed in the rectangular cabinet. The gage, located in Maxwell, Iowa, is connected by means of circuits supplied by General Telephone Co. of Iowa to the U.S. Weather Bureau radar station in Des Moines. To obtain the weather information, station personnel simply dial the unlisted phone number of the remote measuring post and receive the coded rainfall data as a series of audio tones. By counting the "beeps", the weather specialist knows the inches of rainfall at the remote location. Seven other such remote measuring posts are now being established.

One-Man Color-TV Camera. (Top right) A single cameraman is all that is needed to operate a new color broadcast camera recently placed on the market. Color signals may be transmitted by microwave to the dish in the background for relay to broadcasting facilities, or carried by miniature cable. Either way, the hand-held camera and backpack weigh less than 50 pounds and permit the cameraman considerable freedom of movement. The camera was developed by Ampex for use by the ABC network to televise important sporting events.

Electronic "Cars" for Driver Training. (Center) A new computerized car to train student drivers realistically and without risk is shown here. The electronic "car" is equipped with the same instruments and controls found on real cars. Under the hood is an electronic "engine" using IC's which is connected to a digital computer that tells the student immediately what action he should be taking if a driver error is made. The computer also scores the student's performance for the instructor. The system has been developed by Raytheon for use in the Aetna Drivotrainer simulator system. This system is used in driving courses at 600 high schools and colleges.



Portable Color-TV Camera for Space. (Below right) An engineer is shown emerging from a space-simulation chamber carrying what is said to be the smallest compatible color television camera ever developed. Designed by RCA for use in space exploration and related aerospace ground-support activities, the camera and its associated power supply weigh only 56 pounds. The new one-man camera, which employs IC's, is compatible with commercial TV broadcast standards. This allows it to work with existing equipment, such as video tape recorders, without any modifications. Also, the pictures can be broadcast directly by TV networks without being changed to commercial standards by some type of scan converter.



INFRARED Temperature Measurements

By WILLIAM O. HAMLIN

Electronic thermometers using infrared radiation are widely used in industry. Here are the operating principles and applications.

INFRARED electromagnetic rays are invading industrial process control and industrial research—telling temperatures of all kinds of things—plastics, steel, paper, adhesives, and even semiconductors—without touching the measured object. Although infrared's work seems like magic, the principle is simple: all objects, not frozen to molecular inaction, give off radiation in the infrared (IR) spectrum. The strength and wavelengths of these rays are directly related to temperature, according to well substantiated theories. Thus, they can be detected and used to operate electronic thermometers. These IR rays have characteristics similar to light and radio but have different wavelengths. Fig. 1 is a graph showing the IR spectrum of hot objects at various temperatures.

Infrared instruments have a variety of names to catch the user's imagination—"Infrascope", "Thermalert", and

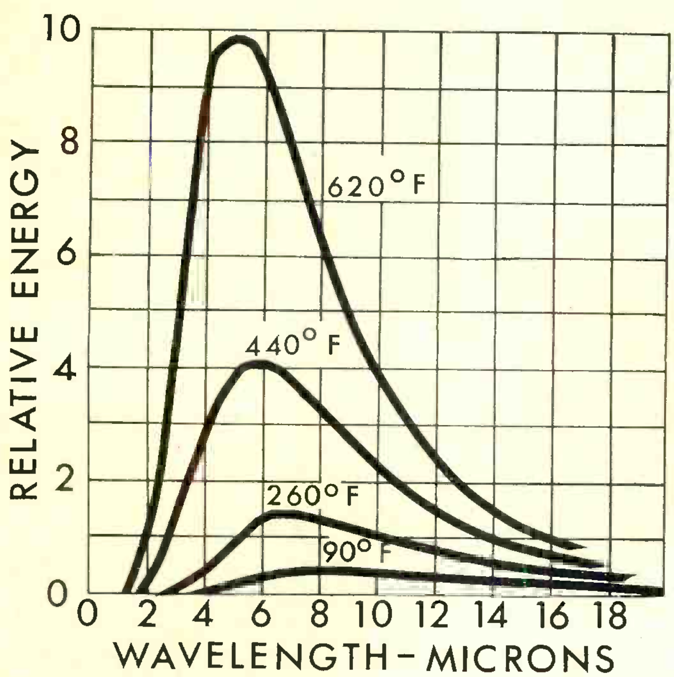


Fig. 1. Infrared wavelengths vs radiation energy for objects that are at the temperatures indicated here.

Fig. 2. One type of industrial infrared monitoring → head, the "Thermalert" made by Raytek of California.

"Heat Spy", for instance—but their generic names are "infrared radiation pyrometer" or "infrared radiometer". However, maufacturers like to refer to their industrial instruments as noncontact thermometers so everyone will know what they are used for. Some IR instruments are small black boxes without meters, some look like telescopes, while others look like death-ray guns of the future.

Fig. 2 shows a "Thermalert", made by *Raytek*. It is designed for continuous process control and mounts on the machinery to monitor temperature of objects subjected to the heating process. A meter, calibrated in temperature, and controller are conveniently mounted at a remote location, such as a control panel, and connected to the monitoring head through a cable. The IR rays enter the monitor head through a hole containing lenses which are fixed focused.

An adjustable-focus instrument is shown in Fig. 3 checking electrode temperature in a high-power tube. The optics of this instrument can resolve spot sizes as small as 0.06-inch across, and it will focus from 6 inches out to infinity. Because they cost more, these instruments are more often found in the laboratory than on the production line.

Hand-held pistol instruments are for general use where high accuracy is not important. They are battery-operated for portability—inspectors can carry one around to check steam pipe temperatures, radiation from heat ducts, furnace temperatures, and to determine insulation efficiency. One type of pistol (Fig. 4) has a very small spot for checking parts and connections on printed-circuit boards.

All these instruments have two requirements for accuracy: the area of radiation looked at must fill the optical field-of-view (like filling the viewfinder in your camera with a picture); and the object should be nearly a 100% efficient energy radiator, otherwise an amplifier gain adjustment is necessary to compensate.

Applications

A luggage manufacturer had problems: plastic halves were heated in an oven prior to molding them together but sometimes they were too hot and sometimes too cold. This quality-control difficulty seemed insurmountable until infrared instrumentation was suggested. Now, the IR temperature monitor points into the oven at the plastic. When the proper temperature is reached, the controller stops the heating cycle and perfect molding results every time. See Fig 5.

A TNT mixer had a safety problem. The hot sticky stuff, churned in a vat, prevented use of a regular thermometer. Yet, if the mix got too hot the workers were in great danger. An infrared temperature monitor was installed above the vat. The monitor connects to an alarm system set at several levels of heat—the first turns on a caution light, the second sets off an alarm bell, and the third triggers a "fail-safe" alarm. This setup is shown in Fig. 6.

Semiconductor manufacturers use infrared to measure temperature of silicon wafers in epitaxial reactors. These are induction furnaces which are completely enclosed to contain a gas atmosphere. The semiconductor material, laid on a carbon boat, is slipped inside an r.f. coil. Regular thermometers can't be used. Thus, infrared does the job by looking through a window and the r.f. coil from ouside the reactor.

A manufacturer of sheet metal articles lays a protective coating of plastic on to steel strip before fabrication. The process is shown in Fig. 7A. The temperature of the steel where it meets the plastic film must be controlled to ex-

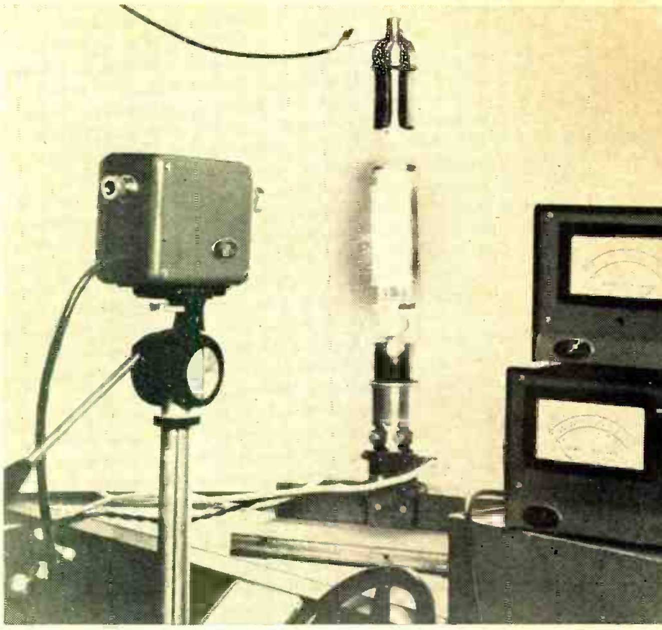


Fig. 3. Adjustable-focus IR unit checks tube electrodes.

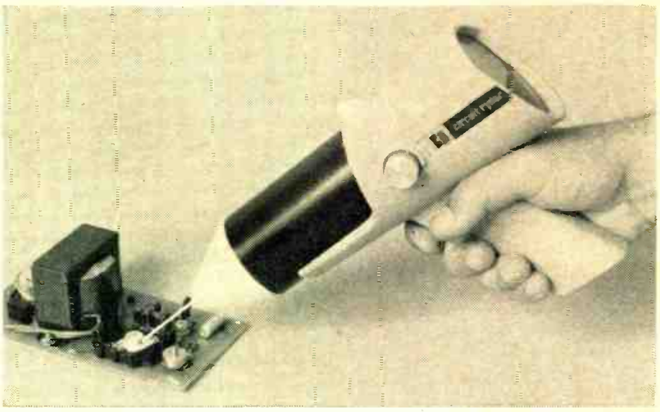


Fig. 4. Hand-held infrared pistol checks transistor temperature. The normally invisible beam has been retouched to make it visible. This is the "Circuit Ryder" unit.

Fig. 5. Temperature control for making plastic luggage.

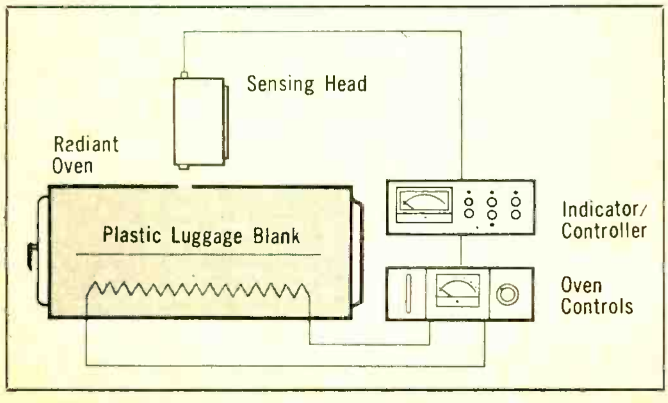
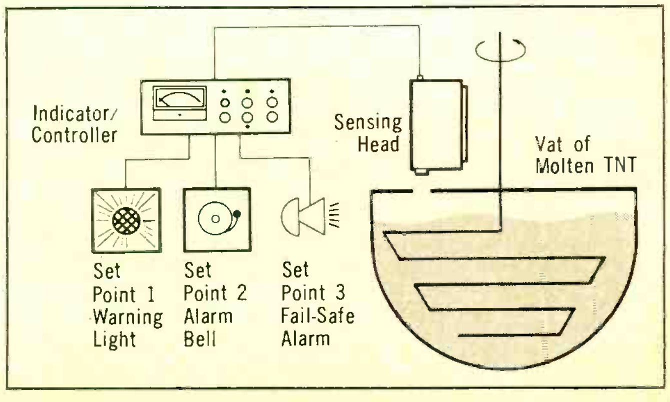


Fig. 6. TNT can be mixed safely thanks to IR monitoring.



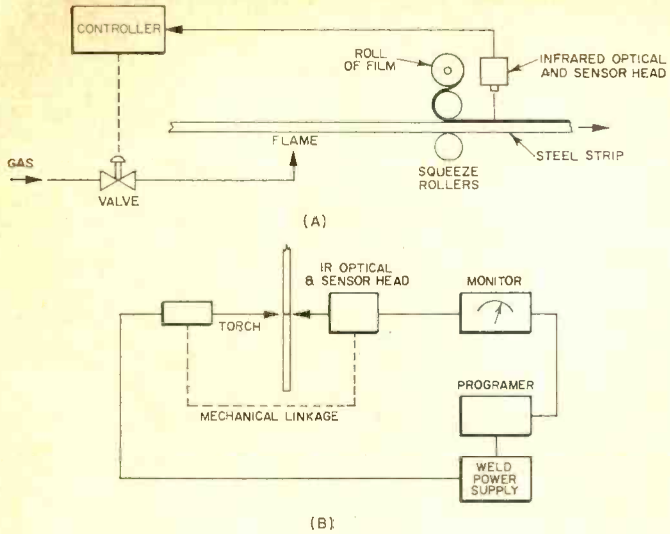


Fig. 7. (A) Plastic protection laid onto sheet metal in critical temperature process. (B) Infrared controls weld temperature.

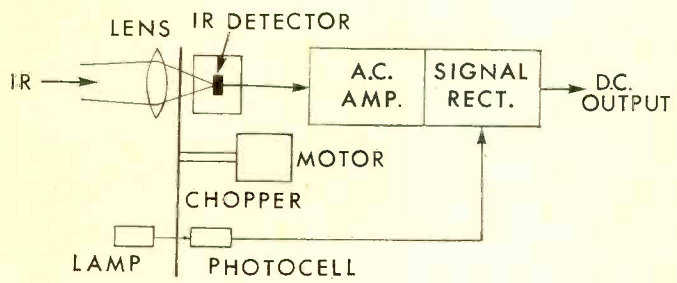


Fig. 8. Block diagram of industrial IR sensing head.

actly the right temperature for uniform bonding and infrared does the job. The IR sensor-head output operates a controller which connects to the gas valve regulating the heating flame.

Applications for temperature measurement and control with infrared are almost unlimited. One important use is in precision welding—providing a watchdog over temperature for the welder. A block diagram of the system in an aerospace application is shown in Fig. 7B—aerospace welding is especially critical and each weld is checked by x-rays for flaws. The IR sensor head is directed at the weld area on the opposite side of the welded places from the torch. The sensor-head electrical output signal, representing the temperature, drives a controller which regulates the welding power. Thus, it is always hot enough for a good joint but not so hot that a "blow through" occurs.

The same advantages apply to small spot welds where overheating can easily damage delicate parts or underheating gives unreliable contacts such as in weld wiring of various types of electronic circuits.

Infrared Theory

Infrared is radiant energy between the wavelengths of 0.77 and 1000 microns. Total strength of the emitted energy for a 100% efficient radiating object is expressed by the equation $W = \sigma T^4$, where W is watts of energy per square meter, σ is 5.7×10^{-8}, and T is temperature in degrees Kelvin (centigrade plus 273) This equation gives the area under the curves shown in Fig. 1.

However, total radiation is seldom measured in practice: the object measured might not be a 100% efficient radiator and the instrument most likely responds only to a small portion of the total radiant spectrum. Radiation efficiencies of some common materials, at 300° F, are as follows:

Bright steel 10%
Gray steel 60%
Rough carbon 75%
Rough aluminum 70%
Polished aluminum 8%

Note: Efficiency of radiation with respect to a perfect radiator is called "emissivity".

Efficiency of radiation varies somewhat with temperature but, referring back to the equation above, temperature has a high mathematical power (exponent) with respect to watts. Therefore, slightly fewer watts of power radiated due to lower efficiency does not drastically upset accuracy. In instrument design the exponent of temperature can be made even larger than T^4 to further minimize the effect of radiation efficiency.

The radiant energy spectrum to which the instrument responds is determined by the detector (similar in principle to a photocell)—it transforms the IR rays to an electrical signal—and also the materials from which the optical lenses are made.

Narrow and selectable bandwidths have certain advantages—the exponent of T can be made larger and the wavelengths detected can be matched to the spectral characteristics of the material being measured. For example, referring to Fig. 1, the distance between the 440°F and 620°F curves is very large at 4 microns but smaller at 8 microns, thus a narrow bandwidth around 4 microns produces a larger output change per degree temperature change than at the longer wavelength.

Many materials have broad, smooth IR spectral characteristics while others do not. For example, temperature of common glass can be measured at wavelengths above about 4 microns, where the glass is opaque. At less than 4 microns, the glass is transparent and the materials behind the glass can be measured—previously mentioned applications of checking electrode temperature of tubes and the epitaxial reactor, are examples of this. Also, the temperature of flames can be measured by placing the bandwidth within the high radiation spectral lines of the combustible products, for example, 2.7 microns wavelength for H_2O (water) and 4.45 microns wavelength for CO_2 (carbon dioxide). Plastics have definite spectral characteristics too: for instance, 8.3 microns for Teflon FEP. Often, in such situations, a narrow bandwidth filter is used on the instrument to accept only these absorption bands.

Instrument Design

A basic infrared instrument is shown in block form in Fig. 8. A fixed-focus lens directs the infrared rays onto a detector. The chopper—like a pin-wheel on a motor—has blades which break up the incoming rays so that the detector's electrical output is an a.c. signal. The blades are highly polished, thus, on alternate half-cycles, a reference temperature is reflected into the detector, establishing a stable zero output between the measured pulses. Also, the blades interrupt a pilot-light beam focused upon the photocell to generate drive for a synchronous signal rectifier. The a.c. amplifier raises the signal level sufficiently to drive industrial-type output devices—usually 100 millivolts at maximum temperature and 0 volts at the minimum temperature.

Most applications need only limited ranges of temperature and the shorter the range, the higher will be the temperature resolution—more millivolts per degree temperature change. Thus indicators are furnished with calibration over a choice of overlapping ranges such as 60° to 250°F, 150° to 400°F, and 250° to 600°F. Set-point controllers can be a part of the indicators to turn power "on" or "off", or set alarms at certain temperatures.

Changes in the lens material and the specific detector employed can alter the temperature range capability of the infrared instrument. A glass lens with a lead sulphide detector responds to wavelengths below about 2.1 microns, is quite inexpensive, and may be used to check on most industrial process temperatures. ▲

electronic fire and smoke detectors

By FRED W. HOLDER

Description of heat- and smoke-sensitive detectors using photoelectric and ionization devices connected to electronic circuitry to sound an alarm. Airborne infrared systems are also used for locating forest fires.

FIRE-ALARM systems are not a recent development. In fact, the first system was patented on May 19, 1851 by William Francis Channing of Boston and Moses Gerrish Farmer of Salem, Mass. Current systems are much better than the 1851 models, of course, because better methods of detecting fires are now available. Many of these use electronics as their basis. The detectors currently in use may be roughly divided into two general categories: heat-sensitive and smoke-sensitive. A third category, which might also be classified as heat-sensitive, comprises those systems using the infrared radiation from a heat source for detection purposes.

Heat-Sensitive Detectors

Two types of heat-sensitive devices are used for fire detection: the fixed-temperature detector and the rate-of-rise detector. In some cases a combination of the two is used, a rate-of-rise detector to indicate a flash fire where the temperature increases rapidly and a fixed-temperature detector to catch those fires that grow too slowly to trigger a rate-of-rise detector. The rate-of-rise detector is generally set to operate when the rate of temperature increase is greater than 15° to 20° F per minute, irrespective of the over-all temperature. Fixed-temperature detectors generally operate at 135° F or 180° F, depending on the type.

The rate-of-rise detector normally gives an earlier warning in unheated or cold-storage areas. The fixed-temperature detector, on the other hand, usually provides better detection of slow fires and reduces the chance of false alarms.

The British supersonic transport, Concorde, uses a fixed-temperature, power-plant overheat and fire detection system manufactured by *Graviner (Colnbrook) Ltd.* The *Graviner* "Firewire Triple FD 300" system uses a continuous detector element as the sensor. This sensing element is made up of an outer stainless-steel capillary tube of 0.077-inch o.d., a stainless-steel wire electrode in the center of the tube, and an impregnated-glass, temperature-sensitive semiconductor material separating the wire electrode from the capillary tube wall. It operates on the temperature-sensitive, charge-storage characteristics of its construction.

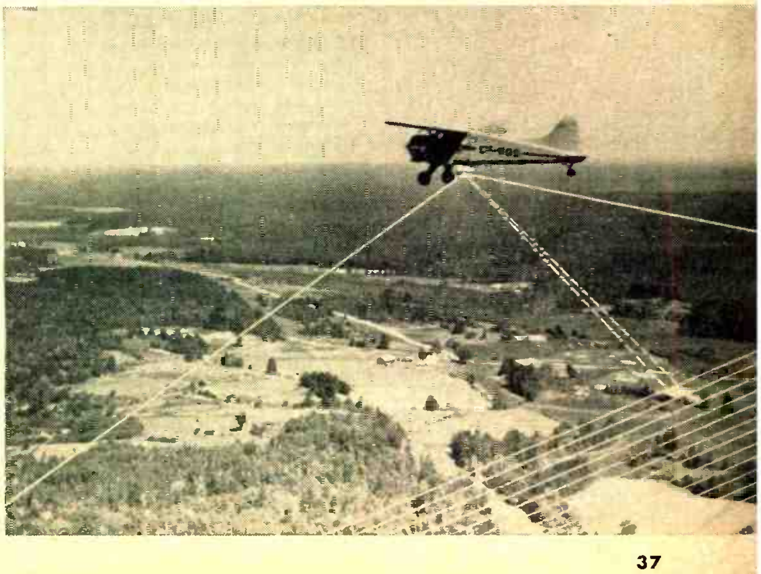
The control unit for this system supplies half-wave, rectified pulses to the sensing element. When heated, the element has the ability to accept, store, and discharge these pulses to the gate of a silicon controlled rectifier, located in the control unit, thus varying the bias on the gate of the SCR.

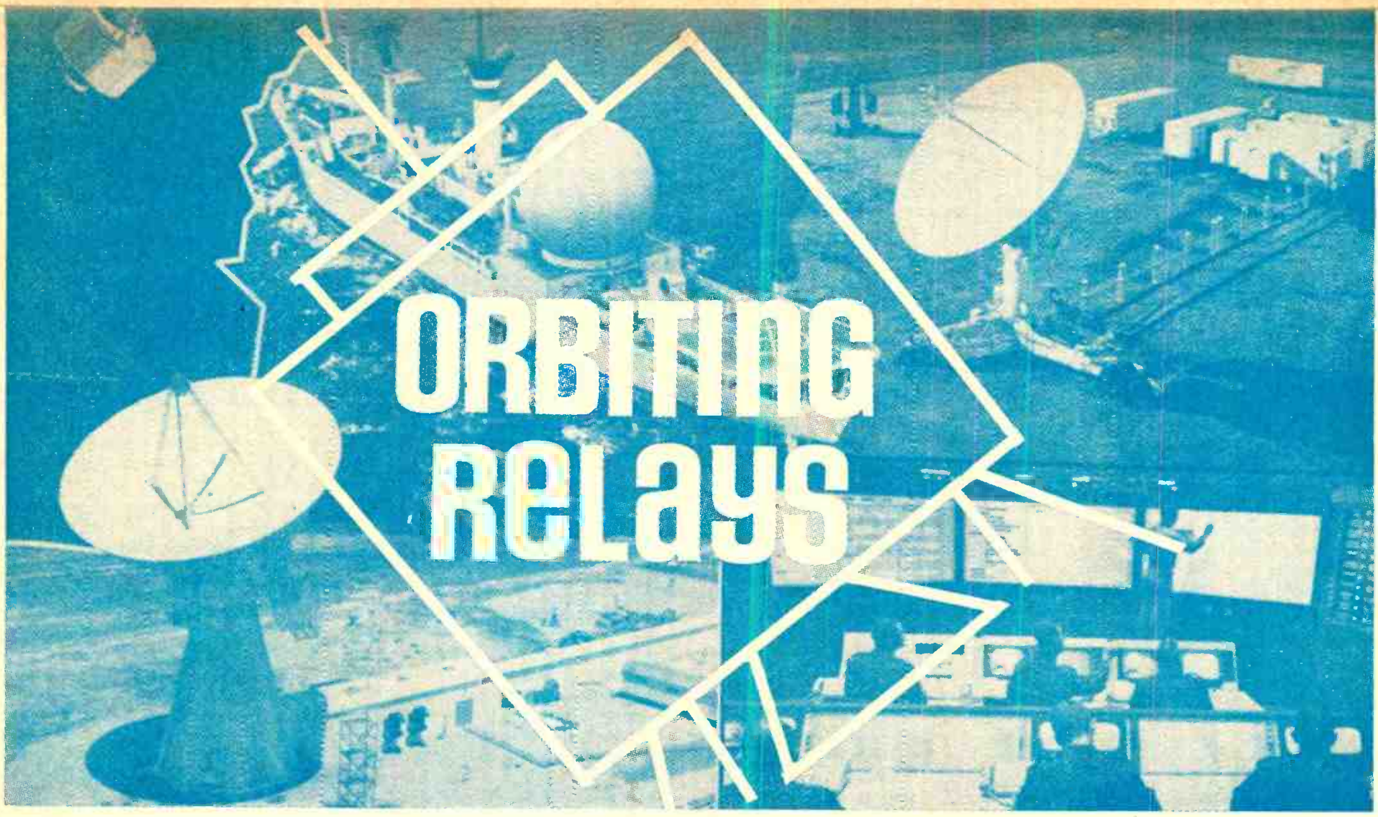
Under normal conditions, the voltage output of the sensor is negligible and the SCR gate has a negative bias. With a rise in temperature, the sensing element transfers electrical energy to the SCR gate. When overheat temperature is reached, the voltage is sufficient to overcome the gate bias: the SCR conducts and energizes a relay to initiate the warning signal. Removal of the overheat condition from the sensing element reduces the voltage applied to the SCR gate, allowing the SCR to stop conducting and de-energize the alarm relay. The system is, therefore, of the automatically reset type.

Smoke-Sensitive Detectors

Smoke detectors may be used by themselves or in conjunction with heat-sensitive detectors to detect a fire and actuate an alarm. Smoke detectors offer the advantage of earlier detection, because a fire produces smoke even before the heat reaches a high enough temperature to activate thermal detectors. This extra second of warning can make it possible to put out the fire before it gets uncontrollable. In addition to this particular advantage, earlier warning provides an extra safety factor, thereby permitting prompt evac-

Scanning pattern produced by AFDS-2 equipment, which helps Canadian forest protection officers locate potential fires.





Orbiting Relays

By ROBERT DARCEY / ATS Project Manager
National Aeronautics and Space Administration

High up out of sight of any rainbow, synchronous communications satellites transmit messages and pictures between the continents. Bigger, more efficient spacecraft will complete the global network.

SATELLITE COMMUNICATIONS had its beginnings during World War II when developments in microwave technology, large-size tracking antennas, and the use of rockets provided the necessary environment to foster growth. Terrestrial communications provided the technological base, while needed expansion triggered the exploitation of space.

Space communications started with the Department of Defense's Project Score, which was designed to transmit a stored message from space to earth. DOD's second venture was the launching of Courier, an advanced version of Score. It had a receiver and operated in real-time as well as on storage capacity.

During this period, NASA launched the first passive communications satellite, Echo I. This satellite consisted of a 100-foot aluminized Mylar sphere operating at an orbital altitude of 100 statute miles. Echo II, an advanced version of Echo I with improvements in rigidity, reflectivity, and size, was subsequently launched in 1963.

Project West Ford, another type of communications system, was designed by MIT and sponsored by the Air Force. The project involved placing in orbit a large number of small (1.77 cm) resonant dipoles. These "space needles" acted as reflecting half-wave dipoles.

The Spacebreakers

The satellites which firmly established space communications were Telstar, Relay, and Syncom. The early satellites, Telstar and Relay, were limited to altitudes of approximately 4000 to 5000 nautical miles. Both satellites were spin-stabilized and could receive and retransmit wideband (TV) signals. These spacecraft were the first to utilize ground stations in other lands and to require the cooperation of foreign governments for their successful operation. They demonstrated the feasibility of real-time intercontinental communications *via* satellite.

The first satellite to provide continuous intercontinental communications was Syncom. This system was brought to fruition by using experience gained with earlier passive and active satellites and by major improvements in launch vehicle capability.

The Syncom series provided the first inclined synchronous and the first stationary or equatorial satellites. A satellite in an inclined orbit is at an angle of 33° with respect to the equator. Thus, as the earth and the satellite revolve around the sun, the satellite moves in a figure-8 pattern across the face of the earth's surface. A satellite in a synchronous equatorial orbit moves west-to-east 22,300 miles above and parallel to the equator. It completes an orbit in 24 hours and, therefore, appears to be stationary.

The second generation of non-military satellites began with the Applications Technology Satellite (ATS) series. These multi-purpose satellites contain special communications equipment to explore the feasibility of high-gain antennas, various modulation techniques, and multiple access, using single sideband techniques.

In addition to this, the ATS series of satellites is attempting to demonstrate the possibility of ground-to-satellite-to-aircraft communications in the v.h.f. band.

Military & Commercial Satellites

About the same time that the Syncom and ATS satellites were being developed, the military was implementing a communications system designed to meet its unique requirements. These satellites are similar in concept to both Telstar and Relay, but are in near-synchronous orbits—they revolve around the earth at a very low rate. Satellites in the military system cannot be positioned by external ground commands, and up to fourteen orbiting satellites (in the same plane) are used for communications reliability.

The Intelsat series of spacecraft are synchronous equatorial satellites which use wide-band and limiting transponders—they are capable of transmitting television and voice signals—in the 4 and 6 GHz frequency ranges. Multiple access is achieved *via* frequency diversity.

To operate effectively as a relay, a communications satellite must be stabilized and have a practical antenna system, that is, one in which the gain never falls to zero. The simplest configuration that fulfills this requirement is a dipole or linear array which is spun about its principal axis.

This type of antenna is easy to stabilize. By placing the electronics in a flat cylindrical package below the antenna and spinning the entire package about its axis, the package is gyroscopically stabilized. The outer surface of the cylinder can be used as a mounting surface for the solar power cells.

This design also provides an ideal thermal environment since the spin tends to average the effects of the "hot side" which is illuminated by the sun, and the "cold side" which faces space. Spinning spacecraft maintain a temperature of 70° ±30° F when in orbit.

The early experimental satellites, from Score to Relay, were launched into inclined orbits at altitudes of thousands of miles. They provided mutual visibility between the United States and Europe for periods of approximately one-half to two hours. Attitude control, when required, was achieved by magnetic torquing.

The orbits of the synchronous Syncom satellites are in the equatorial phase, circular, and at an altitude of 22,300 statute miles. The orbital periods are such that they remain fixed with respect to a given location on the earth. However, the gravitational forces at the synchronous altitude are not uniform and a spacecraft can only be made stationary if there is a secondary propulsion system available to overcome gravitational disturbances. The secondary propulsion systems aboard present spacecraft use high-pressure nitrogen gas, hydrogen peroxide, or hydrazine as fuels. In addition, the sun and moon tend to "pull" the spacecraft into their (ecliptic) orbital planes.

Experimental satellites using other types of stabilization are either being built or are in the planning stages. These include both active three-axes and gravity-gradient stabilization systems.

Although synchronous and non-synchronous satellites are almost identical electronically, the synchronous satellite enjoys some very special advantages. Synchronous satellites provide continuous communications coverage of a given area, while non-synchronous systems can be used for only two hours (depending upon the satellite's altitude). Also, synchronous satellites need but a single antenna for efficient communications. Non-synchronous satellites, on the other hand, require three antennas: one to carry on communications, a second to lock on a new satellite coming over the horizon and thus prevent loss of data, and a third antenna which is used as a backup.

Second-Generation Spacecraft

The second generation of synchronous satellities is concerned with developing high-gain antennas and exploring various modulation and multiple-access techniques.

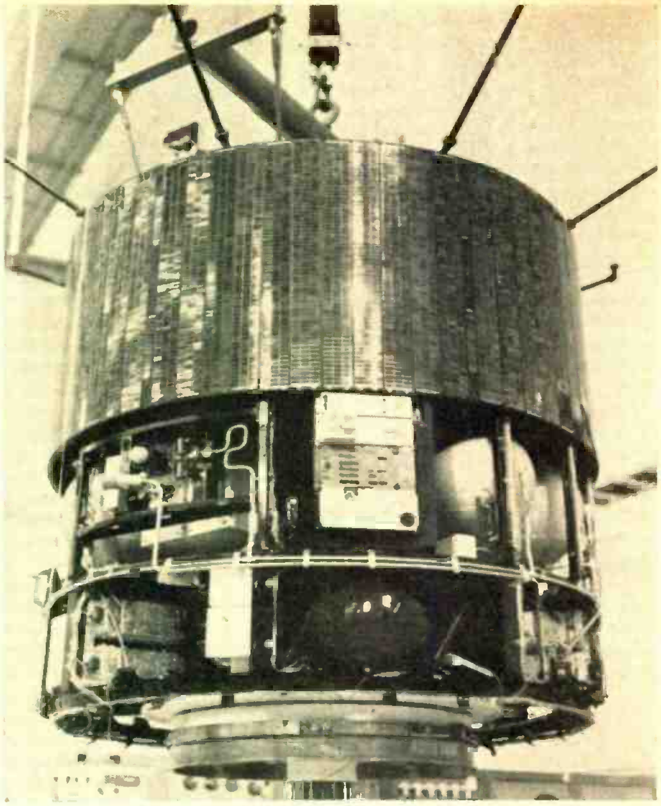
Assuming that one wishes to communicate with any part of the earth visible from a synchronous satellite, the most efficient antenna system would radiate all of the spacecraft's power directly toward the earth. To accomplish this, the spacecraft must have a directional antenna with a pattern gain of approximately 18 dB. The ATS program successfully tested both a mechanical and an electrical version of a directional antenna.

Most spacecraft employ angle modulation which is used because:

It allows the spacecraft transmitter to operate in its most efficient mode (saturated).

It is independent of spacecraft antenna variations.

It trades bandwidth for fidelity.



NASA's Applications Technology Satellite (ATS) is typical of the synchronous satellites being used to study and conduct earth-space-earth communications. Solar panels generate power for the spacecraft's electronics and sensors. The pair of boxes at lower left and the two boxes on the extreme lower right side of the spacecraft are very-high-frequency transceivers. Hydrogen peroxide and nitrogen (stored in the spherical containers) are used to keep spacecraft on-station and spinning.

However, the system does not work well when two ground stations transmit carrier signals to the spacecraft simultaneously. The passage of the signal through the relay causes harmonic distortion in its saturated stages and produces undesirable sidebands. These sidebands reduce the effective transmitter power.

One solution to this problem is to convert all transmissions to pulse-code modulation and to use this signal to angle-modulate a carrier. Each ground transmitter is then allotted a specific "time slot" to transmit its carrier. Experimental tests in which 240 individual voice channels were transmitted through a spacecraft have been successful.

A second solution is to use frequency diversity from the ground transmitter to the spacecraft and then convert the signal to angle modulation before it is retransmitted to the earth. This technique, utilizing single-sideband modulation on the "uplink" and phase modulation on the "downlink", has also been successfully demonstrated.

The major effort in space communications has been directed toward the requirements of the large user, that is, TV and telephone communications companies. These tests were performed at 1.7, 4, 6, and 8 GHz. Recent tests in the v.h.f. band have demonstrated the feasibility of communications between satellites, ground stations, and aircraft. These tests showed that good-quality voice signals were possible between the United States and an aircraft in flight to Japan, Australia, South America, and Europe. During the test, communications reliability exceeded 80%.

Ground Stations

Ground stations are designed to make maximum use of the total communications system. Most experimental stations have at least one 85-foot dish antenna which is capable of tracking both high- and low- (*Continued on page* 79)

Geneva Conference Affects MARINE COMMUNICATIONS

By RICHARD HUMPHREY

Sweeping changes are planned for 2-3 MHz band as well as on v.h.f. as a result of decisions reached at the World Administrative Radio Conference.

THE WORLD Administrative Radio Conference of the International Telecommunications Union convened on September 18, 1967 in Geneva to consider the many problems of maritime communications. The Conference agreed upon far-reaching changes in two marine communications bands which will have a major impact upon that part of the American electronics industry which supplies equipment for these bands.

Briefly: single-sideband radiotelephony is coming to the 2-3 MHz marine band (the one used by most American pleasure boaters) much sooner than anyone expected and an American proposal to expand the v.h.f./FM marine band (which no one anticipated as having much of a chance) received resounding approval.

The single-sideband transitional dates in the 2-3 MHz band to apply *internationally* will be 1973 (no more installation of presently used AM equipment for ship-station use) and 1982 (no more AM emission). In the United States, according to Daniel K. Child, Chief, Aviation & Marine Division, FCC, the dates to be requested in forthcoming rule-making will be 1970 and 1975.

During the changeover periods of 9 years (internationally) and 5 years (in the U.S.), three types of single-sideband will be required: A3A (single-sideband, *reduced* carrier), A3H (single-sideband, *full* carrier), and A3J (single-sideband, suppressed carrier). A3H will provide compatibility with AM equipment which, if installed prior to January 1, 1970 and continually licensed, may be used up to the deadline date of January 1, 1975. The one meaningful exception will be 2182 kHz, the international calling and distress frequency, which will be handled on a "wait-and-see" basis.

A Matter of Timing

American manufacturers have been expecting this transition for some time. So has the rest of the world. No one has denied recently that single-sideband was eventually coming to the 2-3 MHz band nor that it was necessary. The only question: when?

The majority of nations went into the Conference with 1973-1982 in mind. Our delegation supported 1970-1975. Actually, everyone is doing what they said they were going to do in the first place.

The reason we will be sticking to a 1970-1975 timetable is a practical one. First, the U.S. has some communications problems the rest of the world doesn't have. For instance, there are over 30,000 radio-equipped pleasure boats in the New York area alone while France, for example, has but 400. Second, we are a communications-minded people. We probably use more radio-frequency-emitting devices (from garage-door openers to microwave relays) than any other nation in the world. In a world rapidly running out of usable radio spectrum, we naturally feel the pinch first and worst.

It also means we must take the quickest action—which is precisely what we are doing. Our northern neighbor, Canada, plans to have its single-sideband conversion in the 2-3 MHz band completed by January 1, 1974, according to A.G.E. Argue of the Canadian Department of Transport. So we are not alone in marching to a different drummer.

"International coast stations", Mr. Child said, "shall be capable of single-sideband at the earliest possible date. Furthermore", he stressed, "they shall discontinue double sideband (AM) as early as possible *and in any case not later than January 1, 1975.*" (Author's italics.)

A Notice of Proposed Rule Making on the 2-3 MHz changeover, according to Mr. Child, should be out early in 1968. The 1970-1975 dates, he indicated, "are firm".

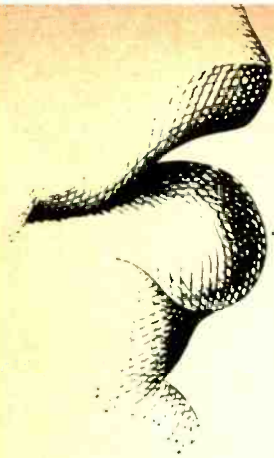
The V.H.F. Marine Band

But by far the most important ruling to come out of the Geneva Conference concerns the v.h.f./FM marine band. Here, too, we will be in advance of the rest of the world. But our position in the v.h.f./FM maritime service is stronger because there is a precedent. The United States has never adhered fully to the existing 28-channel v.h.f./FM maritime service in use internationally. This was mainly because of frequency allocations in this country which predated the v.h.f./FM marine band.

The U.S. begins its v.h.f./FM marine service with channel 6 (156.3 MHz), continues through channel 20, skips to 24 and carries through 28. Channels 15 and 17 are "ghost" channels whose only purpose is to guard channel 16 (156.8 MHz), the calling and safety frequency. In addition, three channels (7, 18, and 19) which are duplex (transmit on one frequency receive on another) in the international framework are simplex (transmit and receive on same frequency) in the U.S. and are suffixed with "A".

A Notice of Proposed Rule Making was issued in March, 1967 expanding the U.S. 18-channel v.h.f./FM marine band to 39 channels by reducing channel spacing from 50 kHz to 25 kHz, along with changing from wide-band FM (±15 kHz) to narrow-band FM (±5 kHz). This proposal sparked much adverse comment from the technical and engineering ranks of the marine communications industry. These people cited the marked reduction in recovered audio and a lessening in capture effect. Without exception, the technically oriented men this author interviewed felt that the increase in the number of channels and services just didn't make up for the loss in the over-all efficiency of the equipment. But this narrow-band, channel-splitting concept is, with some minor changes, just about what the Conference decided to go along with.

It was resolved to adopt the U.S. concept to give a total of 55 channels *internationally*. All nations must begin this changeover by January 1, 1972 and complete the transition by January 1, 1973. *(Continued on page 69)*



MULTIPLEXING: the science of mixing voices

By W. JACK HILL/Lenkurt Electric Co., Inc.

Frequency-division multiplexing systems carry hundreds of telephone conversations over a single wire pair simultaneously. A new technique, time-division multiplexing, will be even more efficient, less costly.

MULTIPLEXING—the method of combining numerous channels for transmission over a single circuit—literally makes today's telecommunications systems possible. Frequency-division multiplexing is a successful method of accommodating a large volume of telephone traffic. By modulating each telephone channel with a different carrier frequency, dozens of conversations can be transmitted over a single wire pair. And now, time-division multiplexing, which uses rapid speech sampling and a binary coding technique to transmit conversation in a string of digital pulses, has come of age.

Whatever the technique, however, the engineering requirements are the same. The transmission of voice by electrical means is centered around the qualities of the human voice and how the ear perceives it.

Young adults can hear frequencies ranging between 20 Hz and about 16 kHz; some can hear tones as high as 20 kHz. And the sound intensities arising from conversation are also widespread. Studies have shown that the intensity range between the weakest syllable of a soft talker and the loudest syllable of a loud talker is about 70 decibels.

The listener judges a communications channel by two parameters: intelligibility and intensity. Interestingly, these two factors are virtually independent of each other. Most speech energy, and hence intensity, is concentrated in the lower frequencies, while the high frequencies contribute most of the intelligibility.

If only those frequencies above 1 kHz are transmitted, only about 17% of the total voice energy is used effectively, but articulation is about 86% perfect. However, if only the frequencies below 1 kHz are used, articulation goes down to about 42%, but 83% of the total energy is transmitted. Telephone engineers have standardized the voice-channel range at 300 to 3400 Hz. Power ranges are about 30 dB.

Special Data Requirements

With the introduction of data to telecommunications, added emphasis is placed on the avoidance of noise and other distortions of the signal. Data—digital forms of information used in machine-to-machine communications—is becoming an increasingly heavy user of voice communications facilities. In the near future, the volume of information transmitted over digital communications facilities will equal and eventually exceed the volume of analog voice traffic.

Data-transmitting machines such as teletypewriters, facsimile machines, and computers each have unique requirements in the telephone system. Their rapid electrical pulses bear little resemblance to the signals produced by the human voice.

White noise (electrical disturbances caused by random movements of free electrons in a conductor) can easily disrupt a conversation between two people, but unless the level is high, it is of no major concern in data transmission. But impulse noise—noise due to a succession of separated

Fig. 1. In frequency-division multiplexing, low-frequency speech signals are shifted up the scale by using individual carriers.

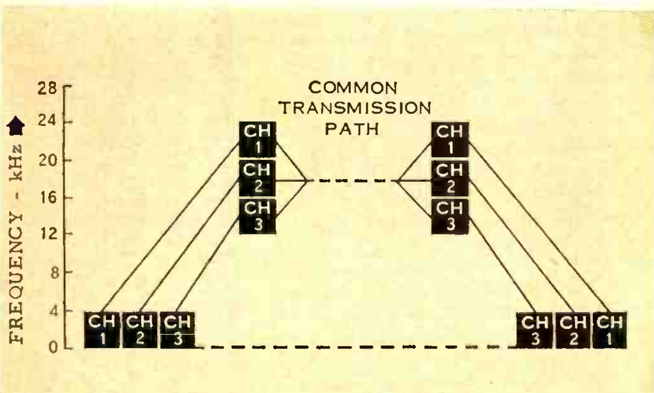
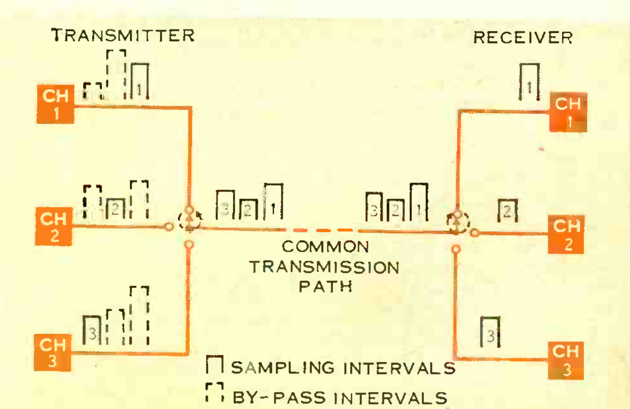


Fig. 2. In time-division multiplexing, voice signals are separated by briefly sampling each channel in a regular sequence.



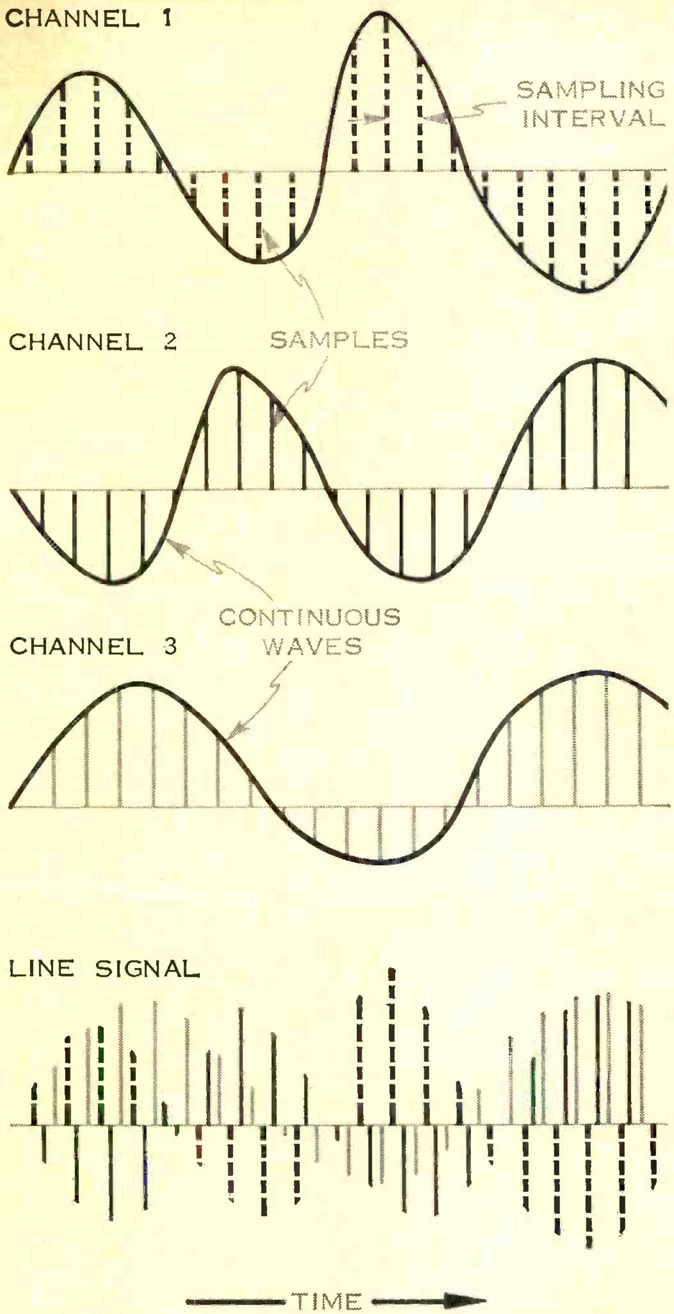


Fig. 3. TDM pulse samples are intermixed on the line. At the receiver, continuous waves are reconstructed from the pulses.

pulses—is another matter. Coming in short "spikes" with high amplitude, impulse noise is seldom heard by the ear but can be fatal to the digital pulses of data transmission.

Attenuation distortion is another concern of the telephone communicator that is becoming increasingly important because of data transmission. Amplitude distortion is caused by non-linearity in the transmission medium. High frequencies are attenuated more than low frequencies. Inductive loading coils reduce amplitude distortion on voice-transmission lines; however, they distort data signals by acting as a low-pass filter.

A signal at frequency A will not travel through a transmission line at the same speed as a signal at frequency B; in addition, their phase relationship will change in proportion to the length of the line. Known as delay distortion, this effect is relatively unimportant in voice transmission because speech components need not bear an exact time relationship to each other for intelligibility. But for data communications, each pulse must be created at the receiver in its original condition. The faster the data rate, the more critical is the demand on the communications channel. Special adjustable equalizers are provided for data circuits to correct attenuation and delay distortion.

Channel Stacking

In frequency-division mutliplexing systems, conversations are stacked one on top of another. This is accomplished by modulating each voice channel with a different carrier frequency. The result is a number of individual circuits, each with its own carrier—like the programs of different radio stations—that can be separated by tuned receivers at the far end.

Each of these carrier channels is 4 kHz wide. Channel 1, for example, might operate between 20 and 24 kHz, channel 2 between 16 and 20 kHz, and so on (Fig. 1). In this way, a number of voice channels can be combined, amplified, and transmitted over the same transmission line. At the receiver end, the combined signals are separated by filters and demodulated to the original audio frequencies.

Channel capacity of a frequency-division multiplexing system is determined by the relationship between the information bandwidth and the center carrier frequency. Modern cable carrier systems are designed to transmit up to 24 channels at the same time; coaxial systems and microwave radio relays exceed that capacity.

At high carrier frequencies, amplifiers that will have a flat response over a given frequency range are easier to build because the information bandwidth is a smaller percentage of the carrier frequency. For example, a 6-GHz microwave radio can carry as many as 1860 voice channels at one time, but the information occupies little more than 0.1% of the total frequency range. And even though the over-all attenuation curve is non-linear, this small portion of the curve is relatively flat.

Economics Lead to TDM

Frequency-division multiplexing (FDM) has served the industry well for many years. But economic factors have kept engineers on the search for more efficient transmission methods. Advances in solid-state technology have brought renewed interest in time-division multiplexing (TDM). Transistors and integrated circuits are ideally suited for high-speed switching; they are reliable and can be manufactured cheaply. In addition, time-division multiplexing eliminates the need for the numerous filters used in FDM, which are bulky and relatively costly.

Time-division multiplexing is accomplished by switching sequentially from one channel to another at a rapid rate (Fig. 2). Each channel occupies the transmission line for a fraction of the total time. In this way, conversations are stacked in time rather than in frequency (Fig. 3). By synchronizing the sampling rate at the receiver end, the signals in each channel may be recreated in their original form.

If the sampling rate is high enough, no information is lost and the signals may be separated again in time at the receiver. In fact, a sampling rate of just more than twice the highest frequency in the original signal is enough. If 4000 Hz is the highest frequency in the telephone channel, 8000 samples per second will precisely duplicate a telephone conversation.

In time-division multiplexing, the analog voice waveform is converted into a series of pulses for transmission. This is known as pulse modulation and may take one of many forms, including pulse-amplitude modulation, pulse-width modulation, pulse-position modulation, and pulse-code modulation. The latter, pulse-code modulation (PCM), has economic advantages which make it attractive to telephone engineers.

PCM in Digital Pulses

Three successive operations are needed to transform the analog speech signal into a series of digitally coded pulses

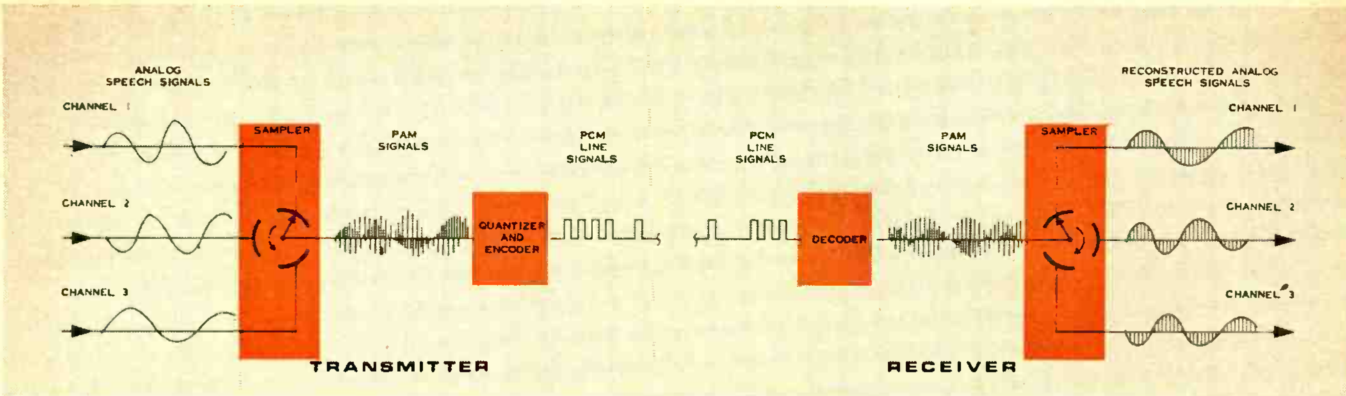


Fig. 4. A simplified time-division multiplexing pulse code modulation (PCM) system

which can then be transmitted over the PCM system. The first operation is to sample the speech signals at a suitable rate and measure the amplitude of the signal. This will result in a train of pulses analogous to the original waveform—they actually appear as pulse-amplitude modulation (PAM). Next, the amplitude of each sample is compared with a scale of discrete values and assigned the value to which it is nearest. This rounding-off process is called quantizing. Next, it is necessary to code each of these discrete values into binary digital form. This train of digital pulses is then transmitted over the line. A three-channel time-division multiplexing system is illustrated in Fig. 4.

It is here that the true value of the PCM system can be seen. Each of the binary pulses is in a fixed and predetermined time position and only the presence or absence of the pulse determines the information content of the signal. Therefore, degradation from noise and attenuation on the line is not critical. An entirely new set of pulses is recreated at each repeater (a substation where telecommunications signals are restored to their original form and retransmitted) and sent on down the line.

In PCM systems designed for speech, a sampling rate of 8000 Hz is appropriate. Each voice channel is sampled every 1/8000 of a second, or every 125 microseconds. The number of successive channels that can be sampled, of course, depends on the duration of the time slot assigned to each sample—the shorter the duration, the greater the number of channels. Current systems are capable of placing 24 voice channels on one PCM carrier system.

When sampled signals are assigned a discrete value, there is always some error. Generally, it is equal to one-half the size of the discrete or quantum step. This is called quantizing error and may be a source of noise. The degree of this quantizing noise is mainly a function of the number of quantum steps used—the more steps, the less the quantizing noise. However, increasing the number of quantum steps increases the bandwidth needed to transmit the coded signals.

Reducing Quantizing Error

One way of reducing the number of steps without sacrificing quality is to make the size of the quantum steps non-uniform, thereby taking advantage of the statistical distribution of speech amplitude. The greater percentage of information in speech signals is carried at low-amplitude levels. If quantum steps are all equal in size, the low-level signal will suffer the greatest amount of quantizing error. If small steps are used where most of the speech information is concentrated, and larger steps in the rest of the amplitude range, the total number of steps required can be greatly reduced.

To decrease the number of quantum steps still further, the amplitude range of the pulse samples can be compressed before quantizing. This compression modifies the normal distribution of speech amplitudes by imparting more gain to weak signals than to stronger ones. The signals are restored

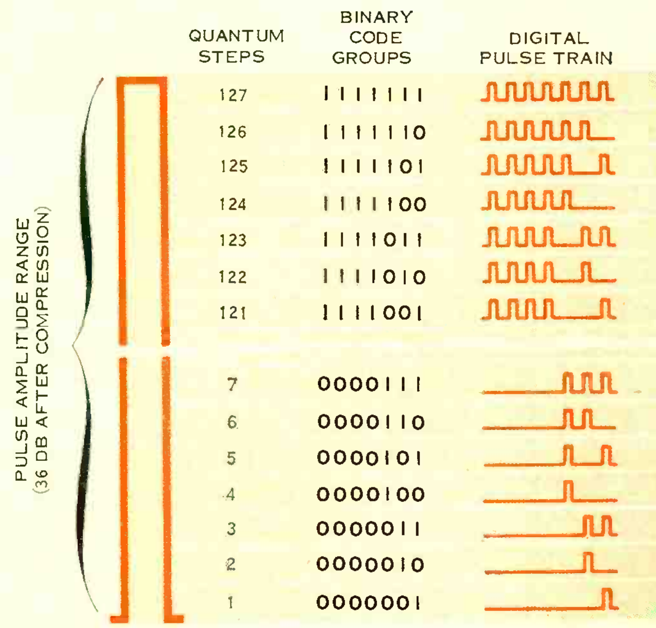


Fig. 5. In PCM, amplitude samples of speech signals are compressed, quantized, and coded into binary form for digital transmission.

to their original level at the receiving end. The combination of these two processes—redistribution of quantum steps and compression—reduces the range of signal powers that must be dealt with and, as a result, the number of discrete levels that must be coded. PCM systems now use 127 quantum steps, each of which must be coded into binary digital form.

A Code of 1's and 0's

If each quantum step is numbered in decimal form, then some type of digital code can be developed to represent each of the numbers. Ordinarily, a binary code is used which consists of a combination or code group of binary 1's and 0's, each group representing a decimal number. Once the code is established, a series of "on-off" binary pulses representing the code groups can be used for transmission.

The number of quantum steps that can be represented with a binary code is 2^n where n is the number of binary digits, or bits, required in each code group. Thus, a 5-bit code is required for 32 (2^5) quantum steps, while a 7-bit code is needed for 128 (2^7) steps. In PCM using a 7-bit code, the speech amplitude range is divided into 127 quantum steps; the 128th step is a zero reference.

In a binary numbering system, the first position at the right corresponds to a value of 1 (2^0), the second position has a value of 2 (2^1), the third has a value of 4 (2^2), and so on. The last position of a 7-bit code has a value of 64 (2^6). See Fig. 5.

The coded line signal consists of a train of pulses in which binary 1's are represented by positive or negative pulses and

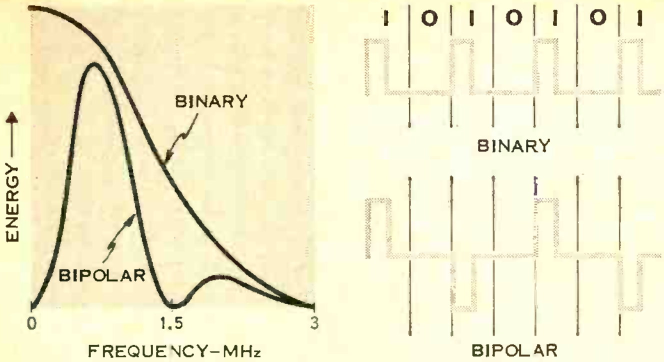


Fig. 6. In a bipolar pulse pattern, most of the signal energy is concentrated at a frequency half the pulse repetition rate.

binary 0's are represented by spaces. A binary 1 in any of the bit positions means that the value of that position is to be counted in the total, and 0 indicates that the value of the position is not to be used. As an example, the pulse train (binary code group) representing the quantum step 121 would be 1111001 (64 + 32 + 16 + 8 + 1 = 121).

Bipolar Transmission

Because the width of pulses in a binary system is one-half the allocated time slot, coded pulses in a cable pair have a 50% duty cycle. By alternating polarity in each successive pulse representing binary 1's, bipolar transmission is created.

In a bipolar transmission system, the analog voice signal is sampled, compressed, quantized into one of 127 quantum steps, and coded into a 7-digit binary code. An eighth digit or bit is added to the code group for each channel and is used to carry signaling information. All 24 channels in a typical system are sampled within a 125-microsecond period, called a frame. An additional bit is added to each frame for use in synchronizing the two system terminals.

Since eight bits are required for each channel and there are 24 channels, 192 time slots are needed. An additional synchronizing slot brings this to a total of 193 time slots per frame. Multiplying the 193 time slots by the 8000-Hz sampling rate, we find that the output pulse train will have a bit rate of 1,544,000 bits per second. See Fig. 7

Several advantages are obtained with the bipolar pulse pattern over straight binary or unipolar transmission. As shown in Fig. 6, most of the energy of bipolar signals is concentrated at frequencies of about half the pulse repetition frequency. This reduces crosstalk. And because bipolar pulses do not have a d.c. component, simple transformer coupling can be used at repeater stations. In addition, the alternating pulse pattern can be used for error detection.

Frequency vs Time

In practice, one hertz of bandwidth per bit is needed for binary transmission. Therefore, the bandwidth of a 24-channel PCM system is about 1.5 MHz. By comparison, a typical 24-channel frequency-division cable carrier system has a bandwidth of only 96 kHz.

There is a basic difference between FDM and TDM systems. In an FDM system, a number of separate channels are spread out across a frequency group so that broadband amplifiers must be able to amplify each channel equally. But in the digital PCM system, where each channel uses the entire bandwidth and channels are separated only by time, non-uniform attenuation (or amplification) is not a problem. It is only the presence or absence of a pulse that is important.

In PCM transmission systems, noise appears in a different form. It shows up as a jitter on the retransmitted pulse train which, if allowed to accumulate, can prevent the perfect retiming of pulses. Special jitter-reducing circuits are needed for long-haul PCM transmission systems.

T1--A First Step

The first operating PCM system, developed by *Bell Telephone* and designated T1, is used in many metropolitan areas to interconnect offices less than 20 miles apart. Although devised primarily for the transmission of analog voice signals in the form of digital pulses, the system's line repeaters are well suited for the transmission of digital data. Means have been developed to provide up to eight 50-kilobit-per-second or two 250-kilobit-per-second data channels on the 1.5-megabit-per-second T1 system.

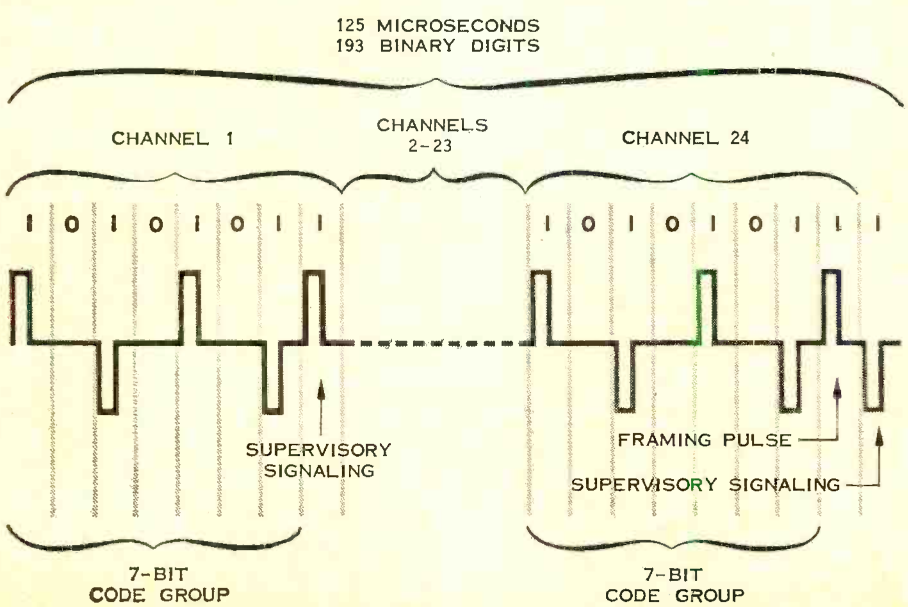
Increased bandwidth or information-handling capability is achieved by upping the bit rate of the pulse train. A second-generation PCM carrier system to be known as T2 will have a rate of about 6.3 megabits per second. It will combine four T1 channel banks and will carry 96 voice channels over a cable pair.

Bell Labs is also experimenting with a PCM TV system for future T4 equipment. It has a sampling rate of 12 MHz and transmits a 9-digit code. The system requires approximately 111 megabits per second, or not quite half the available time period. The remainder of the transmission period would hold 600 voice channels and still have room for a few other services such as data or facsimile.

PCM works well with cable telecommunications systems but is impractical for systems that utilize microwave relays. For example, a 10-MHz-wide telecommunications band is more than adequate for relaying over a thousand FDM voice channels or a color-television signal. However, it can only accommodate a few hundred PCM channels.

While FDM will remain the backbone of telecommunications for some time, economics make PCM increasingly attractive. Solid-state technology, especially integrated circuitry, is particularly well suited for digital transmission systems. This new technology will make telecommunications cheaper and more efficient in the future. ▲

Fig. 7. In the 24 channel T1 carrier system, the 125 microsecond sampling interval (frame) is divided into 193 slots—168 slots for speech data, 24 slots for supervisory signaling, and one slot for synchronization. The bit rate is 1,544,000/sec.



Ring Two—For Tomorrow

By MARTIN W. NABUT/ Bell Telephone Laboratories

Audio signals have replaced d.c. pulses in new consumer communications equipment. They speed up calls and have a world of new applications. Some experimental systems display their messages visually for the deaf.

TELEPHONES have put on new faces: they're more compact and sometimes the dial is in the receiver or base of the handset. But their technological changes are even more startling. In one recent innovation—the Touch-Tone calling system—push-buttons have replaced the rotary dial. And the d.c. dial signals, which operated switches in the telephone company's central office, have been replaced by quick-switching audio tones.

Tone Codes

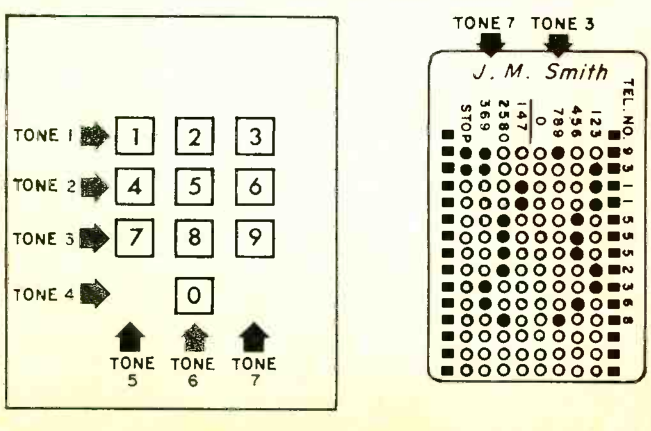
How does Touch-Tone calling work? Touch-Tone signals, in contrast to the d.c. signals generated by a rotary dial, are alternating current pulses. There are sixteen codes, ten of which replace the ten digital rotary dial signals. The remaining six codes are available for other signaling.

Recently, an *RC* integrated circuit with silicon semiconductor amplifiers was developed by *Bell Telephone Laboratories* for the Trimline Touch-Tone telephone. It consists of two switchable oscillators which generate a series of tones in the prescribed pairs—one pair for each dialed digit. One oscillator produces three tones, the other four. The feedback loop in each oscillator includes a notch filter (a variant of the standard twin-T network) to control the oscillating frequency. The pair of tones is coupled to the Touch-Tone telephone by the buffer amplifier stages in the silicon integrated circuit. When a caller presses a digit button he selects a frequency pair by switching a single resistor in each twin-T network.

The two audio frequencies define the button's position in the columns and rows of the phone dial. The higher of the two frequencies indicates the column in which the button is located, while the lower frequency signal signifies its row. There are three column signals and four row signals. See Fig. 1. The oscillator circuit is designed so that tone frequencies can be switched with negligible effect on output level. The two-tone signal is transmitted by wire to a receiver at the phone company's central office. Filters in the receiver separate the two tones.

With both Touch-Tone calling and standard rotary dial telephones still very much part of the telephone system, central offices must be "bilingual"—they must be able to

Fig. 1. When a caller pushes a telephone button, he generates a two-tone audio frequency signal. Punched holes in the plastic card's two columns perform the same signaling function.



translate Touch-Tone signaling and dial pulses into commands to operate switches and relays. This feat of linguistics is accomplished by an "interpreter" called a receiver-converter unit. These units are placed before the dial pulse receiving equipment so that the central office can operate with either rotary or Touch-Tone telephones.

The receiver-converter translates Touch-Tone signals to d.c. signals which are then sent forward through the office. The receiver detects the two frequencies of the Touch-Tone digit and provides a d.c. output on the leads of the associated converter. The converter changes these digit indications from the receiver into the form required by the particular switching equipment. Different types of units have been designed for step-by-step, crossbar, and panel central offices.

Take the arrangements for No. 5 crossbar, the most common type of switching in the *Bell System*. Here the converter circuit is merely a relay translator. The receiver takes the a.c. tones in the 3 by 4 Touch-Tone code and, using the translator, converts them into a 2 out of 5 d.c. code which can be recorded directly in the originating register of the No. 5 crossbar office. The receiver is bridged across the line and if dial pulses are received instead of Touch-Tone signals, they continue on to the originating register.

For Tired Hands

If the Touch-Tone dial seems too burdensome in this age of automation, dialing can be handled automatically with a Touch-Tone Card Dialer, a combination of a card reader and the Touch-Tone dial. The telephone numbers are punched holes on plastic cards.

The digit-frequency relationship for the coded card is much the same as the row-column arrangement of the manual Touch-Tone dial. Two holes are punched in each line of a 14-line card and each pair of holes represents a digit. In manual dialing, each push-button operates a pair of unique switches in the 3 by 4 multi-frequency signaling matrix of the telephone set. The holes in the plastic cards operate similar switches.

To use the Card Dialer, the user inserts an encoded card into a slot on the set, lifts the handset, and pushes the "start" bar. The card is "read" as a drive mechanism automatically ejects it from the slot. Mechanical feelers fall into the punched holes sequentially and read the punched cards by closing coil-tap contacts which select signal frequencies for each digit.

Fig. 2 shows the relationship of the card reader, the Touch-Tone push-button dial, and the standard telephone network. The contacts operated by the card sensors are connected in parallel with normally open push-button contacts. Every button operates a common switch which disconnects the handset transmitter (to guard against noise) and connects the Touch-Tone calling circuit to the telephone network. It also switches an attenuating resistor in series with the receiver and inductor windings.

Pushing the start bar energizes the dial circuit while releasing the start bar begins the reading cycle. When both digit sensors are in the hole on the card, an excitation switch is opened and a two-freqency signal is generated. This signal continues until the sensors are moved out of the holes by the rising card. As the card continues to move, the excitation switch and digit sensors generate a two-frequency signal for each hole of every line.

The housewife can use the Card-Dialer to store her most-often-called phone numbers. However, the capacity of the Card-Dialer is limited to 30 or 40 numbers. An improved repertory dialer, dubbed the Call-A-Matic, has been designed by *Bell Labs*. This set can hold up to 500 numbers on magnetic tape and will dial any one of them at the push of a button.

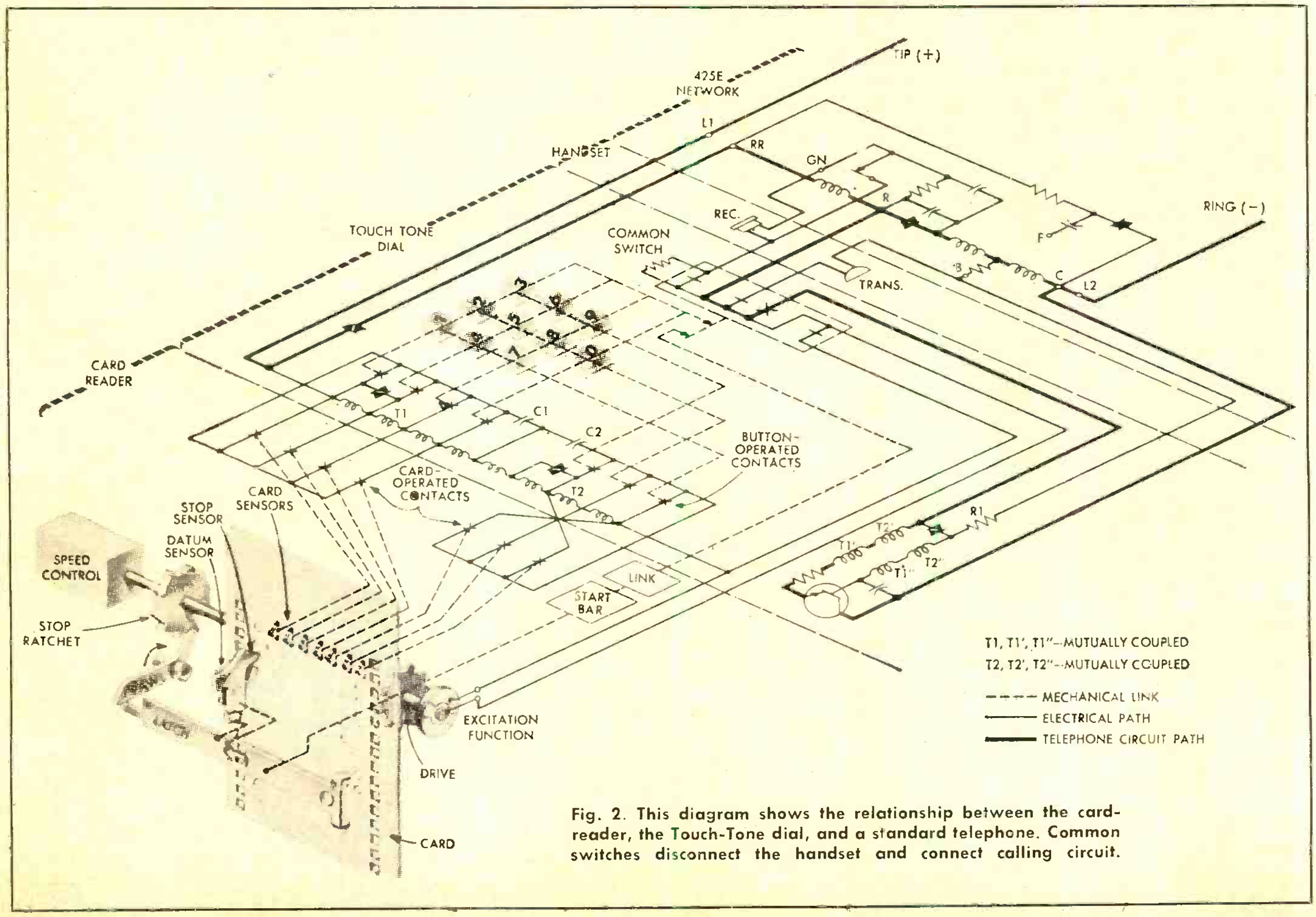


Fig. 2. This diagram shows the relationship between the card-reader, the Touch-Tone dial, and a standard telephone. Common switches disconnect the handset and connect calling circuit.

A Call-A-Matic phone has two tapes: a four-track magnetic tape on which the telephone numbers are stored in binary form, and a polyester film tape on which the user writes or types the name associated with each number. The two tapes move through the set in synchronization so that each name space on the directory tape (the polyester film) corresponds to a memory slot on the magnetic tape. All the user has to do is select a name to get the correct number. Each memory slot holds enough digits to permit direct distant dialing, even from telephone switchboards where outside access and control digits may be necessary.

To store a number on the magnetic tape, the customer lifts a "record-reset" button, selects an entry space on the directory tape, and dials the number with the Touch-Tone dial. While he is making his call, the number is automatically recorded on the magnetic tape. A recording head moves along the tape from one digit slot to another, storing the digits as they are dialed.

Binary code is used for the digits on the magnetic tape because it is an easy way to control the frequency and amplitude of the Touch-Tone signals precisely. In addition, binary encoders are less expensive and easier to manufacture than audio tone encoders. (The audio frequency must be within 0.5 percent of its correct value to be identifiable as a Touch-Tone signal.)

After the number has been recorded, the record-reset button is pushed down. This resets the memory and erases any previously recorded digits. If the customer forgets to reset his phone, an electronic clock in the set pushes the record-reset button 9 seconds after the last digit is recorded.

It is simple to dial a number from the tape memory. The customer uses two fingerwheels to move a name into a viewing window on the telephone. One wheel is used to pick out one of 50 predetermined positions and to turn on the motor which runs the directory tape. There are ten name positions on the chosen alphabetic setting and the second wheel is used to manually select the desired name. After selecting a name, the user pushes the call button. The tape head scans the tape and reads out the digits to the binary decoder. The decoder controls the two oscillators which produce the two tones of the Touch-Tone signal. Another electronic clock, operating in conjunction with the decoder, controls the length of each signal. A 7-digit number is dialed in less than a second.

Electrical and mechanical interlocks in the Call-A-Matic telephone prevent numbers from being accidentally erased or dialed incorrectly. The manual fingerwheel cannot be engaged while recording and the record control circuit is electronically disabled when a call is made from the memory. This avoids erasure and improper recording of information. When the set's faceplate is removed, power is automatically cut off the scanning motor. A speakerphone transmitter and amplifier can be used with either set.

The Call-A-Matic telephone is in production and is available as a 6-button business phone. It is not being made for single-line home use.

Mobile Telephones

Thus far, we have undoubtedly given the impression that all new telephones, for whatever application, are being designed with Touch-Tone dials. Some, notably the MJ mobile radiotelephone set, continue to be manufactured for rotary dial operation.

At present, all mobile telephone calls are handled through the mobile service operator. Only one channel (identified by its phone number) is alloted to a mobile station and if this channel is busy with other traffic, the call is blocked even if the station is able to operate on other idle channels. In addition, most mobile equipment is operated push-to-talk duplex.

The new MJ system, which is being developed by *Bell Labs* and manufactured by such firms as *ITT-Kellogg Co.*, *Motorola Inc.*, and the *Secode Corp.*, will permit the user to dial calls from his car and be called direct from other mobile stations. Nor will he have to press a button to talk—the new system operates full duplex. Automatic channel selection eliminates idle channel searching and calls can be made on any vacant channel.

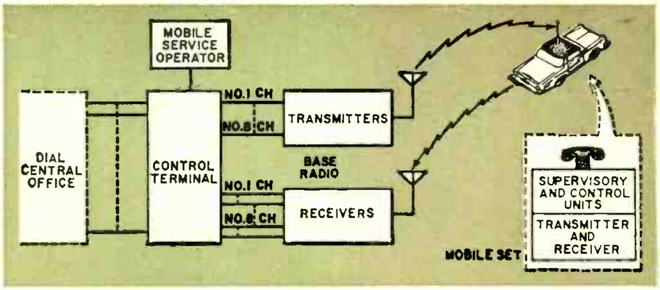


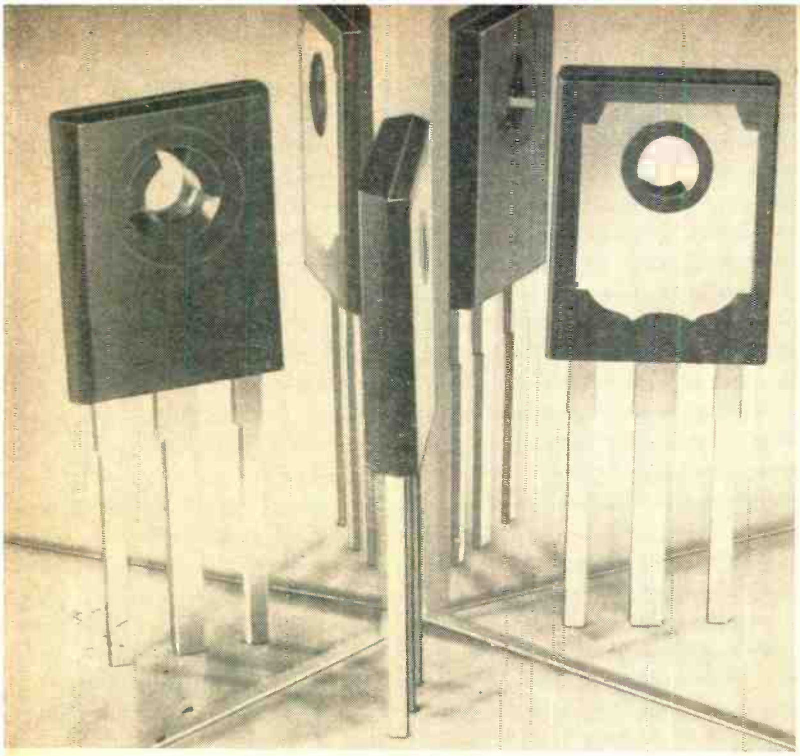
Fig. 3. Automatic equipment in the telephone company's new MJ mobile system switches calls on all eight communications channels. Standby operator is available for cars with manual sets.

Fig. 3 is a block diagram of the major elements of the new MJ mobile system. The control terminal is located in the telephone company's central office. It serves all channels (up to a maximum of eight). The terminal is also connected to a manually operated switchboard. The terminal performs the basic control, signaling, and switching functions; regulates speech transmission levels; and provides a two-wire to four-wire transition where necessary. Wire-line or microwave carrier facilities interconnect the terminal with the base station's radio receivers and transmitters.

The vehicular mobile set consists of a transceiver and control and auxiliary units for dialing, channel switching, logic operations, and selective signaling. The radio transmitter has a normal r.f. output of 20 watts. All sets are equipped to operate on all ten channels in the customer's home service area. An eleventh channel is optional.

One of the most important features of the new mobile transceiver is its automatic marking and channel selection system. Whenever a channel is not being used, its carrier is detected by the control termi- (*Continued on page* 64)

Fig. 4. With the Picturephone set, the user can "zoom" electronically and change the size of field to view a close-up.



Mounting hole is in the center of these power transistors.

PLASTIC POWER TRANSISTORS Advantages and Applications

By DONALD E. LANCASTER

Greatly reduced circuit costs, simplified assembly, and superior circuit performance are promised by these new low-cost transistors.

PLASTIC-ENCASED transistors are now making a serious bid for the high-power semiconductor market, with significant benefits to the user in the form of greatly reduced circuit costs, simplified assembly, and superior circuit performance. Half a dozen major semiconductor manufacturers now make plastic power transistors with dissipations ranging from a few watts to over 80 watts per device, and performance from d.c. to 2000 MHz.

For instance, one plastic-packaged silicon power transistor can safely dissipate 20 watts, has a 300-volt breakdown, is useful to 10 MHz, and costs only about a dollar in single quantities. Let's take a closer look at these new devices and see what specific advantages they offer over older power transistors. Then, we'll look into some of the many possible applications for these new semiconductors.

Some of the leading manufacturers of plastic power transistors are listed in Table 1. Although each manufacturer's particular plastic package is unique, they have a number of things in common. The transistors are small—usually much smaller than an ordinary power transistor with an equivalent rating. They are usually planar devices that start with a flat collector tab which supports the entire semiconductor structure, integrally molded into a silicone plastic or epoxy case. Many of the transistors have a single-hole heat-sink mounting. Both *Texas Instruments* and *General Electric* use packages with a large collector tab out the top, while *Motorola's* approach is to put the mounting hole right through the middle of the plastic package, as shown in the photograph at the beginning of the article. Other packages, such as the *Bendix* and *RCA* designs, differ somewhat in shape and mounting. Some premium u.h.f. plastic transistors make use of very special packages designed for strip-line circuitry where lead inductance and capacitance must be held to an absolute minimum. Nearly all of the plastic power transistors are silicon.

Table 1. List of manufacturers who produce the new transistors.

BENDIX SEMICONDUCTOR DIVISION
South Street
Holmdel, New Jersey 07733

GENERAL ELECTRIC SEMICONDUCTOR
Electronics Park
Syracuse, New York 13201

MOTOROLA SEMICONDUCTOR PRODUCTS
Box 955
Phoenix, Arizona 85001

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Advantages

There are several major advantages in using plastic power transistors for new circuit designs. The prime one is unit cost. Except for the special u.h.f. types, these transistors cost only a dollar or so each in single quantities and well under 50 cents in production quantities. The low price is the result of several factors. The package costs less to make—there's no header, no welded seals, and much simpler lead bonding. Construction and testing are fully automatic. Yields are high. Production is geared to high-volume consumer and automotive electronics markets.

High performance is another major benefit. These transistors arrive at a time in silicon transistor technology when the device specifications far exceed the requirements of many of the circuits in which they would be used. For instance, consider a plastic power transistor used in an ordinary audio circuit. With a 10-MHz cut-off frequency, none of the transistor's high-frequency performance tradeoffs enter into the design. Being silicon, we can forget about leakage and, if we are using a 300-volt transistor in a 20-volt circuit,

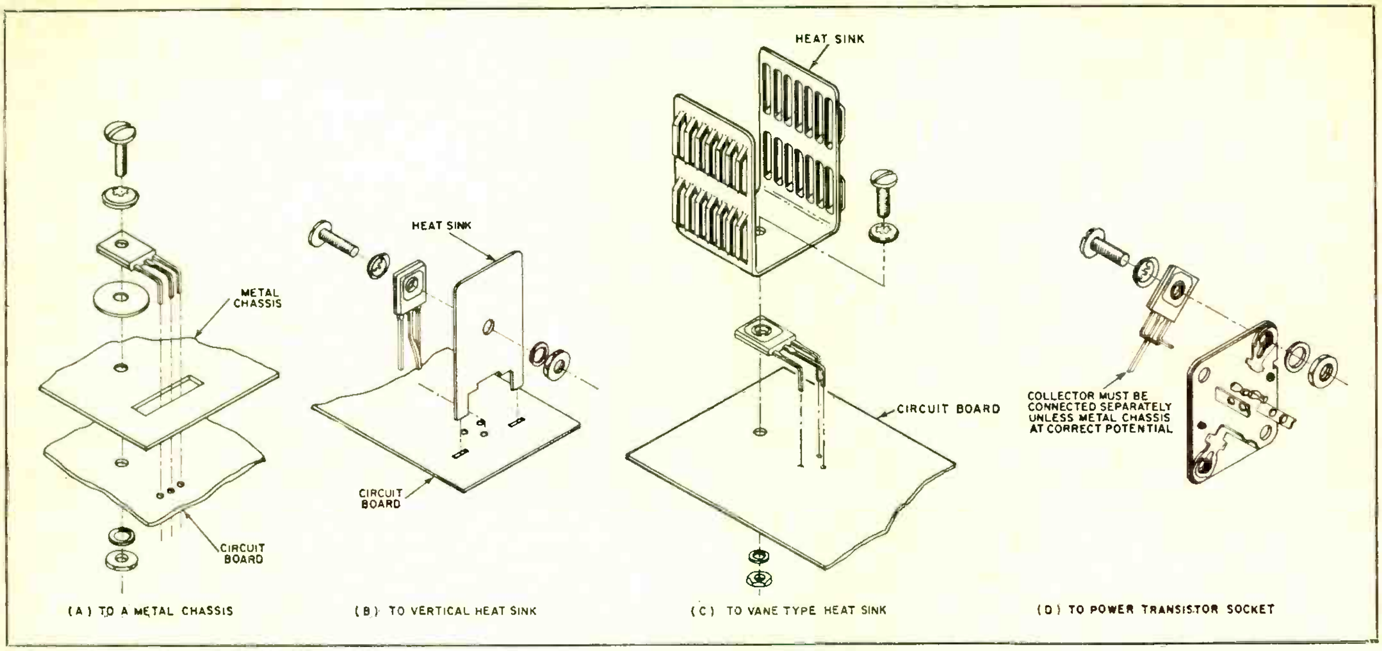


Fig. 1. Here are a number of suggested methods that can be employed to mount the plastic power transistors.

we can certainly forget about secondary breakdown. Thus, for many applications, the actual circuit design is much simpler and easier. This is especially true when updating older germanium circuits.

Another advantage is unique to a few special u.h.f. plastic power transistors. The plastic encapsulation allows a lead geometry more suited to u.h.f. stripline configuration. Wide, thin, low-impedance leads may now be used and circuit strays are more easily controlled.

Mounting Techniques

Another major advantage is easy mounting. You simply bolt, rivet, or sheet-metal screw the transistor to any suitable heat-sink material—no more precision hole patterns in expensive and awkward heat sinks. Where the device must be insulated, you use a single insulated washer instead of the multiple-part mounting kit normally required.

Motorola has several recommended mounting techniques for its transistors that clearly illustrate how easy to mount and how flexible any of the new transistors are. Some of these mounting techniques are shown in Fig. 1. If the dissipation is held to less than a watt or so, no heat-sinking is required and the transistor may be simply printed circuit-card mounted. Even bolting the collector junction to a wide foil area on the PC card will substantially improve the thermal properties. In Fig. 1A, the transistor is mounted directly to a metal chassis. A built-in insulated shoulder isolates the transistor from the mounting screw, while an access hole in the chassis lets the long leads contact a sub-chassis circuit board.

A vertical heat-sink mounting is diagrammed in Fig. 1B in which a large metal tab serves as a radiating fin. This vertical heat-sink mounting is limited to lower power levels. A one-screw, vane-type heat-sink mounting is shown in Fig. 1C. The transistors will also fit conventional power transistor sockets, as shown in Fig. 1D.

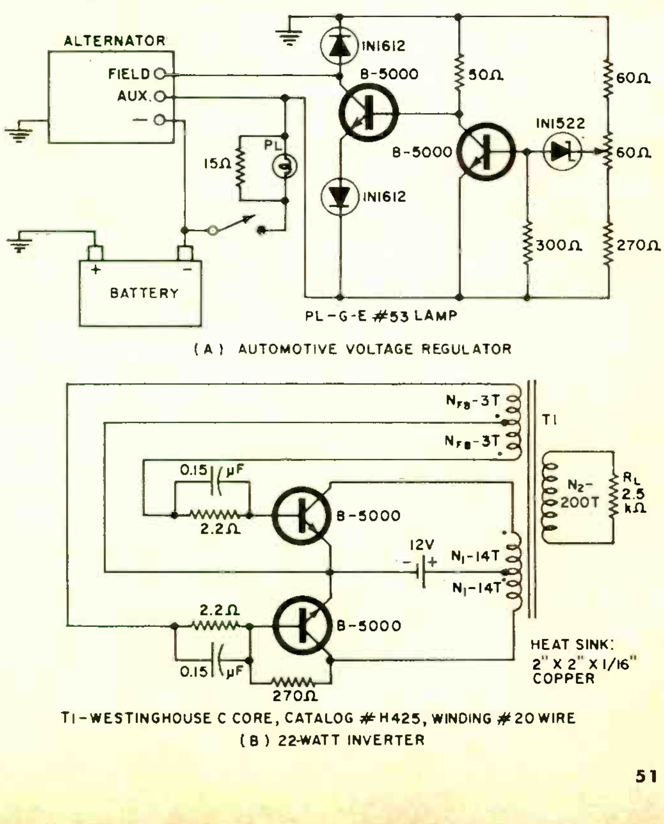
How Reliable?

Some of the earliest transistors ever built used plastic encapsulation with a variety of unsatisfactory results. The plastics were often clear, which made the transistor light-sensitive should the thin paint overcoat be inadvertently scraped off. The plastics used soaked up water. Worse yet, they had air bubbles and voids that would react with the then-unpassivated transistor surfaces.

The results were obvious—parameter variations, wide performance spreads, and outright failures. Small wonder that the circuit designers and the military looked with jaundiced eyes when plastic transistors were recently re-introduced. But this time it was different. New advances in epoxy and silicone molding compounds produced plastics that were void free, non-hygroscopic (absorbed no water), and truly opaque. Meanwhile, transistor technology was coming up with totally passivated surfaces that would not react with any of the molding compounds. The result—a transistor as reliable as conventional units for a fraction of the cost.

The reliability data is now in after thousands upon thousands of test hours and lengthy reports from every leading manufacturer. Plastic transistors are as reliable as conventional ones. Further, there's no temperature restrictions on

Fig. 2. Two applications for the Bendix B-5000 transistor.



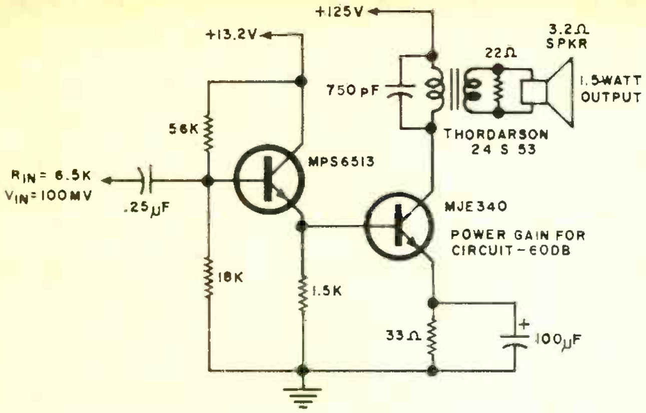


Fig. 3. Line-operated audio amplifier uses $1 transistor.

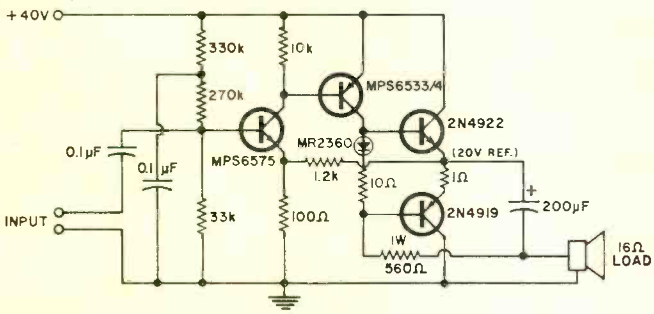


Fig. 4. Complementary symmetry 10-watt audio amplifier.

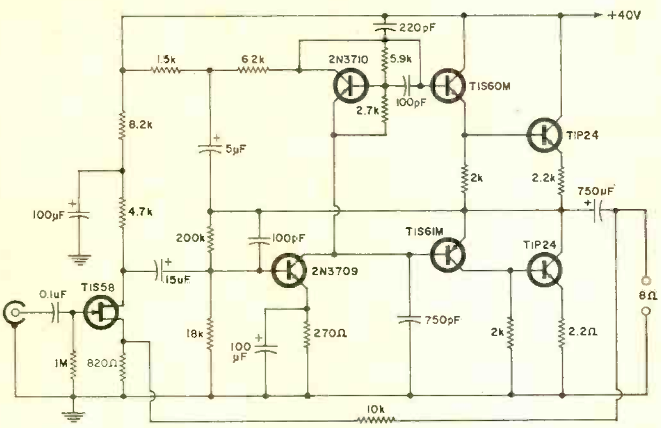


Fig. 5. Circuit of 15-watt quasi-complementary audio amplifier.

these newer devices. Most manufacturers guarantee operation over a −65°C to +150°C operating range.

Many times equipment reliability will be improved by a switch to the plastic devices, due to the simplified mounting and the fewer parts required.

Some Types and Applications

The *Bendix* B-5000 was one of the first plastic power transistors introduced. This one costs about a dollar each in single quantities and is rated to 25 watts and 35 volts, with a maximum allowable collector current of 3 amperes. It measures ¼″ in diameter by ⅛″ high, and is aimed primarily at the automotive electronics market.

Fig. 2. shows two typical applications. In Fig. 2A, two of the B-5000 transistors are used as an alternator voltage regulator, while Fig. 2B shows a 22-watt power inverter used to convert a 12-volt storage-battery power into any desired higher voltage, determined by the turns ratio of *T*1. An output rectifier and filter are also required.

Several manufacturers have introduced low-cost, high-voltage transistors designed for the audio-output stages of a.c.-d.c. equipment and as general replacements for the 50L6 and 50C5 vacuum tubes. Typical devices are the *G-E* 2N4054, the *Texas Instruments* TIP-27, and *Motorola* MJE340.

The MJE340 is the 300-volt, 20-watt, 10-MHz, one-dollar transistor previously mentioned. One typical application is the a.c.-d.c. 1.5-watt line-operated audio amplifier in Fig. 3. Here the MJE340 is powered directly from the rectified power line, while the driver stage and the rest of the circuit is driven from a low-current, 12-volt supply obtained by a resistive divider or an extra winding on the phonograph motor.

This type of high-voltage transistor is most useful for low-current regulated power supplies, relay drivers, and other circuits where a transistor must withstand the full rectified line voltage. "On-off" or switching-mode operation allows the control of up to 55 watts of 117-volt, full-wave rectified power. Another application area is in sweep output stages for electrostatic CRT's and scopes.

A dozen or so plastic power transistors have dissipation ratings ranging from 10 to over 80 watts and thus are ideal for hi-fi and other amplifier designs in the 10- to 50-watt output power class. While many units are available, one typical unit is the *Texas Instruments* TIP-24, a 70-volt, 2-ampere, $1.50 device with a typical gain of 65 and a 10-MHz cut-off frequency. Maximum allowable dissipation is 10 watts.

Two approaches to hi-fi amplifier design are the complementary and the quasi-complementary amplifier. Neither requires a driver or output transformer. The complementary type of circuit requires a matched pair of *p-n-p* and *n-p-n* output transistors, while the quasi-complementary circuit is a bit more complicated, but requires only *n-p-n* output transistors. Figs. 4 and 5 show one circuit of each type. Fig. 4 diagrams a complementary 10-watt audio amplifier using a matched *p-n-p-/n-p-n* pair of *Motorola* transistors. In Fig. 5, a 15-watt quasi-complementary design using two TIP-24's in the output stage is shown. This particular circuit also makes use of an FET as a high-input-impedance preamplifier.

Either circuit provides hi-fi performance to currently accepted standards. They can be used in pairs for stereo.

Higher Power and U.H.F. Transistors

Higher power audio amplifiers and higher current voltage regulators are possible with a new family of *RCA* plastic power transistors. These dissipate 83 watts when used with suitable heat sinks. The 2N5037 is one representative unit, rated at 70 volts and up to 8 amperes of collector current. The frequency response of these larger transistors is somewhat poorer than the 10-36 watt types, typically 1 MHz or so.

We can finish off our plastic power transistor survey by looking at the benefits plastic packaging has brought to the u.h.f. power field. Today's u.h.f. transistors are by no means low in cost, but they do provide superior performance in high-power, high-frequency circuits. This is principally due to the flat, low-inductance, stripline connections possible with the new package, and a lead arrangement better suited to high-frequency circuit designs.

The input impedance of any power transistor in the u.h.f. region is, at best, an ohm or two; any series reactance at all and the entire circuit is badly mismatched and can deliver neither gain nor power. This is why minimum lead inductance and circuit capacitance are required.

The *RCA* 2N5017 produces 23 watts of output power at 400 MHz and as much as 12 watts at 700 MHz, with power gains of 5 or so throughout the u.h.f. range. As a self-excited oscillator, 5 watts of output r.f. may be obtained easily at 600 MHz.

Farther up the frequency spectrum, we come to the *TRW* 2N4976, a u.h.f. stripline plastic power transistor that will provide 1 watt of output and 5 dB of power gain at 2000 MHz. ▲

The Differential Amplifier

By DONALD E. LANCASTER

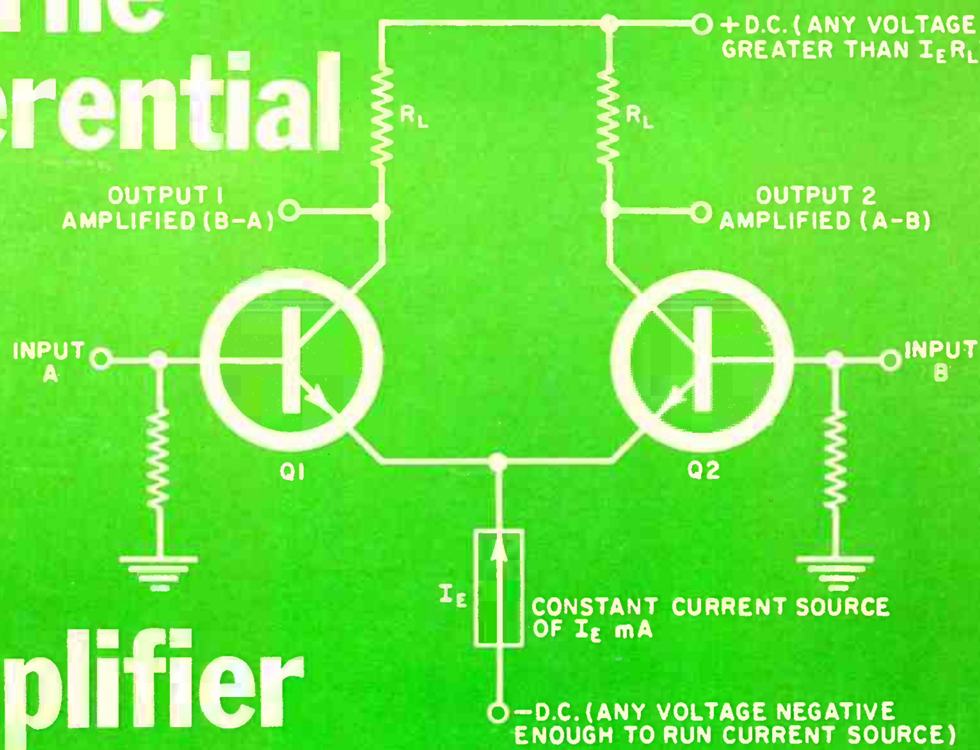


Fig. 1. Basic circuit diagram of the differential amplifier.

A stable, high-gain solid-state amplifier circuit that requires no large capacitors, ignores power-supply noise and ripple, is easy to gain control, limits readily, costs little, and is useful from d.c. up to about 500 MHz.

TODAY'S new accent on miniaturization and integrated circuitry has brought the differential amplifier into sharp focus as an important new cornerstone of future electronic systems. And, it is simple to understand and simpler yet to use.

The differential amplifier (or "diff amp") produces one or two output signals proportional to the *difference* of two input signals. If one input is grounded, it behaves as an ordinary amplifier. There are four ways you might use the diff-amp circuit; with one or two inputs or by using one or two outputs. The two available outputs are always exactly 180° out of phase with respect to each other.

Fig. 1 shows the basic circuit. Two transistors are used. Their emitters are tied together and are driven by a current source. An input signal at A goes through Q1 emitter-follower fashion and through Q2 as a grounded-base stage to arrive at output 2. Neither stage inverts the signal. Q2 provides the voltage gain and Q1 matches the input signal into Q2's low input impedance. An input signal at B goes through Q2 as a common-emitter amplifier to arrive at output 2, with voltage amplification and inversion being provided by a single transistor. Output 2 is an amplified version of the difference (A — B). Look at the circuit in a mirror and you will see that output 1 is an amplified version of the difference (B — A), this time with input A getting inverted by Q1 and B not.

Some handy features of this circuit should suggest themselves. Emitter followers and grounded-base stages can be made gain-stable independent of the common-emitter current gain (β) of the transistors used, so we might rightly suspect that a proper choice of components will make the circuit gain totally independent of the gain of the transistors used. The current source must somehow affect the stage gain, so we have a convenient method of electronically controlling or else setting the per-stage gain to any value we like. Since there are no large capacitors in the circuit, the diff amp can be made extremely small and manufactured as part of an integrated circuit.

If we operate in a *balanced*, or "push-pull" output, mode any supply-voltage ripple or hum would indentically affect both outputs, but the *collector*-to-*collector* output signal would not see this variation. This means the balanced output signal would contain no hum nor ripple, a very definite advantage in low-level or low-noise applications.

The current source always provides a fixed amount of current. Although it can divide up any which way going through Q1 and Q2, the *total* current still must equal the value the current source is providing, and that identical current must be provided by the collector power supply. The supply current required by a diff amp is a constant value totally independent of the input or output signals. Because of this, there is no way that input or output signals can get

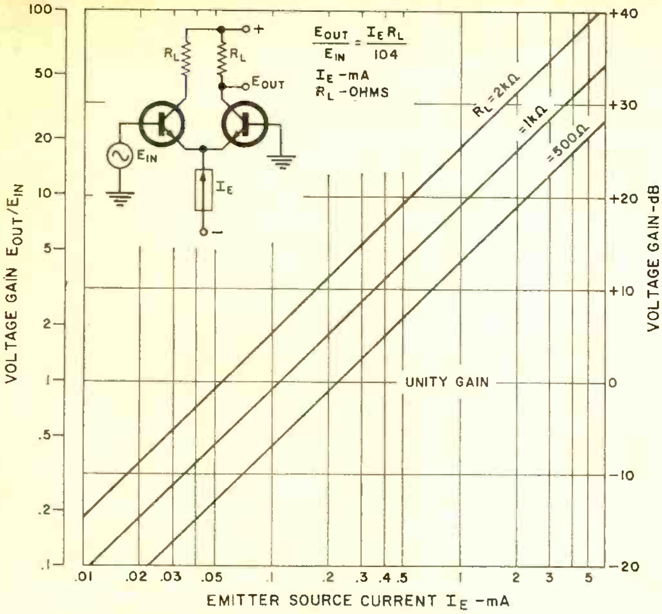


Fig. 2. Single-ended gain curves for the differential amplifier.

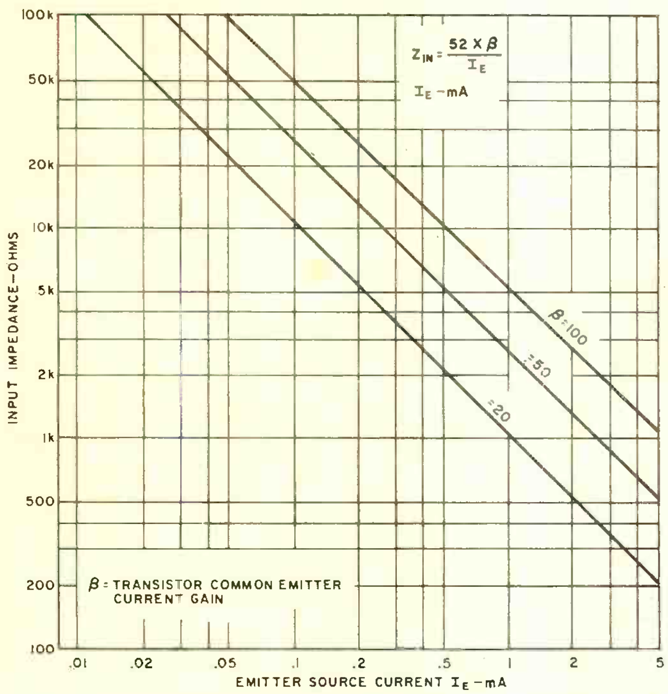


Fig. 3. Differential-amplifier input-impedance characteristics.

into the supply leads. Thus, very little supply filtering and decoupling is normally required due to the constant current drawn from the supply and the fact that the amplifier's output can be made largely independent of hum and ripple. In terms of an electronic system, we can eliminate or reduce the number of large electrolytic capacitors that the engineer often does not consider when circuit development costs are computed.

Disadvantages

The basic circuit requires two transistors which must be a matched pair and must be held at the same temperature. The current source might involve a zener diode and a third transistor, bringing the total semiconductor count to four per stage in some circuits. Because of this, the circuit has not seen too much use in the past for ordinary amplification. Today, the four semiconductors can cost less than the associated components required in a single-transistor amplifier, and they certainly take up far less space. In an integrated circuit, an entire diff-amp stage might be easily put down on a 30-mil square of silicon.

Low-cost matched pairs of transistors are now readily available, and a good match can often be obtained for moderate-performance circuits simply by selecting any two newer semiconductors from a single manufacturer's stock and clipping them together. Matching is no problem at all in integrated circuits; the close spacing and identical geometry automatically provide excellent matched transistors that are always at the same temperature.

Gain Curves

The exact expression for the voltage gain you can expect from a differential amplifier is peppered with all sorts of complicated terms. If we make a few reasonable assumptions, the gain expression can become quite simple. Let's assume that both transistors have a common-emitter current gain (β) of at least 20, that both inputs come from low-impedance sources, and that the current source will provide a few milliamperes at most. The voltage gain is then given by $(R_L \times I_E)$ 104, where R_L is the load resistance in *ohms* and I_E is the total emitter current in *milliamperes*. To get the voltage gain in decibels, we take 20 times the log of the numerical gain, just as in any decibel problem.

We see that only two things affect the gain: the collector load resistors and the source current I_E, making the stage performance nicely independent of transistor parameters.

Fig. 2 shows how you can find the gain of any low-level diff amp. For instance, if you need a 10:1 voltage gain (20 dB) and you must use a 1000-ohm collector load resistor, you would choose an emitter source current I_E of 1.04 milliamperes, or roughly 1 mA. Or, if you were analyzing another circuit with an R_L of 500 ohms and an I_E of 5 mA, you would conclude that the stage gain would be 24:1 or 27.6 decibels.

Now, supposing we reduce the emitter current from 5 mA to 50 microamperes (0.050 mA). What happens? The "gain" drops to 0.24 or −12.4 decibels. We no longer have an amplifier, but an "unamplifier", more properly called an attenuator. We get less signal out than we put in. Simply by varying the emitter current, we can electronically vary the stage gain, and linearly too. This makes the diff amp particularly attractive for a.g.c. and a.v.c. stages and anywhere else it is desirable to electronically control the gain of an amplifier. By careful control of the networks between diff amps, the a.g.c. and a.v.c. action can be obtained without affecting the bandwidth of the amplifier, a very attractive feature for r.f. work.

Our gain curves are for the output voltage you would get from one collector to ground. This is called the *single-ended voltage gain*. The balanced, or *double-ended voltage gain* is the collector-to-collector output voltage, and is twice (or +6 decibels) the single-ended gain. To obtain the double-ended voltage gain from the curves, just double your results or add 6 decibels to get the new figure.

Input Impedance

If we stick to the lower frequencies and the assumptions we made for the gain curves, the input impedance will be given by $(52 \times \beta)/I_E$ where β is the common-emitter current gain of the transistor and I_E is the source current in milliamperes. We have plotted this in Fig. 3, where we see that higher gain transistors and lower values of I_E result in the higher input impedances. For instance, a 1 mA I_E and a pair of $\beta = 50$ transistors will give an input impedance of 2600 ohms.

For our gain equations to be accurate, and for minimum interaction between system gain and bandwidth, the signal source impedance should be considerably less than the amplifier input impedance. A 500-ohm source would work well driving a 5000-ohm input-impedance amplifier. If we wanted, we could cascade several diff amps by using 500-ohm collector resistors and biasing that would keep the input impedance of the next stage 5000 ohms or above. For a.c. systems, we could capacitor- or transformer-couple from stage to stage. However, d.c. coupling is a bit more elaborate as level-shifting techniques and feedback are often required.

Where exceptionally high input impedances are required, emitter followers or field-effect transistors may be added to raise the input impedance to a desired value. Electronic voltmeters (transistor v.t.v.m.'s) are one important example of this particular technique.

Limiting

Without an input signal, each transistor uses half the source current I_E. As one input swings positive, its transistor will draw more current and less current will be left for the other transistor. The *sum* of both transistor currents must always equal I_E. Now, suppose one transistor takes all the available current because of a very positive input. All of I_E will flow through its load resistor, while zero current will be left for the opposite transistor and load resistor. We can have no more output current than I_E, and no less output current than zero. The maximum possible *change* we could get in output voltage must equal the maximum peak-to-peak output signal we could ever hope to obtain. This maximum possible output signal swing is equal to $I_E R_L$ by Ohm's law. We say the differential amplifier *limits* with a peak-to-peak output of $I_E R_L$, independent of how much larger than necessary the input is. Fig. 4 is a plot that lets you determine the limiting output level of any diff amp. We see that the maximum possible output signal we could ever get out of a diff amp with a 1 mA I_E and a 1000-ohm collector load is 1 volt peak-to-peak.

If we want a linear amplifier, we must never allow the output signal to get as big as the limiting output value, or distortion will result. A factor of three makes a good safety margin. On the other hand, if we want the circuit to limit, we simply overdrive the input with a signal strong enough to force the diff amp stage into the limiting mode.

We can make any diff amp limit at a higher level by increasing either I_E or R_L and *vice versa*.

There is hidden beauty in the diff amp as a limiter. *Neither transistor ever saturates*, so we do not have to contend with storage times, d.c. offsets, and other gremlins common to limiters that often interfere with fast, smooth limiting action. Further, the limiting action is equal for positive and negative input excursions. We call this *symmetric* limiting. Symmetric limiting is very much necessary for quality self-limiting FM i.f. amplifiers, forming an important application for diff amps. When used in this manner, the diff amp is often called an *emitter-coupled limiter*. Comparators, squaring circuits, and zero-crossing detectors are other circuit examples which take advantage of these symmetric limiting properties.

Why Matched Pairs?

The base and emitter of any conducting transistor are separated by an internal voltage V_{BE}. Although this is around 0.6 volt for a silicon transistor, the *exact* value of this voltage varies with the particular transistor and changes with temperature. If one transistor had a V_{BE} of 0.60 volt and the other had a V_{BE} of 0.65 volt, it would be just the same as adding an extra 0.05 volt to one input. This would certainly unbalance the amplifier and send much more current through one load resistor than the other. It would also change the gain balance between both sides of the circuit.

To obtain a good balanced circuit, V_{BE} matched pairs of transistors should be used and, if the transistors are not already in the same case, they should be heatsunk or clipped together to allow the circuit to track over a wide temperature range without unbalancing.

Ordinary transistors may occasionally be used if balanc-

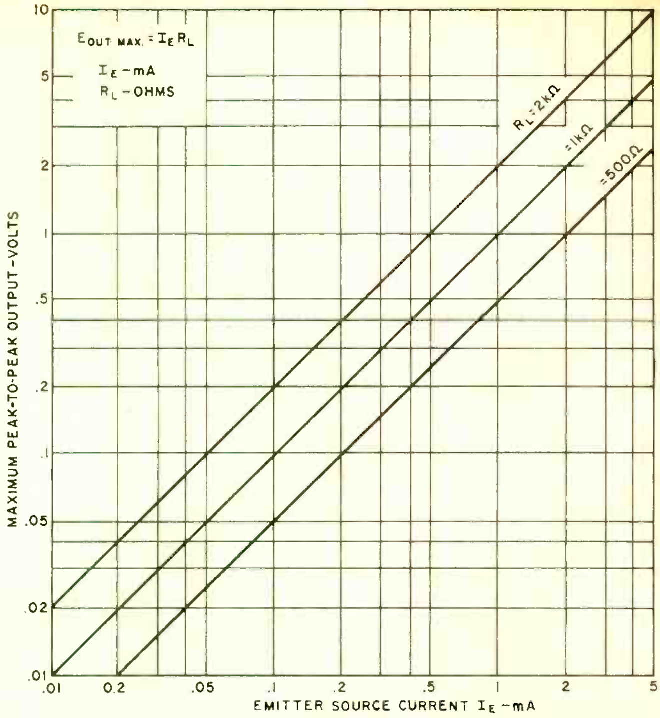
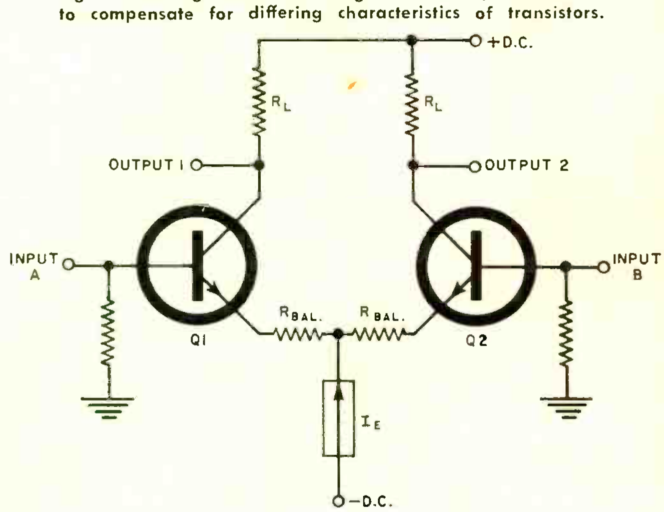
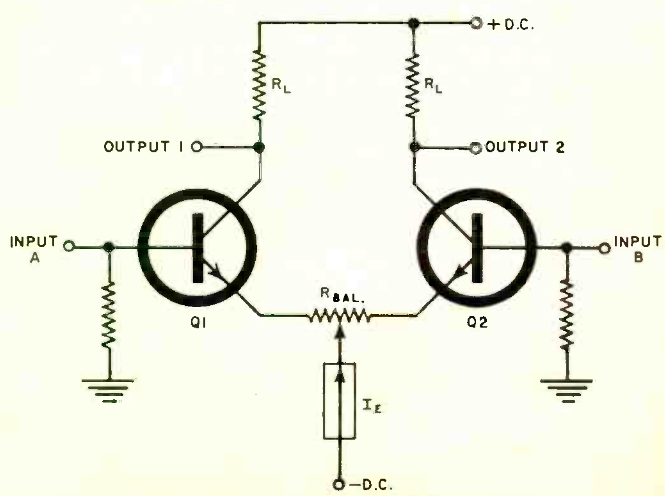


Fig. 4. This family of three curves illustrates the performance of the differential amplifier when employed as limiter. Operation for typical values of load resistance is shown.

Fig. 5. Showing use of balancing resistors or potentiometer to compensate for differing characteristics of transistors.



(A) RESISTORS ARE CAREFULLY CHOSEN TO COMPENSATE ANY V_{BE} DIFFERENCE IN Q1 AND Q2



(B) USING A BALANCING POTENTIOMETER

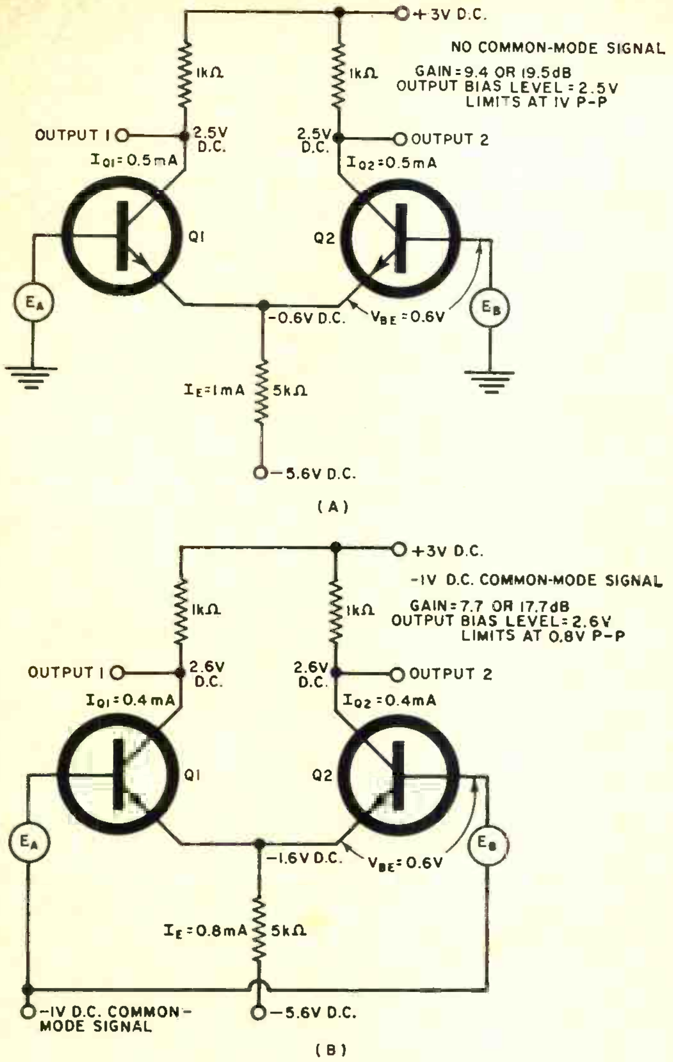


Fig. 6. The effects of a common-mode signal is shown here.

ing resistors are added to the emitters as in Fig. 5A. The resistors are chosen such that an extra V_{BE} drop in one transistor is made up by an equal extra voltage drop in the opposite emitter resistor so that the voltage drops cancel out each other's effects. A pot (Fig. 5B) is usually used instead of the two resistors to allow a control range that will compensate for different transistors. These usually run from 10 to 500 ohms and are adjusted to make both collector voltages identical under no-signal conditions. The balancing resistors will also lower the gain and raise the input impedance, so some performance trade-offs are involved in using ordinary transistors.

Why a Current Source?

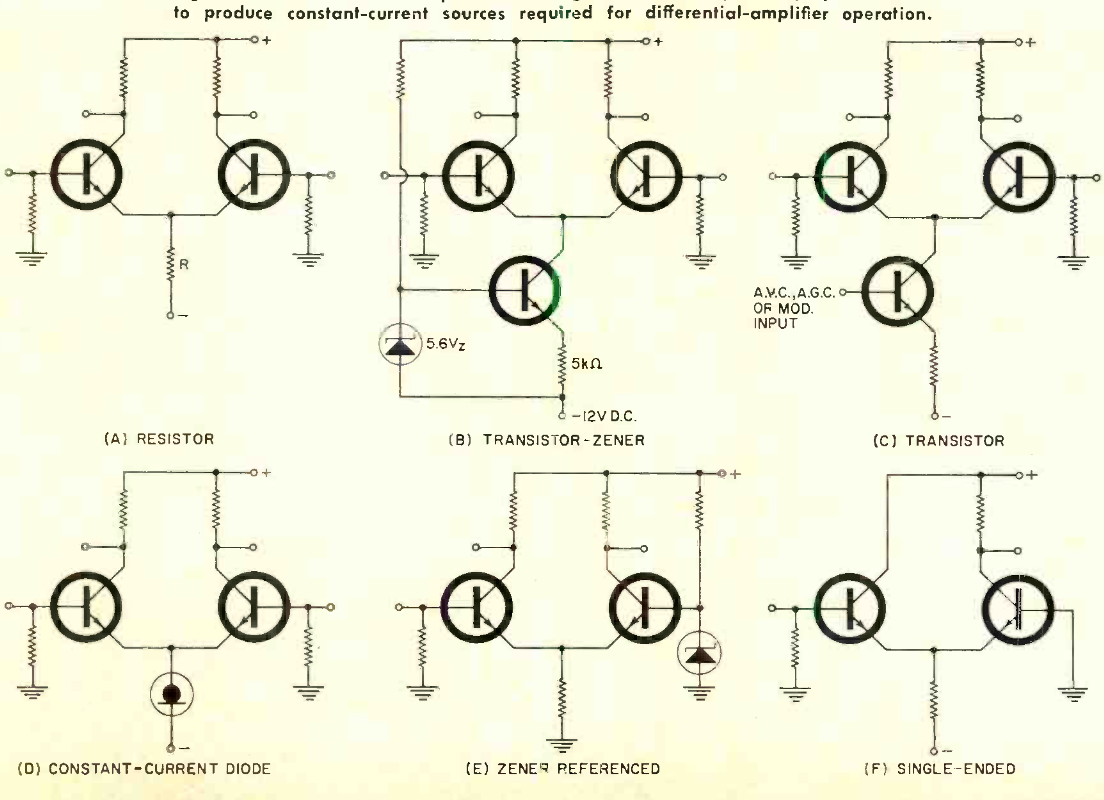
Since we have a difference amplifier, we would not want any signal that appeared simultaneously at *both* inputs to appear in the output. We call such a signal a *common-mode signal,* and the ability to minimize its effect is called the *common-mode rejection* of the amplifier. A perfect current source will have infinite common-mode rejection, since no combination of transistor voltage could possibly change the current out of an ideal current source. The *degree* to which a current source approaches the ideal determines how good the common-mode rejection will be.

If the common-mode rejection is poor, the gain and d.c. bias points will shift with a common-mode input. Power-supply noise and hum also become common-mode signals when two or more balanced amplifiers are cascaded, and could not be properly rejected in a poor amplifier design.

An example can show the effects of a common-mode signal. In Fig. 6A, we have *approximated* the current source by a 5000-ohm resistor and a −5.6-volt supply. We can see that a common-mode signal will change the voltage across the emitter resistor. This will change I_E which, in turn, will change the gain and d.c. operating points of each collector. If we check the gain curves, we will find the amplifier will have a gain of 9.4 or 19.5 decibels without a common-mode input signal, while the collectors will be d.c.-biased at 2.5 volts, determined by Ohm's law as applied to the collector resistors.

Now, suppose we add a common-mode signal of −1 volt

Fig. 7. Here are a number of practical arrangements that may be employed in order to produce constant-current sources required for differential-amplifier operation.



(Fig. 6B). The emitter voltage now drops to −1.6 volts and the current through the 5000-ohm resistor drops to 0.8 mA. The gain drops to 7.7 or 17.7 decibels, a 20% reduction, while the collector operating point goes up to 2.6 volts, and the stage now limits with a 20-percent smaller output swing.

A positive common-mode signal would do the opposite—the gain would increase as would the limiting output level. How bad these effects are depends entirely upon the electronic system. In d.c.-coupled circuits, any shift in operating point at all is bad and must somehow be corrected by feedback. Low-level signals also make the common-mode design problem more severe, as do circuits where a large d.c. offset may accompany a small a.c. signal.

Practical Current Sources

A negative voltage and a resistor is the simplest current source (Fig. 7A). In the previous common-mode example, we saw that a 5000-ohm resistor and a −5.6-volt source would give a 20% gain variation for a 1-volt common-mode signal. A 50,000-ohm resistor and a −50.6-volt source would do ten times better, allowing only a 2% variation, while a 500,000-ohm resistor and a −500.6-volt source would hold the variation to only 0.2%.

There are better ways that employ more reasonable supply voltages. A transistor connected as an emitter follower will provide a constant collector current, independent of supply variations. In Fig. 7B we have used a zener diode and transistor to provide a constant 1-mA source. A different emitter resistor or base voltage will result in a different constant collector current. In Fig. 7C, the source transistor is driven by a control signal. This input allows us to electronically vary the gain, either slowly to provide a.g.c. or a.v.c., or rapidly to provide a modulator or electronic multiplier.

In Fig. 7D, we use a *current-limiting field-effect diode*, a new device that automatically provides a constant current just like a zener diode provides a constant voltage.

Another approach is to eliminate the possibility of a common-mode signal. In 7E, one input is returned to a zener diode. A common-mode signal cannot exist different from that of the zener itself, so a single resistor serves as the current source. This circuit is often used in regulated power supplies, as the slightest difference between the zener voltage and the input voltage produces a strong collector current unbalance which, in turn, is used to correct the input signal, returning it to a value equal to that of the zener, thus providing regulation.

Grounding one input (Fig. 7F) also eliminates the common-mode problem, and once again a single resistor serves as a current source. The same circuit shows another twist—if we only make use of one output, the opposite load resistor is not needed and may be eliminated from the circuit with no change in performance.

The loss of one input does eliminate a lot of circuit possibilities but we still have a gain-stable, low-cost, capacitor-free amplifier or limiter useful for practically any simple low-level application. ▲

(Editor's Note: The careful reader will note that we have shown all the current sources in the various diagrams in this article with arrows indicating the direction of electron-current flow rather than conventional current flow. On the other hand, arrows in standard transistor and diode symbols point in the direction of conventional current. This method of indicating external current flow is entirely consistent with our own practice and with the practice that is followed in most military manuals and in most basic texts.

This method of indicating current flow should not cause any confusion providing the reader keeps in mind that we are usually concerned with the flow of electrons, and that these flow from minus to plus in the external circuit.)

JOHN FRYE

It is a mistake for the beginner to try to conceal his technical ignorance and inexperience from an old-timer.

THE TYRO TECHNICIAN

An attack of the mumps had kept Barney, the hired hand at Mac's Service Shop, away from his bench for three whole weeks; so when he stepped through the door this blustery January morning, still looking a little peaked, he was given a boisterous welcome by both his employer and Matilda, the office girl.

"Welcome back, Barney!" Matilda said, throwing her arms around his neck and giving him a resounding kiss on the cheek. "This place has been like a morgue without your red hair, your freckles, and your impudent teasing."

"I echo those sentiments," Mac said, gripping Barney's hand firmly; "and, while I'll probably live to regret it, I'll admit here and now these last three weeks have taught me to appreciate what a good technician you actually are. In fact, from now on you'll find a little something extra in your paychecks to show I'm not 'just flipping my lip,' as you'd put it."

"Well now!" Barney exclaimed, growing red in the face as he always did when emotionally moved. "All this is enough to give a man a relapse. Here I've been worrying you might not want me back. Didn't that fill-in guy the employment agency sent you work out? From what you told me on the phone, I thought he was supposed to be a real hotshot technician."

"That's what I was led to believe, and I've a hunch that's the way he saw himself; but it didn't take me long to realize he lacked: (1) a solid technical background, (2) any appreciable experience in service work, or (3) even much interest in learning more. The first giveaway was the manner in which he abused tools and equipment. You know how I feel about that. Tool-abusers, wife-beaters, and dog-kickers are all in the same category as far as I am concerned."

"Give me some gory ferinstances," Barney begged.

"He was either too stupid or too lazy to pick the right screwdriver for the job, preferring to use the driver he happened to have in his hand or saw lying on the bench. I mean he used narrow bits on wide screw slots and straight screwdrivers on Phillips head screws. Still worse, he used a hammer on the screwdriver handles, trying to make the screwdrivers serve as punches and chisels. This failure to use the proper tool was bad enough when working with metal screws, but he did the same thing with alignment tools for turning tuning slugs. As you know, I have the proper tool designed to turn any slug encountered in service work, but this bird actually used narrow-bitted metal screwdrivers to turn i.f. slugs designed to be turned with a hexagonal-shaped nylon tool. As you might expect, he cracked two tuning slugs before I put a stop to that."

"Oh I wish I could have heard it!" Barney chortled. "Tell me more. I love this."

"Well, by running the solder gun on its highest heat all the time, even when doing light soldering, he managed to keep the tin burned off the tip. Also, instead of using a soldering tool to loosen wires he was unsoldering, he tried to pry the wires loose with the tip of the gun. Not only did this bend the tip out of shape, but when that tip slipped off the connection, it sprayed molten solder all over the chassis, creating a dandy possibility of hard-to-locate short circuits.

"There's more, but come on back into the service department. I have a stinker of an intermittent radio cooking there. It was supposed to be dead, but it came right on and played perfectly for five hours. Then the dial lamp flickered several times, indicating one of the tube filaments *was* opening up and reclosing; but after that it settled down and has not made a suspicious move since. I've tried the usual things, of course: turning the set on for ten minutes and then off for ten; elevating the line voltage; lowering the line voltage. Right now I'm going to spray all the tubes with freon gas to cool them way down and then turn on the set and see what happens."

He did, and nothing happened. The set came on normally, and the dial lamp never flickered. Mac switched it off in disgust and continued:

"Anyway, this bird got my goat in lots of other ways. He couldn't even use the wire-stripper properly. Invariably he placed the wire in too-small a slot and cut clear through the insulation and into the wire, nicking it badly and placing a strain on the cutting knife before moving the wire over to the proper slot. And he had a thing about not wanting to replace hardware he had removed. If the chassis was held in by four bolts, he would replace only two of them; if he had to take out ten screws to get the back off a TV receiver, he would only put five or six back. You should have seen the aggrieved look he gave me when I told him emphatically that in this shop *all* hardware removed from a piece of equipment was replaced."

"How was he at troubleshooting?"

"Not very hot. He had the kind of single-track mind that is pure poison to good diagnosing. If the last radio he worked on had a leaky capacitor, he expected the next one to have the same fault *even though the symptoms were altogether different!* In his favor was the fact that he *did* get out the service data before starting to work on a receiver, but he didn't use it correctly. He preferred measuring to thinking. Instead of mulling over the symptoms and then taking a few measurements to isolate the difficulty in the portion of the circuit you'd logically expect to find it, he wanted to go straight through the receiver checking every voltage against the service data in the hope of finding one that was off. This was true in spite of my gentle reminder that lots of things could happen in a receiver that would disable or distort the performance without any noticeable change in the d.c. voltages.

"And he did another thing that really grated on my nerves. Some one must have told him that a meter reading is most accurate in the top third of the scale because he carefully set the range switch so this would occur with the voltage he anticipated measuring before he applied the prods. I tried to tell him this was not a good practice when he was actually looking for an *unexpected* voltage, say one you'd find at the cathode of a tube with an open cathode resistor, but he never seemed to read me. I gritted my teeth every time I heard the meter pointer banging the peg when his prod touched the wrong test point—which seemed to be about half the time when he was wading through a printed circuit. You and I set a meter range switch for the highest voltage delivered by the equipment we are working on and make our rapid voltage survey with that. We know the accuracy of our meters, even at the bottom fifth of the scales, will be plenty good enough to reveal a seriously out-of-line voltage. In case we encounter a dubious critical low voltage—as often occurs in transistor work—we can always switch to a lower range for increased accuracy without fear of damaging the meter.

"But this was just part of his being overly concerned about the wrong things and very nonchalant about things actually important. While he never touched the signal tracer or the scope during the two weeks he worked here, he almost wore out the transistor tester checking every transistor in a receiver as his very first step, even before trying a fresh battery or looking for broken antenna leads. You can't be in service work very long without realizing that while tube failures are the most common source of trouble, transistor failures are down toward the bottom of the list. While he carefully used heat-sink tactics on the leads of transistors and diodes he was soldering or unsoldering—even silicon types—he did not hesitate to pull transistors from their sockets and plug new ones in with the power turned on.

"When soldering, he tried to achieve a perfect-looking joint with a very minimum of solder, and to achieve that he didn't hesitate to reheat the joint several times. Our tests with that low-resistance bridge showed that a warmed-over solder joint is like anything else warmed over: not nearly so good as the first time. I told him if he would apply plenty of heat to a clean joint before he applied the solder, he would get a good joint and should let it alone. A small amount of extra solder that flows over the joint is not going to hurt, and it's much more important to have a good low-resistance joint than a pretty one."

While Mac had been talking, Barney had casually pulled the 50C5 from the intermittent radio still sitting on the bench and had sprayed the metal pins of the tube with pressurized freon gas until frost formed all over the bottom of the tube. Now he plugged the 50C5 back in and turned on the switch. The dial lamp did not come on even when Mac suspiciously wiggled the tube in the socket to make sure it was making a good connection. Mac quickly pulled the tube out and checked the filament with the ohmmeter prods touched to the pins. The filament, as he expected, was open.

"Those mumps must have made you smarter," was his grudging comment. "Of course I follow your reasoning. I was trying to cool down the tube elements and make them shrink by spraying the glass envelope, but glass is a good heat insulator and resists the transmission of quick changes of temperature through itself. Metal, on the other hand, is a good heat conductor; so when you sprayed the tube pins you drew a great deal of heat out of the tube elements to which they were connected and got the job done. Of course you were a little lucky in picking on the bad tube the first time, but even that wasn't pure luck. The output tube is the one that most often develops an intermittent filament. Thanks, Barney. You're what I'd call a thinking man's technician!"

"Gee, Boss, thanks!" Barney said mockingly. "Apparently you gave up and let the fellow go after a couple of weeks. Don't you think he will ever make a good technician?"

"I seriously doubt it," Mac replied. "He was more interested in covering up his ignorance than in dispelling it. Had he told me he didn't have too much experience, I'd have put him at jobs he could handle; and if he had shown a desire to learn, I'd have done my darndest to help him. It's a great waste of time to try and con an old-timer into believing you know more than you do. Every move you make under his watchful eyes gives you away."

"I'll not argue with that," Barney said; "but there is only one thing that bugs me: this guy had to be so bad to make me seem good! Well, let's quit palavering and get to work. You never thought you'd hear that from me, did you? Neither did I, but the truth is that my hands literally ache to take hold of tools again." ▲

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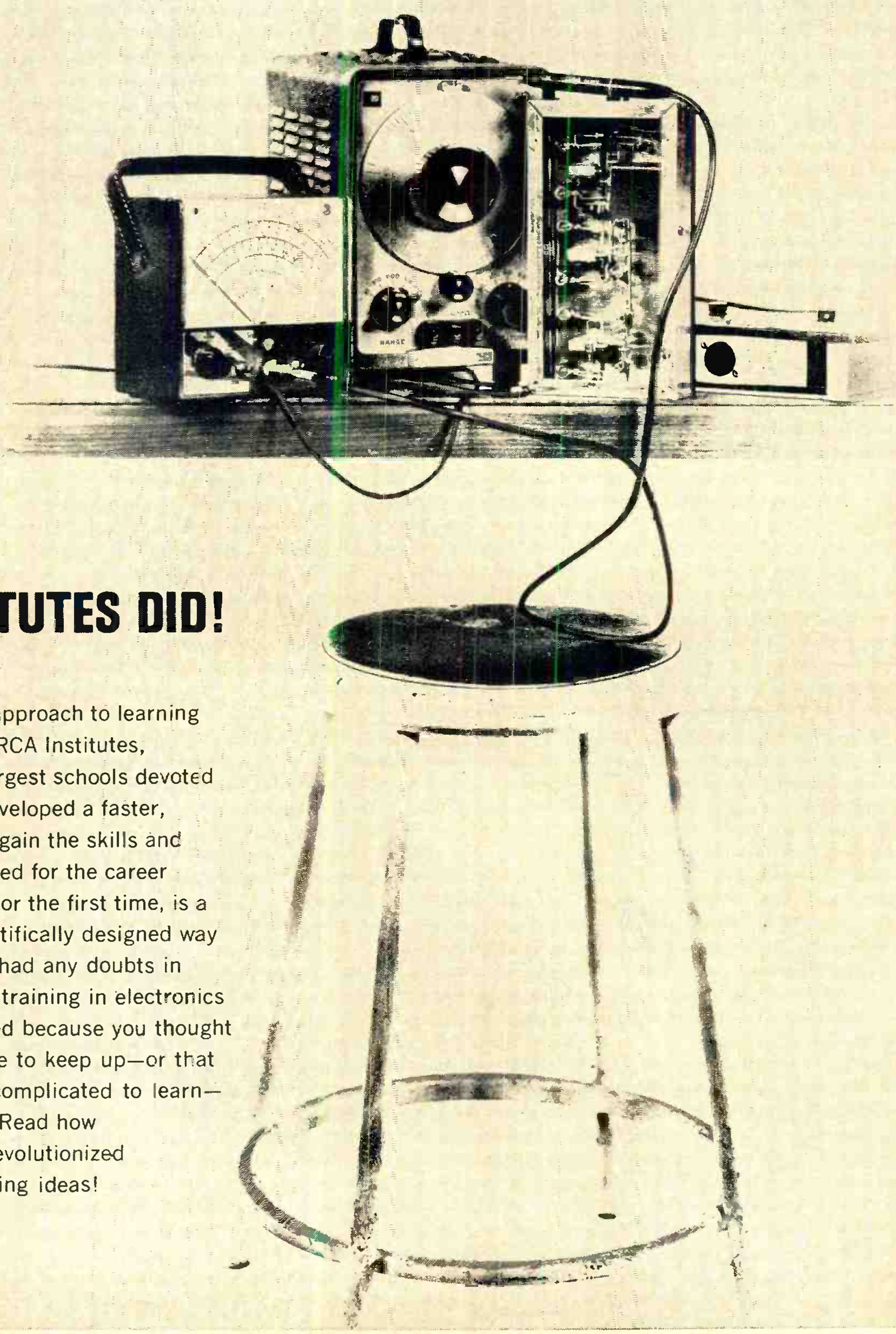

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(Continued from page 49)

nal and modulated with an "idle marking" tone. Off-line receivers continuously hunt through their channels and camp on the marked channel; and the next call in either direction is established over this frequency. As soon as a call is initiated, the control terminal moves the idle tone to another available channel and all off-line sets step to it in readiness for the next call.

The mobile set's receiver is completely transistorized and the transmitter uses tubes only in its final three stages. There are eleven plug-in oscillator units for operation on all the channels. The control unit also uses solid-state components throughout to perform the logic tone-signaling functions.

The user has three push-buttons for selecting the transceiver's mode of operation. He uses an "H" button in his home area to condition his set for duplex operation and make the receiver hunt over local radio channels. Out of his home area, he uses the "R" (Roam) button to condition his set and hunt over the channels in that area. Finally, there is an "M" button which is used when he drives into a manual-system service area. This button bypasses the automatic channel hunting and dialing system and the set works in a push-to-talk mode instead of full duplex. Calls will then go through the mobile service operator. On the other hand, if the mobile phone user with a manual set drives into an MJ system area, the control terminal automatically routes his call to the station operator.

Pictures to Talk By

Among its many communications developments, *Bell Labs* has been experimenting with a videotelephone. The Picturephone was first demonstrated at the New York World's Fair. This year an improved Model II Picturephone will provide limited commercial service between New York, Chicago, and Washington, D.C. Callers will be able to use the system to transmit photos, drawings, and other graphic material as well as human images.

The Picturephone station set consists of a display and camera unit, a control unit, and a service unit. A standard Touch-Tone telephone set, equipped with a 12-button dial, is used for calling. The compact control unit contains four knobs and four push-buttons, and can be placed in a convenient location in front of the Picturephone display unit. One knob adjusts the height of the center of the camera's field of view electronically. Another knob regulates the camera's electronic zoom, a third controls the brightness of the displayed image, and a fourth knob is the volume control for the speakerphone. The microphone for the speakerphone is also in the control unit.

The four push-button controls enable the user to initiate

AN ANCIENT ART?

Did you ever talk about flappers and television in same breath? Well, it was 1927 when Walter S. Gifford, President of the American Telephone and Telegraph Co. and Secretary of Commerce Herbert Hoover in Washington, D. C. first considered the idea of telephones and TV working together. But the history of the videophone runs like this:

- 1929-1931 The first two-way TV system set up between AT&T offices and Bell Telephone Laboratories in New York.
- 1935-1938 TV-telephone service tried by German Post Office.
- 1954-1961 Research videophones developed by Bell Labs.
- 1955 Kay Labs demonstrates a one-mile videophone system.
- 1956-1964 First automatic system demonstrated by Bell Labs.
- 1963 Italy and Japan conduct slow-scan experiments.
- 1963 Pye Telecommunications Ltd. develops a videophone.
- 1964 First public demonstration of Picturephone.

The new MJ mobile system is a full duplex radio. User can dial stations direct from his car on up to eight channels.

or answer a Picturephone or voice-only speakerphone call; to see the transmitted picture; to prevent his picture from being transmitted (a pattern of three horizontal bars is sent instead); and to end the call. For privacy, the speakerphone microphone can be turned off by depressing the first push-button.

The service unit contains the power supply and control circuitry. It can be remotely located up to 85 feet from the Picturephone display unit.

The Model II Picturephone incorporates a new television camera tube. It was developed by *Bell Labs* and combines the best features of the vidicon with the highly developed silicon technology used in integrated circuits. This marriage of tube and semiconductor technologies removes certain shortcomings of present camera tubes and promises a more rugged, longer lasting, and more sensitive camera tube.

The heart of the tube is a new type of target structure consisting of a self-supporting silicon wafer the size of a nickel and containing over half a million silicon photodiodes in an area less than one-half-inch square. The target, only 2 mils (0.002 inch) thick, is fabricated by techniques similar to those used in making silicon IC's.

Like most television camera tubes, the new tube converts an optical image into a pattern of stored electrical charges on the target structure. This pattern of charges is periodically scanned and erased by an electron beam. The video signal is generated as the charge pattern is erased.

One advantage of the silicon target in the new camera tube is that its performance is not degraded or modified by exposure to bright light sources or by electron beam bombardment.

Because of its silicon target structure, the camera tube has good response at room temperature to both visible and near infrared light, and has a higher signal output than most standard camera tubes. In addition, the device has virtually no "lag", a phenomenon giving rise to image smearing in conventional camera tubes. *(For additional details, see the article "New Picture Telephone Goes Commercial" in next month's issue.—Editor)*

Bell Labs is also experimenting with a device that would enable deaf people to communicate *via* telephone by reading letters and numbers flashed on a small screen. The Touch-Tone buttons are used to generate the tones that activate the visual display. The caller sends A, B, and C with the "2" button, D, E, and F with the "3" button, and so on through the alphabet. Pushing the "2" button once indicates A, twice B, and three times C. A memory circuit stores the signals until a letter is fully coded. Thus in the code A is 20, B is 220, and C is 2220. No commerical production of this device is planned at this time. ▲

STEREO BALANCE INDICATOR

By TALMAGE B. YOUNG
Assoc. Prof., Industrial Arts Education
North Carolina State University

If you have difficulty in balancing your stereo system because you have one speaker near you and the other several feet away, a relatively simple circuit can solve your problem.

The circuit (Fig. 1) consists of a 100-μA zero-center meter, a dual 3.5-k potentiometer, a 100-ohm resistor, and two diodes. Parts values are not critical.

Basically, a zero meter reading indicates balance. Each diode rectifies audio from one of the speaker leads. Both diodes point toward the meter, but they are connected to opposite meter terminals. When equal voltages are applied to both diodes, meter terminal voltages are equal. No current flows and there is no meter deflection from zero. When unequal voltages are applied, meter deflection indicates unbalance.

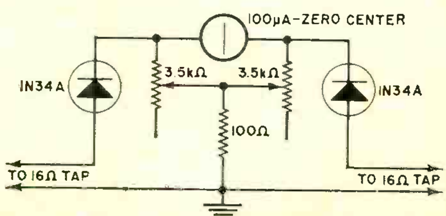
The two 3.5-k pots should be ganged on a single shaft. Before assembly, check resistances at several settings to verify tracking. The diode types are not critical, but germanium diodes will give better sensitivity at low levels.

Sensitivity of this circuit depends upon the resistance of the two potentiometers, and may be adjusted for high or low signal strengths to suit the user. Two variations occur when the resistance is changed. As the control is moved toward the meter, it becomes a shunt of less resistance; as it moves toward ground the total resistance increases and also reduces sensitivity. Maximum sensitivity occurs at an intermediate setting, and for good diode life, only the reduced-sensitivity settings on the *ground* side of the maximum sensitivity point should be used.

Tone control adjustments will affect the balance, so the balance should be adjusted after satisfactory tone adjustments are completed.

If the meter is more sensitive than 50 μA, full-scale, a shunt may be required to prevent excessive deflection. Apparent sensitivity may also be reduced by connecting the indicator to lower impedance level taps. ▲

Fig. 1. This simple, no-capacitor circuit will indicate stereo balance.



Marine Communications

(*Continued from page 42*)

Then, the WARC went even further. It incorporated two changes which may have more effect on the U.S. marine communications community than either narrow-banding or channel-splitting.

The first basic change is a reduction in the maximum power permitted in the v.h.f./FM marine band. Presently, 100 watts d.c. input is the legal limit with the exception of a 15-watt (except in the Great Lakes) ceiling on channel 13 (156.65 MHz). This is the bridge-to-bridge frequency which is intended primarily for ship-pilot use. Under the Geneva rulings, the maximum power allowed will be 25 watts *output* all over the world. This 25-watt *output* limitation implies an approximate d.c. *input* of 50 watts. In effect, the maximum legal power has been cut in half.

Second, all v.h.f./FM marine phones must have a low-power switch. This low-power switch will limit the effective radiated power to *one watt.* This would indicate a transmitter *output* in the neighborhood of 3-5 watts. Mr. Child indicated that the FCC will "probably word this low-power requirement in terms of a transmitter output rating." If this is so, it brings up an interesting point: what happens when a gain antenna is used? If a 3-watt output gives a 1-watt e.r.p. with a quarter-wave whip, the minute a gain antenna is used with this installation, it will be illegal internationally.

The Notice of Proposed Rule Making incorporating these v.h.f./FM changes will, according to Mr. Child, be out "almost immediately".

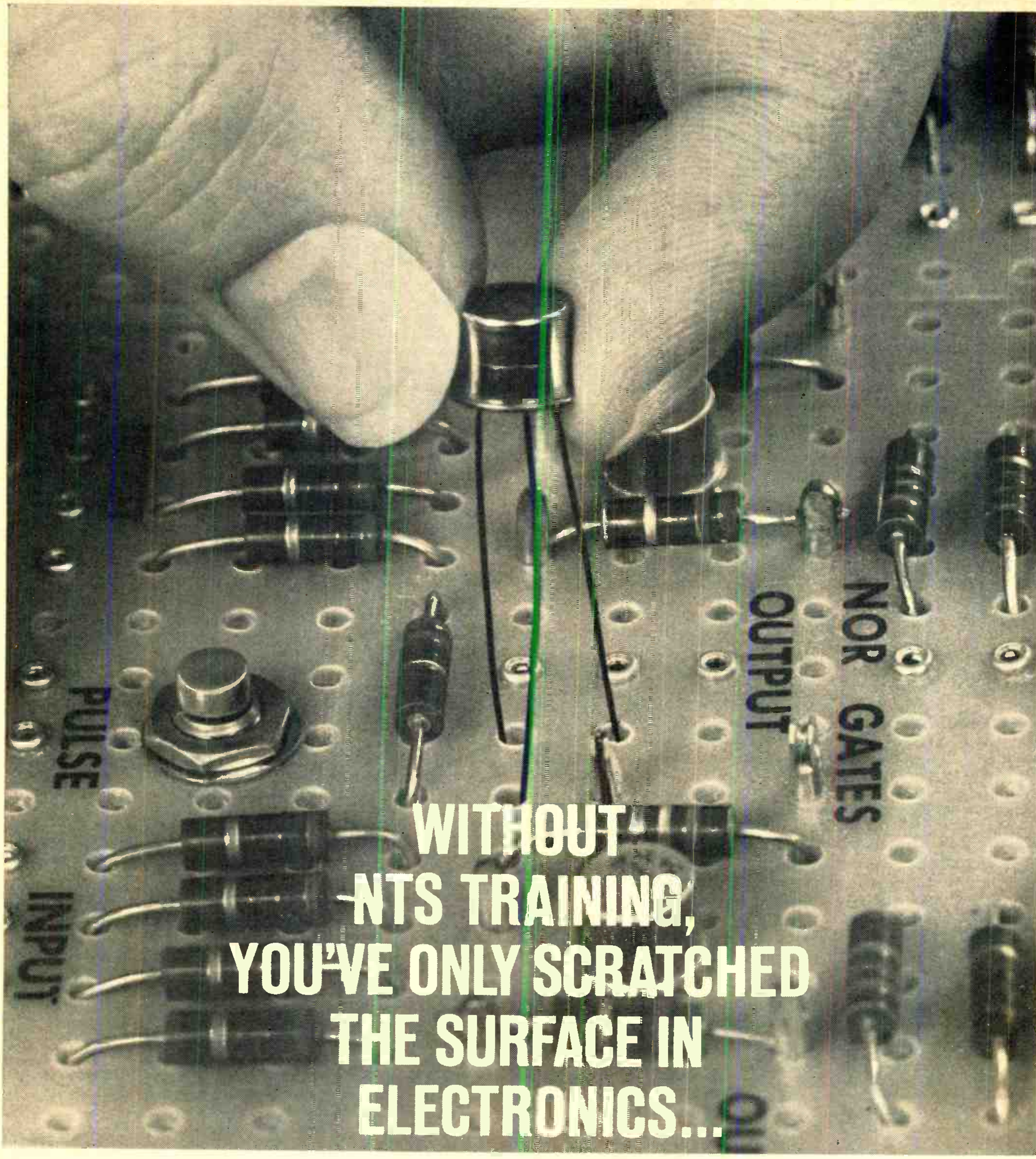
Narrow-banding offers no serious problems to the industry. The reduction in power and the requirement for a low-power position is something else again. The comments from the manufacturers during the February, 1968 Radio Technical Commission for Marine Services Meeting should be interesting.

One other item which the FCC is studying is the requirement for ±0.00025% frequency tolerance for land stations in the v.h.f./FM marine band. This is bound to bring a strong reaction from the industry. This tolerance is considerably more than ±0.001% decided upon by the Geneva Conference. The idea of the 0.00025% tolerance is that it would be a help in tuning up mobile marine gear by using the land station as a secondary frequency standard. Somehow, this author thinks that cooperation from the marine operator and the commercial-shipping coast stations will not be as forthcoming as the proponents of the 0.00025% tolerance think.

While these changes in v.h.f./FM won't affect the nation's pleasure boaters anywhere near as much as the single-sideband conversion in the 2-3 MHz band—the number of recreational craft with v.h.f./FM equipment aboard is minute—the commercial shippers, who rely heavily on v.h.f./FM, are going to have a problem. They will be faced with converting their present equipment to narrow-band FM and, unless a grandfather clause is resorted to, will also have to have additional work done to reduce power and add a low-power switch.

The commercial shippers the author talked to expressed themselves in no uncertain terms. ("How many times do they want me to pay for my radio?") They are not concerned with the Coast Guard's desire to get the bulk of America's pleasure boaters up on the v.h.f./FM marine band nor the FCC's hope to reduce the congestion and interference on the 2-3 MHz band. To them, their v.h.f./FM radios represent money—not only as an investment but a means of making more.

The pleasure boater has his problems facing him in the 2-3 MHz band. The manufacturer of marine communications equipment has both marine services to plague him. ▲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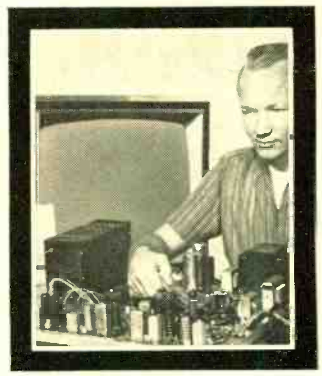

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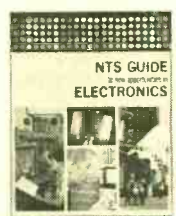

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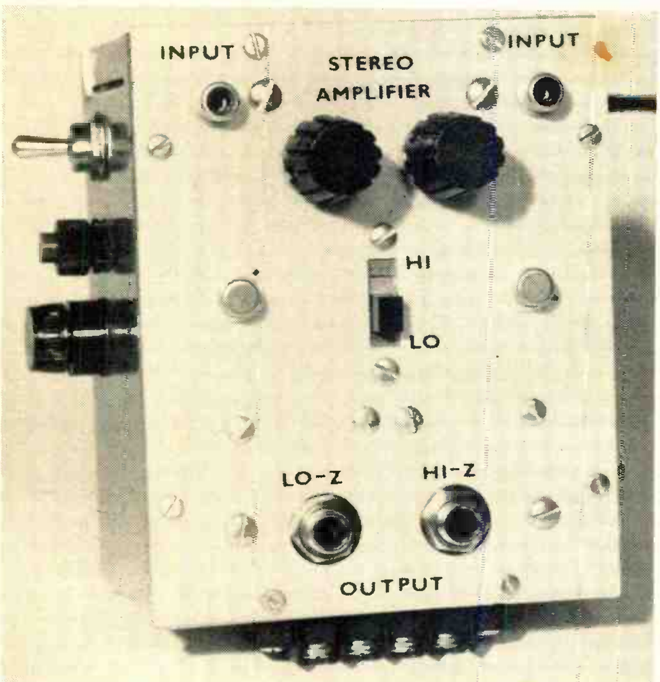
AN INTEGRATED CIRCUIT FOR THE EXPERIMENTER

By G. E. ESTEP

A new moderately priced IC which delivers 250 mW to an 8-ohm speaker can be used as a headphone driver, low-power audio-amplifier, and telephone pickup amplifier.



A stereo headphone amplifier using a pair of NJS716H IC's.

SERIOUS experimenters have avoided integrated-circuit audio amplifiers usually because of high price tags and the limited output current capability of such devices. Both of these objections have been overcome with the *New Jersey Semiconductors* NJS716H. The device combines useful output capability with low distortion and allows any one of four predetermined voltage gains to be used.

This moderately priced device (about $5.75) can deliver up to 250 mW of power to an 8-ohm speaker or headphones and is ideally suited for the experimenter, technician, or engineer who wants to gain experience in working with integrated circuits. The power level is sufficient for many listening conditions using an efficient speaker and is more than adequate for headphones. The device is simple to use, requiring only the connection of coupling capacitors and a power supply.

The IC amplifier includes 11 transistors, 6 diodes, and 18 resistors diffused into a silicon chip only 50-mils square. Internal feedback is placed around the amplifier to stabilize its operating characteristics and to reduce distortion. The voltage gain of the amplifier is set by connecting a single capacitor to the appropriate terminal(s) and may be selected to be ×10, ×20, ×100, or ×200. This allows a wide range of input devices, such as phono cartridges, microphones, tuners, tape recorders, or audio oscillators. Fig. 1 illustrates the pin numbering and the method of connection for each of the available voltage gains.

A stereo headphone amplifier using a pair of NJS716H's is shown in the photo. This amplifier can be used with either low-impedance (16 ohms or less) or high-impedance (400 ohms or higher) headphones by selecting the proper output.

A regulated power supply capable of delivering 18-25 volts at 200 mA is used to power the stereo amplifier. This regulated supply (Fig. 2) will deliver the necessary voltage to the device over a large current range and can be constructed of readily available parts. This same supply can be used to power the integrated circuit in any of the applications shown or for many other uses.

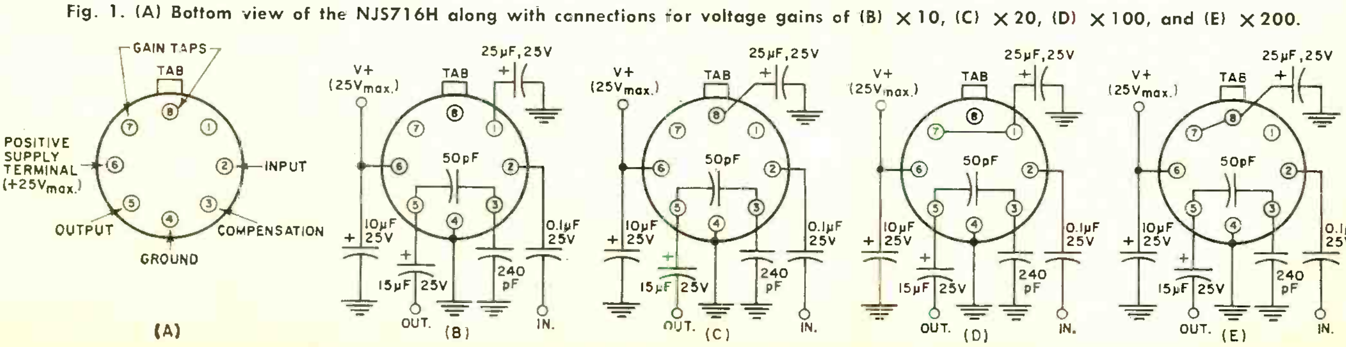
Two precautions must be taken when using the NJS716H: *Observe the power-supply polarity, and do not allow the output of the amplifier to short to ground while the supply is connected.* Failure to observe these precautions may result in permanent damage to the IC. NJS716H characteristics of interest to the experimenter are shown in Table 1.

Circuit Applications

The amplifier connections shown in Fig. 1 are given to illustrate the basic method of coupling the NJS716H to the external circuitry. The various voltage gains are obtained by bypassing the appropriate terminals and input/output coupling capacitors are used to d.c. isolate the amplifier from its source and load. Since the coupling capacitors have very little impedance to the a.c. component of the input and output, there is little signal lost because of their use.

To determine the maximum voltage that should be applied

Fig. 1. (A) Bottom view of the NJS716H along with connections for voltage gains of (B) ×10, (C) ×20, (D) ×100, and (E) ×200.



to the input of the amplifier the approximation may be made that the amplifier will deliver 80 percent of the supply voltage to its load. This voltage divided by the gain of the amplifier yields the maximum input voltage. (This maximum is not the same as that listed in Table 1. The value in the table is the maximum voltage that may be applied to the input of the device without damaging it.)

For example, suppose a 22.5-volt supply is used, the maximum output swing before saturation would be approximately $0.8 \times 22.5 = 18$ V(p-p) and $V_{in} = 18$ V (p-p)/*voltage gain* or 1.8 V (p-p) for a gain of 10, 0.9 V (p-p) for a gain of 20, 0.18 V(p-p) for a gain of 100, and 0.09 V(p-p) for 200.

Any voltage up to the limiting value determined by the above may be applied to the amplifier—the actual value will depend on how the IC is used and the desired output level.

The low-power audio amplifier (Fig. 3) shows how the basic construction may be used with an output transformer to drive a low-impedance speaker. Signal voltage is applied to the pot, which may be varied to adjust the listening level. Any transformer similar to the one indicated on the diagram may be used. Since the amplifier minimum load should not go below 150 ohms to insure low distortion, a transformer that will transform the speaker impedance up to this value must be used. For a 3-ohm speaker the turns ratio required would be approximately $(N_p/N_s) = \sqrt{150/3} = 7{:}1$, or $\sqrt{150/8} = 4.3{:}1$ for an 8-ohm load, or $\sqrt{150/16} = 3{:}1$ for a 16-ohm load.

A headphone amplifier may be constructed using the same circuit as in Fig. 3. Since high-impedance headphones (400-2000 ohms) are used, no transformer is required at the output of the IC. The maximum power that may be delivered to the headphones can be determined from the expression: $P = 0.8\ V+^2/8Z$ where Z is the phone impedance. For example: $P = 16^2/4800 = 53$ mW for a 20-volt supply and 600-ohm headphones.

Combining these circuits into a single stereo amplifier is shown in Fig. 4. The amplifier is basically the same as previous circuits for low-impedance headphones (or speakers) and high-impedance headphones. Individual volume controls are provided for each channel. The transformers used are not critical and any reasonable substitute may be used. To determine what transformer to buy, use the basic relationships given above to relate the speaker (or headphone) impedance to the minimum amplifier load. The parts placement is not critical and may be modified to suit individual needs.

Other low-cost integrated circuits available from *New Jersey Semiconductor* include: NJS703H at $1.50 (an r.f./i.f. amplifier useful to 100 MHz. This device can provide non-saturating limited gain for FM i.f. amplification, or it can be used in AM circuits to give as much as 28 dB of gain at frequencies as high as 100 MHz.); NHS709H at $5.95 (high-gain operational amplifier); and NJS710H at $4.95 (voltage comparator).

These devices may be ordered direct from *New Jersey Semiconductor Products Inc.*, U.S. Highway 22, Watchung, New Jersey 07060. ▲

Table 1. Basic circuit characteristics of the NJS716H.

Input Resistance	10,000 ohms
Output Resistance	1 ohm
Frequency Response	50-50,000 Hz
Harmonic Distortion	0.5%
Maximum Input Voltage	3 V p-p
Maximum Output Power	250 mW
Minimum Load Resistance	150 ohms
Voltage Gains Available	10,20,100,200
Minimum Supply Voltage	18 V
Maximum Supply Voltage	25 V

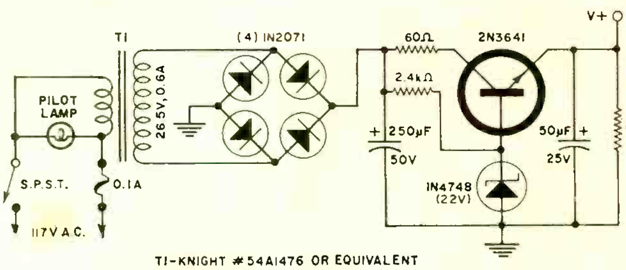


Fig. 2. Power supply circuit used for IC devices.

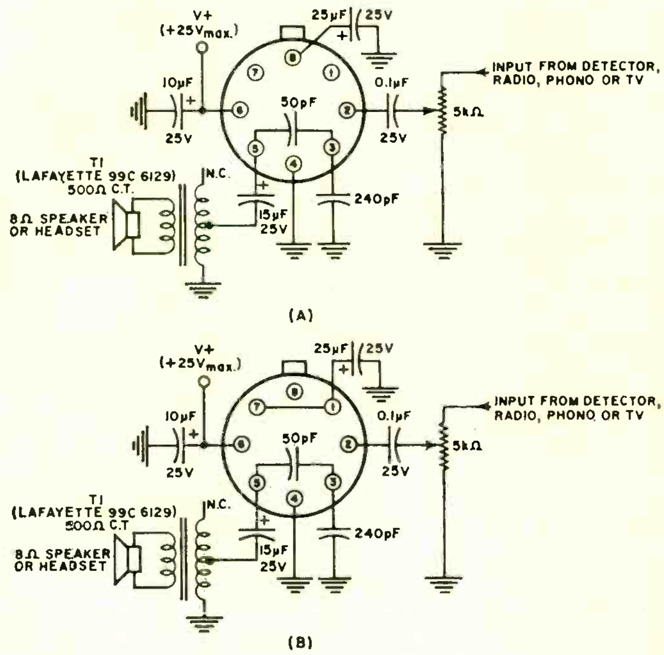
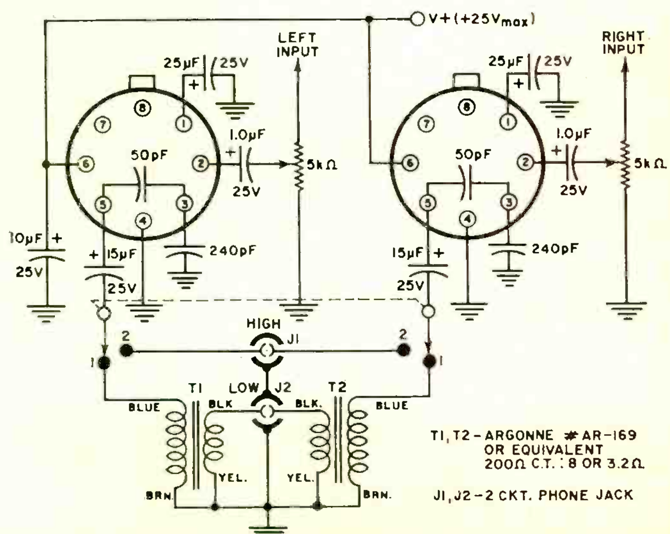
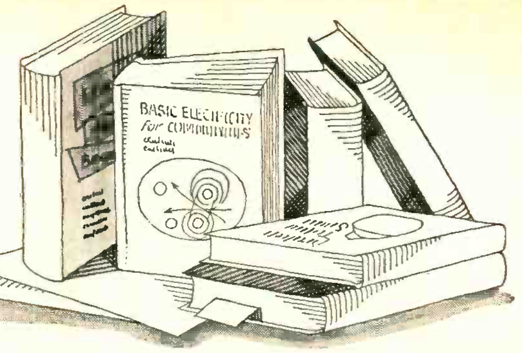


Fig. 3. Low-power amplifier with gain of (A) 20 and (B) 100 times, both employing a single NJS716H integrated circuits.

Fig. 4. Stereo headphone amplifier. High-Z phones are plugged into "High" output; low-Z phones or speakers into "Low" output.



BOOK REVIEWS



"INTEGRATED CIRCUIT TECHNOLOGY" edited by Seymour Schwartz. Published by *McGraw-Hill Book Company,* New York. 331 pages. Price $15.00

This book is subtitled "Instrumentation and Techniques for Measurement, Process, and Failure Analysis", which should just about meet the needs of scientists, engineers, and students involved in the integrated circuit field. The editor, who is with the Electronics Research Center/NASA, has assembled an impressive array of experts to prepare the twelve chapters in the book.

The subjects covered include diffusion and epitaxial equipment; vacuum systems; photo masks; metallization, dicing, and circuit assembly equipment; electron-beam instrumentation; final sealing and encapsulation; infrared testing and mask alignment; screened circuit fabrication equipment; automatic integrated circuit test equipment; instrumentation for advanced microelectronic measurements; investigating failure mechanisms; and microelectronics facilities concepts.

A speaking acquaintance with chemistry, solid-state physics, and math is prerequisite in order to derive the maximum benefit from this book. It would also be helpful if the reader has had some experience working with integrated circuits. The manual is well illustrated with photos, line drawings, exploded diagrams, etc. which will be helpful in amplifying the text material. Companies whose engineers contributed material for this book include *Westinghouse, Philco, Motorola, General Electric, RCA, North American Aviation/Autonetics, IBM,* and NASA.

* * *

"INTRODUCTION TO NETWORK ANALYSIS" by Ben Zeines. Published by *Prentice-Hall, Inc.,* Englewood Cliffs, N.J. 301 pages. Price $10.95.

The author, an instructor at *RCA Institutes,* has drawn on his pedagogic experience to plan and write the type of book a student is likely to need. He doesn't talk down to his reader, neither does he throw out ideas beyond the experience and background of the student.

Since the analysis and performance of networks, network theorems, and network applications have become the province of technicians as well as physicists and engineers, this introduction is welcome. The author expects his students to have had at least preparatory courses in general physics and basic a.c. and d.c. circuit theory.

The text is divided into ten chapters covering steady-state network analysis, network theorems, the Laplace transformation, resonance, coupled circuits, electrical wave filters, band filters, attenuators and equalizers, filter network synthesis, and tuned voltage amplifiers. Since this text is designed to be used in the classroom, there are sample problems completely worked out and then at the end of each chapter a group of problems for the students to solve.

* * *

"YOUR FUTURE IN THE HIGH FIDELITY INDUSTRY" by Bernard Newman. Published by *Richards Rosen Press, Inc.,* New York. 128 pages. Price $4.00. Available from the *Institute of High Fidelity, Inc.*

This volume in the publisher's "Careers in Depth" series covers a field in which, according to the author, almost limitless opportunities exist. Not only are there challenging engineering jobs open but interesting sales and servicing posts as well.

After a brief description of the development of the phonograph, phono records, AM and FM radio and the beginnings of the hi-fi component industry, the author outlines the educational background and the personality traits most useful in those seeking to make a career of hi-fi and audio. There follows brief descriptions of the job functions at the manufacturing level, the sales level—including the manufacturer's rep, and the servicing level. Tips on how to find a job and in preparing a meaningful resumé are also included.

In four appendices, the author lists universities and colleges offering electrical engineering courses, selected readings on hi-fi at various technical levels, a list of magazines which cover subjects of interest to audiophiles, and finally a brief sketch, corporate name, and address of the firms making up the membership of the Institute of High Fidelity, Inc.

The text is illustrated and carries a personal word from Walter O. Stanton, President of IHF, to all those considering a career in hi-fi. ▲

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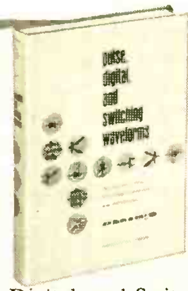

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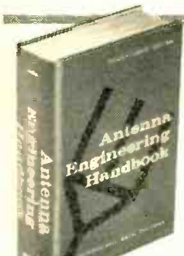

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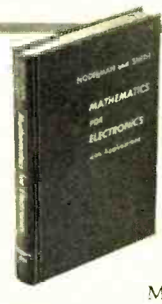

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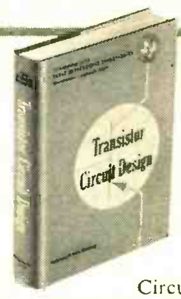

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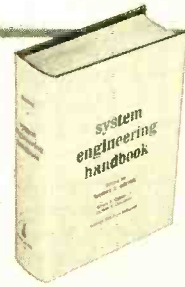

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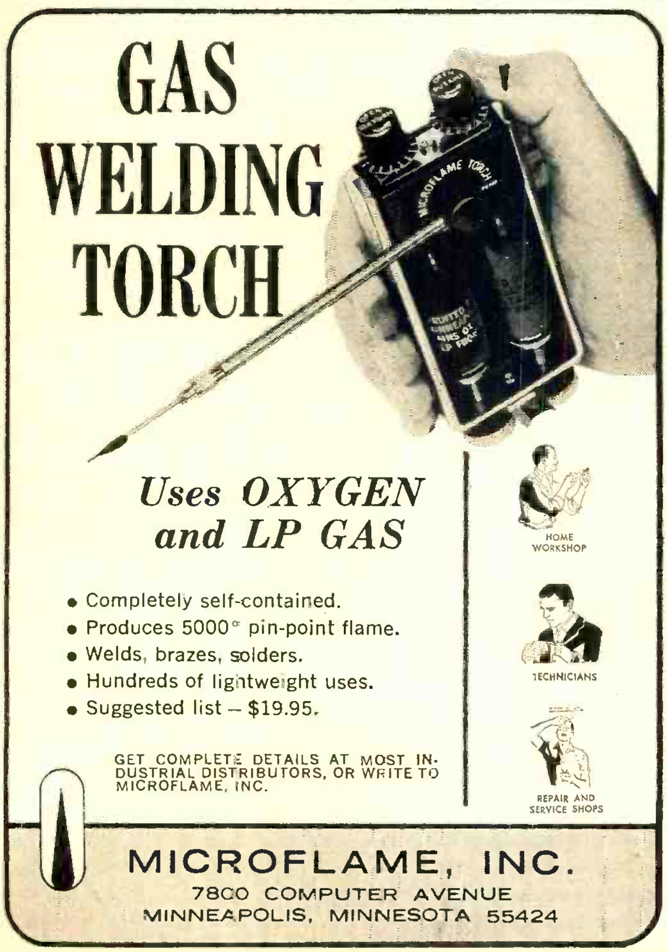

Global Tête-à-Têtes

(*Continued from page* 31)

advances that satellites are introducing internationally have turned attention to their use for domestic purposes. In fact, the Soviet Union recently announced the creation of a domestic system that would include some 20 earth stations between Moscow and Vladivostok to be served by the Molniya satellites. Germany and France have signed an agreement to develop such a competency. Japan and Canada have also discussed systems of their own, and *Comsat* has proposed a domestic pilot program for the United States.

Originally, a U.S. domestic satellite system was viewed largely as an economical means of television distribution. In fact, the Ford Foundation suggested the formation of a nonprofit corporation that would operate a satellite system and serve commercial television stations. Savings or profits from this venture would be earmarked for educational television programming.

Comsat has offered to spend $58 million to finance a domestic satellite pilot program in the U.S. The proposal, which is awaiting FCC authorization, would provide service to all communications users, including television, both commercial and educational. If *Comsat* is authorized to establish such a program, the satellites will have a capacity of 12 color-TV channels or 21,600 voice circuits. The equivalent of two color-TV channels (one each in the Pacific and Mountain time zones) would be made available free of charge for educational demonstrations. *Comsat* has offered to serve as trustee of the program until matters of ownership could be resolved.

Comsat believes a pilot program of this kind would render an invaluable public service. It would provide useful practical experience in systems control, traffic routing, and interconnection for commercial and noncommercial broadcasting; and would assist in the development of economic experience, such as the relationship between rate structure and curves in traffic growth. It would foster experimentation and, at the same time, minimize the premature commitment of capital as well as keep the door open to options that operating experiences might uncover.

A great deal is being written about the potential of "direct broadcast" satellites, where radio and television programs are beamed directly into homes and other places.

Direct broadcasting will soon be technically feasible and perhaps economically feasible too in the near future. Studies have indicated, for example, that such a system could be extremely valuable for educational purposes in densely populated countries, with large land masses, high rates of illiteracy, and inadequate communications facilities. A pilot system of this kind could be established in India for perhaps $40 to $50 million.

However, where countries have highly developed terrestrial systems, such as is the case with the United States, direct broadcast satellites hold less potential. Developed countries require a wide variety of high quality and economical communications which are much more easily attained by other communications media.

Broadband terrestrial facilities already exist in many metropolitan areas of the U.S., and these will be expanded by cable and the forthcoming millimeter waveguide and laser transmission systems. In the future, these facilities might be linked to metropolitan switching centers to provide the public with a new national communications utility. This system could, for a small monthly charge, offer various types of communications in homes or business offices. For example, the communications might include Picturephones, television, newspaper or magazine facsimile, information from central computer data banks, personal banking, shopping, and billing services. Communications beyond the metropolitan area could be relayed *via* satellite to other centers, within and between countries. ▲

Orbiting Relays

(*Continued from page* 41)

orbiting spacecraft. The station receiver's preamps are either cooled (by liquid nitrogen to 20° K) parametric amplifiers or a maser. This improves the receiver's signal-to-noise ratio and increases sensitivity.

In general, the transmitter is a high-power, water-cooled klystron with an output of at least 10 kilowatts. Each station has sufficient base-band equipment to transmit either wide-band data (TV) or multi-channel voice signals. The experimental stations also have specialized test equipment to measure both its own and the spacecraft's operating parameters and the quality of its transmitted and received signals.

Commercial stations operate in their own frequency band. The ground stations transmit in a band starting at approximately 6 GHz and the spacecraft retransmits it in a band near 4 GHz. The size of each ground installation varies according to the anticipated demand. However, their smallest antenna is approximately equivalent to a 40-foot dish and their largest to a 90-foot dish.

Future Systems

Future space communications systems will fall into two classes: one-way systems for television and radio, and two-way systems for telephone communications.

Two-way systems can only be used efficiently by large switching centers which can provide the capability for handling hundreds of telephone conversations at a time. The size and number of these terminals will be limited by their cost.

A one-way system in which a spacecraft has the capability of transmitting directly to an individual user could be demonstrated within the next decade. However, there are many technical and economic problems that would have to be solved first.

To solve these technical problems, the following developments are needed:

Spacecraft with increased power from sun generators or from self-contained nuclear power plants.

Antennas which can focus all their energy at specific earth locations such as North or South America. (Radio energy which falls upon uninhabited areas, such as the ocean, reduces efficiency of the over-all system.)

Establishment of reliable and inexpensive control systems capable of precision pointing.

The development of reliable high-power transmitters for space use.

Some of the economic problems include:

The cost of the user's installation. Spacecraft will probably never be able to compete economically or in signal quality with commercial terrestrial stations.

The cost and ownership of the spacecraft.

The economic impact of the system on small commercial radio stations.

In nine years, communications satellites have advanced from simple transmitters to systems capable of relaying 600 duplex channels across oceans and international boundaries. This phenomenal growth was brought about by a technology and a need. Present-day conditions have increased the technological base and the need for communications. With such incentives, one can expect even greater advances during the next decade.

(Editor's Note: NASA's ATS-C satellite carries a special receiver/transmitter which operates in the 30-300 MHz band. The repeater and its antenna will evaluate two-way communications between ground stations and in-flight aircraft. Some early tests have already proved successful.) ▲

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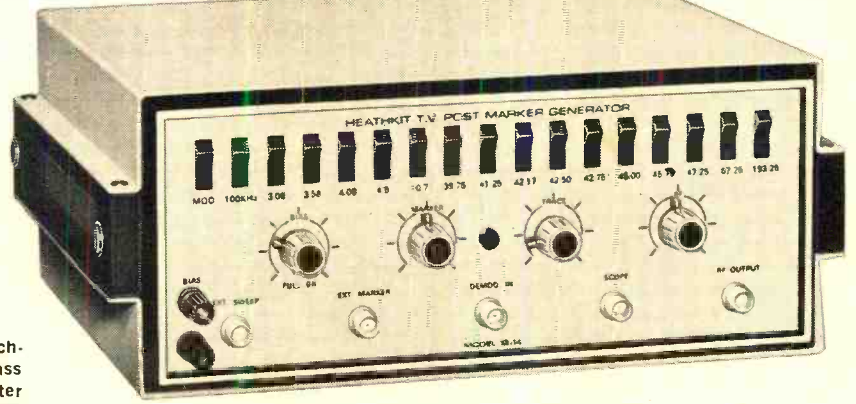

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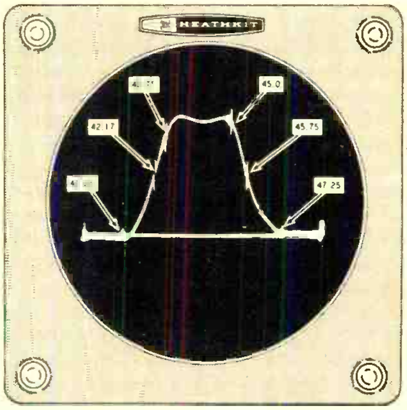
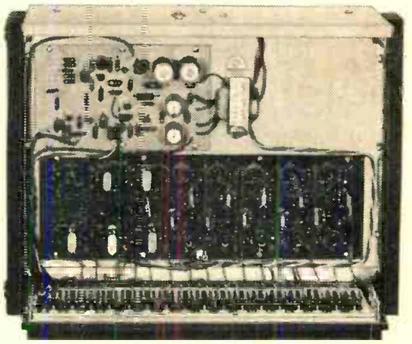


SIX MARKERS SIMULTANEOUSLY. The scope trace above shows how six markers can appear at the same time. Note the trap markers, 6 dB points, and picture and sound carriers . . . all on one trace with the IG-14.



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(Assembled TAW-17 $275)

Speaker System Kit TA-17-1
$120
$11 mo.
(Assembled TAW-17-1 $150)

Special Combination Offer
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Kit TAS-17-2
$395
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$34 mo.
(Assembled TAW-17-2 $545)

All the "big sound" features every combo wants . . . tremolo, built-in "fuzz", brightness, reverb, separate bass and treble boost and more. Delivers a shattering 120 watts EIA music power (240 watts peak power) through two TA-17-1 speakers . . . or 90 watts through one TA-17-1 speaker. Features 3 independent input channels, each with two inputs. Handles lead or bass guitars, combo organ, accordion, singer's mike, or even a record changer. All front panel controls keep you in full command of all the action.

Speaker system features two 12" woofers, special horn driver and matching black vinyl-covered wood cabinet with casters & handles for easy mobility.

NEW! Lowest Cost Solid-State Stereo Receiver

Kit AR-17
$72.95
(less cabinet)
$8 mo.

Features wide 18-60,000 Hz response @ ±1 db at full 5 watts RMS power per channel . . . 14 watts music power . . . inputs for phono and auxiliary . . . automatic stereo indicator . . . outputs for 4 thru 16 ohm speakers . . . adjustable phase for best stereo . . . flywheel tuning . . . and compact 9¾" D. x 2⅞" H. x 11¾" W. size. 12 lbs. Optional factory assembled cabinets (walnut $7.95, beige metal $3.50).

Kit AR-17, (less cab.) 12 lbs. . . . no money dn., $8 mo. . . **$72.95**
Kit AR-27, 7-Watt FM Mono Only Receiver (less cab.) 9 lbs. . . . no money dn., $5 mo. **$49.95**

Kit AR-15
$329.95
(less cabinet)
$28 mo.

Assembled
ARW-15 $499.50
(less cabinet) $43 mo.

World's Most Advanced Stereo Receiver

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Kit AR-15 (less cab.), 34 lbs. . . . $33 dn., $28 mo. **$329.95**
Assembled ARW-15, (less cab.), 34 lbs. . . . $50 dn., $43 mo. **$499.50**

Professional 10-Band Shortwave Receiver

Kit SB-310
$249
$23 mo.

Covers 49, 41, 31, 25, 19 & 16 meter shortwave . . . 80, 40 & 20 meter ham . . . 11 meter CB Includes 5 kHz crystal filter for AM, SSB and CW listening. Features selectivity that slices stations down to last kHz; 11-tube circuit; crystal-controlled front-end and more. 20 lbs. SB-600 8 ohm 6" x 9" speaker in matching cabinet $18.95.

NEW! Solid-State Portable Volt-Ohm-Meter

Kit IM-17
$19.95

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EW Lab Tested

(Continued from page 6)

Wow and flutter were well within specified limits, measuring 0.06% and 0.14% respectively at 7½ in/s when using the *Ampex* 31326-01 test tape. The signal-to-noise ratio, referred to maximum recording level, was about 50 dB on both 7½ in/s and 3¾ in/s (rated at better than 45 dB). The distortion in the record/playback process was low (under 2%) as long as the meter was kept below the red region, but distortion increased appreciably when this level was exceeded by 5 dB. The tape speeds were almost exact, but the fast-forward and rewind speeds were somewhat slow.

In use tests, the deck acquitted itself admirably. At 7½ in/s, the played-back program was virtually indistinguishable from the original. At 3¾ in/s we found it still of excellent quality, though slightly dulled. At 1⅞ in/s, the sound was excessively bassy, though the tone controls on most amplifiers should enable tolerable voice quality to be obtained.

The unit is easy to use, easy to install, and as pleasant to look at as it is to listen to. It would seem to be ideally suited for use with a stereo receiver, since this combination would offer a maximum of operating flexibility and performance for a minimum of cost, along with the utmost simplicity of installation.

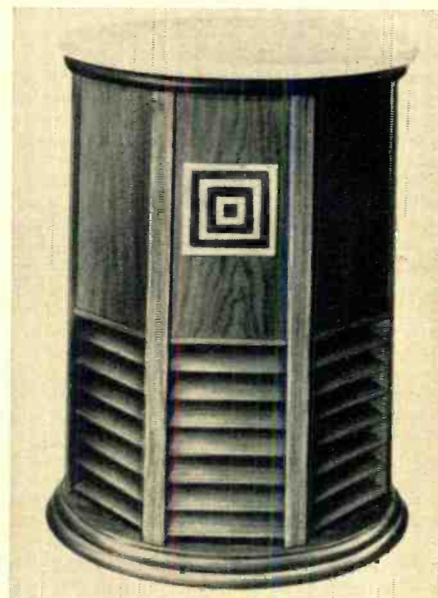
The *Allied* TD-1030, complete with wooden base and accessories, sells for $129.95.

For those who prefer a stereo package, the company offers the TR-1040—a deck/preamp/amp unit with separate speaker systems—for $169.95. ▲

Empire 4000 "Cavalier" Speaker System

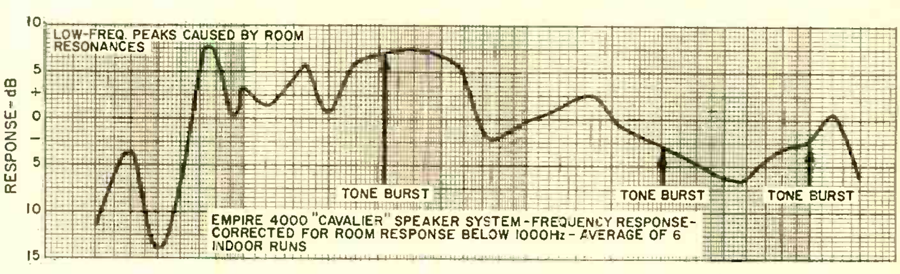
For copy of manufacturer's brochure, circle No. 20 on Reader Service Card.

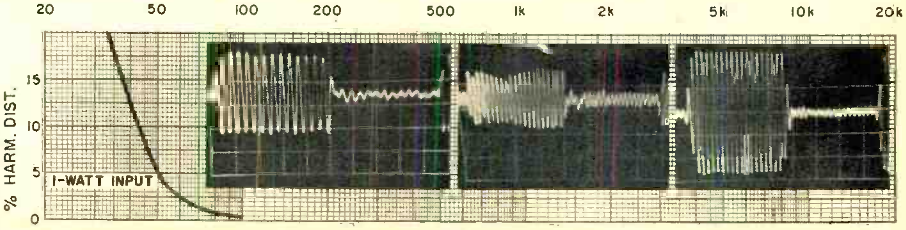
THE *Empire* 4000 "Cavalier" speaker is a two-way system featuring unusual styling. Like the larger *Empire* systems, the Model 4000 is cylindrical in shape. The woofer, instead of facing downward, faces the front and radiates through a louvered opening in the enclosure.



Above 1500 Hz, a single direct-radiator cone speaker about 3″ in diameter takes over. The flat, low-mass cone of the tweeter, which is mounted on the side of the column, has excellent dispersion characteristics. A switch underneath the column selects one of three tweeter levels to suit individual tastes or room conditions.

The woofer of the Model 4000 has a 10″ diameter cone, with a 2″ voice coil and a high-compliance suspension. It also features a heavy ceramic magnet and is rated to handle up to 40 watts of sine-wave power or 60 watts of program power. The column enclosure, finished in satin walnut, stands 25″ high and is 18″ in diameter. It weighs a solid 75 pounds with the optional marble top in place. A walnut-finished wood top is also offered.





In our indoor test room, the speaker was placed a couple of feet from the wall of the room. Three test microphones were placed throughout the room and their outputs averaged during a frequency response run. This was repeated with three new microphone positions. Both curves were averaged to derive a single response curve. The tweeter level switch was set to its middle or "normal" position for these tests. Low-frequency harmonic distortion was measured with the single microphone close to the speaker enclosure and a drive level of 1 watt. Tone burst measurements were made with the microphone about 18″ from the tweeter, on its axis.

There appeared to be a slight "shelf" in the response curve, with the region above 750 Hz some 5 dB lower than the lower frequencies. From 65 to 750 Hz, the response was within ±5 dB, which is quite good in view of the inevitable effect of the room on the low-frequency response. The output fell off rapidly below 60 Hz, except for a peak at 40 Hz.

The higher frequencies were handled very smoothly and without any sharp peaks or holes. From 750 to 15,000 Hz the response varied only ±4 dB. The tone-burst tests revealed a complete freedom from sustained ringing or spurious outputs, and the photographs show typical tone-burst responses. These are better than the average which we have observed in many speaker tests. Harmonic distortion was under 5% down to 50 Hz, rising to 20% at 34 Hz.

In listening tests, we found that the best aural balance was obtained with the tweeter level set to its high position. This no doubt makes the over-all response most uniform over the full range of the speaker. The *Empire* 4000 has a warm, full sound. Its polar dispersion is very good and it does not appear to be critical as to its location in the listening room. This is not a "brilliant sounding" speaker and, in heavily upholstered rooms, may require treble boost from the amplifier for good balance. It is, however, clean and effortless at all times. We would judge its true lower frequency limit to be between 50 and 60 Hz, both because of the drop in output and the rise in distortion at lower frequencies.

The styling of the speaker system is unique, and may well meet the needs of those who object to the usual speaker "box." It can be used as an end table, or free-standing, since it does not require a wall placement. The Model 4000M, with the marble top, is an unusually attractive piece of furniture. This speaker offers a rare combination of good sound and good looks, at a reasonable price.

The Model 4000 sells for $149.95 while the 4000M is $159.95. ▲

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

HIGH-SPEED PULSE GENERATOR

An ultra-fast pulse generator which can produce a pulse of 4 to 10 kV in 50 nanoseconds is now on the market as the Model TS-211.

The pulse generator is all electronic and its

setting can be varied to produce pulses ranging from 20 to 200 volts per nanosecond. The steep wavefront is linear over 10% to 90% of the rise time.

This new ramp generator has application to any high-voltage breakdown problem area in electronics equipment. It can be used to evaluate wire and cable insulation, component testing system evaluation where the physical proximity of components can result in catastrophic damage to others in the event of failure, or anywhere that spurious voltages can go to certain damaging values.

The unit measures 11" high x 11⅛" wide x 18" deep. It weighs 25 pounds and operates from the 117-volt a.c. line. Signalite

Circle No. 126 on Reader Service Card

LIQUID-LEVEL DETECTOR

A new miniature liquid-level detector, designed to replace the more cumbersome mechanical float switch, has just been introduced. It is used to provide a signal when liquid in a container, such as fuel in a tank, has reached a predetermined level. It may be set to operate on rising or falling level and can be fitted with a time-delay circuit if required.

The detector will operate over a temperature range of −76° F to +257° F and has no moving parts inside the tank, making for flexibility of installation. The unit will handle inductive loads without the contact deterioration of mechanical switches.

Designed to operate from supplies between 18 and 30 V d.c., the detector consists of a sensor mounted within the tank and an externally mounted switch unit. Combined weight of the sensor and its switch unit is 3 ounces. Smiths Industries

Circle No. 127 on Reader Service Card

MICROMINIATURE TUNING FORKS

Microminiature tuning forks, designed to meet MIL-STD 202B, occupying less than 0.29 cubic inch, and weighing less than ½ ounce, are now available.

Specifications include accuracy to 0.001%, stabilization time approximately 1 second, 0.2 microsecond or less rise and fall time, and operating temperature from −55 to +125 degrees C. The square-wave output frequencies range from 30 Hz to 25 kHz.

Various input voltage and output level models are available, including a low power consumption unit designed for space application. The units measure 0.750" x 0.935" x 0.375".

Additional information on these units will be supplied on request. Barden

Circle No. 128 on Reader Service Card

HOLOGRAPHY KIT

A kit which includes everything necessary to create original three-dimensional holograms is now on the market as the Model 210. With the kit no special tables, unwieldy set-ups, or expensive apparatus is required. According to the company, excellent holograms can be produced under conditions common in ordinary laboratories.

The kit includes a complete laboratory manual covering theory and step-by-step instructions; spectrographic plates; beam splitters; front surface mirrors; lenses; stands and holders; developing and fixing chemicals; trays and tanks; and all other necessary items.

Although specifically designed for operation with the firm's family of helium-neon gas lasers, the kit can be used with any visible spectrum gas laser operating in the TEM∞ uniphase mode with an output power of over 0.3 milliwatt. University Laboratories

Circle No. 1 on Reader Service Card

PORTABLE LAB POWER SUPPLIES

A new line of laboratory power supplies has just been introduced as the LP series. These all-silicon power supplies are available in six of the

most popular voltage ranges for lab use: 0-10, 0-20, 0-40, 0-60, 0-120, and 0-250 volts d.c. Maximum currents vary from 80 mA to 2 amps. The series features light weight (7 pounds), small size (¼ rack x 10" long), and portability (top-mounted handle).

Features include remote programming, remote sensing, constant E/constant I with automatic crossover, series/parallel operation, front-panel-mounted three-way binding posts, two meters, and wide current limit settability from 1% (or 5 mV) to 105% of rating.

Regulation is 0.01% and ripple is 500 μV r.m.s. Temperature coefficient is a low 0.015% +0.5 mV/°C, so the LP is suited for stringent laboratory R&D applications. The a.c. input is 105-132 V a.c., 45-440 Hz. Lambda

Circle No. 129 on Reader Service Card

PC ETCHING MACHINE

Printed-circuit boards may now be made directly from hand-drawn copy to completed board with a new electronic scanning and etching machine that eliminates the need for photography, darkrooms, chemicals, and trained personnel.

The Directron circuit engraver produces the boards by placing hand-drawn pen-and-ink or pencil copy on a cylinder, scanning the image,

and simultaneously cutting it into a copper-clad epoxy or fiberglass blank sheet that has been attached to a second revolving cylinder. Once started, the machine is completely automatic. Maximum board size is 12" x 18" and copy for various boards up to that size may be ganged and cut at the same time.

Because the machine takes about 3 to 4 hours to scan the 12" x 18" surface area, its makers suggest its use for etching small runs of production circuit boards and for producing prototype and test boards. The machine weighs 750 pounds and operates from 120-volt, 60-Hz power lines. Graphic Electronics

Circle No. 130 on Reader Service Card

IC FM DETECTOR/LIMITER

An integrated-circuit FM detector and limiter which operates by a new technique featuring linear gating and balanced discriminator action, with typical AM rejection of 46 dB, is now available as the Type ULX-2111A "Unicircuit."

The new IC can be used for TV sound channels, in FM receivers, a.f.c. systems, communications receivers, and radar. A single screwdriver adjustment is required to tune the detector in the ULX-2111A. Frequency range extends from 5 kHz to 50 MHz. Output of 0.6 V with a total distortion of less than 1% with a limiting threshold voltage of 400 mV r.m.s. are typical in such applications.

The unit can be operated from a single 12-volt power supply. It is housed in a thin, modified TO-116 dual in-line package. The circuit incorporates 19 transistors, 18 resistors, 6 diodes, and the necessary interconnections. Sprague

Circle No. 131 on Reader Service Card

"HIDDEN-BUG" DETECTOR

The F202B transmitter locator is extremely sensitive and when operated correctly will seek and find any r.f. transmitter that is operating in the frequency range from 0.5 up to and including 750 MHz, no matter whether AM or FM. It can also be used to locate wireless microphones and wireless telephone taps.

The detector operates on a "Geiger counter" principle. It emits a series of beeps which are

used to locate the bug. When approaching an r.f. ... the beeps increase slowly, then more rapidly as the source is neared, finally breaking into a high-pitched whine when the bug is located. S.A.C. Electronics

Circle No. 2 on Reader Service Card

A.C. CALIBRATOR

The Model 745A a.c. calibrator is a precision generator of a.c. voltages over a wide frequency range with voltage accuracy and stability formerly attainable only under tightly controlled environmental conditions, and then only with specialized skills and instruments, according to the manufacturer.

The new calibrator has an output frequency range continuously adjustable from 10 Hz to 110 kHz in four overlapping bands. The output voltage is known with an absolute accuracy of ±0.02% from 50 to 20,000 Hz for a period of 30 days following calibration. Amplitude accuracy up to 110 kHz and from 20 to 50 Hz is ±0.05% and from 10 to 20 Hz, it is ±0.01%. These specifications apply over a temperature range of 20 to 30 degrees C.

Output voltage is selectable with 6-digit resolution in six decade ranges, each with 10% over-

ranging. Maximum range is 100 volts full-scale, with the overrange allowing up to 109.999 volts (1000-volt output will be available in the near future with a companion amplifier). The lowest range is 1 millivolt full-scale which, with 6-digit settability, provides a resolution of 1 nanovolt. Hewlett-Packard

Circle No. 132 on Reader Service Card

PROGRAMMABLE UJT

A design engineer can now program desired electrical characteristics in a unijunction transistor simply by selecting the necessary resistors to meet his particular needs.

The D13T1 programmable unijunction transistor (PUT) allows the design engineer to program eta, interbase resistance, valley current, and peak current to meet his specific needs. The three-terminal planar passivated "p-n-p-n" device is packaged in the firm's TO-98 heat-resistant epoxy.

Of special importance is the D13T1's low leakage current and operating range from 2 to 40 volts. The units are designed to eliminate the need for a wide range of common UJT's for application with sensing circuits, sweep circuits, timers, oscillators, and SCR triggers. General Electric

Circle No. 133 on Reader Service Card

HI-FI—AUDIO PRODUCTS

FLAT PLASTIC LOUDSPEAKER

A new electromagnetic speaker which is designed to replace conventional cone loudspeakers in all types of commercial, industrial, or military applications has just been introduced as the Poly-Planar.

This wafer-type speaker is a flat, lightweight, plastic acoustic panel supported by a shallow plastic frame. It can reproduce a wide range of frequencies from 40 to 20,000 Hz. The new speaker is extremely thin—a 1 1/16" Poly-Planar being the equivalent of a 20-watt, 12-inch woofer and tweeter combination.

The speaker is constructed of completely waterproof material. The speaker's material is also impervious to temperature extremes, humidity, shock, and vibration. It can be manufactured by automatic machinery and both the acoustic panel and supporting frame can be molded at a fast production rate. Magnetic as-

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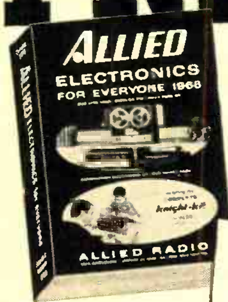

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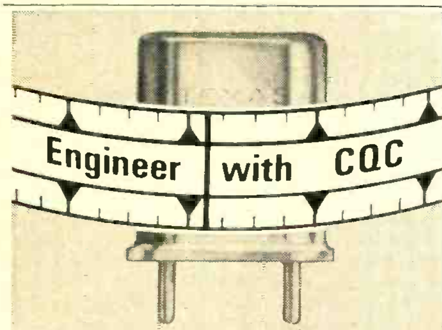

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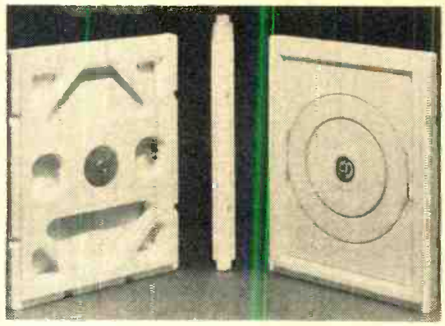

semblies can also be premolded into the frame and voice coils molded into the diaphragm.

Additional details on this new speaker will be supplied on request. ERA Acoustics

Circle No. 3 on Reader Service Card

STEREO CARTRIDGE

The 24TA "Playmate" stereo cartridge covers a frequency range from 20 to 15,000 Hz and features 25 dB separation at 1000 Hz. Designed for a tracking force of 4 to 7 grams, the new cartridge has a compliance of 3×10^{-6} cm/dyne.

The cartridge weighs 3.5 grams with the mounting bracket and is designed to fit standard ½" mountings. Recommended load is 250,000 ohms to 1 megohm at high impedance; for magnetic-type inputs a simple network must be installed in each channel.

The needle which comes with the cartridge can be flexed 180 degrees without harm. The cartridge is available in turnover combinations of 0.7- and 3-mil sapphire; dual 0.7-mil sapphire; 0.7-mil diamond and 3.0-mil sapphire, and 1.0-mil diamond and 3.0-mil sapphire. Sonotone

Circle No. 4 on Reader Service Card

CARTRIDGE TAPE DECK

A solid-state, 8-track stereo cartridge playback tape deck designed to be used with any hi-fi system has been introduced as the CP-250.

The new unit permits automobile stereo cartridges to be played in the home. The cartridge is simply inserted into the CP-250 for instant

playback. Individual program lights indicate which track is playing. Each track will play automatically in sequence, or change to the next track at the touch of the program selector button.

The deck includes solid-state preamplifiers, flux-field heads, and is designed to be operated in either horizontal or vertical position. The unit measures 9⅝" w. x 4⅛" h. x 9¼" d. Concord

Circle No. 5 on Reader Service Card

FM RECEIVER KIT

The "Knight-Kit" KG-980 is a 50-watt solid-state FM-stereo receiver which features premium-quality silicon transistors and transformerless driver and output circuits.

Frequency response of the amplifier is 18-30,000 Hz ±1 dB. The FM tuner has a four-stage front-end including two r.f. stages for sensitive reception even in fringe areas. The circuit automatically switches to stereo and an indicator light goes on when a stereo broadcast is received. The critical FM front-end and i.f. sections are factory assembled and aligned.

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Other features include a precision tuning meter, speaker muting switch, tape monitor, front-panel stereo headphone jack, and rocker-type switches. Inputs include magnetic phono, tape monitor, and auxiliary (ceramic phono).

The receiver measures 16" w. x $13\frac{1}{2}$" d. x 4" high. A walnut wood case is available at extra cost. Allied Radio

Circle No. 6 on Reader Service Card

STEREO TAPE DECK

The new Sony TC-255 is a four-track solid-state stereo tape deck which incorporates a number of technical improvements usually associated with professional recording equipment.

The deck has self-contained solid-state preamplifiers for the recording and playback of four-track stereo tape, two professional type vu meters,

automatic tape lifters for the preservation of both heads and tape, and an automatic sentinel shut-off switch.

It features a vibration-free motor and a scrape flutter filter which is a special idler located between the erase and playback heads that eliminates tape modulation distortion.

The deck operates at $7\frac{1}{2}$, $3\frac{3}{4}$, and $1\frac{7}{8}$ in/s and has an exclusive retractomatic pinch roller for easy tape threading. The digital tape counter is useful for precise editing, cutting, and tape indexing. Superscope

Circle No. 7 on Reader Service Card

INTERCOM SYSTEM

The Model 10643 intercom provides voice communications between ten remotely located stations, services five independent two-way conversations concurrently, or a ten-station conference call, and may be integrated into existing p.a. systems.

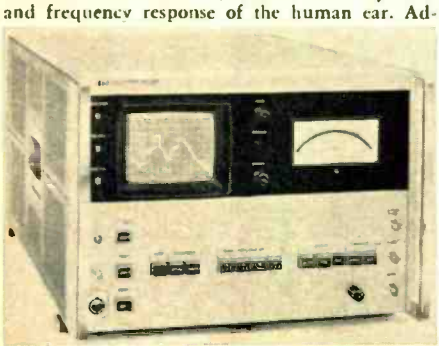
The system operates from a single central power supply. Operating voltage is 24 volts d.c. $\pm 10\%$, with the power required per station less than 10 watts.

The unit has a frequency range of 300-5000 Hz, may be mounted as a console or in a relay rack, and is 10" wide x $5\frac{1}{4}$" high x 10" deep. The "on-off" switch light indicates d.c. power input while the standby light functions as a ready mode indicator. Artisan Electronics

Circle No. 8 on Reader Service Card

LOUDNESS ANALYZER

The Model 8051A loudness analyzer separates the audible spectrum into 20 frequency bands using a bank of parallel filters. The gain through each filter channel is adjusted for the amplitude and frequency response of the human ear. Ad-



ditionally, the instrument accounts for the masking effect wherein predominant sounds mask weaker, higher frequency sounds.

After subjective weighting, each channel is displayed sequentially on a CRT so the loudness contribution of each frequency band can be analyzed. A meter indication of total loudness is derived by integrating the area underneath the CRT curve, presenting an accurate measure of loudness—for broadband as well as narrow-band sounds—unlike conventional sound-level meters which simply measure sound pressure level.

Frequency coverage is from 45 Hz to 14 kHz. In addition to the CRT display and meter indication, the instrument provides several outputs for recording measurements. A technical data sheet on the 8051A will be forwarded on request. Hewlett-Packard

Circle No. 134 on Reader Service Card

CB-HAM-COMMUNICATIONS

MARINE RADIOTELEPHONE

A new 100-watt v.h.f. marine radiotelephone providing 12-channel operation in the 156-162 MHz marine band has just been introduced as the Model 626 "Maricom".

Designed for pleasure boats, small commercial vessels, and shore stations, the new model has a dual front-end, fully transistorized receiver that permits simultaneous monitoring of the Safety

and Calling Channel 16 (156.8 MHz) and one of the duplex marine radiotelephone ship-to-shore channels (Public Correspondence Channels 24 through 28). Two standard frequency configurations are available: nine simplex, two duplex, and one receive channel for Weather Bureau transmissions on 162.55 MHz; and six simplex and six duplex (or five duplex and one receive channel for WX).

The Model 626 is rated at 30 watts output and is available for either 12-volt d.c. or 117-volt a.c. operation. Full details are available on request. Comco

Circle No. 9 on Reader Service Card

23-CHANNEL CB TRANSCEIVER

An ultra-compact 23-channel transceiver which incorporates an IC plus 15 transistors, is now available as the Model HB-23. A synthesis-type frequency control section utilizes a maximum of 16 crystals for full 23-channel operation. Optional individual plug-in crystals permit economical addition of two channels with each additional crystal. A tuned 455-kHz mechanical filter assures sharp selectivity with good adjacent-channel rejection.

The dual-conversion receiver features a 0.7 μV sensitivity, a.n.l., variable squelch, and push-pull audio amplifier. The transmitter provides full 5-watt input. An illuminated front-panel meter monitors "S" units on receive and relative power output during transmit.

The transceiver, which measures $5\frac{15}{16}$" w. x $7\frac{7}{8}$" d. x $2\frac{1}{8}$" h., is designed for either 12-volt d.c. negative or positive ground. It can be used on 117-volt a.c. lines with an optional power supply/charger. Lafayette

Circle No. 10 on Reader Service Card

BASE-STATION ANTENNA

A new broadband base-station antenna, which is available in two frequency ranges, is now available.

The No. 540-509 is designed for the 450-462 MHz range while the No. 541-509 is for the 458-470 MHz service. Featuring pattern adjustment in the field, the upper section of the antenna can be rotated, thus positioning the dipoles for offset or omnidirectional pattern. Gains are 10 dBd offset and 7.0 dBd omnidirectional, tested and rated to EIA Standard RS-329. Electrical specifications include nominal input impedance of 50 ohms, bandwidth 12 MHz, and v.s.w.r. of 1.5:1. The antenna is at d.c. ground potential, providing excellent lightning protection. Communication Products

Circle No. 11 on Reader Service Card

6-CHANNEL TRANSCEIVER

The new "Dyna-Com 6" is a 5-watt, 6-channel "walkie-talkie" which measures only $3\frac{1}{4}$" w. x $10\frac{1}{2}$" h. x $2\frac{1}{6}$" deep. An integrated circuit, used in transmit/receive and audio limiting stages, complements the 12 additional transistors.

The transceiver features crystal-control on any six of 23 channels, an automatic compressor/range-boost circuit, pi-network antenna output, and a battery condition/automatic relative-r.f. indicator. The receiver section features less than 1-μV sensitivity and a mechanical filter for razor-sharp selectivity.

A unique, removable battery pack facilitates changing the NiCad batteries. An optional portable dry-cell power pack keeps an extra reserve of power on hand. The unit may also be connected to an auto, boat, or tractor battery and external antenna. It comes with transmit and receive crystals for channel 10, telescoping whip antenna, and leather shoulder strap. Lafayette

Circle No. 12 on Reader Service Card

R.F. PREAMPLIFIER

An all-band frame-grid preamplifier, covering the range 6 through 160 meters, has just been introduced as the Model PT r.f. preamp.

Designed for use with ham-band transceivers, special control circuitry allows the Model PT to be connected to virtually any transceiver without modification. The transceiver must have a control circuit built in for use with an external linear amplifier. This control circuitry is used to bypass the PT preamp during transmit.

A frame-grid tube is used, permitting a wide range of gain control with high sensitivity. The unit comes complete with built-in power supply and connecting cables. Aerotron

Circle No. 135 on Reader Service Card

HYBRID CERAMIC FILTERS

A new line of hybrid ceramic filters designed for a broad variety of applications, providing a tuned transformer at the input terminal, stop-band rejection up to 90 dB, and contained in a package measuring one-half cubic inch, is now available as the TCF 4 and TCF 6 series.

The filters are computer-designed and consist

of a ladder network of ceramic resonators combined with the tuned transformer to give a d.c. path at input. Applications include c.w., AM, and FM radio for mobile, aircraft, marine, or stationary equipment operation as well as navigation equipment.

Information on available units plus full electrical specifications will be forwarded on request. Clevite

Circle No. 136 on Reader Service Card

POWER TRANSISTORS FOR CB

Two new silicon "n-p-n" planar transistors, designed specifically for use in the output stages of 5-watt CB transmitters, have been introduced as the RCA-40581 and 40582.

Both devices are triple-diffused, silicon planar "n-p-n" units mounted in TO-39 hermetic-metal packages. The 40581 is a higher power version of the company's 40082 and is intended to provide an unmodulated power output of 3.5 watts in a CB transmitter. The 40582 is a higher power version of the 40446 and is also intended for use in the power output stage. Both units have a factory attached diamond-shaped mounting flange which allows operation with increased power output. RCA Electronic Components

Circle No. 137 on Reader Service Card

MANUFACTURERS' LITERATURE

SWITCH APPLICATIONS

The latest edition (No. 28) of "Uses Unlimited", an informative 8-page illustrated booklet describing more than a dozen switch applications that are helping to solve industrial problems, is now available.

One of the features explains how mercury switches aid food production by ensuring dependable operation of an automatic sprinkler irrigation system, while another item describes a method of speeding delivery of office mail. Micro Switch

Circle No. 13 on Reader Service Card

ANECHOIC CHAMBERS

A new 4-page folder, seventh in the New Designs series, describes and illustrates nine recently built "Eccosorb" microwave anechoic chambers. Emerson & Cuming

Circle No. 14 on Reader Service Card

WIRE MARKERS

More than 5000 different self-sticking wire markers are listed in a new 20-page catalogue (No. 100-B). In addition, several dispensing methods to speed wire identification are described.

Featured in the booklet is a high-speed wire-marking machine the ("Markermatic") that is capable of identifying up to 1000 or more wires per hour. W. H. Brady

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PERMANENT MAGNETS

A new 26-page illustrated booklet entitled "How to Magnetize, Measure and Stabilize Permanent Magnets" is currently available. Topics covered include the selection and use of magnet charging and treating equipment, Hall-effect gaussmeters, and a complete system approach to permanent-magnet charging and measurement.

In addition, the booklet contains a table of permanent-magnet materials as well as a glossary of terms and definitions. RFL Industries

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TECHNICAL TRAINING

Nine home-study courses in electronics are described in detail in a new 50-page full-color-illustrated brochure. Subjects offered include practical TV and radio servicing; color-TV servicing; electronic communications; FCC licenses; industrial and computer electronics; stereo, hi-fi, and sound systems; and basic electronics. Each course includes professional or training kits, kit manuals, and step-by-step lessons. National Technical Schools.

Circle No. 16 on Reader Service Card

ACCREDITED SCHOOLS

A new directory of accredited private home-study schools (Fall, 1967) is now available. More than 90 schools are listed in the publication, and each entry includes the institution's name and address, date of founding, and a brief rundown of courses offered. National Home Study Council

Circle No. 17 on Reader Service Card

TAPE RECORDING

The fundamentals of magnetic tape recording, with special emphasis on analog instrumentation applications, are presented in a new 44-page illustrated application note (No. 89).

Entitled "Magnetic Tape Recording Handbook", the publication discusses magnetic recording principles, tape recorder heads, tape-transport mechanisms, magnetic tape, and special techniques. Hewlett-Packard

Circle No. 139 on Reader Service Card

RECORD-PLAYING EQUIPMENT

A new 16-page manual on the various components of the record-playback system has been published. Entitled "The Record Omnibook", the illustrated booklet covers the turntable, record-changing mechanisms, stereo tonearms, stereo cartridges, and record care. Elpa

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D.C. AMMETER SHUNTS

A complete selection of standard-model d.c. ammeter shunts is shown in a new product bulletin (No. 7). Included are ten types of portable and switchboard units with rated capacities to 30,000 amperes. Empro

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INSTRUMENTATION BROCHURE

A new 12-page illustrated brochure (No. CC-4) describing the company's Multi-Vider system for d.c. measurement—an integrated, low-cost divider-detector combination with provision for plug-in adapters—has been issued.

Included are precision current and voltage sources; voltage dividers and null detectors; voltage references and calibrator systems; and a full line of computer, instrument, and production resistors, resistor networks, and other components. Julie Research Labs.

Circle No. 141 on Reader Service Card

TRANSFORMER LAMINATIONS

Complete electrical and mechanical data on a wide range of high-performance electromagnetic transformer-core laminations is contained in a new comprehensive 144-page catalogue.

Included are dimensional diagrams of available shapes, magnetic design formulas, magnetic path dimensions, and information on the various

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materials and gauges in which each lamination type is available. In addition, the catalogue provides cross-indexes of lamination types and shapes. Magnetic Metals

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IC RELIABILITY

Two new brochures covering the reliability of integrated circuits are now being offered. The first is a full-color, 16-page publication (Bulletin SC-9999) which outlines how over-all reliability of company products results from the interaction of six major factors: product design, failure analysis and correction, production control, process control, testing, and human factors.

The second booklet, entitled "Plastic Package Reliability Report", contains specific reliability test data on the company's plastic dual in-line package. The report (Bulletin SC-10211) concludes that this particular IC package is capable of passing all applicable MIL-STD-750A and 202C qualification tests. Texas Instruments

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RELAY/SWITCH CATALOGUE

A new 26-page illustrated catalogue covering a line of relays, switches, push-button control stations, and reversing drum controls is now being offered. Complete mechanical and electrical specifications are provided for all devices listed.

Along with the catalogue, the company is also making available a 12-page cross-referenced replacement guide (No. RC-100) for potential-type motor-starting relays. More than 1400 listings are included. Relay and Control

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MOTOR CATALOGUE

Described and illustrated in a new 64-page catalogue is a complete line of motors and associated products. Included in the publication (No. 15-68) are fractional hp motors, synchronous motors, gearmotors, timers and counters, tachometer speed-indicating systems, and motor speed controls.

In addition, the catalogue contains technical information, including useful formulas, torque and watt output ratings, connection diagrams, and motor dimensions. B&B

Circle No. 145 on Reader Service Card

ALUMINUM MANUAL

Complete technical information on aluminum forms, alloys, and tempers is contained in a new edition of the "Alcoa Aluminum Handbook", a 296-page hard-cover publication.

The new reference book is designed to help users make the most advantageous choice of aluminum products to fit production needs. Introductory pages cover alloy and temper designation systems and advantages of aluminum. The remainder of the book is devoted to tabular data on sheet and plate; foil; wire, rod, and bar; extrusions; tube and pipe; electrical conductor; structural shapes; forgings and rings; ingot; and castings.

The handbook is available on letterhead request to Aluminum Co. of America, 798 Alcoa Building, Pittsburgh, Pa. 15219. ▲

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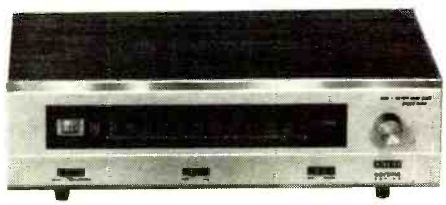

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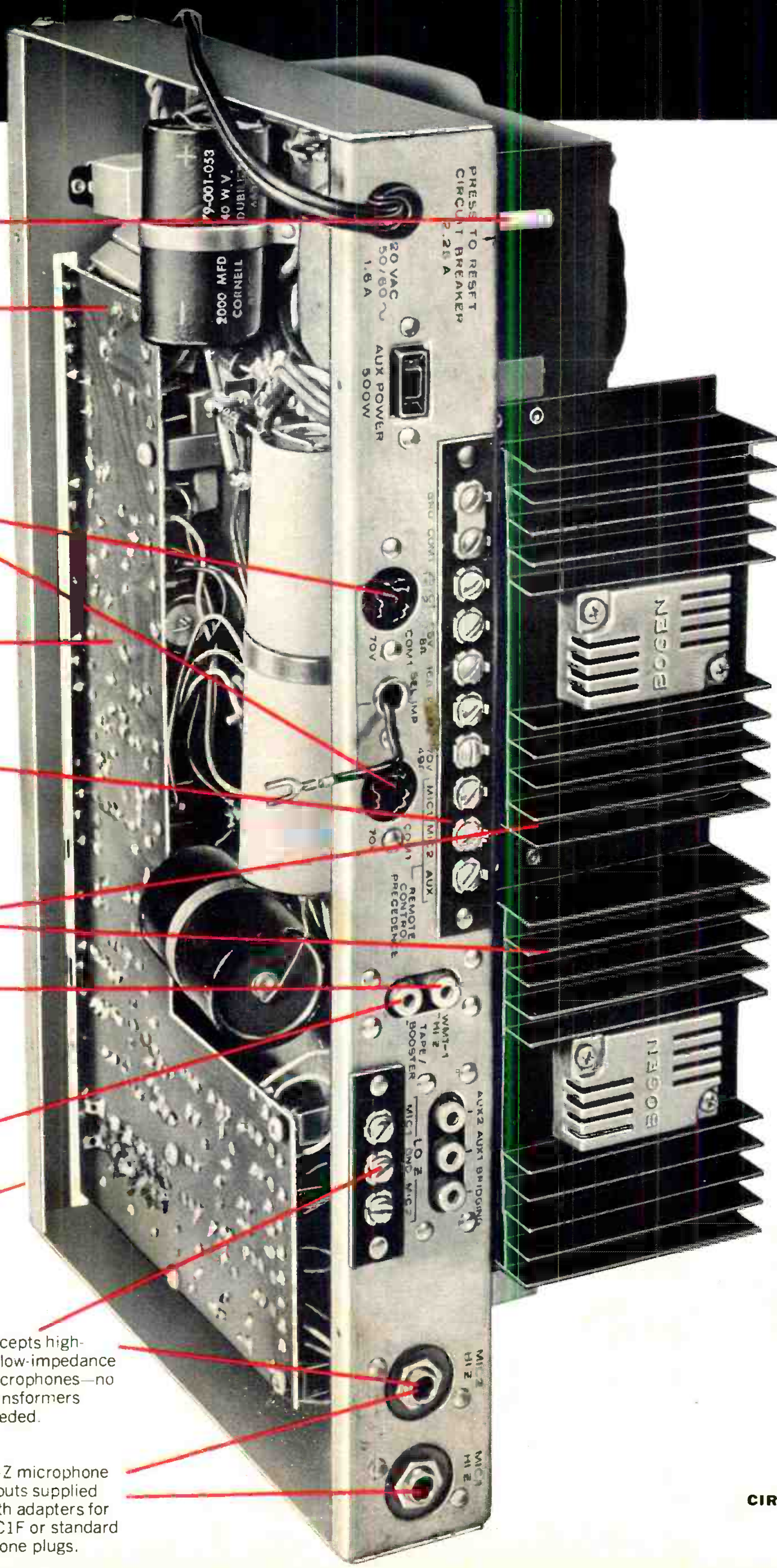

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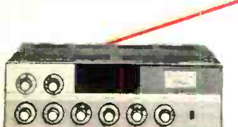

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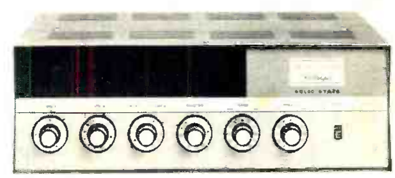

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