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JULY, 1970
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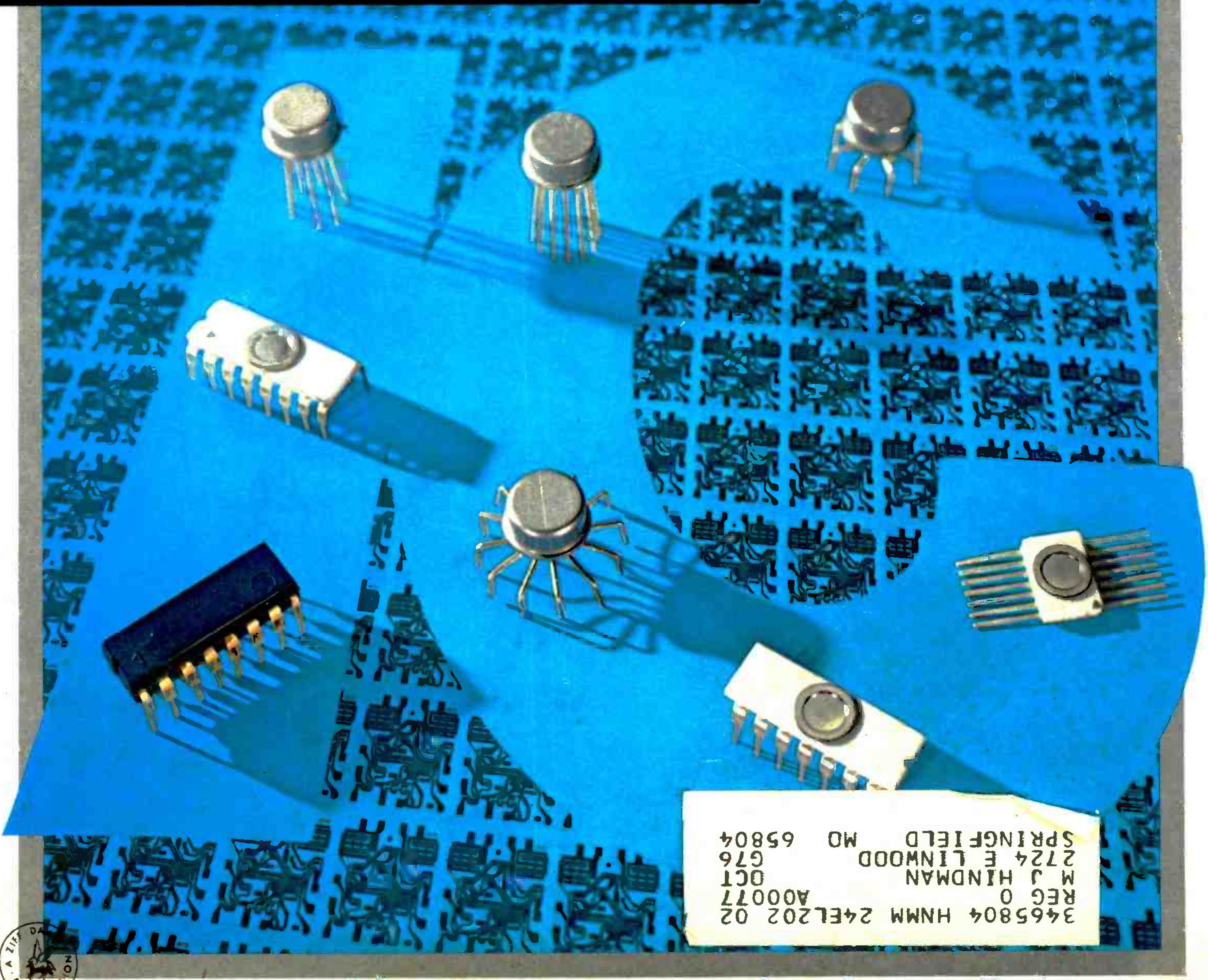

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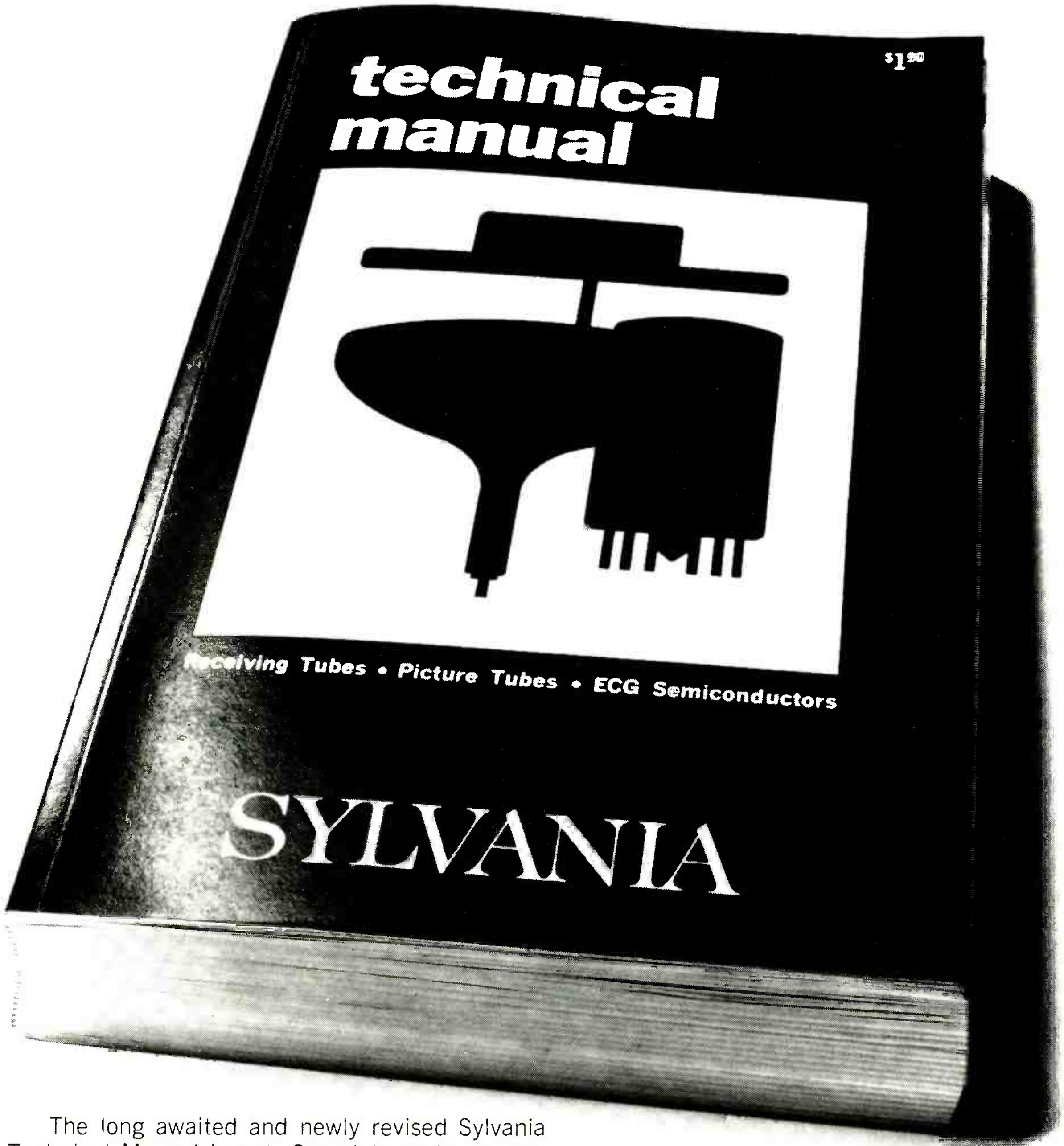

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Electronics World

JULY 1970 VOL. 84 NO. 1

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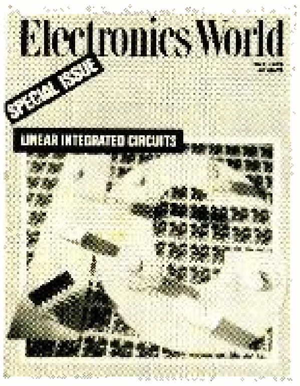

THIS MONTH'S COVER ties in with our 20-page Special Section on Linear Integrated Circuits. The photo shows a number of typical IC packages, including the round TO-5 configuration with straight and formed leads, the 14- and 16-lead dual in-line ceramic and plastic packages, and the 14-lead flat-pack. In the background is the metalization pattern for an audio-amplifier IC. For details on these products, refer to the various feature stories in our Special Section. Cover photograph by J. M. Semonish and F. Frasca of RCA Solid State Division.

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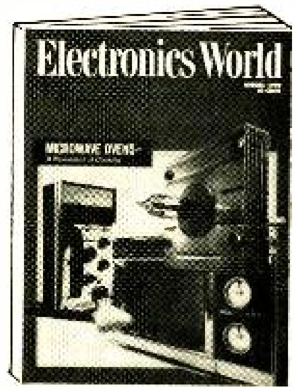
Coming Next Month

Special Feature Article



MICROWAVE OVENS

Part 1 of this two-part series covers the operating principles and designs of such ovens—and analyzes their capabilities as well as shortcomings. It takes a technically sophisticated design to make such ovens perform as claimed yet be safe and reliable enough for continuous use in homes and commercial restaurants.

IS OMNIDIRECTIONALITY DESIRABLE IN A LOUDSPEAKER?

Don Davis of Altec-Lansing thinks not and explains why he believes that directional speakers which cover the listening area with direct rather than reverberant sound provide the most faithful reproduction of the original sound.

PUTTING REED SWITCHES TO WORK

These magnetically operated devices have long been used as proximity switches—but they have other applications in the field of logic. Don Blacklock explains how they are used, what units are available, and how to select them.

TRANSMISSION DELAYS & ECHOES IN SATELLITE COMMUNICATIONS

User complaints regarding transmission delays on overseas phone calls via satellite have failed to materialize—thanks to effective echo suppression techniques developed for handling such problems over these long transmission paths.

FET'S AS AUDIO SWITCHES

By applying voltage to the gate and keeping drain-to-source voltage at zero, it is possible to control the resistance of an FET. Applications in audio circuits and power supplies are discussed.

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

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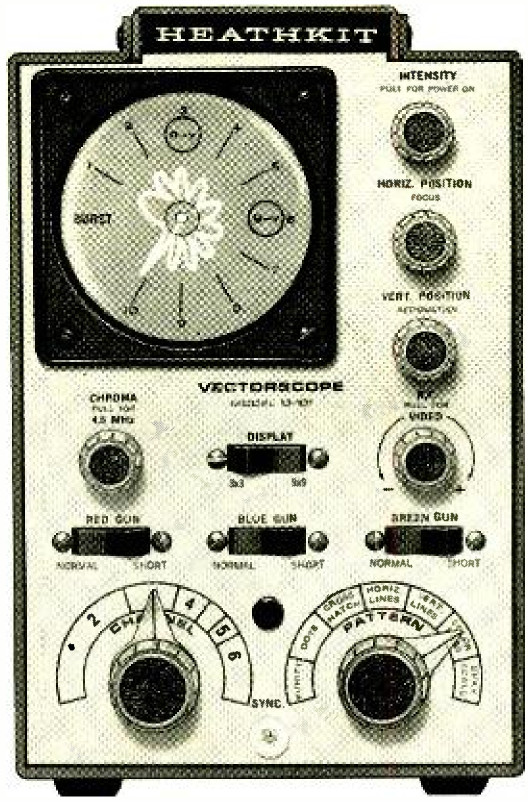

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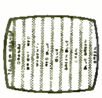
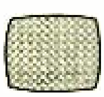
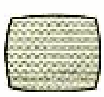
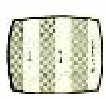
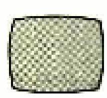
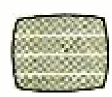

Color Bars


Dot Pattern

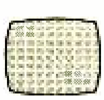

Horizontal Bars

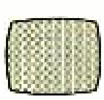

3x3 Color Bars

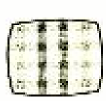

3x3 Dot

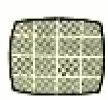

3x3 Horizontal

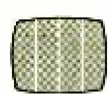

Shading Bars


Cross Hatch


Vertical Bars


3x3 Shading


3x3 Cross Hatch


3x3 Vertical

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*The number of dots, lines, and bars indicated for a 9 x 9 display is the number displayed if the receiver under test has no overscan.

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LETTERS

COMPUTER TIME-SHARING

To the Editors:

I read with interest David L. Heiserman's article "Computer Time-Sharing" in the March, 1970 issue. The concepts involved in time-sharing are quite complex and usually difficult to explain to a general audience. Therefore, I am pleased to see a publication with such wide appeal as yours undertaking such an effort.

I'm a little sorry though that you didn't see fit to mention us in your list of manufacturers of time-sharing computers. We have been involved in producing time-sharing systems as long as anyone and longer than most that you did mention.

I should also point out our experience in time-sharing isn't confined to large-scale installations. Some of our small computers, such as the PDP-8, can time-share too. These range from a 4-user, desk-top model to a fair-sized swapping system, the TSS-8.

ASHLEY D. GRAYSON, PDP-10 Mktg.
Digital Equipment Corp.
Maynard, Mass.

* * *

SILICON TRANSISTORS AS ZENERS

To the Editors:

The very useful bit by J. Charles on "Using Silicon Transistors as Zeners" (Jan., 1970, p. 86) would be made even more so by adding the *forward*-biased collector junction to the zener—using emitter-to-collector instead of emitter-to-base connections. This adds about 0.6 volt to the zener voltage as well as significant temperature compensation, particularly if the operating current is chosen for optimum compensation.

It is even practical, sometimes, to use the normal reverse-biased collector junction as a zener (some transistors have very sharp "knees") if you need a high-voltage zener.

Mr. Charles has offered a short, concise article whose value far outweighs its length. Many good things to him!

ROGER K. ODOM, Eng. Mgr.
Sparta Electric Corp.
Carmichael, Cal.

* * *

SHIELDED TWIN-LEAD

To the Editors:

My thanks to ELECTRONICS WORLD for the very comprehensive survey published in the January, 1970 issue, "TV-FM Lead-In: What Kind To Use." Why is it, with all the inherent advantages of shielded twin-lead, that no company makes connectors for it? Nor are there any v.h.f.-u.h.f. splitters or multi-set couplers with a ground terminal for the shielded drain wire.

We have been using shielded twin-lead for the past 3 years. Its performance is excellent but, contrary to your statement about ease of installation, there are several difficulties. The cable is bulky and relatively inflexible; therefore it cannot be unobtrusively routed around the walls of a room. In connecting the cable to the antenna terminals of the television set, one must deal with the problem of the two stripped conductors bearing the weight of the cable, and this may be a considerable strain if the terminals are two or more feet above the horizontal run of the cable. Also, one has the problem of just how to connect the cable shield and drain wire to the chassis. Furthermore, because of the lack of connectors, there is no easy or neat way to connect the cable to the antenna itself.

N. POSCH
La Crescenta, Cal.

* * *

PLANTS & ELECTRONICS

To the Editors:

In response to the many letters received commenting on my article "Electronics and the Living Plant" (ELECTRONICS WORLD, Oct., 1969), we have designed an acoustical plant response detector. The instrument permits basic experiments in the new field of galvanic plant behavior and produces changes in audio pitch as selected specimens react to physical stimulation. We also have printed circuit boards available for those who wish to build their own units. For information write to: *Electro-Physics Lab.*, Box 3284, San Bernardino, Cal. 92404.

L. GEORGE LAWRENCE
San Bernardino, Cal.

* * *

TRIGGERED-SWEEP SCOPE

To the Editors:

I have built the "Triggered Sweep for Any Scope" (Nov., 1969 issue) and find that it performs beautifully even though I used perf board and non-specified semiconductors.

I would like to request that the circuit be expanded to include a slow-sweep (one to look at heart beats,

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about 1.43 per second). I have tried several modifications with mediocre results.

JOHN E. SCHUBERT
827 Minnesota St.
Lantana, Fla. 33460

* * *

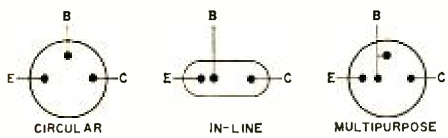
TRANSISTOR-TESTER SOCKET

To the Editors:

Your recent article on a "Multirange Transistor Tester" (in the April issue) showed a transistor socket with four terminals. What is the purpose of this socket?

RAYMOND CARTER
Detroit, Mich.

This is a multipurpose socket that will accommodate transistors whose pin



arrangements are either in-line or arranged in a circle as shown in these bottom views.—Editors

* * *

PARTS FOR PHONOS

To the Editors:

In reply to your "Radio & Television News" paragraph regarding "Hunting Old Recorder and Phonograph Parts," let me advise you and your readers of another source of tape-recorder and phonograph parts. My company furnishes most parts from stock, not just a few key parts. We have the most complete stock of tape-recorder and phonograph parts under one roof; that is, in excess of 10,000 parts.

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* * *

SINGLE-SIGNAL S.W. RECEIVER

To the Editors:

The article titled "A Single-Signal S.W. Receiver" (April, 1970, page 64) contains a suggestion which, if followed, would result in a violation of local electrical codes. These state that earth grounds, such as cold-water pipes, may not be used as returns for mains current.

To insure that the antenna lead does not become "hot" due to failure of the antenna-coupling capacitor, it would be better to use two 300-pF capacitors in series, and connect to the line in the conventional manner using a two-pronged plug. A lightning arrester connected to the antenna at the point of entry would prevent catastrophic failure of the two capacitors due to a lightning surge. The probability of two capacitors failing in a short mode is negligibly small.

ALEX PATERSON
Nutley, N. J. ▲

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Radio & Television news

By FOREST H. BELT/Contributing Editor

Where There's Smoke . . .

There isn't always fire. So reports National Electronic Associations from a survey they made nationwide. The survey indicates only about 4000 television receivers caused "fire damage" in the past 12 months. Half produced no flame damage. That's infinitesimal, with somewhat over 85 million television receivers now in use.

One key factor was pointed out in the NEA report. Technicians say "burned-out fuse," "burned-out dial lamp," "burned resistor," or "burned-out tube." None of these phrases has anything to do with fire, but customers often interpret them incorrectly. The odor of an overheated transformer or resistor can be misconstrued by an untutored set-owner as something afire. With the scare stories being circulated by a few politicians and careless mass media, technicians must be careful how they report ordinary set failures to their customers.

Future Grows for Quadrasonics

Four-channel sound, with speakers behind the listener as well as in front, seems firmly the hi-fi wave of tomorrow. Two "mass" producers of home electronics are now on the quadrasonics bandwagon. Until now, quadrasonic systems were pieced together from components built by hi-fi specialists.

RCA Victor Records will release five- or six-dozen quadrasonic tape cartridges later this year. *RCA Sales Corp.* is already offering a four-channel home sound system. It incorporates an AM/stereo-FM tuner that also receives v.h.f./u.h.f. TV sound. The tape player is a converted 8-track unit.

Almost simultaneously *Motorola* announced its "Quad 8" four-channel add-on unit for automobiles. Front-to-back sound seems to have truly caught on.

Second Service Technician Convention

The National Alliance of Television & Electronic Service Associations (NATESA) has set its 1970 convention for August 14-16. It will be held at the Pick-Congress Hotel in Chicago. NATESA has planned seminars on managing an electronics servicing business.

Before this convention that of the National Electronic Associations will be held in St. Louis during mid-July—see "Technicians Plan Their Convention," page 6, last month's column.

Emergency Channel for CB

After years of pushing, proponents of Citizens Band radio got the Federal Communications Commission to set aside channel 9 (27.065 MHz) for emergency use exclusively. Beginning the end of July, CB channel 9 can't be used for anything except messages involving protection of life and property. Presumably, that includes helping stranded motorists, the chief intent of those asking for reallocation of channel 9.

The FCC should clarify how to use channel 9, otherwise those who misuse CB channels anyway will tie up a lot of air time "helping" each other.

One efficient way is to designate 27.065 a "calling and safety" frequency. Everyone stands by on channel 9. To establish contact, an operator makes his initial call on that frequency. Once he raises a station that can help him, both switch to a mutually agreeable channel. That clears the safety channel for other emergencies. This concept should be promoted through REACT, HELP, and CB club organizations. Backed by fines for those who "fat-chew" on channel 9, this idea would put most CB use in the "public interest" category sensible users have made for it in a few localities.

RCA Selects "ServiceAmerica"

ServiceAmerica is the name chosen by *RCA* for its new organization which will service all brands of TV sets and other home-entertainment products. It will operate independently of *RCA Service Co.* (which services only *RCA* brand and *Whirlpool* appliances) and will offer servicing on all brands of radio, television, and home entertainment appliances. *RCA* plans to open the first *ServiceAmerica* center in the Philadelphia area by mid-year; the second is scheduled for the San Francisco area; and then gradually will be expanded nationwide.

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RCA Executive Vice-President A. L. Conrad points out that the service business is growing faster than new product sales, and should exceed new-set dollar volume for the first time in 1970. Studies conducted by *RCA* show that the volume of the television service business alone will grow $600 million over the next four years.

Foreseeing objections on the part of individual service organizations, *RCA* made it clear that black-and-white and color picture tubes, vacuum tubes, and other parts will be purchased directly from independent local distributors. It wasn't made clear, however, whether the service technicians would use only *RCA* tubes and components.

RCA will be stepping up its programs for training service personnel in order to meet the needs of *ServiceAmerica*. Present plans call for five weeks of basic training, plus one day a week for additional study over the following six months.

TV Servicing Reasonably Profitable

Nightclub comedians, notwithstanding, the radio and TV technician is not among the top small business operations from the standpoint of profitability, according to the "Yearbook for 1969" just published by the Accounting Corporation of America. The Yearbook gives statistical details on 9124 business firms in 48 basic small-business categories as revealed by a computer study of data supplied by several hundred accountants serving small business enterprises doing from $25,000 to $300,000 in volume.

The often-maligned TV service technician showed an average profit of 12.98 percent before taxes in 1969. From the standpoint of profits, the new car dealer is at the bottom of the list. The data shows that in 1969 the average profit before taxes in this field was 4.21 percent, just slightly better than the 4.15 percent of the previous year. Used car dealers are next to the bottom with an average profit of 4.35 percent, down from 4.54 percent in 1968.

The fastest growing business, from the standpoint of volume, is beauty shops while the auto parts and accessories businesses lag behind in growth. There must be some sort of message here.

The highest profit margins shown by the study are by motel operators with a ratio of profit to sales indicated as 23.42 percent, up slightly from the 23.12 percent recorded in 1968. All of the profit margins are based on sales rather than on investment.

Improved Color Uniformity in TV Sets

Better color uniformity on home color sets may be achieved through use of the proposed Vertical Interval Reference (VIR) signals by broadcast stations. The EIA committee, chaired by Bernard D. Loughlin, VP for Research at *Hazeltine*, is planning preliminary field tests of VIR signals.

These VIR signals would give broadcast stations a constant color reference to confirm, before the signal is broadcast, that the chrominance-to-luminance ratio is correct and that the color burst represents a proper reference for both the phase and amplitude of the chrominance signal.

Several variants of the VIR signal will be tried during the preliminary tests. The signal contains chrominance, luminance, and black-level references, and is proposed for Line 20 during the vertical interval just before the start of picture information. Tests will start with the signal on both fields, although some tests will be run with the signal on only one field.

Present planning calls for local on-air tests in the New York City area to be run before the middle of June with network tests scheduled for completion early in July. (More about this in a feature article in next month's issue.)

Flashes in the Big Picture

Cable-TV audience data can be gathered electronically with new channel-monitoring device from *H & B American*, large cable operator. . . . Los Angeles Better Business Bureau, with help of California State Electronics Association, is setting up office to arbitrate disputes between service shops and customers. . . . Electronic Industries Association is gearing up for long-range study of where electronics industry is heading: survey to cover next 15 years. . . . *Zenith* now claims to be number-one in color-set sales, spot held by *RCA* virtually since inception of color TV. . . . U.S. has over 860 TV stations now, about one-third of them u.h.f.; 20 percent of total are education stations. . . . More than half of all radios sold this year receive FM; that's good news for our nearly 2600 FM stations. . . . Japanese firms are cooperating to develop all-IC color TV, same as they are for all-IC stereo-FM set (which hasn't appeared as yet). . . . It's a Crazy Business Dept.: People on welfare in North Carolina can now own color TV and high-quality stereo; before, they were automatically ineligible for welfare payments if they owned either. Wonder if the new ruling also applies to Cadillacs? ▲

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EMCBT ORGANIZED for MOBILE CB-ers

A new organization has been set up to provide 24-hour-a-day monitoring of the Citizens Band emergency channels as a crime deterrent, police and fire department aide, and a highway emergency service.

Known as EMCBT (Emergency Monitoring Citizens Band Team), the new group maintains headquarters in Orange, California. The association is made up of two groups; county organizations and a national group whose membership consists of truckers, military personnel, and businessmen who travel.

Each local organization has its own set of bylaws and the monthly dues of $2.00 are retained by the club to finance its own activities and purchase equipment. The one-time initiation fee of $5.00 is turned over to the national headquarters to defray the costs of membership cards, car and/or truck decals, assistance cards, membership certificates, and administration expenses.

EMCBT is open to any person who holds a class-D license issued by the FCC. At present there are chapters in Spokane, Washington; Cheyenne, Wyoming; Peoria, Illinois; South Bend, Indiana; Niles, Michigan; Rochester, New York; Kechi, Kansas; and Orange, California. The various chapters obtain sponsors locally, while the "mobile" membership report to national headquarters but are permitted to attend local chapter meetings in any city where they happen to be.

Members are available to assist the police in search and rescue missions, in disasters if called upon by authorities, to help with such campaigns as the March of Dimes, Red Cross, etc., and in Civil Defense exercises. With the association's 24-hour-a-day monitoring service, members are expected to assist authorities by reporting suspicious persons, fires, or other hazardous conditions. At present EMCBT monitors channel 14, which is one of the three channels designated by the FCC for emergencies.

Complete details on EMCBT are available from Harold Morrell, President, EMCBT, P.O. Box 1644, Orange, California 92668. When writing, specify whether you are interested in organizing or joining a local group or wish details on membership. ▲

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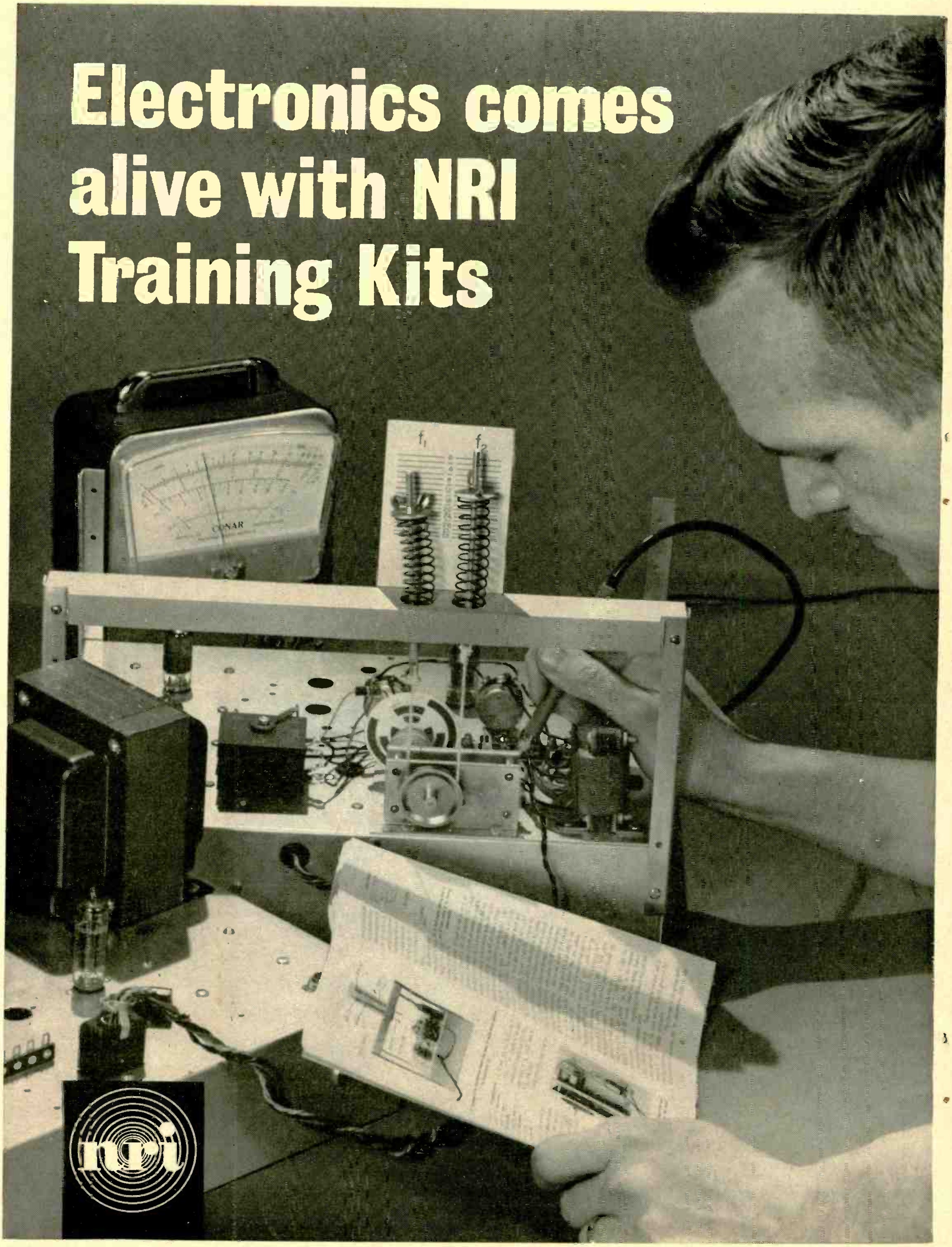

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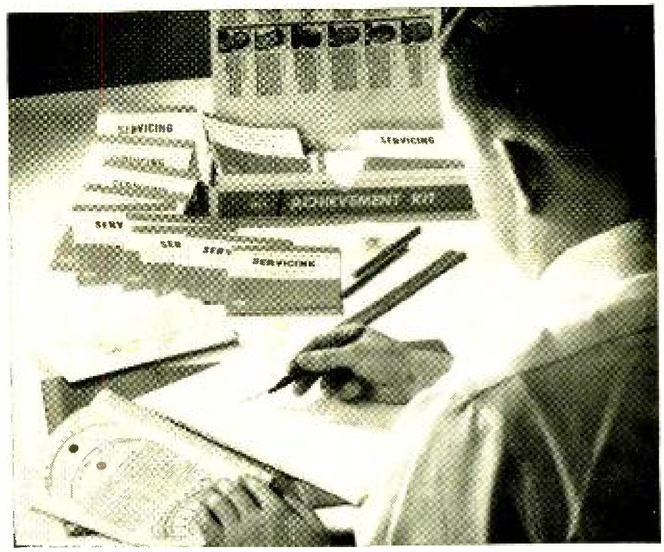

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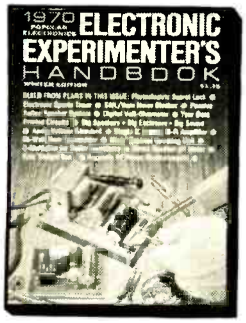

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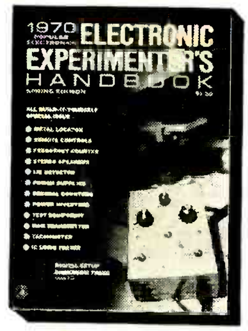

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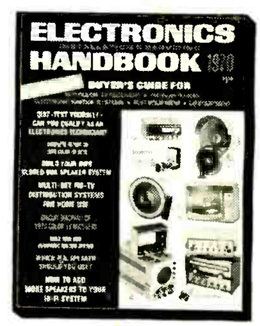

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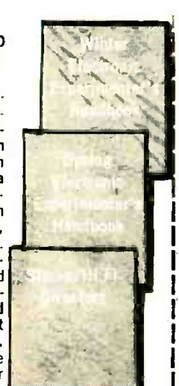

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Find R.M.S. Values Graphically

By WESLEY A. VINCENT / Government Electronics Div., Motorola Inc.

By using graph paper and counting squares, you can obtain the effective values of a voltage or a current waveform.

THOSE familiar with electronic terminology recognize the abbreviation r.m.s. as meaning the root-mean-square or effective value of a current or voltage waveform. I_{rms} or V_{rms} stands for the equivalent direct current or direct voltage value of a time-varying current or voltage which would produce the same amount of heating. While the r.m.s. value of a sine wave is 0.707 times its peak value. this relationship does not hold true for waveforms of other shapes. Furthermore, most common v.t.v.m.'s with an r.m.s. scale determine r.m.s. values for sine waves only. The r.m.s. values for other waveforms are usually in error.

If a waveform can be described by an equation and thus is known analytically, the r.m.s. value can be obtained using analytical methods. However, in many cases an exact value may not be necessary and a quicker method for obtaining the r.m.s. value may be obtained using graphical techniques. By using graph paper and counting squares, the r.m.s. value of most periodic waveforms can easily be obtained.

To find the r.m.s. value for a current or voltage waveform, first square the waveform. Next, determine the average or mean value of the squared waveform. To find the average value, divide the area under the squared waveform during one period by the length of one period. And, finally, take the square root of the average value determined in the above step.

Let's look at two examples. First consider a square wave of voltage whose amplitude is ±50 volts or 100 volts peak-to-peak, as shown in Fig. 1A. First the waveform is squared as shown in Fig. 1B. The amplitude of the squared waveform is 2500. The mean or average value for one period is also 2500. In the last step we take the square root of the squared amplitude, which is 50. Thus 50 volts is the r.m.s. value of the square wave. More generally, we can conclude that the r.m.s. value of a square wave is equal to its peak value or one-half of its peak-to-peak value.

In the next example let's find the r.m.s. value for the current waveform shown in Fig. 1C. Again we first square the waveform. The squared waveform in Fig. 2A is obtained by squaring the end points and a few in-between points to get a general idea of the shape of the waveform. For the next step the average or mean value of the squared waveform must be obtained. Using graph paper, the number of squares is determined under the squared waveform for one period. For Fig. 2A approximately 81 squares were counted using 10 divisions-per-inch graph paper. The average is now determined by dividing the area by 20, the number of divisions in one period. Thus the average value would be approximately 4 as shown in Fig. 2B. The r.m.s. value is determined by taking the square root of the squared value, and is found to be 2 amps r.m.s. (Fig. 2C).

The r.m.s. values for other periodic waveforms are determined in the same manner. Using this graphical technique, approximate answers can be found quickly. To determine r.m.s. values more accurately use higher density grid graph paper and spend a little more time in determining the shape of the squared waveform and area under the squared waveform. ▲

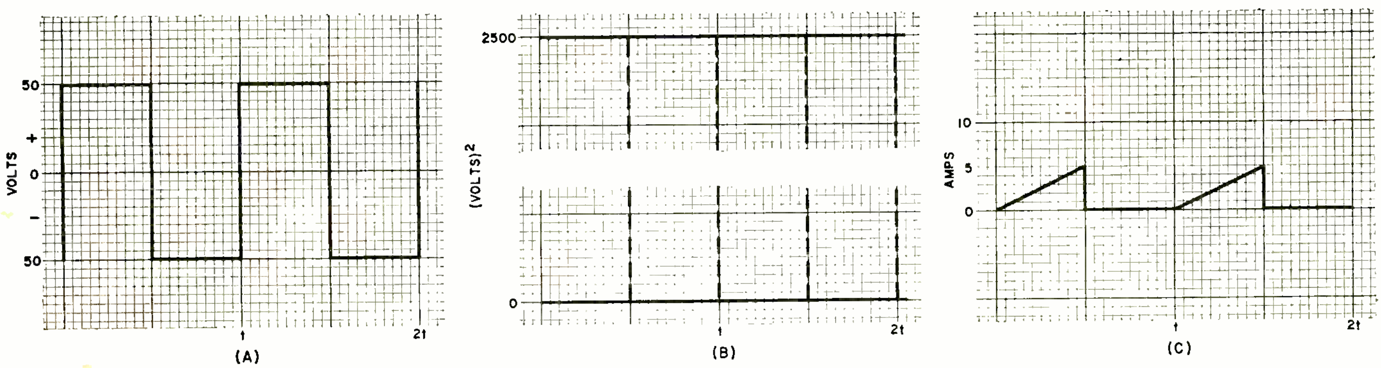
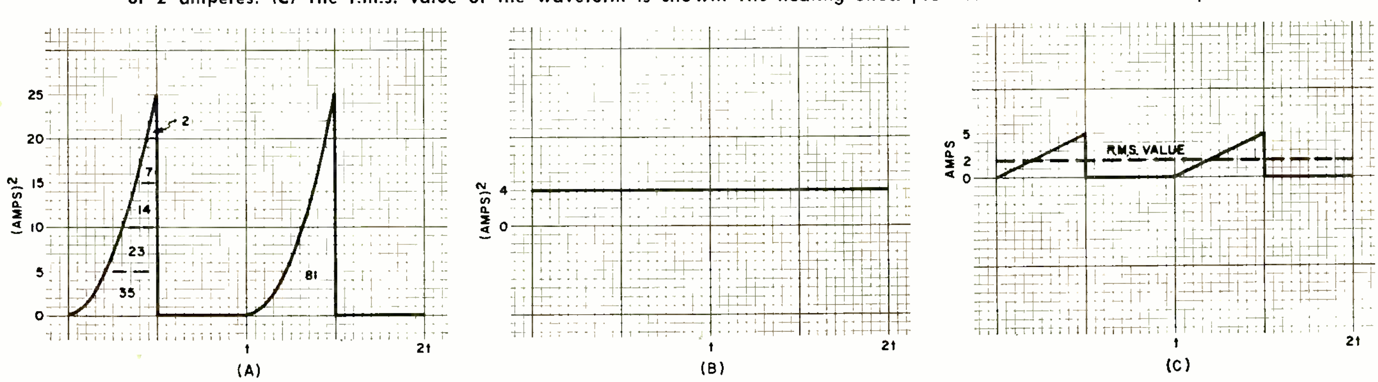


Fig. 1. (A) Square waveform of voltage—one complete cycle or period of the waveform is denoted by t. (B) Square waveform after squaring; the average squared value is the same as the squared value and the r.m.s. value is the same as the peak value, or 50 volts. (C) Sawtooth current waveform whose r.m.s. value is to be found in the second example covered.

Fig. 2. (A) Current waveform of Fig. 1C squared. Area of the squared waveform is determined by counting squares on the graph paper. (B) Average value is determined by dividing area of the square waveform during one period by the length of the period. The average value here is 81 divided by 20, or approximately 4. The r.m.s. value is the square root of 4, or 2 amperes. (C) The r.m.s. value of the waveform is shown. The heating effect produced is the same as 2 amps d.c.



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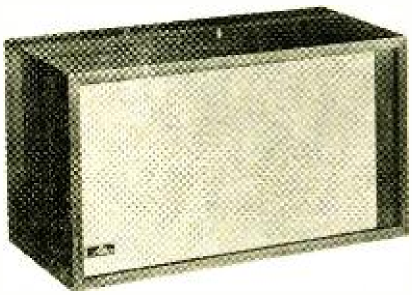
HI-FI PRODUCT REPORT
EW LAB TESTED
by Hirsch-Houck Labs

Altec 892A Madera Speaker
Scott Model 382-C Receiver

Altec 892A Madera Speaker

For copy of manufacturer's brochure, circle No. 1 on Reader Service Card.



THE *Altec Lansing* 892A Madera is a medium-sized "bookshelf" speaker system, measuring 23¾" wide by 13" high by 11¾" deep. It weighs about 39 pounds and, although it is relatively large as "bookshelf" systems go, it should present no installation difficulties for shelf mounting.

The 892A is an 8-ohm, two-way system, with a 10" high-compliance woofer in a fully sealed enclosure, crossing over at 2500 Hz to a compression-loaded horn tweeter. A three-position slide switch in the rear of the enclosure controls the high-frequency level, with the "normal" position giving maximum highs, and the others cutting output by 3 dB and 6 dB above about 3 kHz.

The tweeter horn is oriented horizontally, so that optimum high-frequency dispersion will be obtained with the enclosure mounted horizontally, as on a shelf. If it is installed on the floor, in a vertical position (for which its size and styling are well-suited) one would expect some change in high-frequency polar dispersion. However, this effect, if it existed, was undetected by our ears and we would not consider this to be a significant factor.

Averaging the outputs from eight microphones throughout the room, we obtained a smoothed response curve. It correlated well with the way the speaker sounded to our ears. Over-all, the response was within ±5 dB from 55 Hz to 16 kHz (our microphone response falls off rapidly above 15 kHz), with notable smoothness in the important mid-range between 250 and 2250 Hz, where the output was constant within ±1.5 dB.

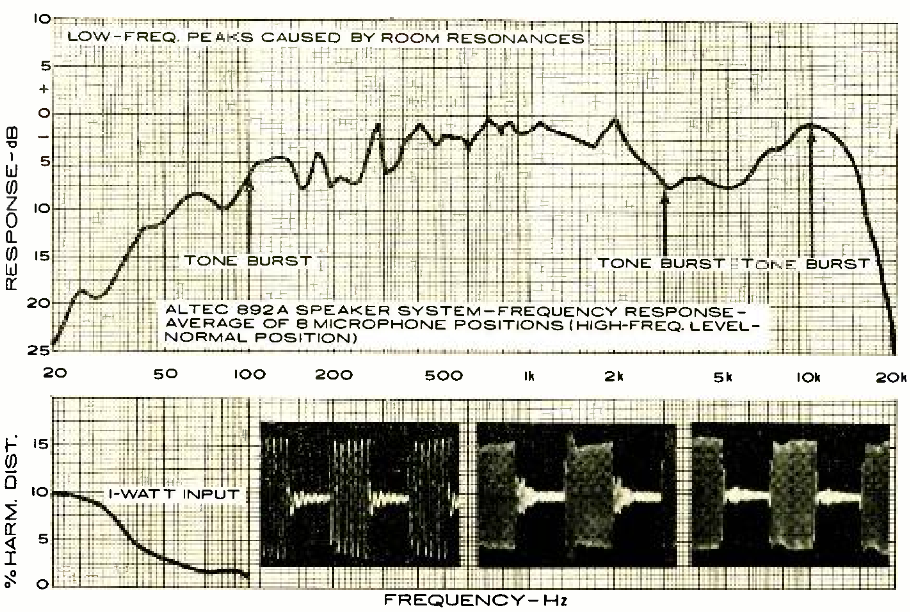
The tweeter output, even at its maximum or "normal" setting, was about 5 dB below that of the woofer just below the crossover frequency. The resulting curve had a "sway-back" effect in the 2.5- to 8-kHz region. The high-frequency output rose to a broad maximum (equal to the mid-range level) in the uppermost octave, centered about 10 kHz.

At the low end, the output fell off smoothly and rather gradually at a 6dB/octave rate below 100 Hz. The useful lower limit is about 35 Hz, although the output at that frequency was down about 15 dB from the mid-range level, when the speaker was wall-mounted. Placement on the floor, and particularly in a corner, should boost the lowest frequencies appreciably.

Even at the lowest frequencies, the distortion remained low, albeit at a reduced output level. At a 1-watt drive level, the distortion was under 2% above 60 Hz, reaching 5% at 38 Hz and 10% at 20 Hz. Tone-burst response was generally good, although some ringing could be seen between bursts at most frequencies between 300 Hz and 3 kHz. However, there was never a severe distortion of burst shape or generation of spurious frequencies. At low and high frequencies, the tone-burst response was excellent.

Listening to the 892A, we noticed a slightly dry, distinctly projected character to the sound. Evidently the ear interprets the response curve as though the mid-range were elevated relative to the lows and highs, instead of the latter being below the level of the middles. The speaker sounds clean and well-balanced, with no obvious emphasis on any portion of the spectrum. We preferred the "normal" tweeter level setting. The speaker efficiency, although moderately low, is nevertheless appreciably higher than that of the least efficient acoustic-suspension types. We were able to drive the speaker very adequately with a good 15-watt-per-channel amplifier.

The *Altec Lansing* 892A Madera sells for $145.00. ▲



Scott Model 382-C AM/Stereo-FM Receiver

For copy of manufacturer's brochure circle No. 2 on Reader Service Card.

WE have often been asked how integrated circuits can benefit the user of high-fidelity equipment. In a few circuits—notably the limiters of FM tuners—IC's actually outperform most discrete circuits. However, in most cases, the major advantage of IC's is economic. If it costs the manufacturer less to design and build a product, some of his savings can be passed on to his customers.

H. H. Scott has taken the lead in making most effective use of IC technology in its new Model 382-C stereo receiver. Not only are IC's used wherever they can improve the performance or reduce costs, but the receiver incorporates a number of design and construction features rarely found in consumer electronic products.

To appreciate the design of the receiver, one must examine its circuits in

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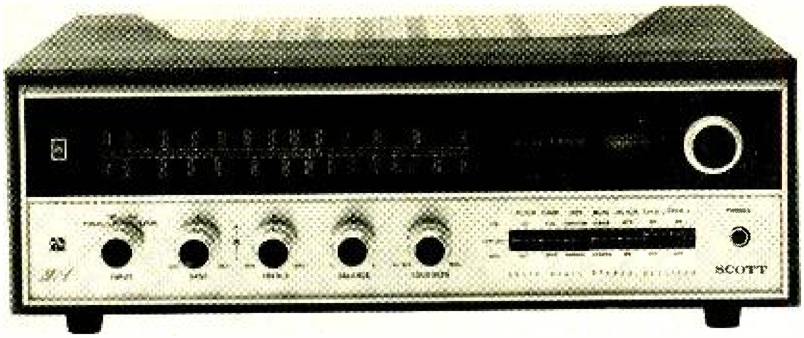


some detail. It is soon apparent that most of the familiar circuit symbols are missing from the schematic, replaced by cryptic rectangles and triangles representing IC's. The FM front-end is conventional but completely up-to-date, with an FET r.f. amplifier and bipolar transistors as mixer and oscillator. The i.f. amplifier has an IC gain stage followed by a four-pole pair crystal filter. Two more IC's provide gain and limiting, with a full-wave voltage-doubling rectifier supplying a.g.c. voltage to the FET r.f. amplifier. The only adjustable component in the i.f. section is the transformer that couples the signal to the ratio detector.

The manufacturer has introduced the "Perfectune" FM tuning indicator, which is far easier to use and more accurate than a zero-center tuning meter, let alone a relative signal-strength type of tuning meter. An IC voltage comparator senses the d.c. output of the detector and lights a lamp when the input is essentially zero, corresponding to correct tuning. The lamp illuminates the word "Perfectune" on the panel. Even a slight mis-tuning, indistinguishable to the ear or even on many zero-center meters, causes the lamp to go out. A noise-operated inhibit circuit prevents the lamp from being actuated unless a station is tuned in.

The AM tuner front-end has an FET mixer and a bipolar transistor oscillator followed by a fixed-tuned 4-pole 455-kHz band-pass *LC* filter. The i.f. is perhaps the ultimate in simplicity, with an FET input stage followed by an IC amplifier and a full-wave voltage-doubling detector. The detector has lower distortion than the usual half-wave detector and probably contributes to the excellent AM quality of this receiver. (See article "High-Quality AM Section in New Hi-Fi Receiver" by Klaus J. Peter in the June issue.)

The multiplex section uses a single IC for practically all its functions. The only other active device on this board is a single-transistor noise amplifier. The multiplex IC, developed by *Motorola*, is claimed to have exceptionally uniform separation across the audio spectrum, which we confirmed in our laboratory tests.

The phono preamplifier uses a single IC for both channels. A few external resistors and capacitors are added to create what must be the simplest stereo phono preamplifier on the market. The tone control and loudness-control section consists largely of discrete components, but does have an encapsulated network of 11 resistors which eliminates much of the board wiring. Each channel has a single FET source-follower output stage.

In its power-amplifier sections the receiver uses discrete components only. The drivers are direct-coupled to the complementary-symmetry output stages, which in turn are direct-coupled to the speakers. The only coupling capacitors in the power section are located directly at the input, to isolate them from the tone-control stages.

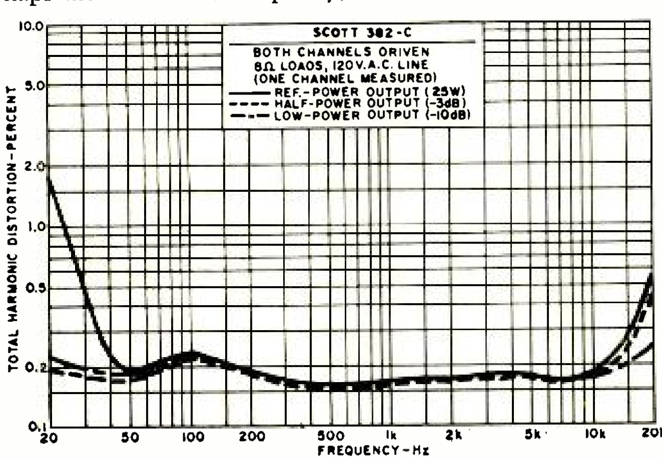
The 382-C is a compact receiver, measuring 15" wide, 4¾" high, and about 13½" deep behind the panel with the adjustable AM rod antenna fully extended. The actual chassis depth is only 10⅛". It has two pairs of speaker outputs, activated by individual push-buttons on the front panel. One pair of speaker terminals uses the normal screw-type connections; the other has phono jacks for compatibility with certain speakers made by *Scott* and others.

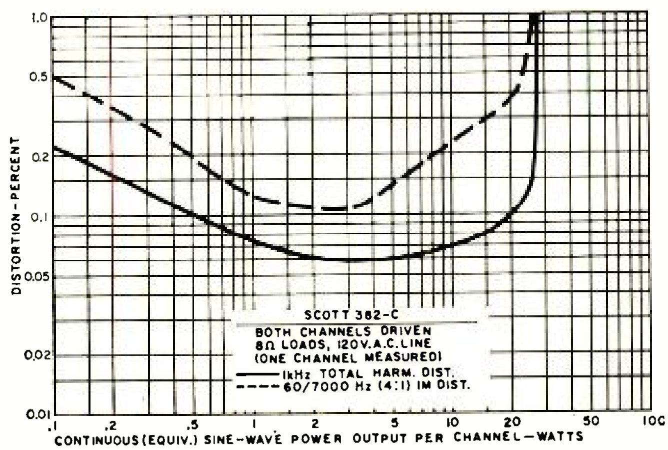
Other front-panel push-buttons control FM muting, loudness compensation, mono/stereo mode, tape monitoring, and a high-cut noise filter. Knobs operate the input selector, volume and balance controls, and the tone controls. The latter are concentric types with slip clutches so that they can be individually adjusted for each channel. The illuminated dial face is opaque when the receiver is off. There is an illuminated tuning meter (relative strength indication suitable for antenna orientation) used for FM and AM, although FM tuning is more properly done with the "Perfectune" system. Next to the "Perfectune" indicator on the panel is a red stereo-FM indicator which lights when a stereo signal is received.

The manufacturer applied several sets of power ratings to the 382-C, such as 110 watts (IHF±1 dB, 4 ohms) and 25 watts for both channels driven continuously into 8 ohms.

We used 25 watts per channel as a reference full-power level for distortion measurements. At 25 watts, distortion is under 0.5% from 30 to 20,000 Hz. Over most of that range it is under 0.2%. At half power or less, distortion is typically under 0.2% over the full frequency range of 20 to 20,000 Hz. Into 4-ohm loads, the available power is about 33% greater than with 8-ohm loads; into 16 ohms it is reduced by about 33%.

The tone-control characteristics are conventional, and they are mild in their action. A similar situation exists with the loudness compensation, which boosts the lows moderately. We used it much of the time when listening to the receiver, since it did not add the unnatural heaviness that is typical of so many loud-





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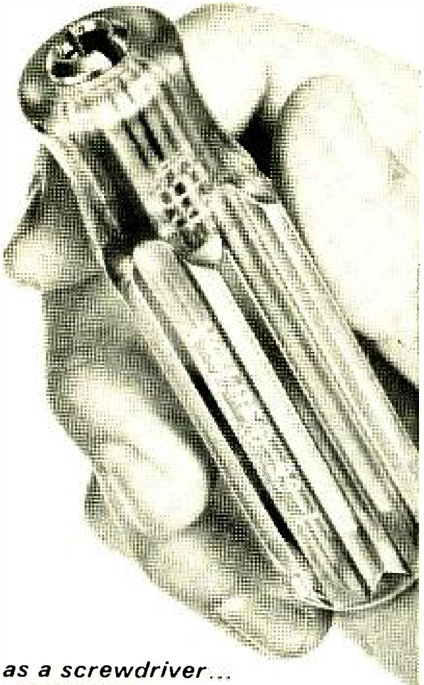
have you any idea how many ways you can use this handle?



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cut filter has a 6 dB/octave slope above 4 kHz, which is similar to most such circuits, although we would prefer a steeper slope beginning at a higher frequency. The RIAA phono equalization was within ±0.5 dB from a frequency of 30 to 15,000 Hz.

The audio amplifiers require 0.25 volt (Aux) or 1.9 millivolts (Phono) for 10-watts output. Hum and noise are −70 dB referred to 10 watts on Aux and Phono inputs.

The FM tuner has an IHF usable sensitivity of 1.8 microvolts, with full limiting at 3 microvolts—one of the steepest limiting curves we have measured to date. Its distortion is about 0.85% at 75-kHz deviation. Frequency response is ±1.5 dB from 30 to 15,000 Hz. Stereo separation is better than 20 dB over the full 30 to 15,000-Hz range and typically between 25 and 30 dB. (*Separation and distortion figures, although good, do not duplicate the manufacturer's specs due mainly to the limitations of the signal generator used by our lab to make the measurements.—Editor*)

In addition to its novel circuit features, the unit employs plug-in circuit boards which should simplify servicing if any is ever needed. Virtually all the chassis wiring uses wire wrap rather than soldering. This is a highly reliable technique, long used by the telephone company.

The favorable impressions which we formed of the receiver during our tests were fully confirmed when we tuned and listened to it. Everything feels "just right," and the tuning action could hardly be better. The FM muting operates with only a faint click, and there is absolutely no noise burst when tuning on or off a station. The Stereo-FM light goes on as soon as the muting is removed (when a stereo transmission is received), but the "Perfectune" light only appears when the tuning is exactly on-center. This is not just another gimmick, but a really worthwhile improvement that results in exact tuning.

The unit proved to be very sensitive, to no one's surprise. Its sound quality leaves nothing to be desired. The AM sound is worthy of special comment, since it is audibly superior to the run-of-the-mill AM tuners used in practically all stereo receivers. Even though its frequency response does not match that of the FM tuner, it has a clean, undistorted sound that is always easy to listen to and should certainly not offend a critical listener's ears.

The *Scott* 382-C sells for $299.95. The 342-C, identical except for the omission of AM, is $269.95. Both are excellent values, and should be able to compete effectively with many imported receivers which have tended to dominate the low- and medium-priced receiver market. ▲

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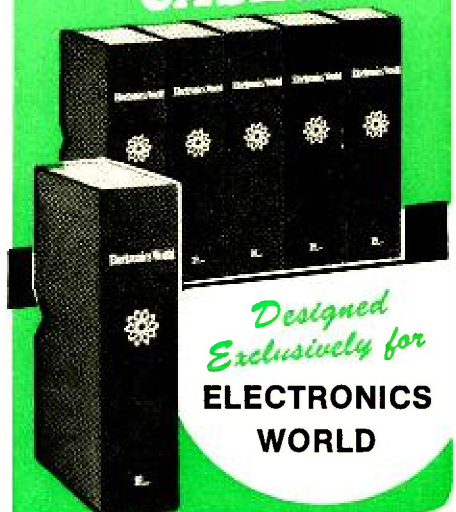

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NEWS HIGHLIGHTS

Color-TV Telephone

Toshiba (*Tokyo Shibaura Electric Co., Ltd.*) has developed what is believed to be world's first Color-TV telephone. Device, using standard telephone and display console, is designed for two-way communications for both inter-office and long-distance transmission over coaxial cables. When the person called picks up receiver, his image is automatically projected in color on 12-inch picture screen at caller's console. A 3-inch black-and-white monitor is included on console that displays caller's image. Optical system, which separates input light into red, green, and blue signals, two color tubes in parallel, and electrical circuits are located in viewing console. Unit makes use of NTSC system for processing video signal.

Computer—Win, Place, or Show

Shenandoah Downs and Charles Town racetracks in Charles Town, West Virginia are using an advanced computer-controlled parimutuel ticket-issuing system that minimizes betting time, provides greater flexibility for betting operations, and helps reduce burden on racetrack staffs. System, devised by *American Totalisator Co., Inc.,* long known for its ticket equipment and its odds and pay-off tote boards at racetracks, dog races, and jai-alai games, is built around two small but powerful 12,288 16-bit word memory *Varian* 620/i general-purpose minicomputers. Designed to compile betting information, calculate odds, and accurately perform all bookeeping functions required by law, computerized system also runs various public displays on track infield and other locations. Smart betters are laying odds that, by post-time, racetracks all over the country will be using minicomputers to save time and energy and reduce errors.

Automating Semiconductor Production

With increasing demands being made on semiconductor manufacturers, automatic semiconductor processor developed by *Hitachi, Ltd.* could prove a godsend. New ion-implantation process, being groomed as a replacement for present thermal-diffusion method, has successfully performed automated manufacture of diodes, transistors, and MOS components in trial runs by *Hitachi*. Some advantages claimed over thermal process are: ion beams can be implanted simultaneously into maximum of 9 silicon wafers, and processing of large number of semiconductor devices with uniform characteristics is possible (40 wafers can be handled per hour); computer-controlled automatic production is possible (adjustment of ion source and acceleration voltage can be handled easily and safely at ground potential); amount of impurities can be monitored during processing (direct measurement and control of ion beam current is possible); and processing can be made at relatively low temperatures (400°-900°) compared to thermal-diffusion process (1000°-1200°C).

New IHF President

Walter Goodman, president of *Harman-Kardon, Inc.*, elected president of the Institute of High Fidelity (IHF). Twenty years' experience in audio industry and more than ten years' trade association background more than qualify him for this position. In addition, Herbert Horowitz, president of *Empire Scientific Corp.*, was elected a member of the Board and vice-president and Walter O. Stanton (*Stanton Magnetics*) re-elected to Board and position of treasurer. Rounding out the Board are William Kasuga (president of *Kenwood Electronics, Inc.*), E. L. Childs, (president of *Elpa Marketing*), William H. Thomas (president of *JBL*), Don Palmquist (*Altec Lansing*), Larry LeKashman (*Electro-Voice*), and John Hollands (*BSR USA*).

Lifeline for Trapped Miners

Looking for foolproof methods of communicating with trapped miners, engineers at *Westinghouse Georesearch Laboratory* have proposed low-frequency radio system that may work. Caveins usually render wire and standard radio communications systems useless. Using new system, *Westinghouse* engineers have transmitted a signal to a coal mine tunnel 450 feet underground, obtaining good reception. Plans are to develop standard radio system applicable to many mining situations (day-to-day communications and telemetry of data on factors such as gas, dust, heat, and rock strain to warn of possible catastrophe).

New Lines for Old Lines

Spurred by size of medical electronics market in U.S. ($40 million in 1970) and future potential (15% yearly growth), *Raytheon Company* forms new business group in its Microwave and Power Tube Div., Waltham, Mass. Headed by Dr. Howard Scharfman, Manager of Medical Electronics, this group will develop and market equipment in fields of nuclear medicine, ultrasonics, and radiotherapy. . . . Foreseeing rapid growth of solid-state technology, due to its increased use in design and manufacture of government, industrial, and consumer products, *RCA* creates new Solid-State Division. *RCA's* Integrated Circuit Technology Center of Research and Engineering and the solid-state operations of company's Electronic Components activity are combined to form new division. William C. Hittinger, former president of *General Instrument Corp.*, appointed vice-president and general manager of the new division and will report directly to Robert W. Sarnoff, chairman and president of *RCA*. Mr. Hittinger, veteran of almost 25 years in electronics, brings in-depth semiconductor experience to his new post.

Coming Events

On July 14-16, the 12th Annual Symposium on EMC (Electromagnetic Compatibility) will be held in Anaheim, Calif. Over 60 exhibitors and technical discussions covering problems of electrical interference, shocks, and radiation and monitoring are scheduled. Admission charges vary from $5-$8 per day to $21-$37 for 3-day package. Attendees' wives admitted free to all functions, except programmed ladies' activities. . . . Fourth Annual Audio/Recording seminar to be held July 13-17 at Brigham Young University. Demonstrations, exhibits, and technical topics such as studio acoustic reverberation devices, disc mastering, professional recording studio equipment and techniques, etc. are planned. Tuition is $70 for advanced registration (postmarked no later than midnight, July 1st) and $85 thereafter. Write Special Courses and Conferences, 242 Herald R. Clark Building, Brigham Young University, Provo, Utah 84601. . . . On September 15 and 16, a conference will be held at University of Washington to explore recent developments in laser technology, highlight new approaches, and examine possible areas of application. Conference is being co-sponsored by U.S. Air Force Office of Scientific Research and UW Aerospace Research Laboratory. Regisatrion fee is $15. ▲

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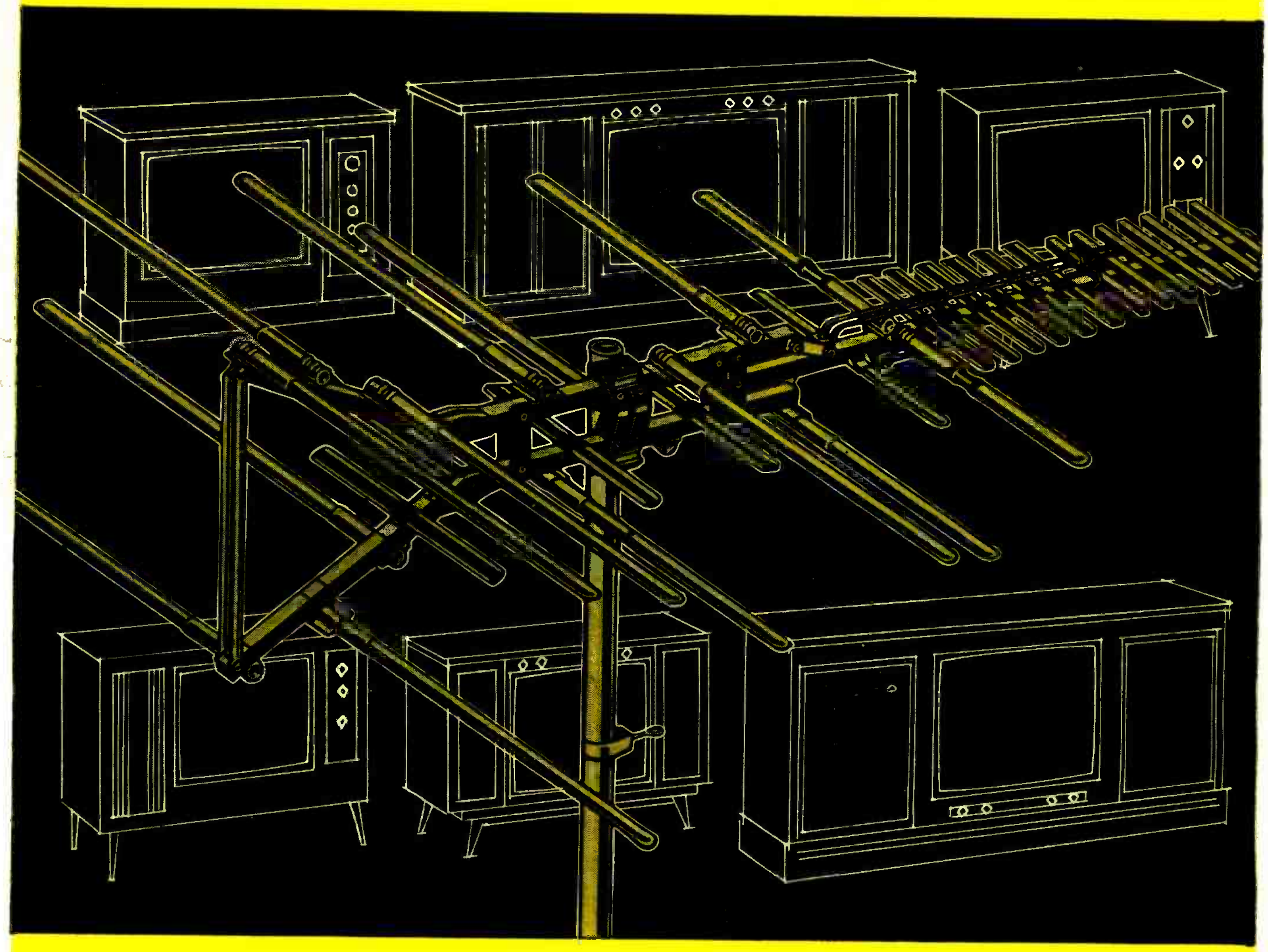

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ELECTRONICS & METEORITES

Photograph of the moon-like Barringer Meteorite Crater located in Arizona. This 4150-foot-diameter, 570-foot-deep crater has been object of scientific study for many years and has been used as a training site for moon-bound astronauts.

By L. GEORGE LAWRENCE

Electromechanical and electronic instrumentation is helping us learn more about meteorites, leading to knowledge about our solar system and celestial mechanics.

AS an organized study, the science of *meteoritics* dates back only about a century and a half. Early romanticists interpreted meteors as manifestations of the gods, and comparative linguistics tells us that "iron" is related in many languages to the words for "sky" and "star." Today, science is especially interested in electrical, optical, mechanical, and biological phenomena associated with these celestial bodies. It's only too true that "meteorites are where you find them." But electronic aids, notably in the instrumentation phase of field work, continue to bring more insight to this unique and dramatically fascinating field.

Technically, a streak of light observed when a "shooting star" or meteoroid enters the atmosphere is known as a *meteor*. A spectacularly brilliant event receives the designation of *fireball*. And, if the object explodes, it's referred to as a *bolide*. That portion of a meteoroid which survives a fiery, frictional death in the atmosphere and reaches the ground is called a *meteorite*. Descriptions like *cosmic dust* and *meteoritic dust* encompass micrometeorites and other debris of meteoric origin.

Dynamic Interactions

From studying physics, we know that natural forces cannot exist alone. Side-effects start to emerge when energy modifications or transformations take place, each of these being peculiar to a given primary event. Meteoroids are no exception to this rule.

Initially, in deep space, the presence of micrometeoroids can be detected by space probes which are equipped to confirm impact by using acoustical-type transducers and strain sensors. Touching, say, a microphone's diaphragm with a finger produces a similar "impact" response. Thus, it is possible to *weigh* striking bodies and record the frequency of strikes.

Electronically, ionization phenomena associated with meteorites entering the atmosphere are of particular interest in communications. V.h.f. reflections from ionized meteor trails express themselves as a Doppler-effect whistle on the r.f. carrier of a signal being received, or there may be signals from stations not normally heard.

For descriptive purposes, the ionization trail may be regarded as a cylinder with a mean length of 15,000 meters for sporadic meteors and 25,000 meters for shower-type meteors. Almost instantly after it is formed, the cylinder has a cross section of about 2 meters at an altitude of 115 kilometers, decreasing to roughly 3 centimeters at 85 kilometers. The cylinder grows by diffusion of electrons at an estimated rate of 140 m^2/s at 115 kilometers down to about 1 m^2/s at 85 kilometers. The mass of ions produced per second frequently is regarded as proportional to the object's loss of mass in the atmosphere with trails generally divided into *overdense* and *underdense*. The transition occurs at a linear density of about 10^{14} electrons per meter.

Meteor cameras are available to record phenomena in the sky. Typically, a visual trail will be seen *before* an electronic instrument—such as radar—detects the object.

Fig. 1 shows an ideal radar return from a meteor trail as recorded by Drs. H.S.W. Massey and R.L.F. Boyd. The amplitude of the radar echo is a function of time. In the parlance of science, amplitude varies as a *Fresnel* diffraction pattern, caused by fluctuation in the signal as the ionization trail grows larger, to a Fresnel zone and through several Fresnel zones.

These happenings are of short duration, but meteoroid

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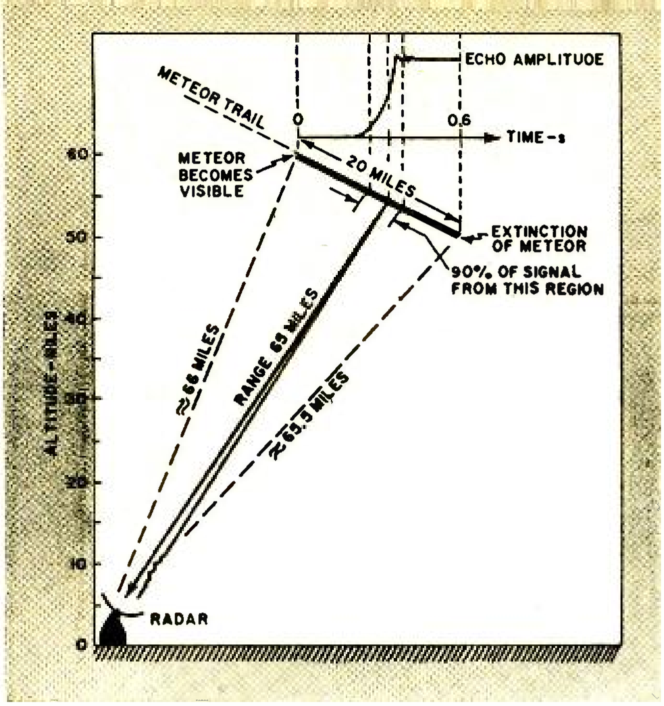

Fig. 1. Recording of radar return received from meteor's trail. The amplitude of the radar echo is plotted as function of time.

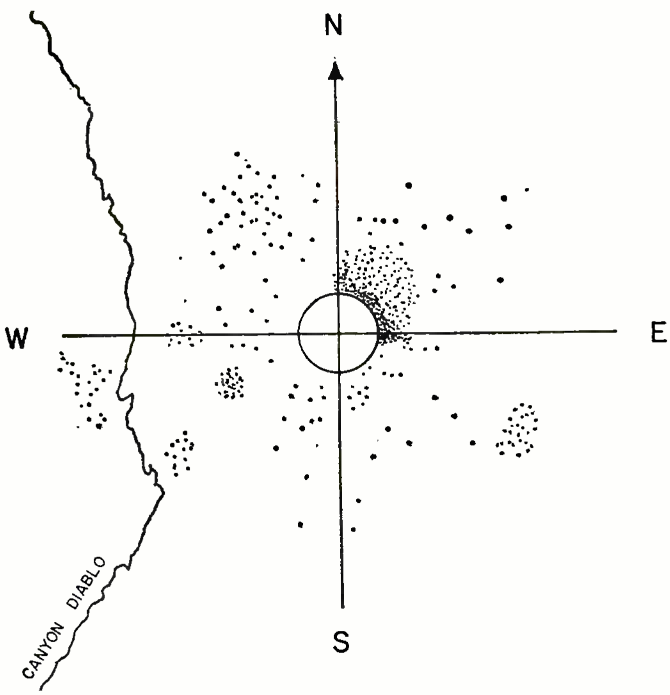

Fig. 2. Simple field map showing distribution of meteoritic material (nickel-iron) around Barringer Meteorite Crater.

showers of great magnitude and length can give fluttery v.h.f. reception from geographical distances up to 1500 miles on both the 50- and 144-MHz bands. It appears that the normal high/low ratio in the daily cycle of meteoroid showers is between 3 and 5. The *low* tends to arise during local early evening hours, the *high* during early morning hours. The *annual* high-to-low ratio is between 2 and 3, with the low rates being in the early months of the calendar year and higher incidence occurring during the last part.

Impact Craters

A vastly more impressive picture develops when fallen meteoroids, or *meteorites*, are considered. Colossal forces are liberated when large objects strike the terrestrial lithosphere, sudden changes in the planet's geomagnetic and geoelectric states. The most recent and most notable fall of this type occurred on June 30, 1908, in the Russian Tunguska, Siberia. Changes in planetary geomagnetism were recorded at Potsdam Observatory (near Berlin, Germany). Geophysical stations at London, Irkutsk, Jena, and other places recorded shock waves and strong seismic disturbances.

However, the bulk of pertinent investigation comes about after the fact (so to speak). It is geophysical work which involves the use of mechanical and electronic instruments for gathering data in the field. Field operations might stretch over many years, since large craters do not yield their secrets easily. But these topographical features permit us to reach, after data has been evaluated, conclusions on celestial mechanics, the make-up of our solar system, and, by inference, the properties and cause of similar features found on other planets.

It's to that end, then, that large aggregations of meteorites and impact phenomena are studied conveniently at large craters. In the United States, the foremost site is Barringer Meteorite Crater, Arizona (see lead photograph). Located between Winslow and Flagstaff, this great natural wonder has an average diameter of 4150 feet, a depth of 570 feet, and is 3 miles around the rim by footpath. It has been estimated that the ejected detritus, a large part of which comprises the rim, was close to 400,000,000 tons. Astronauts continue to visit the site for training purposes and scientists hope to pry more data from it. The crater was a long-time component of Indian lore, but was known to white men only since 1871.

Typically, the investigation of meteorite craters has a geophysical delineation and involves a quadruplet of integrated geological, gravitational, magnetic, and electrical research methods. The latter two are electronics-oriented and involve special equipment.

Initially, at the start of investigations, evidence must be obtained that a given topographical feature is a meteorite crater. This is done by considering, for example, accidental finds of nickel-iron fragments and their distribution patterns. In the case of Barringer Crater, these accumulations were plotted on simple field maps (Fig. 2).

The next question is a big one: Did the meteorite penetrate the lithosphere? If so, is it still in the crater? Of course, if the object had vaporized on impact, no bulk mass can be expected. Another question is that of ricocheting. If, as has been implied many times about Barringer Crater by its critics, the high-velocity meteorite had bounced off and attained an airborne course toward the Gulf of Mexico, there would be no bulk mass either. But scientists (at least the more curious ones) would then look for secondary effects caused at the time of impact. This includes an examination of unusual terrain modifications, like sink pits containing

Fig. 3. Field map showing the hypothetical southeast flight trajectory of Barringer Meteorite toward Gulf of Mexico.

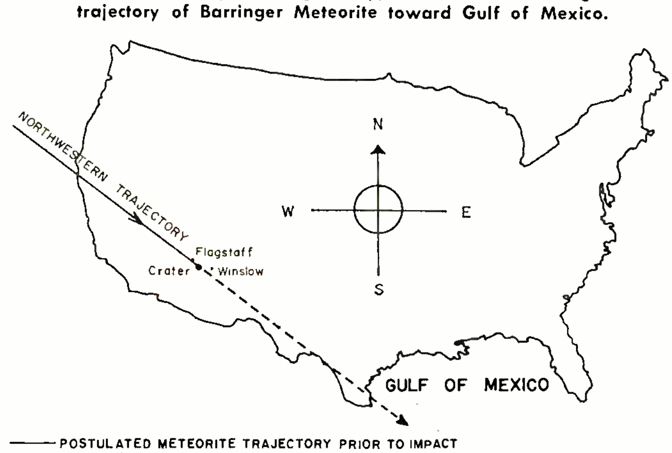

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Fig. 4. Portable electronic flux-gate magnetometer shown on-station at rim of Barringer Meteorite Crater. The magnetometer is used to determine the meteorite's geomagnetic profile.

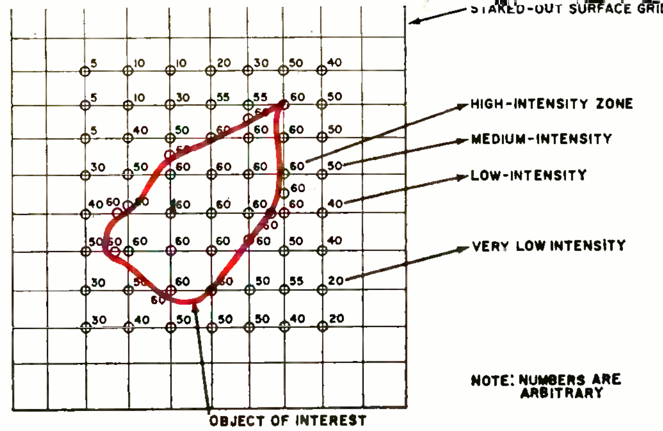

Fig. 6. Grid-method procedure for plotting geophysical anomalies. Magnetometer readings are taken at grid's ties and high values are connected to give profile of buried metallic mass.

nickel-iron meteorite fragments or directional cave-ins of honeycombed terrain.

Fig. 3 shows a field map which contains a hypothetical flight trajectory of the Barringer Meteorite towards the Gulf of Mexico to the southeast. Collapsed underground cavities, as investigated some years ago, exist at the junction of Chevalon Creek and Wildcat Canyon, about 30 miles S.E. of the crater proper.

Nevertheless, taken together, the totality of these and related pre-survey studies can be qualified only after instrumentation-derived data has been evaluated. The specific type and character of the equipment to be chosen is subordinated to these aspects.

Magnetic Profiling

In exploration geophysics, the use of magnetometers is widespread. However, to apply conventional types to meteorites is, in the majority of cases, uneconomical. An average iron meteorite, buried a few feet deep, is not magnetically effective beyond a radius of 5 or 10 feet. Unless the object's location is known within fairly close limits, a very dense grid of magnetometer stations must be employed. The method works best, it appears, when there are large concentrations of meteoritic material in subsurface sediments. This enables the instrument to detect geomagnetic anomalies, *i.e.*, regions that deviate in readings from non-magnetic or non-ferrous fill material.

In a typical survey situation dealing with meteorites, the magnitude of a magnetic domain is an important factor in arriving at a diagnostic conception of its cause. A good geomagnetic profile will indicate, for example, the intrusion path and zones of magnetic "peaks" of meteoritic substance. Data such as this can indicate if there is mineable material at convenient points of access or why the strata at some crater's rim section is arched higher than adjacent areas of it. Arching might indicate that large amounts of extraterrestrial property have caused an uplift of the rim system.

Fig. 4 shows a portable electronic magnetometer on station at Barringer Crater. The instrument is secured, during rest periods, on a tripod and prevented from swaying in the prevailing high winds by arresting chains.

The magnetometer is of the flux-gate type. The operational concept is given in Fig. 5. Like similar instruments, the device is based upon the knowledge that the magnetization curve of many ferromagnetic materials is non-linear. Thus, wire-wound coils having such cores change their alternating-current reactance when a unidirectional magnetic field (such as the earth's) is impressed on an artificial field set up by an a.c. current flowing in the coil. High-permeability alloys (typically Mu-metal) are used, permitting the "external" geomagnetic field to induce a magnetization which is an appreciable part of the cores' saturation. This type of flux-gate becomes extremely sensitive to field changes, since it operates in the saturation region—the sharp "knee"—of the B-H curve.

Electronically, the flux-gate head contains two thin strips of Mu-metal. They are wound with identical windings and excited by a 1-kHz oscillator producing a sine-wave output. The two windings are connected in such a manner as to make the alternating fields *additive* around the closed-core Mu-metal circuit. If an external magnetic field is applied along the axis of the core system, the exciting field in one core will be aided, the field in the other opposed. When both the external (or *ambient*) field and the exciting field are additive, the total flux is increased and the B-H saturation point is reached earlier in the excitation cycle. Conversely, when the ambient field opposes the 1000-Hz excitation flux, total flux is attenuated and saturation is reached at a later period in the gate's excitation cycle. The difference in time between maximum fields in each Mu-metal strip gives a *phase lag* and distortion of the waveshape. This unbalance, seen across resistor *R*1, gives a small resultant peak voltage.

The magnitude of the induced pulse train is a proportional replica of the impressed ambient geomagnetic field. Finally, after integration and processing, a d.c. product becomes available for readout in magnetic *gammas* (1 *gamma*, γ, equals 10^{-5} oersted/gauss).

The average geomagnetic field in the United States peaks out at about 60,000

Fig. 5. Operational diagram of the portable electronic flux-gate magnetometer.

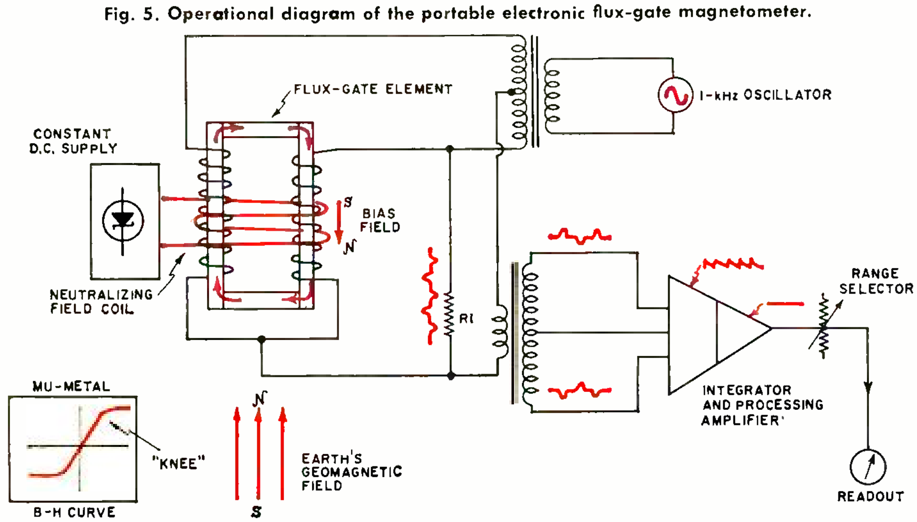

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Fig. 7. Worden gravity meter. Instrument is used to survey craters when magnetometer approach is too complex.

gammas. However, since the magnetometer operator is concerned primarily with very small field changes, part of this field must be canceled. In the case of flux-gate magnetometers, this is easily accomplished by impressing a magnetic bias field upon the sensors.

Various in-field mapping procedures are available. One of the simplest ones, the grid method, is shown in Fig. 6. The grid can be laid out by using stakes and bands. The magnetometer (or other instrument) is then calibrated at a "neutral" base station and readied for use. Finally, by taking readings at the grid's ties, specific data profiles can be plotted and connected. Fig. 6 shows that all maximum values—say, 60 *gammas*—have been connected. It provides an outline of the object of interest, its density, resting place, and so on.

As was pointed out earlier, magnetometer stations must be spaced at very close intervals in order to obtain acceptable resolution of meteoritic bodies. Magnetic anomalies of this type tend to be surprisingly low. A net *gamma* value of 60 applies to Barringer Crater's meteoritic fill materials.

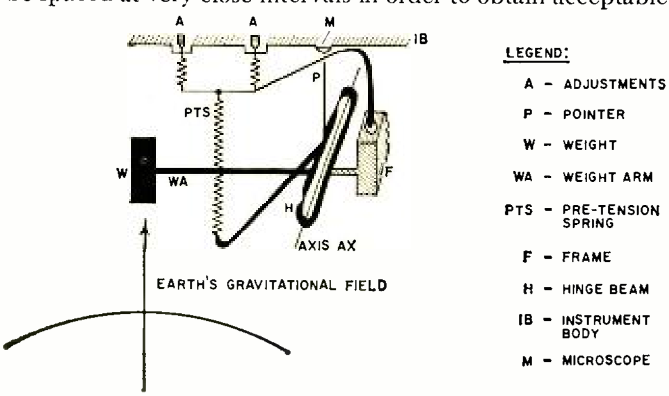
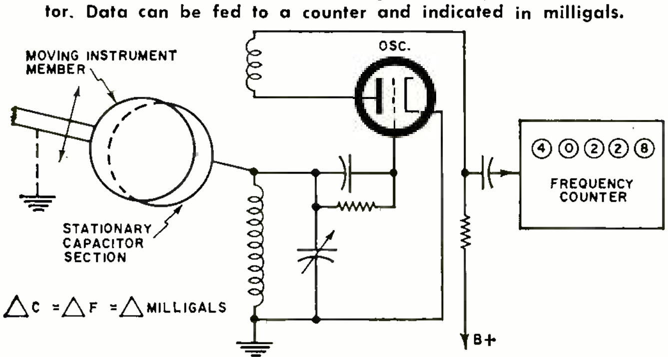


Fig. 8. System schematic diagram of the Worden gravity meter.

Fig. 9. Capacitive transducer method for data pickup from moving instrument members. In case of gravimeter, changes in capacitance at capacitor sections change frequency of LC oscillator. Data can be fed to a counter and indicated in milligals.



However, if the magnetometric approach is too complex, craters can be surveyed with the gravimeter first to obtain a general idea about its contents. The magnitude of a given subsurface anomaly is dependent upon the density, geometric configuration, depth, and location of a structure or meteoritic intrusion.

An outstanding instrument for this purpose is the Worden gravimeter (Fig. 7). This design, shown schematically in Fig. 8, is held in unstable equilibrium about the axis AX. Thus, gravity pulling on the weight or mass of the weight arm causes a slight counterclockwise rotation which decreases the angle between the pre-tension spring and the inclined arm attached to its base. That lessens the opposing clockwise moment of the spring and provides the required instability.

The readout, composed of a pointer and scale with magnifying microscope, gives indications in milligals per scale division. (The Gal, named after Galileo, is the c.g.s. unit of acceleration or 1 cm/s^2. The 1/1000th part of a Gal, mGal, is roughly one-millionth of the normal gravity at any place on earth. Most gravity anomalies seldom exceed a few milligals.)

Since gravimeters cannot be read out with ease, continuous efforts are being made to simplify this tiresome "stooping" process by using electronics. A basic pick-off principle is shown in Fig. 9. The design uses a high-frequency oscillator whose *LC* circuit receives increasing or decreasing capacitance values from an instrument-activated tuning member. The latter is grounded while the oscillator's tank system remains stationary. Thus, changes in capacitance can be expressed, *via* frequency changes, in milligals or other values of interest. The availability of low-power IC-type electronics and miniaturized digital indicators should, in time, permit considerable improvement in gravimeter operation. Currently, the instrument must be set down, leveled, and then the operator has to bow down, kneel, or sit down to read it. However, aside from the fact that gravimeters involve different physical principles than magnetometers do, the basic diagnostic grid and other profiling methods are fairly similar.

A somewhat identical situation also holds true of radioactivity-type surveys which may be performed as an augmentation to other explorations. Here, as is shown in Fig. 10, sedimentary samples are picked up and held against a Geiger counter's detection tube. Log entries are then plotted *versus* topographical and other terrain details. The illustrated station was near Barringer Crater's last exploratory drill shaft. In August, 1922, the site was abandoned after the tool reached a depth of 1376 feet and became irretrievably wedged in what is believed to be buried meteoritic mass. Barringer Crater has no radioactive features, the cosmic background being normal at 0.02 mR/h.

Electrical Investigations

In the search for conducting material bodies, such as meteorites, relatively simple electrical techniques have suggested themselves. While many meteorites have been found by using various types of "treasure locators," the use of these devices is limited to metallic bodies buried only a few feet below ground.

In general terms, electrical prospecting is based upon three characteristics of rocks: resistivity, or inverse conductivity, is one; electrochemical activity and dielectric constant are the other two.

Resistivity is of primary interest, being defined as the resistance (in ohms) between opposite faces of a unit cube of given material. Thus, if the resistance of a conducting cylinder of length, l, and a cross-sectional area, S, is R, the resistivity ρ (rho) can be expressed by the formula $\rho = RS/l$.

In the metric system, the unit of resistivity is the ohm-centimeter. Current, I, is related to an impressed voltage, V, and the resistance, R, by Ohm's (*Continued on page* 71)

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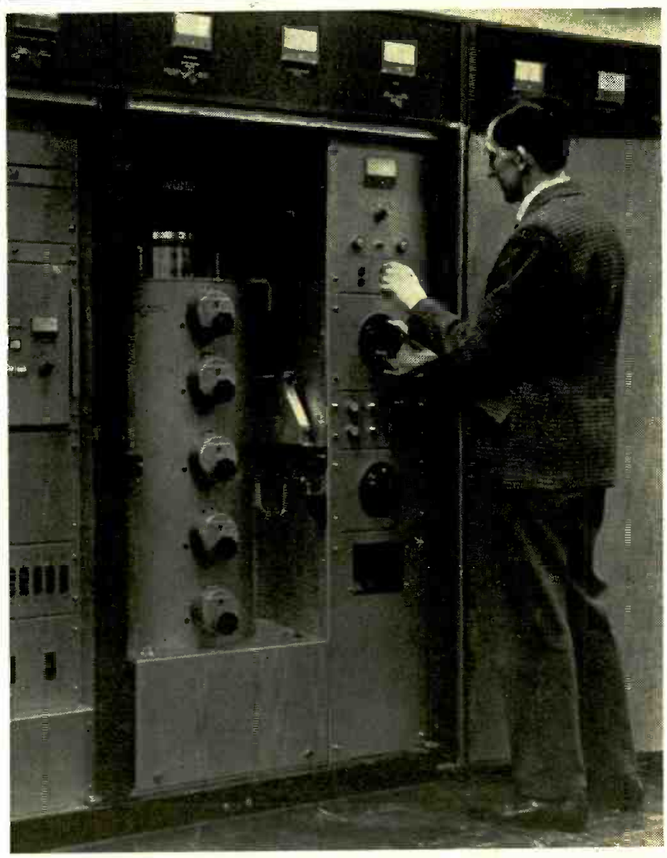
Recent Developments in Electronics

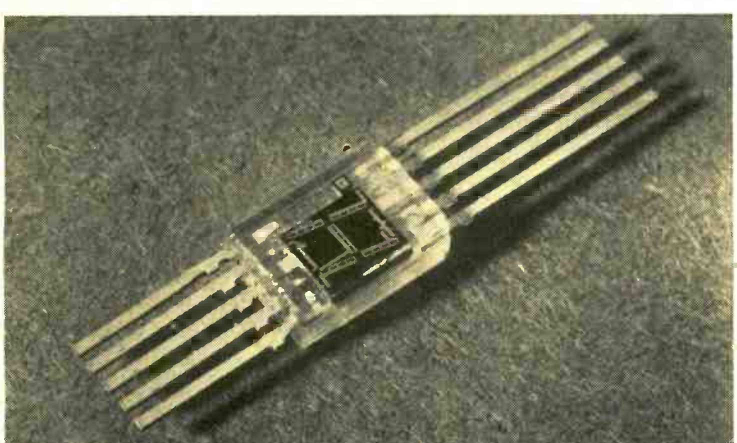
Global Satellite Station for Colombia. (Top right) Worldwide communications via the Atlantic Intelsat III satellite were inaugurated recently for the people of Colombia. The satellite earth terminal, located about 60 miles northeast of Bogota, will provide international color TV, voice, and telegraph communications. The ground station will permit tie-ins to Brazil, Chile, Peru, Mexico, United States, Italy, Spain, and West Germany. The station, with its 97-ft dish antenna, is the 17th such system built by ITT Space Communications.

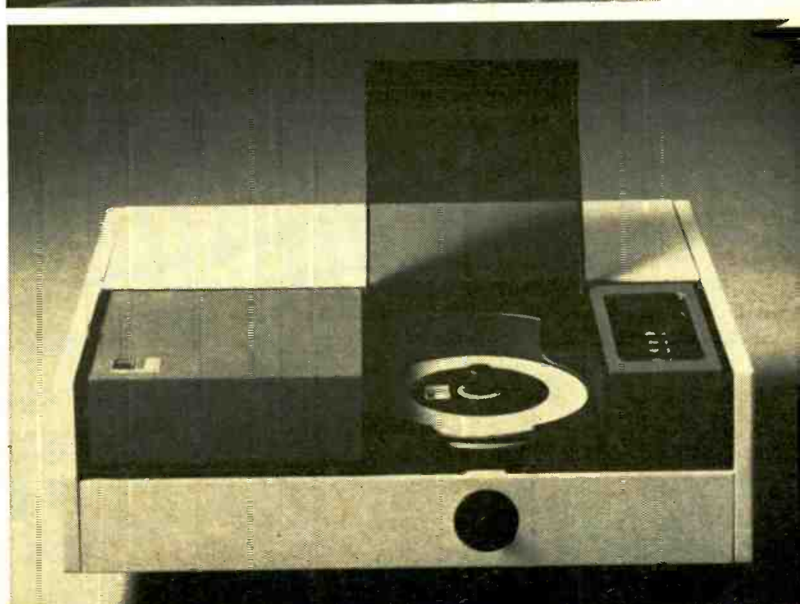


Five-cavity Klystron for Color TV. (Center) The first installation of a new specially developed 5-cavity klystron is making possible transmission of high-grade, 625-line resolution color-TV programs to London. The tubes, used as high-gain power amplifiers (25 or 40 kW) in the u.h.f. TV band, will be installed at many stations through a network that will eventually bring 3-channel color programming to all the United Kingdom. The klystron, developed by Varian Associates, is expected to be highly reliable because its r.f. cavities are integral with the tube itself; hence, unattended transmitter operation is feasible.

Monolithic Light-Emitting Diode Readout. (Below left) The first monolithic light-emitting diode alphanumeric readout to be offered commercially is shown here. The new readout is a 7-segment display developed by Monsanto. The active light-emitting areas are planar, formed by zinc diffusion into "n" type gallium arsenide phosphide wafers and emit bright, red light. The monolithic construction permits obtaining more than 200 footlamberts with only 8 milliwatts (1.6 V at 5 mA) power input per segment. Other advantages include flatness of display, elimination of high-voltage power supply, and lack of parallax. Price of display units is $12.45 in small quantities.

Electronic Video Recorder Plays Back Color. (Below right) CBS Electronic Video Recording Div. has been giving a number of public demonstrations of its color EVR unit, which plays prerecorded motion pictures on special film through color-TV receivers. The player, shown in the photo, is being made by Motorola to sell for $795. The market is expected to be schools, businesses, and institutions. A reel of the film will provide a 50-min black-and-white or a 25-min color program with sound. We found the picture quality to be excellent. A library of films for the new player is expected to be made available shortly although specific information on their price is not definite as yet.





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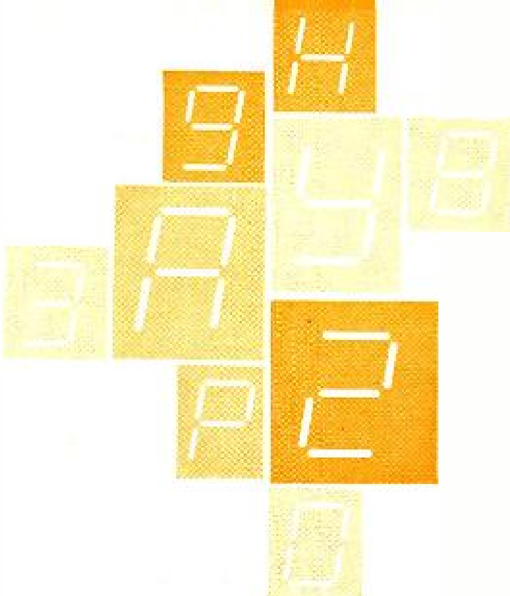


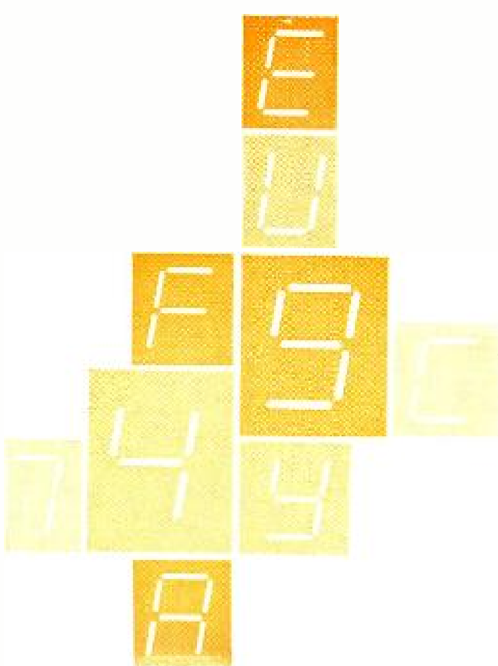
DIGITAL INSTRUMENTS YOU CAN BUILD

Part 1. Low-Cost Digital Readouts

By DONALD L. STEINBACH

Research Engineer Sr., Lockheed Missiles & Space Co.

Part 1 of a series for those interested in the design and operation of digital-type test instruments or for those who would like to build their own. This article discusses some high-performance, low-cost digital readouts.



"Digital Instruments You Can Build" is a series of articles for those who want to design and build their own digital test instruments. The series is neither a "take it or leave it" collection of equipment schematics nor a complete course in digital instrument design. It is a group of articles introducing some typical components and subsystems used in digital instruments, and demonstrating at least one design approach to creating each of several items of digital test equipment from these components and subsystems. The reader who is not specifically interested in designing or building digital instruments will find the series a rather painless way of increasing his understanding of how digital instruments function.

The first three articles of this series will deal with low-cost digital readouts, counting and decoding circuits, and integrated circuits, in that order. Treating these rather broad subjects as separate topics early in the series eliminates a good deal of repetitious detail from the equipment-oriented articles to be presented later, and gives the reader a chance to become familiar with some of the key components and subsystems before encountering them as part of a total system.

Various digital instruments will be developed, beginning with the fourth article of the series. The instruments will be introduced in order of increasing complexity or functional relationship, and will include a digital clock, a general-purpose digital event counter, a high-performance digital counter and high-speed prescaler, a d.c. digital voltmeter, an a.c. digital voltmeter, a digital ohmmeter, a digital capacitance meter, and a digital thermometer. Multi-function instruments may, of course, be derived by adding the specialized circuitry from each instrument to a basic "main frame."

Different combinations of digital readouts and associated circuitry are used in each instrument; the various configurations are interchangeable so that the builder has the option of selecting those that best suit his individual requirements. Every effort has been made to achieve an effective balance between cost and performance in all phases of the equipment designs. Comments and suggestions from readers are welcome, and additional items of equipment will be developed if sufficient interest is indicated.

DIGITAL readouts display numerical information directly in digital form rather than in analog measure as is the case with a conventional meter movement. They provide the visual data interface between man and instrument, and should be selected with that thought foremost in the designer's mind. Display devices are available in various forms: electroluminescent panels, cathode-ray display tubes, electromechanical display devices, projected image displays, edge-lighted displays, matrix displays, displays using solid-state light sources, numerical indicator tubes, segmented indicator tubes, and segmented indicator modules. Only the latter three types are considered in this article.

Numerical Indicator Tubes

Numerical indicator tubes are gas-filled, cold-cathode tubes functionally related to the familiar neon bulb. They contain at least one anode and a separate cathode for each numeral or character to be displayed.

The individual cathodes are formed in the shapes of the

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characters they are to represent and the entire formed cathode glows when voltage is applied between it and the anode. One input lead is required for each character in the tube and (normally) only one lead is energized at any given time.

The characters are perfectly formed, but only those characters included in the tube at the time of manufacture can be displayed. A minimum anode supply voltage of about 170 volts d.c. is required, and the driver circuitry must be capable of switching up to approximately 70 volts d.c. The cathodes are stacked one behind the other, giving the viewer an illusion that the characters are moving toward or away from him, and limiting the maximum viewing angle. Character height is restricted by the practical limitations on the size of the enclosing evacuated glass envelope.

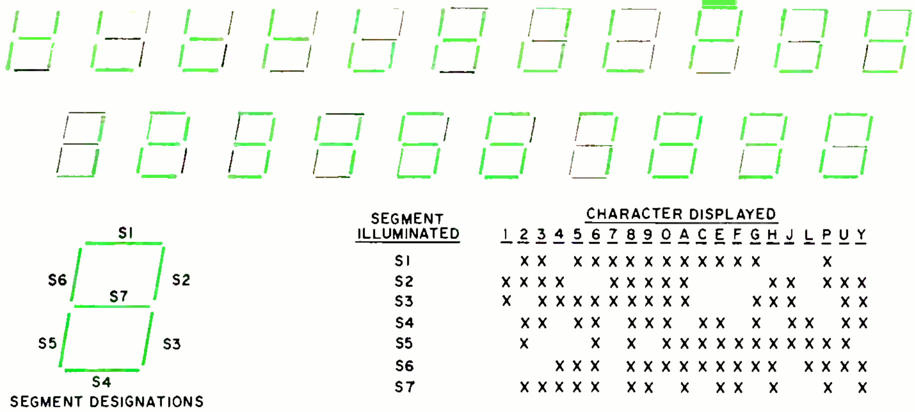

Fig. 1. Diagram showing how seven-segment readout devices are capable of displaying ten numerals (0-9) and eleven letters (A, C, E, F, G, H, J, L, P, U, and Y). Numerals 1, 5, 8, and 0 are used to represent letters I, S, B, and O, respectively.

Segmented Indicator Tubes and Modules

Segmented indicator tubes and modules consist of several individual bars or segments lying in a single plane—the usual format is seven individual segments arranged in the form of a block numeral eight (Fig. 1). The desired character is generated by illuminating the combination of segments that most closely duplicates the shape of the intended character. One input lead is required for each segment, and up to seven segments may have to be illuminated simultaneously. The indicator tubes may be incandescent, fluorescent, or cold-cathode gas-filled; the modules usually contain individual incandescent or neon bulbs.

Most of the numerals displayed by these devices are imperfectly formed, but ten numerals, a minus sign, and eleven letters (A, C, E, F, G, H, J, L, P, U, and Y) may be created with a single indicator. Since all segments are in the same plane, wide viewing angles are possible. Character height is restricted by the size of the tube envelope, but the size of a module using individual lamps is essentially unrestricted.

Typical Digital Readouts

The general characteristics of some representative digital readouts are summarized in Tables 1, 2, and 3. The vendor data sheets indicated in the "Mfr." column of these tables will be supplied by the manufacturer on request. These sheets provide complete data on the electrical and physical characteristics of each device and should form the basis for any design activity. These readouts will be used in the digital instruments described in future articles, and are selected from among the lines offered by seven manufacturers.

Driver Circuit Fundamentals

The drive circuitry associated with a digital readout must provide for energizing the appropriate numeral or segment while maintaining the readout voltage and current param-

Table 1. Available types, cost, and general characteristics of a number of numerical indicator tubes.

MFR.	TYPE NO.	CHARACTERS DISPLAYED	DIMENSIONS: CHARACTER HEIGHT (in) NOMINAL	DIMENSIONS: SEATED HEIGHT MAX. (in)	DIMENSIONS: ENVELOPE DIA. MAX. (in)	COST (1-24)	NOTES
Amperex Electronic Corp. Dist. Sales Dept. Hicksville, N.Y. 11802 Data Sheets on ZM1000/ZM1001 indicator tubes	ZM1000	0-9 and decimal point to left of numerals	0.60	1.670	0.750	$5.70*	Pins on both tubes resemble those on conventional miniature receiving tubes. May be soldered directly to PC board or used with 14-pin socket (supplied with tubes) that can either be PC board or chassis mounted. Pins are located on 0.100" centers. Tubes have dynamic life expectancy of 200,000 hours.
	ZM1001	"+", "–", "⌣", "X", "Y", "Z"	0.60	1.670	0.750	$7.35*	
Burroughs Corp. Electronic Components Div., Box 1226, Plainfield, N. J. 07061 Bulletins 1061, 1132, and 1153	B-5750	0-9 and decimal points to right and left of numerals	0.515	1.500	0.530	$6.75	Both tubes have long tinned leads for soldering directly to PC board. Leads are located on various centers (0.090", 0.096", and 0.097"). Combination pin-straightener and standoff is located between bottom of tube envelope and PC board (Fig. 2, left). Tubes have dynamic life expectancy of 200,000 hours under normal d.c. operating conditions.
	B-5856	"+", "–"	0.510	1.350	0.510	$7.15	
National Electronics Inc., Geneva, Ill. 60134. Data sheets on NL-940 and NL-941 readout tubes	NL-940	0-9 and decimal points to right and left of numerals	0.515	1.500	0.530	$7.15	Leads are located on 0.090", 0.096", and 0.097" centers and are intended to be soldered directly to PC boards. Both tubes use fairly high standoffs to raise seated height of tube to 1.500" (Fig. 2, right). Dynamic life expectancy is 200,000 hours.
	NL-941	"+", "–"	0.515	1.500	0.530	$7.15	

*Cost in quantities of 1-99.

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MFR.	TYPE NO.	CHARACTERS DISPLAYED	DIMENSIONS			COST (1-99)	NOTES
			CHARACTER HEIGHT (in) NOMINAL	SEATED HEIGHT MAX. (in)	ENVELOPE DIA. MAX. (in)		
Alco Electronic Products, Inc. P.O. Box 1348, Lawrence, Mass. 01842 Catalogue RE-698	MG-17	0-9, "—", and upper left & lower right decimal points	0.433 (max)	1.650	0.413	$4.95	MG-17 is a seven-segment cold-cathode, gas-filled tube designed for either d.c. or pulsed operation. Decimal point locations allow tube to be used upright or inverted. Colon can be formed by using upper and lower decimal points in two adjacent tubes. Intended to be soldered directly to PC board. MG-19 is a nine-segment neon-readout type.
	MG-19	0-9, "+", "—", and lower right decimal point	0.433 (max)	1.650	0.413	$4.95	
RCA Electronics Components, P.O. Box 270, Harrison, N. J. 07029. Data sheets on DR2000/DR2010/DR2020/DR2030 digital display devices	DR2010	0-9 and lower left decimal point	0.600	1.625	0.785	$5.75	Readouts are composed of individual incandescent filaments arranged on a dark background. DR2010 and DR2000 are seven-segment displays. All tubes fit standard 9-pin miniature tube sockets but can be soldered directly to PC board. Do not exhibit filament droop sometimes associated with readouts of this type. Etched glass can be placed in front of display to produce a broader stroke; a Fresnel lens will provide a larger display size. Minimum life expectancy is 100,000 hours.
	DR2020 (Fig. 3, left)	"+", "—", and "1"	0.600	1.625	0.785	$3.25	
	DR2000 (Fig. 3, right)	0-9	0.600	1.625	0.785	$5.50	
	DR2030	"+", "—"	0.600	1.625	0.785	$3.25	
Tung-Sol Div., Wagner Electric Corp., 630 W. Mt. Pleasant Ave., Livingston, N.J. 07039 Data sheet T438	DT1704B	0-9 or A, C, E, F, G, H, I, J, L, O, P, S, U, and Y	0.570	1.75 (nom.)	0.71 (nom.)	$5.30	Unique low-voltage vacuum fluorescent devices. They have 1.6 volt (a.c. or d.c.), 45-mA filament; application of 10 to 25 volts d.c. to appropriate anode causes that segment to fluoresce with a blue-green glow. Obvious advantages are low anode voltages and extremely low anode currents. DT1704B is seven-segment readout which fits 9-pin miniature tube socket. DT1705D is seven-segment readout that fits 10-pin miniature socket. DT1707B, a four-segment readout, has a standard 9-pin miniature tube base.
	DT1705D	0-9 and lower right decimal or A, C, E, F, G, H, I, J, L, O, P, S, U, and Y	0.570	1.75 (nom.)	0.71 (nom.)	$5.75	
	DT1707B	"+", "—", "1" and lower right decimal point	0.570	1.75 (nom.)	0.71 (nom.)	$5.40	

Table 2. Some of the types available, cost, and general characteristics of various segmented indicator tubes.

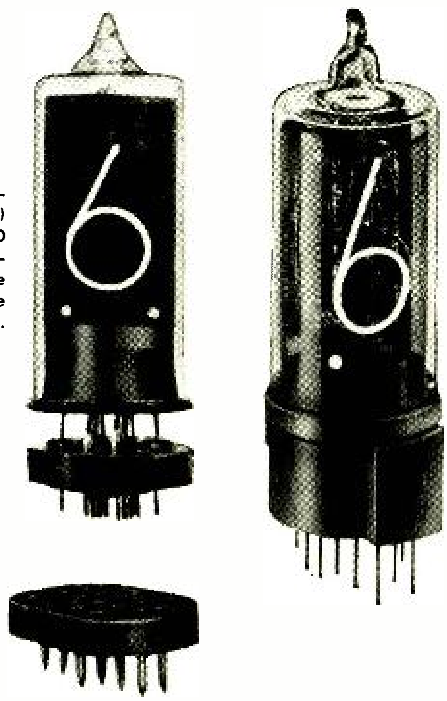

Fig. 2. Two types of numerical indicator tubes. (Left) Burroughs Type B-5750 and (right) National Electronics Type NL-940. The characteristics for these tubes are given in Table 1.

eters within specified limits. The exact configuration of the driver circuitry is a function of the logic control polarity, the readout supply voltage polarity, and the readout operating mode. Five different driver circuit configurations are required to accommodate the readouts described in this article.

Low-voltage incandescent readouts (MS-4000BR, 710-Series, and DR2010/DR2020) consist of either individual lamps or individual lamp filaments. The readout supply voltage can be of either polarity and current limiting is not required. A typical driver circuit uses low-voltage *n-p-n* transistors (Fig. 5A) to complete the return circuit to each segment when a positive voltage is connected to the transistor base resistor.

The low-voltage fluorescent readout (DT1705D/DT1707-B) requires the application of a positive voltage to the anode segment to cause that segment to glow; all of the anode segments share a common cathode. The simplest driver circuit supplies a negative voltage to the cathode and grounds the anode through a *p-n-p* transistor when a negative voltage is applied to the transistor base resistor. A more useful driver uses a *p-n-p* transistor in the common-base configuration (Fig. 5B) so that the anode is energized when a positive voltage is applied to the transistor emitter resistor. Note that the emitter source becomes part of the anode return path.

The high-voltage, cold-cathode readout driver circuits *must* include a current-limiting resistance otherwise the read-

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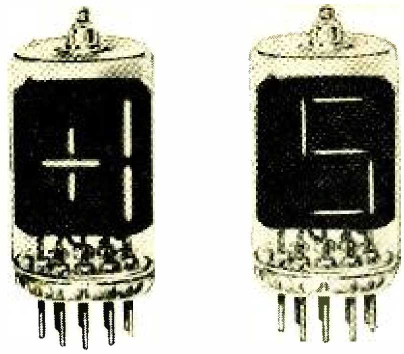

Fig. 3. Two types of segmented indicator tubes. RCA (left) Types DR2020, displaying three characters ("+", "—", and "1") and (right) DR2000, displaying numerals (0-9).

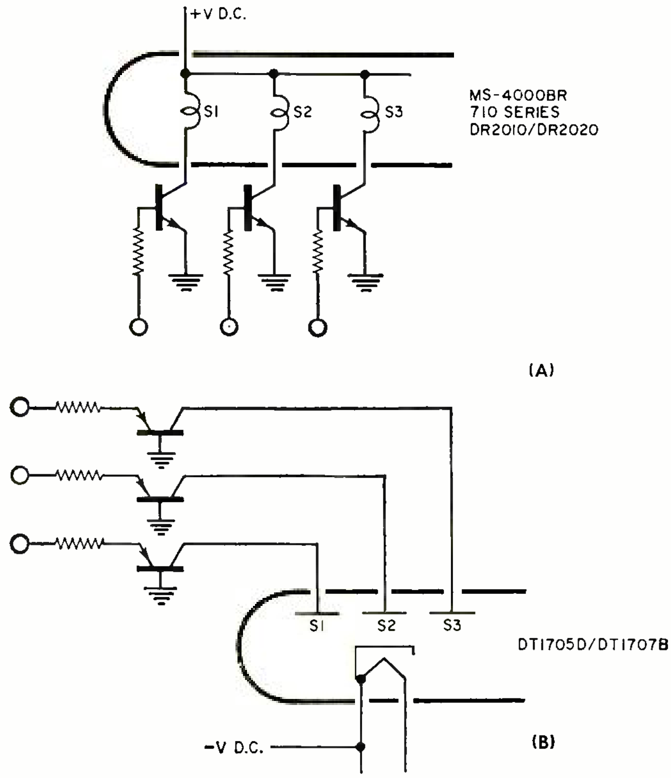

Fig. 5. Driver circuit configuration for the low-voltage (A) incandescent and (B) fluorescent segmented readouts.

outs will draw excessive current and destroy themselves. They are designed to operate within well defined current limits; the lower limit is that required to maintain a uniform glow discharge; the upper limit restricts electrode erosion and extraneous glow discharge. Permissible operation regions are defined on the applicable device data sheets published by the manufacturers.

Driver circuits for the ZM1000/ZM1001, B-5750/B-5856, and NL-940/NL-941 are similar. The ZM1000 requires a separate decimal point resistor and both the ZM1000 and ZM1001 require a priming resistor (Fig. 6B). The *Burroughs* and *National* devices do not use a separate decimal point resistor (Fig. 6A) *unless* the decimal point is energized alone. The single anode resistor sets the readout operating current, and its value is a function of the supply voltage.

The MG-17 anode current varies in accordance with the number of cathode segments that are energized, and a single anode resistor cannot be used to establish the tube operating current. Instead, identical resistors are connected to each of the seven cathode segments to establish their operating current, and higher resistances are connected to the decimal points since their current requirements are lower.

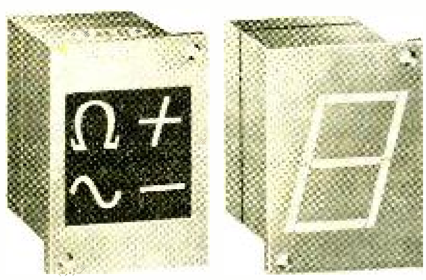

Fig. 4. Two types of segmented indicator modules. Dialight Types (left) 711 caption module, and (right) 710 numeric readout with 1-in character size.

Contrary to what seems to be popular opinion, the driver transistors used with high-voltage, cold-cathode readouts need not withstand the entire supply voltage when the transistor is not conducting. Since at least one cathode is always grounded, the d.c. potential at the anode is established at the tube breakdown or ionization voltage (typically 150 volts d.c. to 180 volts d.c.). The voltage at all extinguished cathodes needs only to be sufficiently positive (*Continued on page* 61)

Table 3. The various types, cost, and general characteristics of some available segmented indicator modules.

MFG.	TYPE	CHARACTERS DISPLAYED	DIMENSIONS: CHARACTER HEIGHT (in)	MAX. OVER-ALL MODULE (in) W	H	D	COST (1-99)	NOTES
Alco Electronic Products, Inc. P.O. Box 1348, Lawrence, Mass. 01842. Catalogue RE-698	MS-4000 BR	0-9	0.614	0.562	1.184	1.412	$6.93	Seven-segment incandescent readout modules. Red filter, bulbs, and socket are included in price. Each segment requires 40-60 mA at 3-5 volts d.c.
Dialight Corp., 60 Stewart Ave., Brooklyn, N. Y. 11237. Catalogue L-181	710-0300-005	0-9	1.000	1.250	1.750	1.506	$6.79	Modules (Fig. 4) do not include lamps, but suitable 6, 10, 14-16, and 24-28 volt incandescent lamps and 160-volt neon lamps are available from Dialight and other sources. No. 344 bulbs are used for 14-16 volt operation even though normally considered a 10-volt, 14-mA bulb. When operated at 16 volts, No. 344 bulb will last well in excess of 100,000 hours average life claimed in data sheet. No. 344 bulb available from Dialight for 55 cents each.
	710-0301-005	0-9, lower right decimal	1.000	1.250	1.750	1.506	$7.79	
	710-0302-005	0-9, upper left decimal	1.000	1.250	1.750	1.506	$7.79	
	711-1855 caption module*	*	*	1.250	1.750	1.506		

*Module provides a backlighted transparency that displays an explanatory caption. Lighted area may present a single message or may be divided into 2, 3, 4, or 6 individually switchable areas. For example, by using four separate sections, plus and minus signs may be presented one above the other, leaving two other areas for symbols or words (Fig. 4, left).

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Busy air route traffic control center
with controllers working their scan-converted radar displays.

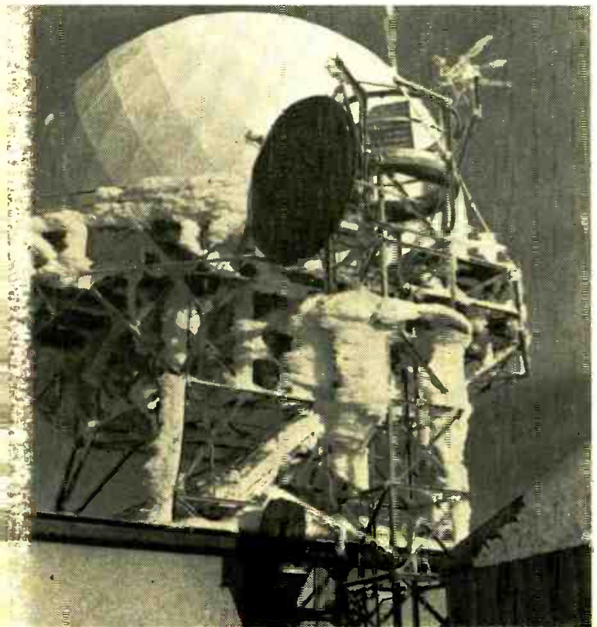
Radar in Air Traffic Control

By HOWARD L. McFANN / Project Manager
National Aviation Facilities Experimental Center, FAA

A vast intercontinental aircraft surveillance system utilizing special radar and beacon equipment is helping make flying safer. Here are technical details on equipment and its performance.

THE air traffic control specialists in our aircraft control centers and terminals depend on real-time positional data obtained from a vast intercontinental aircraft surveillance network. Each of the sites within this network is equipped with specialized radar and beacon equipment. This article gives an idea of the scope of the system and describes some of the radars being used.

The FAA's radar network includes 64 long-range radars plus 25 military joint-use systems serving the 22 air route traffic control centers located in the United States and such far away places as the Canal Zone, Guam, Honolulu, San Juan, and Alaska. Complementing the enroute system are 120 FAA and 37 military-terminal radars providing short-range coverage at landing fields around the world. Today's radar complex provides approximately 90-percent radar coverage at altitudes of 24,000 feet and above, and 60 percent for all Instrument Flight Rule (IFR) air traffic at the lower altitudes.



An enroute radar antenna tower in northwest U.S. The radar antenna is protected by the large plastic geodesic dome. The smaller antenna in front is used for a microwave link.

Skilled Technicians Needed

It is obvious that the installation, maintenance, operation, and modernization of the FAA's radars require thousands of capable technicians. The men selected for this work must have strong interests in electronics backed up by either three years of formal training or experience in some related electronics field.

Qualified candidates are usually hired at the GS-6 or GS-7 Apprentice level and immediately begin specialized training leading toward the GS-11 Journeyman grade. Preparation includes on-the-job training under the supervision of experienced co-workers, participation in the excellent home-study program offered by the FAA Academy, and resident courses in the Academy's classrooms at Oklahoma City, Okla.

Specialized Radars Used

Although each of the sites in the FAA's network is equipped with the air traffic control radar beacon system (see "Air Traffic Control Transponder Identifies Radar Targets" in the February issue of ELECTRONICS WORLD), radar is considered the primary source of positional data. This is because aircraft can be "seen" without their having to carry cooperative transponders. General aviation pilots, operating on limited budgets and restricted in the amount of equipment

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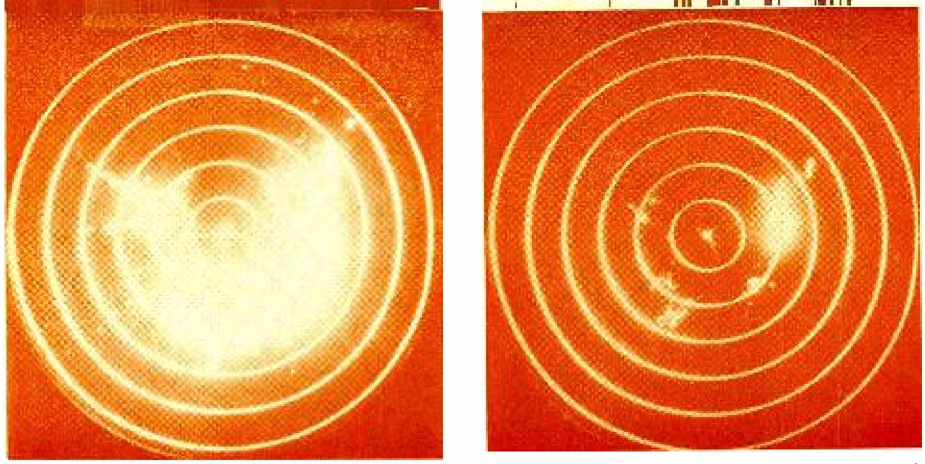

These comparison photos of the radar display show the dramatic reduction of weather clutter with circular polarization.

their light planes can carry, consider this an important factor in radar's favor.

The equipment installed at the sites can be categorized by the operational function performed. The far-flung air routes surrounding the traffic control centers are served by the Administration's Air Route Surveillance Radars (ARSR series) and, where economically feasible, joint-use military equipment. The enroute radars have the high power and low pulse repetition rates needed to provide long-range coverage out to 200 nautical miles.

The terminals are served by the Airport Surveillance Radars (ASR series). In this application, power output is not as important as range accuracy and high data-refresh rates. Several terminals are also equipped with a high-resolution radar, called the Airport Surface Detection Equipment (ASDE), to observe taxiing aircraft and ramp vehicles. The operating characteristics of representative types of these systems are listed in Table 1.

Enroute System

The high power output of the ARSR-2 is obtained from an amplitron tube. Although similar to magnetrons in construction, they are driven rather than being self-oscillating. The 450-kW peak pulse power to drive this tube is obtained from a conventional magnetron. A design feature permits bypassing the amplitron in case of failure so that the station can stay on the air with a 10-dB reduction in power.

A *cosecant*-squared antenna assures radar coverage of both high- and low-flying aircraft. The slowly rotating antenna is protected by a rigid plastic dome which absorbs a negligible amount of power.

The antenna feed system has been designed so that power can be radiated with either linear or circular polarization. Tests have confirmed the effectiveness of the circular-polarized mode in reducing weather clutter by as much as −15 dB. This is illustrated by the comparison photographs above.

A low-noise parametric amplifier boosts the weak radar echoes and distributes them to Moving Target Indicator (MTI) and normal radar receivers. The MTI receiver is used to cancel stationary and slow-moving targets within the region of ground clutter while the normal receiver provides the sensitivity to pick up distant targets. Performance in the MTI range is enhanced by using a staggered pulse repetition frequency to raise the "blind" speed.

Other than for maintenance purposes, the detected video is not displayed at the radar site. Rather, it is transmitted along with triggers and antenna-servo signals *via* microwave links to the air route traffic control center for use by the controllers. Each center is fed by several strategically located long-range radars to provide coverage throughout its operational boundaries.

At the center, the range and bearing radar video is converted into a television-type display by a high-resolution (945 lines) scan converter. The advantages of the television

Table 1. Comparative characteristics of the three types of radar systems used for air traffic control.

	ENROUTE SYSTEM (ARSR-2)	TERMINAL SYSTEM (ASR-5)	AIRPORT (ASDE-2)
Transmitter			
Frequency Band	L (1300-1350 MHz)	S (2700-2900 MHz)	K (23.6-24.5 GHz)
Peak Power Output	4.5 MW	400 kW	50 kW
Pulse Width	2.0 μs	0.83 μs	0.02 μs
Pulse Repetition Rate	360 pps	1030 pps	14,400 pps
Receiver			
Sensitivity (dBm)	110 MTI, 111 Norm.	107 MTI, 109 Norm.	80
Noise Figure	4 dB	4 dB	25 dB
Video Bandwidth	3 MHz	2 MHz	50 MHz
Anti-clutter Circuits	STC, IAGC, FTC	STC, IAGC, FTC	STC, IAGC, FTC
Antenna			
Scan Rate	6 r/min	15 r/min	60 r/min
Gain	34 dB	34 dB	34 dB
Polarization	LP, CP	LP, CP	LP, CP
Beamwidth	1.2° H, 3.8° V	1.5° H, 5.0° V	0.25° H, 1.0° V
Type Reflector	csc^2	csc^2	Parabolic
Maximum Range	200 nmi	60 nmi	4.5 nmi

Notes: MTI = moving-target indicator; STC = sensitivity time control; IAGC = instantaneous auto. gain control; FTC = fast time constant; LP = linear polarization; CP = circular polarization; csc^2 = cosecant squared.

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Terminal-radar site showing the cosecant-squared antenna reflector. The horizontal antenna mounted above the radar reflector is the L-band antenna used for radar beacon system.

display are brightness and storage. The brighter radar picture enables the controllers to function more efficiently with higher background light in the control room, and the storage feature facilitates identification of aircraft trails. The trails, formed by simultaneous display of successive hits, indicate aircraft course and speed.

Terminal System

Radars used in the terminal area range out to 60 nmi with 400 kW of peak power. An S-band magnetron feeds a *cosecant*-squared antenna that gives reliable vertical coverage up to 20,000 feet. Antenna rotation is a faster 15 r/min. To assure an adequate number of hits per scan on targets, the mean pulse repetition rate is set for 1030 pulses per second. The equipment design includes all of the desirable features found in the enroute radars, such as circular polarization, low-noise paramps, and MTI/normal receivers.

Unlike its enroute counterpart, the ASR's are usually located at the airports, close to where their data is to be observed. Therefore landlines can be used to transmit the radar video to the display area.

Indicators are installed in both the Instrument Flight Rules control room and the tower cab. The IFR controllers use, depending on the facility, either conventional "dark-tube" PPI scopes or the scan-converted displays. Special high-brightness indicators are installed in the glassed-in towers to overcome the high ambient light. This display system, called the BRITE-1, also operates on the scan-conversion principle.

Airport Surface Detection

At present, only eight terminals have ASDE capability. Operating in the *K*-band with a peak power of 50 kW, the equipment distinguishes aircraft and vehicles on the runways and taxiways. This remarkable feat is achieved by radiating a 20-nanosecond pulse through an extremely narrow-beam parabolic antenna. Special wide-band receivers and video amplifiers prevent deterioration of the returned signals. For example, the receiver i.f. bandpass is ±3 dB from 87.5 to 172.5 MHz. Over-all video bandpass is 50 MHz.

The fine-grain resolution of the display is such that aircraft types can be identified by their outlines. However, system performance degrades during excessively damp or rainy weather due to absorption and scattering of the r.f. energy. Unfortunately, it is at these times that the ground controller most needs the system.

Future Developments

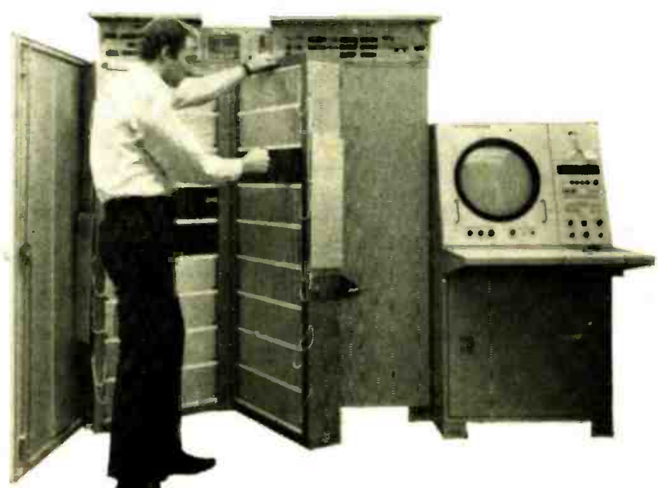
The FAA is constantly exploring ways to improve performance of its air traffic control radar systems. An "in-service-improvement" program, for instance, examines new techniques in radar detection. The more promising developments are evaluated at the Administration's National Aviation Facilities Experimental Center (NAFEC), located near Atlantic City, N. J., or in the field. Now being examined is the application of special circuitry to radar receivers to improve the clutter-rejection capabilities of radar.

Long-range programs include replacements of the older radars with improved designs. A modern solid-state terminal radar, the ASR-7, is now in final stages of test.

The most ambitious program underway is automation of the control function to ease the workload on the controller and increase utilization of our airspace. As part of this plan, the radar video is first digitized, then processed into target report messages for transmission over telephone lines to the center computer. This advanced system is located at one of the radar sites feeding the Jacksonville, Florida air route traffic control center. ▲

High-resolution ASDE radar display. Note the clear demarcation of the buildings, runways, and ramps of the airport.

The digitizer now being installed at enroute radar sites.



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The Integrated Circuit–Its Future

A projection into the 1970's for linear, digital, and large-scale integration. Its future impact on engineers, technicians, and managers is also explored.

IF the automobile had improved over the past 10 years in the same degree as the integrated circuit, the average car would now sell for $10 and cruise at 10,000 miles an hour. This analogy may appear a bit fanciful, but it serves to illustrate, in a way that most graphs and tables cannot, the remarkable growth and vigor of the integrated-circuit industry. Since the early 1960's, total integrated-circuit business has increased by a factor of ten and the complexity of integrated circuits has doubled each year.

According to Dr. Robert Noyce, a pioneer in the development of integrated circuits and now president of *Intel Corp.*, this trend will continue if economic motivation exists and some process limitations can be overcome. An area where substantial economic return is foreseen is the semiconductor memory. This component promises to become the most significant member of the computer-memory family in the 1970's.

Dr. Noyce believes that one limitation is the optical resolution of the photo-processing techniques used today. He sees an approaching plateau in the field while new methods are being developed. A second limitation is finding a "universal" high-complexity circuit building block. "Although some progress has been made. . . . , solutions are not yet adequate." Still, Dr. Noyce is most optimistic for the future, especially in the field of semiconductor memories.

In the view of Jack Kilby, Assistant Vice-President of *Texas Instruments*, who is often credited with the invention of the integrated circuit, with the exception of the operational amplifier, no similar versatile monolithic block has been developed and none is now in sight. "If future progress in integration is to occur, substantial changes in the entire process by which electronic equipment is designed and manufactured will be required. Emphasis must shift from the stable production of high rates of standard parts to a highly flexible process capable of designing an almost infinite variety of parts, most of which will be produced in extremely small quantities."

Linear Integrated Circuits (LIC's)

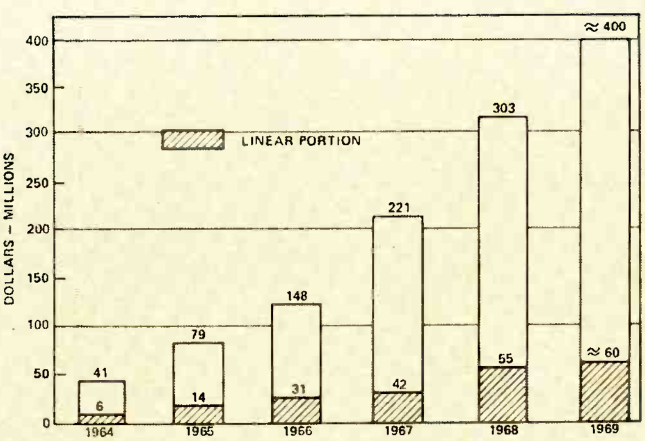
As the following articles in this Special Section will show, applications for LIC's are virtually unlimited. They are used as operational, power, sense, r.f.-i.f., and microwave amplifiers, multipliers; comparators; voltage regulators; etc. Linear IC's now constitute roughly 15% by dollar volume of the total integrated-circuit market (Fig.1). In the past few years, the annual dollar growth rate has been approximately 30% while the annual decline in price has been about the same percentage (Fig. 2). This performance should continue through the early 1970's.

Present linear-IC sales break down as follows: 45% military, 35% industrial, and 20% consumer. It is expected that the relative percentage of military sales will decline, the relative percentage of consumer sales will rise rapidly, and the fraction of the market held by industrial applications will increase at a moderate pace.

With increasing use of the LIC it is expected that household appliances will be more sophisticated and will require far less maintenance. Automobiles may have a central processor to control virtually all the functions of the vehicle, including fuel injection, ignition, voltage regulation, and engine electronics. In comparing products that use IC's with those that do not, it is safe to say that the former will provide more advantages for the same selling price.

In the industrial market, LIC's will reduce labor and engineering costs by simplifying the design cycle, decreasing the number of parts purchased and assembled, and cutting down engineering and testing times. In military gear, component cost is usually such a small percentage of total equipment cost that cost savings are not a major consideration.

Fig. 1. Growth of U.S. monolithic IC industry (after Motorola).



Photomicrograph in background at top of this page is part of new Fairchild μA757C, a linear IC employed for high-gain i.f. amplification with a.g.c. It can be used in AM, FM, or communications receivers. OEM price is under $5.

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Fairchild Semiconductor contends that the number of new LIC's introduced each year will double for the next several years. The new circuits will be faster and cheaper, will operate at higher frequencies, and will generate more power. Custom designs will become more common and, in a few years, there will be large-scale integrated (LSI) linear devices and circuits with high-voltage (300 V) and high-power-dissipation (15 W) capability. (With the low-cost packages now available, one is limited to about ½-watt dissipation per chip.) Other advances will include chips that contain both a transducer and an LIC, and individual trimming of resistors on the chip for custom adjustment of parameters.

Digital Integrated Circuits (DIC's)

The DIC was first used in military computer systems where reliability and small size, not cost, are prime concerns. As the price of these circuits started to decline, they were used more and more in what is today their major market—commercial data-processing systems. With further declines in price, they entered the field of industrial application, such as process control, instrumentation, and communications systems. As prices continue to decrease, it is certain that DIC's will be found in a number of consumer products. The industry has been built and will continue to build on high volume and low cost.

MSI Building Blocks. An MSI (medium-scale integration) circuit is frequently defined as one with a complexity of greater than 15 gates. Discrete gates are rapidly being replaced by MSI building blocks that perform entire functions—multiplexing, decoding, counting, etc. In the future it is expected that most of the logic circuitry found in digital systems will consist of these MSI building blocks.

MSI is beginning to encroach upon territory that traditionally has been the exclusive province of the LIC. Two examples are digital frequency synthesizers, which are finding application in military systems, in AM-FM radios, and digital voltmeters. These digital devices are more stable and easier to control than their linear counterparts.

A comparison of the average cost per gate using standard MSI circuits with that of conventional diode-transistor logic (DTL) and transistor-transistor logic (TTL) is shown in Fig. 3. As new applications are found for the DIC and processing improvements are made, the number and complexity of standard MSI building blocks will continue to grow. Efficient design of MSI circuits can only be realized by close liaison between system and logic designers and IC engineers.

Memories. At present, only a fraction of one percent of all digital IC's are used as memory devices. But by 1976, *Fairchild Semiconductor* estimates that the semiconductor memory market will be close to a half-billion dollars, and by the end of the decade, about 70% of all memory devices will be DIC's.

Semiconductor memories can be either bipolar or MOS. The bipolar devices are superior to magnetic memories in one important respect—speed. Increased speed is needed beause magnetic memories are significantly slower than the latest logic circuitry. MOS memory devices, although at present no faster than magnetic memories, are now competitive with them in both price and performance. In the near future, the MOS devices will be less expensive for a large number of applications.

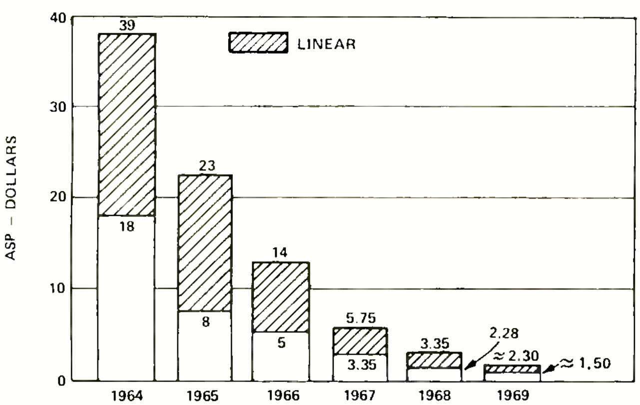
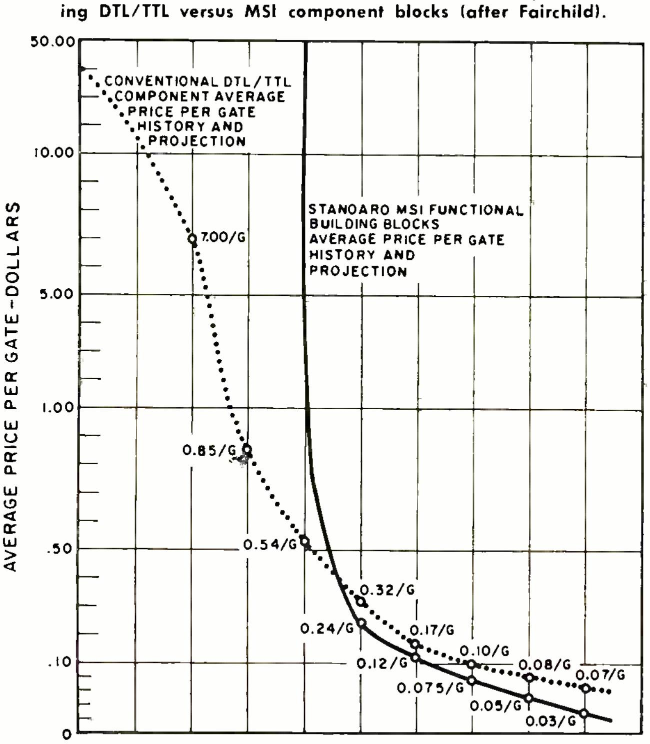


Fig. 2. The decline in the average selling price (ASP) for monolithic integrated circuits according to Motorola figures.

Fig. 3. Comparison of average selling price per gate using DTL/TTL versus MSI component blocks (after Fairchild).



Large-Scale Integration (LSI)

An LSI circuit is usually defined as a monolithic device with a gate complexity greater than 100. One LSI chip usually represents an entire subsystem or system. Because the modern design trend is towards higher complexity and smaller size, the LSI field is growing at an exceptionally fast rate. Some predict that by 1972 dollar volume will reach 60 million.

Invariably, LSI dictates custom design. Extremely intricate and built to exacting specifications, an LSI circuit is, as a rule, good for just one particular application. Hence, only a few circuits of LSI complexity, primarily memories, have been standardized.

Most LSI circuits in operation today contain MOS devices; bipolar LSI circuits are used when the application requires high speed. In the very near future, several companies will introduce LSI devices using silicon-gate technology, a variation in the structure of MOS devices. The silicon-gate circuit has a number of advantages over the MOS circuit, not the least of which is its compatibility with bipolar circuits.

There is a limit to the complexity of an LSI structure. To increase circuit complexity, it is usually necessary to increase the size of the chip. For a given fabrication technique, however, as one increases chip size, chip yield per silicon wafer decreases and cost rises. (At present, an economically feasible LSI chip is roughly 130 mils on a side.) Since this problem is inherent in the technology, it can never be entirely eliminated, but its severity can be reduced by improved processing.

A second difficulty is the customer-interface problem. The design and implementation of any custom LSI circuit

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demands a technical discussion between buyer and manufacturer concerning any problem unique to the circuit in question. Because such a dialogue takes time and requires highly skilled personnel on both sides, it severely restricts the number of customers any one manufacturer can handle. To help solve the problem, semiconductor manufacturers are now using cellular building blocks and computer-aided design techniques.

Hybrid Technology

Although the preceding observations were directed to monolithic technology, it should not be inferred that thin-film or thick-film hybrids are out of the picture. For small integrated-circuit production runs, the hybrid approach is often the most economical. In some applications, like microwave circuits, the hybrid IC is currently the only practical approach. A number of companies are active in the development of new materials, processes, and chips for the hybrid field. This activity should continue into the '70's.

Impact on Personnel

Integrated circuits are changing the kind of work an engineer does and the kind of engineering jobs available. Because it is easier and cheaper to make an integrated-circuit transistor than passive components like capacitors or inductors, the circuit man must adopt a new design philosophy. With discrete technology, it was desirable to use few transistors; with integrated circuits one avoids inductors and capacitors and uses as many transistors as possible.

The engineer who uses IC's is very often more of a systems designer than a circuit designer. He has to work with block diagrams, subsystems, and systems, rather than with components and devices. As the IC market expands, and as IC's replace many electromechanical and mechanical devices, the demand for engineers, particularly electrical engineers, will propably increase. Mechanical engineers will find it necessary to learn about IC's simply to keep up with changes in package design and thermal problems.

The technician will use mini-computers and time-sharing terminals to perform fairly complex simulation instead of the traditional breadboarding. Testing and troubleshooting will be easier since the technician will work with blocks and subsystems rather than with components. In general there will be more variety and less drudgery. Higher levels of knowledge will also be required.

The impact of the integrated circuit on management will be far-reaching and, in some cases, profound. A great many managers, including those in non-technical fields, will have to become familiar with the advantages and capabilities of these circuits. A smaller, but still significant number, may be compelled to reorganize and reorient their companies if they are to remain competitive.

A manager must now think more in terms of systems and subsystems. He must be better organized if he is to handle the enormously increased flow of information and must be less reluctant to change his product when technological innovations call for such a change. The impact of LSI on systems manufacturers will be especially great. If a systems manufacturers uses LSI, then much of his systems development may be done by semiconductor companies outside of his plant. Such an arrangement will place greater demands on him as a manager. He will have to "manage" people not on his payroll and establish close liaison with the semiconductor manufacturer. Sending a salesman over to take an order will not do; the manager himself will have to become more intimately involved with operations at every stage. ▲

Differential Comparators

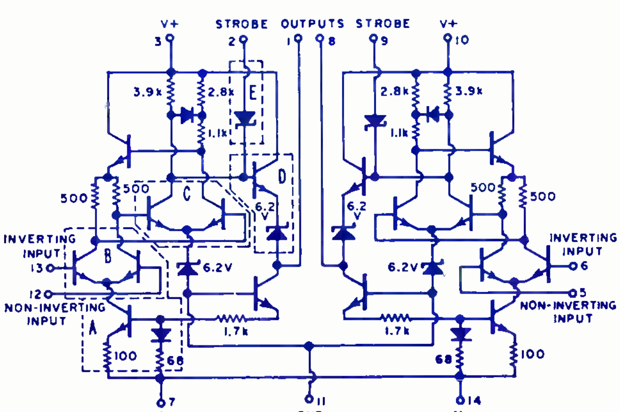
By RICHARD F. BRUNNER / Sr. Applications Engineer, Motorola Semiconductor Products Inc.

An IC differential comparator is a high-gain voltage amplifier, with differential input and single-ended output, which is primarily designed to convert analog (or linear) signals into digital logic levels. Typically, a comparator contains two or more stages of gain with translation and buffering (see figure).

The characteristics of the differential comparator lend themselves to many diverse applications. Originally the comparator was designed to be used as a core memory sense amplifier. However, it takes two comparators (both on the same chip) with their outputs tied together, and a resistor divider network to provide the rectification and reference voltage, respectively, required to perform the sense amplifier function.

The differential comparator also makes an excellent differential line receiver when digital data has to be transferred from one cabinet or "black box" to another which may be several hundred feet away. One of the most basic uses of the comparator is as a level detector.

The two stages of gain are accomplished with a differential am-



plifier. One of the outstanding features of this amplifier is its ability to amplify a difference signal across its inputs and to attenuate signals common to both inputs. This type of amplifier also exhibits excellent balance; both halves of the amplifier are matched so that electrical symmetry exists between both halves of the circuit. This balance tends to enhance common-mode rejection (ratio of differential gain to common-mode gain) and gain linearity. Excellent electrical tracking is also maintained, that is, balance is maintained with variation of signals, power supplies, and temperature.

In many comparator applications the input to the first amplifier stage can swing several volts positive and negative. This requirement, along with the current source (A) technique used with differential amplifiers, necessitates that both a positive and negative power supply be used.

The input amplifier (B) is followed by a second differential amplifier stage (C) with a single-ended output as compared to the double-ended (differential) output of the first stage. The output of the second stage has a d.c. level several volts above ground. Consequently, an emitter-follower and zener diode (D) are used to level-shift the output downward to make it compatible with DTL or TTL saturated logic. The emitter-follower output also functions as a buffer between the output of the comparator and the load it is driving.

The strobe input (E) of the comparator performs a logic "and" function; the comparator output will go high (+3 volts) only if a positive signal is applied to the non-inverting input or a negative signal applied to the inverting input at the same time the strobe input is made high. If a negative signal is applied to the non-inverting input or a positive signal to the inverting input at the same time the strobe is high, the comparator output will remain low. Hence, only those signals that are present during the time the strobe is high are detected. The strobe can be disabled by tying its input high ($\geq$3.0 volts) or it can be used to hold the comparator output low ($-$0.5 volt) by tying its input to ground.

Other applications include Schmitt trigger, pulse shaping, zero-crossing detector, oscillator, and a window discriminator, to name just a few. ▲

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Monolithic LIC's for Consumer Products

By RICHARD A. SANTILLI / Manager, Linear Applications, Solid State Division, RCA

For the home-entertainment or consumer market, the 1970's will truly be the decade of integration as IC's become more widely used in TV's, radios, audio, and automotive equipment.

THE small-signal electronic circuits in consumer products have been steadily evolving to linear integrated circuits (LIC's). At present, major inroads have been made in home-entertainment products, specifically color television. Before discussing the technical details, a brief survey of the market and the general requirements for integrated-circuit (IC) penetration is warranted. The total consumer market is represented by many products, a partial listing of which is given in Table 1. A few of these products are more readily converted to IC's; therefore, it is easier to assess their requirements, timing, benefits, and economics.

As an example, it is possible to *partition* a radio or television receiver, examine a functional block of either tube or discrete solid-state electronics, and estimate fairly accurately its cost and thus determine what the IC must contribute in order to penetrate this market in high-volume usage. All that is done is to replace one set of electronics performing a function with another set capable of doing the same job.

The picture changes, however, when similar comparisons are attempted with mechanical or electromechanical

Table 1. Listing of consumer products with LIC potential.

MAJOR CATEGORY	TYPICAL APPLICATIONS OR PRODUCTS
TV	Small-signal processing in color and black-and-white receivers
Radio	AM, AM-FM in console, table, portable, or automotive receivers
Audio	Mono, stereo, tape equipment
Household Appliances	Washers, dryers, ovens
Musical Instruments	Organs
Visual Equipment	Projectors, cameras
Automotive	Heating and air-conditioning controls, anti-skid devices

systems, such as washers or dryers. Here, simple mechanical timers (with associated switches) provide a great deal of power switching and timing at low cost. However, as features are added, mechanical complexity and cost increase while reliability decreases, until a point is reached where solid-state control makes sense. Although it is realistic to predict that IC's will make sizable inroads in this market, the timing is difficult to predict because of consumer's demands and desires and the need for continual systems development for the best performance/cost ratio.

In any event, predicated on penetration into the first three domestic market areas shown in Table 1, it is anticipated that the growth pattern for monolithic LIC's will be:

	1969	1971	1973
Units (millions)	9.7	34	100
Dollars (millions)	8.0	29	75

Today, for an LIC to enter these areas involves well-defined requirements. Specifically, these are:

1. LIC Contributed Value: The consumer market is an extremely price- and cost-competitive market. Unless the IC provides functions not presently included in the system, it is simply taking over a job handled by tubes or discrete transistors. It is unlikely that IC's will penetrate the market in quantity unless it can be projected that volume-usage pricing would be competitive. Although a portion of a circuit considered for integration can be easily assessed relative to its cost on the basis of pellet size, circuit complexity, and package, its true cost cannot be determined until user specifications are fixed and yields established. Even with computer-aided design techniques, this problem cannot be resolved in many critical circuits until the product is made, because of complex a.c. testing requirements. Because of these stringent contributed-value requirements, consumer IC designs tend to be "custom" rather than general-purpose circuits.

2. System Simplicity and Reliability: The advantages of system simplicity and reduced component and interconnect count are established facts. Reduced inventory requirements provide a significant advantage to the user. Improved reliability is implied with the simplified IC system, provided rigid reliability criteria are applied to the IC. We have established mechanical and environmental require-

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ments (including operating and storage life) which are at least as severe as those for a single discrete bipolar device intended for the same function. The final reliability can only be established, however, in the ultimate system where all malfunctions and maladjustments can occur.

3. Circuit Advantages: Monolithic technology provides inherent circuit advantages relative to component matching (active or passive), temperature compensation, and voltage regulation that permit the ultimate system performance and IC stability.

4. Serviceability: This is being attained in more complex systems, such as TV receivers, through the use of sockets and/or replaceable or plug-in boards. The latter approach seems to be especially popular.

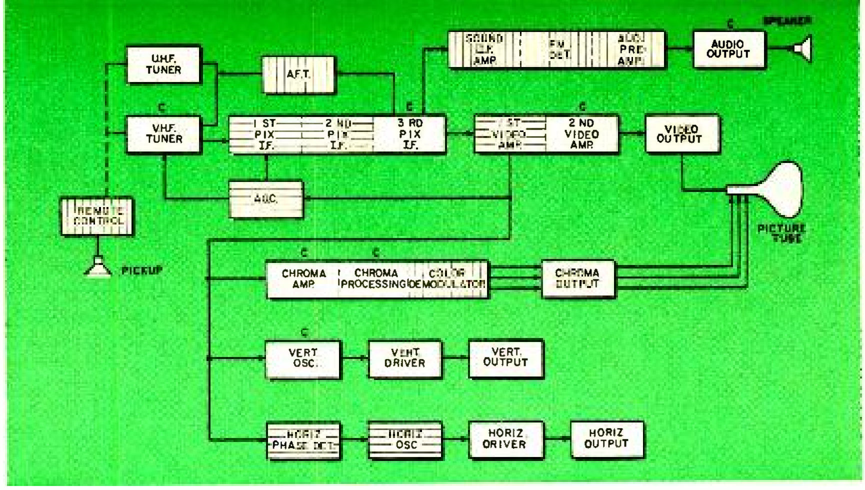


Fig. 1. Block diagram of color-TV set with lined blocks showing presently available IC's and blocks marked with "C" indicating other circuitry now capable of being integrated.

Television Receivers

As mentioned earlier, major inroads have already been made in this area. The major effort has been directed towards color TV, with black-and-white receivers benefiting from the development work and a few of the compatible circuits. Exclusive of the u.h.f. tuner, present-day monolithic technology is adequate to develop IC's capable of performing all other small-signal functions in a color-TV receiver. The task of partitioning the receiver for integration presents a difficult and sometimes arbitrary problem. It is naive to believe that one such system will suffice. More likely, a few systems will evolve and intercombinations will permit many options. The vertically lined functional blocks shown in Fig. 1 indicate areas in which reasonable industry agreement exists on partitioning. IC's are now available to handle these functions and those of the horizontally lined blocks. Areas marked "C" indicate other circuitry capable of being integrated today.

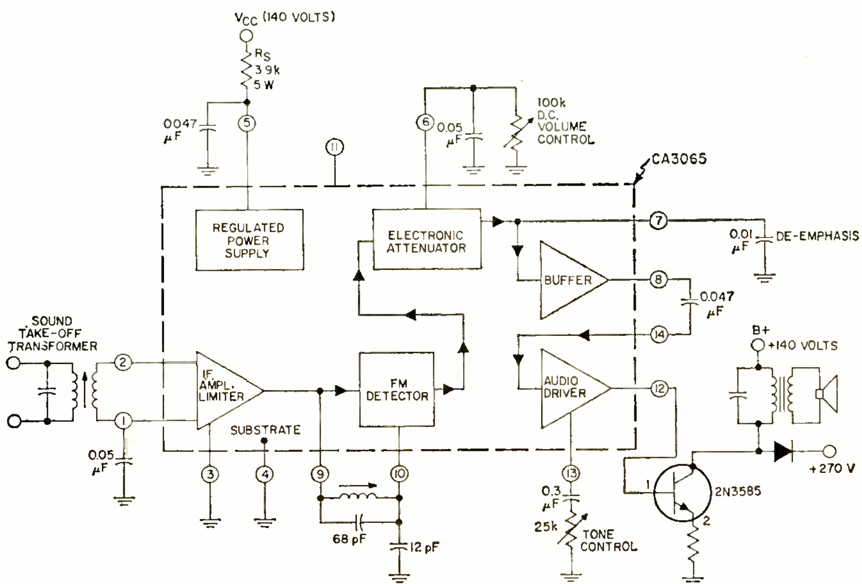
Exclusive of the replacement of a discrete stage with a simple IC (a differential amplifier), the first LIC for television was introduced in 1966. The circuit, the present CA3014, consists of a sound-i. f. amplifier/limiter, an FM discriminator, and an audio emitter-follower output. This IC started in production in the *RCA* CTC25 chassis, and replaced the commonly used tube i. f. amplifier and quadrature detector. Since then, the sound-i. f. amplifier has progressed through several stages, each successive one incorporating additional circuitry while providing more contributed value with fewer peripheral components.

Today's sound-i. f. amplifier, the CA3065, is shown in block form in Fig. 2. By comparison with the previous circuit, this IC has better limiting sensitivity (200 μV maximum as compared to 400 μV maximum at 4.5 MHz), plus a zener power supply. This provides a stable supply for the chip while simplifying the power-supply decoupling network by eliminating an electrolytic capacitor. In addition, the conventional double-tuned discriminator transformer is replaced by a single-tuned coil, an isolated biased audio amplifier with 20-dB gain replaces the emitter-follower, and a d. c. volume control following the detector is incorporated into the design. The d. c. volume control permits the use of a single unshielded wire to the volume-control potentiometer which may be bypassed, if necessary, for hum suppression.

A remote-control amplifier and an automatic-fine tuning (a. f. t.) circuit were quick to follow the sound-i. f. amplifier in 1967. A block diagram of the CA3035 remote-control system is shown in Fig. 3. The IC is an ultra-high-gain (132 dB at 40 kHz), low-noise amplifier consisting of three separate amplifier sections. The single-ended amplifiers are normally capacitively coupled with small-value capacitors to provide the required low-frequency roll-off. Internal bias circuits establish stable operating conditions for amplifier sections Nos. 2 and 3 as a function of supply voltage and temperature; amplifier section No. 1 is stabilized by d. c. feedback from terminal 3 to terminal 1. The unit is supplied in a 10-lead, TO-5 package. Because this circuit represents, basically, the receiver portion of the remote-control system (up to the relay drivers), it is compatible with electromechanical or the more recently introduced all-electronic systems, and thus has not suffered from technical obsolescence.

As in the case of the sound-i. f. amplifier, automatic-fine-tuning systems have progressed through several generations since their introduction. Basically, the functions on the chips have remained the same; a biased wide-band i. f. isolation amplifier/limiter (up to 60 MHz), an FM-detector network, and an error-voltage amplifier. However, per

Fig. 2. Block diagram of the present sound-i.f. amplifier, the CA3065.



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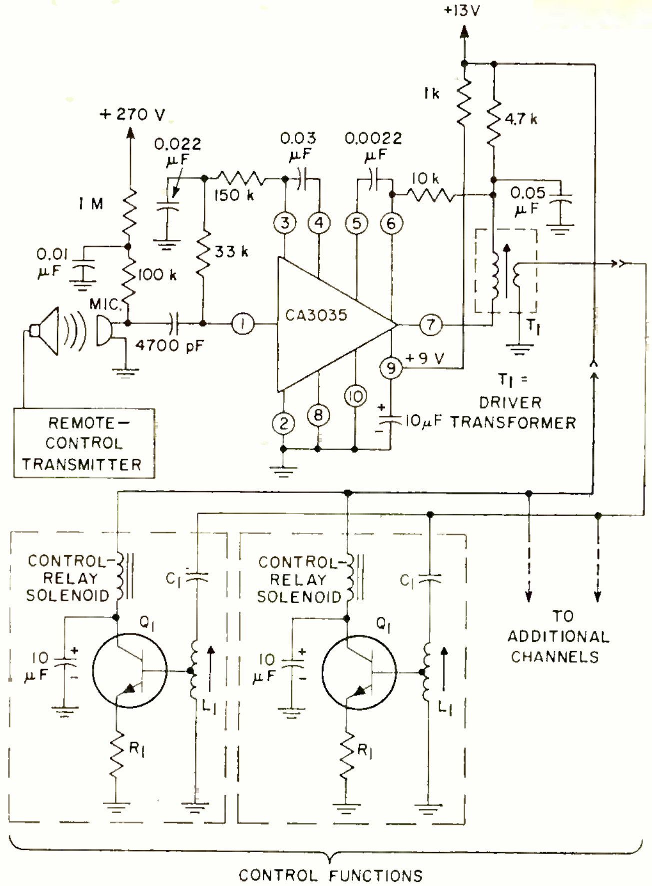


Fig. 3. Remote-control system using integrated circuit.

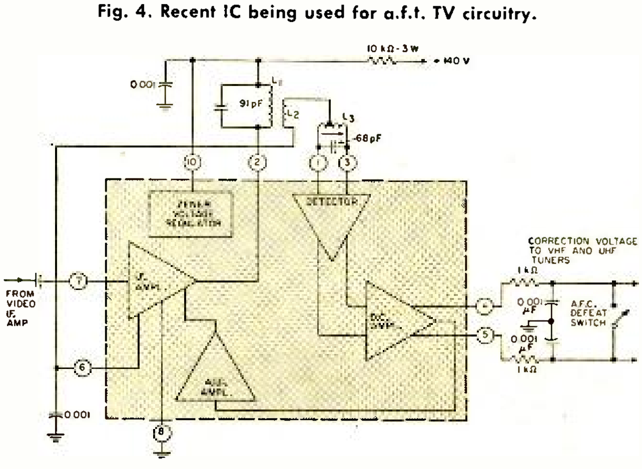
formance has been improved and the peripheral circuitry has been simplified. The recently introduced CA3064 is shown in block form in Fig. 4. The i.f.-amplifier gain has been improved by 20 dB (45.75-MHz picture-carrier reference), a zener supply has been incorporated, and bypassing has been simplified in the i.f. amplifier through the use of a single-ended i.f. amplifier. The IC is available in a 10-lead TO-5 package.

These three IC systems have had a good field history since 1966. Although 27 million digital monolithic IC's were sold in 1966, no significant field history existed for monolithic LIC's in this application. Some common failures which were uncovered in the laboratory and which are relevant to all IC's for TV applications include:

1. In receivers in which the sound IC was used to drive an audio-output tube directly, warmup tube arcing was transmitted through the grid to the audio preamplifier of the IC and damaged the preamplifier. Inclusion of a series resistor, having a minimum value of 0.1 megohm, between the preamplifier and the tube grid solved this problem.

2. Because picture-tube arcing can induce significant ground transients, all receivers should be thoroughly studied for the effects of such arcing relative to IC damage. Instances have been investigated where IC's "mysteriously failed" on receiver life tests. Artificially induced picture-tube arcing duplicated the failure, and a simple improved ground layout solved the problem.

Fig. 4. Recent IC being used for a.f.t. TV circuitry.



The prime area of current development in the TV industry is chroma demodulation. A basic circuit which has been well received by major receiver manufacturers is shown in Fig. 5. The circuit is a doubly balanced demodulator, balanced for chroma as well as the 3.58-MHz reference. It operates in a synchronous-detection manner in which the chroma is fed to the constant-current source in a differential-amplifier circuit while the reference is applied to the differential amplifier. The doubly balanced configuration provides cancellation of the 3.58-MHz reference and minimizes the need for filtering at the outputs. The outputs of the two decoders are fed to a resistive matrix in which the color-difference signals are developed and then delivered individually to the outputs through emitter-follower isolation amplifiers.

Several domestic as well as foreign IC manufacturers have introduced IC's for other portions of the receiver. Examples of such IC's are as follows:

1. *Motorola* MC1352P: first and second pictures-i.f. amplifiers, a.g.c. gating amplifier, and i.f. and r.f. a.g.c. amplifiers.

2. *ITT* TAA790: sync separator, horizontal oscillator, automatic frequency control, automatic phase control, and noise blanking.

3. *Phillips* TAA700: video preamp, gated a.g.c. detector/amplifier, noise detector and gate, sync separator, automatic horizontal sync circuit, and vertical sync amplifier.

Although the primary penetration has been in color TV, black-and-white receivers can and do use the compatible devices. Dominant among these IC's is the sound-i.f. amplifier. It is anticipated that black-and-white TV will justify development of some of its own custom IC circuits.

IC's in Radios

The immediate radio market is for home-entertainment and automobile AM and AM-FM radios. Until recently, the AM radio designer had few options in the use of an IC for AM; specifically, he could use an array, a differential amplifier, or an audio preamplifier circuit. The new TA5640 now offers the designer a flexible and versatile "front-end" circuit (up to 30 MHz) compatible with composite i.f. amplifiers in AM-FM receivers.

The new IC consists of an r.f. amplifier with an a.g.c. circuit, a mixer-oscillator, two i.f. amplifiers, and a 5.5-volt zener reference supply. The a.g.c.-amplifier portion of the circuit acts as a variable unbypassed emitter resistance for the low-noise r.f. amplifier stage.

The mixer-oscillator stage is a differential amplifier with a constant-current source. The r.f. input is fed into the differential amplifier (either push-pull or single-ended). The oscillator is a common-base configuration using two transistors in parallel as the active element. Single-ended feedback is provided from the common collectors through the external oscillator tuned circuit to the common emitters. Because oscillator current can flow in either leg of the differential amplifier, or both, and this current is fixed by the constant-current source, a.g.c. may be applied to the mixer without objectionable oscillator pulling or blocking. Thus, the circuit behaves more as a mixer-oscillator than conventional bipolar self-oscillating mixer circuits (autodyne converters). Two i.f.-stages are provided, one with unbypassed emitter resistance for good linearity and dynamic range.

This i.f. configuration provides maximum versatility for

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composite AM-FM i.f.-amplifier configurations. A typical block diagram of an AM-FM receiver is shown in Fig. 6. The first and second i.f.-amplifier stages are *RC*-coupled and composite for AM and FM. The FM i.f. output of the second i.f. amplifier is transformer-coupled to the high-gain amplifier block, which is a portion of another IC, the CA3075. This IC, developed and optimized specifically for FM i.f. applications, consists of a three-stage direct-coupled amplifier/limiter, an FM detector network with an isolated emitter-follower amplifier, and an audio preamplifier. The FM detector requires only a single-tuned coil, thus simplifying alignment while minimizing cost. The −3-dB limiting sensitivity of the i.f. gain block (10.7 MHz) is 500 μV maximum, and recovered audio at detector output is 525 mV minimum.

The audio amplifier is a single-stage amplifier with emitter-follower input (for high input impedance) and emitter-follower output. The amplifier provides an audio gain of 21 dB. No external bias components are required for the audio amplifier.

These two IC's permit many AM-FM receiver options for either mobile or home-entertainment applications. The IC's are available in 16-lead dual in-line packages.

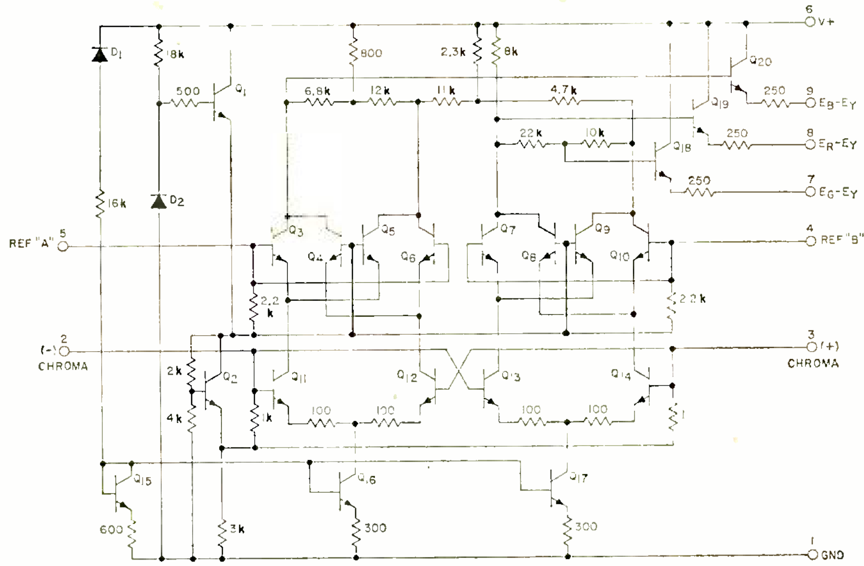


Fig. 5. Circuit diagram of the components on the integrated-circuit chip which is employed for chroma demodulation in TV.

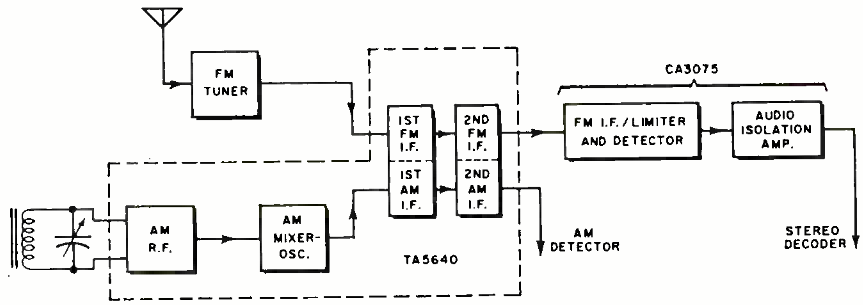


Fig. 6. AM-FM receiver "front end" with two integrated circuits.

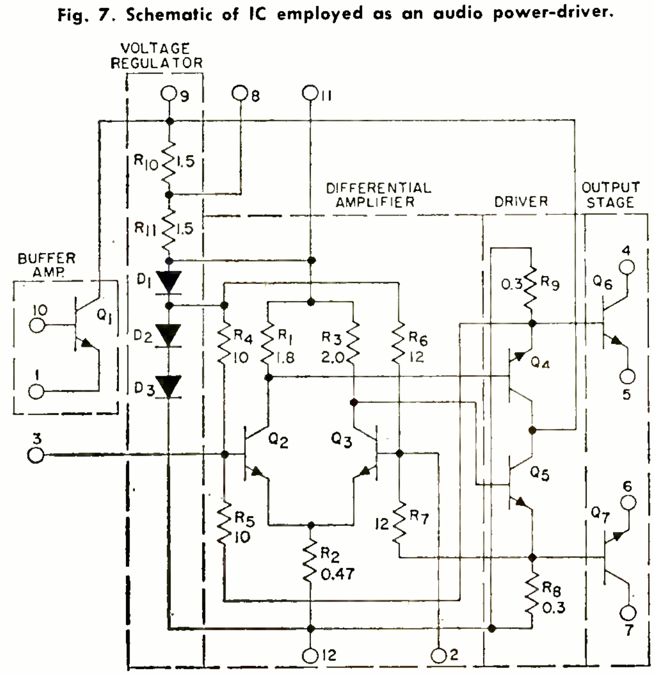
Audio Equipment

In audio equipment, monolithic IC's have started to invade the stereo-preamplifier and low-power audio-amplifier market. The availability of multiple amplifier IC's, such as the CA3052, has provided stereo circuit designers with a new tool and additional degrees of design freedom. This IC consists of four identical independent low-noise amplifiers that can be connected to provide all the amplification necessary in a stereo preamplifier. Each of the amplifiers consists of a differential amplifier (Darlington input) driving a common-emitter amplifier. Internal negative d.c. and a.c. feedback is provided from the output of the common-emitter amplifier to the non-inverting side of the differential amplifier. The a.c. feedback may be adjusted by controlling the a.c. impedance from the non-inverting side of the differential amplifier to ground. When this point is a.c.-bypassed, a maximum gain of 58 dB per amplifier is obtained with a bandwidth of 300 kHz. Equalization for phonograph or tape can easily be incorporated with appropriate *RC* networks between the amplifier output and the non-inverting side of the differential amplifier.

Low-power IC audio amplifiers (up to 5 watts) have been common in the consumer marketplace for the past two years. Basically the designs are of a driver-output configuration, with output circuits of the conventional push-pull (transformer-output) or quasi-complementary-symmetry type. A typical example is the CA3020A shown in Fig. 7. This circuit consists of a differential-amplifier configuration that provides gain as well as phase inversion and drives emitter-follower amplifiers which drive the isolated outputs. A temperature-compensated bias circuit is incorporated, together with an optional emitter-follower buffer input stage for increased input impedance. Common applications include the power-driver function for the conventional audio-output stage. In this case the IC outputs are fed to a driver transformer which is connected to conventional power transistors. These transistors drive a loudspeaker directly.

The use of LIC's in consumer products is on the increase. Leading the way are home-entertainment products in which the transition is better defined. Major inroads can be made by the mid-1970's. Although most non-entertainment applications are in the drawing-board stage and require improved systems or a better performance/cost ratio, the trend is there. For consumer products, the 1970's will be a decade of integration. ▲

Fig. 7. Schematic of IC employed as an audio power-driver.



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in 1966. From 1961 to 1966 he was a member of the technical staff of RCA Laboratories. In December 1966, he transferred to the Technical Programs Laboratory of RCA Electronic Components, as Project Engineer. In July 1968, he assumed his present position. He has lectured at Brooklyn Polytechnic, the City College of New York, and at numerous company Management and Engineering training programs. He is author or co-author of ten published papers and has two patents. He is chairman of the IEEE Basic Sciences Committee of New York Section and co-founder of the committee on Computer-Aided Design and Applications of Devices.

IC's for Microwaves

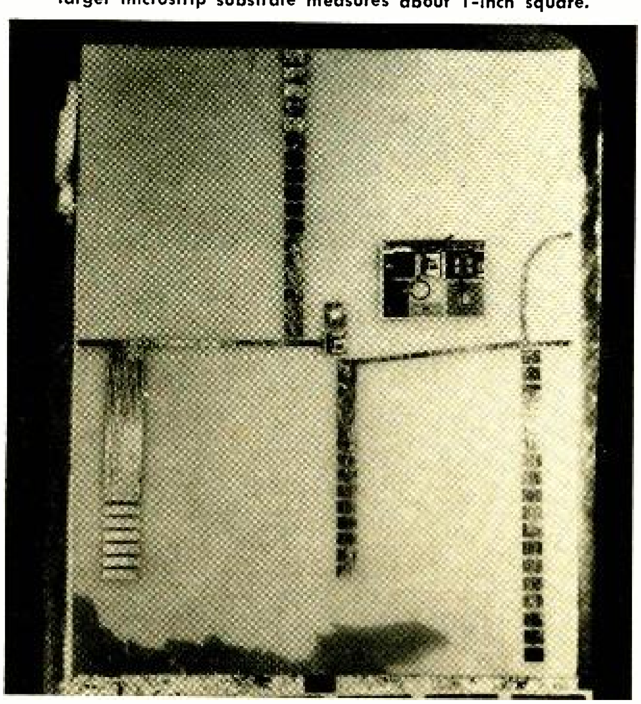
By RONALD B. SCHILLING/ Eng. Leader, Microwave Microelectronics
Solid State Division, RCA

Where medium or low r.f. power is needed, microwave IC's are replacing large, bulky vacuum tubes and associated plumbing.

MICROWAVE integrated circuits (MIC's) are now coming into their own. For several decades the microwave industry relied on active devices such as magnetrons, klystrons, traveling-wave tubes, and crossed-field and backward-wave oscillators, together with waveguide, coaxial, and stripline circuitry. Systems using these devices and circuits were often characterized by large size, short life, low reliability, and high cost. Since 1965, when integration made inroads into the microwave field, MIC's have been demonstrating the feasibility of replacing former methods and have started performing medium- and low-power microwave functions.

Why do system designers decide to use MIC's instead of conventional approaches? The major reasons include lower cost, the potential for higher reliability and longer life, smaller size and weight, improved reproducibility, and improved performance in certain applications. The reduced cost of MIC's can be attributed to batch-fabrication techniques. As is the case with integrated circuits for other frequencies, both the material costs and the cost of production are low. The use of photolithographic techniques in place of cavity machining also yields an impressive cost advantage.

Fig. 1. Comparison of 2-GHz, 1-watt lumped-element and microstrip amplifiers having equivalent performance. The lumped-element circuit, approximately one-tenth the size of the microstrip version, has been placed on the microstrip substrate (at right center) for this photograph. The larger microstrip substrate measures about 1-inch square.



The high reliability and long life of MIC's are a result of using solid-state devices. Solid-state components can last as long as the system in which they are being used. In addition, integration techniques minimize interconnects and high-reliability connection methods, such as bonding and beam leads, eliminate the usual requirement for cables and connectors.

Size is reduced when waveguides, coaxial, and stripline circuits are replaced by the MIC techniques of microstrip or lumped elements. This reduction in size and weight with MIC's is important in antenna-mounted, airborne, spaceborn, "manpack," and portable equipment.

Reproducibility in MIC's is obtained with batch-fabrication methods involving thin-film, thick-film, and photolithographic techniques. Such techniques lead to a very uniform product. The most variable elements in MIC's are active semiconductor devices and their preselection substantially decreases the effects of device variability.

Improved performance can be attained in MIC's by working at the chip level of the active device. At these high frequencies it is extremely important to eliminate parasitics associated with device packages.

The relatively new field of microwave integrated circuits has advanced beyond the laboratory stage and a large variety of MIC's, covering a wide range of applications, have been developed. Components and subsystems as well as systems utilize MIC's; available types include mixers, multipliers, parametric amplifiers, up-converters, wide-band low-noise and wide-band high-power transistor amplifiers, phase shifters, TR switches, directional couplers, and filters. Receivers, transmitters, and transmit/receive modules have also been developed.

System designers can use MIC's in communications, radar, ECM, and instrumentation systems spanning the frequency range from a few hundred megahertz to approximately 15 GHz, while some preliminary work has been done at 35 and 90 GHz. Although such functions as the generation of high power and narrow-band low-loss filtering are difficult to achieve with MIC's, a group of moderate-power MIC transmit modules can be used in a phased-array

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antenna to produce high power. The size advantage associated with MIC's is important in phased arrays because elements must be spaced on approximately half-wavelength centers. Solid-state, phased-array radar offers such advantages as reliability, multifunction capability, and gradual degradation. An experimental 9-GHz radar with 600 transmit/receive modules has been built.

MIC Techniques

As is the case with conventional IC's, two basic technologies—monolithic and hybrid—can be used for MIC's. Monolithic MIC's employ resistive isolation in high-resistivity wafers of silicon or gallium arsenide, with resistivities in excess of 1000 ohm-cm. Planar devices are fabricated in an epitaxial layer and use is made of top-surface contacts. At present, monolithic technology suffers from losses, processing problems, and limitations on device performance which result in low yield and poor performance.

Monolithic MIC's represent a future-generation MIC technique which is still quite a few years away. A potential advantage of the monolithic approach is the reduction and control of parasitic inductances which occur when circuit and device are joined. This advantage is extremely important for millimeter-wave circuits. However, the major approach today is the hybrid technology discussed and illustrated in this article.

Hybrid MIC's are fabricated on high-quality ceramic, glass, or ferrite substrates. The passive circuit elements are deposited on the substrate while active devices are mounted to the substrate and connected to the passive circuit. Active devices may be used in chip form, in chip carriers, or in small plastic or hermetic packages.

Hybrid integrated circuits can be divided into *distributed* and *lumped-element* circuits. The most popular form of distributed circuit is the microstrip transmission line which consists of a strip conductor separated from a ground plane by a dielectric layer. Other distributed-circuit versions are the suspended-substrate, slot-line, and coplanar-waveguide transmission lines. The lumped-element form of hybrid IC incorporates components small enough to behave electrically as capacitors, inductors, and resistors, independent of frequency over the range of interest. Advances in semiconductor technology have made possible fabrication techniques that yield components which are small enough to behave as true lumped elements at microwave frequencies.

At present the over-all frequency range of MIC's is from a few hundred megahertz to approximately 15 GHz. Because of technological limitations, lumped-element techniques are at present feasible only below 3 GHz. In this range lumped elements are very competitive with microstrip circuits.

In all MIC's, passive circuitry is required for filtering or impedance transforming. Providing these functions with microstrip requires line sections with dimensions on the order of an eighth to a quarter of a wavelength. Space requirements can be minimized by using high-dielectric substrates. Lumped elements must, by definition, have dimensions significantly less than a wavelength; the rule of thumb is 0.02 wavelength. As a result, lumped-element circuits are much smaller than microstrip equivalents.

Fig. 1 compares 2-GHz, 1-watt, lumped-element and microstrip amplifiers having equivalent performance. The lumped-element amplifier is approximately one-tenth the size of the microstrip amplifier. Although the smaller size as achieved by the lumped-element approach may be an advantage in some cases, microstrip circuits are usually small enough for many applications.

Two key advantages are gained by using lumped-element circuits, both because of the small size. These are: reduced cost and adaptability of the lumped-circuit component in a hybrid subsystem. Because of the small size of lumped-element circuits, many devices can be batch-fabricated simultaneously on a ceramic wafer in the same manner as transistors. Consequently, because optimum use is made of batch fabrication, the cost of lumped-element circuits is lower than that of microstrip lines, which are usually made one at a time.

The losses of lumped-element circuits are somewhat greater than those of microstrip circuits. Inductors and capacitors with *Q's* of 100 and several hundred, respectively, have been fabricated using lumped elements, as compared with *Q's* of 200 to 400 for microstrip resonators.

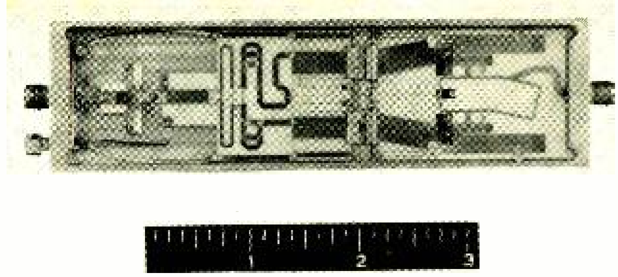

Fig. 2. This microstrip S-band power module can produce a power output of 15 watts at a 3-GHz frequency.

"Make-or-Buy" MIC's?

Microwave-system designers and manufacturers must often consider the pros and cons of establishing their own facility for fabricating MIC's. An important requirement for a successful MIC venture is the existence of an active-device capability. Success in producing state-of-the-art MIC power

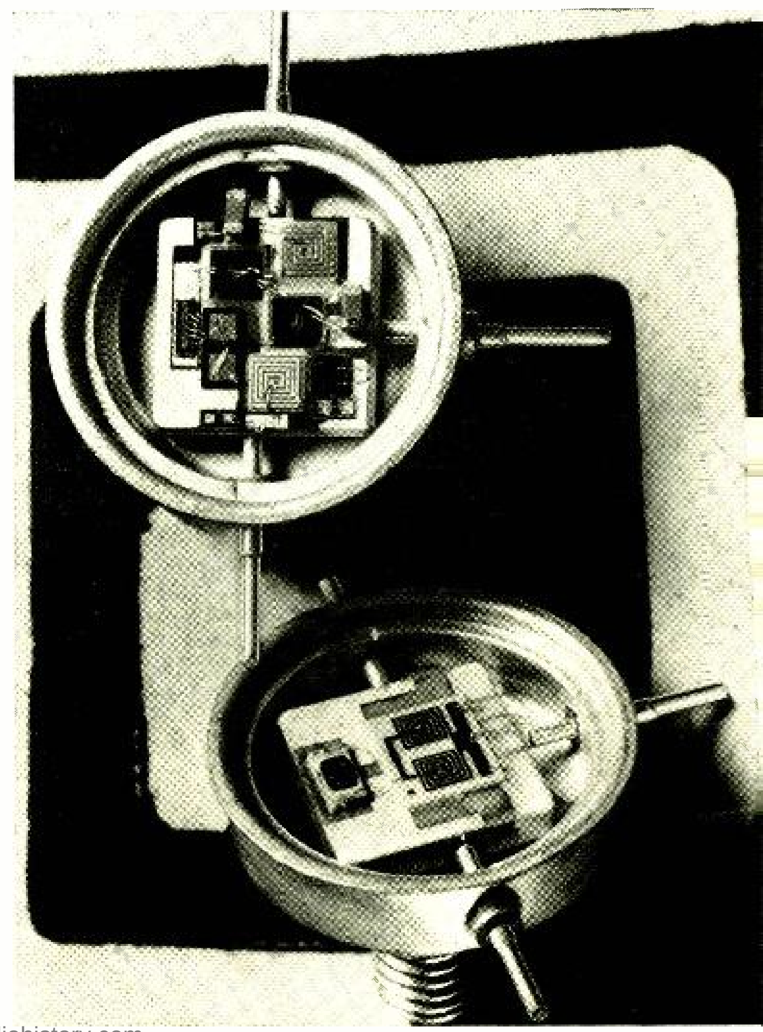

Fig. 3. Examples of lumped-circuit hybrid IC's using wirebonding for interconnections. The upper unit is a u.h.f. power amplifier which delivers an output power of 17 watts with a c.w. input power of 4 watts, at a frequency of 225 to 400 MHz. The lower unit is a combiner/divider for the same frequency band. Both these devices are available in either stud or studless packages.

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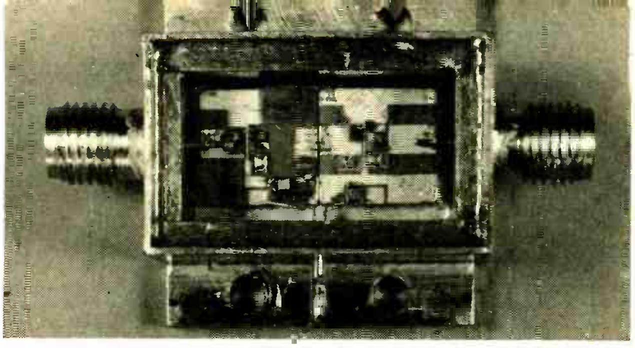


Fig. 4. A two-stage cascaded amplifier providing 20-dB gain at 2.2 to 2.3 GHz. Output power is 1 watt. This assembly, housed in a hermetic package measuring about 1 by ½ inch, uses wirebonding to the device elements themselves along with deposited interconnections shown.

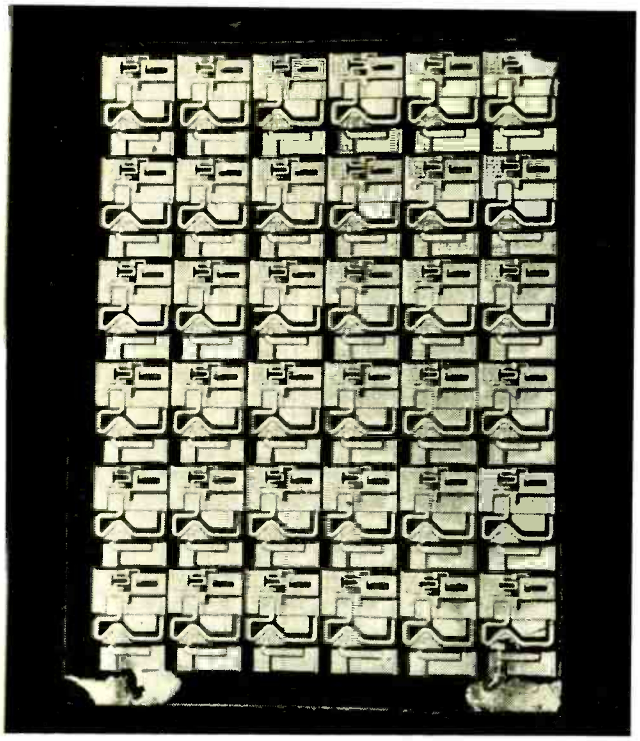
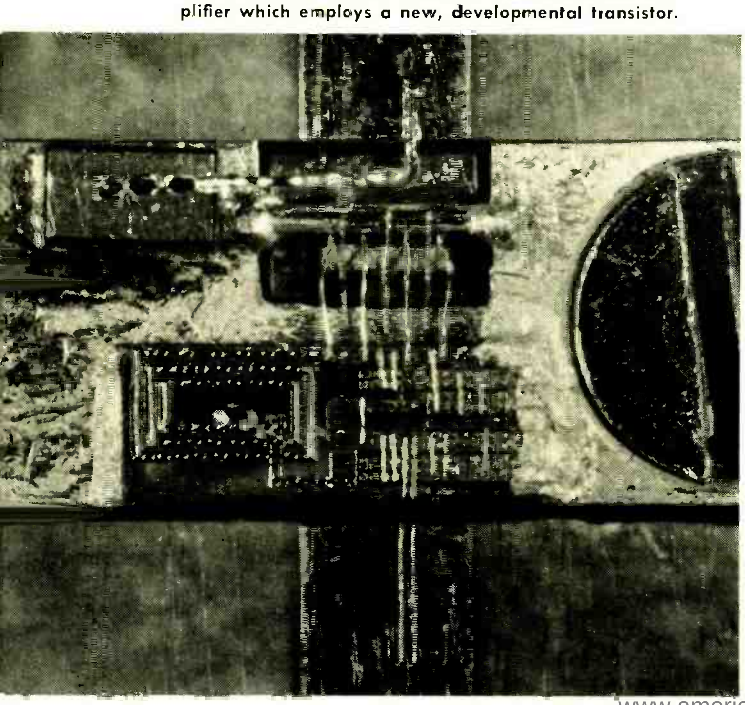


Fig. 5. Output stage of the amplifier shown in Fig. 4. This sapphire wafer, measuring 1 by ¾ inch, has deposited on it the interconnections for 36 amplifiers. The sapphire wafer is later sliced apart for separate use.

Fig. 6. Closeup of 2.25-GHz, 5.6-watt microwave amplifier which employs a new, developmental transistor.



availability of state-of-the-art microwave power transistors in chip form. Selection, pre-testing, mounting, and bonding of pellets is accomplished through close cooperation between MIC and transistor personnel.

A second major requirement for fabricating MIC's is the establishment of a hybrid-circuit facility. Techniques of evaporation and plating of metals, deposition of oxides, and photolithographic processes are just a few of the standard techniques required for MIC fabrication. Component manufacturers have made huge equipment investments in these areas and can meet various system needs both economically and effectively.

Although component manufacturers can supply MIC's on a large scale, system designers have other options when small quantities of units are required for feasibility studies or special applications. As an example, preselected devices can be purchased in carriers that are compatible with MIC's. Designers can also purchase precoated substrates and define circuit patterns with inexpensive photolithographic equipment. In this way small quantities of MIC's can be fabricated at reasonable cost.

Examples of MIC's

Fig. 2 shows a microstrip MIC capable of providing a power output of 15 watts at 3 GHz with a 1-dB bandwidth of 13 percent centered at 3 GHz. The input signal of 100 milliwatts at 1.5 GHz is amplified in a preamplifier made up of two 2N5470 pellets followed by a 2N5921 pellet driver. The power is then split into two balanced channels, each containing a triple-chip power amplifier using the 2N5921 and a varactor doubler. The outputs of both doublers are combined in a hybrid ring. The 2N5921 transistors are mounted in special microstrip chip carriers. The carrier includes an internal impedance transformation that changes the transistor impedance to a resistive value of 20 ohms. The S-band power module shown in Fig. 2 is intended primarily for phased-array applications.

Lumped-element circuits may be constructed in two forms. The first incorporates chip devices and chip thin-film inductors, capacitors, and resistors. The chips are mounted on a substrate and interconnections are made by wirebonding. An example of an MIC fabricated with the wirebond approach is the *RCA*-TA7702 shown at the top of Fig. 3. This device produces an output power of 17 watts from 225 to 400 MHz with a c.w. input power of 4 watts. A 100-watt u.h.f. system was constructed using this 17-watt amplifier and power combiner/divider as basic building blocks. The c.w. power output of 100 watts ±1 dB was obtained from 225 to 400 MHz, with a gain of 11 dB and collector efficiency of 50 to 60 percent across the band.

Fig. 4 shows a 1-watt, 20-dB gain, 2.2 to 2.3-GHz amplifier fabricated with chip elements and housed in a developmental MIC package. Chip elements interconnected with wirebonds provide a quick method for debugging and "tweaking" an amplifier prior to fabrication by using interconnections that are deposited simultaneously with the circuit elements. The only wirebonds in this case are to the device. This particular method results in good reproducibility.

Fig. 5 shows the output stage of the amplifier of Fig. 4, which is batch-fabricated using deposited interconnects. The 1-watt amplifiers of Figs. 4 and 5 use the 2N5920 transistor. A 5.6-watt, 6-dB gain, 2.25-GHz amplifier using the 2N5921 transistor is shown in Fig. 6.

Sufficient data on MIC's has been obtained to indicate that this approach to microwave hardware will be cheaper to produce (even in modest quantities) than conventional waveguide or coaxial circuits and will provide essentially equivalent performance. It can also be expected that the frequency range of MIC's will be extended as higher levels of sophistication are attained. ▲

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The author, for the past year, has been working on the development of linear integrated circuits in the advanced circuit development section. Previously, he worked for the Re-Entry Systems Department of General Electric Co., designing instrumentation and automatic and semi-automatic equipment. After leaving GE in 1968, he joined Philbrick/Nexus Research and developed operational amplifiers and nonlinear function modules. The author attended MIT in Cambridge.

New Developments in Monolithic Op Amps

By ROBERT C. DOBKIN / Advanced Circuit Development Section, National Semiconductor Corp.

Improved op amps are now available at lower cost, with higher operating speeds, lower input currents, and greater frequency response—due to improved processing and super-gain transistors.

NEARLY one million monolithic amplifiers are now being sold each month. Prices have dropped from $70 in 1965 to less than $2 today, even for relatively small quantities. In fact, the cost is low enough so that these devices can be used as simple components in applications where operational amplifiers would not have even been considered a couple of years ago.

Operational amplifiers are designed for high gain, low offset voltage, and low input current. As a result, d.c. biasing is considerably simplified in most applications; and op amps can be used with fairly simple design rules because many potential error terms can be neglected. Also, circuit performance of op amps is almost entirely dependent upon external feedback elements rather than the open-loop transfer function of the amplifier.

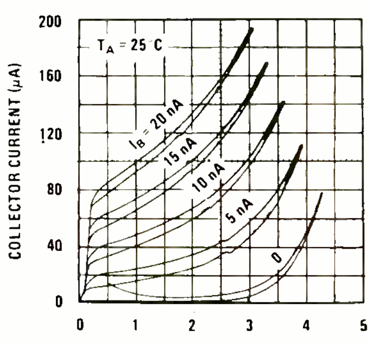
Operational amplifiers have undergone intensive development lately. In the past year, the input bias currents of monolithic amplifiers have been reduced by about three orders of magnitude. They can now surpass discrete amplifiers in many applications. Operating speeds have also been increased. Amplifiers are now available with bandwidths of 10 MHz and slew rates of 10-30 V/μs. Power consumption has also been reduced, with devices now available operating at less than 200 μA quiescent current.

Two factors have been responsible for the reduction in input bias current of modern op amps. Improved processing has raised the current gain of the *n-p-n* transistors from 100 to above 400 at low currents. Further, super-gain transistors, a component not available to discrete designers, have been developed to provide current gains above 4000.

Super-Gain Transistors

The current gain of an *n-p-n* transistor depends, for one thing, on the length of the emitter diffusion cycle during manufacture. Devices which are diffused for unusually long periods will exhibit increased current gain at the expense of breakdown voltage. A super-gain transistor is one that has been driven for the highest possible current gain. Fig. 1 shows characteristic curves for such a device. Current gains in excess of 4000 can be obtained, but the breakdown voltage is only about 4 V. High-gain transistors like these can be built on the same chip with standard *n-p-n* transistors by using two separate emitter diffusions. With this technology, it is possible to design circuits which take advantage of the high current gain, yet can be operated at high voltages.

The low-voltage, super-gain transistors can provide an order of magnitude improvement in input current specifications of the monolithic operational amplifiers made by the improved processing. The voltage-follower circuit shown in Fig. 2 illustrates their use. High-gain primary transistors are used in the input stage to get very low input bias current. *D1* is included to operate *Q2* at near-zero collector-base voltage, and the collector of *Q1* is bootstrapped to the output for the same reason. Hence, low-voltage transistors can be used on the input.



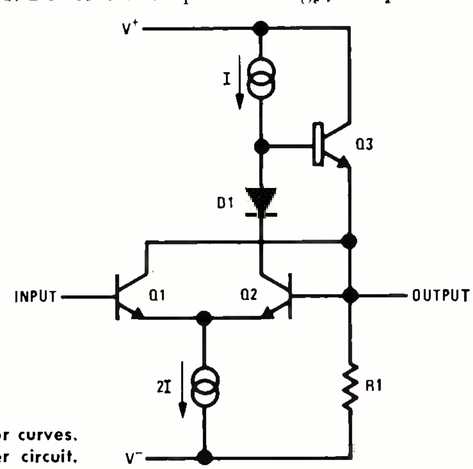


Fig. 1. (Above) Super-gain transistor curves.
Fig. 2. (Right) The voltage-follower circuit.

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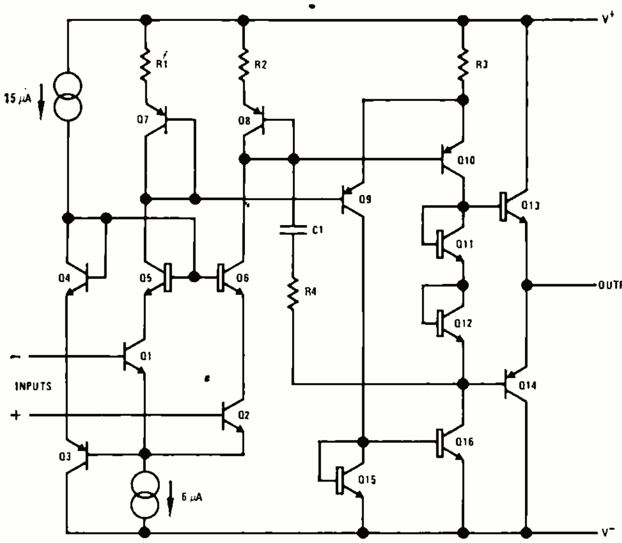


Fig. 3. General-purpose operational amplifier using bootstrapped high-gain transistors in the input stage.

The only transistor that sees any voltage is $Q3$, which buffers the output. Its current-gain requirements are not stringent, so a moderate-gain secondary transistor can be used. In this particular design, the high-gain ($Q1$, $Q2$) and high-voltage ($Q3$) transistors are combined to take advantage of the best characteristics of both.

Because the input transistors are operated at zero collector-base voltage, high-temperature leakage currents do not show up on the input. Field-effect transistors which, in the past, have been an obvious choice for the input stage of low-input-current operational amplifiers, suffer from leakage because there is no way to operate them with no voltage across the gate junction. In applications covering a −55° C to +125° C temperature range, super-gain transistors, which can give worst-case bias currents of 3 nA and worst-case offset currents of 400 pA, have a distinct advantage over FET's. With existing technology, they can equal FET's over a −25° C to +85° C temperature range, and it is not difficult to foresee their superiority over a 0° C to +70° C temperature range. Furthermore, matched pairs of super-gain transistors exhibit typical offset voltages of 0.5 mV to 1.0 mV with temperature drifts about 2 μV/° C compared with 40 mV and 50 μV/° C for FET's. Certainly, discrete FET's can be compensated or selected for better offset or drift, but at a substantial increase in cost. MOS transistors, which do not have leakage problems, are no alternate solution because they exhibit gross instabilities in offset voltage.

Incorporating super-transistors in the input stage of a general-purpose operational amplifier is not as easy as in a voltage follower. Because the circuit must operate over a wide range of common-mode voltages, there is no simple way to operate the input transistors at zero collector-base voltage. However, this is certainly not impossible; and one circuit for doing it is shown in Fig. 3. The design uses more active components than a standard design, but this poses no problems in a monolithic circuit.

The input pair, $Q1$ and $Q2$, is operated in a cascode connection with $Q5$ and $Q6$, which stand off the common-mode voltage. The bases of $Q5$ and $Q6$ are bootstrapped to the common-mode voltage seen by the input transistors *via* $Q3$ and $Q4$. Hence, the input transistors are always operated with near zero collector-base voltage.

Four IC's are presently being produced using super-gain transistors to obtain low input currents. They are the LM102, LM108, and LM110 manufactured by *National Semiconductor* and the MC1556 manufactured by *Motorola*.

Improved Frequency Response

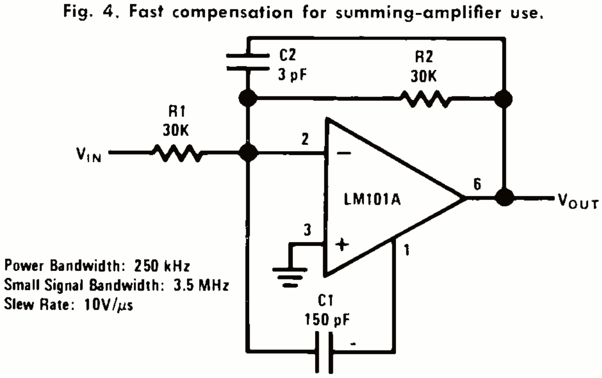
Another area where operational amplifiers have undergone improvement is in frequency response. General-purpose amplifiers have about 1 MHz small-signal bandwidth with unity gain compensation. The primary speed limitation is due to the poor frequency characteristics of the lateral *p-n-p* transistor used for level shifting. The response above 2 MHz, especially the excess phase shift, gets so bad that it cannot be used in a feedback amplifier at higher frequencies.

The voltage follower shown in Fig. 2 does not have a problem with the lateral *p-n-p* transistor since no level shifting is required. Hence, a wide-band device can be built which has a high slew rate. One such monolithic circuit, the LM110, provides a small-signal bandwidth of 10 MHz and a slew rate of 30 V/μs. Because it uses super-gain transistors, input bias currents less than 10 nA are also realized.

Feedforward compensation may be used to improve the high-frequency performance of some standard amplifiers, in certain configurations. An example of this is shown in Fig. 4. An LM101A can be compensated by bypassing the lateral *p-n-p* transistor to get slew rates of 10 V/μs, a power bandwidth of 250 kHz, and a small-signal bandwidth as high as 10 MHz. Further, high-frequency gain error is reduced (for example, by a factor of 50 at 100 kHz compared to standard compensation) so it is possible to take advantage of the faster slew. The feedforward compensation, which is no more complicated than standard compensation, provides more than an order of magnitude better performance in high-frequency applications. However, feedforward compensation only works when the device is used as a summing amplifier where the feedforward capacitor does not have to be charged and discharged to swing the output.

For applications requiring a fully differential high-speed op amp, the μA715 can be used. This device uses resistor level shifting to circumvent the problems associated with lateral *p-n-p* transistors at high frequencies. It provides small-signal bandwidths of 10 MHz and slew rates of 15 V/μs.

Fig. 4. Fast compensation for summing-amplifier use.



Some Design Problems

Because of their low input currents, the LM110 and LM108 open up many new design possibilities. However, extra care must be taken in component selection and in the assembly of printed-circuit boards to take full advantage of the performance. Further, unusual design techniques must often be applied to get around the limitations of some components.

The holding accuracy of a sample and hold circuit is directly related to the error currents in the components used. Therefore, it is a good circuit to use to explain some of the design problems involved. Fig. 5 shows one configuration for a sample and hold circuit. During the sample interval, $Q1$ is turned on, charging the hold capacitor, $C1$,

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up to the value of the input signal. When *Q1* is turned off, *C1* retains this voltage. The output is obtained from an op amp that buffers the capacitor so that it is not discharged by any loading. In the holding mode, an error is generated as the capacitor loses charge to supply circuit leakages, including the input current to the op amp, the leakage current of the holding capacitor, board leakages, and the off current of the FET switch.

When high-temperature operation is involved, the FET leakage can limit circuit performance. This can be minimized by using a junction FET, as indicated, because commercial junction FET's have lower leakage than their MOS counterparts. However, at 125° C even junction devices are a problem. Mechanical switches, such as reed relays, are quite satisfactory from the standpoint of leakage. However, they are often undesirable because they are sensitive to vibration, they are too slow, or they require excessive drive power. If this is the case, the circuit in Fig. 6 can be used to eliminate the FET leakage.

When using *p*-channel MOS switches, the substrate must be connected to a voltage which is always more positive than the input signal. The source-to-substrate becomes forward-biased if this is not done. The troublesome leakage current of a MOS device occurs across the substrate-to-drain junction. In Fig. 6, this current is routed to the output of the buffer amplifier through *R1* so that it does not contribute to the error current.

The main sample switch is *Q1*, while *Q2* isolates the hold capacitor from the leakage of *Q1*. When the sample pulse is applied, both FET's turn on, charging *C1* to the input voltage. Removing the pulse shuts off both FET's and the output leakage of *Q1* goes through *R1* to the output. The voltage drop across *R1* is less than 10 mV, so the substrate of *Q2* can be bootstrapped to the output of the LM108. Therefore, the voltage across the substrate-drain junction is equal to the offset voltage of the amplifier. At this low voltage, the leakage of the FET is reduced by about two orders of magnitude.

It is necessary to use MOS switches when bootstrapping the leakages in this fashion. The gate leakage of a MOS device is still negligible at high temperatures; this is not the case with junction FET's. If the MOS transistors have protective diodes on the gates, special arrangements must be made to drive *Q2* so the diode does not become forward-biased.

In selecting the hold capacitor, low leakage is not the only requirement. The capacitor must also be free from dielectric polarization phenomena. This rules out such types as paper, Mylar, electrolytic, tantalum, and high-K ceramic. For small capacitor values, glass or silvered-mica capacitors are recommended. For the larger values, ones

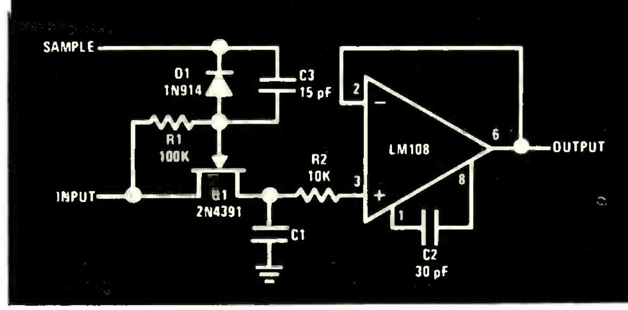

Fig. 5. Circuit arrangement used for sample and hold.

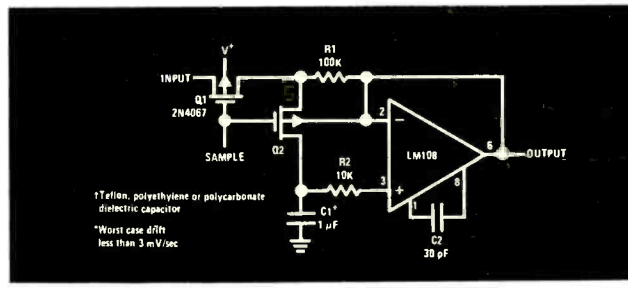

Fig. 6. Sample and hold circuit arrangement in which the leakage due to FET switches has been eliminated.

with Teflon, polyethylene, or polycarbonate dielectrics should be used.

When the hold capacitor is larger than 0.05 μF, an isolation resistor should be included between the capacitor and the input of the amplifier (*R2* in Fig. 6). This resistor insures that the IC will not be damaged by shorting the output or abruptly shutting down the supplies when the capacitor is charged. This precaution is not peculiar to the LM108 and should be observed with any IC op amp.

Other Applications

The differential input single-ended output instrumentation amplifier is one of the most versatile signal-processing amplifiers available. It is used for precision amplification of differential d.c. or a.c. signals while rejecting large values of common-mode noise. By using integrated circuits, a high level of performance is obtained at minimum cost.

Fig. 7 shows a basic instrumentation amplifier which provides a 10-volt output for 100-mV input, while rejecting more than ±11 V of common-mode noise. To obtain good input characteristics, two voltage followers buffer the input signal. The LM110 is specifically designed for voltage-follower use and has 10,000-megohm impedance with 3-nA input currents. This high value of input impedance pro-

DEFINITION OF TERMS

Input Offset Voltage: That voltage which must be applied between the input terminals through two equal resistances to obtain zero output voltage.

Input Offset Current: The difference in the currents into the two input terminals when the output is at zero.

Input Voltage Range: The range of voltages on the input terminals for which the offset specifications apply.

Input Bias Current: The average of the two input currents.

Common-Mode Rejection Ratio: The ratio of the input voltage range to the peak-to-peak change in input offset voltage over this range.

Supply Current: The current required from the power supply to operate the amplifier with no load and the output at zero.

Voltage Gain: The ratio of the output voltage swing to the change in input voltage required to drive the output from zero to this voltage.

Slew Rate: The internally limited rate of change in output voltage with a large-amplitude step function applied to the input.

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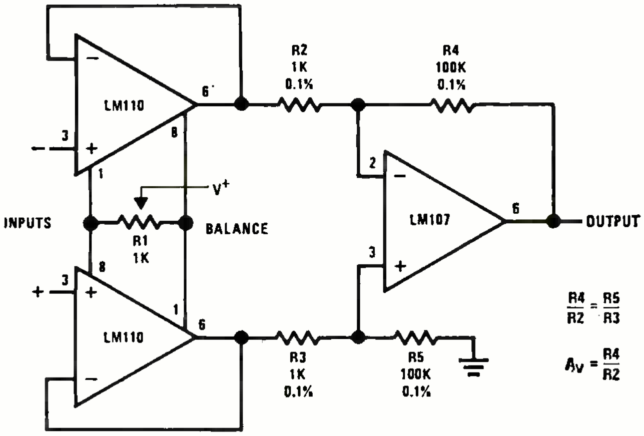

Fig. 7. Differential input instrumentation amplifier.

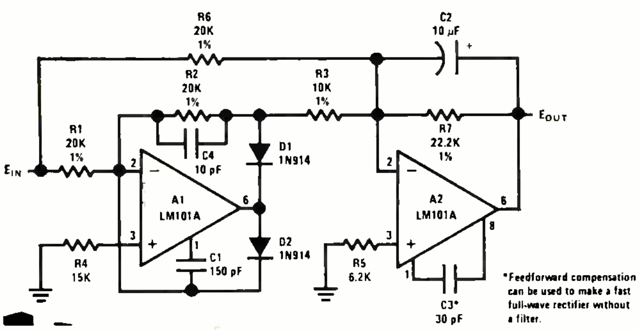

Fig. 8. Circuit for a precision a.c. to d.c. converter.

vides two benefits: it allows the instrumentation amplifier to be used with high source resistances and still have low error; and it allows the source resistances to be unbalanced by over 10,000 ohms with no degradation in common-mode rejection. The followers drive a balanced differential amplifier which provides gain and rejects the common-mode voltage. The gain is set by the ratio of $R4$ to $R2$ and $R5$ to $R3$. With the values shown, the gain for differential signals is 100.

To obtain good common-mode rejection ratios, it is necessary that the ratio of $R4$ to $R2$ match the ratio of $R5$ to $R3$. For example, if the resistors had a total mismatch of 0.1%, the common-mode rejection would be 60 dB times the closed-loop gain, or 100 dB. However, it is possible to trim any one of the resistors to obtain common-mode rejection ratios in excess of 100 dB.

By using diodes in the feedback loop of operational amplifiers, very accurate a.c.-to-d.c. converters can be made. The turn-on threshold of the diode is divided by the open-loop gain of the amplifier, allowing linear rectification of even millivolt signals.

Fig. 8 shows a wide-band a.c.-to-d.c. converter. The input signal is applied through $R1$ to the summing node of an inverting operational amplifier. When the signal is negative, $D1$ is forward-biased and develops an output signal across $R2$. As with any inverting amplifier, the gain is $R2/R1$. When the signal goes positive, $D1$ is non-conducting and there is no output. However, a feedback path through $D2$ reduces the negative-output swing to -0.7 V, and prevents the amplifier from saturating. $A2$ sums the half-wave rectified signal and the input signal to provide a full-wave output.

Since the LM101A is used as an inverting amplifier, feedforward compensation can be used. This compensation allows the rectifier to operate at high frequencies with high accuracy.

Filtering, or averaging, to obtain a pure d.c. output is done by $C2$. It rolls off the frequency response of $A2$ to give an output equal to the average value of the input The filter time constant is $R7C2$, and must be much greater than the maximum period of the input signal. For the values given, the time constant is about 2.0 seconds. This converter has better than 1% conversion accuracy to about 100 kHz and less than 1% ripple at 20 Hz. The output is calibrated to read the r.m.s. value of a sine-wave input.

Choosing an Op Amp

Choosing an operational amplifier is not an easy task. In addition to the newer monolithic devices now available, there are older amplifiers, such as the 709, plus hybrid and discrete units to evaluate.

The choice of amplifier naturally depends on the application. If the circuit requires low d.c. error, an op amp with low offset voltage and low input current is necessary. Most monolithics offer low offset voltage; however, input current can vary three orders of magnitude among different devices. The input current produces a voltage drop across the source resistance, causing an error. Therefore, when high source resistance is used, low input current is even more important. For example, the error due to a balanced 1-megohm source resistance is about 40 mV for a 709, while it is only 0.8 mV for a low-input-current device such as the LM108. Unbalanced source resistance causes even higher errors.

Low input current is also useful in photodiode amplifiers, sample and hold circuits, analog memories, oscillators, and active filters. Using a device like the LM108, low-frequency circuits can be designed with reasonable-size capacitors. A 1-Hz oscillator can be built using capacitors no larger than 0.01 µF. Even in moderate-impedance circuits, low-input-current amplifiers simplify design, since the effects of source resistance can be ignored.

Another important consideration in the choice of an amplifier is bandwidth. This is especially important for a.c. applications. Wide bandwidth lowers the gain error at high frequencies; however, wide-band response is not an unmixed blessing. A fast amplifier is more sensitive to supply bypassing, stray capacitance, and capacitive loading. More care must be taken to insure stability with a fast amplifier, such as the LM110, than with a general-purpose device like the LM101A.

For most applications an externally frequency-compensated amplifier is more useful. Because the compensation capacitor is not included on the IC chip, it can be tailored to fit the application. When the amplifier is used only at low frequencies, the compensation capacitor can be increased to give a greater stability margin. This makes the circuit less sensitive to capacitive loading, stray capacitances, or improper supply bypassing. With 300-pF compensation, an LM101A will tolerate a 10-µF capacitive load without oscillation.

With closed-loop gains greater than one, the high-frequency performance can be optimized by making the compensation capacitor smaller. If unity-gain 1-MHz compensation is used for an amplifier with a closed-loop gain of ten, the gain error will exceed 1 percent at frequencies above 1000 Hz. This can be extended to 10 kHz by reducing the compensation capacitor by a factor of ten. This is the same response achieved by an amplifier with a 10-MHz unity-gain bandwidth. In many cases, optimized compensation allows the use of an inexpensive general-purpose amplifier for wide-band applications. Also, there are alternate compensation networks, such as feedforward compensation, which can greatly extend the high-frequency response.

The advances made in lowering input currents and extending the frequency response of monolithic amplifiers make them significantly more useful in analog circuitry. In many cases the amplifier is no longer the limiting factor in circuit performance. Both the performance and low cost make the IC operational amplifier an attractive device for linear design. ▲

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For the past four years the author has been responsible for disseminating technical information about Motorola products and developments. In this capacity he has worked with research engineers, production engineers, application groups, and product marketing personnel. Prior to joining the company, he worked for Ameco, Inc., preparing training material on use and maintenance of CATV equipment.

Monolithic Multipliers

By IRWIN R. CARROLL
Supervisor, Technical Communications, Motorola Semiconductor Products Inc.

These IC's provide outputs that are functions of the products of two inputs. Used in mathematical manipulations, as well as for frequency doubling, phase detection, and modulation.

A MULTIPLIER circuit, as the name implies, provides an output that is a function of the product of two inputs. The methods used to achieve this function are many, depending on the kinds of inputs to be multiplied and what the output must be coupled to. One of the earlier methods used (other than purely mechanical means) was a servo-driven potentiometer. Rather simple in concept, these electromechanical multipliers could handle either a.c. or d.c. signals, but were quite slow and subject to mechanical wear.

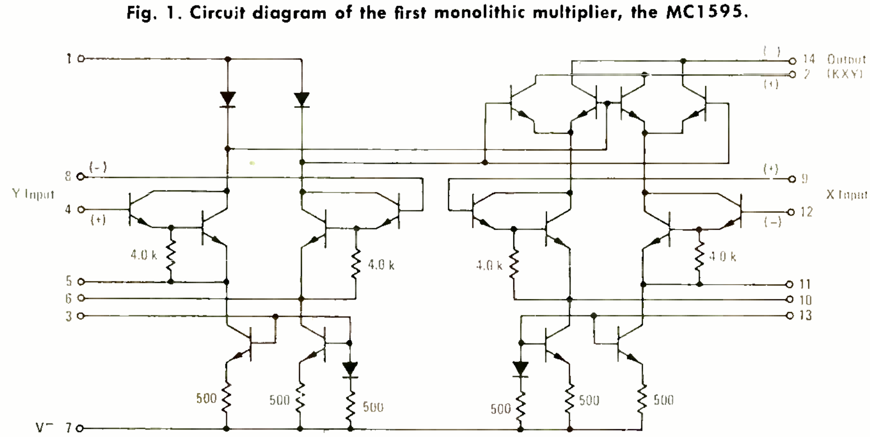
Methods of obtaining a purely electronic multiplier included a dual-grid vacuum tube. Each grid represented an input and the resulting plate current, the product. Also, there are Hall devices and magnetoresistors that have been used. In the digital-computer field, digital techniques have been used quite successfully and, for digital inputs and outputs, will be around for quite some time. However, when the inputs and outputs must be analog, the use of analog-to-digital and digital-to-analog circuits add considerably to the already high component count of a digital approach.

Analog methods of obtaining the multiplier function with semiconductors has, up to now, represented a rather expensive approach. This is due, in part, to the close matching of active devices required for any degree of accuracy and the difficulty in doing this with discrete transistors.

Early in 1969 the first monolithic multiplier became a reality. Its design was based on the variable transconductance principle where the gain of a common-emitter amplifier is a function of the product of the input signal and the magnitude of the effective emitter resistance. Since it is relatively easy to match monolithic differential amplifiers, a significant cost breakthrough was realized. This new building block, designated the MC1595, was introduced by *Motorola* and is shown schematically in Fig. 1. It is known as a four-quadrant multiplier because the output, or product, has the proper sign for any possible combination of positive and negative inputs. A comparable discrete or potted-module multiplier of this type typically costs around $100 while the monolithic version is less than $20.

To fully appreciate the potential of a low-cost, accurate multiplier, it is necessary to consider the number of operations that are dependent on the product of two variables. Obviously there are the arithmetic manipulations of multiplication, division, squaring, square root, and ratios, but in terms of applications, the number becomes staggering. For example, the monitoring of power, brake horsepower, and fluid flow; the solution of complex, nonlinear equations

Fig. 1. Circuit diagram of the first monolithic multiplier, the MC1595.



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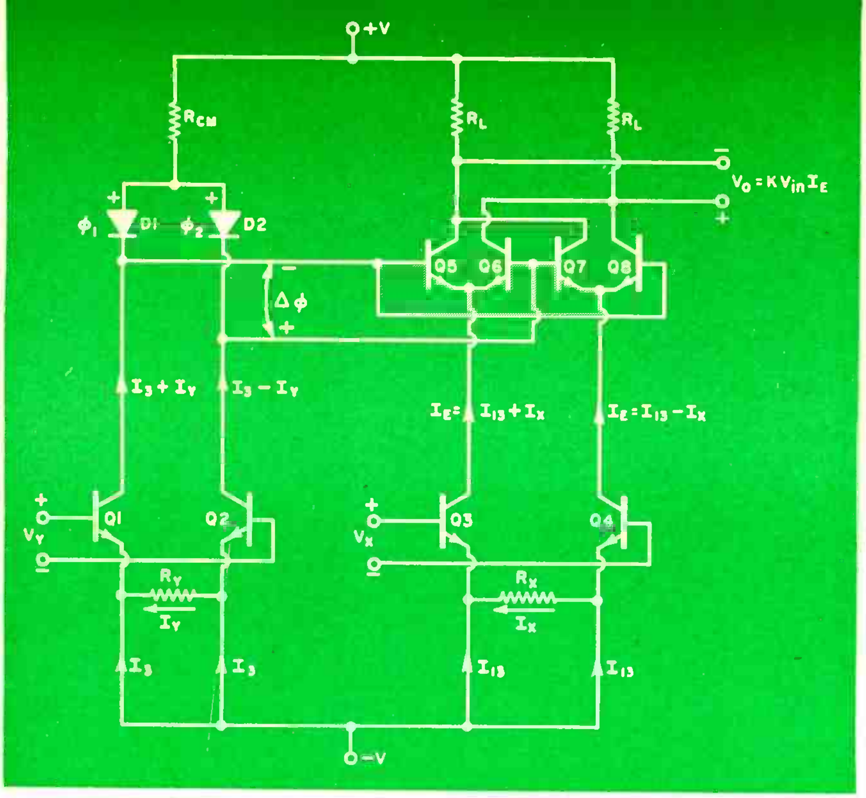

Fig. 2. The basic equivalent circuit of the multiplier.

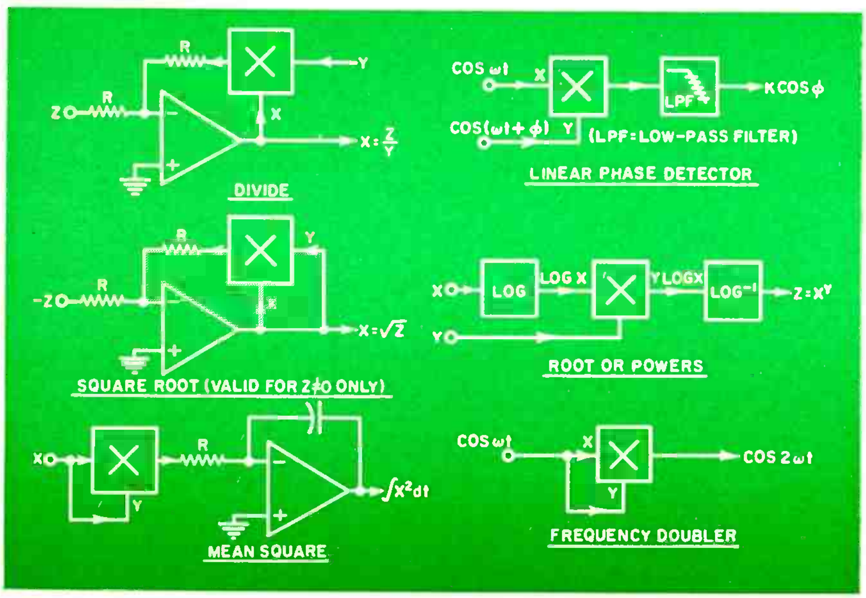

Fig. 3. Circuit functions possible with the multiplier.

(using analog-computer techniques), and root-mean-square problems; the generation of trigonometric functions; the performance of operations such as frequency doubling; phase detection, modulation, and dynamic gain control, are just a few of the possibilities.

In its present form, the monolithic multiplier is a very basic circuit and as such has maximum versatility. This basic nature also has disadvantages in that external components must be added in greater number than would be required for a more specialized circuit. Also, a clear understanding of the circuit itself is necessary to utilize it fully and efficiently.

Operation of Circuit

A complete mathematical treatment of the operation of the multiplier is much too lengthy to be presented here. However, the basic concepts will be presented in order to demonstrate its use.

The basic equivalent circuit of the MC1595 is shown in Fig. 2. The main amplifier is a dual-differential amplifier with cross-coupled collectors (*Q5*, *Q6*, *Q7*, *Q8*), whose output can be expressed as: $V_o = KV_{in}I_E$. This equation contains two variables, V_{in} and I_E, and if each of these variables can be controlled independently and linearly, linear multiplication will result.

Note that I_E, the emitter currents to the dual-differential amplifier are the same as the collector currents of *Q3* and *Q4*. These, in turn, are linear functions of the input voltage, V_x, because the output current of a differential amplifier operating with a constant-current source is a direct function of its differential input voltage. Therefore, the output voltage of the dual-differential amplifier is linearly related to its own emitter current, the I_E component of the equation. Normally, the output current of an amplifier has an exponential relationship to its input (base-emitter) voltage. If the voltage ($\Delta\phi$) applied to the base terminals of the main amplifier were a linear function of the signal voltage, V_y, the output current would be an exponential function of same.

To eliminate this nonlinearity, the V_y signal is preconditioned before being applied to the main amplifier. This is done by passing the current resulting from the V_y signal through diodes *D1* and *D2*. As the linear current passes these special diodes, the voltage developed across them is logarithmic—a nonlinearity that is the exact complement of the nonlinearity produced in the amplifier transistors. As a result, the output current of the amplifier, in response to its base voltage, is also linear.

For the model shown in Fig. 2, the *K* or constant component is determined by: $K = 2R_L/R_xR_yI3$ which represents the gain of the over-all circuit. In the final circuit, the resistances are external parts so that the gain can be easily adjusted to meet a specific requirement.

The output voltage, V_o, is V_x times V_y times a factor *K* which represents the gain of the circuit, or the "scaling factor." The scaling factor is a constant that is under the control of the user. Obviously, since the output voltage is the product of the input voltages, a circuit gain of unity or greater would result in very large output voltages, unless the inputs were quite small. Because of this, the desired gain must be calculated by the user, and is dependent on the magnitude of the input voltage anticipated in a particular application.

Circuit Applications

Fig. 3 shows several examples of the types of circuits that are possible using the multiplier in conjunction with operational amplifiers.

So far, emphasis has been on d.c. operation of the multi-

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plier. But what happens when a.c. signals are fed into the inputs? Fig. 4 illustrates a basic although not obvious use of the multiplier—frequency doubling. When a signal (in this case less than 5 volts peak-to-peak) is coupled to both the X and Y channel inputs, the output is the doubled frequency plus a d.c. offset.

The best way to understand what is happening is to express the sine-wave signal in terms of cosines of the frequency in radians: $e_x = E\ cos\omega t$. In this case, the e_y input is the same frequency so the output: $e_0 = K\ (E\ cos\omega t)\ (E cos\omega t) = K\ E^2\ cos^2\omega t$. From trigonometric identities: $cos^2\omega t = \frac{1}{2}(1 + cos\ 2\omega t)$, hence, $e_0 = (KE^2/2)\ (1 + cos\ 2\omega t)$, the doubled frequency. In the example shown, the output is capacitively coupled so that the d.c. term is blocked.

By using this same principle and applying differing frequencies, a carrier and a modulating frequency, to the two inputs, double-sideband, suppressed-carrier, balanced modulation results. By adding an external pot which adjusts the d.c. voltage applied to the input to which the modulating signal is applied, the output of the circuit is a conventional double-sideband AM-modulated waveform. If a single-sideband signal is injected into one input and the carrier frequency into the other, and if the output is applied to a low-pass filter, demodulation occurs.

Although the MC1595 performs the preceding functions quite well, it has only a 3-MHz bandwidth (3 dB). A modification of the basic multiplier circuit, however, can greatly extend this range. In Fig. 5, the schematic shown is of the MC1596, a multiplier designed for high-frequency operation. When compared to the MC1595 schematic, it becomes readily apparent that the Y-channel preconditioning has been removed.

The MC1596 is a lower cost unit, less than $8.00, and has a bandwidth of 300 MHz. Fig. 6 illustrates this device being used as an SSB demodulator (product detector). The carrier signal is coupled to the Carrier Input and is of sufficient amplitude for switching the dual-differential amplifier (300 mV is optimum). The composite SSB signal is fed to the Signal Input with an amplitude ranging from 5 to 0.5 volts. The output is audio. This same circuit can also be used for AM detection by applying composite and carrier signals in the same manner. This simplified circuit does not, however, truly multiply both inputs since amplitude information is removed from the carrier input side.

The selection of either the high- or low-frequency multiplier is dependent, of course, on the nature of the intended application. It is interesting to note that the bandwidth specification of multipliers can be given in different ways. For example, the 3-dB bandwidth of the MC1595, as mentioned earlier is typically 3 MHz. Another specification for bandwidth is based on the relative phase shift between V_x and V_y. For a 3° relative phase shift, bandwidth is 750 kHz and for a 1% absolute error due to input-output phase shift, the bandwidth is 30 kHz.

If the multiplier is to be used with an X-Y plotter, it should be remembered that some plotters already contain a level-shifting circuit that rejects the d.c. offset voltage, greatly simplifying design. In all other d.c. applications, this is a factor to consider. When a.c. operation is the only consideration, capacitive coupling provides the d.c. blocking.

The versatility of the MC1595 has a trade-off in that it requires external circuitry. This was in no way a mistake in design but very intentional. There have been complaints that it requires too much circuitry or that adjustment is tedious. This multiplier is, unquestionably only the first of a family. Future members will be more specialized and easier to use. But, they will sacrifice versatility in that they can not be as easily tailored to designs removed from their primary intended application. The MC1595, because it isn't tied to such an objective, is probably as versatile a unit as will ever be developed in this category and, like the 709 type op amp, will probably be around for a good many years. ▲

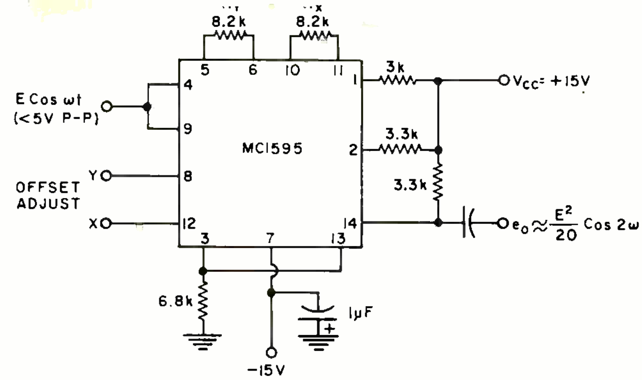


Fig. 4. Using multiplier for frequency-doubling operation.

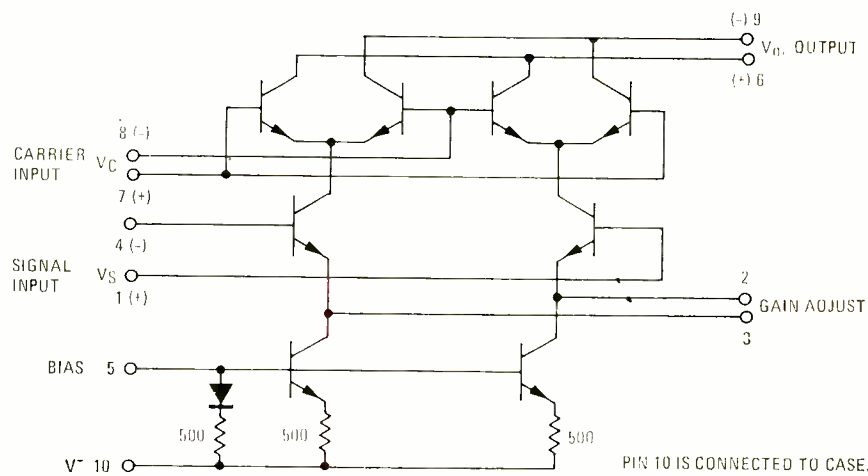
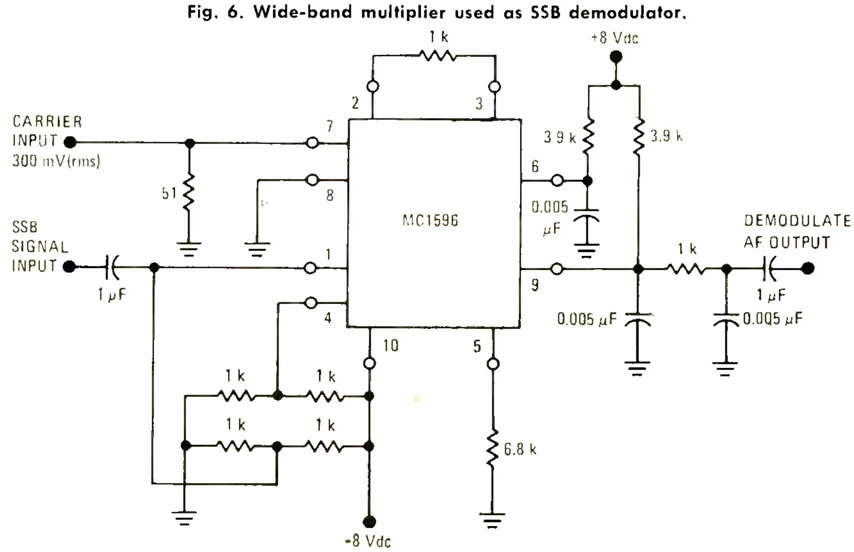


Fig. 5. Circuit of the wide-band monolithic multiplier.

Fig. 6. Wide-band multiplier used as SSB demodulator.



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The author has five-years' experience in hybrid microcircuit engineering and small-quantity production. He graduated from "Technische Hollschule" in Karlsruhe, W. Germany. He is a charter member of the International Society for Hybrid Microelectronics.

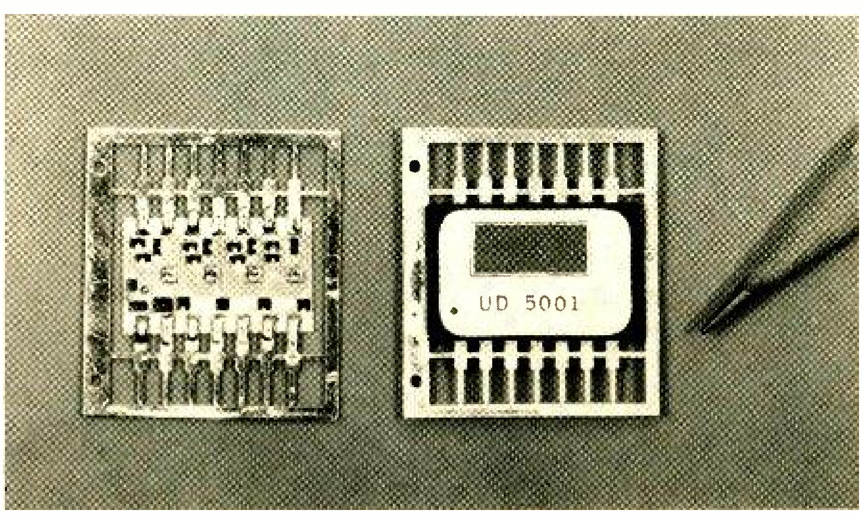
Hybrid Integrated Circuits

By DIETRICH P. WUERTH / Manager, Hybrid Microcircuit Engineering
Sprague Electric Co.

Combining tiny discrete components, IC's, and elements made by thin- and thick-film techniques—all in single integrated-circuit package—provides unique characteristics and many advantages.

A hybrid integrated circuit is defined as one combining thin- or thick-film IC's with monolithic IC's and discrete elements, all within a single package. The objective of the hybrid IC designer is to interconnect, for a particular application, the most suitable types of passive micro networks, active micro elements, and discrete components, and to package these elements with technical and marketing aspects in mind.

During the course of miniaturization of electronic systems, many types of microcircuit elements were developed as well as interconnection techniques and packaging methods.



This hybrid integrated circuit consists of individual IC's, transistor and diode dice, all eutectically bonded to a thick-film resistor network. Interconnections from the microcircuit elements to conductors on the alumina substrate are made by thermocompression bonding. Unit is then epoxy transfer molded. This is a quad line driver.

Microcircuit Elements

Thin-Film Resistor Networks: In thin-film technology, the materials are deposited by various techniques on either silicon, glass, or glazed-alumina substrates. Adjustment of the very accurate resistors is achieved by wet anodization, scribing, or laser-beam cutting, depending on the material used. The range of thin-film resistor material is limited by the sheet resistivity of approximately 200 ohms per square.

Thick-Film Resistor Networks: In thick-film technology, the material is deposited by screening or printing techniques on alumina substrates. Adjusting the resistors is taken care of by sand blasting, scribing, or laser-beam cutting. The range of thick-film resistor materials is very wide, from 10 ohms per square to 10 megohms per square.

Capacitors: Capacitors can be produced by thin-film or thick-film techniques; however the values achievable are limited. Most commonly used are multilayer ceramic and tantalum capacitors. Multilayer ceramic capacitors are available in reasonable sizes (0.1 x 0.1 inch^2) in NPO characteristic up to 1000 pF and in K1200 characteristic up to 50,000 pF.

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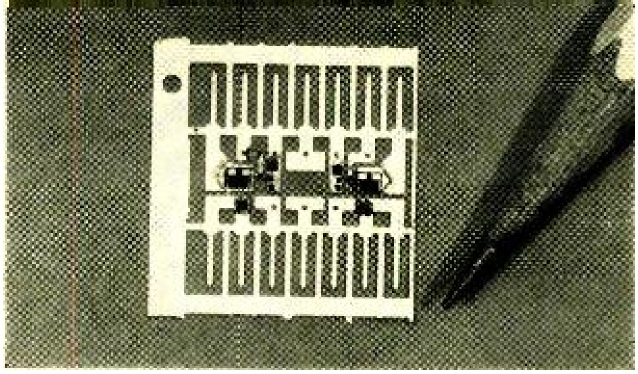
The use of tantalum capacitors in hybrid microcircuits is undesirable and restricted by their size and temperature environment. A tantalum capacitor, rated at temperatures from −55° C to 125° C, designed into a hybrid microelectronic package with a requested temperature rating from −55° C to +100° C is only acceptable if the temperature rise inside the hybrid package does not exceed +25° C.

Semiconductors: Generally, semiconductors are applied to hybrid microcircuits either in die form, or in micro package form. Semiconductors in die form allow greater density and better heat-transfer characteristics in the hybrid package but are more difficult to manufacture than semiconductors in micro packages.

Monolithic IC's: Many times monolithic integrated circuits are used in hybrid microcircuits to obtain more complex or more accurate functional circuits. Hybrid microcircuits may therefore be considered complementary rather than competitive with monolithic integrated circuits.



In this hybrid IC, thin-film resistor chips, transistor and diode dice are bonded to gold-plated Kovar lead frame. Interconnections are made by thermocompression-bonded gold wires. Unit, a dual driver, is later transfer molded.

Interconnection Techniques

Solder Reflow: Both thick-film and thin-film networks may be produced to be compatible with solder-reflow assembly techniques. To avoid delamination of pad areas, controlled assembly techniques are necessary; and to avoid "pad lifting," the thermal expansion factors of the materials interconnected have to be matched. Thermal cycling or thermal shock degrades the adhesion of the pad-substrate interface.

Capital investment for this technique is low; however, the cost of the microcircuit elements used is high. For low-quantity production, this technique has economic advantages.

Chip and Wire: Eutectic die bonding in hybrid-microcircuit assembly causes many problems, especially with the increased number of die attachments in more and more complex circuits. The time in which semiconductors are exposed to temperatures above 400° C exceeds the limit where good conductivity of the eutectic formation can be guaranteed. A badly connected die is usually the start of other problems; the heat transfer from the heat column to package bottom to eutectic to semiconductor becomes poor and inconsistent. Later in the process, this can cause problems in the thermocompression wire-bonding process. Units with such inherent problems will usually exceed the $V_{CE\ (SAT)}$ requirements. A solution to this problem is to use an infrared local heat sensor on the die-bonding equipment controlling the time during which the die is exposed to high temperature.

In general, semiconductors are manufactured with aluminum pad areas. Using gold wire and thermo-compression bonding can result in many problems such as unreliable bonds in the intermetallic interface, while using aluminum and ultrasonic bonding causes problems since the die-geometry on semiconductors is generally not large enough.

Advanced Interconnection: The objective in advanced interconnection techniques is to interconnect microelectronic elements reliably on a large-scale basis. Two major techniques were developed: point-to-point interconnection using wires and direct point-to-point interconnection.

The first method is represented by such techniques as "beam lead interconnection," "spider bonding," and some other proprietary techniques. The second method is represented by "flip chip bonding," and "ductile pad bonding." Which of the techniques is more reliable and economical has not yet been established. Both are applicable to integrated circuits, semiconductors, thin-film resistor networks, and to capacitors.

Packaging Techniques

Microcircuit elements and interconnection techniques are normally given adequate attention by the designer. Packaging techniques, however, seem to be neglected. For example, yield factors reported for seals on a ceramic flat package are very low (10-30%). Of the standard packages available, TO-5 and TO-8 packages in multi-lead configurations seem to be the most successful (80% yield).

Reliable packaging results when the following procedures are employed:

1. Use of materials in which thermal expansion factors are matched.
2. Use of materials which can stand temperatures applied in the assembly process.
3. Use of reliable sealing methods.
4. Use of materials of good thermal conductivity. ▲

CORE-MEMORY SENSE AMPLIFIERS

By RICHARD F. BRUNNER / Senior Applications Engineer, Motorola Semiconductor Products Inc.

More specialized than comparators, this circuit can sense binary state of magnetic memories and convert these signals to system logic levels.

IC core-memory sense amplifiers, used as interface circuitry between memory and logic elements of a computer (Fig. 1), are designed to sense the low-level bipolar voltages produced by magnetic memories, determine their logic levels ("0" or "1"), and then provide an output which is compatible with the logic family being used. Typically, a core-memory sense amplifier consists of a linear amplifier, rectifier, a threshold detector, and logic gate with strobe (Fig. 2).

A brief description of how a core-memory system functions should be helpful in getting an over-all view of what is required of a sense amplifier and how it functions.

Data is written into a core by coincident current pulses on X, Y, and sense-inhibit lines. The magnitude and direction of these pulses is such that after the pulses have been applied, the cores have a remanent flux density of +B or −B (typically, +B is defined as logical "0" and −B as logical "1"). A memory cycle starts with all cores at "O." These cores that have coincident X and Y drive currents are switched to "1," whereas those receiving

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coincident X, Y, an inhibit current remain at "0. To read the memory, all cores in a particular word are pulsed in the "0" direction, that is, the currents in the X and Y lines are reversed. The cores storing a "1" switch to "0" and induce a signal on the sense-inhibit line. Those cores storing a "0" also induce a signal on the sense line, but since this corresponds to the relatively small change in flux density from $+B$ to $+B_S$ (saturation), the "0" signals are much smaller than the "1" signals.

The voltage pulses of the core output signals may be either positive or negative. Bipolar signals are generated because the sense winding goes through half the cores in one direction and the remaining cores in the other direction.

Two differential amplifiers are used as the input stage of the sense amplifier to provide the gain necessary to make the low magnitude (0 to 50-mV range) core output signals compatible with the logic families being used (DTL or TTL). The differential voltage gain of the amplifier is given by the equation: $A_{V\,diff} = R_L/(r_e + R_e)$ where R_L is the load resistance, r_e is the emitter diffusion resistance, and R_e is the emitter degeneration resistance. Since the gain is a function of resistor ratios, rather than absolute values, fairly constant gain results. (A gain of 100 is sufficient for this type of sense amplifier.)

In addition to gain, wide bandwidth is essential for the faithful reproduction of the high-speed pulses generated on the sense windings. Consequently, emitter-follower buffering is used between amplifier stages to enhance the frequency response. Buffering reduces Miller capacitance effect which, in turn, widens the bandwidth.

During any read and write cycle both noise and core output signals ("1" or "0") are generated on the sense windings by the fast switching pulses being sent down the cores' X- and Y-word lines. However, since the noise signals are common to both ends of the sense windings, the common-mode rejection characteristic of the differential amplifier serves to attenuate these signals. Consequently, only the difference signals ("0's" and "1's") generated on the sense windings are amplified.

Once the input signals have been amplified to a sufficient level, they must be rectified so that they are of the correct polarity to interface with the various logic families. Rectification is accomplished with a pair of emitter-followers tied at both collector and emitter. (The paired emitter-followers can be said to perform the logic "or" function for the analog signals applied to their bases.)

The threshold detector or amplitude discriminator is, perhaps, the most critical portion of the sense amplifier and requires capacitance coupling from the wire "or" output to the input of the logic gate. Its function is to determine which signals generated by the switching cores are "0's" and which are "1's." Signals that do not exceed the threshold are a "0" and those exceeding the threshold are "1." The threshold is determined by the d.c. voltage at point A (Fig. 2), which is set according to the voltage applied to the threshold adjust points.

As shown in Fig. 2, there is an "uncertainty" region associated with the threshold in which the output state of the sense amplifier is undetermined. This region designates the maximum variation in threshold, and any amplified signal in this region can produce either a "1" or "0" output. The variation in threshold is mainly due to process variables, input offset of the differential amplifier stages, temperature, and power-supply changes.

Since the voltage difference between a "1" and a "0" is small, it is important that the uncertainty region be held to a minimum. This is accomplished by the differential amplifier which characteristically maintains excellent balance between the amplifier inputs. By keeping the input offset to a minimum, the transistor pair of the differential amplifier stays well matched over temperature and power-supply variations.

The string of diodes (Fig. 2) serve to offset or cancel the diode and transistor junction voltage variation over temperature in the logic gate and threshold detector.

The final stage of the sense amplifier is a standard diode-transistor-logic (DTL) gate. The strobe enables the gate only when the desired signals are present at the amplifier input. This action prevents the gate from being falsely triggered during the time there is noise present on the sense amplifier. Note that the output is in the high state when the strobe input is grounded. With the strobe held high (≥2.4 volts d.c.) the output will go low (≤0.4 volt) if the signal at point A exceeds the 1.4-volt d.c. threshold of the DTL gate. If the signal at point A does not exceed the 1.4-volt threshold, then the DTL gate will remain in the high state. ▲

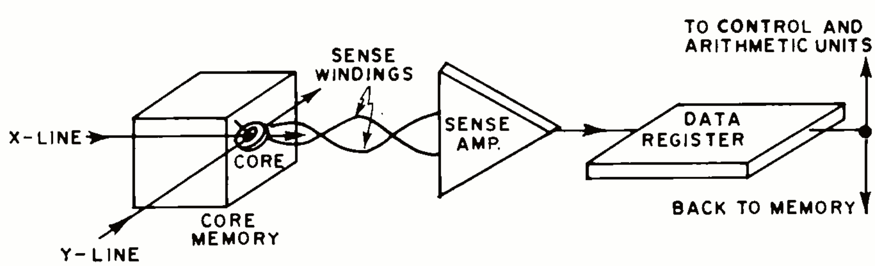
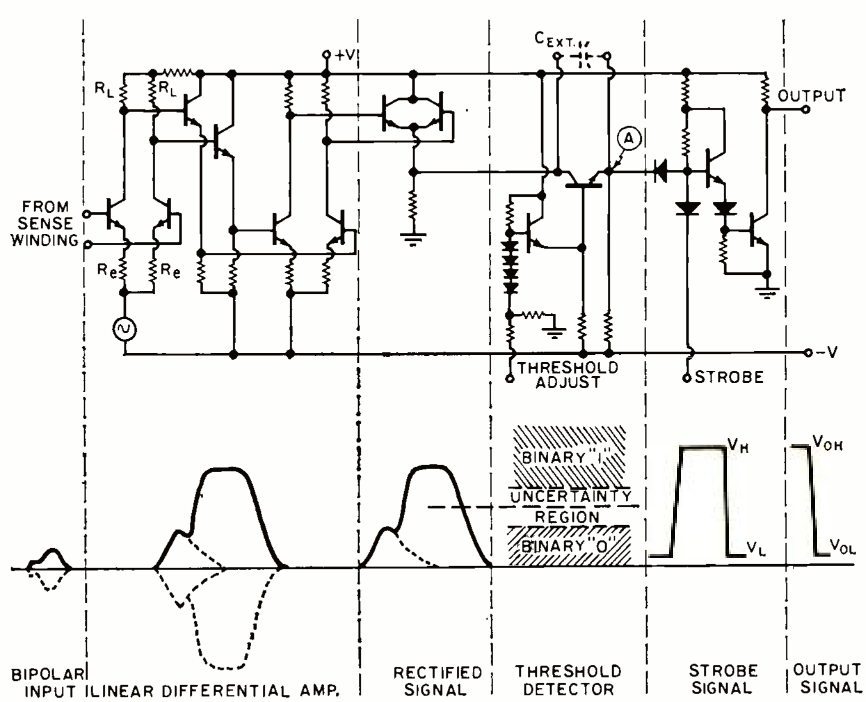


Fig. 1. The IC core-memory sense amplifiers are used as interface circuitry between the core memory and the logic elements of a computer.

Fig. 2. Simplified schematic of core-memory sense amplifier circuit. Some of the typical signals present at each of its stages are included.



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ELECTRONICS— The White Knight?

Electronics may provide solution to most serious problem of the decade: how to reverse pollution.

By **John Frye**

A SEVERE electrical storm had brought activity at Mac's Service Shop to a standstill. It was a shop rule never to work at the bench while a thunderstorm was in progress. Matilda, a notorious coward when it was storming, was perched nervously on a stool in the center of the service area; Mac sat swinging his legs on the service bench; Barney stood in the rear door looking out at the rain splattering down on the steaming asphalt of the parking lot.

"Mac," Barney said, "do you go along with all this sudden concern about pollution?"

"If you're asking if I like breathing clear air, drinking clean water, and hoping to live a normal healthy life span, the answer is an emphatic 'yes,' the shop owner replied.

"I'm inclined to go along with you," Barney said. "The anatomy and biology courses I took last winter at the extension center made me keenly aware of the sensitivity of the human organism to its environment; and lately I've been soaking up a lot of information from books, magazines, newspapers, and TV on the rising danger of pollution. I've just about reached the conclusion that (a) either a great many smart scientists are wrong, or (b) the human race has got itself and all living things into considerable trouble."

"I'm afraid the ecologists aren't wrong," Mac answered. "Theirs is a new science—only 70 years old—and by its very nature it must deal in generalities and avoid the narrow specialization we usually associate with a science; but very few other scientists are challenging the ecologists' dire predictions that include:

1. In the next ten years many city people will have to wear gas masks to survive.
2. In the early 1980's air pollution teamed up with a temperature inversion will kill thousands in some U. S. city, and within that same decade a major ecological system—soil or water—will break down somewhere in this country and new diseases that humans cannot resist will reach plague proportions.
3. Residual DDT accumulating in human livers will increase liver cancer and make the use of some common drugs dangerous.
4. Rising noise levels will cause more heart disease and hearing loss."

"How did we ever get things in such a mess?" Matilda asked petulantly, removing her hands from her ears long enough to hear the answer above the echoing growl of the thunder.

"It wasn't hard," Barney assured her. "All we had to do was keep trying to push up the GNP and ignore everything else; to subscribe to the philosophy that 'What's good for *General Motors* is good for the country'; to grow impatient with nature's calm, deliberate, and often inscrutable way of doing things and try to speed up, selectively, some of her processes and to destroy other things of hers for which we, in our blindness, could see no immediate use; to insist on trying to fit an infinitely expanding population, from which the natural brakes of predators and disease have been greatly loosened, into a finite world; and, above all, to remain woefully ignorant of how an ecological system really works."

"So how does it work?" Matilda wanted to know.

A Delicately Balanced System

"Every ecosystem has four basic elements," Barney lectured. "First, there are inorganic substances such as gases, minerals, and compounds. Second, there are 'producer plants' that convert these substances into food. Third, there are animal consumers which use this food. Fourth and finally, there are 'decomposers,' bacteria and fungi, which turn dead protoplasm into usable substances for the producers. Green plants play a key role in this cycle, for only they can harness the sun's energy and combine it with elements from air, water, and rocks into living tissue, the vegetation that sustains animals, which in turn add their wastes and corpses to natural decay. Nature's efficient reuse of decay builds up productive topsoil in which to grow producer plants, but it takes 500 years to create one inch of good topsoil.

"This whole cycle is a delicately balanced thing. It was started at least 400 million years ago when some primeval accident caused plant life to enrich the atmosphere to about 20% oxygen plus nitrogen, argon, carbon dioxide, water vapor, and a few other trace ingredients, that constitute an ideal mixture for sustaining life as we know it here on earth. Plants, animals, and bacteria used and reused the gases at equal rates so the life-giving mixture was preserved. Seventy percent of the earth's oxygen was, and still is, produced by ocean phytoplankton. The entire system modified temperatures, curbed floods, and set the stage for man's arrival some 5,000,000 years ago.

Man, the Polluter

"For a few million years he lived at peace with the system, but with the advent of the industrial revolution he began to tinker with it. In the ensuing years he has managed to injure every unit of this life-sustaining cycle. He chopped down the trees, plowed under the grass and plants, and paved over the top of them. He polluted the air with countless millions of tons of smoke and fumes and noxious gases. His concentrated excreta and waste products of his factories poisoned the streams and lakes until many of them can no longer sustain any but the most primitive slimy forms of life—and some ecologists are beginning to fear for the oceans themselves. He has used his chemical fertilizers and his herbicides and his insecticides to upset the balance of nature at every turn. He has polluted the biosphere far beyond its ability to cleanse itself under conditions of continuing pollution. In short, mankind has fouled his own nest."

"You two are beginning to give me the creeps," Matilda complained. "What can we do about it?"

"Remember that old TV commercial for a washing prod-

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uct in which a white knight went charging about touching dirty garments with his lance and transforming them into gleaming white?" Mac asked. "Well, I picture electronics as a White Knight. If we are to work our way out of our very serious predicament, much of the job will be done by electronics. In a way, this is only right; electronics and electricity have contributed their share of pollution. Power-producing plants are major air polluters. So are gasoline-powered automobiles that depend on an electric spark for ignition. Electro-chemical factories almost always appear on a list of water polluters. We know what hi-fi, the transistor radio, p.a. systems, and amplified musical instruments have done to pollute nature's silence," Mac said, sliding off the bench and striking a spraddle-legged pose and twanging an imaginary guitar.

"Quit it!" Matilda giggled. "I plead guilty, your honor, on behalf of electronics. What can my client do to make restitution?"

"First, let me mention the obvious ways: electronic precipitators are chiefly responsible for cutting down on the fly-ash and other materials otherwise belched out of factory and power-plant chimneys. Many believe the electric car is the ultimate answer to pollution from the internal combustion engine. Pollution - sensing - telemetry - relaying equipment located along the banks and the tributaries constantly monitor the Ohio River. Satellites send down an endless stream of reports electronically concerning the condition of crops and forests and the oceans.

"But electronics can and must do much more, especially in the fields of measuring and monitoring pollution—which must precede any attempt to control it. Mayor Lugar of Indianapolis recently said if his city wanted to make water returned from sewage disposal plants 99% pure instead of the present 91%, they would not know where to buy the equipment. He was pointing out the need for basic research, for the setting up of standards, and for the manufacturing of hardware to control pollution."

"And for those people who refuse to work at anything—even saving their own lives and those of their children—except for money," Barney said, "there's plenty of that involved in the anti-pollution business. It's estimated that in the next five years it will take $30 billion dollars to halt pollution of the nation's waterways and another $60 billion to clean up the air. Politicians have gotten the word. As Senator Edmund S. Muskie puts it: 'In the past we have had to fight against all kinds of political pressure, public apathy, and ignorance. Now the wind is blowing at our back.' The Water Pollution Administration is already moving ahead with a $48-million nationwide electronic instrument system that will monitor the water quality and pollution of almost all interstate streams and river and many coastal waterways."

"But what we still desperately need to avoid squandering money uselessly," Mac pointed out, "is more knowledge about the interaction of various units of our ecosystems. Take a single example: destroying the seemingly useless hippopotamuses in South Africa caused schistosomiasis to increase until this debilitating disease is as bad in many localities as malaria was 50 years ago. Hippos kept the river silt stirred up and moving as they bathed and bull-dozed natural irrigation channels out to the bank by their single-file movements. Without this, the rivers silted up, flooded over adjacent land, and caused a proliferation of schistosomiasis-carrying water snails."

"We're making a start on acquiring that kind of knowledge," Barney offered. "George Van Dyne and 80 other scientists are trailing every imaginable creature on the Western prairie to discover how a grasslands ecosystem responds to various stresses. The data will be used for a computer-modeling scheme. Ideally, the entire environment should be subjected to computer analysis and systems control. Then, before we drained a marsh for a new housing development, built a power dam that flooded millions of acres and placed added strain on the earth's crust, wiped out an insect or rodent population, or dumped radioactive material into the ocean, we could ask the computer what would be the immediate and far-reaching effect on our environment—and by 'our environment,' I mean that of the whole world."

"Sounds to me as though our struggle against pollution may be the final solution to war—one way or the other," Matilda suggested. "Either we fight together for the survival of humanity or else we die together in our common pollution."

"Now who's crepe-hanging?" Barney teased; "but you're right. If conditions are as serious as ecologists warn, the hero of this decade may well be the cartooned little bespectacled, pith-helmeted zoologist with his butterfly net instead of the glamorous space-suited astronaut and his towering rocket. I believe a young man interested in electronics can do no better than to enter the anti-pollution branch of this tremendous field and dedicate his lance to the service of Mac's White Knight. This is true no matter if it is money, a wish for interesting and vital work, or a desire to serve humanity that motivates the young man. That's where the action is going to be the next couple of decades at least." ▲

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C.E.T. Test, Section #6

TV Alignment

By DICK GLASS*

What is your electronics servicing I.Q.? You must get 75% on entire exam to pass.

This is the sixth in a series of 12 test sections to be published monthly. While these test exam sections are not part of the actual NEA C.E.T. examinations presently being administered, they are similar in nature. Should you find you are able to correctly answer 75% or better, you might be a candidate to become a registered CET. You can take the exam in your area but you must show 4 years of experience to qualify.

(Answers will appear next month.)

Answers to last month's quiz appear on page 81

1. A television response curve can be plotted with a conventional AM generator and v.t.v.m.
- *(a) only if a scope is also used*
- *(b) only if a marker generator is used*
- *(c) only if a sweep generator is also used*
- *(d) only*

2. Which of the following indications would usually not signify possible misalignment of a color-TV i.f. section?
- *(a) weak color*
- *(b) blurred color*
- *(c) color displayed to right of B&W image*
- *(d) color out of lock*

3. When aligning most color-TV receiver video i.f. circuits, the sound carrier would normally be placed:
- *(a) as near 100% as possible on the sweep waveform*
- *(b) at the 50% point on the slope*
- *(c) near the baseline on the sweep waveform*
- *(d) sound carrier has no relationship in the sweep waveform*

4. In a 40-MHz i.f. section, 47.25 MHz might refer to:
- *(a) the video carrier frequency*
- *(b) the sound carrier frequency*
- *(c) color subcarrier frequency*
- *(d) the adjacent sound frequency*

5. Identifying various frequency points on the video sweep waveform usually is done by using a:
- *(a) sweep generator*
- *(b) triggered scope*
- *(c) marker generator*
- *(d) dot generator*

6. The color-TV bandpass amplifier is expected to pass what frequencies?
- *(a) 3.08-4.08 MHz*
- *(b) 3.25-4.25 MHz*
- *(c) 3.58-4.13 MHz*
- *(d) 3.03-3.58 MHz*

7. An a.g.c. substitution box, used in alignment, usually:
- *(a) has a high impedance*
- *(b) has a low impedance*
- *(c) must not interfere with the set's developed a.g.c.*
- *(d) must not "swamp out" the set's developed a.g.c.*

8. The video detector load resistor:
- *(a) is a good place to connect scope to view sweep waveform*
- *(b) normally will be 100k-ohms or greater in value*
- *(c) might be expected to develop a peak-to-peak video waveform from 25 to 50 volts across it*
- *(d) is not a good place to connect a scope*

9. Many TV technicians align sound circuits in modern TV receivers using only the station signal and the tech's ear.
- *(a) this is OK*
- *(b) a sweep generator and scope must also be used*
- *(c) an FM generator and scope must also be used*
- *(d) a sweep generator, marker, and scope must also be used*

10. The sweep generator is usually connected during sweep alignment of the video i.f.'s at:
- *(a) the antenna terminals*
- *(b) the mixer grid (or base)*
- *(c) the i.f. link*
- *(d) first i.f. grid or base input*

*Executive V.P., NEA, 12 South New Jersey St., Indianapolis, Ind. 46204, assisted by Lew Edwards, chairman of Test Make-up Subcomm.

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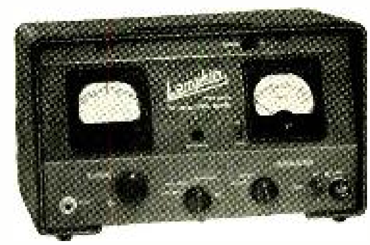

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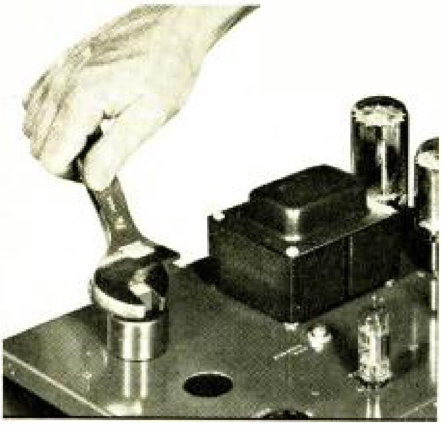

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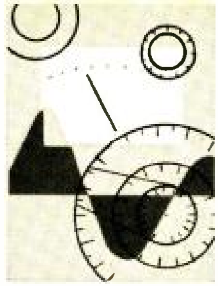


TES EQUIPMENT

Product Report

Leader Model LBO-501 Oscilloscope

For copy of manufacturer's brochure, circle No. 3 on Reader Service Card.

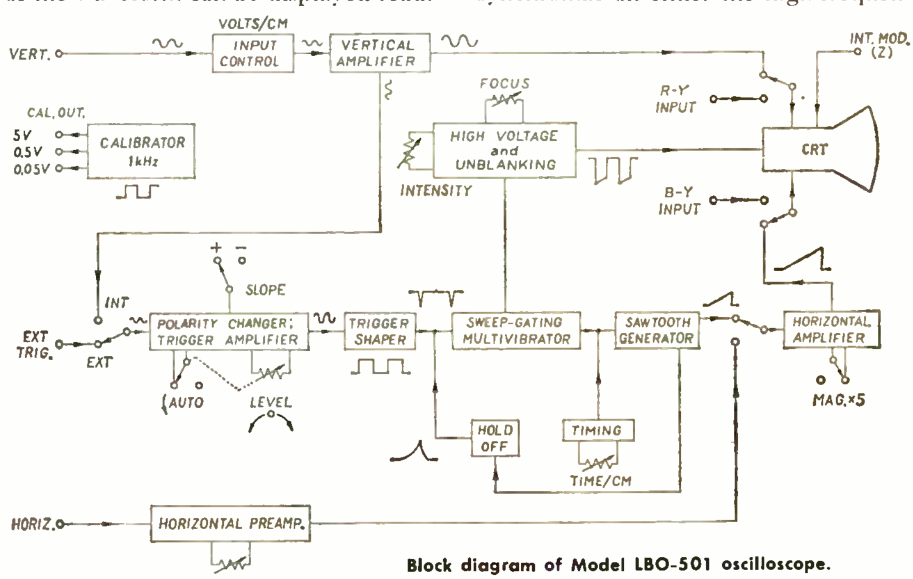
THE new *Leader Instruments* LBO-501 triggered-sweep oscilloscope provides capabilities usually associated with far more sophisticated and more expensive instruments. This hybrid (tube and transistor) 5-inch scope can be used to measure d.c. voltages and can handle signals up to 10 MHz. It can measure rise time, pulse width, and decay times of pulses using the calibrated triggered sweep.

There are two modes of sweep operation, "Normal" (triggered) and "Automatic" (free-running). In the triggered operation, there is a choice of the point on the slope of the waveform at which the sweep is initiated so that any portion of the waveform can be displayed readily. The triggered-sweep range is from 0.2 μs/cm to over 0.2 second/cm, and vertical sensitivity is 20 mV (p-p)/cm.

The input circuit consists of a 9-position compensated and calibrated attenuator that permits accurate display of a wide range of incoming signals. The low-capacitance input probe, which is sold separately, is a newly styled retracting hook type that is fully insulated all the way to the tip.

Although triggered-sweep scopes are widely used in laboratories and in industry, they have not been employed by the TV servicing industry because of their high cost. This imported instrument, priced at $340, is somewhat more competitively priced than most other triggered-sweep scopes, so that it should be in the running not only for industrial uses but also for servicing applications.

The difference between a triggered scope and a more conventional free-running instrument is that the former has a one-shot sweep circuit. The electron beam remains blanked out and in a stationary position until the sweep is triggered on by an input waveform or pulse. When turned on, the beam sweeps across the CRT displaying the incoming waveform and then returns to rest. Each succeeding pulse or cycle causes the sweep to be produced and the beam to travel across the CRT screen. The triggered sweep feature makes it possible to observe non-repetitive transients and to synchronize on either the high-frequen-



Block diagram of Model LBO-501 oscilloscope.

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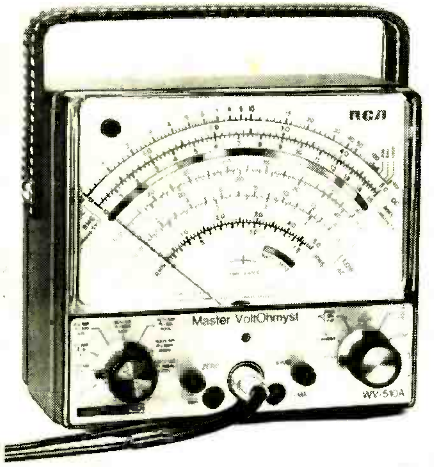
cy or low-frequency components of a complex waveform. The horizontal deflection is calibrated in time, making it possible to measure the duration or frequency (reciprocal of time) of waveforms or pulses. The vertical amplifier is calibrated in volts per centimeter making precise amplitude measurements possible. ▲

RCA Model WV-510A Electronic V. O. M.

For copy of manufacturer's brochure, circle No. 4 on Reader Service Card.

THE successor to the old v.t.v.m., but with its circuits now transistorized, is still alive and kicking in spite of the introduction of digital instruments. Widely used in servicing, as well as in industrial and laboratory applications, the analog meter doesn't have the accuracy of the digital meter (this one is ±3 percent of full-scale). But there are quite a few of us who can accurately read the position of a moving pointer over a scale, especially if it is mirrored. Most important, price of the analog meter is much lower than a digital instrument and its design lends itself to battery operation and portability quite readily.



The latest *RCA* "Master VoltOhmyst" is the Model WV-510A. This portable electronic v.o.m. operates either from internal batteries or from the a.c. power line. It can readily be used on the service bench, in the home, or on the laboratory bench.

The meter measures d.c. and a.c. voltages up to 1500 V, direct current up to 1.5 A, peak-to-peak voltage of complex waveforms up to 4200 V, and resistance values up to 1000 megohms.

The solid-state measuring circuit features excellent zero stability and linearity. The current drain is very low, assuring long battery life. Accuracy is maintained throughout the usable life of the batteries and a convenient battery-test function is provided.

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Triplett Model 8000 Digital V. O. M.

For copy of manufacturer's brochure, circle No. 5 on Reader Service Card.

ALTHOUGH *Triplett* is well known for its wide line of conventional analog or pointer-type meters of all kinds, the company is keeping up with the digital field as well. A digital meter, although more expensive than an analog meter, provides highly accurate readings in digital form so that the inexperienced user or one requiring more accurate readings need not guess at the position of a pointer moving over a scale.

The new 3½-digit solid-state Model 8000 measures d.c. voltage and current, resistance, and the r.m.s. values of a.c. voltages and currents. It can be used in the lab, on the production line, in educational work, or for general-purpose servicing. Measurements are displayed by three gas-filled readout tubes. Also, the numeral "1" is displayed for over-range measurements. The readout display is complete with a movable decimal point, automatic over-range indication, and auto-polarity for d.c. functions. This latter function means that the user need not know or set the polarity of any d.c. voltage he is interested in measuring.

Maximum voltage range is 1000 volts on a.c. or d.c.

The meter has protective circuitry which prevents damage to the tester when excessive voltages are applied. It has as much as a 50 percent over-range, and a sample rate of six times per second prevents blinking of the display.

Company engineers are especially proud of the practically zero kickback current, thereby allowing voltage measurements in high-resistance circuits at the stated accuracy of ±0.1 percent of reading ±1 digit. This kickback current is an internally generated current at the meter input circuit which would flow in an external circuit, producing an erroneous voltage drop.

The digital meter operates from the a.c. power line. Premium PC boards and heavy construction are used to provide strength and isolation from interfering fields. A stored metal leg is used to elevate the front edge to facilitate table-top use. Size of the Model 8000 is 10$\frac{5}{16}$ by 4⅛ by 8⅞ inches deep. Price of the instrument is $575. ▲

FM Share of Radio Market Exceeds 46%

THE Consumer Products Marketing Services of the EIA has reported that the FM share of the total home radio sales passed the 50% mark for the first time last year—55.3% of the record 41,476,000 receivers that have been sold.

FM penetration of total U.S. radio sales, including auto radios, reached a record 46.1% in 1969. See table below for the receiver figures.

	1969			1968		
	TOTAL SALES*	FM*	%	TOTAL SALES*	FM*	%
Table	4,681	2,280	48.3	6,383	3,315	51.9
Clock	7,801	4,121	52.8	5,376	1,730	33.0
Portable	26,932	14,504	53.8	22,563	10,902	48.3
Total	39,414	20,905	53.0	34,322	15,947	46.4
TV/Phono/Comb.	214	214	100.0	274	274	100.0
Radio/Phono Comb.	1,848	1,848	100.0	1,920	1,920	100.0
Total	41,476	22,967	55.3	36,516	18,141	49.6
Automobile	11,939	1,677	14.0	12,510	1,369	10.9
Total	53,415	24,644	46.1	49,026	19,510	39.7

*All in 000 units

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Digital Instruments You Can Build

(*Continued from page* 31)

(approximately 70 volts d.c.) to assure that a glow discharge cannot be sustained on the "off" cathodes. Thus, a transistor having a collector-to-emitter breakdown voltage in excess of 70 volts will serve adequately as a driver.

It is interesting to note that the driver transistor collector will usually be pulled up into the breakdown region because of the few microamperes of current drawn by the "off" cathode. This is permissible as long as the transistor power dissipation ratings are not exceeded and a stable operating point can be maintained.

Availability

New readouts are being introduced almost daily. The readouts described in this article are, in the author's opinion, those offering the greatest performance at the least cost. Understandably, these readouts will not be obtainable from the corner electronics store, or even from the major mail-order distributors. However, the components *are* available, and the reader should contact the manufacturers indicated in the tables to obtain the relevant data sheets and the name of the nearest distributor.

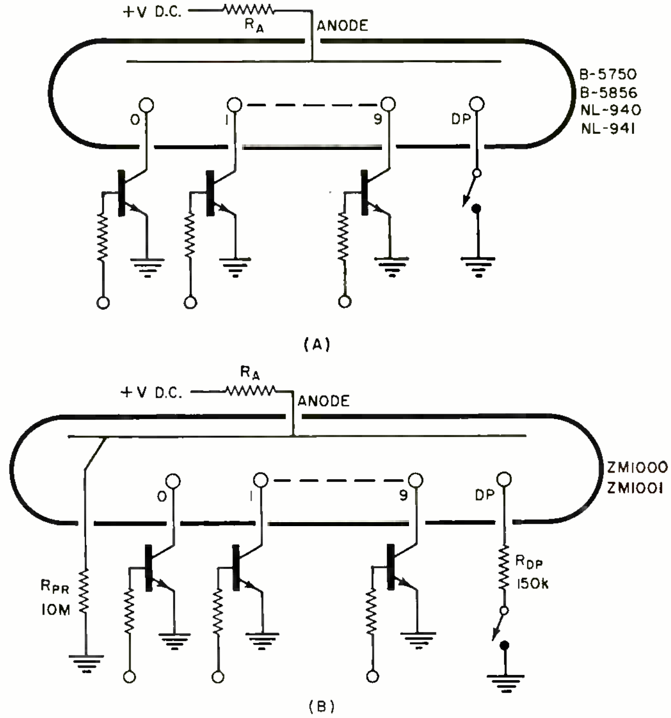
Prices

Prices of the readouts are given in the tables *for information only*. It must be understood that the stated prices are correct as of the date this article was written, but are subject to change without notice. Before a particular design is discarded on the basis of price alone, the reader should obtain current prices. Based on recent industry trends, prices are more likely to decrease than increase.

Next month's article will describe various counting and decoding circuits compatible with either segmented or numerical display devices.

(Continued Next Month)

Fig. 6. Driver circuit configurations for (A) Burroughs B-5750 and B-5856 and National's NL-940 and NL-941 devices that do not require separate decimal-point resistor unless the decimal point is energized alone and for (B) Amperex Types ZM1000 and ZM1001 which require a priming resistor. Type ZM1000 also requires separate decimal-point resistor.



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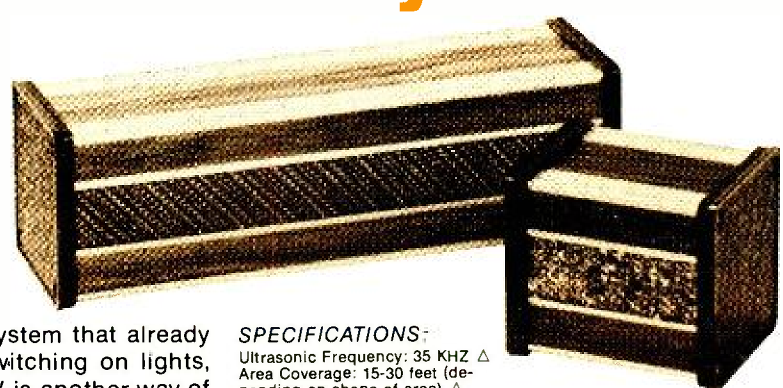

When you have an intrusion detection system that already cuts theft potential 95% by automatically switching on lights, why add sound? Environmental Variance. EV is another way of saying that numerous individual and business premises are subject to varying levels of background noise, including cars, trucks, trains and industrial activity... as well as varying levels of outside people-traffic. This is why DeltAlert's new audio capability is the answer to Environmental Variance, and why it's your answer to total intrusion detection.

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Solid-State Locked-Oscillator FM Limiter/Detector

By ERNEST J. JARROLD / Technical Specialist
Avionic Controls Dept., General Electric Co.

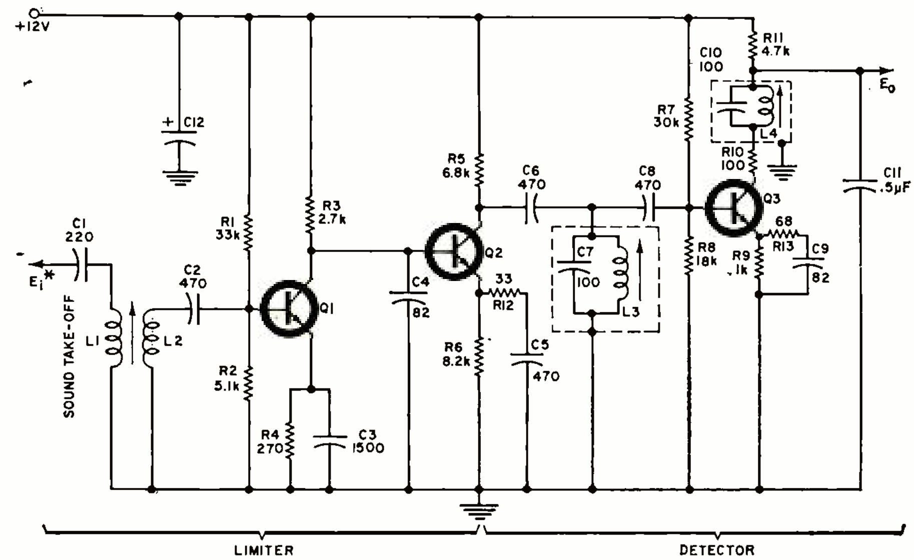
Design of solid-state version of circuit for TV sound detector. Has better limiting, more audio recovery, and greater sensitivity than ratio detector.

MOST transistor television receivers made today use a conventional tuned-amplifier ratio-detector system for the audio detector. Generally the source for this detector system is the video detector in the TV set that uses the intercarrier sound system. At this detector the 4.5-MHz FM sound carrier is buried within a video signal that has large components of amplitude modulation. Further, it is expedient from a TV system-cost standpoint to have negative sync at the video detector. This is done in such a way that the amplitude modulation due to this negative sync "puts a bite" into the 4.5-MHz FM audio carrier—known as "downward modulation" of the audio carrier. This type of amplitude modulation is hard to eliminate from the limiter and detector output. Consequently, it is not unusual to have an audio detector system that invariably couples some portion of the amplitude-modulated video sync pulses through the limiter and detector to appear as unwanted "sync buzz" at the speaker.

For many years the ratio-detector circuit has met—with a bare minimum—the stringent requirements of an audio detector for TV receivers. Relatively recently, the locked-oscillator detector has been used to advantage. This type of circuit needs a multigrid vacuum tube, but provides a definite performance improvement over the ratio detector. The transistor counterpart of this type of circuit has remained a novelty.

Description of Operation

As shown in Fig. 1, the signal is coupled-in through the sound take-off transformer from a low-impedance source, $C1$ and $L1$ forming a series-tuned circuit. From the secondary of the transformer capacitive coupling is used to the base of the limiter stage $Q1$, which operates in a dual mode. At low signal levels it acts as a sine-wave amplifier, and at high signal levels it is a sine-wave-driven grounded-emitter switch. For the circuit of Fig. 1 an amplifier-type transistor was used although better performance, with improved AM rejection, might be obtained by using a switching-type transistor, at not much difference in cost (see Fig. 2).



NOTES:
CAPACITORS ARE IN pF UNLESS OTHERWISE SPECIFIED
Q1, Q2—FAIRCHILD S1062 OR 2N3394
* FOR HIGH-IMPEDANCE SOURCE USE PARALLEL RESONANCE
L3, L4—12µH, Q—50
Q3—2N2369 OR 2N5027

Fig. 1. Limiter and locked-oscillator detector designed for TV sound use.

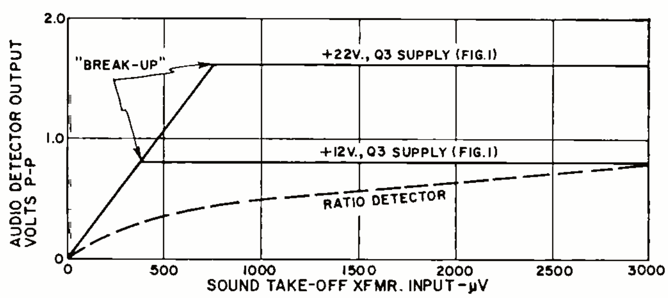


Fig. 2. Limiting curves for ±24 kHz FM modulation.

The output of this switching stage is very nearly a square wave with a fundamental frequency equal to the incoming signal frequency. Limiting action of the incoming signal is achieved by the saturation of $Q1$. As the signal into the $Q1$ base gets stronger, the $Q1$ collector voltage waveform remains constant. This square wave is integrated into a triangular or sawtooth wave by the action of capacitor $C4$ and the load resistor for $Q1$, $R3$. The fundamental frequency is still equal to the incoming signal. $Q2$ acts as an amplifier stage. Its load resistor, $R5$, and the coupling capacitor, $C6$, are a current source for the following detector.

The detector, $Q3$, is similar in performance to the vacuum-tube locked-oscillator detector, although it differs somewhat in concept. The conventional locked-oscillator audio detector using a vacuum tube achieves quadrature grid detection by means of the phase relationships between the pulsed current at the first and third grids. The latter, called the quadrature grid, is tuned for parallel resonance at the center frequency of the incoming signal.

Operation of the detector of Fig. 1 might be easier to understand by thinking of it as an active slope detector. The oscillator portion of $Q3$ consists of a tuned-base, tuned-collector oscillator,

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for its feedback path. The choice of transistor type for this stage is rather critical, a good non-saturating switch type giving best performance. Such a type is available in an epoxy package at low cost. This stage must be a dependable oscillator, but it has to be able to track the frequency of the incoming signal. The emitter is essentially grounded to r.f. frequencies. The collector tank is tuned to a frequency higher than the incoming signal, the linear portion of the lower half of the parallel tank response curve being tuned at the signal frequency (Fig. 3).

With no frequency modulation of the incoming signal, the oscillator is operating at a frequency of f_2. As the incoming signal is lowered in frequency to f_1, the oscillator then operates at this lower frequency of f_1—provided the signal is strong enough to lock-in the oscillator. Conversely, when the signal is raised to f_3, the oscillator frequency rises to f_3. The pulses of collector current through Q3 flow through the Q3 tank and *R*11. As the frequency of these pulses changes, due to the changes in incoming signal frequency, the impedance presented to these current pulses changes, and this causes a change in the amplitude of the Q3 collector current pulses. This change in amplitude of the current pulses is seen as a voltage change across *R*11. Fig. 4 shows some waveforms that illustrate the mechanism described. The similarity, in end results, to the quadrature grid detector action can be noticed.

Capacitor *C*11 is a bypass to ground for the oscillator portion of the Q3 output. It acts as an integrator or filter to the i.f. voltage pulses across *R*11 and also serves as a deemphasis capacitor, working in conjunction with *R*11, to attenuate the higher audio frequencies out of the detector.

Discriminator-Curve Characteristics

An interesting observation of the detector in action can be made by viewing the "break-up" (detection threshold) curves of Fig. 5. In Fig. 5B the random carrier noise can be seen at each side of the curve as the oscillator falls out of sync with the signal. This occurs since the AM and FM modulations are random and non-synchronous with each other. In Fig. 5C the AM carrier noise vanishes and in its place can be seen a decaying transient sine wave. This represents the beat output obtained from the frequency difference between the signal and the oscillator, as the oscillator is falling out of synchronization with the signal.

Compared to a transistor, a vacuum-tube pentode is a better device for use in a locked-oscillator detector application, since it has available the additional power gain of the audio amplification due to the quadrature grid. A tube circuit, however, is inherently more susceptible to variations in stray capacitance, which may influence the crossover point of the curve. A typical value of quadrature grid tank capacitance in a tube set may be about 20 pF or less. In this transistor circuit the tank capacitances are five times larger so that the effect of long-term change of printed-wiring-board stray capacitance is much reduced. This has been a production problem in early vacuum-tube locked oscillator detectors.

The point where the detector curve crosses the frequency axis is somewhat a function of ambient temperature. This is due mostly to the variation in capacitance with temperature of *C*7. With a silver-mica capacitor, a detector crossover frequency shift of +18 kHz was observed for an ambient change of from 24° to 56°C. This could be improved by choosing a capacitor with a suitable temperature coefficient.

The detector curve crossover point had about 20-kHz shift for a 5% variation in power-supply voltage.

Tuning Method

A sweep-generator signal is recommended, at least for the initial checkout (as follows).

1. A strong signal is fed into the input. Use about 200 mV r.m.s., 4.5 MHz, ±25-kHz FM deviation and set the sweep

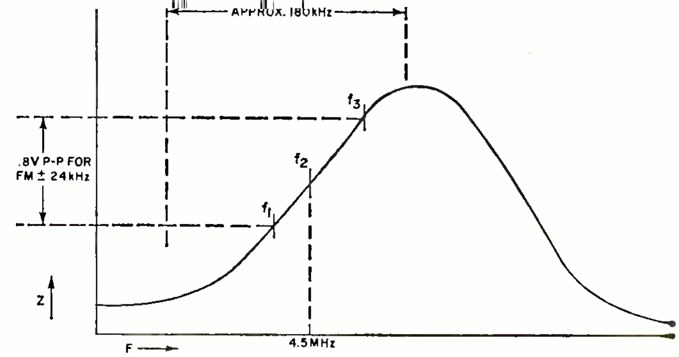


Fig. 3. Impedance of Q3 tank for incoming frequencies.

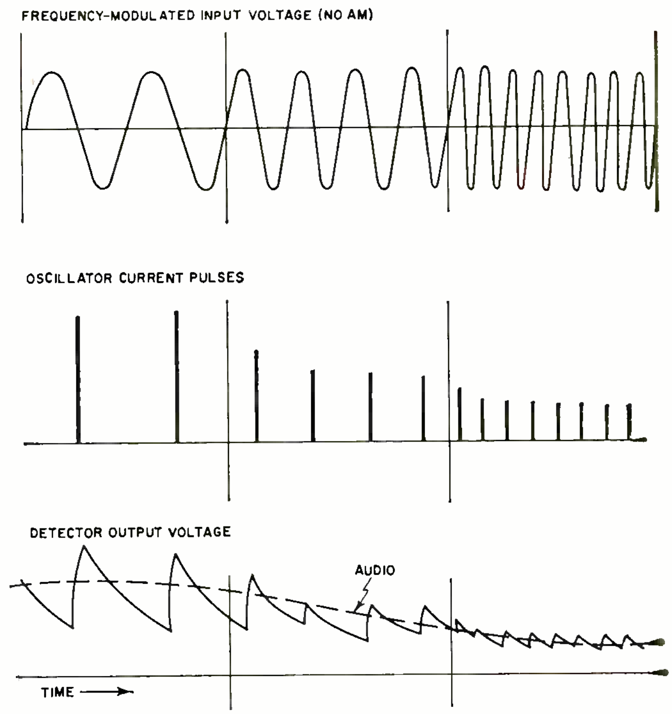
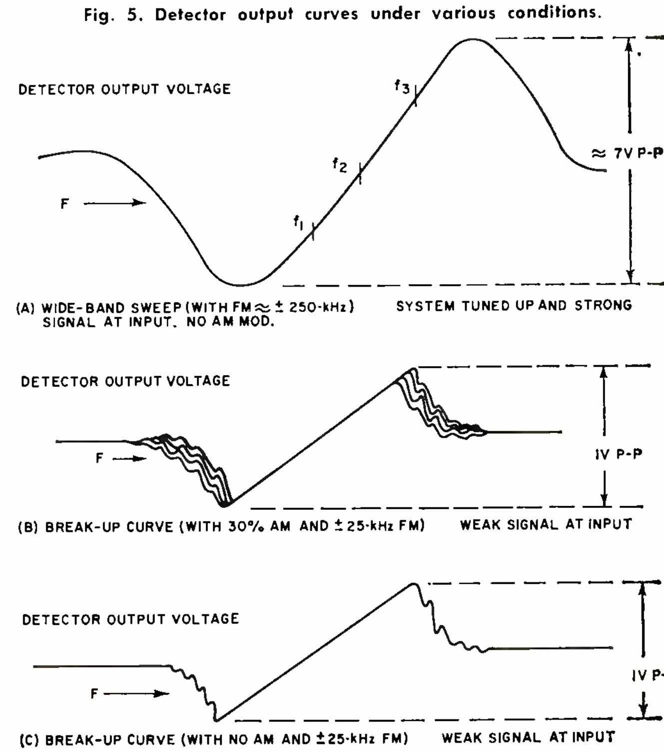


Fig. 4. Waveforms showing the operation of the detector.

Fig. 5. Detector output curves under various conditions.



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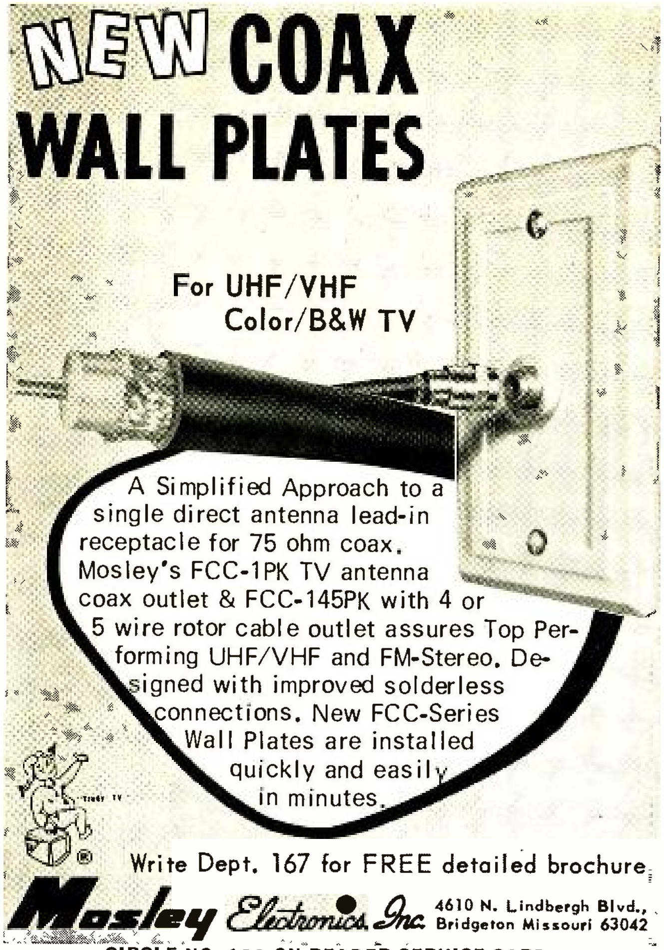

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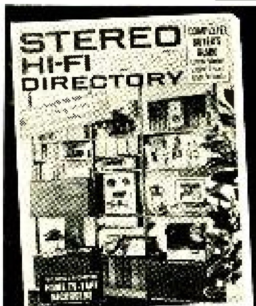

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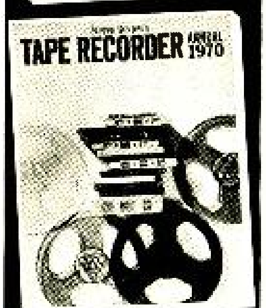

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width to about 200 kHz. The vertical input of a scope is connected to the detector output and the vertical gain set about ¼ volt per cm.

2. $L4$ is tuned for a positive slope of audio recovery (increasing output voltage for an increase in signal frequency) of about 1 V p-p and for maximum linearity. There is also a point in $L4$ slug tuning at which a negative slope is obtained, but this gives poor sensitivity and will not produce the proper "break-up" (detection-threshold) characteristic.

3. The signal amplitude is now reduced until the detector curve moves along the horizontal, or frequency, axis and begins to leave the scope screen. Adjusting the $L3$ slug will return the curve back toward the center. The input voltage amplitude is further reduced while keeping the curve in view with the slug adjustment of $L3$. Finally, the signal will be reduced to the point where the curve will not move along the horizontal axis. The detector is now tuned and only the sound take-off transformer remains to be tuned. Proper tuning of the transformer increases detector sensitivity so that "break-up" can be achieved at a lower input level.

Noise Suppression

The suppressor resistor $R10$ is very beneficial. Although it diminishes detector audio recovery somewhat, it greatly reduces audio "tweets," those unwanted video signals appearing on the low-band TV channels. These are caused by harmonic generation in the audio or detector system, which is picked up in the video, r.f., or i.f. system. $R10$ should be a small resistor (¼ or ⅛ watt) and kept close to the chassis, with both leads very short, especially at the collector side.

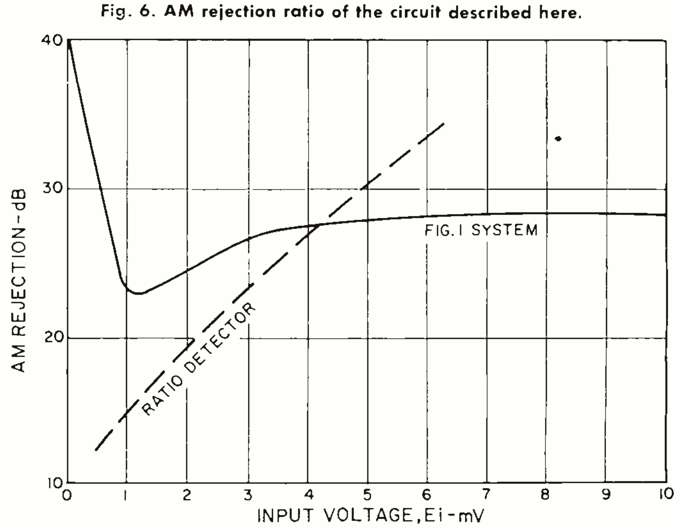
Another consideration that is quite important to audio "tweet" suppression is the ground paths of the i.f. limiter and detector. Ground leads carrying large signal currents should be returned to the point that will give the least ground-plane currents.

Shielding of the oscillator-detector was not necessary when these precautions were observed. An earlier model of this system, which gave greater audio recovery, used a higher power supply voltage (22 volts) but this circuit needed shielding to reduce audio "tweets."

Fig. 2 previously showed how the limiting curve of this system is superior to a ratio-detector system. This is particularly true for weak signals. The limiter had good buffering action so that the 4.5-MHz signal in the oscillator-detector does not enter the video detector and appear in the picture. Fig. 6 shows the AM rejection ratio of the circuit compared to a ratio detector.

The author acknowledges the assistance of Mr. Edward Eachus and Mr. Robert Dome, both of the *General Electric Company* for their help in this effort. ▲

Fig. 6. AM rejection ratio of the circuit described here.



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BOOKS

"INFORMATION TRANSMITTAL AND COMMUNICATING SYSTEMS" by John P. Froehlich. Published by *Holt, Rinehart and Winston, Inc.*, New York. 269 pages. Price $3.95 paperbound.

This volume is designed as a classroom text yet can serve equally well as a home-study guide for technicians who service such communications systems.

Following the author's preface explaining how the text is laid out, the subject is dealt with in five chapters: communication, signal transmission in electrical networks, amplitude modulation, angle modulation, and pulse modulation. The presentation is in conversational style but the treatment is mathematical and the student should have a working knowledge of trigonometry, algebra, and basic calculus in order to deal with the various problems and be able to work out the equations.

* * *

"HANDBOOK OF PRACTICAL ELECTRONIC TESTS AND MEASUREMENTS" by John D. Lenk. Published by *Prentice-Hall, Inc.*, Englewood Cliffs, N.J. 297 pages. Price $15.00.

This is a thoroughly practical handbook for the practicing professional electronics technician. It tells what can be tested with basic instruments and how to go about it.

The author ranges from the testing of various components through the techniques for measuring such quantities as inductance, impedance, frequency response, circuit Q, distortion, s.w.r., etc. All of these procedures can be performed with basic test equipment of the type encountered in all laboratories and most shops. Since the author has assumed that his professional readers will not need to be instructed on how to use the test equipment, he concentrates on specifics and application data. Readers are strongly advised not to skip a prefactory chapter dealing with safety precautions—they may be basic but have often suffered from an offhand contempt because of familiarity.

* * *

"ELECTRONIC TEST & MEASUREMENT HANDBOOK" by John J. Schultz. Published by *Tab Books*, Blue Ridge Summit, Pa. 17214. 220 pages. Price $7.95 hardbound, $4.95 softbound.

This is a specialized volume for those involved in maintaining and troubleshooting receivers, transmitters, transceivers, antennas, and various pieces of accessory equipment used with such basic units. The author has set 220 MHz as his limit since, he feels, equipment needed to test higher frequency gear is not available to the average technician or ham.

The eight chapters cover general test procedures, the basic test instruments and equipment that will be needed, receiver circuits, transmitter circuits, antennas and transmission lines, audio and video equipment, accessory equipment and components, and system and interference tests. A useful appendix provides reference data, charts, and formulas that the technician can use in his work.

The text is lavishly illustrated with diagrams, charts, photographs of various pieces of commercial equipment, and line drawings.

* * *

"RADIO HANDBOOK" by William I. Orr. Published by *Editors and Engineers, Ltd.*, New Augusta, Indiana. 888 pages. Price $13.50.

It hardly seems possible that this is the 18th edition of a popular reference work which grew from a slim volume in 1935 into this huge tome. But it is.

As always, this text is addressed to hams and their engineering counterparts and provides a wealth of useful, up-to-date information on all sorts of ham equipment as well as RTTY circuits and semiconductors. FET's and IC's have been incorporated in a number of the designs so that the ham building his gear from this book can take advantage of the latest circuits and techniques.

Roughly half of the chapters deal with basics and serve not only as excellent background for the student but invaluable reference material for the old-timer. Another dozen or so chapters deal with ham station specifics, while the next two chapters cover electronic test equipment and workshop practice. The final chapter is an over-all review of radio mathematics and calculations. Four appendices provide useful data on color codes, inductors, copper wire, and conversions.

Those trying to decide on what single volume would be the most useful in his technical library won't go far wrong in picking this handbook.

* * *

"EFFECTIVE TECHNICAL SPEECHES & SESSIONS" by Howard H. Manko. Published by *McGraw-Hill Book Co.*, New York. 169 pages. Price $7.95.

Subtitled "A Guide for Speakers & Program Chairmen," this handy volume would seem to be a "must" in almost anyone's library—whether a research engineer who must present the fruits of his labors before the IEEE or a service technician whose association expects him to outline troubleshooting procedures on a new TV set for his fellow technicians.

The author, who is Director of Research & Development at *Alpha Metals*, is well equipped to offer such advice since he is much in demand as a speaker and moderator at technical sessions throughout the country.

His advice is practical and down-to-earth and if more persons honored by requests to address their peers would follow his suggestions, technical sessions would be more interesting, more informative, and better attended.

The text is divided into three parts: the speaker and the speech, organizing a technical meeting, and finally parliamentary procedures, contributed by George W. Cavanaugh, a registered parliamentarian. Every chapter is packed with practical and important tips and procedures, which should be studied and digested for maximum effectiveness. With all this information under his belt, the prospective speaker should be able to put his ideas across with the least amount of strain to himself and his audience.

* * *

"AUDIO CYCLOPEDIA" by Howard M. Tremaine. Published by *Howard W. Sams & Co., Inc.*, Indianapolis, Ind. 1703 pages. Price $29.95.

This is a second edition of the basic reference book which first appeared in 1959. Its revision was completed just before Dr. Tremaine's untimely death last year.

As the ten years since the previous volume was published have witnessed giant strides in the development of standards, the use of semiconductors in all types of audio equipment, and the emergence of sophisticated recording techniques, this book has been extensively revised to reflect present state-of-the-art.

Twenty-five chapters cover everything from basic principles of sound through all types of equipment and techniques for reproducing sound, to test equipment, audio-frequency measurements, installation techniques, and general information in the form of useful charts and tables. An extensive and comprehensive index permits the user to pinpoint the specific information he is seeking so that the "Cyclopedia" can be used both as a reference work and study text. The book is lavishly illustrated and presented in a useful and easy-to-read format. ▲

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Another reason two-way radio men earn so much more than radio-TV service men is that they are needed more often and more desperately. A home radio or television set may need repair only once every year or two, and there's no real emergency when it does. But a two-way radio user must keep those transmitters operating at all times, and *must* have their frequency modulation and plate power input checked at regular intervals by licensed personnel to meet FCC requirements.

This means that the available licensed experts can "write their own ticket" when it comes to earnings. Some work by the hour and usually charge at least $5.00 per hour, $7.50 on evenings and Sundays, plus travel expenses. A more common arrangement is to be paid a monthly retainer fee by each customer. Although rates vary widely, this fixed charge might be $20 a month for the base station and $7.50 for each mobile station. A survey showed that one man can easily maintain at least 100 stations, averaging 15 base stations and 85 mobiles. This would add up to at least $12,000 a year.

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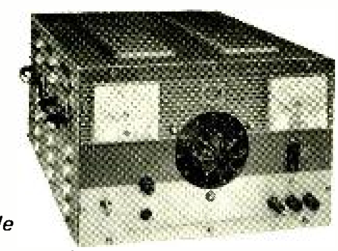

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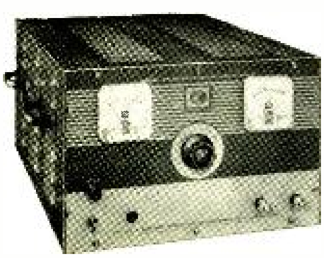

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There are two reasons for the excellent stability provided by the transistor array of this configuration. First, the reverse-biased base-to-emitter zener-reference diode and forward-biased base-to-emitter compensating diodes are on the same chip and provide excellent thermal tracking. Second, the designer can use two transistors of the five-transistor array as a constant-current generator for the compensated reference-diode array.

The temperature coefficient of the 7-volt base-to-emitter zener diode is on the order of +3 millivolts per °C at 500 microamperes, while the forward base-to-emitter diodes are about −1.7 millivolts per °C at the same current. Thus, the two diode-connected transistors overcompensate slightly and yield a net temperature coefficient of −0.005 percent per °C.

The best way to operate a zener diode is with a series resistance that is high in comparison with the zener impedance; in the application under discussion, this zener impedance is about 220 ohms. The two remaining transistors are connected as a constant-current transistor and zener-diode reference for the current source, to obtain the desired high series resistance and thus provide the excellent line regulation.

When a group of these *RCA*-CA3046 arrays were operated in the configuration shown, the worst unit yielded a temperature coefficient of −0.0024 percent per °C over the range of −55°C to +75°C. Line regulation on the worst unit was 0.0012 percent for each percentage change of input voltage. Typically, the −8.45-volt output variations were less than 2 millivolts over the −16 to −25-volt input range. The absolute output voltage should be within 5 percent of −8.45 volts. ▲

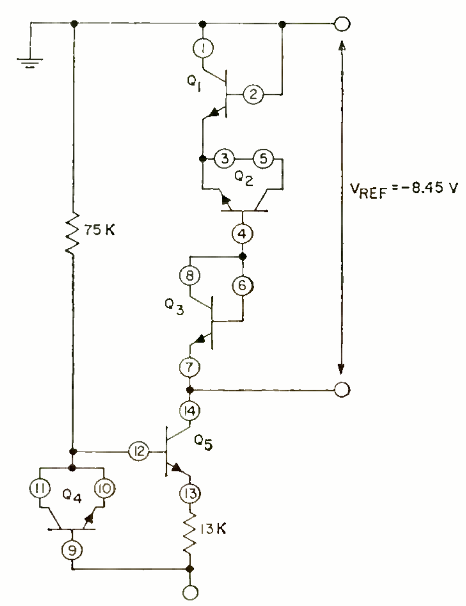

Fig. 1. Diagram of simple, low-cost reference voltage supply which uses an RCA-CA3046 transistor array.

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(Continued from page 26)

Law: $I = V/R$. The conductivity of planetary material is defined as $1/\rho$, the *reciprocal* of its resistivity. The range of the latter, as regards rocks and rock materials, is very great. The range extends from 10^{-3} to 10^{17} ohm-cm. Minerals and rocks from 10^{-3} to 10 ohm-cm are considered good conductors; intermediate ones from 100 to 10^{9} ohm-cm; and poor ones from 10^{10} to 10^{17} ohm-cm. However, differences are not consistent. Anomalously low resistivities are a specific feature of metallic meteorites.

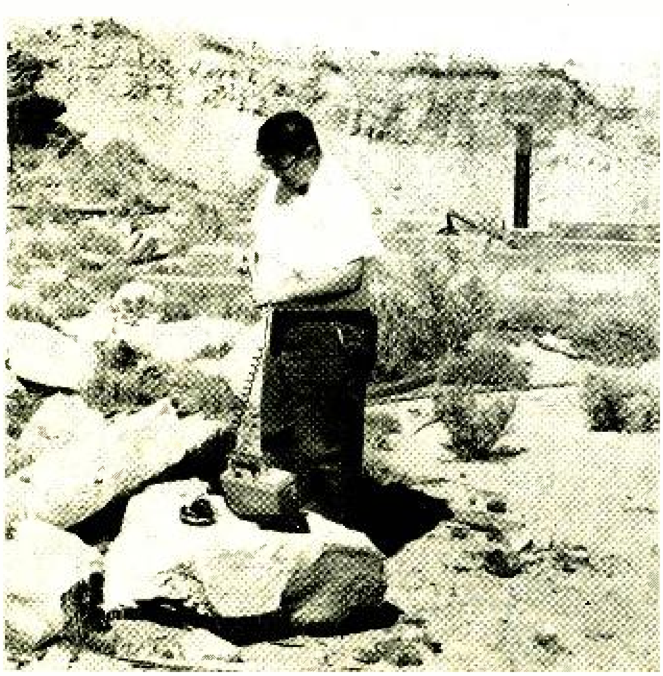
Under favorable conditions, resistivity methods can help to find the depths of layers in the earth having high or low conductivities and might afford an approximate determination of the shape of discrete ore bodies or meteoritic fill material. A variety of approaches is available, but it is a common objective to obtain an approximate idea of what is buried beneath the earth before extremely costly drilling operations commence.

Typically, as shown in Fig. 11A, a d.c.-excited electrode placed in the ground will give rise to potential differences. If we take two exploration electrodes and a readout to measure these differences between points *B* and *C*, then between *C* and *D*, and so on, we will find a given value between points *D* and *E*, because our (imaginary) bowls are partly short-circuited by the conducting layer, *CL*. Note that the "far" electrode is placed at a considerable distance from the test site and provides a current-return path.

If the lower layer, *CL*, is a less efficient conductor than the upper strata, the electrical potential between points *D* and *E* would be larger. Here, the bowls are partially *insulated* as compared to the conducting overburden. Results may be plotted as shown in Fig. 11B. Resistance will *dip* if high conduction is invoked by the presence of meteorites.

However, taken together, electrical methods (which also include inductive techniques based upon low-frequency loop methods and the like) tend to be characterized by low penetration and resolving power. Better diagnostic data can be obtained by measuring the resistivity of drill holes. Geological

Fig. 10. Geiger counter being used to make radioactivity-type survey at Barringer Meteorite Crater's last exploratory drill shaft. The abandoned drill hole, secured by iron casing and wooden plug on top, can be seen at the rear of the photograph.



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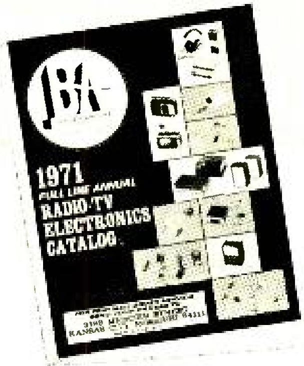

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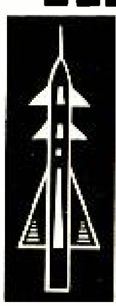

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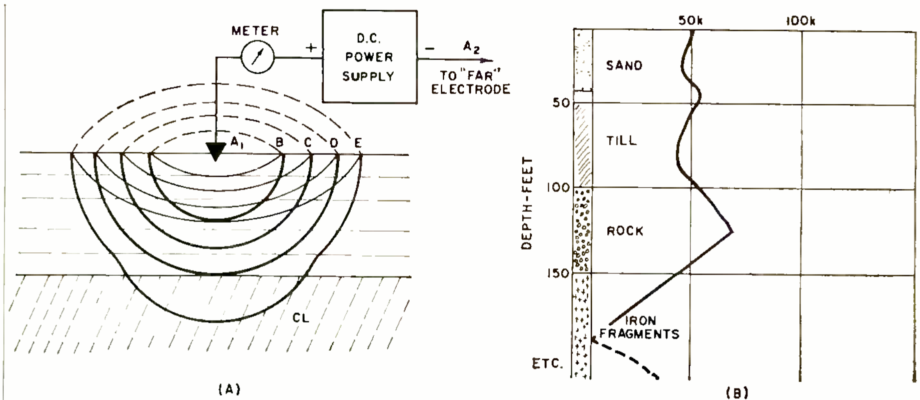


Fig. 11. Basic electrical profiling system used for checking underground resistivity of meteoritic fill material. Two exploration electrodes, meter, and d.c. power supply are used to (A) measure potential differences between points B and C, and C and D, etc. until bowls (imaginary) are partly short-circuited by well-conducting layer CL. Results are (B) plotted and when resistance begins to dip (high conductance) the presence of meteorites is indicated. Note that one electrode is placed at a distance from test site and provides current-return path.

observations, coupled with magnetometer- and gravimeter-based surveys, appear to be more promising.

Oceanic Meteorites

It was oceanographer Sir John Murray who directed attention to deep-sea meteoritic deposits as early as 1876. The size of these small spherules seldom exceeds 0.2 millimeter and more frequently is in the 30 to 60-micron range. Of black or brown color, they are collected by using search magnets pulled over the ocean's floor. Careful cuts normally reveal a nucleus of iron which is enclosed by a magnetic crust.

The annual accumulation of meteorites over the planet's surface has been estimated to be about 2.5 to 5 million kilograms. Thus, considering that the oceanic system covers 71 percent of the globe, given distributions within the marine environment can be calculated.

Iron is but a trace element in sea water and present primarily in colloidal form, such as iron hydroxide and in combinations with fluorides or organic substances. There is about 0.002 to 0.02 gram of iron in one metric ton (1000 liters) of water. Normally, at the ocean's surface, solubility is less than 10^{-7} milligram per ton.

It is not known how deep-sea meteorites affect marine ecology. But in deep ocean areas, far from land, there are reasons to expect that lack of essential iron and manganese can reduce the rate of plant growth. Iron is required for haemitin compounds, which are vital for photosynthesis. The addition of iron and manganese to sea water collected far offshore and enriched with nitrate and phosphate, quite often led to faster growth and larger crops of diatoms and phytoflagellates.

From the point of view of electronics-based instrumentation, no special equipment systems are yet available to investigate "bulk" meteoritic deposits, if any, in the sea. Marine-type magnetometers are towed behind oceanographic research vessels, but most data obtained this way pertains to the ocean's geological features at large.

Summary

The investigation of meteorites and their secondary phenomena is a challenging undertaking. Various geophysical methods must be used and/or especially developed in order to determine their properties and effects on earth.

This interest is reflected in the collections in museums around the world. Chicago's Natural History Museum houses what is probably the largest such collection. Research and field work are conducted by university-based scientists, government agencies, and, to a lesser extent, by instrumentation engineers seeking and testing new detection principles. ▲

BIBLIOGRAPHY

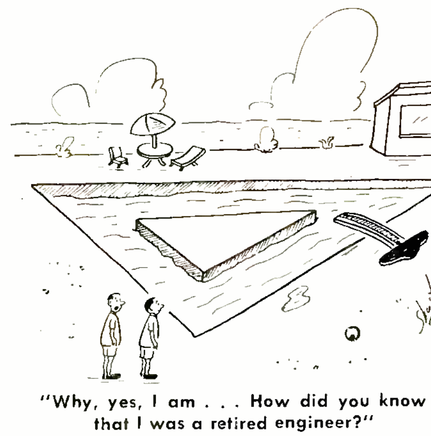
Jakosky, J.J. et al: "Geophysical Investigation of Meteor Crater, Arizona," Proceedings of A.I.M.E., Vol. 1932, pp. 63-98

Jakosky, J.J.: "Exploration Geophysics," Trija Publishing Co., Second Edition, 1960

Heide, F.: "Meteorites," University of Chicago Press, Second Edition, 1964

Nininger, H. H.: "Arizona's Meteorite Crater," American Meteorite Museum, 1956

Foster, G.E.: "The Barringer (Arizona) Meteorite Crater," Barringer Crater Co., 1957.



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"ENVIRONMENTAL" SPEAKERS

A new series of "environmental" speaker systems which will be marketed under the "Aquarius" label are now available for distribution.

Four models in a wide variety of sizes, shapes, colors, and component combinations are in the line. Utilizing primarily reflected rather than

direct sound, the Aquarius systems employ various combinations of computer-calculated loading reflectors, radial diffraction slot panels, and direct radiators for localization. As a result the sound is extremely diffuse and encompassing.

The high-fashion Aquarius 2, for example, is 40 inches high x 18 inches wide x 15½ inches deep. It comes in white or red and has a black textured fabric grille cloth. Speaker components include a 12" low-frequency woofer, two 5" mid-range speakers, 2" high-frequency tweeter, with a matched dividing network. Impedance is 8 ohms. JBL

Circle No. 6 on Reader Service Card

ELECTRONIC LECTERN

Several new features have been added to the "Ampli-Vox" sound-column lectern which the company claims results in improved performance and user convenience.

The new model offers an output to tape recorder, a separate "on-off" switch, and new integrated circuitry in the amplifier design. This permits the speaker to tape-record his speech and eliminates the need to reset the volume each time the unit is turned on.

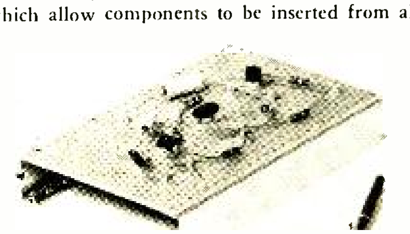
The lectern is a complete p.a. system which works on 10 flashlight batteries that power the 25-watt solid-state amplifier. A professional dynamic cardioid microphone and six full-range 5" speakers in a sound column are included. The lectern height is adjustable from 36" to 40" and the unit has hidden wheels for easy movement. An a.c. adapter and a reading lamp are available as accessories if desired. Chambron Electronics

Circle No. 7 on Reader Service Card

BREADBOARDING KIT

A compact and inexpensive breadboarding kit that is large enough for normal circuit development but small enough to be put away in a desk drawer is now available.

The kit is available with solderless connectors which allow components to be inserted from all



directions, or locking, feedthrough solder-type terminals can be supplied. Switch and pot brackets are furnished in each kit and are of the positive-retention type. Right-angle brackets and universal "Z" brackets are also included.

The phenolic deck measures 6½" long x 4" wide x 3/32" thick. The holes are 0.093" spaced on 0.265" grid centers. The phenolic deck mounts on two rails, 1" high. Houle

Circle No. 8 on Reader Service Card

FM CONVERTER FOR CARS

The "Stereo Magic" Model DFC-887 FM converter is designed to fit under the car dashboard to provide FM reception from any AM car radio. Only two holes must be drilled in the dash beneath the present AM radio. The converter is hooked up by means of the two plug-in antenna leads provided plus a connection to the 12-volt positive power supply. Eastern Specialties

Circle No. 9 on Reader Service Card

DESOLDER TOOL

An imported desolder tool, widely used in electrical and electronic factories throughout Europe, is now available in the U.S. for the first time.

The new tool simplifies the removal of electronic components from circuit boards, tube sockets, and all electronic or electrical connections. The barrel is of metal and the plastic point keeps the barrel from being overheated.

Complete details on this guaranteed tool are available on request. Continental Products

Circle No. 10 on Reader Service Card

DIGITAL VOLTMETER

A new digital voltmeter, Model VT 300, measures 17 ranges of d.c. and a.c. volts and d.c. and a.c. amps. Range change is accomplished with interchangeable plug-in cards.

This 3½-digit instrument features a built-in power supply, automatic zero, overrange indi-

cator, internal calibration reference voltage, BCD output, end-of-measurement signal output, and an external trigger input. Accuracy is ±0.1% of reading and ±0.1% of full scale. There is also a provision for optional extended range. Dixson

Circle No. 11 on Reader Service Card

CARDIOID MICROPHONE

A new directional-type cardioid microphone, designed specifically for use in broadcasting, recording, night clubs, public-address, and other applications where background noise creates a problem has been introduced as the Model 2203.

The unit is a low-impedance (150-ohm) version of the company's Model 2266. Its directional characteristics are such that it is "live" to sound originating in front of it and dead to sound arriving from the rear.

The all-steel unit can be switched from use as a hand microphone to stand mounting. It is designed to withstand severe mechanical shock as well as extreme temperature and humidity. The unit comes with an "on-off" line shorting switch and a 20-foot two-conductor shielded cable. Frequency response is 50-15,000 Hz. Turner

Circle No. 12 on Reader Service Card

NOISE REDUCTION UNIT

The Model 100 noise reduction unit is the first direct adaptation of the Dolby audio noise reduction system for use as a separate component with any high quality home tape recorder.

The licensed Dolby circuitry is of the new "B-Type" developed specifically for home tape recording and pre-recorded commercial tape releases. It is designed to reduce hiss and other noise

inherent in the tape-recording process without changing the musical integrity of the recorded signal. The system operates on both the record and playback functions of a tape recorder.

The Model 100 is a simultaneous record-playback control center consisting of two separate sections: a record section incorporating microphone and line preamplifiers and the record Dolby System circuits, and a playback section with the playback Dolby System circuits and playback line preamplifiers.

The unit is designed to be interconnected with any tape deck and takes over all adjustments from the deck.

The unit measures 12⅞" wide x 5" high x 8¾" deep. An optional walnut cabinet is available. Advent Corporation

Circle No. 13 on Reader Service Card

IC PROJECT KITS

A new series of integrated-circuit project kits that require only a soldering iron and simple hand tools to build has been introduced. With the four kits, the experimenter can build a mike preamplifier, a two-channel mixer, an audio oscillator, and an oscillator-amplifier.

The kits include both active and passive components, predrilled printed-circuit boards, and complete instructions for building the equipment. All the circuits are battery operated and incorporate the latest IC technology to permit the builder to learn how to work with IC's.

A kit enclosure and hardware pack, which provides a functional enclosure for any of the four IC kits, is also available. RCA/Electronic Components

Circle No. 14 on Reader Service Card

DIGITAL PANEL METER

A new low-cost, low-power 3½-digit digital panel meter, which measures only 2.359" high x 4.140" wide x 4.846" deep, is now available as the Model 5020.

The new DPM features a fluorescent readout in a single plane and non-blinking with a fast 1-second response. The circuit is engineered with a high sensitivity of 10 millivolts and 100-megohm input resistance as standard, plus 100% over-range.

The Model 5020 provides readings to 1999 and positive over-range indication at 2000. IC's and other stable semiconductors are used throughout.

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The meter employs a dual-slope analog-to-digital conversion technique providing high noise rejection, stability, and accuracy for precise voltage or current measurements, according to the company.

There are six d.c. voltage ranges and seven d.c. current ranges. Voltage accuracy is ±0.1% of reading ±1 digit while the current is ±0.15% of reading ±1 digit. Triplett

Circle No. 15 on Reader Service Card

SOLDER REMOVER

Using the wicking principle, the new "Solder Blotter" is designed for the fast removal of solder. The product is packaged in two sizes of interlocking hand-size spools that prevent finger burning during desoldering and eliminate waste and tangles.

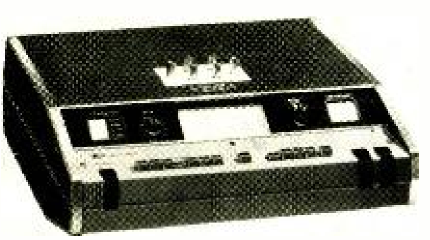
The remover wick can be used with a conventional 35-watt or higher temperature soldering iron and will work with all types of connections—post, pot, or lug. The blotting material leaves the work surface free of residuals or flux contamination. Easy Electronic

Circle No. 16 on Reader Service Card

SOLID-STATE "Q" METER

Hewlett-Packard has introduced a new solid-state "Q" meter, the Model 4342A, which covers the "Q" range from 5 to 1000 in a frequency band from 20 kHz to 7 MHz. Three new features, which are designed to speed and simplify measurements, include push-button controls, automatic leveling, and the elimination of easily overloaded elements.

The direct-reading, expanded scale of the unit displays "Q" measurements from 5 to 1000 and



makes it easy to see very small changes in "Q" resulting from varying test parameters. In addition to measuring circuit "Q" directly, the Model 4342A determines coil inductance, distributed capacitance, effective series resistance, and the self-resonant frequency of capacitors.

Those wishing full specs on this instrument should address their letterhead requests to the Inquiries Manager of the company at 1501 Page Mill Road, Palo Alto, California 94304

FLUORESCENT DISPLAY

The Electronic Tube Division of Sylvania Electric Products Inc. has introduced a fluorescent display device which the company says provides bright, sharp readout of digits and decimal point at low drive and power levels.

The Type 8843 offers a wide viewing angle with no parallax. Digits from zero to nine are formed on a single plane near the envelope sidewall. Digits are generated by excitation of applicable combinations of up to seven phosphor-coated segments. These anodes are energized by electrons emitted by a directly heated common cathode. An additional anode displays the decimal point.

T-6½ glass envelope. It is suitable for use in test equipment, computers, instrumentation, and other applications requiring numeric display.

For complete details on the 8843, send your letterhead request to the company at 1100 Main Street, Buffalo, New York 14209.

FAST-ACTING FUSES

Fast-acting, subminiature Picofuses are now being offered in amperages from 1/16 through 15 amps. These units are designed to be used for circuit protection in computers, sophisticated airborne instruments, and other microelectronic circuits. Five of the fuses weigh one gram.

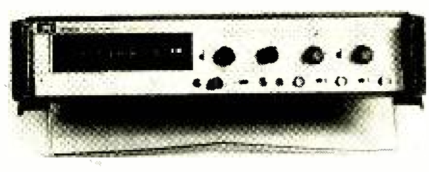
The fuses are provided with solder-coated copper leads, 0.025-in in diameter, except for the 15-A fuse which has a lead diameter of 0.032 inch. The leads are 1½ inches long so that the fuse may be soldered into the circuit or inserted into diode-type clips or mountings. Blowing characteristics are 100% four hours minimum, 200% five seconds maximum. Littelfuse

Circle No. 17 on Reader Service Card

150-MHz COUNTER/TIMER

Monsanto Electronic Instruments, 620 Passaic Avenue, West Caldwell, N.J. 07006 has added the Model 120A 150-MHz universal counter/timer to its line of digital counters.

More than 60 percent of the components in the



new instrument are medium-scale IC's and its 8-digit readout features the company's solid-state light-emitting numerics (LEN).

A new and useful feature of the Model 120A is automatic ranging. All frequency and period measurements are displayed with maximum resolution automatically without the operator having to resort to manual time-base measurements. However, the instrument can also be used manually. The instrument includes a full range of counter/timer functions, programmability, and binary-coded decimal (BCD) output. The unit can be remotely programmed for time-base selection, function selection, start/stop operation, trigger level, slope selection, and display.

Complete data on both the 8-digit and 9-digit versions of the counter/timer is available upon letterhead request.

WIDE-RANGE CARDIOID

The RE20 is a rugged, wide-range cardioid microphone which has been designed especially for recording and broadcast applications.

The case is machined from solid-steel bar stock and the unit has built-in shock mounting and electrical shielding. According to the company, the microphone is unaffected by hard use or abuse. A built-in pop filter eliminates any breath or wind noises. An external mounting, including extra shock protection, is available for boom or stand use. Electro-Voice

Circle No. 18 on Reader Service Card

SYNCHRONIZED ROTATOR

A permanently synchronized TV antenna rotator which is fully lightning protected has been introduced as the "Pris-Matic PM-1" rotator.

The rotator can be mounted at any point on a TV mast since the mast unit weighs only 4½ pounds but can support all conventional TV antennas and some amateur beams.

According to the company, the rotator has a repeatability of 3 degrees or less, has no wind slippage, and is usable in temperatures from —40° to +140° F.

The solid-state control unit, which is powered by 117 volts a.c. at 1/3 A, is housed in a decorator-

lighted panel. Blonder-Tongue

Circle No. 19 on Reader Service Card

BASE-STATION UNIT

The "Ranger 23" is a tube-type base-station transceiver featuring a cascode front-end and low-noise nuvistor and full-time range expand.

The unit provides full 23-channel operation, with all crystals supplied, and 19-tube performance with a hand-wired chassis. Features include exclusive modulation, illuminated "S"-r.f. meter, modulation indicator, 100% modulation, a.v.c., 15-μV sensitivity, pi network, and 3.4-watt audio output—all housed in a rugged heavy-duty cabinet.

Designed for 117-volt, 60-Hz power-line operation, the transceiver can be powered by an optional 12-volt mobile power supply if desired. Courier

Circle No. 20 on Reader Service Card

3-WAY SPEAKER SYSTEM

The Grenadier 6000M is a three-way speaker system featuring a 10-in woofer, mid-range radiator, and an ultrasonic tweeter. Frequency response is 30-20,000 Hz and impedance is 8 ohms. The system will handle 75 watts.

The speaker is housed in a satin walnut-finish enclosure with an imported marble top (walnut finish top available as the Model 6000). Over-all dimensions are 18" diameter x 24⅝" high and the system weighs 60 pounds. Empire Scientific

Circle No. 21 on Reader Service Card

HAND-HELD FM PORTABLES

Three solid-state, 4-watt personal/portable FM two-way radios are now available as the Model Series HC-400. All models require a 12-volt nominal power supply and are battery operated. All three are designed for operation in the 450-512 MHz band.

The basic unit (HC-400) measures 7.5" x

2.78" x 1.3" and is available with one or two channels and noise squelch. The second version, an expanded service unit, is identical to the basic model except that it is designed for use with a heavy-duty NiCad battery and is 1.5" deep. It is available with up to two channels and/or continuous tone squelch. The third unit, a deluxe 4-channel, 4-watt version, measures 7.5" x 2.78" x 1.7". It can be equipped with any standard EIA continuous tone squelch frequency.

Each unit has an internally telescoping 6½" whip antenna. All are housed in rugged cases which feature aluminum frames and high-impact plastic covers. Hallicrafters

Circle No. 22 on Reader Service Card

STEREO TUNER/AMPLIFIER

A solid-state AM/stereo-FM tuner/amplifier has just been introduced as the Model 2000A.

The unit has a music-power (IHF) output of 120 W at 4 ohms and 90 W at 8 ohms and a continuous power rating of 43/43 watts at 4 ohms

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and 35/35 watts at 8 ohms. THD is less than 0.8% at rated output. Amplifier frequency response at normal listening levels is 10-50,000 Hz ±1 dB.

FM tuner sensitivity is 1.4 μV for 20-dB quieting and 1.8 μV (IHF). S/N ratio is better than 60 dB and selectivity is better than 40 dB at 98 MHz. Stereo separation is better than 35 dB at 1000 Hz.

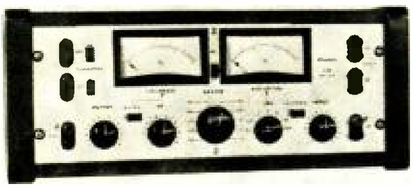
A data sheet giving full specifications on this tuner/amplifier will be forwarded on request. Sansui

Circle No. 23 on Reader Service Card

IM DISTORTION ANALYZER

An IM distortion analyzer which was developed to meet production-line requirements for high-quality audio components is now available.

The new instrument features accurate measuring capability through 0.01% and guarantees a



residual IM level of less than 0.005%, with seven full-scale ranges from 100% to 0.1%.

According to the company, operation is simple enough for use by production-line personnel and rapid enough to make possible sequential readings across the entire power band in a matter of seconds. Of solid-state construction, the analyzer uses FET's. The instrument measures 7" x 19" x 7". Crown International

Circle No. 24 on Reader Service Card

ULTRASONIC INTRUSION ALARM

A new ultrasonic intrusion alarm, the "Crime Alert," can be set up in minutes to protect areas of approximately 200 square feet and a range of 15 to 20 feet.

Unauthorized movement activates the built-in "Sonalert" alarm and any spotlights, sirens, recorders, or other devices plugged into it. The unit is equipped with a 3-A, 330-W auxiliary outlet to activate other protective devices.

The alarm can be powered from any 117-volt, 60-Hz a.c. outlet. Mallory Distributor

Circle No. 25 on Reader Service Card

MEGOHMMETER

A compact megohmmeter which weighs only 17 ounces, measures 5¾" x 3½" x 2⅞", and indicates resistances to 100 megohms at 500 volts d.c., is now on the market as the Model 2001 "Meg-Chek."

Designed for field or shop-testing applications where bulk and expense must be minimized, the instrument is a one-hand, push-button operated unit.

The megohmmeter is powered by penlight cells. It employs transistors, printed circuits, and a taut-band meter for maximum stability and long life. A leatherette carrying case protects the

instrument and provides space to store two 5-foot test leads and the operating manual. Associated Research

Circle No. 26 on Reader Service Card

BLANK 8-TRACK CARTRIDGES

Blank 8-track "Scotch" brand cartridges, 40 and 80 minutes in length, are now available to provide the home recordist with convenient lengths for recording desired programs.

The tape is a heavy-duty type featuring special lubricated backing designed for clean, smooth continuous-loop operation. Cartridges are packaged in a box with reusable sleeve which protects the tape from outside contaminants and supports the cartridge for upright bookshelf storage. A pressure-sensitive label is included with each cartridge. 3M

Circle No. 27 on Reader Service Card

SOLDERING TOOL

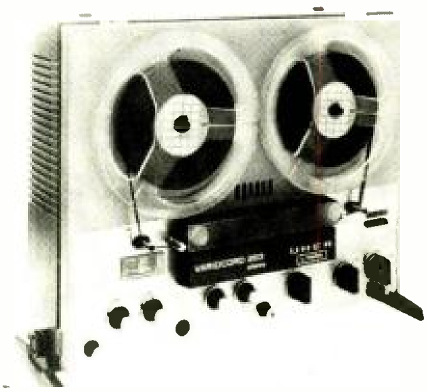
The new "Tempmatic" GT7A is an all-purpose electronic and electrical service tool which can replace most irons and bulky soldering guns. The pistol-grip tool is transformerless and weighs a scant 7 ounces. Its interchangeable plug-in powerhead automatically regulates temperatures of the 3/16" workpoint so that it does not exceed 700° F and a long-reach barrel permits soldering in tight places. Extra powerheads are available.

The tool operates from 120-volt, 60-Hz a.c. Weller Electric

Circle No. 28 on Reader Service Card

QUARTER-TRACK RECORDER

The Uher "Variocord 263" is a quarter-track stereo machine which can be equipped with an



optional two-track head assembly which, when used with the four-track head, provides sound-with-sound performance.

Wow and flutter is 0.05% at 7½ in/s, frequency response is 30-20,000 Hz at 7½ in/s, and power output is 6 watts r.m.s. per channel. Built-in stereo monitoring speakers are automatically silenced when external speakers or stereo headphones are connected. All input and output connections are made with plugs and jacks, eliminating screw-type fastenings.

The unit is housed in a brushed silver, gray, and walnut enclosure which measures 17½" x 13¼" x 7". The recorder may be operated in any position. Martel Electronics

Circle No. 29 on Reader Service Card

V.H.F. FM RECEIVERS

Two FM receivers for operation in the 30-50 MHz and 144 MHz bands have been introduced. Both units feature a complete assortment of optional equipment, including a sequential tone alarm decoding facility.

The radios are available in four model designations. Model TM II-H1 has a single-channel, narrow-band reception capability in the 144-172 MHz band. The TM II-L1 is the same for operation in the 30-50 MHz range. Models TM II-H2 and L2 feature six-channel reception capability in their respective frequency ranges.

Sensitivity for all models is rated at 0.5μV and selectivity is set at 50 dB ±15 kHz. Audio output is 5 watts maximum.

(Continued on page 80)

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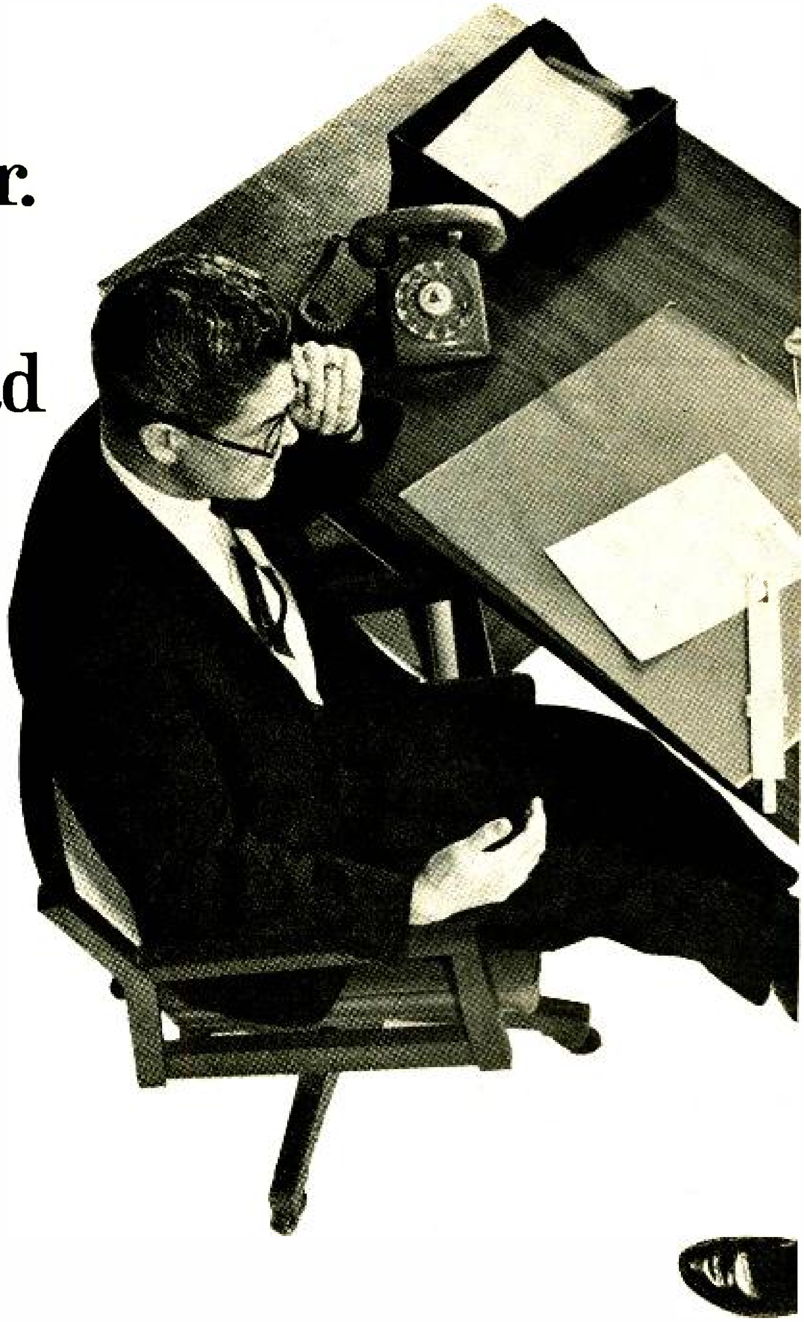

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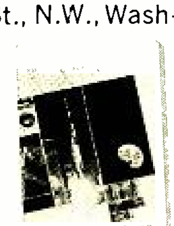

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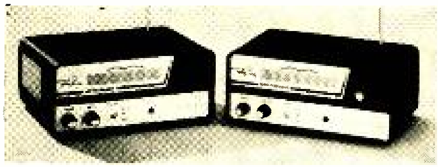


The receivers operate on 117 volts a.c. with accessories for 12 V d.c. or internal NiCad battery power supply available. Regency

Circle No. 30 on Reader Service Card

BEHIND-THE-SET SPLITTERS

To split combined u.h.f.-v.h.f. and FM signals from a single transmission line into their respective behind-the-set terminals, two new splitter models—3030 and 7530 have been introduced.

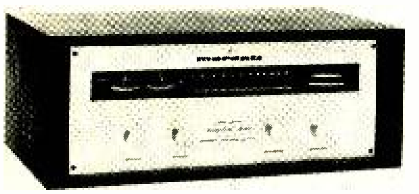
The Model 3030 splits the signals from a 300-ohm downlead while the Model 7530 has a 75-ohm input. The Finney Co.

Circle No. 31 on Reader Service Card

AM/STEREO-FM TUNER

A moderately priced AM/stereo-FM tuner has recently been introduced as the Model 23. The tuner offers such features as signal-strength and center-channel/multipath meters, a patented "Gyro-Touch" tuning mechanism, interstation muting, IC's, and a black-out dial panel.

Frequency response is 20-15,000 Hz ±1 dB,



FM sensitivity is 2.4 μV or better, and stereo separation is 40 dB at 1000 Hz. The tuner uses two FET's and four IC's and operates from 117 volts, 50-60 Hz.

The tuner measures 15⅜" w. x 5¾" h. x 12½" d. Marantz

Circle No. 32 on Reader Service Card

NEW MICROPHONE LINE

A new line of microphones that includes both cardioid and omnidirectional models has been introduced to meet the requirements of recording, p.a., paging, and entertainment applications.

The omnidirectional microphones (MKO) are available in seven different models which can be used as hand-held, stand-mounted, or lavalier units. The cardioid microphones (MKC) are available in five models.

Complete specifications on these new microphones will be supplied on request. Fanon

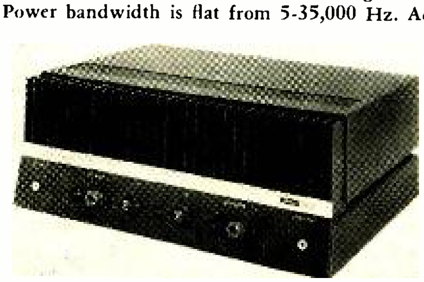
Circle No. 33 on Reader Service Card

STEREO AMPLIFIER

The "Citation" line of audio components has been re-activated with the introduction of the "Citation Twelve" stereo amplifier.

Component parts are assembled on a single, heavy-duty etched circuit board which plugs into special non-corrosive connectors mounted on the chassis. Two separate power supplies, each with its own transformer and electrolytics, drive each channel independently.

Frequency response extends to below 1 Hz and beyond 100,000 Hz at normal listening levels. Power bandwidth is flat from 5-35,000 Hz. According to the company, distortion at all frequencies from 20-20,000 Hz at full rated power is virtually unmeasurable.



As with earlier units in this line, the Twelve will be available in both kit and assembled versions. Harman-Kardon

Circle No. 34 on Reader Service Card

COLUMN SPEAKER

The new 1201B column speaker is designed for use with the company's A105 and A109 systems. It has a power rating of 50 watts continuous power, a frequency response from 70 to 14,000 Hz, and an impedance of 8 ohms. The system uses two heavy-duty 10-inch cone-type speakers.

A pair of 1201B's with a 60-watt control console can make a sound system suitable for small clubs. The speaker is portable, weighing 35 pounds, and measures 30" x 11" x 14". Altec Lansing

Circle No. 35 on Reader Service Card

MANUFACTURERS' LITERATURE

WATTMETER DATA

A new four-page short-form catalogue (SP-70) listing coaxial load resistors, absorption wattmeters, and directional wattmeters is now ready for distribution.

The featured product is a portable peak (and average) reading directional r.f. wattmeter which has been equipped with a battery charger/eliminator for extended bench use.

In addition to providing basic performance specifications and prices, the new catalogue also describes related custom-built accessories such as coaxial filters and a new self-cooled 10-kW r.f. terminating system. A useful chart of r.f. letter band designations with their associated frequencies is also included. Bird Electronic

Circle No. 36 on Reader Service Card

TAPE-RECORDER MIKES

A handy chart which permits the selection of the correct microphone for use with any tape recorder has been issued.

Since some recorders need 200-, some 500-, and others 50,000-ohm microphones or require specialized or European plugs, this handy cross-reference permits the user to find the proper mike for his unit immediately.

The company has four replacement microphones designed to fit over 90% of all recorders and cassettes on the market. The cross-reference chart is designed to assist in picking the right one. Mura Corp.

Circle No. 37 on Reader Service Card

ELECTRIC CLIPS

An 8-page catalogue which lists a complete line of electric clips and insulators for quick, temporary electrical connections has been issued as Catalogue No. 350.

Specifications are given for each clip and the line is fully illustrated. Included are miniature, alligator, insulated alligator, crocodile, "Pee-Wee," general-purpose test, heavy-duty test, and battery clips. Also listed are welding ground clamps, a general ground clamp, and plier-type clips for automotive battery booster cables and battery chargers and testers, etc. Mueller Electric

Circle No. 38 on Reader Service Card

MICROFICHE SCHEMATICS

A microfilmed parts listing and service reference for television, radio, tape recorder, and record player models is now available. The new listing is described as the start of a whole new data system that is geared to save time and speed up replacement parts service. Designed for distributors, the new system will be used primarily at parts counters for quick identification of the company's components.

The easy-to-use index and 14 uniquely arranged microfiche cards, designated PAR-1, show parts lists and schematics covering a six-year period—or equivalent to the data contained in over 125 parts data books. The current series covers models released during 1962 through 1967. Supplementary data covering 1968 through 1970 will be issued shortly. RCA Parts and Accessories

Circle No. 39 on Reader Service Card

VARIABLE TRANSFORMERS

A two-page bulletin, GEA-8114A, describing a line of plug-in "Volt-Pac" variable transformers for laboratory or machine-shop applications is now available for distribution.

Suitable for heat control, motor-speed control, appliance testing, lamp intensity control, and other applications requiring adjustable a.c. voltage, the units are available in 120- or 240-volt models.

The brochure includes ordering information, dimensions, and line-voltage connection instructions. General Electric

Circle No. 40 on Reader Service Card

TEST EQUIPMENT/COMPONENTS

A new 48-page catalogue which lists an extensive line of test equipment, meters, power supplies, waveguide and coaxial components, and special components from over 100 manufacturers both here and abroad is being offered as Catalogue No. 32

The units are listed, pictured in most cases, and a brief description of performance specifications given. Prices are included for each item in the catalogue. Bayton Electronics

Circle No. 41 on Reader Service Card

POWER SUPPLIES

Nine new lines of d.c. power supplies are covered in a new catalogue supplement just issued. Most of the new models were introduced at the IEEE Show in March.

Pictured and described are a new LV series of high-efficiency, low-ripple power modules designed to power TTL, ECL, DTL, RTL, and HTL logic; the LW series designed for powering transistor circuitry, relays, motors, lamps, and solenoids; the LXD-3-152 dual-output tracking power supply for op amps; an IC regulated laboratory supply with built-in tracking overvoltage protection; and an LCS-A package modular supply that is IC-regulated and available in 19 fixed voltage models to 150 V d.c. and up to 3 amps and five wide-range models to 120 V d.c. up to 2 amps. Lambda

Circle No. 42 on Reader Service Card

HAM ANTENNAS

An 8-page, two-color brochure that pictures and describes the "Hustler Ham" line of antennas for fixed-station and mobile, high-frequency, v.h.f. and u.h.f. amateur band coverage, mobile antenna accessories, and s.w.r. bridges is now available. New-Tronics Corp.

Circle No. 43 on Reader Service Card

LOGIC HANDBOOK

Digital Equipment Corporation, Maynard, Mass. 01754 has just issued the Sixth Edition of its 448-page "Logic Handbook."

The book includes an introduction to solid-state logic, application notes, description and prices of more than 200 standard logic and accessory items available from the company, as well as data on logic modules that are provided for interfacing the firm's older computer lines.

For a copy, address your letterhead request to Department P of the company.

HYBRID-CIRCUIT CHART

Sylvania Electric Products Inc., 1100 Main St., Buffalo, N.Y. 14902 is offering a new guide to thick-film hybrid circuit design in chart format.

The guide contains hybrid-design guidelines, packaging information, and data on active devices, substrate materials, capacitors, and commercially available inks. Typical parameters of key hybrid materials are listed and given visual representations in the guide to provide the user with a comprehensive source of information. The chart folds to a convenient 8" x 11" size for filing or opens to 15" x 22" for wall mounting.

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Deltron, Inc., Wissahickon Ave., North Wales, Pa. 19454 has just issued a new 32-page power-supply catalogue and engineering manual. The publication gives detailed information on eleven separate lines of standard power supplies including modular types, system supplies, laboratory units, and special-purpose types for operational amplifiers and IC's.

A complete family of accessories and options, including rack adapters, meter panels, crowbars, over- and under-voltage detectors, and other related items are also pictured and described.

Address letterhead requests to the attention of the Power Division of the company.

HYBRID MICROCIRCUIT DESIGN

Circuit Technology Incorporated, 160 Smith St., Farmingdale, N.Y. 11735 has published an authoritative 28-page "Hybrid Microcircuit Design Manual for the '70's."

Included are specific and detailed listings of the benefits to be derived from hybrid microcircuits, a comprehensive survey of equipment and facilities for producing the microcircuits, tips for hybrid-microcircuit designers, listings of standard components which may be used in hybrids, and typical circuits with circuit diagrams and complete specs.

ITFS HARDWARE CATALOGUE

JFD Electronics Corp./Systems Division, 15th Avenue at 62nd St., Brooklyn, N.Y. 11219 has issued an 8-page catalogue of hardware for equipping school districts and individual schools with complete Instructional Television Fixed Service (ITFS) 2500-MHz microwave systems.

Available on letterhead request, the new publication covers 10-watt transmitters, mini-power transmitters, micro-power transmitters, repeaters, receiving systems, down converters, distribution systems, transmitting and receiving antennas, accessories, and calibration equipment.

COMPONENT SELECTOR

The Marketing Services Department of Cornell-Dubilier Electronics, 150 Avenue "L," Newark, N.J. 07101 has just issued a new edition of its "Component Selector."

The 120-page guide contains listings of all of the firm's "Sprint" standard stocked items, along with extensive engineering data on them. New lines of standard stocked items are also included: filters, enclosed general-purpose relays, dual-temperature-rated tantalum foil capacitors, and others.

SELENIUM RECTIFIER DATA

The Semiconductor Division of International Rectifier, 233 Kansas Street, El Segundo, California 90245 is offering a new 40-page, illustrated engineering brochure, B-108, covering an extensive line of selenium rectifiers, transient voltage suppressors, and contact protectors.

Each type of selenium device or assembly is presented in an individual section giving application information and features along with illustrative drawings, graphs, charts, and photographs. Replacement lists are included in the book giving other part numbers cross-referenced to the equivalent IR device.

Address your letterhead request to Dept. 781 of the company.

DUAL IN-LINE ASSEMBLIES

A single-page engineering bulletin (No. 22,500) describing a group of assemblies which provide various configurations of resistance and capacitance for use in data and signal-processing systems is now available from Sprague Electric.

A copy will be sent upon letterhead request addressed to the company at 115 Northeast Cutoff, Worcester, Mass. 01606. ▲

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52, 53	Sprague Electric Co.
58	Leader Instruments
60	Triplett Corporation

The Altec Lansing photo was listed as being on page 72 instead of 76 in last month's Photo Credits. Sorry for the error.

Answers to C.E.T. Test, Section #5

Published in Last Month's Issue:

1. (d) Internal arc-over or other meter damage may result from the very high a. c. pulses in either of these output stages.
2. (a) This is a good method of determining shorted windings in tube-type receivers. If "B+" boost voltage rises when the yoke is disconnected, it is an indication yoke is at fault.
3. (a) By disconnecting the H.O. stage plate cap, the screen then draws excessive current and in seconds will be permanently damaged.
4. (b) Usually a squeezed raster at the bottom indicates output section trouble, and at the top probably oscillator section fault. Open linearity capacitor should cause bottom raster trouble.
5. (c) When any tube or other part is changed in the horizontal or high-voltage section, the high voltage should be checked and reset to manufacturer's recommended level.
6. (d) 300 mA is the "closest" answer, actually it may be excessive and manufacturer's recommendations should be followed exactly. However, it is the best answer.
7. (d) They help damp any tendency for the yoke to oscillate at its resonant frequency.
8. (a) Commercial adapters are sold for fitting between the damper tube and its socket. These are used to add this capacitance.
9. (b) Rolling "up" normally indicates vertical frequency is too low, rolling "down" indicates too high vertical frequency.
10. (a) The d.c. corrective voltage is used to control the frequency of the horizontal oscillator.

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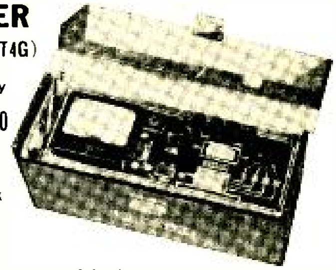

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GENERAL INFORMATION: First word in all ads set in bold caps at no extra charge. All copy subject to publisher's approval. **Closing Date:** 1st of the 2nd month preceding cover date (for example, March issue closes January 1st). **Send order and remittance to:** Hal Cymes, **ELECTRONICS WORLD,** One Park Avenue, New York, New York 10016.

FOR SALE

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PRV	3A	7A	20A	70A
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100	.50	.65	1.00	4.00
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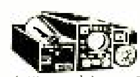
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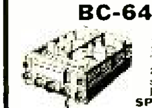
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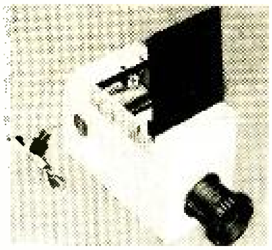

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Yesteryear's ballrooms echo in mirrored lights that richochet to the beat of today's discotheque. Up to 1,000 lustrous, clear, handmade glass mirrors on each ball create fantastic lighting effects. Motorized—they cast reflections that blow the mind! Ideal for light shows, displays, restaurants, hotels, and modern stores.

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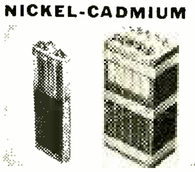

Terrific value—slightly used gov't surplus. Lightweight 5 cell, 6 volt, 4 Amp-hour battery with almost unlimited life. Extremely high current output. Recharges in 1 hour with Edmund kit, won't deteriorate when left discharged. Minimum maintenance—few drops of water per year. Rugged, shock-and-vibration resistant nylon case. Delivered partially charged, filled with electrolyte. 3⅛" x 2" x 6". 2 lb.

Stock No. 70,942AK .... (battery) .... $15.00 Ppd.
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PSYCHEDELIC LIGHTING HANDBOOK

100 information packed pages! Fully explains latest in psychedelic lighting equipment, techniques, developments. Covers all facets of psychedelic light-show production including strobes, black lights, projectors, crystals, organic slides, mirrors, color organs, polarized color light boxes, MusicVision, etc. Shows how to "psychedelize" parties, musical groups, shows or how to set up "electric trips" for private gatherings. 8½" x 11" looseleaf paper punched for 3 ring binder.

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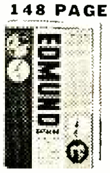

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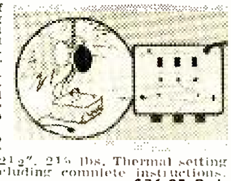

Create tremendous variety of unusual & beautiful lighting effects with this low-cost top-quality 1500-Watt unit (500 W. per channel). Compare with others selling for twice the price. Has pilot light, plus individual sensitivity controls and channel indicator lights. Can operate ten 150 W. "spots" or 200 Christmas lights. Uses reg. house current—attaches to audio source w/RCA-type phone plug. 5¼" x 6¾" x 2½". 2½ lbs. Thermal setting plastic case. 6-ft. cord. Including complete instructions.

Stock No. 71,223AK .... $34.95 Ppd.

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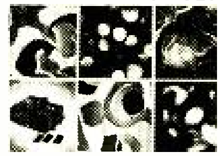

Dazzling, avante-garde visual effects. Fantastic variety. Incredibly beautiful. Special package offer contains all necessary apparatus. Create floating, exploding, fiery bursts of color like "Symphony of Spheres," "Chromatic Starbursts," "Crystal Starburst." Features 35mm 500 W. fan cooled projector—produces big image at short distance. Accepts two 9" diam. wheels (Dry Kaleidoscope & Hexidoscope). 2 cylindrical accessories (6" Colored Cloud & 5" Hexidoscope w/six internal mirrored walls). Perfect for entertaining, parties, photography. Complete instructions.

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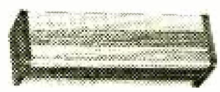
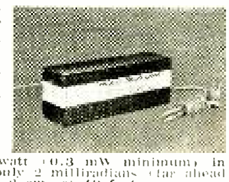


Silent, economical, easy to install. No special attachments or electrician needed. Just plug in socket—then plug lights and/or alarm into it. Activates when it "hears" someone. Resets automatically. Ultra-sensitive up to 30 ft. Sensitivity control can adjust out pet noise. Convenient for night light—eliminates fumbling or injury in darkness. Ideal for apartment, home, office, plant. Walnut finish with built-in timer on-off switch. 35KZH frequency: 110-130v, 60 Hz AC.

No. 71,283AK ... (10⅜"X3¼"X3¼") .. $59.95 Ppd.

NEW $99.50 HELIUM-NEON LASER!



Completely assembled, instant-starting w/ three times power output of comparable models. Steady, ripple-free light of moderate (safe) power. Excellent collimation. Particularly useful for studies, experiments in holography, interferometry, diffraction, optical alignment. Simple and safe to use—just plug in, switch on. The 4½ lb. unit reaches 75% power in 2 secs.; full power, typically 0.5 milliwatt (0.3 mW minimum) in 3 mins. Beam divergence only 2 milliradians (far ahead of competition); beam only 2 cms at 40 feet.

Stock No. 79,004AK .... $99.50 Ppd.

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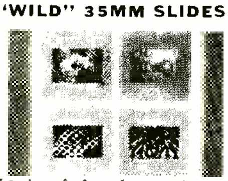

Created by Hollywood's premier special lighting effects man—Bob Beck. Produce fantastic backgrounds, light shows, psychedelic slide shows, etc. 81 premounted slides especially selected for impact, vividness and/or intriguing scene. Range from "way-out" group of eyes to kaleidoscopic images, optical illusions, etc. Low-cost unduplicated sets fill popular Kodak Carousel tray. Ideal for modern professional—Loads of fun for amateurs.

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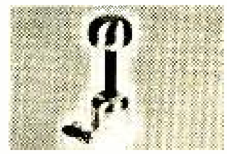

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ELECTRONICS WORLD
July 1970

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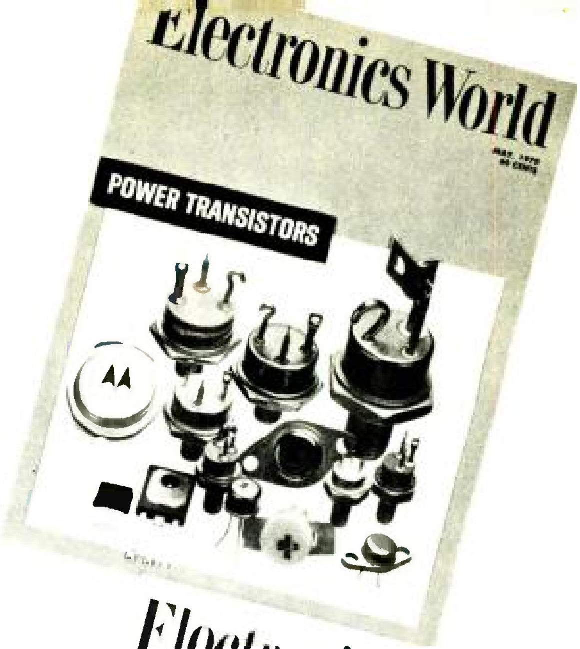

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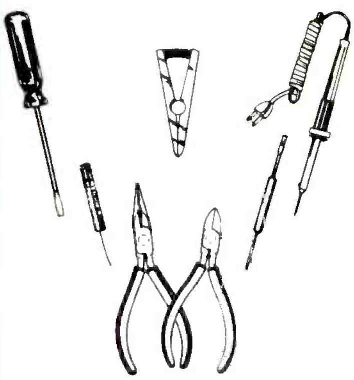

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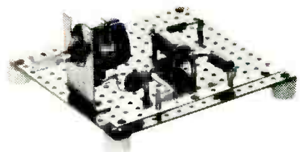

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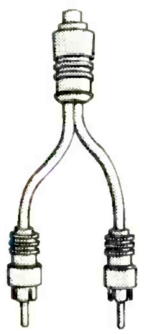

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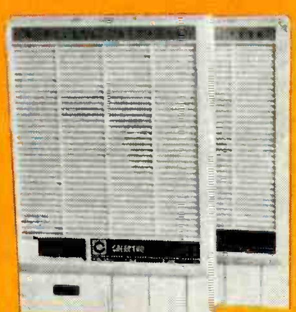

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