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SEPTEMBER, 1964
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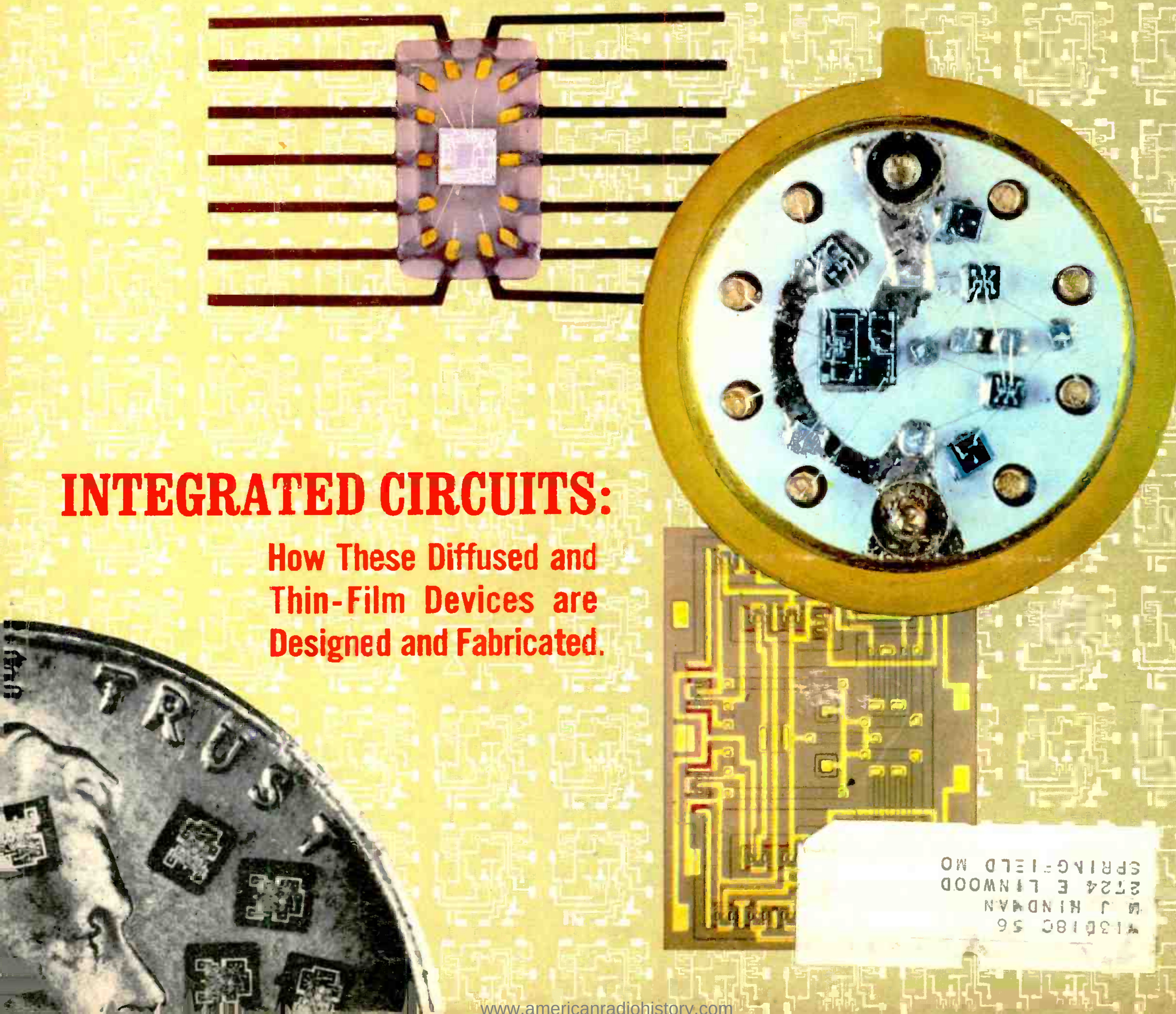

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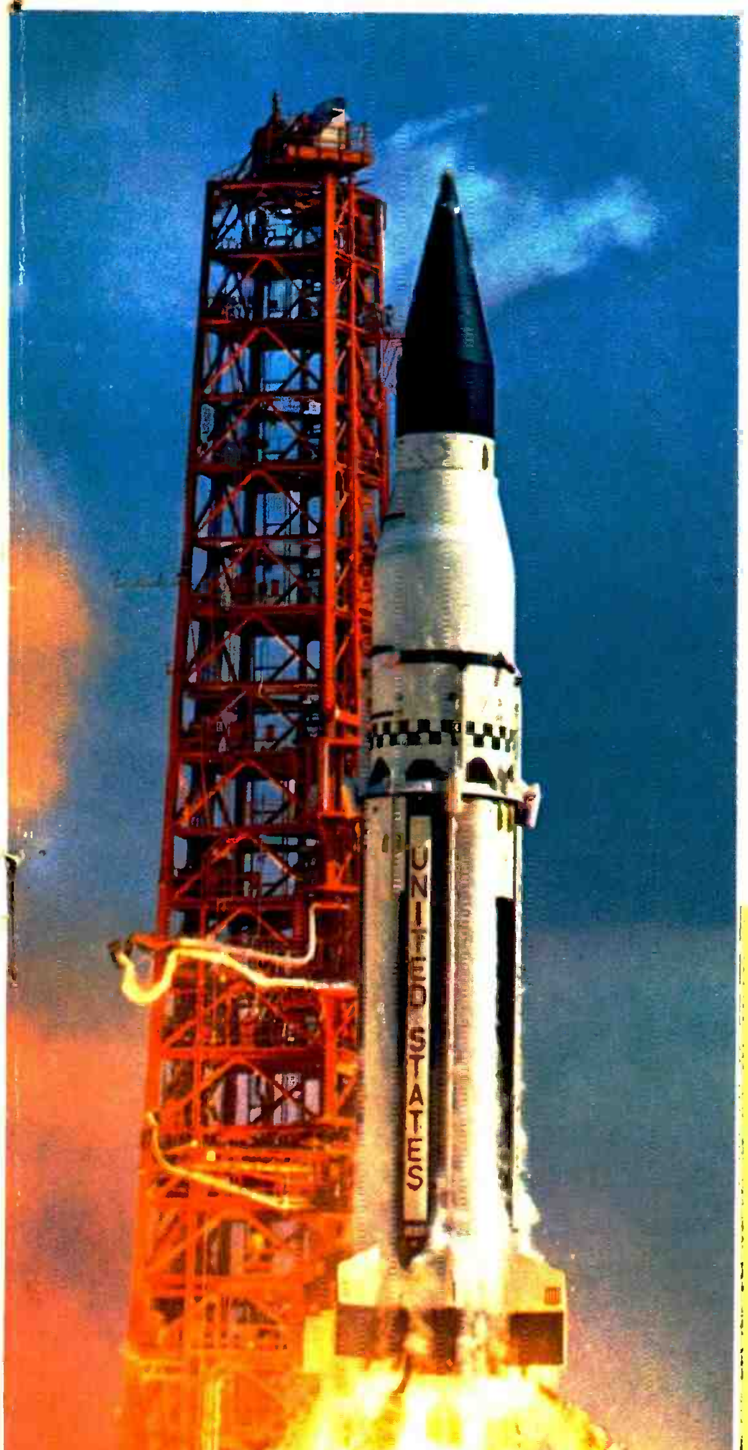

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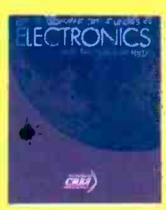

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Electronics World

SEPTEMBER 1964
VOL. 72, No. 3

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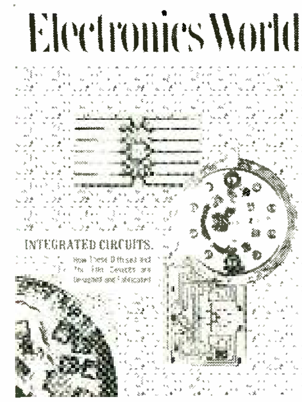
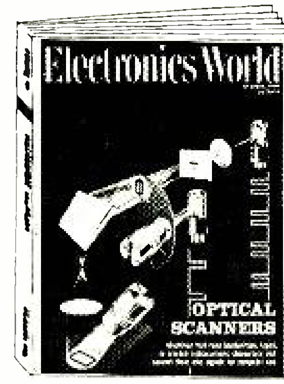
MONTHLY FEATURES



SUPERIMPOSED on a background made from an actual mask, these integrated circuits illustrate the state-of-the-art. The rectangular monolithic circuit contains 14 transistors, 10 resistors, and 2 capacitors on a 60 by 80-mil silicon chip. The multiple-chip unit mounts a complete monolithic circuit surrounded by separate component chips. The flat package, housing a monolithic circuit, is a typical space-saving arrangement. The actual size of the monolithic circuit chips is compared with a section of a penny. (Cover photos: Courtesy of Motorola and Sylvania.)

COMING NEXT MONTH



OPTICAL SCANNERS— MACHINES THAT READ
Ken Gilmore takes a look at the various techniques either in use or under development whereby printed or written words and numbers are translated into the "language" computers "understand." Such scanners generate signals automatically with a speed, accuracy, and economy that humans can't match.

"TRANSISTOR WILLIAMSON" STEREO AMP
Recently developed transistors make it possible to transistorize one of the most popular audio circuits ever designed. Keith H. Sueker of Westinghouse describes a dual 30-watt unit, complete with parts list, which is based on an unusual complementary push-pull emitter-follower output circuit.

HELICAL VIDEO RECORDER FOR TV
Details on Ampex' new rotating-head portable TV tape recorder which is finding wide application in educational, medical, and industrial closed-circuit work.

MEASURING THE "SONIC BOOM"
With the development of supersonic aircraft under way, the FAA is conducting extensive research into the effects of "sonic boom" on residential and commercial structures. Jim Kyle describes the tests currently being run in the Oklahoma City area, equipment being used, and some of the results obtained.

4- AND 5-LAYER SEMICONDUCTOR DIODES
A comprehensive discussion of the circuits and applications for avalanche-mode semiconductor switches. Included are high-powered audio amplifiers, d.c. transformers, dimmers, and computers.

LIQUID-TEMPERATURE CONTROLLER
Where critical temperature control is involved, this solid-state unit can be used to maintain a liquid bath to within a few hundredths of a degree for a 24-hour period.

TAPE-WINDING NOMOGRAM
A series of charts make it simple to wind exactly the right amount of 0.5, 1, or 1.5-mil tape on standard reels to yield various recording times.

TEMPERATURE-SENSITIVE DEVICES
When the resistance of a circuit component can be changed by temperature, it finds many unusual applications in electronics. Here are a number of these uses.

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FEATURES:	AMPEX 2070	CONCERTONE 800	CONCORD 884	EICO RP-100 WIRED	FREEMAN 200	NORELCO 401	REVERE M-2	ROBERTS 400D	SONY 500	TANDBERG 64	V-M 740	WEBCOR EP-2360	VIKING 220
6 HEADS	No	Yes	No	No	No	No	No	No	No	No	No	No	No
3 MOTORS	No	Yes	No	Yes	Yes	No	No	Yes	No	No	No	No	Yes
AUTOMATIC REVERSING FOR RECORD & PLAY	No	Yes	No	No	No	No	No	No	No	No	No	No	No
PUSH BUTTON CONTROLS	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes
REMOTE CONTROLLABLE	No	Yes	No	No	No	No	No	Yes	No	No	No	No	Yes
SOUND ON SOUND	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
BUILT-IN ECHO CONTROL	No	Yes	No	No	No	No	No	No	No	Yes	No	No	No
CENTER CAPSTAN DRIVE	No	Yes	No	No	No	No	No	No	No	No	No	No	No
TRANSISTORS	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	No	No	No
TAPE LIFTERS	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No	No	No	No
OPERATES BOTH HORIZONTAL & VERTICAL	Yes	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes	No	No	Yes
COSTS UNDER $400	No	Yes	Yes	No	No	Yes	Yes	No	Yes	No	Yes	Yes	No

One look at the chart above should prove to your satisfaction that the Concertone 800 is your best value in stereo recorders!

What the chart does not show you is that Concertone's industry exclusives — double Reverse-o-matic® (automatic reversing at each end of the tape), and six heads — combine to give you continuous music playback and recording with the touch of a button.

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CONCERTONE

For the record

WM. A. STOCKLIN, EDITOR

LOOKING BEYOND OUR PROBLEMS

MOST everyone in the electronics industry, and particularly those in defense work, realize that the military cutback in electronic equipment has affected the growth pattern of our industry. How seriously is a matter of opinion. We are still getting reports on this matter through independent surveys taken across the country. Unemployment among engineers and scientists is at an all-time high, particularly in companies along the east and west coasts.

At the same time, financial embarrassment among manufacturers and distributors has reached another peak. During the year ending March 31st, 118 companies failed, leaving a debt of $50 million (this compares with 88 companies for the previous year). According to EIA, 32 of these companies were in components, 14 in instruments, 9 in research and development, 12 in entertainment devices, 8 in systems, and 3 in data-processing.

It is a paradox that while business in general is at an all-time high, our own industry is beset by problems. There are many reasons: changes in government expenditures, competition from abroad, falling sales prices on many products, and a generally changing technology.

Our ten years of expansion have come to a halt and, although there are many other reasons, the cutback in military expenditures ignited the fuse. But why all the pessimism—it had to come. No industry has ever had such a growth pattern as ours. This industry, as we know it, was really born in the early 40's and within some 20 years has become one of the country's largest.

We are, without any doubt, going through a re-adjustment period. This does not indicate a catastrophe, but just a leveling-off period. This is a time for company executives to re-orient their thinking and, for many, time to change their product mix to be a little more independent of military funds. Robert C. Sprague, chairman and treasurer of *Sprague Electric Co.* and former chairman and president of EIA, refers to this period as "roll-over."

He recently predicted that despite reduction in military spending, total sales for our industry will grow from today's $15 billion to a record high of $25 billion in 1973. Even eliminating defense funds, dollar sales will double in 10 years, from $7 to $15 billion. He also predicted the emergence of a new technology (unknown at the present time) around 1973, and the astounding rate of technological improvement and innovation over the past decade will continue into the next decade.

The greatest growth potential for the electronics industry lies in sales of electronic equipment and components to industry. Computers and data processing have constituted the most rapidly growing segment of the industrial electronics market for the past 10 years. He predicted that by 1973 total annual value of electronic data handling equipment will have reached about $3.6 billion—some $2.3 billion more than today.

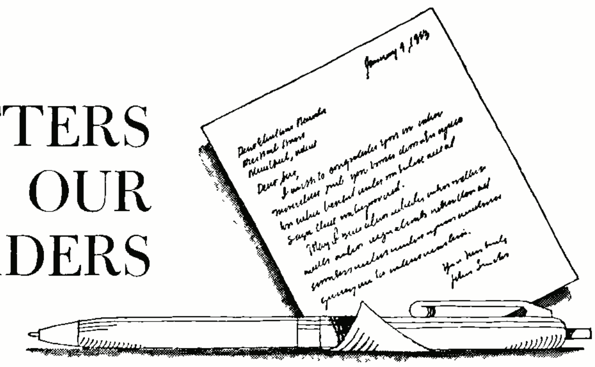
Even more exciting are the industrial electronic markets other than computers and data processing machines. In the past ten years, total sales of electronic equipment in these other industrial markets have more than tripled, from $535 million in 1953 to $1.8 billion in 1963. Sales of components in this area, which have gone from $169 million in 1953 to more than a half-billion in 1963, are likely to reach $1.3 billion by 1973.

Other industrial product areas include electronic industrial control and processing equipment, test and measuring devices, electronic navigational aids, and medical electronics—all of which should increase substantially.

A second significant growth area for the electronics industry is consumer goods—radios, television, hi-fi, tape recorders. From $730 million last year, the volume of components used in the consumer area should reach more than $1 billion by 1973; and the volume of all electronic equipment, including components, should grow from $2.2 billion last year to $3.2 billion in 1973, at an annual growth rate of around 4%.

Certainly there are serious problems in selected areas but many of the over-all industry problems are psychological. Military expenditures had been increasing at the rate of almost 10 percent a year from $3.2 billion in 1953 to $7.8 billion in 1963. What the cutback means is that this growth pattern will not exist in the future. Mr. Sprague estimates that between now and 1968 the growth rate will be 1.1 percent and by 1973, the total defense billing should actually be around $10 billion a year. There will be no major decline and once everyone in the industry realizes this, optimism will prevail. ▲

LETTERS FROM OUR READERS



ACOUSTIC SUSPENSION SPEAKERS

To the Editors:

I go through ELECTRONICS WORLD page-by-page and, needless to say, "Letters" is one of the features that I read. As a consequence, I was very interested in Edgar Villchur's letter headed "Loudspeaker Improvements" in the June issue.

I'm not interested in getting into a controversy with Ed one way or the other; however, I do think exception should be taken to the second sentence in the third paragraph of his letter. If he wants to make the statement, "This is why *Acoustic Research* introduced *their* acoustic suspension system in 1954," that is fine; but *Electro-Voice* and *AR* were involved in lengthy and expensive litigation to establish prior art and this matter has been settled to our satisfaction. This word change may be a very subtle one, but we think it's rather important to make.

LAWRENCE LEKASHMAN
Electro-Voice, Inc.
Buchanan, Mich.

We believe the main point made by Mr. Villchur was not who invented the acoustic suspension speaker but that any lag in woofer development is the result of "a misplaced emphasis on redesign of the speaker driving motor, rather than of the driven mechanical and acoustical system."—Editors.

* * *

TRANSISTOR-IGNITION BALLASTING

To the Editors:

Correspondence with many users of our transistor ignition coils indicates that the ballasting of such coils is not clearly understood. This is an important point as too little current will lead to poor performance, but too much current may lead to failure of transistor(s) and diodes. While the coils are usually the most rugged system component, excessive heat can produce deterioration over a period of time.

Our coils are conservatively rated at 10 amperes *recurrent peaks*. Too frequently they are set up for 10 amperes *average* at *idling* engine speed. Battery voltage may be as low as 11 to 12 volts under such conditions, rising to 14 to 15 volts in the normal operation. This voltage rise will increase current by as much as 35%. Also, since the average current depends on dwell angle, which is usually 60 to 70% of (total) cam angle per cylinder, *peak* current is often 40 to 66% greater than average.

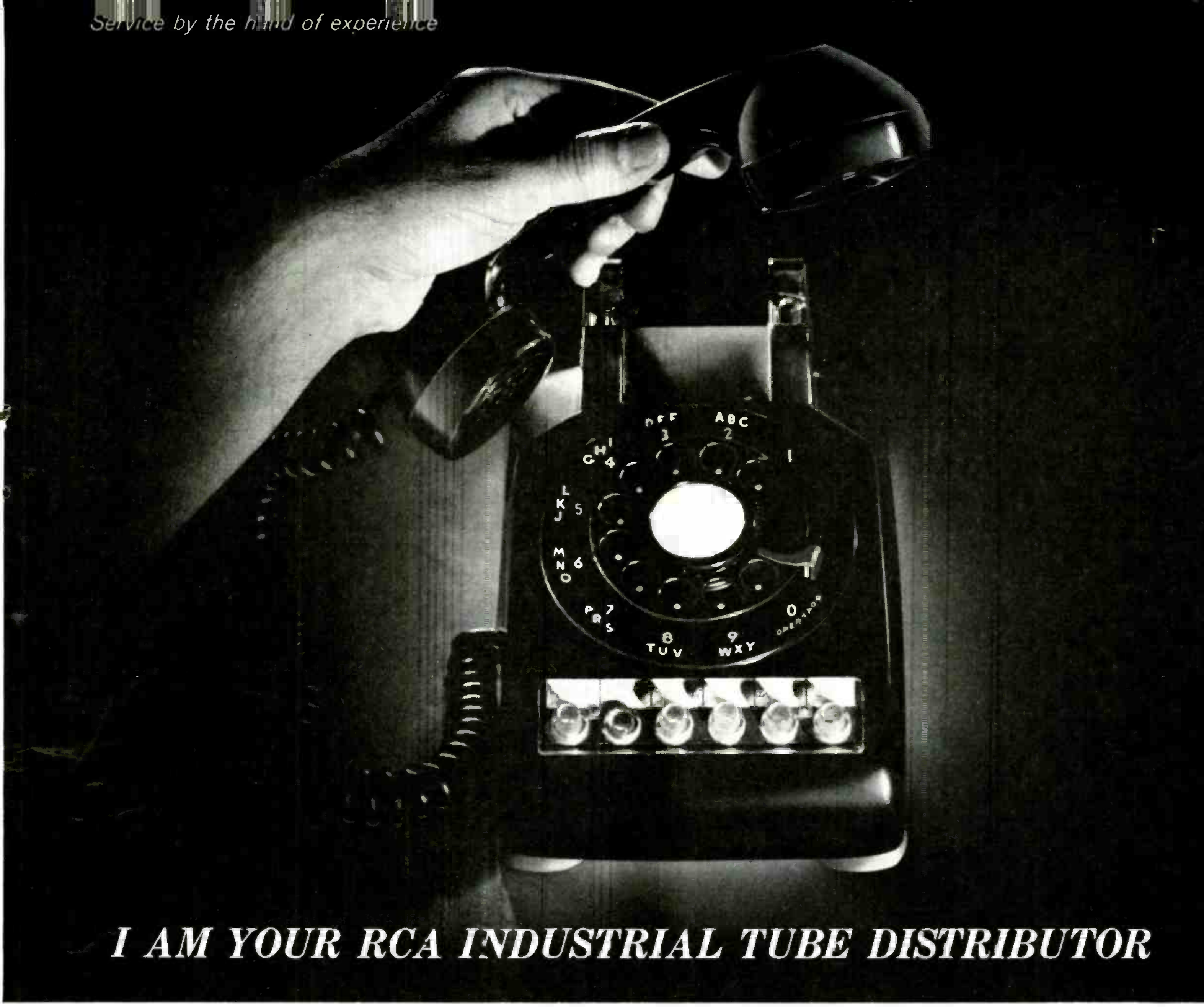
These two factors are compounded, leading to actual peak currents in the 15-22 ampere range with 18-20 a. being highly probable if these factors are not understood. Considering that heating increases as the *square* of current and may thus reach *200 to 485%* of design maximum, it is not suprising that a transistor may occasionally fail, or a coil show some signs of high-temperature operation.

Actually, little is gained in driving efficient coils with extreme current. The T400LR, for example, will deliver 40-45 kv. at 10-amp. *peak* currents. This is about four times the typical engine requirement. In fact, diode protective circuits may limit output to about 20 kv. (with a 60 v. diode), in which case output would be "saturated" for primary currents exceeding about 5-6 amp. At currents above 5-6 amp., no great increase in output results but improved rise time may improve operation somewhat.

We do have the problem of *low* current when the battery is loaded by the starting motor, especially in sub-zero weather. Under these conditions, battery voltage may be as low as 60-70% of normal. This suggests that peak coil current should not fall below 4 to 6 amp. while cranking, or a somewhat higher figure if allowance for moisture and low fuel volatility is required.

We recommend a 20-30% increase in current while starting to allow for such factors. This can be obtained: (a) by *temporarily* bypassing part of the current-limiting resistance; or (b) by use of a positive temperature coefficient ballast with a suitably low *initial* resistance. The *running* resistance in each case should limit current to the coil rating at the maximum voltage setting. This should be assumed to be 7.5 and 15 v. for nominal 6- and 12-v. systems.

In the former method for the T400LR coil, 0.30 to 0.35 ohm is a good choice of starting ballast and about 0.65 to 0.70 should be added while running for a total of about 1.0 ohm. This gives ap-



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proximately 10-ampere peaks at 15 v. in popular one- and two-transistor circuits. Stalled current will be about 8 amp., which is a good value for setting up.

Illustrating the second method, our B12U8 starts at 0.35 ohm cold and increases to 0.9 to 1.0 ohm while operating for the same effect. A bonus is the continual increase of resistance in case of regulator failure with voltage in excess of 15 v.

It is also worth noting that some ballast action is desirable in 6-v. systems to avoid coil overheating, unless stray and coil resistance is adequate.

Some transistor coils have ratings which may be less than that of the example above and it is good practice to understand them *before* operating. A good rule is limiting coil dissipation to approximately 25 watts under normal operating conditions, and using *r.m.s.* current values and primary resistance for the calculation.

W. F. Palmer
Palmer Electronics Labs., Inc.
Carlisle, Mass.

Therefore, those readers who have suggested 10 or more amps. of current with the engine not operating, run the risk of coil and semiconductor burnout. —Editors.

* * *

HIGH-VOLTAGE INDICATOR

To the Editors:

The recent article "Diode Curve-Tracer & Analyzer" by Jim Kyle (June issue) brought to mind a simple and worthwhile improvement which could also be applied to other types of equipment that use exposed high-voltage terminals.

In order to call attention to the high voltage, I would suggest that a flashing neon lamp be mounted directly between the exposed terminals. The lamp can get its d.c. voltage through a small rectifier. A large series resistor and shunt capacitor can be used to make the lamp flash at a low but conspicuous rate.

A. Wiegert
Winnipeg, Manitoba

* * *

COMPUTER LOGIC FUNDAMENTALS

To the Editors:

In the discussion of the logic example in my article "Computer Logic Fundamentals" appearing in the June, 1964 issue, the "NOR" function is correctly written as $A + B + C = \overline{D}$. However, the equivalent of this is $\overline{A + B + C} = D$, not $\overline{A} + \overline{B} + \overline{C} = D$, as you have shown.

The example of DeMorgan's Theorem near to top of the second column on p. 46 should then read, "Thus, $\overline{A + B + C} = D$ is the same as $\overline{A} \cdot \overline{B} \cdot \overline{C} = D$."

S. C. Lukens
Sylvania Electric Products Inc.
Woburn, Mass. ▲

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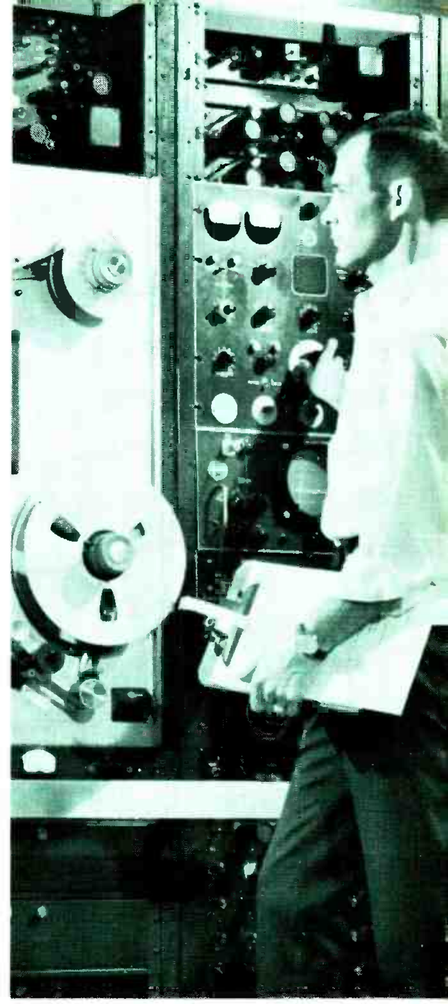

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Performance is the big plus when you install University Uniline Sound Columns. Unlike conventional columns, Uniline employs specially-designed speakers with higher power handling capacity. "Acoustic-Tapering — *another University exclusive,* prevents excessive high frequency beaming and assures a uniform sound volume within its fan or beam. The result—higher intelligibility, optimum sound dispersion at all frequencies, greater listening comfort. All individuals hear the same sound! The table below shows complete specifications for all Uniline Sound Columns, including the new weatherproof model CSO-6 for outdoor installation. For complete PA Loudspeaker Catalog, write Desk S-9.

	UCS-6 Full Range Music and Speech	CS-4 Full Range Music and Speech	CS 3 Music and Speech	CSO-6 Full Range Music and Speech
speakers	6 extended range 8"	4 extended range 8"	8 special multi-design	6 extended range 8"
frequency range	55—17,000 cps	70—17,000 cps	150—10,000 cps	55—17,000 cps
power capacity	120 watts IPM*	80 watts IPM*	25 watts IPM*	120 watts IPM*
impedance	16 ohms	8 ohms	16 ohms	16 ohms
vertical angle	16°	22°	22°	30°
horizontal angle	120°	120°	120°	120°
dimensions	59¼" x 10⅞" x 9⁄16"	40⅜" x 11" x 9⁄16"	48" x 7½" x 8¾"	60¼" x 11⅞" x 7¾"
shipping wt., lbs.	61	46	33	61

*Integrated program material.

UNIVERSITY LOUDSPEAKERS *Division of Ling-Temco-Vought,* Oklahoma City, Oklahoma

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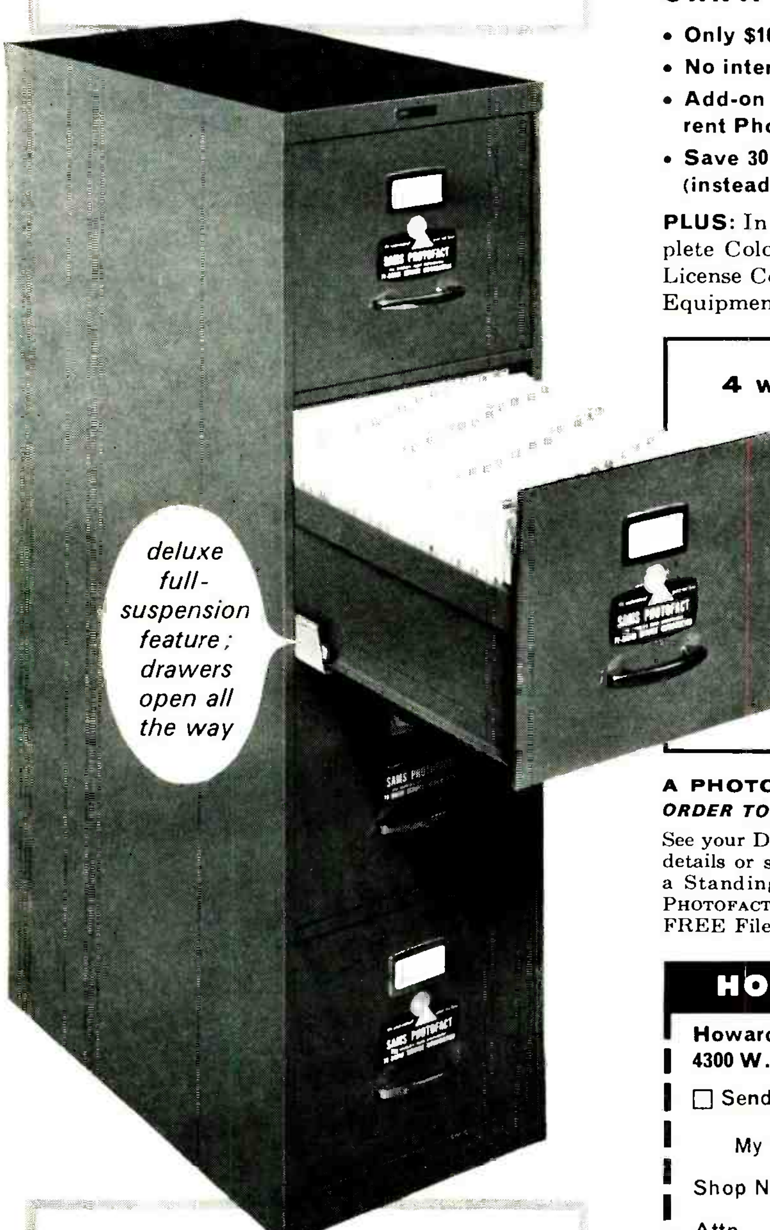

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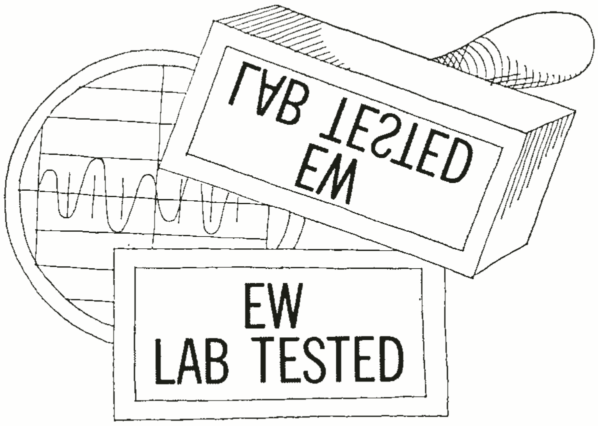


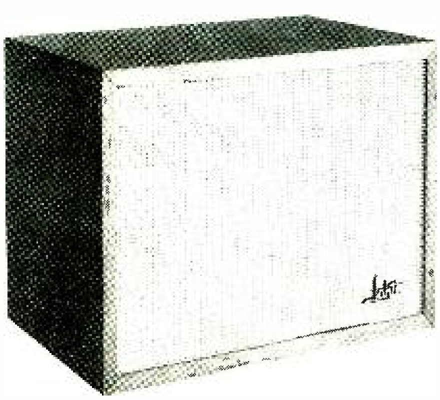
HI-FI PRODUCT REPORT

TESTED BY HIRSCH-HOUCK LABS

Lahti U-2 Speaker System
RCA SK-46 Microphone

Lahti U-2 Speaker System

For copy of manufacturer's brochure, circle No. 63 on coupon (page 19).



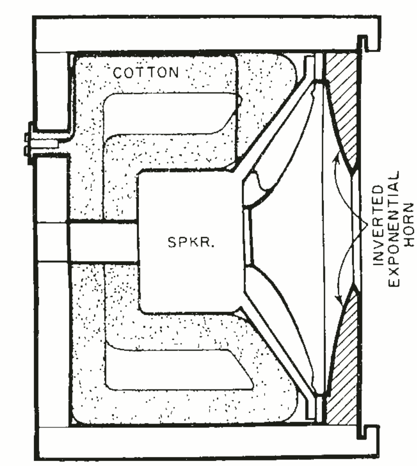
THE *Lahti* speaker, manufactured by *Lahti of Ann Arbor, Inc.*, is a remarkably effective solution to the problem of designing low-cost, ultra-small speaker systems. The firm's smallest unit, the U-2, measures only 9⅝" high by 11⅜" wide by 7⅞" deep, occupying one-half to one-third the volume of most bookshelf speaker systems. The U-2 should fit any bookshelf with ease and, weighing only about 10 pounds, will not unduly strain the most frail supporting structure.

The U-2 is a fully enclosed system, using an 8" woofer and a 3" cone tweeter, with a capacitive crossover at 3000 cps. The box is constructed of ¾" chipboard, with rigid, fully glued construction.

(Editor's Note: We have just learned that a patent has been issued on this design. As shown at the right, the woofer is front-loaded by an inverted exponential horn terminating in a 2⅞" diameter sharp-edged radiating opening. Although front-loading has been used before, this has often produced undesired resonances or waveform cancellation. Because of the high pressure on one side of the horn, energy is transferred into space in a uniform radial pattern.)

We measured the frequency response of the unit with the speaker mounted on a shelf about 4 feet from the floor, averaging the response curves from seven different microphone locations in the room. It has an outstandingly smooth low- and middle-frequency response, within ±2.5 db from 100 to 2000 cps. There is a dip at the 3000-cps crossover frequency, with a relatively smooth and strong response maintained all the way up to 15,000 cps. Its over-all response is ±5 db from 95 to 15,000 cps, which would be considered excellent response for a much larger speaker system. It is interesting to note that *Lahti*, unlike most speaker manufacturers, publishes specific frequency response curves on the U-2. The company claims, with exemplary accuracy, a response of ±6 db from 90 to 12,000 cps in an anechoic environment and a typical room response of 65 cps to 12,000 cps. It is quite possible that, with corner mounting, the lower limit could have been extended to 65 cps.

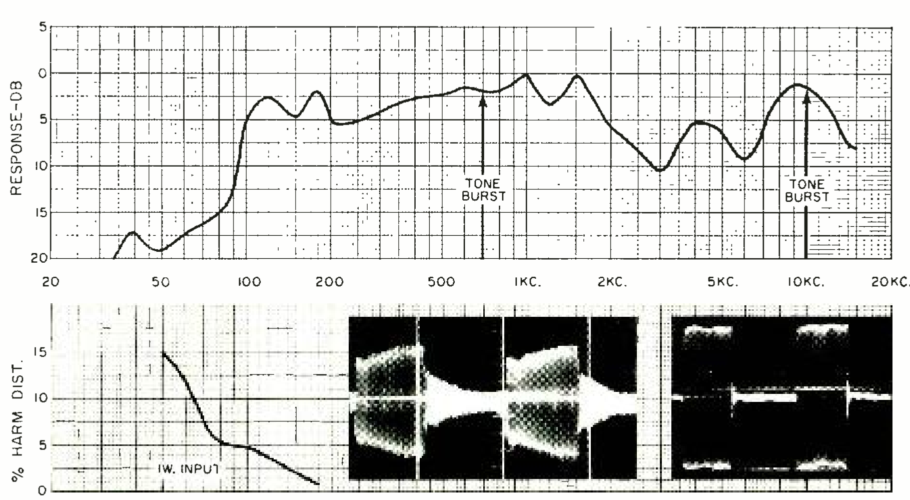
The harmonic distortion of the speaker was, at a 1-watt electrical input level, about 1% at 180 cps, rising slowly to 6%



at 75 cps, and more rapidly to 15% at 50 cps. However, the output falls off rapidly below 90 cps, so that there is no boominess or muddiness from frequency components too low for the speaker to reproduce. Its output is clean throughout its useful range and drops to inaudible levels at lower frequencies.

The high-frequency tone-burst response of the U-2, typified by the 10-kc. tone-burst photo, is well-nigh perfect. Lower frequencies, such as the 700-cps example, exhibit some ringing. Throughout most of its range, the speaker has exceptionally good tone-burst response.

The test data indicates that this is a fine little speaker and listening tests confirm this beyond any doubt. It has a superbly balanced sound, not favoring either end of the spectrum, and without any peakiness or the boxy sound which often plagues very small speaker systems (and some larger ones as well). Subjectively, it seems to generate an astonishing



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Tips for Technicians

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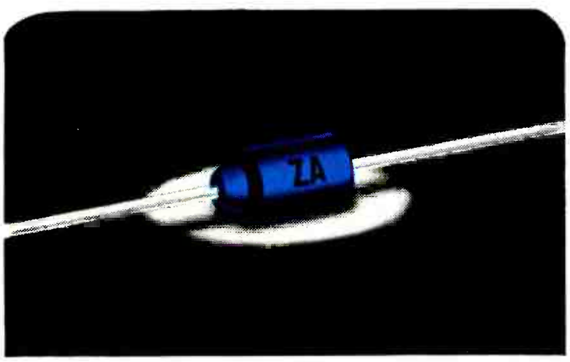
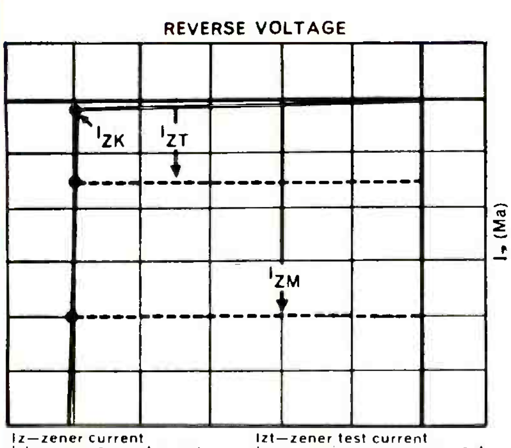
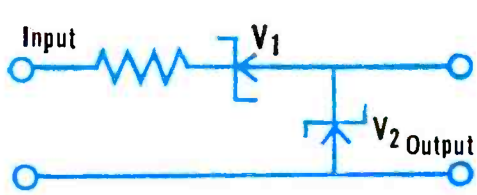
New Kind of Zener Diode







Typical shunt overvoltage protection circuit using zener diodes. Output is controlled between V_1 and V_2.

A zener diode, as you're probably aware, is a special kind of semiconductor which has excellent voltage regulating characteristics. It's the solid-state successor to the gas discharge tube. It acts like a rectifier diode, blocking current in the reverse direction, until the "zener voltage" is reached—then it starts to conduct with a capital C. The zener diode can carry appreciable current continuously. So this makes it a fine regulating device. You can use it in power supplies where you need highly accurate output. Or you can use it in clipper or clamper circuits, by biasing the diode negative.

The big news in zener diodes is that you can now get them from Mallory at a price which makes them practical for service work, experimentation, or commercial circuitry. The news-maker is the new Mallory Type ZA molded-case diode. Its electrical properties and reliability record are comparable to those of military grade units. In fact, we use the same silicon cell in the ZA as in the zener diodes we make for military requirements. But the price is only about *half* that of hermetically sealed diodes.

The ZA is rated 1 watt at 25°C. If you install it in a hot spot, you can use it at ambients up to 100°C, derating linearly to 0.5 watt. Voltage ratings go from 6.8 to 200 volts, in small increments so that you can get exactly the regulating voltage you need. Standard tolerances are 20%, 10% and 5%.

You'll like the cold-case design of the ZA. No need for insulating sleeves when you squeeze it into tight layouts. It's so small—only 3/8" long by 0.220" in diameter—that it fits practically anywhere.

Your Mallory distributor has the Type ZA in a range of ratings. He also stocks Mallory silicon rectifiers . . . including handy packaged doubler, bridge and center-tap circuits. See him soon!

volume of clean acoustical output. At moderately high levels, the plastic grille cloth flaps energetically and a breeze can be felt a foot in front of the speaker, yet there is no sensation of straining or distortion.

With its most attractive selling price of $39.95 in oiled-walnut finish, or $29.95 in unfinished chipboard, the *Lahti* U-2 (or a pair of them for stereo) can be the heart of an excellent budget-priced music system. Its efficiency is moderate and it can be driven by any amplifier of 10 watts or higher rating. ▲

RCA SK-46 Microphone

For copy of manufacturer's brochure, circle No. 64 on coupon (page 19).

FOR many years, ribbon microphones have been used in broadcast and recording applications where high quality and a directional response characteristic are required. Broadcast-quality ribbon microphones, being both bulky and expensive, have not found wide acceptance in home-recording and public-address installations, which usually use some form of dynamic microphone. The *RCA* SK-46 velocity microphone, overcoming both size and cost objections, is aimed at this market.

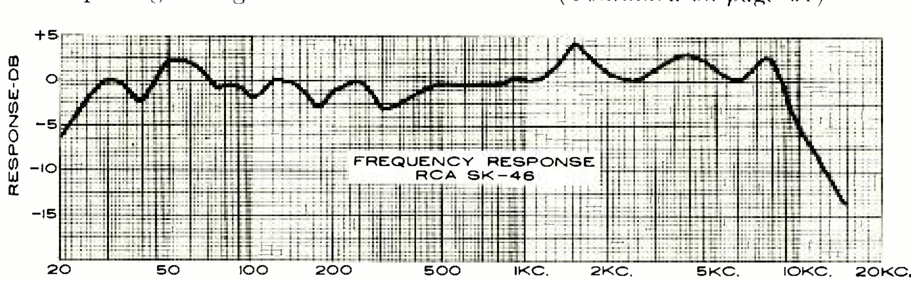
Most microphones, whether they are ceramic, dynamic, or capacitor types, respond to the *pressure* of acoustic waves impinging on a diaphragm. Such microphones are inherently omni-directional, but can be converted to a directional pattern (usually a cardioid) by special design techniques. The ribbon microphone, on the other hand, is inherently responsive to the *velocity* of the sound waves passing through it from front to back (or *vice versa*). An extremely light, corrugated aluminum ribbon is suspended in the air gap of a powerful magnet. The velocity of the air passing over the ribbon causes it to vibrate in the magnetic field, generating a small voltage in the ribbon itself. A step-up transformer, usually built into the microphone case, matches the very low ribbon impedance (on the order of 0.1 ohm) to a standard impedance level such as 200 ohms, and raises the output voltage to a more useful level.

Velocity microphones are inherently bi-directional, responding equally well to sounds from the front or back, but discriminating against sounds arriving from either side.

The *RCA* SK-46 is a compact ribbon microphone, with over-all dimensions of 5⅛" high by 1⅞" wide by 1⅜" deep, including a swivel-mounting adapter for standard ⅝-27 microphone-stand coupling threads. The case is finished in dark gray, with satin chrome front and rear screens. The microphone weighs 13 ounces, less cable. A 25-foot, two-wire shielded cable is attached permanently to the microphone. As shipped by the manufacturer, the SK-46 is wired for a 200-ohm impedance, which will match amplifier or line impedances between 150 and 250 ohms, as well as high-impedance inputs. To obtain a higher output when driving a high-impedance amplifier input, the transformer within the microphone case may be re-wired for a 15,000-ohm impedance.

We tested the microphone by mounting it about 8 inches in front of a loudspeaker, on its central axis. A calibrated capacitor microphone was taped to the boom so that its diaphragm was in the plane of the SK-46 screen, as close to it as possible. Plotting the response of the speaker with both microphones on a single sheet of graph paper, we were able to determine the response of the test

(*Continued on page 61*)



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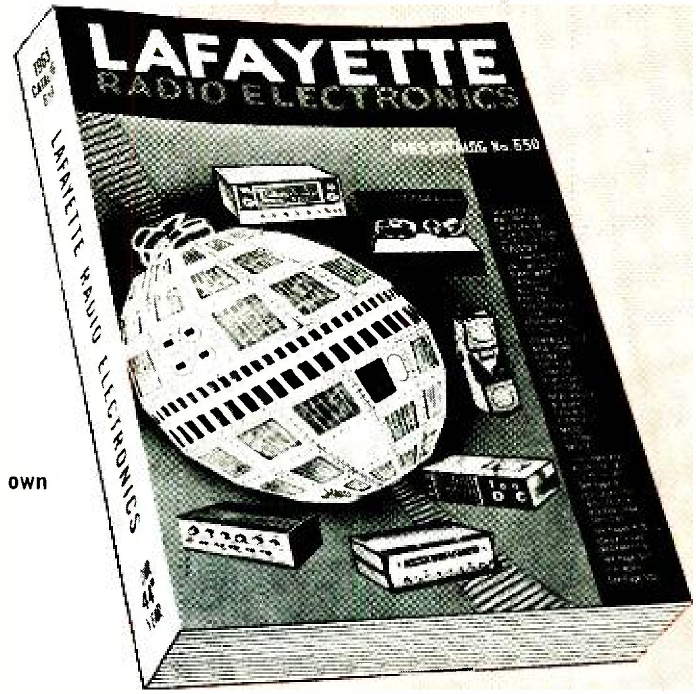

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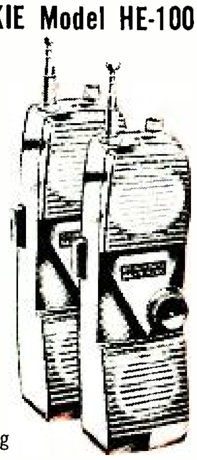

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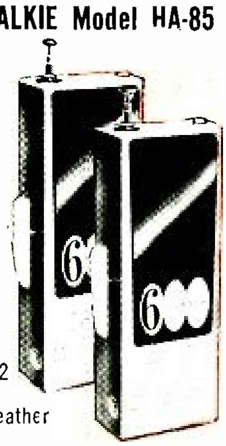

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FEATURING AUTHENTIC MECHANICAL FILTER

Model HB-500

Small, Compact . . . Measures Only 11$\frac{7}{16}$"Wx6$\frac{11}{16}$"Dx3"H.
Low Current Drain . . . 350 ma on Receive, 850 ma on Transmit.

■ *12 Crystal Transmit Positions plus 12 Crystal Receive Positions* ■ *23 Channel Tunable Receiver with Precise Vernier Tuning* ■ *Dual Conversion Super-heterodyne Receiver* ■ *15 Transistors, 3 Diodes, 1 Zener Diode plus 1 Thermistor* ■ *Zener Diode Voltage Regulated Receive Oscillator for Superior Frequency Stability* ■ *Dependable Sealed Relay Switching* ■ *Automatic Noise Limiter* ■ *Variable Squelch* ■ *For 12 Volt DC Mobile Operation (Negative or Positive Ground) or for 117V AC Operation when used with Matching Solid State AC Power Supply (Optional)* ■ *Meets All FCC Regulations Part 95*

If you're looking for a high-performance CB transceiver in a small, compact size, you'll want the HB-500! Using advanced solid-state circuitry, this transceiver offers full 5-watt performance, yet is small enough to fit conveniently into the most compact car. And, battery drain is so low as to be negligible—the transceiver draws no more than .35 amps on receive, .85 amps on transmit. As a result, you need neither heavy-duty battery nor generator—an important advantage in mobile applications! The transmitter features full crystal control on any 12 of the 23 CB channels. Dual conversion receiver with better than .5 μv sensitivity offers 12 crystal-controlled channels, plus full 23 channel tuning capability. A 455 Kc mechanical filter provides ultra-sharp receiver selectivity—virtually eliminates adjacent channel interference! Other features include an efficient Automatic Noise Limiter, variable Squelch for silencing the receiver on standby, spotting switch for exact frequency location on tunable receiver, "S" meter and illuminated channel dials. This rugged transceiver offers instantaneous, cool-running operation and features printed circuit, all-transistor design. Equipped with mobile mounting bracket, push-to-talk dynamic microphone, crystals for operation on channel 12. Operates on 12V DC (neg. or pos. ground) or on 117V AC with optional solid-state power supply. Imported.

Model HB-500.

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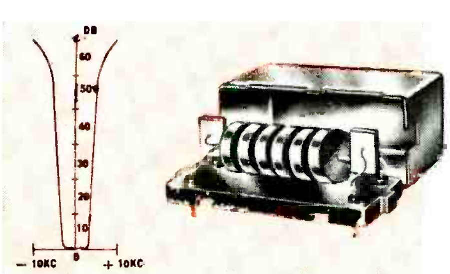

With CB channels only 10 Kc apart, selectivity is important! In the HB-500, ultra-sharp selectivity is achieved by means of a true mechanical bandpass filter in the 455 Kc IF section. At 10 Kc on either side of the center frequency, the filter provides 60 db of attenuation — an extremely high rejection ratio that assures complete adjacent channel rejection!

Model HB-501 Solid State AC Power Supply

Matching solid state AC power supply for HB-500 for fixed station operation (at home, business office). Transceiver rests on power supply to form attractive integrated unit. Size 11$\frac{7}{16}$x6$\frac{11}{16}$x3$\frac{11}{32}$". Imported.

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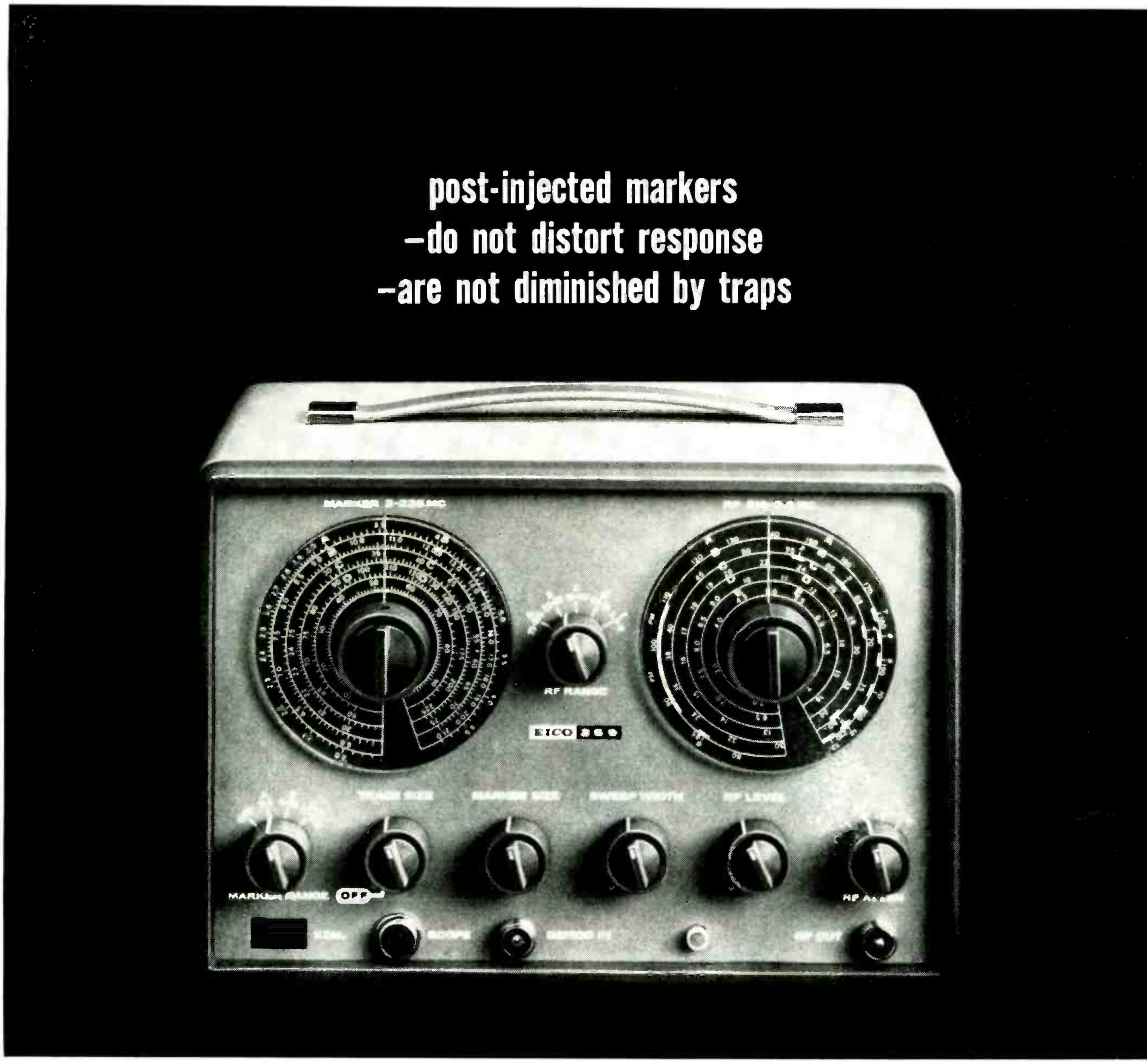


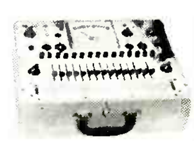
EICO 369 tv-fm sweep & post injection marker generator

With the 369, circuit response is not affected by markers and markers are not affected by circuit response. The 369 feeds only the required sweep signal to the input of the circuit being aligned or tested. At the output end, a demodulator cable picks off the signal and feeds it to a mixer stage inside the generator, where the markers are added. The combined signal is fed to the oscilloscope. This means that circuitry under test or alignment is not affected by the marker signal, and that traps in the circuitry will not reduce or eliminate the marker.

The EICO 369 has a controllable inductor sweep circuit—all electronic, with no mechanical parts to wear and give trouble later. The sweep generator is independent of the marker generator. It has five ranges: 3.5–9 mc; 7.5–19 mc; 16–40 mc; 32–85 mc and 75–216 mc. All five ranges are fundamentals; tuning to the desired center frequency is simplified by a 6:1 vernier dial and a 330° scale. Output impedance is 50 ohms. Retrace blanking is obtained by both direct grid cut-off and indirect B + cut-off (via the AGC chain) of the oscillator with a blanking tube that conducts during the negative excursion of the 60 cps sine sweep. A three-stage AGC circuit keeps the level of the swept signal constant over its entire frequency range, even when the widest sweep width of 20 mc is being used. A phasing control at the rear of the EICO 369 adjusts permanently the horizontal sweep signal fed to the scope.

The marker generator in the EICO 369 has 4 ranges covering 2–225 mc. The highest range, 60–225 mc, is the third harmonic of the next lower range. All other ranges are fundamentals. Frequency setting is simplified by a 6:1 vernier dial and a 330° scale. As a rapid check of marker generator alignment a 4.5 mc crystal is supplied with each generator. When plugged into a front panel socket it automatically turns on a fixed frequency marker oscillator. The 4.5 mc signal produced by this oscillator is mixed with the variable frequency marker. The 4.5 mc crystal is used also for alignment of sound circuitry in TV Receivers.

The demodulated wave form with the post injected marker is fed to the vertical input of the "scope", and the horizontal sweep to the horizontal input of the "scope" through one shielded two-conductor cable. Separate level controls for trace size and marker size on the front panel can be used independently. Kit **$89.95;** Wired **$139.95**



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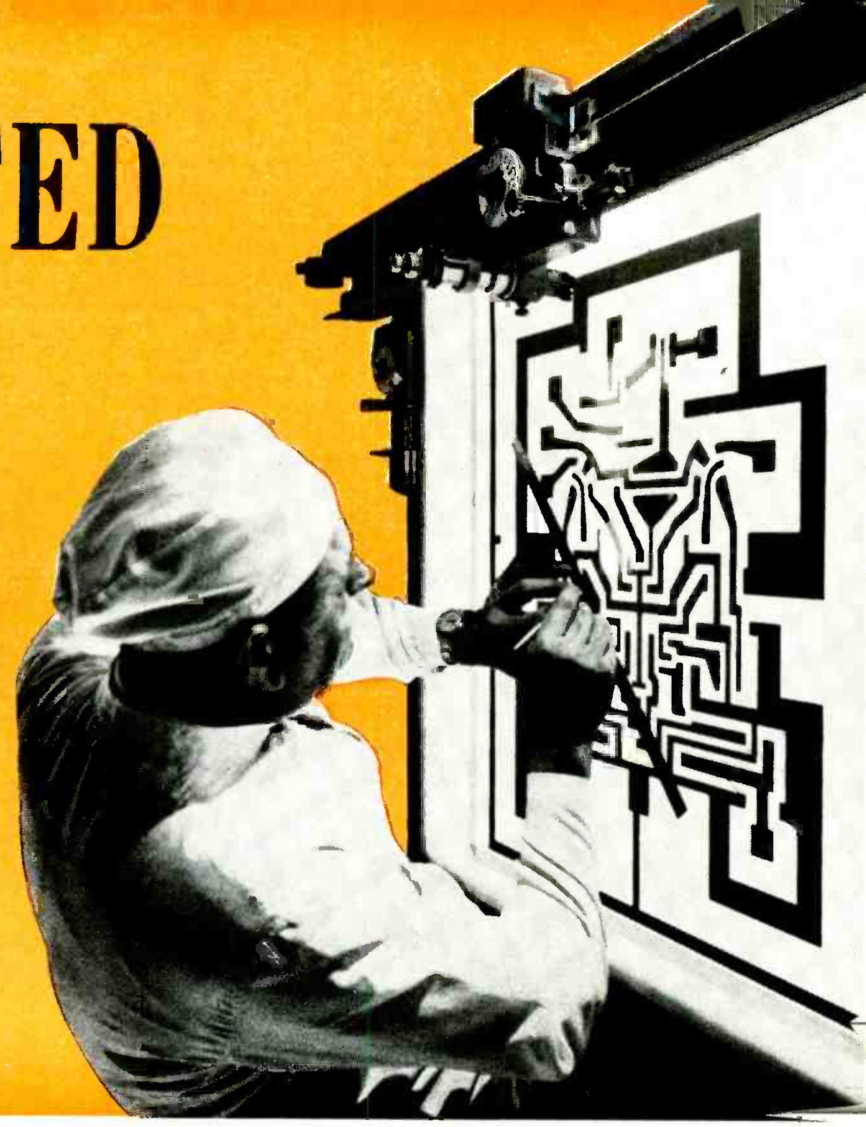
CIRCLE NO. 178 ON READER SERVICE PAGE

INTEGRATED CIRCUITS

By LESLIE SOLOMON / Associate Editor

Electronic circuits are becoming microscopic in size. We can now make multi-transistor units small enough to pass through the eye of a sewing needle. Here are the details of how these devices are made.



INTEGRATED circuits are the result of reducing the size and weight of active and passive electronic components almost to the vanishing point. In fact, it becomes possible to incorporate a multi-transistor circuit consisting of 28 active (transistor and diode) and passive (resistors and capacitors) components in an area the same size as the letter "O" in this type face.

It is also a big business, and will be even bigger as time goes by. It has been estimated that by 1973 the dollar volume of integrated circuits may reach between $500 million and $1500 million. In one forecast made by some members of the electronics industry, the figure of $700 million volume by 1973 has been mentioned.

Integrated circuits can also save considerable money for the electronics industry. Patrick E. Haggerty, president of *Texas Instruments, Inc.*, recently stated that by 1973 every one-billion dollars worth of conventional circuitry can be replaced by a half-billion worth of integrated circuitry for a potential saving of 50% to Government, industrial, and consumer users. Mr. Haggerty also stated that further economies in hardware, chassis construction, and wiring will save many millions in each of the three markets.

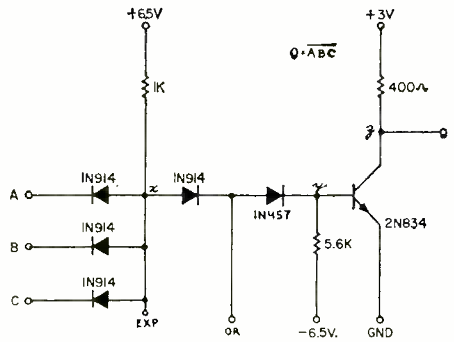
By 1973, Mr. Haggerty estimates that the potential value of conventional circuits that technically could be replaced by integrated circuits could run to $2440 million for Government, $1330 million for industrial, and $650 million for consumer users.

According to Herman Failkov, vice-president of *General Instrument Corp.*, the estimated usage of miniaturized package assemblies should increase from $75 million in 1964 to about $250 million in 1968. At the same time, the estimated usage of monolithic integrated circuits will go from $50 million in 1964 to about $350 million in 1968.

When will these small circuits see wide use in consumer electronics? Here, all experts agree that the cost of the integrated circuit is the determining factor. Size will not play an important role at this time. The size differential between vacuum-tube devices and the transistor-printed circuit devices was great. The size differential between transistor circuits and integrated circuits will not be as great because the final size is dependent on the size of the other components that go into making up a radio or TV set.

Dr. Robert Noyce of *Fairchild Camera and Instrument Corp.* claims that the crossover point in the relative price of conventional and integrated circuits has been reached. The price of a certain transistor, as supplied to a military contractor, is between $3 and $5 in small quantities, while in quantities of 50,000 or more, the price goes down to 75c to $2. Dr. Noyce also stated that typical integrated circuit prices are about $4 per transistor in small quantities, but in quantities over 50,000 they have gone down to under $1 per transistor, although $1.50 to $1.75 is average. Dr. Noyce pointed out that savings apply mostly to digital systems where most of the development has taken place. Low-usage integrated circuits, linear circuits in particular, are still more expensive than their conventional counterparts.

Cost per circuit is very important in the use of integrated circuits. A typical monolithic circuit starts with a set of masks costing up to several thousand dollars, depending on the complexity of the circuit. The actual silicon wafer cost is



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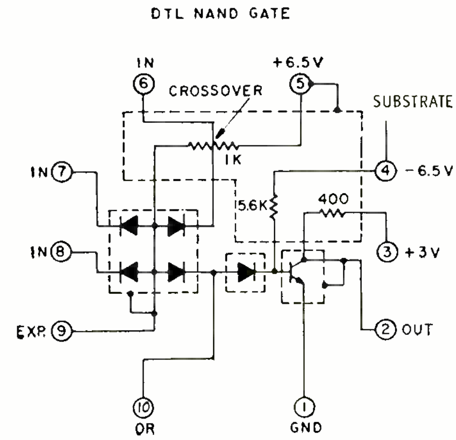

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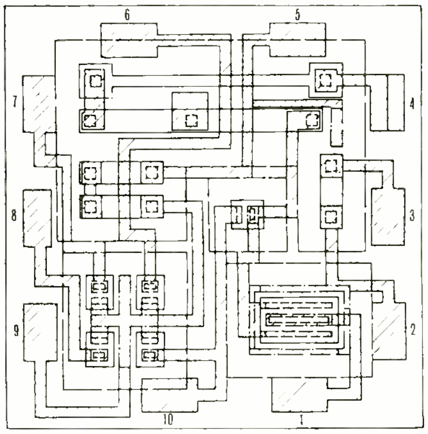
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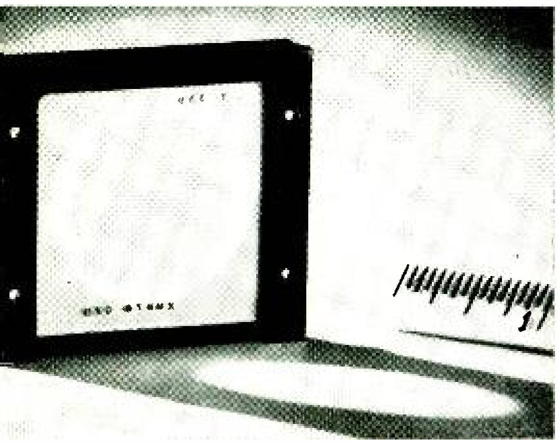
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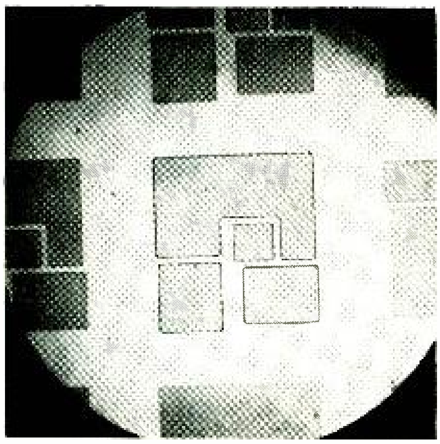
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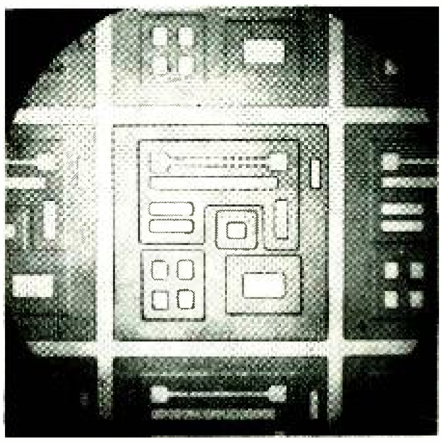
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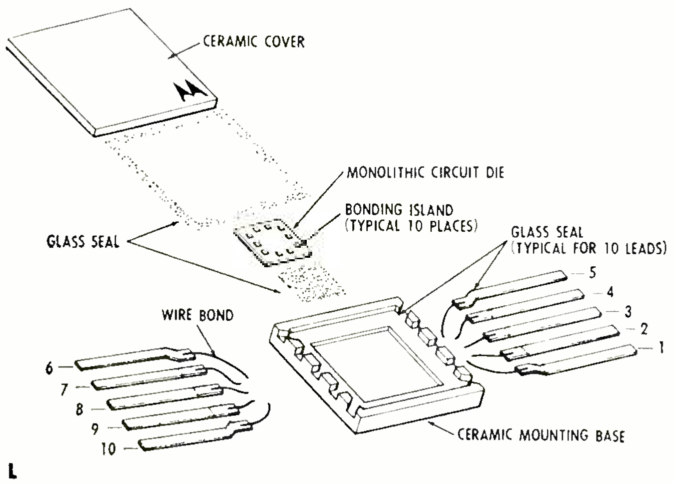

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about $10 and between 100 and 400 separate chips can be made from a single wafer. Because of the many things that can go wrong during the manufacturing process, the yield of operating chips can be anywhere between 10 and 50 percent of the number available from a wafer. Other manufacturing processes, such as testing and mounting the wafer in its final holder, also add to the cost per unit.

There is another problem with consumer electronics. Where one manufacturer has a desire for a particular circuit, another will want to use his pet circuit. This means that separate integrated circuits would have to be made for each of these manufacturers, thus increasing unit price. Standardization of some circuits such as audio amplifiers may have to be arrived at to reduce the price of these units. Conservative estimates are that integrated circuits will start arriving in the consumer field in quantities some time within the next 4 to 5 years, probably starting with the larger manufacturers who have both integrated circuit facilities already in operation within their corporate structure and a radio or TV set manufacturing facility.

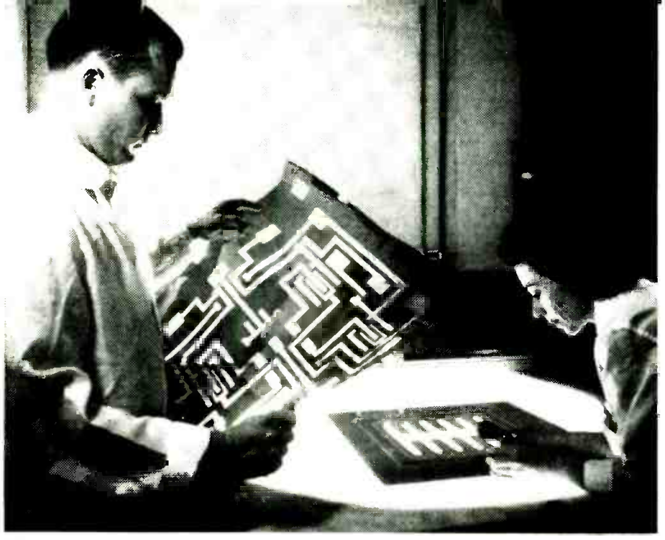
Several steps in introducing integrated circuits to the consumer market have already been taken. *Westinghouse Electric Corp.*, for example, has demonstrated an experimental integrated circuit radio about half the size of a man's finger. Recently, *Motorola* unveiled a 120-mc. transceiver, designed for the Air Force, and shown in Fig. 1. This unit uses 29 separate mountings, some containing monolithic circuits, some with thin-film components, while others mount discrete components.

Examples of monolithic integrated circuits contained within the transmitter-receiver include a 120-mc. r.f. amplifier and four 12-mc. i.f. amplifiers. This prototype unit weighs 15 oz., has a receiver sensitivity of less than 1 μv. and a transmitter power output of 50 mw.

A microelectronic i.f. amplifier (shown in Fig. 2) has been developed by *General Instrument Corp.* with a center frequency of 25 mc., a gain of 70 db, and a bandwidth of 2 mc. This unit can be used with center frequencies to 60 mc. This unit uses several multi-chip circuits, each packaged in a TO-5 can. The amplifier features 70 db of a.g.c. range and several such stages can be cascaded.

Probably the first section of consumer electronics to take advantage of integrated circuits is the hearing-aid manufacturers. Using a 6-transistor plus passive elements silicon chip fabricated by *Texas Instruments*, the *Zenith* hearing-aid monolithic circuit (shown in Fig. 3) is so small that 10 of them can be stacked in the space the size of the head of a conventional kitchen match. The entire hearing aid weighs one-quarter of an ounce with the battery. Of great importance is the fact that the use of an integrated circuit offers as much as 500% greater reliability over previous hearing-aid circuits.

At the present time, the biggest users of integrated circuits are those concerned with the logic elements as used in



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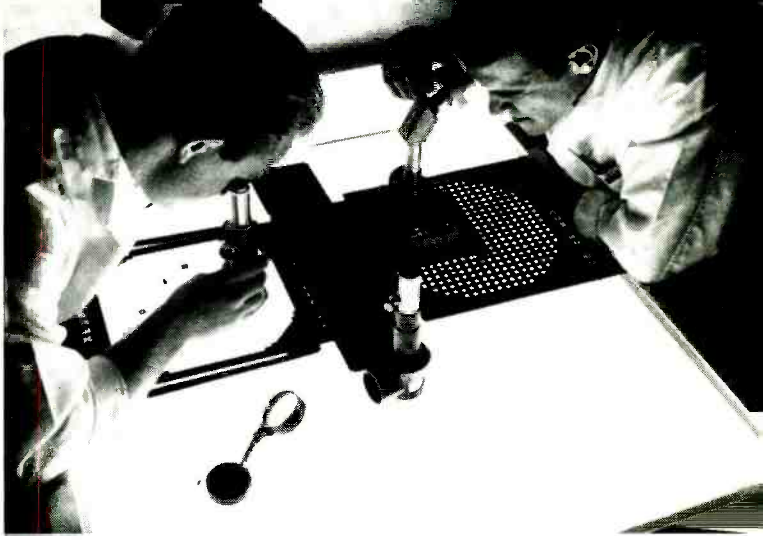

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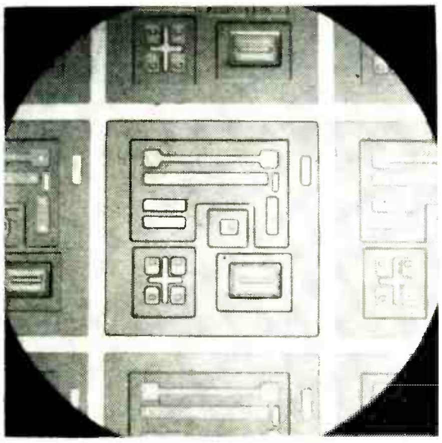

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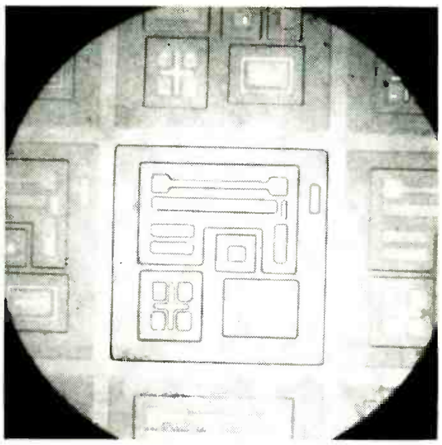

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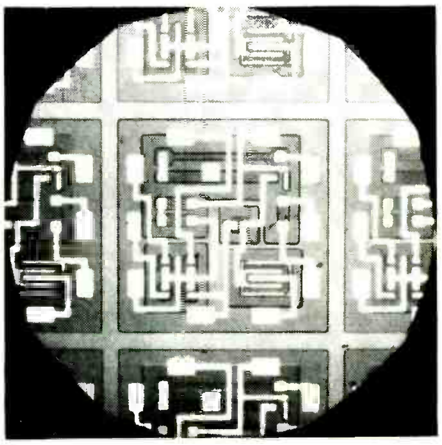

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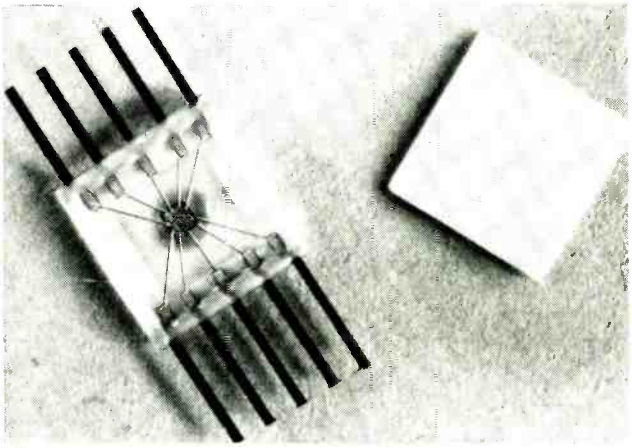
Evolution of a monolithic circuit. (A) Circuit of a diode-transistor logic gate as it comes from the circuit designer. (B) The circuit redrawn to desired mechanical layout to satisfy package connections. (C) Overall mask layout. Each layer of completed circuit has its own mask. Note the 10 metal connection lands around perimeter. (D) Skilled artists draw individual masks many hundreds of thousands of times larger than life. (E) Advanced photo techniques are used to lay out optically reduced mask. (F) The final mask for one layer. Each dot on the screen represents the original mask greatly reduced. There will be a separate mask for each layer of the completed circuit. Sections of wafer showing (G) isolation diffusion, (H) base diffusion, (I) emitter diffusion, (J) pre-ohmic etch, and (K) aluminum metalizing. (L) Monolithic circuit ready to be mounted in flat ceramic package. (M) This is the way the customer gets the actual circuit shown in (A).



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digital computers and other data processing devices. This is because the large number of identical circuits needed in these computing devices makes maximum use of a single set of circuit masks and the associated manufacturing operations, thus reducing the cost of each discrete chip.

Types of Integrated Circuits

Today's integrated circuit technology involves two basic processes—thin-film techniques, in which passive components (resistors and capacitors) are deposited as layers of materials on an inert substrate; and a semiconductor technique (monolithic) where both active and passive components are formed on, or in, a tiny chip of semiconductor material.

Because of the limitations imposed by each approach (for example, thin-film passive components must be used with outboard semiconductors coupled to the thin films; and with monolithic circuits once a resistor or capacitor is formed, it cannot be changed for experimental reasons), a third approach is being used. This method has various names, but generally the term "hybrid" or "multi-chip" circuit is used. These hybrid circuits are often used during experimental development so various resistors, capacitors, and semiconductors making up the test circuit can be changed. They are also used when parts values that cannot be obtained with monolithic techniques must be used. Each type of circuit, and how they are fabricated, will be discussed.

Monolithic Circuits

A monolithic integrated circuit is one in which more than one electrical component is fabricated and interconnected as a single, solid-circuit element. As previously stated, it is possible, using modern electrochemical techniques, to fabricate a relatively complex circuit incorporating several forms of semiconductors and their associated resistors and capacitors on a common substrate that is itself a semiconductor material, such as silicon.

An enlarged photo of such a device, manufactured by *Sylvania,* and containing 28 active and passive components, is shown in Fig. 4. The individual circuit chips shown on the cover will give an idea of the final size of these extremely small devices.

The basis for the creation of a monolithic circuit is the chemical process known as "diffusion." In its simplest terms, diffusion is very similar to ordinary wood staining. If the surface to be stained (diffused) is cleaned, and a suitable mask containing a desired shape cutout is placed over the area to be stained (diffused), then application of a stain (diffusing chemical) to the mask will produce the desired stained (diffused) area.

The monolithic circuit starts with the growth of a high-purity silicon crystal, by placing a seed crystal into molten silicon and slowly withdrawing it under precise control to form a single crystal about six inches long and about one inch in diameter. The crystal can be grown with impurities to make it either a p- or n-type crystal.

Germanium integrated circuits are almost non-existent due to the technical difficulties in producing the necessary later diffusions and passivating layers suitable for supporting the metal film circuit interconnects or thin-film passive elements.

The long silicon crystal is then sliced with a fine diamond saw into many thin wafers, each about 12-thousandths of an inch thick. The wafer is lapped flat and chemically etched to form a smooth, shiny surface. The finished wafer is about .005 of an inch thick and about one inch in diameter.

Masking

The masks, used to cover the desired sections of the silicon chip for the various diffusion processes, are made many thousands of times larger than "real life" by skilled artists. The lead photo shows an artist preparing one such mask that will be reduced 250,000 times in size before it reaches working proportions. Advanced photolithographic techniques are used to reduce each mask down to the size where about 400 of them can be formed in the space the size of the silicon wafer (about as big as a 25¢ piece).

One mask is used to create each layer in the silicon substrate. Depending on the complexity of the circuit, up to 20 masks may be used to create a particular circuit.

Components

By proper arrangement of the various diffusion layers, it becomes possible to create transistors, diodes, resistors, and capacitors, each working because of the differences existing at the interfaces between the various diffused layers.

Starting with the silicon wafer, the layers are diffused to the required depth and shape by the desired p- or n-type diffusion. Other masks, used to apply either other diffusions or a silicon-dioxide insulating layer, are then used until the final components are made.

A cross-section view of a conventional planar transistor, such as made by *Fairchild Semiconductor,* is shown in Fig. 5A. This transistor consists of a p-type base and an $n+$ emitter diffused into n-type bulk material (wafer). Many transistors can be made on the same wafer, but they will all share a common collector circuit.

An integrated circuit transistor of the same type is shown in Fig. 5B. Here, the collectors are electrically separated from each other by an additional p-type diffusion which results in an additional diode, called the isolation diode, tied to the collector of each transistor. When these isolation diodes are reverse biased, the collectors of the individual transistors are isolated from the other circuit elements. Since the isolation diode anode covers the back surface of the entire wafer, collector contact must be made at the top as shown in Fig. 5B.

Integrated-circuit diodes of three basic types may be obtained from a transistor-type structure. The common-cathode configuration is shown in Fig. 6A. Common-anode arrays can also be fabricated as shown in Fig. 6B. Diodes may also be formed by using a multiple emitter transistor arrangement.

Integrated-circuit resistors are generally obtained in one of two basic ways. One method is to arrange patterns of resistive thin-film material on the surface of a substrate, making intraconnections as required. The other method lies in using the bulk resistivity of one of the diffused areas in a similar manner. In either of these cases, the resistance value obtained is proportional to sheet resistivity and pattern length, and inversely proportional to pattern width.

A cross-section view of a diffused resistor is shown in Fig. 7. The resistor consists of a long, narrow region of p-type base diffusion in what is normally an n-type collector area. The resistor thus formed has distributed diode properties as well as linear resistance characteristics.

When a positive voltage is applied to one end of the resistor, that end of the p-n junction becomes forward biased, allowing just sufficient current to flow to supply reserve leakage current to the back-biased isolation diode. The remainder of the resistor p-n junction remains reverse-biased since all the n-type material is at essentially the same potential. Practical resistance range is 20 to 20,000 ohms.

As with resistors, integrated-circuit capacitors may be ob-

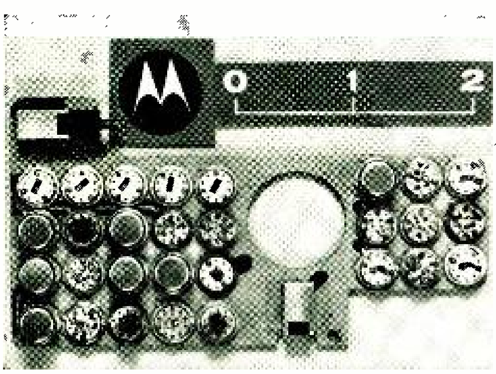

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Fig. 1. This 120-mc. transceiver designed by Motorola, uses a combination of monolithic, thin-film, and discrete devices.

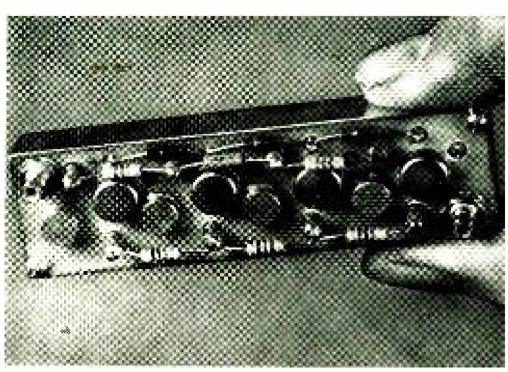

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Fig. 2. Microelectronic i.f. amplifier by General Instrument Corp. has center frequency of 25 mc. and bandwidth of 2 mc.

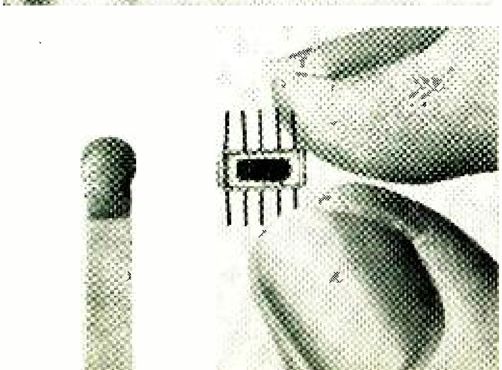

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Fig. 3. Tiny hearing aid by Zenith uses monolithic circuit made by Texas Instruments. The match shows amplifier size.

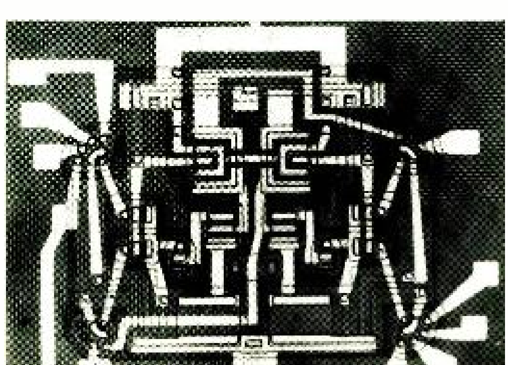

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Fig. 4. This monolithic circuit is made by Sylvania and contains 28 active and passive electronic components. Size of this device is smaller than the letter "O" of this type.

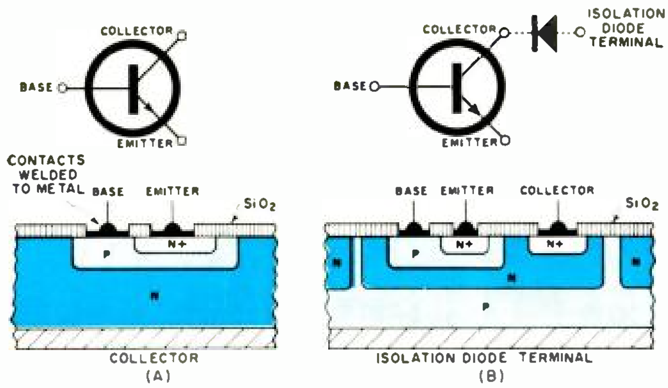


Fig. 5. (A) Construction of a conventional planar transistor. (B) Construction of an integrated circuit planar transistor.

tained through either thin-film or junction (diffusion) techniques. Generally, these will be an emitter-base junction or metal-oxide silicon (MOS) types.

Several examples of junction types are shown in Fig. 8. Junction capacitors are inherently voltage dependent and must be used in the back-biased, or non-conducting condition. The back-to-back configuration shown in Fig. 8B insures this bi-polar operation.

A collector-base junction can be used by itself or in parallel with the base-emitter junction for a capacitor such as shown in Fig. 8C. However, due to the high series resistance and the high relative shunt isolation capacitance at the collector, this type of capacitor is impractical.

Fig. 8D shows two types of metal-oxide-semiconductor (MOS) capacitor structures. The electrodes, separated by the thin oxide layer, are obtained by using a heavily doped diffused region and a surface film of metal. The capacitance value, and voltage breakdown, are determined by the thickness of the SiO_2 layer separating the two plates.

Once the wafer has been treated so that all the individual circuits are complete, it will contain up to several hundred individual monolithic circuits (chips). A close microscopic inspection of the wafer may show that many chips may have faults due to pinhole imperfections, improper diffusion, or some other flaw that will make the circuit inoperative. These faulty circuits are marked for later removal.

The wafer is then cut into individual chips using a glass-cutting technique. A diamond scribe is used to make the fine separation scratches on the wafer between the individual circuits. The wafer is then mechanically separated along these lines into uniform square dice.

The dice are then thoroughly cleaned, dried, and inspected once again for defects. Each die is then mounted to its particular header using a high-temperature alloy. The header connector leads are then spot-welded to their connecting points. Following this lead welding, a final optical inspection is made to guarantee that the circuit has not been damaged. After this inspection, the circuit is then closed up in its mount and tested for electrical characteristics.

Thin Films

The major difference between thin-film circuits and conventional printed circuits is one of thickness. Although a printed circuit uses so-called microminiature components soldered to wiring plated on the insulating substrate, this type of circuit is still some large fraction of an inch in thickness.

Thin films, on the other hand, are coatings whose thickness can be measured in microns, making them far thinner than a human hair. These thin-film coatings can be fabricated from various chemical elements to form resistors and capacitors of various values. Although being produced in laboratory experiments, active elements such as transistors, diodes, and other semiconductors are not presently available in thin films. When they are to be used, separate, discrete, extremely small active devices can be mounted to the thin-film circuit.

A simple analogy of one of the processes commonly used in the manufacture of thin-film components and circuits is the deposition of an extremely thin layer of soot on a glass using the smoke from a candle flame as the source of soot. If some geometric shape is placed on the glass surface facing the candle flame, then this shape will be outlined in soot.

If, instead of a candle, various chemical elements were

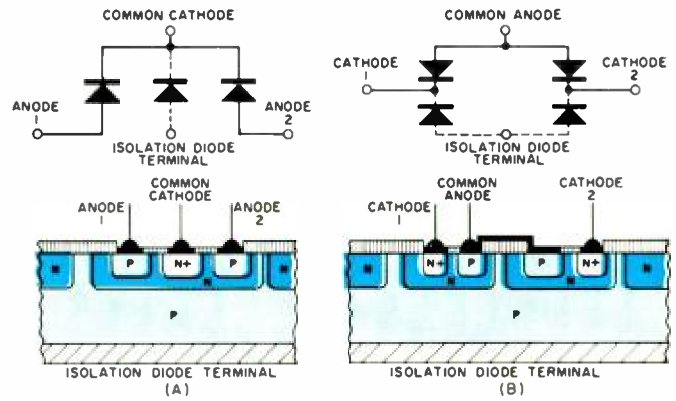


Fig. 6. (A) Construction of a common-cathode pair of diodes. (B) Construction of a pair of diodes having a common anode.

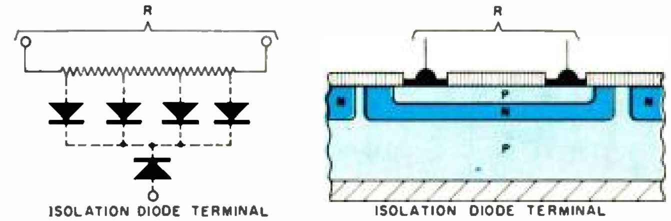
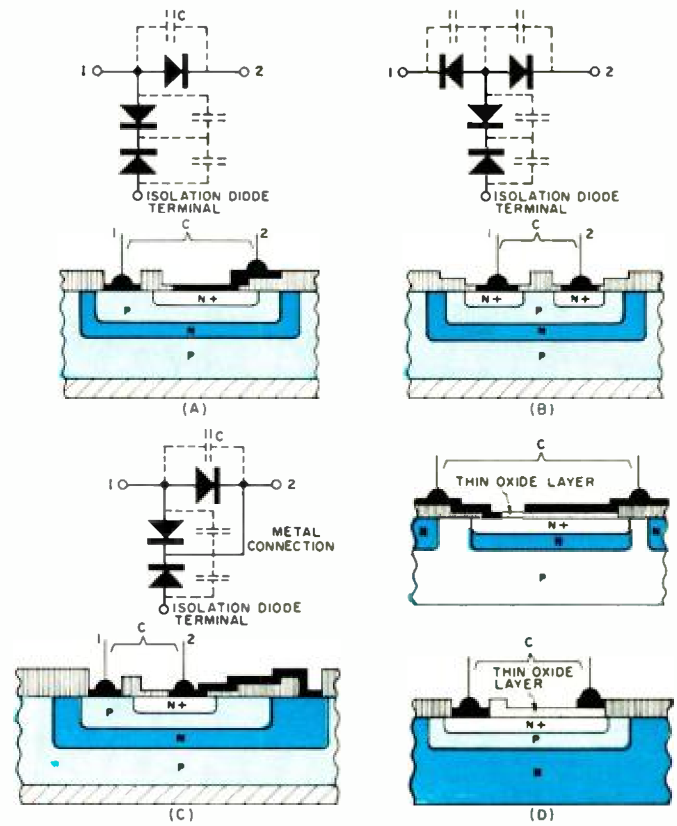


Fig. 7. How a monolithic circuit diffused resistor is made.

Fig. 8. Junction capacitor structures. (A) Emitter-base junction. (B) Emitter-base junction, back to back. (C) Emitter-collector-base junctions in parallel. (D) Some monolithic circuits use a metal oxide semiconductor type of capacitor.



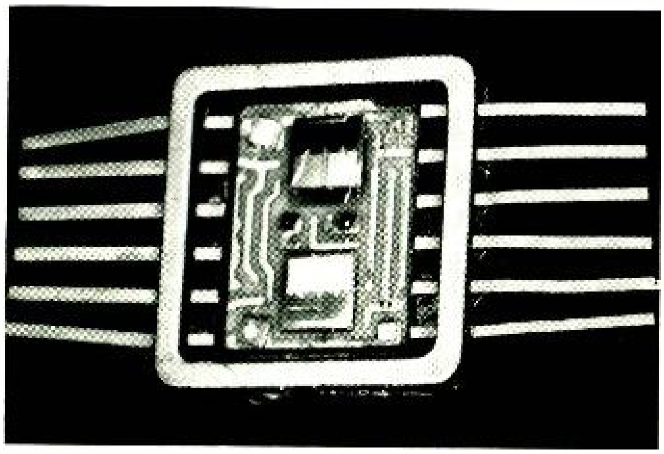


Fig. 9. Typical example of a hybrid circuit made by General Instrument Corp. Eight separate chips are used on this unit.

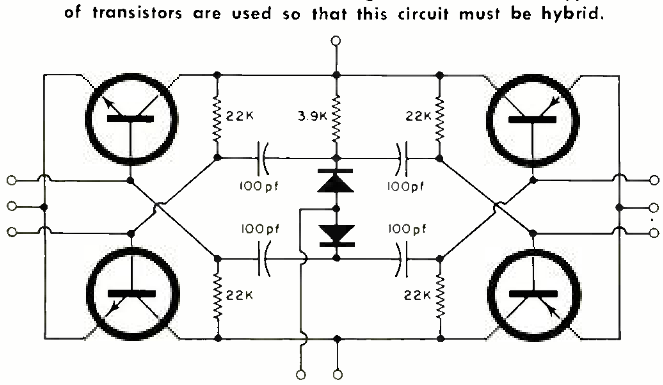
burned so that their "soot" was deposited on the substrate, then the "shadow" of the shielding shape, having the chemical characteristics of the chemical burned, would result. If the deposited chemical "soot" has a certain resistance value per unit area, then the resultant deposited shape would have a resistance dependent on its shape. By varying shape and areas of the deposition, different values of resistance could be obtained. If, on the other hand, a metallic layer were deposited on the insulating substrate, and then this layer were covered by a thin insulating layer, and then another metallic layer were deposited directly over the first one, it becomes possible to create a capacitor having very thin dimensions, whose capacitance value is a function of the mutual area between the metallic layers. In such cases of thin-film components, the insulating substrate acts only as a mechanical support.

Besides resistance and capacitance, it is also possible to fabricate a thin-film inductor by forming a spiral of conductive material. Because a large number of turns is required to make a significant inductance value, and since the thin-film coating itself has some resistance, a very low "Q" results for inductors with values much over 1 to 2 μhy. When large values of inductors are required in some applications, special microminiature units are mounted on tiny substrates.

Deposition of thin films is accomplished by the transportation of matter from a heated evaporation source to a condensation surface (substrate) in a vacuum. Because the electrical parameters of thin-film components depend largely on their geometries, the masks used to shape these components are made many times oversize so that they can be made clean and sharp edged. They are then reduced to their final size using high-resolution photo techniques.

At present, only passive components are being fabricated using thin-film techniques. Some transistor-like devices and other semiconductors are being made in the laboratory. Microminiature transistors and diodes, 28-thousandths of an inch square, have been fabricated by *IBM* for the use in the System/360 data-processing system.

Fig. 10. The actual circuit of Fig. 9. Two different types of transistors are used so that this circuit must be hybrid.



Besides resistors, capacitors, and certain types of inductors, other types of thin-film components are being manufactured. Thermocouples used to monitor temperature rise in a lubricating fluid have been deposited on a paper base for use in narrow spaces; lubricating films have been deposited on fused quartz to evaluate the potential of thin-film lubricants; and thin-film aluminum coatings are being applied to various optical devices such as lenses and mirrors.

Hybrid Circuits

Although the monolithic, or fully integrated microcircuit, in which all the components share and are interconnected on a single common substrate, has revolutionized many areas of circuit design, it is not universally applicable to all problems under all circumstances. In the present state of the art, the monolithic circuit has certain disadvantages.

One technical limitation to the freedom of design of these circuits is the problem of either physical or electrical interaction of components sharing the same common substrate. In a monolithic circuit, where a large number of components share a common substrate, the substrate material must of necessity be a compromise between the ideal or optimum characteristics for the necessary circuit resistors, capacitors, transistors, diodes, or other semiconductor devices. The substrate material may be ideal for one component but far from ideal for another. It is also possible to have heat-sensitive components sharing the same substrate as a heat-producing component. This can compromise circuit operation. Also, in many cases some circuit values may be required that cannot be obtained with monolithic techniques. For example, practical inductors have not been made in monolithic circuits as yet. If a circuit requires an inductor, then either a thin-film one or a tiny lumped inductor must be affixed close to the monolithic circuit (on the same header) and interconnected into the microcircuit.

Because hybrid or multi-chip circuits are essentially an assembly of discrete tiny components, they are ideal for small production runs where costs are of great importance. They are also used for circuit evaluation and testing before being made in monolithic form. In the hybrid configuration, it is relatively easy to change components to suit circuit changes.

Although hybrid circuits are composed of an assembly of thin film and possibly tiny discrete components, they are not physically large. In fact, they usually occupy the same size mounting package as a monolithic circuit.

One such hybrid circuit is the NCS-390 complementary flip-flop made by the *General Instrument Corp.* and shown in Fig. 9. This basic computer counting device has the circuit shown in Fig. 10 and is .375-inch square. Because two different types of transistors were required by this circuit, and under present techniques both cannot be laid down on the same silicon wafer, this flip-flop uses the hybrid construction. It includes eight separate microminiature chips including four transistors (2 *n-p-n* and 2 *p-n-p*), two diodes, and two resistor-capacitor networks. The smallest chip used is 20-thousandths of an inch square. As with all hybrid circuits, various component chips (circuit values) can be changed as desired.

The eight chips are interconnected on an alumina (ceramic) wafer by pure gold wires, each 10-thousandths of an inch wide (less than one-tenth the diameter of a human hair). Each silicon chip is alloyed to the interconnecting wire in an unbreakable bond. The unit is then hermetically sealed in a nickel alloy case to prevent the entry of moisture. The finished circuit is only three-eighths of an inch square and six-hundredths of an inch thick.

Another example of the use of hybrid circuits is the *Motorola* two-way radio shown in Fig. 1. An examination of many of the devices shown discloses the use of many hybrids, both as circuits and individual thin-film components. ▲

POWER & RESISTOR CHARTS

By ROBERT JONES

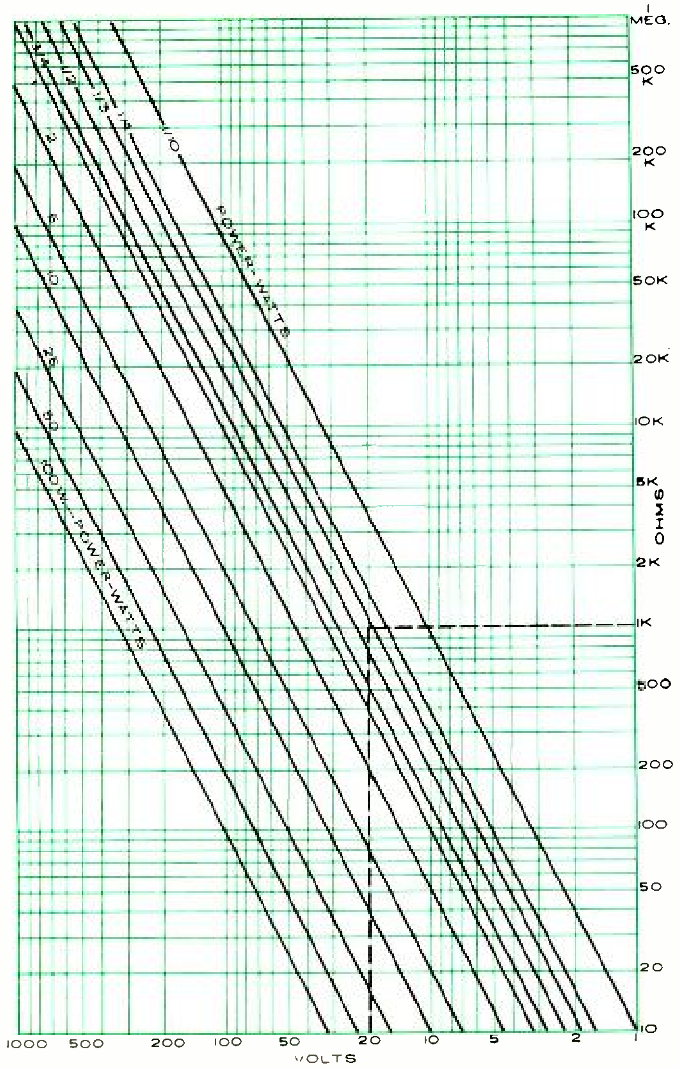
The solution to problems based on the common power formulas is simplified by the use of two graphs.

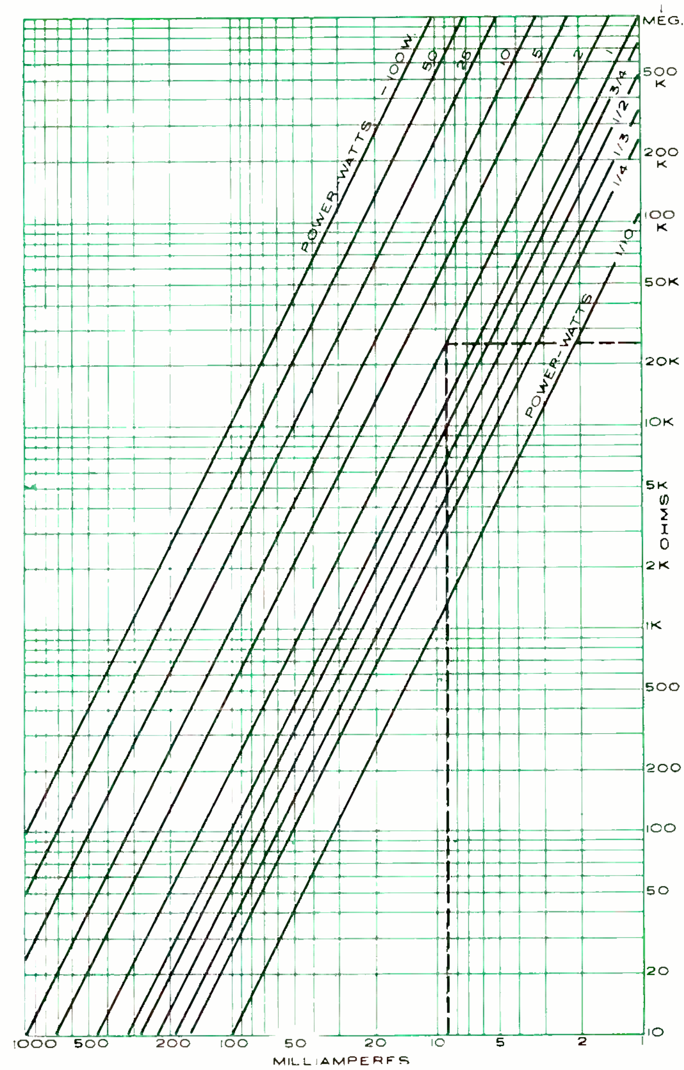
DO you have difficulty with, or find it time consuming, when the maximum current or voltage that can be tolerated by a resistor of given power rating must be found? While most technicians armed with a slide-rule can find a reasonably quick answer to the formulas $P = E^2/R$ or $P = I^2R$, considerable effort and much thought often goes into the longhand method if many values must be calculated.

By using the left-hand chart below, the solution of E, R, or P can be readily found when any two of the values are known. Application of the right-hand chart provides the solution to I, R, or P.

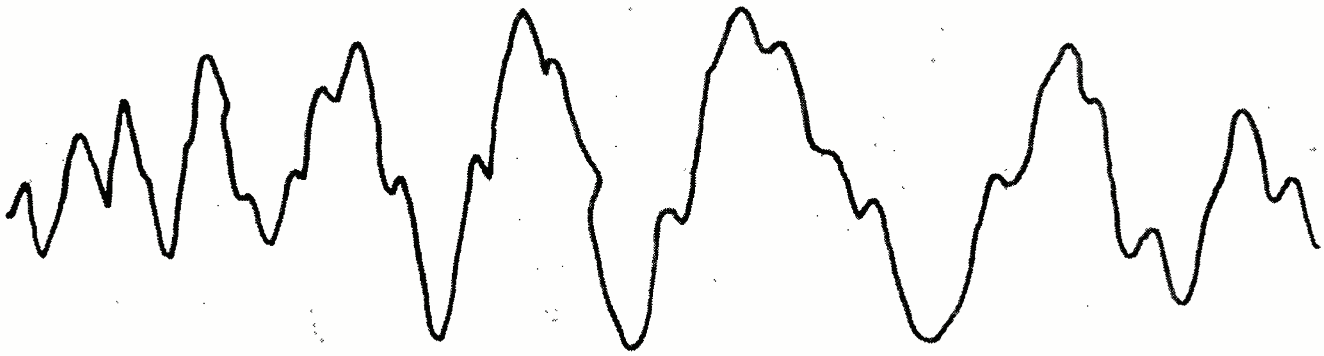
Some examples to try on the charts include: 1. Given a resistor of 1000 ohms with a voltage across it of 20 volts, find the wattage of this resistor. The answer to this simple example is 0.4 watt. Use the left-hand chart by first finding the applied voltage on the voltage scale, then following this line upward until it intersects the line representing the given resistance in ohms. Note that the answer shown by the chart is between the ⅓-watt and ½-watt diagonal power lines. The larger of the two wattages is the closer to the higher conventional wattage rating. For safety, this wattage is usually doubled.

2. What is the maximum current that can be safely passed by a 2-watt, 25,000-ohm resistor? Using the right-hand chart, locate the 2-watt diagonal line and follow this along to the 25,000-ohm horizontal line. From the point where these lines intersect, follow the vertical line down to the current scale on the chart. The answer is shown to be close to 9 ma. ▲





NOISE FIGURES OF V.H.F. AMATEUR CONVERTERS



By WILL CONNELLY, W6QID

Significance of this factor, techniques of measurement, and methods of improving noise performance of ham v.h.f. systems.

THE selection of a new v.h.f. converter or an appropriate converter design can be a worrisome task. Specifications abound and prices range over a nearly 3 to 1 ratio. The inveterate peruser of converter ads and articles will note that the one technical parameter stressed by *all* manufacturers and writers is low-noise performance, or low *noise figure*, and that the lower this number, the better the converter is claimed to be.

There are some complications to this noise figure business which have been inadequately explored in amateur literature. Not too many hams really understand noise figure. Fewer still have access to the sophisticated and costly test equipment required to measure it accurately. And still fewer, including some of the manufacturers of the equipment know how to make an accurate noise-figure measurement, even with the equipment that is required.

Noise Figure

What, exactly, is noise figure? When a noise-figure rating is assigned to a converter (or receiver or amplifier), it implies that the converter is less sensitive than a theoretically perfect, completely noise-free converter—one which cannot be achieved in practice. In essence, the statement of noise figure is a form of comparison between the signal-to-noise power ratio of real and imaginary equipment. (Noise figure may be expressed as a ratio of two powers, but is generally expressed as the logarithm of the ratio, in decibels.) The higher the numerical rating, the more the real converter diverges from the performance of the imaginary perfect standard. Thus a converter with a noise figure of 3 db is half as sensitive (that is, has one-half the signal-to-noise ratio power) as a theoretically perfect converter.

At any temperature above absolute zero, molecules move within any substance and, in the process of moving and colliding with each other, generate electrical power. This generated power is *white noise* and is evenly distributed across the entire radio spectrum. For any sample band of frequency, say 10 kc., the amount of noise generated will be the same; *i.e.*, the noise power in a 10-kc. wide sample of spectrum near the broadcast band will be the same as the noise power in a 10-kc. sample of spectrum taken at a microwave frequency. If the sample band is 100 kc., the amount of noise power within the sample is ten times greater than it was in the 10-kc. sample. The higher the temperature to which the noise-producing object is raised, the higher will be the noise power developed. Note that the term *power* is used, for it, unlike voltage, will be constant irrespective of the resistance of the material.

For example, an antenna, even though it is completely shielded from all the cosmic and man-made noises to which it would be subjected in a real situation, will produce noise by virtue of the fact that it is constructed of matter. At resonance, this antenna will act as a pure resistance (the radiation resistance) across which noise power will be developed, and this resistance is the effective shunt resistance to the otherwise noiseless input of the theoretically perfect converter. A finite limitation, the magnitude of white noise, now establishes the *absolute power sensitivity* of the converter and provides a standard for comparison.

Noise Powers

The comparison standard, the *absolute power sensitivity of a theoretically perfect amplifier,* has been converted to a graph, Fig. 1. This graph is based on a temperature of about 300°K (approximately room temperature), which is the generally accepted reference temperature among engineers. Note that it would be possible (and in the opinion of the author, highly advisable) to express noise figures as a *noise temperature* instead; 300°K is proving to be too high a temperature in an age when parametric amplifiers and cryogenic techniques permit *negative* noise figures. It is, however, a current reference standard and convention shall be served.

Fig. 1 gives the relationship between noise power and bandwidth at about 300°K. Bandwidth is the point at which the amplitude of signals passing through the converter has fallen to the half-power, or 3-db-down points, on either side of the center frequency. The power levels are expressed in convenient *decibels below one milliwatt,* or *dbm,* to which decibels may be added or subtracted. Zero dbm equals one milliwatt, -10 dbm equals one-tenth (10^{-1}) mw., -20 db is equal to 1/100th (10^{-2}) mw., -120 dbm equals 10^{-12} mw., and so on.

Referring to the graph, it can be seen that for a bandwidth of 1 kc., the absolute power sensitivity is -144 dbm. This is 4 x 10^{-18} watt or 4 micromicromicrowatts (or 4 attowatts). If this noise power is developed across a 50-ohm load, such as a feedline, the noise voltage will be 0.014 microvolt.

When the signal fed to the converter is of the same strength, *i.e.*, the signal and noise powers are equal and the signal-to-noise ratio is unity, the power output delivered by the converter will rise 3 db over the level for noise alone. *It is upon this principle that noise-figure measurement is based.*

The observation made earlier to the effect that noise power increases ten times (10 db) for each ten-fold multiplication of bandwidth is shown by the graph. The corollary is that the absolute power sensitivity, or minimum detectable signal strength, of a receiver increases 10 db for each decade by which bandwidth is reduced. This is *system bandwidth.* A two-meter converter may have half-power response of 6 or 8 megacycles, but the i.f. of the communications receiver which follows it may be only 3-kc. wide. The bandwidth at the point from which intelligence is taken, or at which a measurement is made, determines absolute power sensitivity. In this case, it is the 3-kc. bandwidth.

Measurement Precautions

There are several methods of measuring noise figure. Two of these will be described. Some manufacturers of low-noise equipment are incapable of making accurate measurement. This conclusion is the result of first-hand experience with some of the sources of measurement error. These will be listed in the hope that noise-figure measurement by professionals will eventually be improved.

1. To achieve a measurement accuracy of one decibel, the signal generators, noise sources, attenuators, and power indicators should have individual accuracies at least ten times better, or 0.1 db. Yet noise figures down to a tenth of a decibel are often seen in print, implying measurement-device accuracies of 0.01 db. Such equipment is remarkably rare.

2. The device which measures the output power of the system must be a *true power indicator.* This means a thermocouple device, usually a bolometer power meter.

3. Signal generators must be thoroughly shielded to prevent leakage signals on the order of millimicrovolts.

4. Measurements must be made in screened rooms.

5. A converter or amplifier just on the verge of oscillation will show a noise figure appreciably better than the true noise figure. It may even show a negative noise figure.

6. If the receiver used in conjunction with a converter, or if the converter itself, has poor image rejection, the converter noise figure will appear to be several db better than the true noise figure.

7. For best noise figure, a converter must be *critically mismatched* to the antenna. To avoid the introduction of impedance discontinuities which will distort the measurement, the cable between the signal source and the converter must be made a precise electrical half-wave. This is done with an adjustable line, such as a "trombone," and an impedance or conductance bridge capable of accurate performance at the converter input frequency.

8. All stages in the measurement system must be operated in a linear mode. In practice, this means that no a.v.c. may be used during the measurement process and that measurements at the receiver audio stage, which follows a non-linear detector, are unacceptable.

9. If the gain of the converter is low, the noise figure of the receiver with which it is used can affect the indicated noise figure.

10. If "spot" noise figures, using the c.w. signal generator method, are to be measured, the system bandwidth must be accurately measured first and, for optimum accuracy, the passband must be symmetrical about the center frequency.

Measurement Techniques

Now to the technique of measurement, which will assume that all factors enumerated have been given due consideration. In Fig. 2, an r.f. signal generator is connected through a precision attenuator to the input of the converter. A switch permits the input to be connected to a 50-ohm resistor. The detector diode is removed from the receiver and the power meter is connected across the secondary of the last i.f. transformer. The converter input is connected to the resistive source and the receiver gain is adjusted for roughly half-scale indication on the power meter. Switching the input to the signal generator source, the attenuator is next adjusted for a rise of precisely 3 db on the output indicator, and the attenuator setting noted. Assume that the receiver i.f. bandwidth has been measured at 3 kc. and that the attenuator reading is −136 dbm. Referring to the graph of Fig. 1, it can be determined that the absolute power sensitivity of the ideal equipment would be a fraction over −139 dbm. *The difference between the actual measurement and the theoretical sensitivity is the noise figure*: slightly over 3 db.

The measurement just made is the *spot* noise figure *at one particular frequency.* The noise figure of a properly aligned 2-meter converter will usually be within a half db or so from one end of the band to the other.

The second system of absolute measurement delivers *average* noise figure. In place of a signal generator, a noise source is used. One type of noise generator is the "thermionic diode," which permits direct readings from the generator itself. Other precise generators utilize neon, argon, or fluorescent-light gas-discharge sources of noise, and have fixed output. The gas-discharge sources are used in the same manner as the signal generator, while the thermionic diode source requires only that the 3-db rise in output be precisely observed, the bandwidth (*Continued on page* 78)

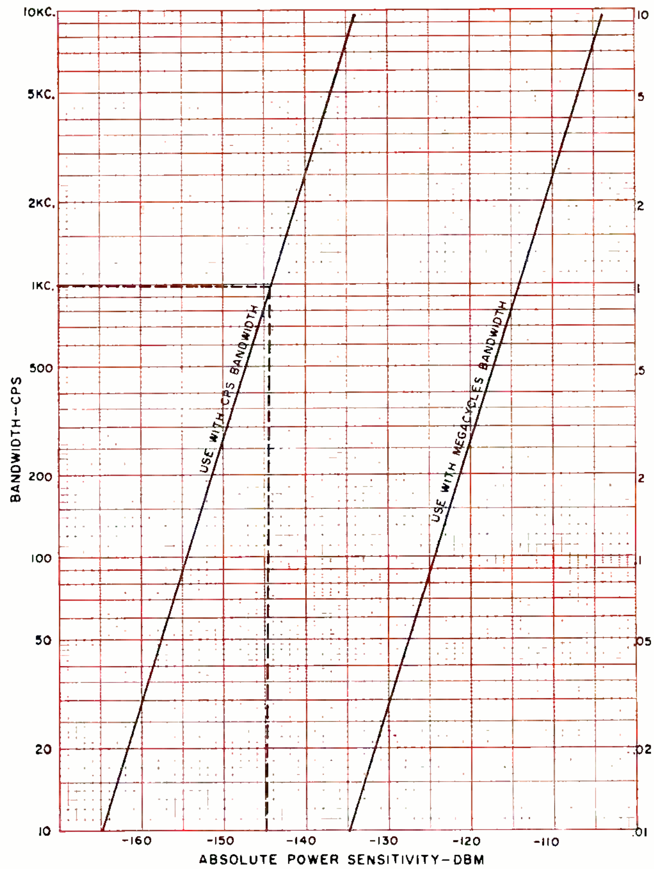
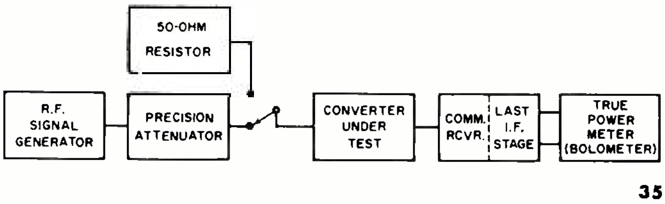


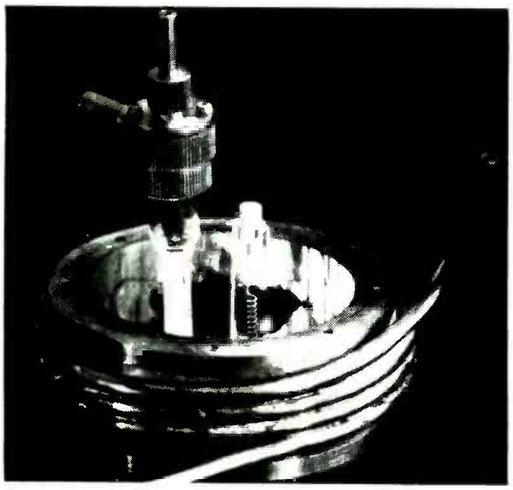
Fig. 1. Absolute power sensitivity of perfect amplifier for various amounts of bandwidth at about room temperature (300°K).

Fig. 2. Test-equipment setup for measuring noise figure.



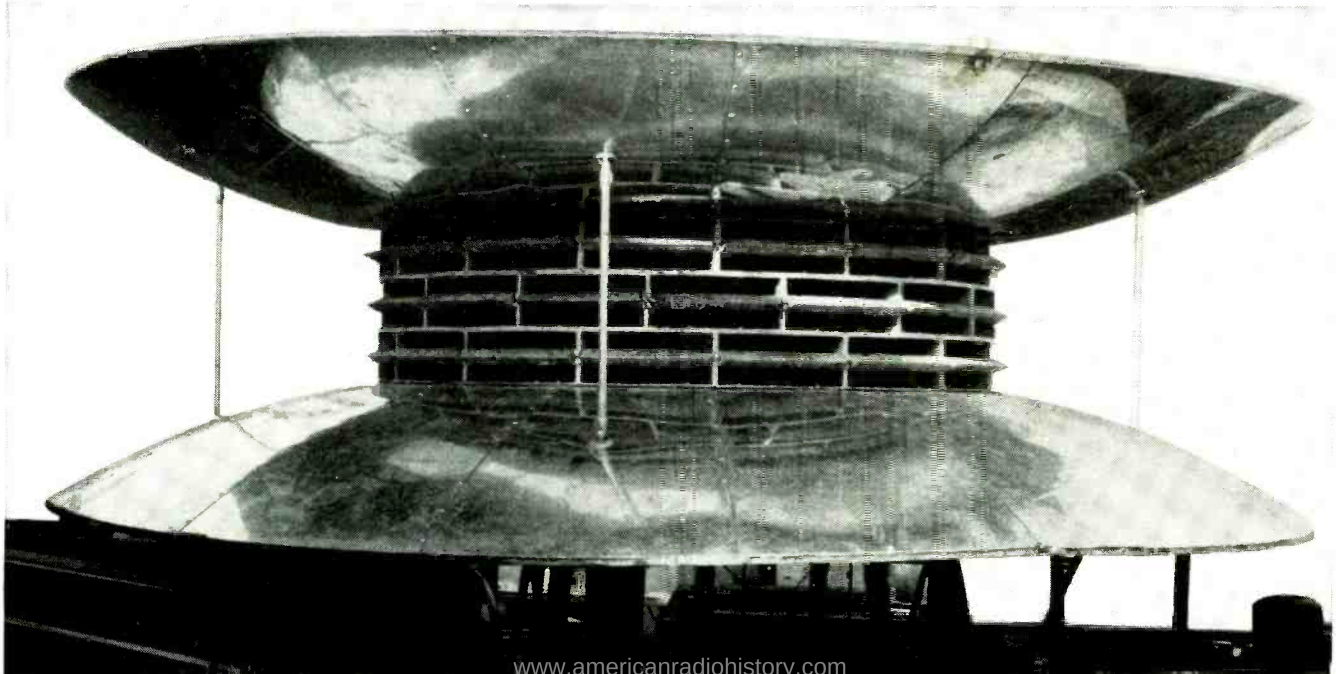
RECENT DEVELOPMENTS in ELECTRONICS

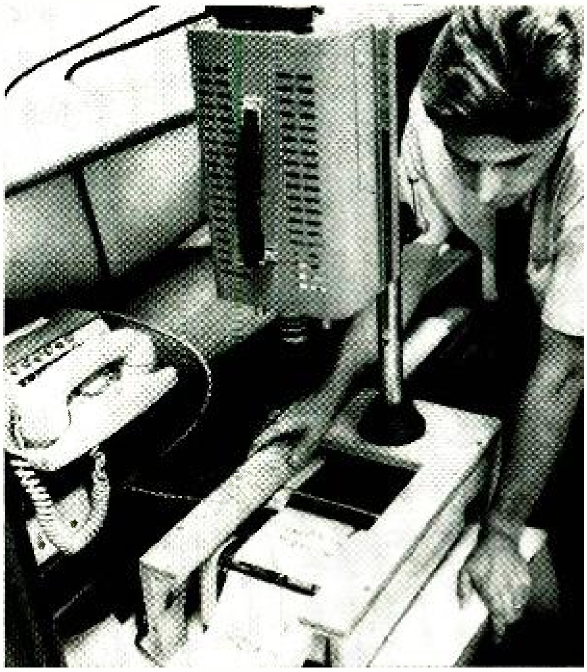
Rare-Earth Garnet C. W. Laser. (Below) The development of rare-earth aluminum garnet crystals at Bell Labs has made possible a solid-state optical maser which operates continuously at room temperature with only a small fraction of the pumping power previously required. The crystal (rod at left within elliptical housing) is pumped with a standard spiral-filament tungsten lamp that has a life of thousands of hours. This new development is a step in putting solid-state lasers on an equal footing with gas types for c.w. use.



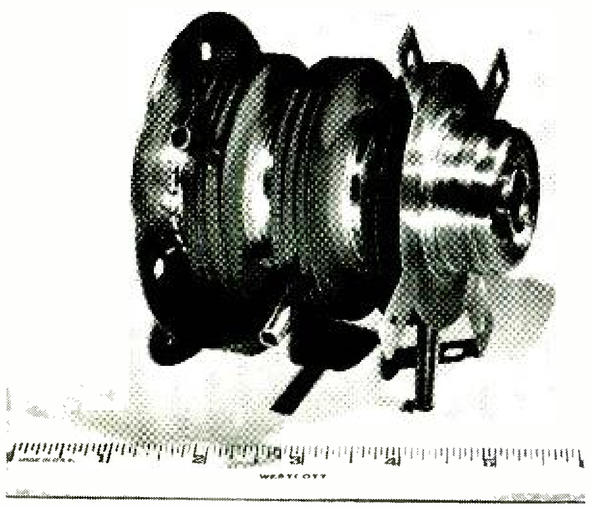
Epoxy Resins in Electronics. (Above) Plastic epoxy resins are finding more applications in the electronics industry as time goes on. For example, they are used in bonding wrap-around safety-glass panels to TV tubes. Photo shows engineer at Dow Chemical Research Labs using polarimeter to measure stress developed during curing of resin. Another technique to prevent implosion is the use of a metal band, formed under pressure around the TV tube faceplate. Epoxy resins bond the metal band and metal mounting frame to the tube. The resins, because of their good electrical properties, are used for laminates (printed-circuit boards), potting and encapsulation, and in manufacture of a good many electrical and electronic components.

7000-lb. Outdoor Loudspeaker. (Below) Probably the most powerful loudspeaker ever built is used nightly at the N.Y. World's Fair "Fountain of the Planets" water pattern and fireworks display. Reproducing the music accompanying the display, the speaker rises on a hydraulic lift behind the cascading water curtain. The speaker, designed by RCA Laboratories, is 16 feet in diameter and weighs 7000 lbs. The center section is made up of 3 circular tiers, each containing 16 cast-aluminum folded horns with separate driver speakers. Two huge metal saucers act as a circular terminating horn.





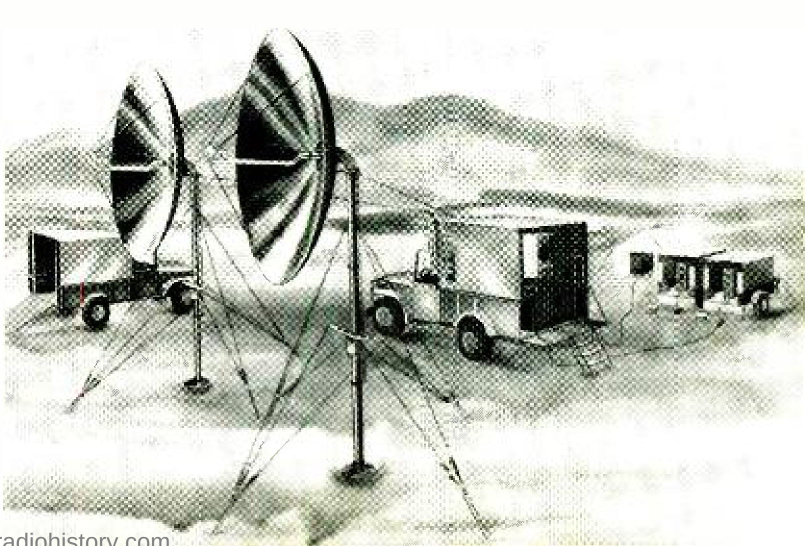
Electronic Blackboard. (Above) An electronic writing machine has replaced the traditional blackboard for a nuclear engineering class at Georgia Tech. Equations written by the instructor in Oak Ridge, Tenn. on a Victor Electrowriter travel 200 miles by telephone lines to be reproduced on a second unit at the university. A CCTV camera on the machine relays pictures of the moving pen to students. The main advantage of the system is its low cost because of the use of ordinary telephone lines.



Thermionic Energy Converter. (Above) This module incorporates three series-connected thermionic energy converters which operate in a single vacuum area with a single cesium reservoir. The module was designed by RCA to convert nuclear heat directly into electricity in a liquid metal loop system. During a recent test, stable power output of over one watt/cm.^{2} of emitter area was obtained at an emitter temperature of 1500 degrees K. The power output of this module is 60 watts at 0.84 volt. This development may lead to the design of electrical power systems for use in space vehicles.

Infrared-aimed Laser Radar. (Below) An engineer is shown adjusting a new infrared-aimed laser radar during a recent test. This Sperry-designed system promises a ten-fold increase in on-target precision over microwave radar trackers and has permitted the use of narrower, more intense laser beams for higher signal-to-noise ratios. The passive IR sensor is gimbal-mounted between the trunnions which carry the laser optics. The laser transmitter beams its pulses from the U-shaped aperture atop the trunnion at right (directly below engineer's hand). The reflected laser light beam returns through a similar aperture at the top of the trunnion at left.

Tactical Communications Link. (Below) Rendering of new 5000-mc. line-of-sight and over-the-horizon radio communications equipment developed by ITT Federal Labs. The system, designed for the Army, constitutes a complete radio terminal requiring only connection to existing area communications facilities to be operational. The equipment, designated AN/TRC-112, is completely transistorized except for a klystron power tube. The system consists of a radio shelter containing transmitting-receiving equipment, two 10-ft. parabolic antennas, and two power generators. It can be transported in two ¾-ton vehicles, each towing a small power-unit trailer. Multi-channel telephone, teleprinter, or data from standard military or commercial sources can be handled.



CAPACITANCE TRANSDUCER SYSTEMS

By SIDNEY L. SILVER

Various forms of unusual capacitors are used by industry to determine the level of liquids in a storage tank or the pressure of liquids flowing through hydraulic plumbing.

IN modern instrumentation and control systems, the principle of capacitive variation is frequently employed in transducer design to sense mechanical changes and convert them to corresponding electrical signals. Capacitance transducers are capable of linear and angular measurement with a high degree of conversion stability, excellent linearity, and infinite resolution. These devices produce accurate measurement for a wide range of basic physical quantities including pressure, humidity, vibration, thickness, torque, and liquid level. In addition, physical phenomena related to motion such as displacement, velocity, and acceleration may be readily translated into a useful voltage or current output. Since the force requirements of capacitance transducers are very low, extremely small changes in electrical capacitance can be detected with negligible distortion.

Principles of Operation

The design of capacitance transducers is based on the inherent property of two or more charged metallic elements which enables them to store electrical energy in an electrostatic field between the conductors. The capacitance so formed is a function of the effective area of the conductors, the distance which separates them, and the dielectric constant of the insulating material between the conductors. A change in any of the three parameters caused by the physical quantity acting on the transducer will produce variations in electrical capacitance which may then be accurately calibrated.

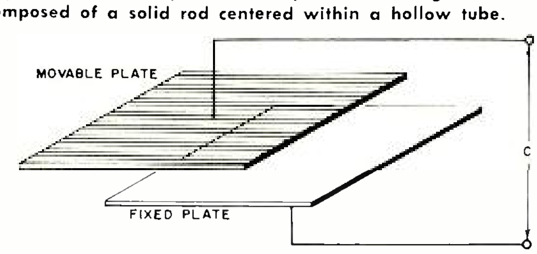
In its simplest configuration, a capacitance transducer system consists of a sensing probe, or pickup, containing a fixed plate and a movable plate separated by a suitable dielectric. In other modes of construction, the electrodes are fixed and the dielectric material serves as the variable element. The normal capacitance between the terminals of a capacitive sensor is the value obtained when electrostatic lines of force are uniformly distributed over the inner surface of the electrode plates, and when the electrostatic field is composed of straight lines extending directly from one electrode to the other. For the simple parallel-plate transducer shown in Fig. 1A, the capacitance can be computed from the formula $C = .225KA/D$ where C is the capacitance in pf., K is the dielectric constant of material between plates (for air, K is approximately equal to 1), A is the plate area in square inches, and D is the distance between plates in inches.

For the cylindrical transducer shown in Fig. 1B, which consists of a rod within a tube, the capacitance is determined by the equation $C = .644KL/[\log_{10}(b/a)]$ where L is the length of cylindrical electrodes, b is the inner diameter of the outer electrode, and a is the outer diameter of inner electrode.

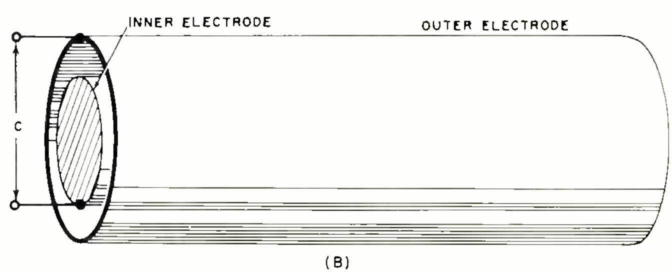
In addition to the rectilinear lines of force, a portion of the electrostatic field is established in the region beyond the edges of the metal plates and the dielectric material. This is referred to as fringing, or edge effect. Fringing is indicated in Fig. 2A by the curved electrostatic lines of force which bulge outward. This undesirable effect contributes stray capacitance to the measurement and makes the actual capacitance greater than the computed value. For precision measurement involving extremely small capacitance changes (in the order of .1 pf.), fringe-capacitance error is kept to a negligible value by making the distance between the electrode plates very much less than the plate dimensions. In the design of a capacitive sensor formed by two circular plates, for example, the ratio of plate radius to plate separation must be greater than 200 to 1, in order that fringe effects contribute less than 1% of the total capacitance.

To further reduce fringing capacitance sufficiently for precise calculation, a guard ring arrangement is sometimes employed to sharply define the edge effects and prevent them from entering into the measurements. As illustrated in Fig. 2B, an auxiliary guard electrode surrounds one of the plates (center electrode) of a capacitance transducer so that they are insulated from each other by a very narrow gap. The opposite plate (base electrode) is made larger than the center electrode, so that all of the fringing lines of force are confined to the guard electrode and the base electrode. The guard ring is grounded and the center electrode is maintained at a low potential while the base electrode is connected to a higher potential with respect to ground. By this means, edge effect does not enter into the direct capacitance between cen-

Fig. 1. (A) Capacitive displacement transducer consists of two parallel metallic plates. (B) Cylindrical configuration is composed of a solid rod centered within a hollow tube.



(A)



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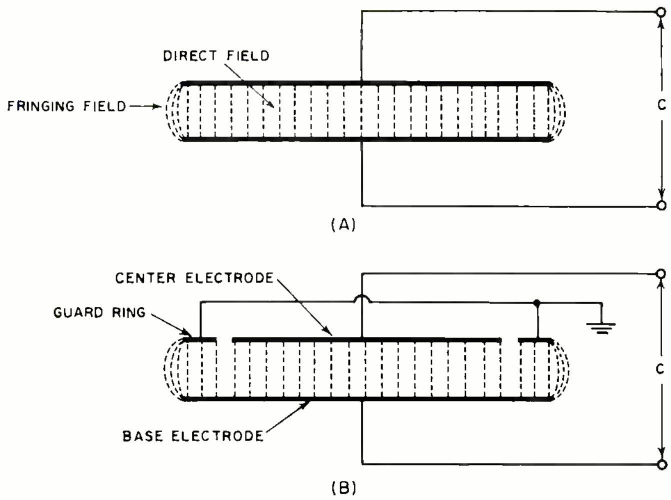


Fig. 2. (A) Effect of fringing lines of force on parallel-plate capacitor electrodes. (B) Guard ring reduces fringing.

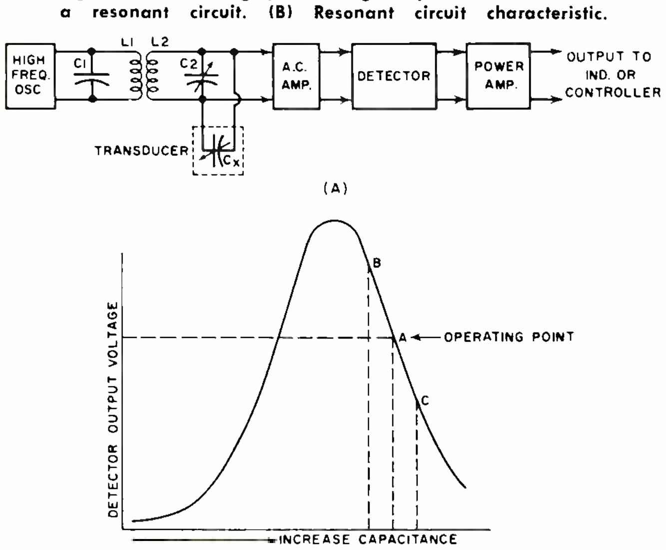
ter and base electrodes, which permits a precise calculation of capacitance value from the geometry of the capacitive transducer elements and the type of dielectric.

Electrical Systems

Several methods exist for converting variations in transducer capacitance into a useful, readable signal which can be applied to a precision meter, a recording instrument, or a process control system. The most common measuring techniques are the resonance method, the beat-frequency method, and the measuring bridge method (in which the electrode plates are energized by an a.c. source so that changes in capacitance, and hence in capacitive reactance, are detected as voltage or current variations).

A typical example of the resonance method is the frequency-modulated system shown in Fig. 3A. In this configuration, the transducing element (C_X) forms part of a tuned resonant circuit (*L2*, *C2*), which is loosely coupled to the tank circuit (*L1*, *C1*) of a high-frequency oscillator. In Fig. 3B, the tuned resonant circuit is adjusted by varying *C2* so that the operating point *A* lies on a linear portion along one slope of the resonance curve. A variation in transducer capacitance produced by the measured parameter results in a deviation of the operating frequency between points *B* and *C*, and consequently a linear output voltage is developed at the output of the detector. The detector output is sufficient to drive a moving coil indicator directly, but a power amplifier is required when it is necessary to feed a recording instrument.

Fig. 3. (A) Measuring system using a capacitive transducer in a resonant circuit. (B) Resonant circuit characteristic.



In the beat-frequency method, the transducer element and a calibrated capacitor are part of the total capacitance in the resonant circuit of a variable-frequency oscillator. The v.f.o. is made to "beat" with a fixed oscillator, usually crystal-controlled, so that a zero-frequency difference exists between them making the output of the system zero. Small changes in transducer capacitance cause the resonant frequency of the v.f.o. to shift so that a signal appears at the output of the demodulator. The amount of adjustment of the calibrated capacitor needed to restore the tunable oscillator to a zero-beat condition with the fixed oscillator depends on the capacitive change caused by measured quantity.

Fig. 4 shows a common form of bridge circuit employed in an amplitude-modulated carrier system. In this circuit, the r.f. voltage from a high-frequency oscillator is inductively coupled to a center-tapped secondary which forms two arms of an *LC* bridge. The bridge also comprises a calibrated capacitor (C_B) and a capacitance transducer (C_X). At balance, when C_B is equal to C_X, the output of the system is zero. Any change of C_X due to the measurable quantity causes the bridge to deviate from balance, so that a control signal is produced whose magnitude and phase depend on the bridge unbalance. Phase discrimination is maintained by re-inserting

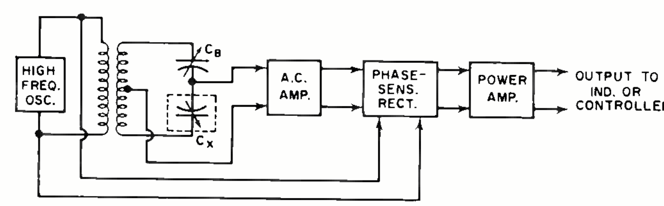


Fig. 4. This high-frequency, bridge-type transducer circuit is commonly used with some types of capacitive instrumentation.

the carrier at the phase-sensitive rectifier producing, for example, a positive output signal when the input is in phase with the reference and a negative signal when the input is out of phase. To restore the bridge to balance, C_B is adjusted (either manually or by means of a servo system) until it equals the measuring electrode (C_X).

Applications

Capacitance transducers are frequently employed in the precise measurement of fluid pressure of gas, oil, steam, and hydraulic materials. In such measuring systems, small displacements (ranging from micro-inches to a few thousandths of an inch) caused by variable pressure are frequently measured by a thin, flexible, metallic diaphragm which forms the movable element of a variable capacitor. A typical electrode assembly is shown in Fig. 5, in which the diaphragm is separated by an air gap from a stationary capacitive plate. As the fluid pressure increases in the pipeline, the pressure-sensitive diaphragm is deflected toward the fixed plate, which decreases the thickness of the dielectric and results in an increase in electrical capacitance. Conversely, a decrease in pressure increases the distance between the electrodes, and the capacitance decreases. To reduce the response to shock and vibration, the movable diaphragm is made very stiff in order to provide a high natural resonant frequency (10 kc. to 500 kc., depending on diaphragm dimensions). The diaphragm is rigidly clamped and electrically grounded to the metal frame while the fixed electrode is mounted on ceramic insulators.

In Fig. 5, the transducer capacitance (C_X) formed by the two electrodes is connected in parallel with a built-in coil (*L5*) to comprise a tuned resonant circuit. In order to provide mutual coupling between the capacitance transducer assembly and the tuned circuit of the electronic unit (*L2*, *C2*), a low-impedance coaxial line (approximately 50 ohms) is utilized, with each end terminated in link coils ($L3$, $L4$). This technique of link coupling eliminates the undesirable effects of varying cable capacity (such as caused by vibration) when reflected into a high-impedance load. It also permits the use of very long cable runs with minimum noise and attenuation between the pressure sensor and the electronic converter unit. The converter unit contains a discriminator and associated amplifier circuitry. Any capacitance change in the pressure sensor causes the discriminator to shift its characteristics with respect to the oscillator, resulting in a proportional output voltage as a function of applied pressure.

The electrical-capacitance effect provides a relatively simple means of continuously measuring and controlling the level of fluids inside sealed vessels or open tanks. In this application, the spacing factors of a capacitance transducer are held rigidly constant so that the variable parameter is the dielectric constant of the material to be measured.

Fig. 6 shows a capacitance system suitable for the level measurement of nonconductive fluids such as liquefied gases and petroleum products (oil and gasoline). The inner probe forms one electrode of a capacitive element which consists of a cylindrical metal rod, usually fabricated of stainless steel. The rod is rigidly supported by Teflon insulators within a

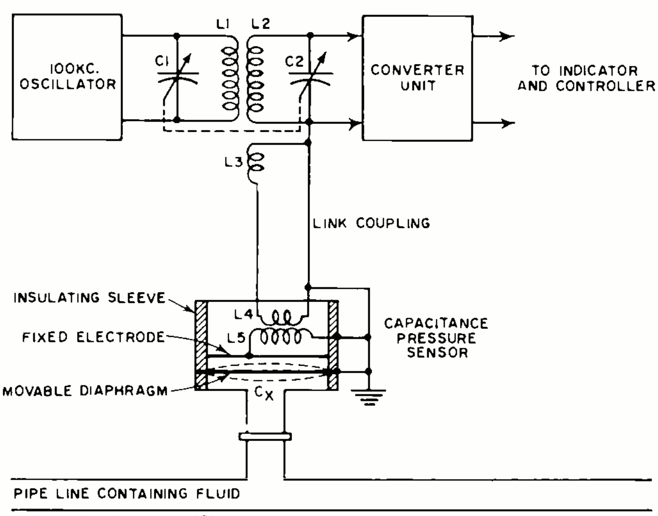


Fig. 5. This capacitance-type liquid pressure transducer is designed to operate with frequency-modulated carrier system.

cylindrical metal tube which forms the other electrode of the electrical capacitance. Finally, the entire electrode assembly is immersed in the electrically grounded storage tank. Portholes are located along the cylindrical tube to allow access of the liquid to the space formed by the concentric cylinders. Since the dielectric constant of the nonconductive fluid is higher than that of the air or vapor above the liquid, the capacitance between the electrodes is a function of the height of the liquid column in the vessel. Thus, as the liquid level rises in the tank and a larger proportion of the electrodes is surrounded by the fluid, the electrical capacitance rises proportionately. Assuming that the electrode structure has a uniform dimension along its vertical axis, the linear capacitance so formed (of the order of 10 to 100 pf.) may be accurately calibrated to give a direct reading in gallons or in feet of depth of the tank.

In Fig. 6, the sensing probe (C_X) forms one arm of a capacitance bridge which is energized by an r.f. source. Frequencies ranging from 100 kc. to 1 mc. are generally employed to permit large measurement currents to flow in the bridge, thus making the system extremely sensitive to small capacitance changes. Variations of transducer capacitance result in an unbalance of the bridge which is detected by the phase-sensitive demodulator, whose output is determined by the amplitude and sign of the capacitive unbalance. To put

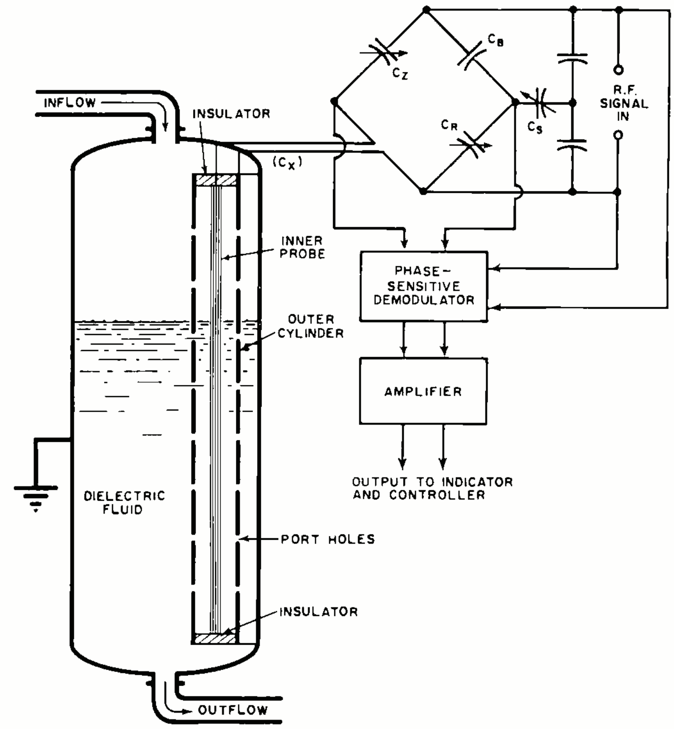
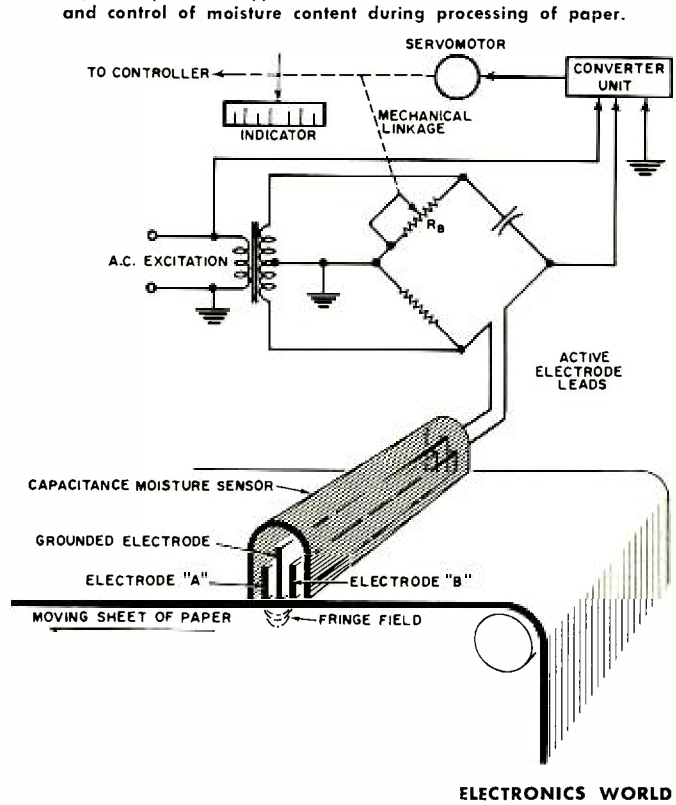


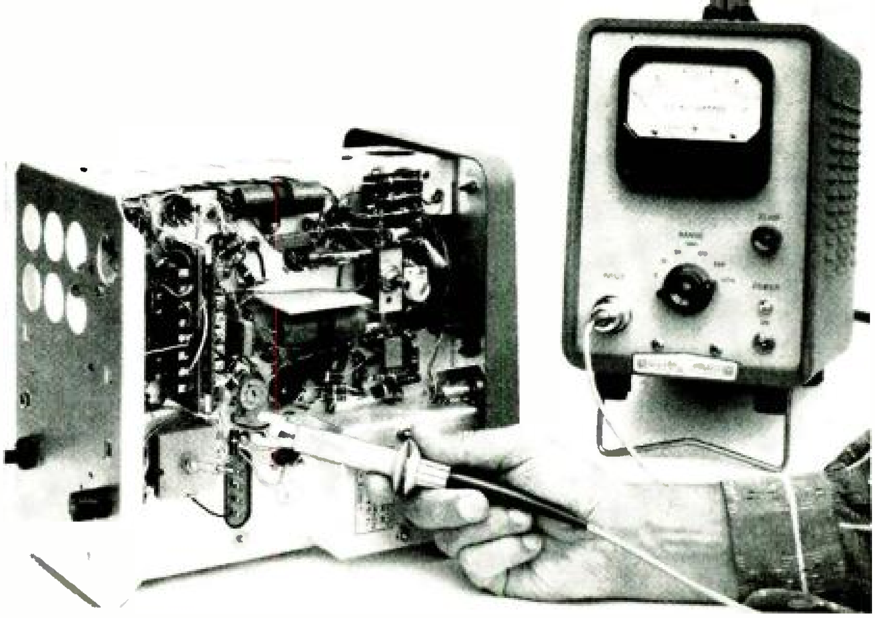
Fig. 6. Capacitance transducer system used as level measurement for tanks of various types of nonconducting liquids.

the system into operation, the zero adjust control (C_Z) is set to equal the transducer capacitance (C_X) when C_X is at minimum value or when a zero indication is required by the measured variable. C_B is a fixed capacitor which equals the reference capacitor (C_R) when C_R is at its minimum value. The span control (C_S), which determines the range of the instrument, is adjusted for the necessary amount of C_X change to give a full-scale deflection of the indicator.

Another type of capacitance-measuring device is employed for the level determination of fluids which are electrically conductive. In this case, the primary sensing element is a metal rod which forms one (*Continued on page 68*)

Fig. 7. Capacitance-type instrument used for the measurement and control of moisture content during processing of paper.



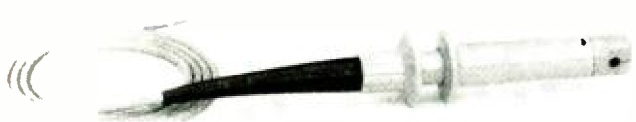


Current probe has tong-like jaws which simply clip around wire to measure d.c. current. The Hewlett-Packard Model 428A clip-on milliammeter shown here has full-scale measuring ranges from 3 ma. to 1 amp. Probe is also used with the Model 428B, which has a full-scale measuring range from 1 ma. to 10 amperes.

CLIP-ON D.C. CURRENT PROBE

By ARNDT BERGH, GEORGE S. KAN & CHARLES O. FORGE
The Hewlett-Packard Co.

Operating principles of a milliammeter that can measure direct currents without opening the circuit or loading.



Arrow on the probe shows current direction for up-scale reading.

DIRECT current can be measured easily with a clip-on current probe. The probe simply clips around the conductor without requiring that the circuit be opened or disturbed in any way. A ground connection is not even necessary.

Instruments using such a probe have a number of obvious applications. The probe can be clipped around a conductor at any place in the circuit where there is a half-inch length of wire with enough room around it to accommodate the probe. (On printed-circuit boards, small loops of wire can be placed in series with circuits where current measurements are to be made.) Even the current within a carbon resistor can be measured provided that the resistor is small enough (less than 3⁄16" diameter) to allow the probe jaws to close around it.

An arrow on the probe shows the direction of current flow (conventional positive to negative) that causes an up-scale deflection of the meter pointer. The orientation of the wire within the probe is not critical, just as long as the tong-like jaws close completely around it.

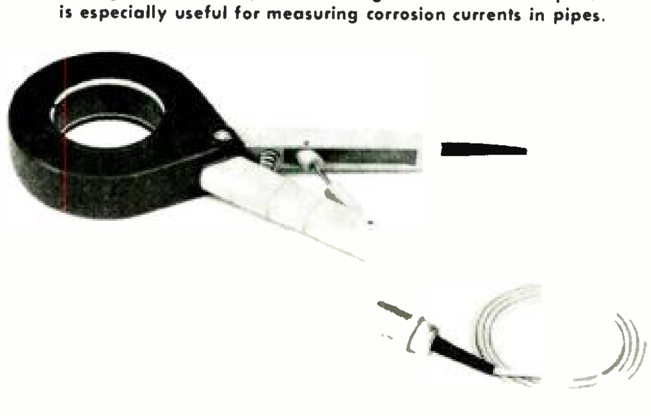
Current probes of this type can make measurements that were not possible with previous methods. The insertion of a conventional milliammeter in series with a low-impedance circuit, for example, often affects the impedance and thus the performance of the circuit. Similar difficulties arise when a small resistor is inserted in a circuit for the purpose of reading the voltage drop from which the current can be calculated. This does not happen when a current probe is used since the probe adds no series resistance to the circuit.

The absence of circuit loading thus makes the probe useful for measurements that used to be difficult or even impossible, such as the detection of circulating ground currents. A ground lead or strap can be left undisturbed when a current probe makes a measurement so that the feeble voltages which cause the currents are not affected.

Other uses for current probes arise from their ability to measure the sum total of the currents in several conductors that are within the probe jaws all at the same time. In this case, currents which flow in opposite directions subtract. This makes it possible to balance the currents in a push-pull stage, for instance, by running the plate leads in opposite directions through a current probe and then adjusting the circuit for a null.

Current probes have a wide measurement range; for instance, the range of the *Hewlett-Packard* Model 428B Clip-On D.C. Milliammeter is from 1 ma. full-scale to 10 amps. This instrument responds to currents smaller than 50 μa. and sensitivity can be increased even further by looping the conductor through the probe several times. The probe is virtually burn-out proof, being able to withstand overloads of hun-

Large-aperture probe measures d.c. currents in cable shields, waveguide structures, or other large conductors. This probe is especially useful for measuring corrosion currents in pipes.



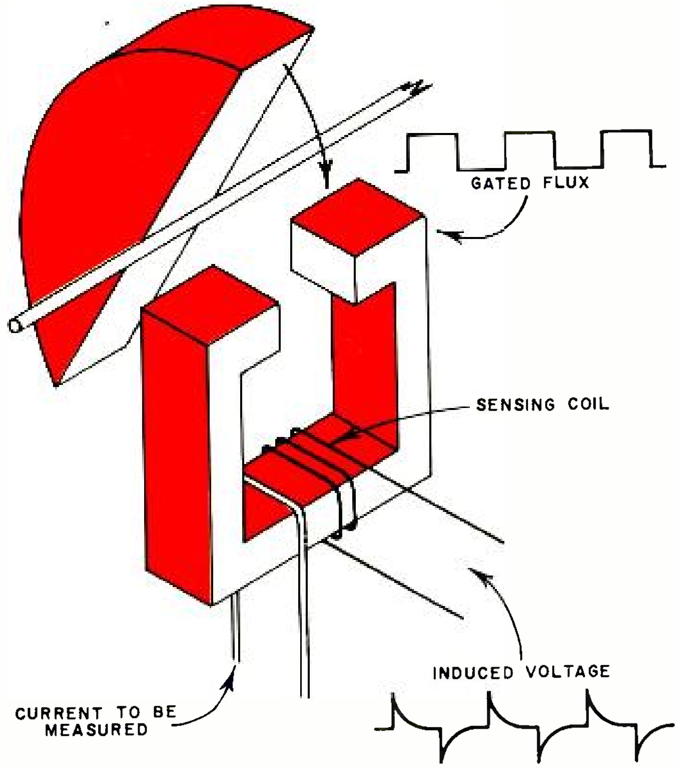


Fig. 1. Magnetic flux being gated by spinning "shutter."

dreds of amperes that might occur during a measurement.

The instrument may also be used to measure low-frequency alternating current (up to 400 cps). The indicating meter itself does not respond to a.c. but the instrument generates an output voltage that is proportional to the measured current. The voltage is available at a front-panel jack for use with a scope, an a.c. voltmeter, or a d.c. chart recorder.

How It Works

The d.c. current probe operates by sensing the weak magnetic field around a current-carrying wire. Unlike a.c. current probes, however, it does not function simply as a transformer that uses the measured wire as a one-turn primary winding.

The d.c. current probe is a refined version of the second-harmonic flux-gate magnetometer, a sensitive detector of magnetic fields. Flux-gate magnetometers have been widely used in aircraft compasses and in submarine detection equipment (the MAD or magnetic anomaly detector).

The flux-gate magnetometer principle achieves such sensitivity that it senses easily the 0.0006-gauss magnetic field around a conductor carrying 1 ma. By contrast, the earth's magnetic field is nearly one thousand times stronger. Careful magnetic shielding of the probe is an obvious requirement.

A magnetic field induces a voltage in a wire only when the field changes with respect to the wire. To enable a d.c. field to induce a voltage in a sensing coil, the current probe uses a form of flux-gating. The flux-gating principle is illustrated in Fig. 1 where the rectangular core represents the probe jaws, with a single current-carrying wire passing through. The semi-circular device is a spinning "shutter" which completes the magnetic path around the core whenever it rotates into the gap.

Even though the current in the wire is a steady d.c., the flux in the core switches from a maximum, when the shutter is in the gap, to a minimum when the shutter is out. The sensing coil therefore is exposed to an alternating flux. The maximum value of this flux is governed by the current in the measured wire so that the a.c. voltage induced in the sensing coil *is proportional to the current in the measured wire.*

Energy for operation of the flux-gate is supplied by the shutter, not by the measured circuit. This means that no energy is extracted from the measured circuit and the presence of the probe disturbs the circuit hardly at all.

The mechanically operated probe described here would, of course, be too unwieldy for use in circuit probing. In practical applications of this principle, gating is achieved by saturable magnetic cores which are driven into and out of saturation by a large a.c. drive signal. When the cores are saturated, their permeability is greatly reduced and this results in few flux linkages between the sensing coils and the current in the measured wire. When the cores are out of saturation, permeability is high and the flux linkages are greatly increased. This electrical gating achieves the same effect as the mechanical shutter but a sturdy, more compact, and much simpler probe assembly results.

The actual probe circuitry of the Model 428A/B units (as far as is known the only such instruments available) has a different configuration than that implied here. The drive coils and sensing coils are combined by use of a bridge configuration, as shown in Fig. 2. The bridge is balanced as far as the drive signal is concerned, so the drive signal is suppressed in the output. Less than 15 mv. of drive signal is coupled into the measured circuit. The connections for two of the coils are reversed, though, so voltages induced by the gated flux from the measured wire generate an output.

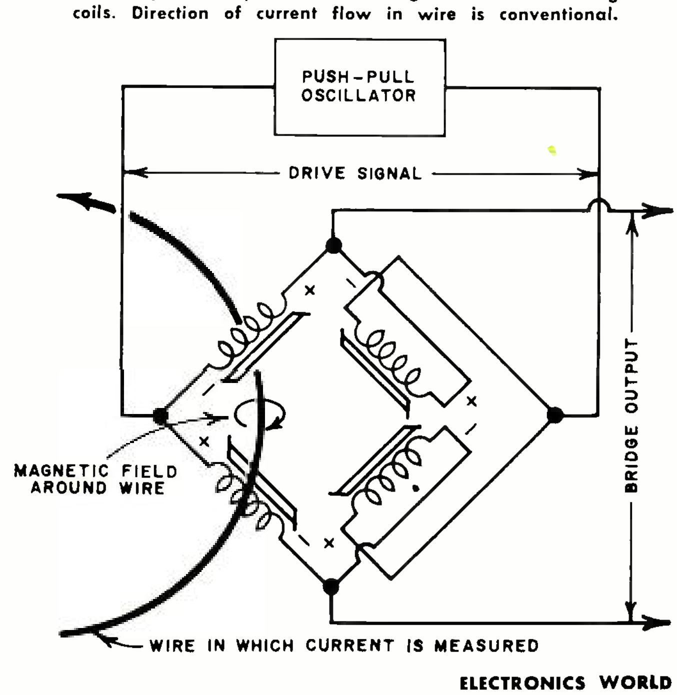
Affiliated Circuitry

A simplified block diagram of the probe and metering circuit is shown in Fig. 3. A push-pull *LC* oscillator supplies the 20-kc. drive frequency. This frequency is high enough to reduce the necessary size of the cores and coils but not so high that core losses become serious.

Flux gating occurs at a 40-kc. rate since the core saturates twice during each cycle, once during the positive-going part of the drive waveform, and once during the negative-going part. Hence the name "second harmonic flux-gate magnetometer." The bridge output is, therefore, a 40-kc. signal.

The bridge output is amplified in a tuned amplifier and then rectified in a synchronous detector. In the synchronous detector, shown in Fig. 4, capacitor *C* is charged to a d.c. voltage that is proportional to the bridge output. The synchronous detector preserves the polarity of the bridge signal so that if the signal polarity were reversed (shifted

Fig. 2. Bridge circuit used in d.c. current probe. Plus and minus signs show polarities of voltages induced in sensing coils. Direction of current flow in wire is conventional.



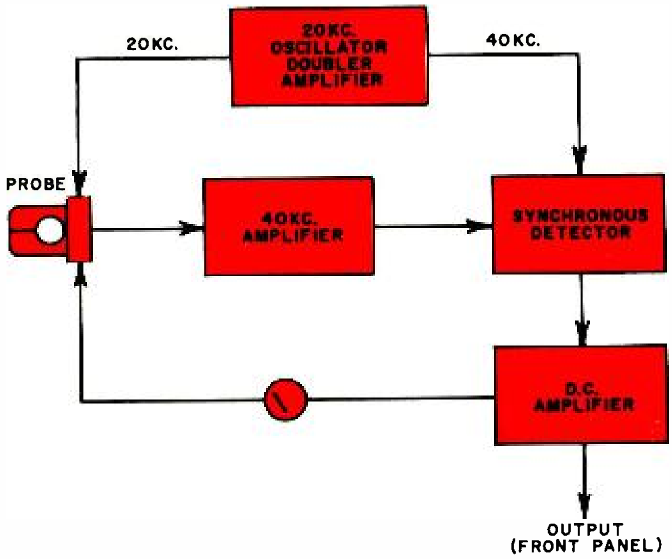


Fig. 3. Simplified block diagram of d.c. current probe circuits.

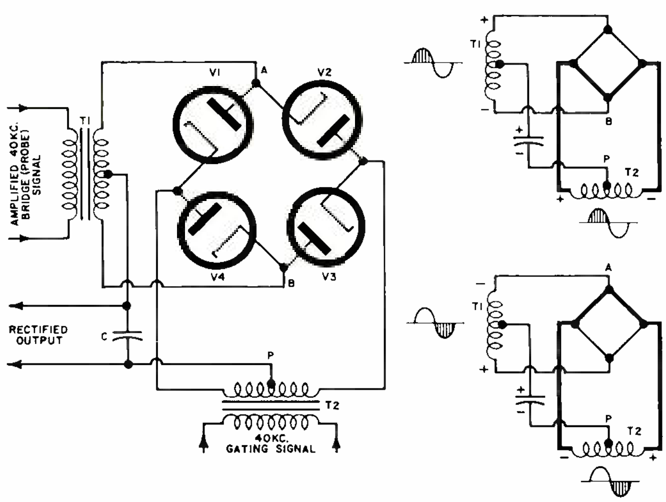
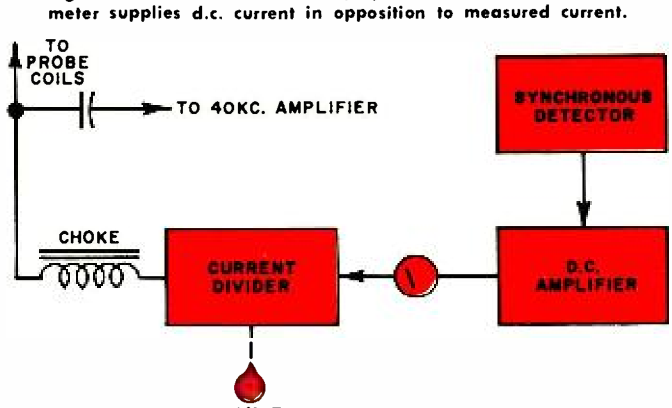


Fig. 4. Synchronous detector produces either positive or negative d.c. output, depending on phase of probe signal. Large gating signal turns on pairs of diodes alternately. When V1 and V2 are on (lower right), point A effectively is at same potential as center-tap P. On alternating half cycles, point B is brought to same potential as P (upper right). This action switches connections between P and T1 secondary so that C becomes charged to d.c. voltage that is proportional to the probe signal. (Heavy lines show current path on shaded half cycles.) Now if the polarity of the probe signal is reversed with respect to the gating signal, then the polarity of the charge across C is reversed on both half cycles from that shown.

Fig. 5. The feedback circuit employed in the clip-on milliammeter supplies d.c. current in opposition to measured current.



180°), capacitor C would charge to the opposite polarity.

The voltage on the capacitor corresponds to the amplitude of the current being measured. This voltage drives a d.c. amplifier which supplies current for the indicating meter.

The preceding description outlines circuitry for driving a meter in accordance with the current in a wire being measured. Accuracy, however, is affected by the non-linear behavior of the magnetic circuits, as well as by non-linearities and changes of gain in the amplifiers. To insure that the meter indicates *accurately* what the measured current is, negative feedback is used in an interesting manner. The feedback loop includes the magnetic circuits in the feedback path by bringing the feedback all the way back to the point where the magnetic field is sensed.

In any negative-feedback system, as is well-known, a portion of the output signal is fed back to the input where it opposes the input signal. What actually happens is that the input to the amplifier represents the very small *difference* between the input signal and a fraction of the output signal. The amplifier therefore minimizes the error that exists between the actual output signal and what the output signal should be, as indicated by the input signal. Feedback insures that the amplifier output "tracks" the input signal so that a feedback amplifier may be considered as an all-electronic servo system where the input signal is the "control" voltage.

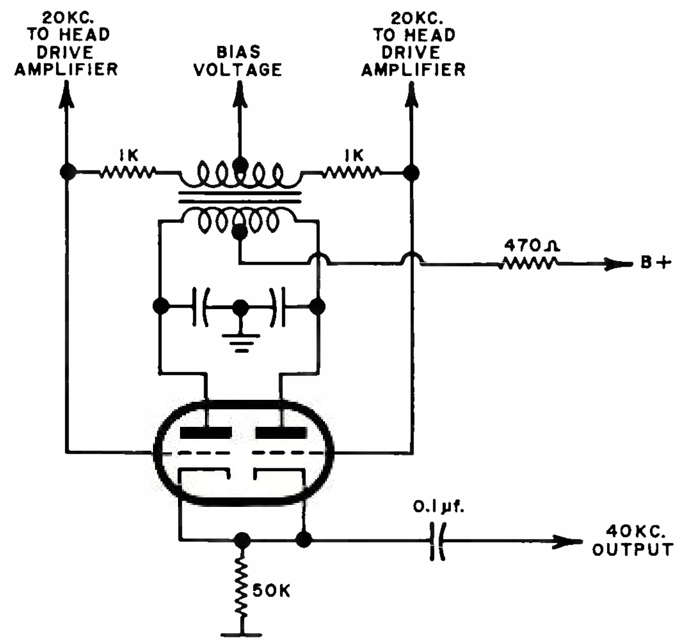
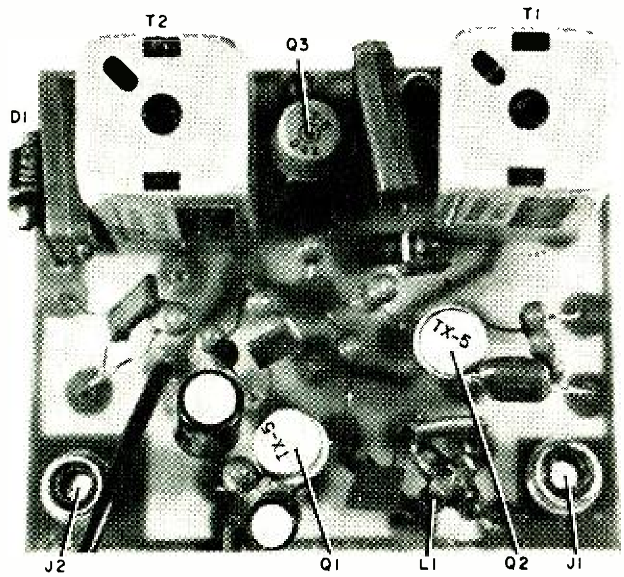


Fig. 6. Push-pull oscillator has unbypassed cathode which "follows" most positive grid, thereby acting as a doubler.

This principle is applied to the d.c. current probe by passing a portion of the d.c. output current back into the sensing coils in the direction that generates ampere-turns which oppose the ampere-turns of the measured current (Fig. 5). The probe actually senses the much smaller magnetic field which results from the difference between these two sources of ampere-turns. Core non-linearities now affect only the loop-gain of the system and since the gain of the amplifiers is very high, the effect of non-linearities is negligible. The output current therefore tracks the wire current quite closely and changes in amplifier gain influence the output current hardly at all. As a result of this use of feedback, the Model 428B, in a laboratory environment, is able to read current with an accuracy considerably better than its rated accuracy of 3% ±0.1 ma. (The instrument is specified at 3% to account for a wide (*Continued on page* 88)



Top view of the demultiplexer. A 3" x 2½" x 2" printed board was used by author; conventional wiring can be used instead.

SCA BACKGROUND-MUSIC DEMULTIPLEXER

By GARLAND P. KUNTZ

Construction of simple transistorized adapter to be used with FM tuners for the home reception of background music.

SUBSIDIARY Communications Authorization (SCA) background music, if transmitted by one or more of your local FM stations, can provide many hours of listening pleasure in your home. The principles of transmission of SCA were explained in an article by Robert W. Winfree in the December, 1963 issue of this magazine. Therefore, it is not proposed to rediscuss them. However, a completely novel and new method of demultiplexing SCA background music will be discussed. (Note that reception of these signals must be restricted to one's own home and they must not be used for profit, as in a place of business.)

Many circuit designs for SCA music have been discussed and printed since its inception, the latest of which appears in the above-mentioned article. Each circuit contained known methods of FM detection. These methods can be classified into two groups, the heterodyning-discriminator, or ratio detector, and decoder-counter detector. While such methods of demodulation functioned satisfactorily, they did not all eliminate the problems that continue to plague the listener. Some of the major problems are:

1. Incomplete separation of main channel and multiplex subcarrier. In other words, inadequate filtering out of the main channel program.
2. Inadequate muting when the subcarrier signal was reduced or else shut off completely between the records.
3. Complexity of design.
4. Difficult to construct.
5. High cost of construction.

One would think that faithful reproduction of the modulated program would be a problem. Such is not the case and has not been a problem with any of the circuits presented.

The merits of each circuit will not be discussed. Instead, the principle of the circuit given here will be outlined.

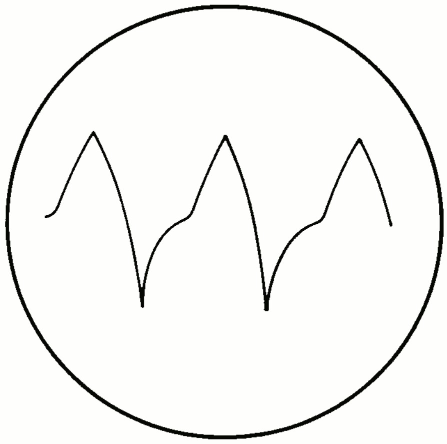
The circuit in Fig. 2 is unique in design. It consists of three transistors and a diode. The heart of its operation is in *T1* and *T2*.

In order to listen to SCA music, the 67-kc. FM-modulated signal must be demodulated. The simplest method would be to filter out the main program, amplify the 67-kc. subcarrier, and detect it. At first this would appear to be a tall order, but with the principle of oscillators in mind, and knowing that they can be made to lock in with a synchronizing signal, the problem of amplification disappears. This is exactly what *T1* and *Q3* do. This stage oscillates at 67 kc. with sufficient amplitude that minor audio and music leaks from the main-channel program are too weak to change its frequency or to amplitude modulate it. Thus we have only the subcarrier signal.

The next step is to have the 67-kc. oscillator swing with the frequency modulation of the incoming SCA signal. To provide for adequate swing, the "Q" of *T1* must be reduced to allow sufficient bandwidth in order that the 10% modulation swing of the SCA 67-kc. subcarrier can be accepted. *R9*, the 1000-ohm resistor placed in series in the tuned circuit, accomplishes this.

With the FM-modulated 67-kc. subcarrier comes the problem of detection. In the circuit of Fig. 2, detection is accomplished by means of slope detection and negative limiting. The secondary of *T2* is tuned above the incoming resonant frequency. Thus, as the subcarrier swings above and below 67 kc., the amplitude varies in proportion to the amount of the swing and at the audio rate of the swing. Detection is completed by limiting the negative part of the signal with *D1* connected to the high side of the secondary coil.

Fig. 1. Scope pattern that should be seen when T2 and R12 are correctly adjusted.



To complete the detector and improve quality of reproduction, the extremely high "Q" of the secondary winding must be lowered. To lower the "Q" of this circuit, *R12*, a 10,000-ohm resistor, was added as shown in the diagram.

The 67-kc. signal is filtered in the output circuit by *R13* and *C11*, leaving a fairly high-level audio. The audio level is far more than enough to drive the auxiliary or phono inputs of any audio amplifier.

Good signal conversion and detection cannot be accomplished without excellent filtering of the main program. Such filtering is done by the circuits of *Q1* and *Q2*. The bulk of the filtering action occurs in *C1* and *L1*.

Q1 and *Q2* are high-gain stages. It

might be thought that one transistor would do the job. However, in order to have a strong enough signal to lock in and control the oscillation of Q3, the larger input signal that would have been required for a one-transistor filter circuit resulted in enough main program material to amplitude-modulate the oscillator stage. As common-emitter stages have fairly low input impedance, additional filtering of the main program can be had as well as the required amplification of the subcarrier by means of low-value capacitance coupling between stages.

Muting is unnecessary as no signal passes when the subcarrier is inactive. Any leakage must occur either at the station, or as a direct result of some multipath signal reception or misalignment of the FM tuner. Should a slight whistle occur when the subcarrier is reduced or cut off, *T1* is not aligned properly.

Construction & Alignment

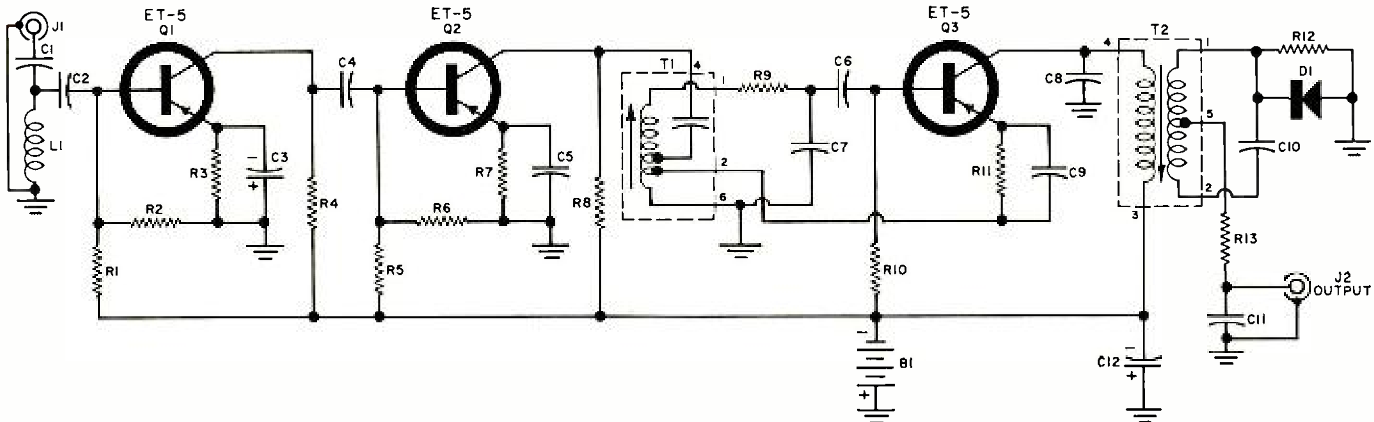
As far as construction is concerned, the photo shows a suggested layout. The printed board was made from a kit and it is very easy to do. The only recommendation is that the

(Note that the demultiplexer unit must be connected to the multiplex-output jack of the FM tuner. If such a jack is not available, then a tuner connection must be made that is ahead of the de-emphasis network. If this is not done, then the network attenuation will prevent the passage of any of the 67-kc. SCA signal.)

The second method is to temporarily short out *R9* and adjust *T1* for the best sound. This will be poor at best but by listening one can determine a point where it sounds better than at any other. Such action tunes the oscillator to the subcarrier. The poor sound is due to the fact that the "Q" of *T1* has been increased and the oscillator will swing only a very little, causing distortion. Afterwards, remove the short on *R9*.

With *T1* aligned, tune *T2* for the best sound. Should there be distortion in the program, temporarily replace *R12* by a large-value potentiometer. Adjust the pot and retune *T2* until the distortion disappears. Then measure the value of the resistance used in the potentiometer and replace it with a fixed resistor of that value.

Such a unit as described here can be installed inside most



R1—100,000 ohm, ½ w. res.
R2, R12—10,000 ohm, ½ w. res.
R3, R7, R9—1000 ohm, ½ w. res.
R4—4700 ohm, ½ w. res.
R5—47,000 ohm, ½ w. res.
R6, R13—15,000 ohm, ½ w. res.
R8—3300 ohm, ½ w. res.
R10—220,000 ohm, ½ w. res.
R11—3900 ohm, ½ w. res.

C1—.0015 μf. capacitor
C2, C4, C9—.01 μf. capacitor
C3—30 μf., 6 v. elec. capacitor
C5—.05 μf. capacitor
C6—.02 μf. capacitor
C7—820 pf. capacitor
C8—150 pf. capacitor
C10—300 pf. capacitor
C11—.005 μf. capacitor

C12—10 μf., 15 v. elec. capacitor
J1, J2—Phono jack
L1—120 μhy. peaking coil (J. W. Miller #6153)
T1—19-kc. locked osc. trans. (J. W. Miller #1354-PC)
T2—38-kc. output trans. (J. W. Miller #1355-PC)
Q1, Q2, Q3—Raytheon ET-5, 2N190, or equiv.
D1—1N43 or equiv.
B1—9-volt transistor battery

Fig. 2. A synchronized oscillator, operating at 67 kc. and swinging with the modulation, is the basis of operation.

connections between *T1*, *Q3*, and *T2* be kept as short as possible, for their length will affect the value of *R12*.

The final step in building this circuit is the alignment. Two methods can be employed, depending on the test equipment on hand. The use of both procedures is preferred.

The first method involves the use of an audio signal generator and oscilloscope. Using a low-capacity probe on the scope, connect the vertical scope input to the collector of Q3 and the audio signal generator to the horizontal input. Set the audio signal generator at 67 kc. and, by use of a Lissajous pattern, adjust *T1* to 67 kc.

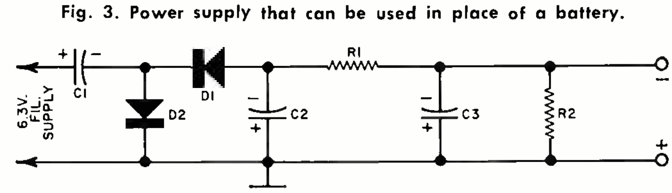
Now connect the vertical scope input to pin 5 of *T2*, the center tap of the secondary. By adjusting *T2*, secure the pattern shown in Fig. 1. Should the desired pattern not be obtained, temporarily replace *R12* with a high-resistance potentiometer, then adjust the pot and *T2* to obtain the desired pattern. Then replace the potentiometer with a fixed resistor of the same value.

After alignment by the above method, connect the demultiplexer to an FM tuner adjusted to a station transmitting an SCA signal. Make a final adjustment of *T1* by the second method described below. The unit is now ready for operation.

FM tuners. It can be left attached to the multiplex output of the tuner as long as stereo reception is not required. If a stereo demultiplexer is also used, suitable switching will be required.

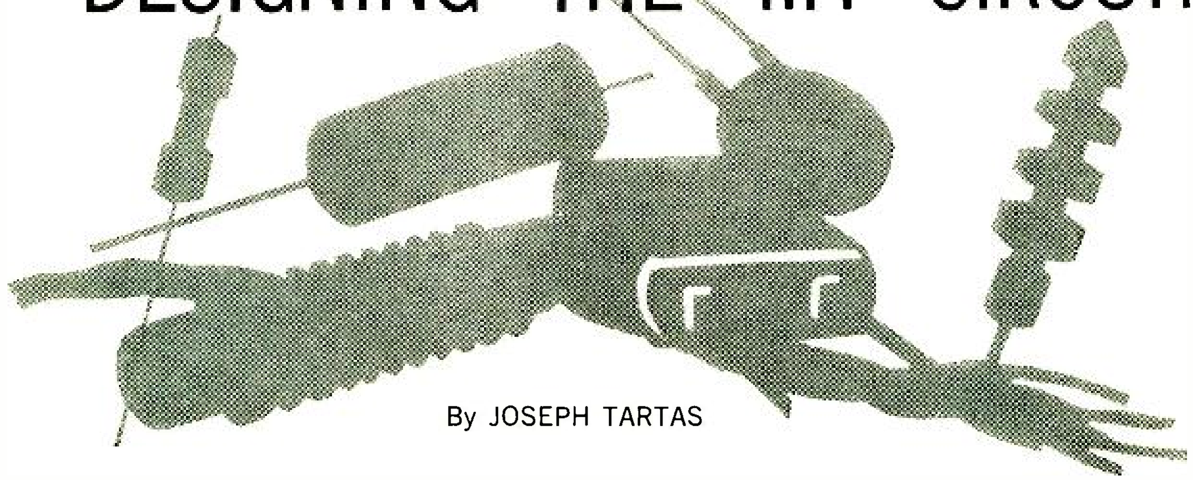
The unit can be powered by a 9-volt battery. Such a battery will last for a very long time as a little less than 3 ma. is drawn. For this reason, no power switch was used in the author's unit. Such a switch can be installed in one of the battery leads if required. Fig. 3 details of method of obtaining the required power from the filament supply. ▲

Fig. 3. Power supply that can be used in place of a battery.



R1—470 ohm, ½ w. res.
R2—1000 ohm, ½ w. res.
C1, C2—100 μf., 15 v. elec. capacitor
C3—2000 μf., 15 v. elec. capacitor
D1, D2—Silicon rectifier (top hat), 1N2483 or equiv.

DESIGNING THE I.F. CIRCUIT



By JOSEPH TARTAS

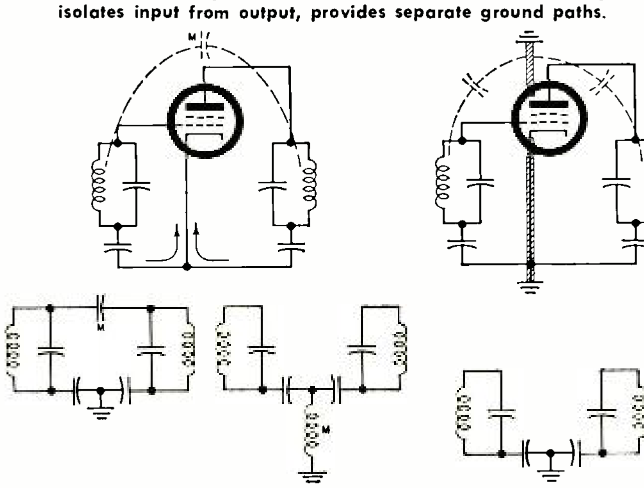
When building high-frequency equipment, component placement, shielding, and even the lead lengths of capacitors and resistors play a very important role.

THERE are many considerations in the design of the i.f. portions of a receiver, whether it be a low-frequency communications receiver or a v.h.f. television set. All of these considerations fall into either of two classifications: physical or electrical. Since these are interrelated (capacitance depends on size of plates and separation, and high-frequency inductance depends on lead or path length), it is difficult, if not impossible, to completely divorce one from another.

The first consideration in the physical design should be the placement of the i.f. section with relation to the mixer stage. In order that maximum gain be attained immediately after the mixer to avoid introduction of additional noise (either thermal or hum) to the noise level already present at the mixer output (due to the antenna and r.f. stage), the input of the first i.f. amplifier is usually located physically near the mixer output circuit. The i.f. stages usually proceed in a string, so that the output of one feeds directly into the next; thus wiring capacitances are kept to a minimum. In most cases, the connections are made by means of the component leads only.

Shielding is always required to some degree and is used in several ways. The most common type of shielding is an aluminum can in which the resonant circuits are enclosed. This can may contain only a coil and its loading resistor, or it might include a bifilar-wound coil (one with two windings with turns adjacent to each other) and a trap, with separate powdered-iron cores accessible at each end for tuning the coil and trap individually. A shield in the form of a partition and made from low-resistance sheet metal, such as copper or aluminum, is sometimes used to divide a string of high-gain amplifiers when regeneration due to feedback occurs. The r.f. currents flowing through the chassis can be made to follow separate paths by this method. Regeneration or oscillation occurs when plate currents flow back to the grid and are re-amplified in the same way as acoustic feedback in a public-address system. Without an interstage shield, coupling can take place between the circuit input and output coils, or through ground current loops as shown in Fig. 1A. A shield isolates the input and output circuits, prevents direct coupling, and provides separate and low-inductance ground paths for grid and plate r.f. currents as shown in Fig. 1B.

Fig. 1. (A) Without interstage shield, common coupling takes place between coils and ground-current loops. Capacitive or inductive coupling, or a combination may occur. (B) Shielding isolates input from output, provides separate ground paths.



In addition to reducing feedback problems, the shield may also prevent coupling between large coils in succeeding stages. Although the capacitance, or mutual inductance, existing between two successive coils may be extremely small, there still might be sufficient coupling at the high signal levels to produce feedback.

In selecting the proper dimensions for a coil shield, several factors must be taken into account. If a high loaded coil "Q" is to be maintained, the shield must be of sufficient proportions relative to the coil dimension so as not to reduce "Q" below a predetermined minimum. At the same time, the shield will have an effect on the coil inductance such that the inductance measured in the open will be reduced inside of a shield by an amount dependent on many factors. The metal in the shield acts as a shorted turn, or as a shorter path for the magnetic lines, depending upon its proximity to the coil winding. The result is the same as if the coil turns had been spread out, since fewer magnetic lines link the turns of the coil. In essence, the inductance is then reduced. The factors include the relation of coil diameter to coil length, coil diameter to shield diameter, coil length to shield length, and whether the coil shield is square or round.

The "Q," since it is a function of losses, depends upon skin effect (varying with frequency), number of turns in the coil (and hence degree of magnetic and electrostatic coupling to the shield), resistivity of the shield material, and the relationship between shield length and diameter, coil length and diameter, and the relationship between coil and shield. The effect is that of adding a resistance in series with the coil and its resistance, and since "Q" is a ratio of X_L/R, "Q" is reduced as R is increased.

Fig. 2 shows the amount of reduction that may be expected when various shields are placed over an unshielded inductance. The effects on "Q" may be calculated, but since this is rather involved, a good rule of thumb for minimum effect on both inductance and "Q" is to make the shield diameter at least 3 times the coil diameter, and at least one coil diameter longer than the coil length (assuming the bottom end of the coil is at r.f. ground and mounted on the same plane as the bottom of the coil shield). For the worst case, the reduction will only be approximately 10%, and for the best case about 1% for those dimensions. Keep in mind that the maximum power dissipated in a loaded tank circuit should be in the load. The unloaded "Q" should be as high as possible relative to the loaded "Q" for this to take place. If the unloaded "Q" includes the effects of the shield, then a lower unloaded "Q" due to the presence of the shield reduces the power delivered to the load, the rest being dissipated as losses in the shield. This is in agreement with the definition of "Q," the ratio of energy (or power) stored to the energy delivered to the load.

In addition to coil and interstage shields, additional isolation is achieved by the use of tube shields on all i.f. tubes.

This leads to another consideration in the physical placement of components, and a good example of why i.f. stages are usually laid out in a straight line across the chassis. The shortest distance between coils should be such that there is no coupling from coil to coil, except through intentional coupling of the tube circuitry. Under these conditions, the longest distance between coils becomes a straight line.

Components

The choice of components should be carefully considered when working with circuits above a few megacycles. At low frequencies the inductance of wire leads is negligible, but as the frequency increases so does the inductance of these wires. Also, at the higher frequencies the coil inductances become considerably smaller for the same fixed capacitances. Under these conditions, the inductance of the wire leads is a large part of the total inductance and must be considered in all cases. The normally small distributed capacitance of a coil forms a resonant circuit with the coil inductance, and this resonance must also be considered at all times, as in the case of r.f. chokes.

The combination should be regarded as a parallel-resonant circuit, with an impedance of "Q"X where X is the reactance of either element (C or L) at its resonant frequency. The best choke is one that is self-resonant at some frequency slightly higher than the frequency of the circuit in which it is used. Additional stray capacitance usually lowers the choke to the desired frequency. This resonant frequency is not particularly critical, since the normally available r.f. chokes are of reasonably high "Q" and are of reasonably high impedance for considerable frequency deviation from the exact frequency of resonance. Regardless of whether the choke appears inductive or capacitive, it is still quite a high impedance to the r.f. that it is supposed to block. Fig. 3 shows the variation in self-resonance for r.f. chokes made by six different manufacturers.

Fig. 4 shows the relative capacitances related to the individual turns of a coil. As shown in (A), there exists a capacitance between adjacent turns, as well as a smaller capacitance to some other turn, which is resolved into one equivalent capacitance. At (B), the effect of capacitance to ground can be seen. Consider C_c as the distributed capacitance of the coil and $C1$ and $C4$ as bypass capacitors normally used with an r.f. choke. Any additional capacitance ($C2$ and $C3$) to ground will lower the resonant frequency. This can be more easily seen when redrawn as at (C). The net capacitance consists of the parallel combinations of $C1$ and $C4$ in series, $C2$ and $C3$ in series, and C_c. If there is excessive lead length or internal lead inductance in the bypass capacitors, the net reactance of the bypasses may be cancelled or become inductive, in which case the resonant frequency, or resonant impedance of the entire network, may become inadequate or undesirable. This problem is compounded with a multi-*pi* r.f. choke.

It is for just the reasons outlined that it is not a good practice to arbitrarily select a large value of inductance for an r.f. choke for use at the higher frequencies. While it is assumed that the reactance increases with the inductance, there is the

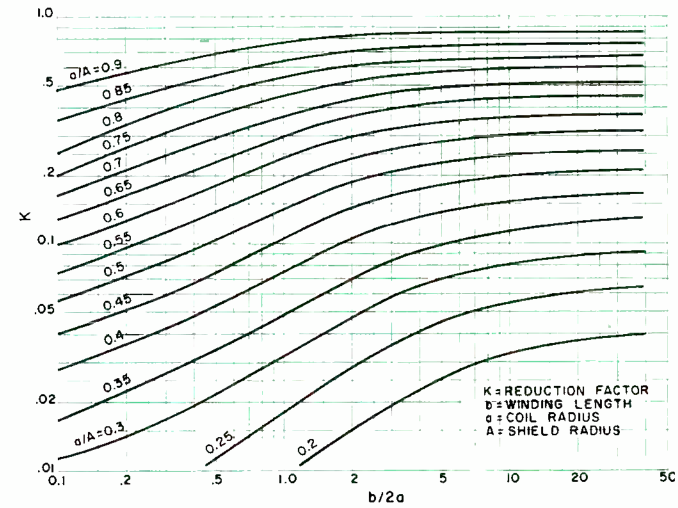
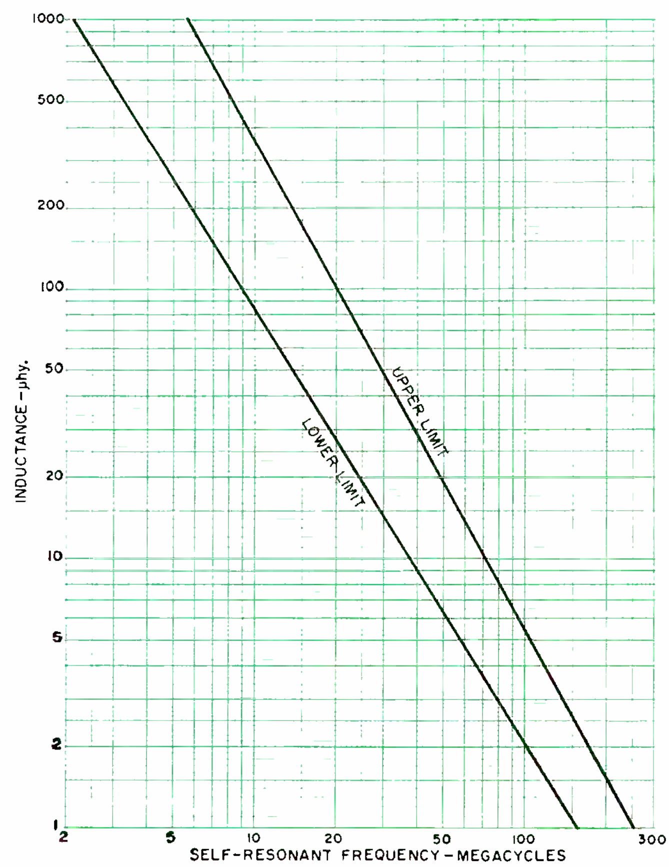


Fig. 2. Curves for determination of decrease in inductance produced by coil shield. K × 100% is amount of inductance reduction. For a square shield, A is .6 of the length of one side. Coil must be single layer for this graph to apply.

Fig. 3. The self-resonant frequencies of some typical values of r.f. chokes as manufactured by six different companies.



Capacitance (in pf.)	Lead Length (in inches)	Approx. Resonant Frequency (in mc.)
100	1/8	230
	1/4	190
	1/2	150
	3/4	130
	1	120
	1 1/4	98
470	1/8	110
	1/4	92
	1/2	72
	3/4	60
	1	54
	1 1/4	47
1000	1/8	80
	1/4	67
	1/2	53
	3/4	44
	1	40
	1 1/4	35
1500	1/8	64
	1/4	53
	1/2	42
	3/4	35
	1	32
	1 1/4	27

Table 1. Resonant frequency of some tubular ceramic capacitors.

limiting factor of the shunt capacitance of the coil, which at some frequency begins to act as a bypass and thereby greatly reduces or cancels the effectiveness of the r.f. choke.

Capacitors

Capacitors exhibit self-resonances also. At higher frequencies the leads appear as inductances and the capacitances normally used vary over a wide range. They can be selected to provide a high or low impedance and can be either capacitive, resistive, or inductive. A capacitor can look like a series tuned circuit at some high frequency and can be represented as a resistor at resonant frequency. At a higher than resonant frequency, the net reactance is inductive because $X=X_L-X_c$ and X_L is greater.

Table 2. Resonant frequency of some mica capacitors.

Capacitance (in pf.)	Over-all Length of Body & Leads (inches)	Approx. Resonant Frequency (in mc.)
100	1/2	145
	3/4	120
	1	110
	1 1/2	92
	2	80
470	1/2	58
	3/4	52
	1	47
	1 1/2	40
	2	35
1000	1/2	42
	3/4	38
	1	34
	1 1/2	28
	2	24
5000	1/2	20
	3/4	18
	1	16
	1 1/2	13
	2	11

Three types of resonances can occur in the more common disc-type capacitors. These are (1) low-frequency resonance due to the length of the external leads; (2) medium high-frequency resonance due to internal connections when two or more discs are connected in parallel to obtain a high capacitance in a small physical size; and (3) high-frequency resonance due to resonant cavity effects in capacitors with high dielectric constants.

Normally, the low-frequency resonance is the one we are most particularly interested in, as the other types of resonance are not normally encountered at i.f. frequencies. This low- frequency resonance (actually the reference to low frequency is only relative) is invariably a series resonance and is only useful to enhance the effects of a bypass capacitor. This is done in two ways. If it is series resonant at the frequency of interest, the bypass impedance is at a minimum (possibly much less than the capacitive reactance alone), and it sets the upper useful limit of capacitance for the frequency range and aids in the selection of the proper bypass capacitor and the lead length.

Because the chassis path is often part of the lead inductance, the resonant frequency of a given capacitor will be lowest when the area enclosed by the leads is a maximum, and measurement under these conditions is recommended for "worst-case" conditions. Otherwise, a grid-dip meter can be used for a good approximation where the frequency of resonance is not critical. Fig. 5 shows the variations encountered

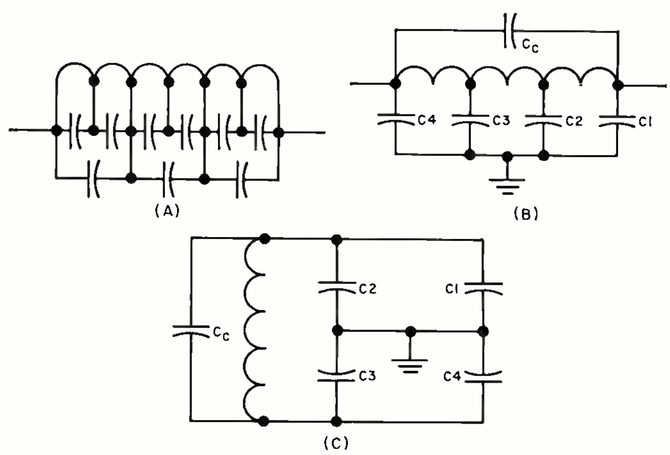


Fig. 4. (A) Capacitance between individual turns of a coil. (B) Effect of capacitance between coil and ground (C1 and C4 are bypass capacitors). (C) Equivalent circuit of (B) showing effect of capacitors on the resonant frequency of the coil.

by *RMC* on their "Discaps," using a special test jig and a grid-dip oscillator, in the "worst-case" condition of leads positioned 90 degrees apart and equal in length.

Typical resonant frequencies for various lead lengths are shown in Tables 1 and 2 and cover the other body styles of capacitors most commonly used in i.f. and r.f. circuits. The tabulation in Table 3 gives an idea of the inductances encountered in a length of typical hook-up wire, values not insignificant at r.f. frequencies.

Resistors

Resistors are not as critical as those components already covered, but their lead lengths and capacitance should be kept in mind. A ½-watt resistor has about .1 to .5 pf. between leads at the body ends, depending upon the particular type, and the inductance of the leads is considered as being in series with this capacitance. In a pinch, a high-value resistor (1 to 10 megohms) may be used as a low-value capacitor, with a leakage resistance equal to the resistance value. Any resistor so used as a low-value capacitor should have its value picked so as not to influence circuit operation.

Supply Line Filtering

Because of the large amount of signal amplification within the i.f. circuit, there is a good chance of signal currents feeding back from the output stage to earlier stages unless certain precautions are taken.

Filaments may be supplied in three ways: single lead with ground returns (chassis or common bus), series string with no ground connections, and twisted-pair feed with grounded transformer center-tap.

If no filtering is used, r.f. current, as well as line frequency, flows through all of the filaments. The small capacitance from filament to cathode within the tube prevents the 60-cps frequency from modulating the cathode because its impedance (reactance) at this frequency is several hundred megohms. At 40 mc. however, the series impedance is only a few hundred ohms, and some means must be taken to prevent these currents from flowing to the cathode and being amplified within the stage to cause regeneration or oscillation. The usual procedure is to use an inductance and a bypass capacitor at each filament. The inductance should be of very low d.c. resistance so that a minimum filament voltage drop occurs, and yet there should be enough inductance to provide a fairly high impedance to the r.f. current. The bypass should be large enough to have a reactance that is low compared to the filament resistance. At 40 mc., a value of 1000 pf. is usually sufficient for tubes commonly used as i.f. amplifiers.

The plate circuits are, of necessity, high-impedance circuits across which considerable signal voltage can develop. It is therefore essential that great care be taken to prevent any of these signal voltages from reaching any tube elements or circuits other than those desired.

Some set manufacturers use resistors in conjunction with proper value bypass capacitors, and others use r.f. chokes either in place of, or with, resistors. Resistors are less expensive than chokes but have several disadvantages. The resistors cause *IR* losses as voltage drops, and therefore the tolerable value of resistance depends upon the amount of d.c. current flowing in that circuit. The maximum resistance allowable may not provide a high enough impedance to isolate the small r.f. currents which have a lower *IR* drop. Finally, the resistors are not frequency sensitive (except at very high frequencies) and will not reduce signal currents at the same rate as the d.c.

An r.f. choke, because of its lumped constants, has its own characteristic resonant frequency. At this frequency the resonant impedance is very high while the d.c. resistance remains very low. If the installed self-resonant frequency of the choke is the same as the frequency at which the maximum impedance to the r.f. current in the supply lines is desired, then the maximum attenuation of the signal currents traveling down that line is obtained.

If sufficient attenuation is not achieved with a single filter section, a double section consisting of two chokes, a resistor, and a choke, or two resistors in conjunction with the appropriate bypass capacitor values, is necessary.

A.G.C. Line Filtering

Under normal operating conditions, the control grids do not draw any current, and the associated a.g.c. circuitry needs only supply a fixed (within small limits) voltage. In this case filtering is easily done with resistance values as high as a megohm, without a voltage drop. The associated bypass capacitors should not be any higher than necessary since the time constants must be considered. It is also good practice to use resistance values no higher than one megohm, otherwise the resistance would approach the value of leakage resistances within the circuitry.

Recently introduced ferrite beads may be used extensively for filtering in new designs. These are tiny cylindrical beads that may be strung on a wire, and which, because of their magnetic qualities and lossy material, cause an increase in the inductance of the wire with a simultaneous attenuation of signals in the wire. Attenuation in this case is due both to the inductive reactance and to the *IR* losses due to r.f. only, since there is no d.c. current in the core. Four of these beads can increase the inductance of a 2-inch piece of wire 15 times, and at the same time can cause an attenuation of the signal by 6 db over a very wide frequency range. These beads are particularly useful in the filament leads, as shown in Fig. 6, since they filter without producing any filament voltage drop. They are extremely cheap in production quantities, and cost less than resistors and chokes.

Another component combines a capacitor and ferrite beads in a single unit to produce a combination of bypass capacitance, increased series inductance, and lossy ferrite, all in one unit. These units are expensive, however careful design of new r.f. and i.f. circuits might allow one of these composite units to replace several components with a worthwhile saving of space and assembly costs. ▲

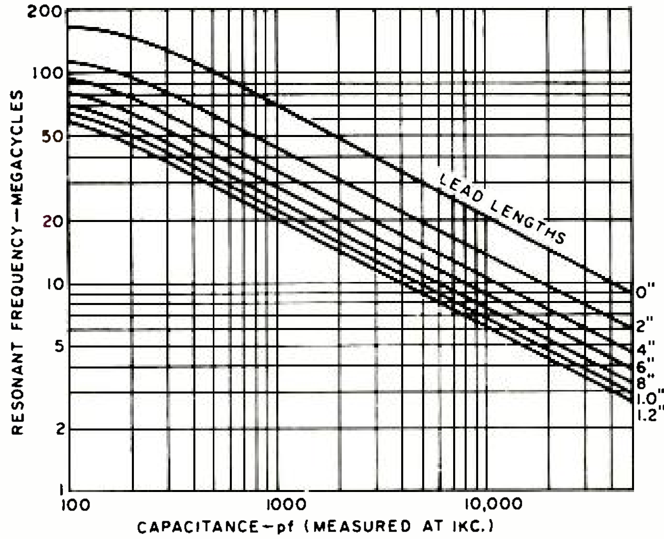
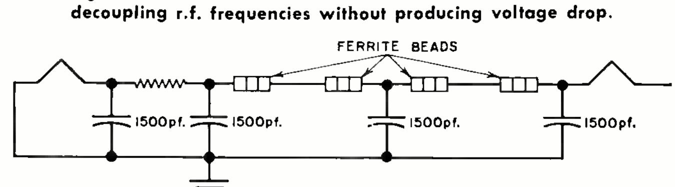


Fig. 5. Resonant frequency of some typical capacitors as a function of their lead length (22-gauge wire is assumed).

Wire Size	Length (in inches)	Approx. Inductance (on μhy.)
20	¼	0.0031
	½	0.0064
	¾	0.0115
	1	0.019
	1½	0.031
	2	0.04
24	¼	0.0037
	½	0.0082
	¾	0.014
	1	0.022
	1½	0.036
	2	0.05

Table 3 The high-frequency inductance of lead wires

Fig. 6. Ferrite beads in the filament circuit are used for decoupling r.f. frequencies without producing voltage drop.



SELECTING HIGH-FREQUENCY TRANSISTORS

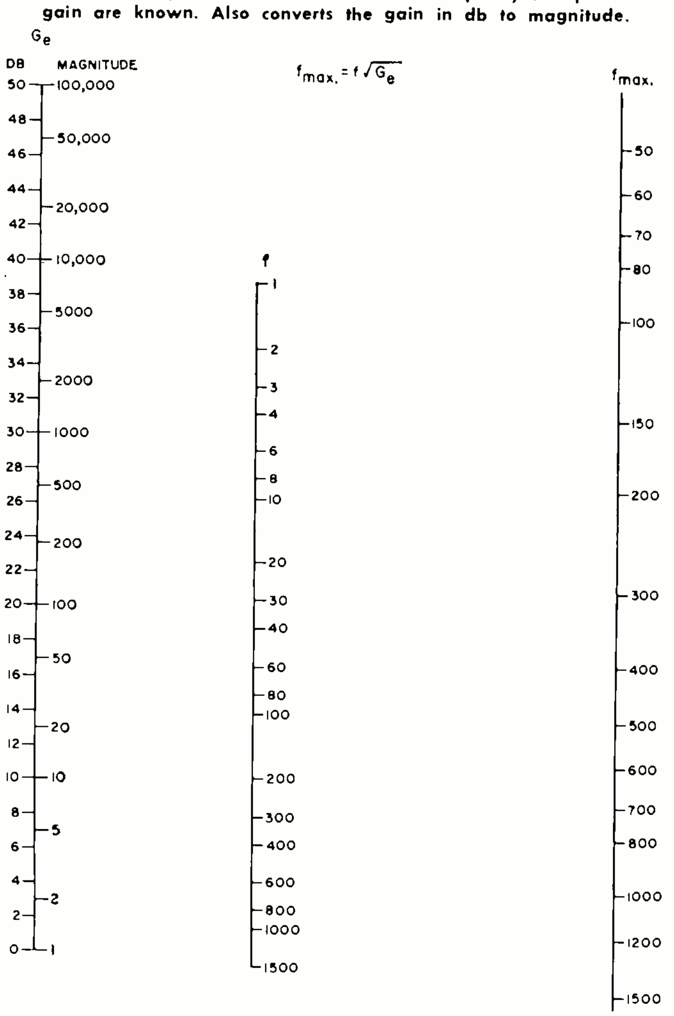
By ROY HEJHALL & DARRELL THORPE
Motorola Semiconductor Products Inc.

How do you pick the right transistor for high-frequency use? How do you convert from one transistor parameter to another? The answers to these, plus a simple nomogram parameter conversion approach, are given in this article.

IN your sporadic shopping forays through electronic catalogues for a high-frequency transistor, have you become thoroughly confused by the various methods used to specify high-frequency transistor characteristics? Well, you are not alone. The usable high-frequency range of operation for transistors is perhaps one of the most perplexing characteristics to evaluate when selecting a device for a particular circuit application, particularly if the only source of information is a mail-order house catalogue which gives a minimum number of transistor specifications.

You have probably noticed that several terms, or parameters, are commonly used by the various manufacturers to describe the high-frequency capabilities of transistors. The three parameters most often encountered are: (1) the maximum frequency of oscillation (f_{max}) or (f_{osc}); (2) the gain-bandwidth product (f_T); and (3) the *alpha* cut-off frequency ($f\alpha_b$). In addition to these three parameters, a fourth parameter sometimes encountered is the *beta* cut-off frequency ($f\alpha_e$).

Fig. 1. Nomogram determines f_{max} when frequency and power gain are known. Also converts the gain in db to magnitude.



There has been considerable confusion concerning the validity and relative merits of these terms which categorize the high-frequency characteristics of transistors. Therefore, it is important to arm yourself with a clear understanding of each of these terms before shopping for a high-frequency transistor. In addition, you may wish to compare two or more transistors which have different parameters specified. To make a meaningful comparison in this case, you must also know something about the interrelationships between these various parameters.

The first part of this article describes these parameters. The interrelationships between them will then be discussed, and, finally, nomograms are given for fast, simple conversions from one parameter to another.

Maximum Oscillation Frequency

The maximum frequency of oscillation (f_{max} or f_{osc}) is the most useful specification for the selection of transistors for high-frequency communications circuits because it sets a frequency limit above which the transistor is unable to amplify. Thus, f_{max} is defined as that frequency at which power gain is unity, or 0 db, in a neutralized common-emitter circuit with the transistor input and output impedances matched to the source and load impedances respectively. It derives its name from the fact that f_{max} is the highest frequency at which oscillation is theoretically possible.

Fig. 2 shows the power gain characteristic curve for a *Motorola* MM1151 high-frequency transistor. As indicated by the curve, the power gain is 0 db or unity at 2000 mc. which means that this device has an f_{max} specification of 2000 mc. Notice that each time the frequency is halved, the power gain increases 6 db. This is a general characteristic of all transistors and the curve is commonly referred to as having a 6-db-per-octave slope.

The curve in Fig. 2 tells us the maximum power gain available from a transistor at frequencies below f_{max} in a perfectly matched and neutralized circuit such as those used in receiver r.f. and i.f. amplifiers. This statement refers to the fact that maximum power transfer from a transistor, or for that matter a generator, vacuum tube, or any transducer, occurs when the load impedance is equal to the output impedance of the device. Therefore, to obtain maximum available power gain from a transistor amplifier, the coupling network between stages should match the input impedance of the following stage to the output impedance of the preceding stage. The high power gain obtained in matched circuits sometimes results in sufficient regenerative feedback to cause oscillation; therefore the circuit must be neutralized.

A significant exception to the general practice of impedance matching is the r.f. power amplifier, such as the output stage of a transmitter. Power-amplifier circuits are deliberately mismatched to obtain the desired power output with a given voltage swing. Transistors that are specifically characterized for this type of service have a power gain specified at some power output. For example, the 2N2949 has a 12-db power gain specified at 3.5 watts output at 50 mc.

The power gain in the flat region of the curve is dependent upon the low-frequency current gain of the device. Fig. 2 indicates that the maximum available gain (MAG) from the MM1151 transistor at low frequencies is considerably more than 40 db. However, because of stability problems, it is not practical to operate transistors at their MAG in the flat region. Therefore, it is not usually wise to extend the power gain curve beyond 40 db. This statement holds true for any transistor or vacuum tube circuit. Notice also, that a 6-db-per-octave slope is equal to 20 db per decade. Then, if 40 db is assumed to be the maximum useful gain, the knee of a power gain curve occurs at $f_{max}/100$ (2 decades).

By knowing the f_{max} specifications and assuming 40 db as the maximum useful gain, a neutralized power gain curve can easily be constructed for any transistor. Of course, the knee of the curve will be at $f_{max}/100$.

Occasionally, f_{max} is specified indirectly on high-frequency transistor data sheets. This is done by specifying the power gain (G_e) at some frequency (f). If this is the case, the f_{max} can be calculated from:

$$f_{max} = f\sqrt{G_e} \quad \ldots\ldots \quad (1)$$

where f is the frequency at which gain is specified, and G_e is the power gain in magnitude (not in db). Fig. 1 shows a nomogram of this equation and a conversion of db to magnitude.

Although f_{max} defines the maximum frequency at which a transistor could oscillate, it is quite obvious that an oscillator operating at this frequency cannot supply power to a load. A good rule of thumb for an oscillator is to choose an f_{max} at least twice the desired operating frequency.

Gain-Bandwidth Product

The gain-bandwidth product (f_T) is a transistor characteristic that expresses the frequency at which the a.c. common-emitter current gain (β or h_{fe}) is equal to 1 (0 db). Fig. 3 shows a plot of current gain *vs* frequency for a typical transistor. As shown in the figure, h_{fe} is unity at 450 mc. which indicates that the f_T is 450 mc. for this transistor. Notice, that like the power-gain curve, the slope of this curve also changes at a 6-db-per-octave rate. The flat portion of the curve represents the low-frequency current gain of the transistor. This low-frequency current gain is often referred to as β_o of h_{feo} and is usually measured at 1 kc. (Since current gain varies with frequency, the terms β_o or h_{feo} are used to define the low-frequency, usually measured at 1 kc., current gain of a transistor.) The knee of this curve occurs at $f\alpha_e$, the *beta* cut-off frequency, which defines the frequency at which h_{fe} is down 3 db from its low-frequency value.

If h_{feo} and f_T are known, $f\alpha_e$ can be found from:

$$f\alpha_e = f_T/h_{feo} \quad \ldots\ldots \quad (2)$$

It is interesting to note from Eq. 2 that transistors having the same f_T but different gains will have considerably different bandwidths ($f\alpha_e$). This is an important factor in wide-band amplifiers since gain can be traded for bandwidth either by proper selection of the transistor or with feedback.

The value f_T is sometimes specified indirectly on high-frequency transistor data sheets. This is done by specifying h_{fe} at some frequency above $f\alpha_e$, thus, f_T is then obtained by multiplying the magnitude of h_{fe} by the frequency of measurement. This relationship arises from the 6-db-per-octave characteristic of the h_{fe} *vs* frequency curve above $f\alpha_e$. Since

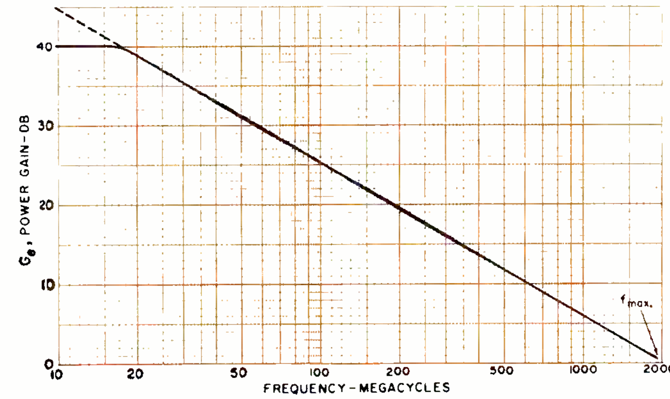


Fig. 2. Power gain vs frequency for a particular transistor.

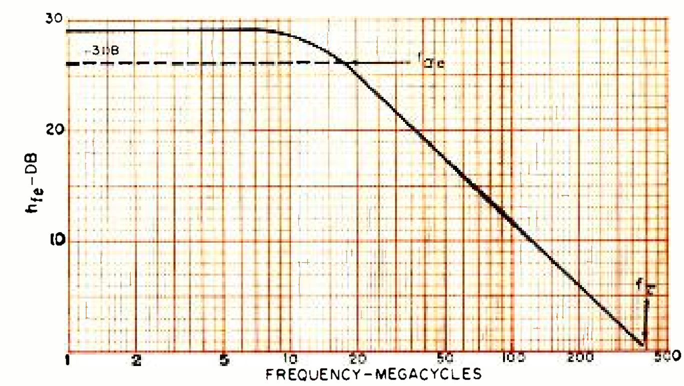


Fig. 3. Current gain vs frequency for a typical transistor.

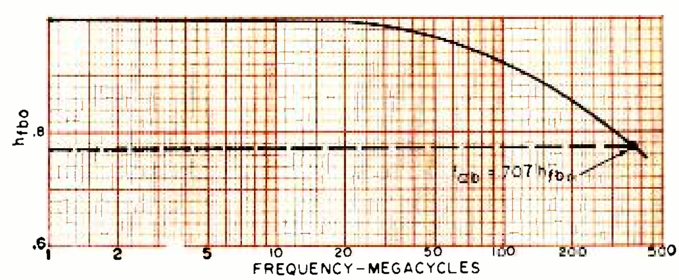


Fig. 4. Common-base current gain for a typical transistor.

6 db represents a current-gain magnitude of 2, h_{fe} is halved each time frequency is doubled, and *vice versa*. Therefore, the product of h_{fe} and frequency on the sloping portion of the curve yields f_T.

For example, consider the *Motorola* 2N2217 silicon transistor. The data sheet gives a typical h_{fe} of 4.0 at 100 mc. Because $f_T = h_{fe} \times$ frequency, therefore $f_T = 4 \times 100 = 400$ mc.

The use of f_T, in general, has its greatest application in switching and wide-band amplifier circuits. However, as discussed later, a high f_T usually indicates a high f_{max} and therefore, f_T can be used as a good over-all parameter to indicate frequency limitations.

Alpha Cut-off Frequency

The *alpha* cut-off frequency ($f\alpha_b$) is defined as the frequency at which the common-base current gain (h_{fbo} or α_o) is down 3 db from its low-frequency value or α has dropped to .707 of its low-frequency value. A plot of common-base current gain for a typical transistor is shown in Fig. 4.

The term $f\alpha_b$ is not being used in many instances today to specify transistor frequency responses for communications applications. This is because $f\alpha_b$ is difficult to measure and, in some cases, may not even exist.

Interrelationships

Now that we have a basic background of the significance

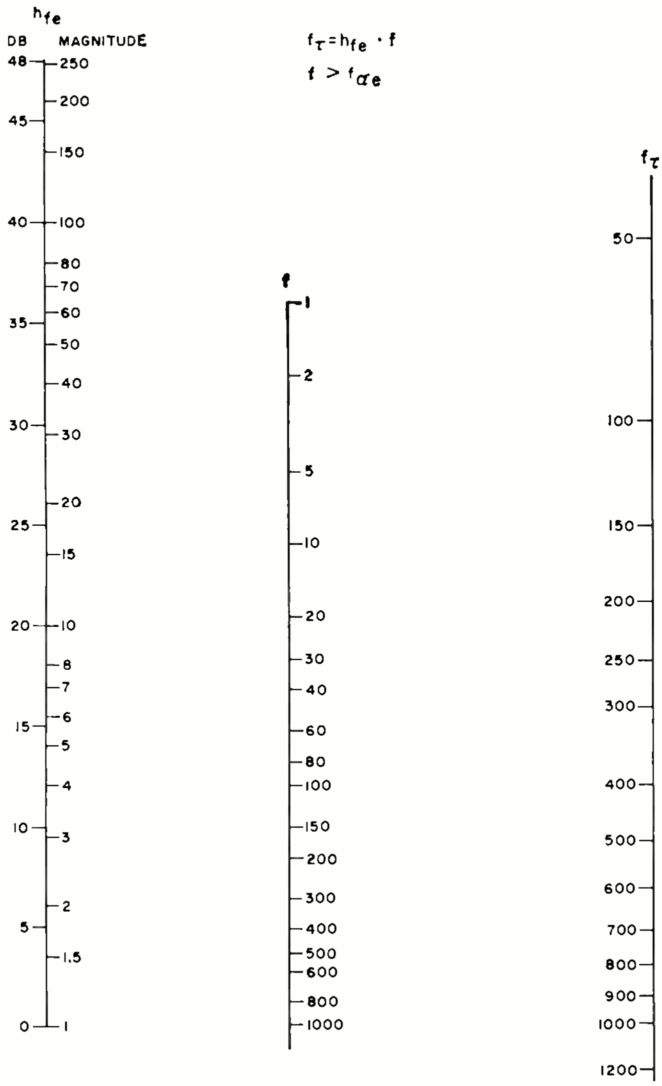
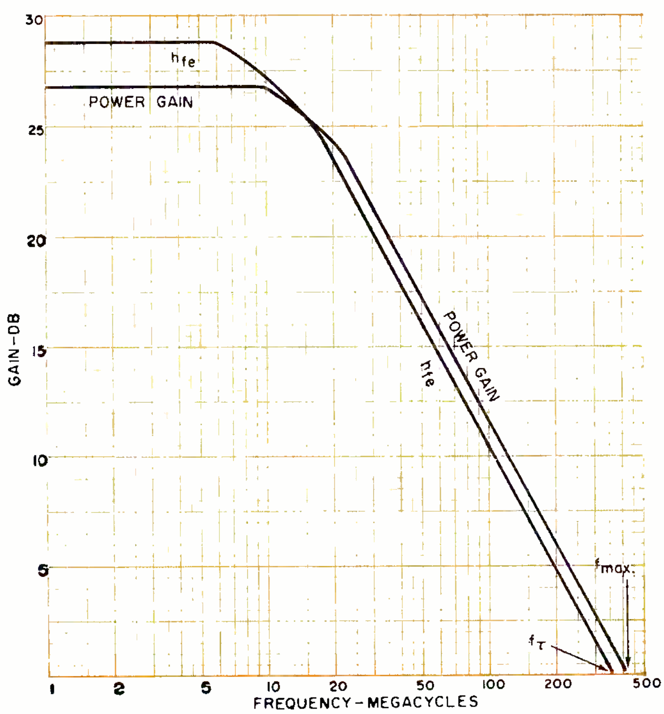


Fig. 5. Nomogram shows the relationship between gain-bandwidth product (f_T) value of h_{fe} at 1 kc. in db or magnitude, and common-emitter, current-gain cut-off frequency ($f_{\alpha e}$).

Fig. 6. Both power gain and h_{fe} of a transistor (2N741) drop very rapidly as the maximum oscillation frequency is neared.



of the three common transistor high-frequency response parameters, let's examine the interrelationship among them and methods of converting from one specification to another.

The gain-bandwidth product f_T is related to $f_{\alpha b}$ by

$$f_T = K_\theta \times h_{fbo} \times f_{\alpha b} \ldots\ldots (3)$$

where h_{fbo} is the low-frequency value of *alpha*, the common-base current gain; and K_θ is a function of phase shift in the base region and has a value between 0.5 and 1.0 depending upon the transistor structure, *i.e.*, mesa, MADT, alloy, etc.

In the interest of simplifying Eq. 3, a value of 0.8 for K_θ may be assumed for most transistors with reasonable accuracy. Using this assumption, a nomogram has been constructed for rapid conversions between f_T and $f_{\alpha b}$ (see Fig. 7). To use this nomogram, simply place a straightedge through known values on any two scales and read the unknown on the third scale.

Note that the h_{fbo} scale also contains a scale for h_{feo}, the low-frequency value of *beta*, the common-emitter current gain. Use either h_{fbo} or h_{feo}, whichever is known. If neither is known, h_{fbo} may be assumed to be 1 without significant error with most modern transistors. Thus, Fig. 7 enables reasonably accurate conversions between f_T and $f_{\alpha b}$ to be made even if nothing else is known. For example, assume that $f_{\alpha b}$ is specified at 1000 mc. for a transistor and it is desired to compare this transistor with one with f_T specified. The h_{fbo} is specified as .98. From Fig. 7, f_T is just under 800 mc.

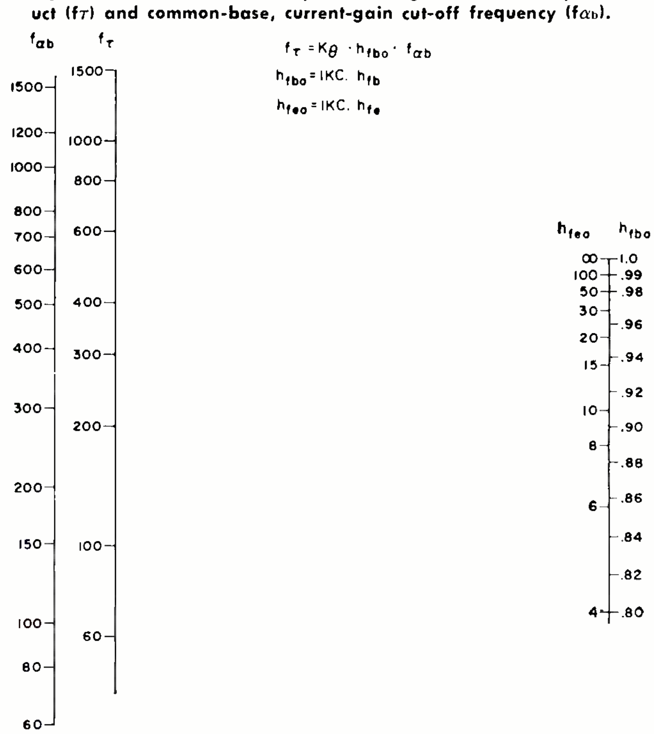
As previously stated, $f_{\alpha e}$ is related to f_T by $f_T = h_{feo} \times f_{\alpha e}$.

Fig. 5 is a nomogram solution to this equation. As with all nomograms in this article, merely place a straightedge through known values on any two scales and read the unknown on the third.

f_T and f_{max} do not have a fixed relationship. In most cases, f_{max} will be slightly higher than f_T. Both their absolute and relative values vary considerably among different transistor types. However, if no other information is available, f_{max} may be assumed to be slightly greater than, or about, 1.3 f_T.

As a general rule of thumb, a transistor which is specified as a switching transistor has an f_{max} slightly lower than f_T because the internal construction (*Continued on page 67*)

Fig. 7. This shows relationship between gain-bandwidth product (f_T) and common-base, current-gain cut-off frequency ($f_{\alpha b}$).



AUTOMATIC DEGAUSSER FOR COLOR TV

Permanently installed degaussing coil helps produce clean color-TV pictures.

By WALTER H. BUCHBAUM

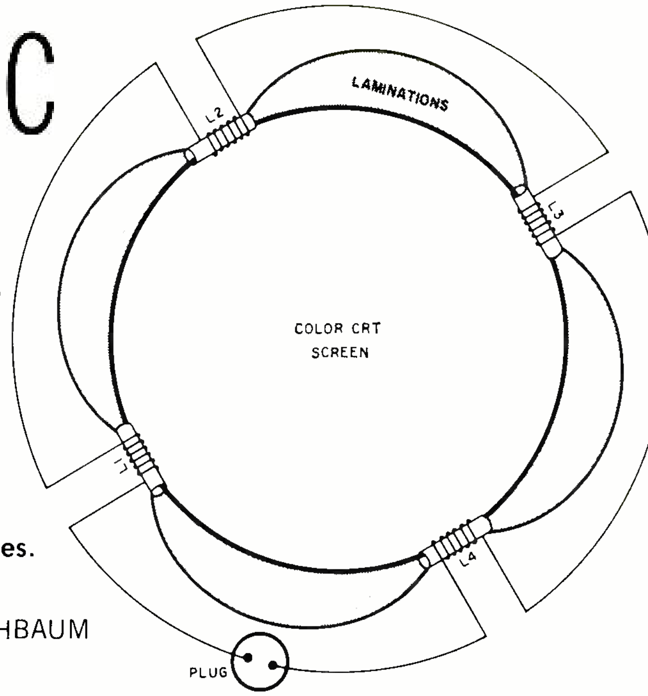


Fig. 1. The steel-laminated ring with associated coil mounts around the color tube to act as a permanent degaussing coil.

ANYONE who has serviced or installed a color-TV receiver is familiar with the problem of obtaining good color purity over the entire screen. Even after a set has been properly installed and all adjustments have been made, some color contamination remains which the purity coil adjustment cannot seem to cure. This is particularly visible on monochrome reception. This effect is due to stray magnetic fields and generally requires degaussing of the picture tube. Most technicians wind their own degaussing coil which is then connected to an a.c. outlet, placed in front of the picture tube screen, withdrawn and then unplugged.

With the picture tube properly degaussed, local screen impurities due to stray magnetic fields are eliminated and it is possible to obtain a pure monochrome raster. Very often a discriminating viewer will complain after a few days that color contamination is again present. Degaussing the CRT will usually clear this trouble. Housewives, however, continue their struggle against dirt and diligently slide the vacuum cleaner under and around the color-TV set, or else move the set to clean underneath it. Occasionally a youngster lugs a toy containing a battery motor in front of the color set. Other electrical appliances such as dishwashers, mixers, can openers, etc., are often separated from the color set by only a thin wall and all of these devices create stray magnetic fields which can affect the color screen.

The degaussing assembly used by *RCA* is mounted around the screen of the CRT tube as shown in Fig. 1. The degaussing system consists of sheet steel laminations on which four degaussing coils are mounted. After the four coils are in position, the segments are riveted together to form a ring. The reason for bulging the steel out between the coils is to reduce magnetic impedance and provide maximum flux.

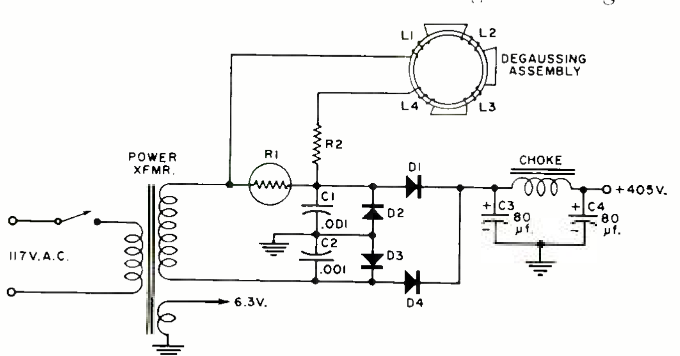
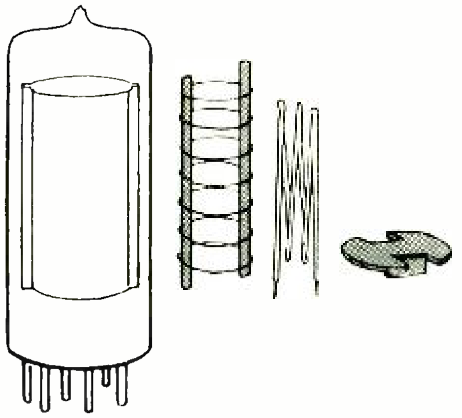


Fig. 2. Current through degaussing coils depends on warm-up resistance of thermistor R1 and voltage-dependent resistor R2.

Degaussing action is brief and occurs only during the set's warm-up period. The length of the degaussing period is determined by *R1* (Fig. 2), a thermistor connected in series with one side of the power transformer secondary. When the set is turned on, the tubes draw no current and *R1* is cold. As the cold resistance of this device is about 120 ohms, this allows current to flow through the degaussing coils *L1* through *L4* and through *R2*. This latter resistor is voltage-dependent and limits the current through the coils. The resistance of *R2* increases when the voltage across it decreases. The varying field set up in the coils causes a corresponding magnetic field in the laminated metal shield which circles the screen, just as the technician's degaussing coil does.

As the tubes start to draw more current, *R1* heats up and its resistance drops. This reduces the current through the degaussing coils until, when properly hot, *R1* is only about 4 ohms. At that point the current through the degaussing assembly drops to a negligible value since *R2* increases until it is much higher than *R1*. The entire warm-up period takes less than a minute, but this is sufficient to properly degauss the color picture tube. Actually, the most important features of proper degaussing are the location of the magnetic field, which is factory preset, and the gradual reduction of the strength of the field, which is governed by the warm-up cycle of *R1*. Both of these factors are automatic and need no adjustment. What is more, degaussing takes place every time the set is turned on from a cold start, assuring freedom from stray magnetic fields when the customer wants to use the set.

RCA has found in preliminary field trials that the automatic degaussing feature saves initial degaussing at most installations and also reduces the number of "nuisance" calls. Because automatic degaussing is provided, set owners no longer will experience the varying color impurities which seem to change from day to day and which present such a headache to the service technician. Thus a relatively simple device and circuit have solved another of the apparently random bugs which have plagued color set owners. ▲



INNOVATIONS IN RECEIVING TUBES

Without much fanfare, a number of changes are being made in vacuum tubes to improve their performance while reducing their size.

By JOHN R. COLLINS

If you examine the current literature on electronics, you can hardly fail to come away with the impression that receiving tubes are a forgotten component, being overshadowed by dramatic discoveries in semiconductors, thin films, and the more esoteric microwave tubes. This is unfortunate because receiving tubes are an excellent example of continued product improvement through applied engineering. Compared with those produced a decade ago, modern receiving tubes give much longer service on the average, are capable of far greater amplification, will operate at much higher frequencies, and are less subject to noise and microphonics. As a result, new radios and television sets give generally superior performance, often with a smaller tube complement.

Although new envelope shapes and sizes are readily apparent by casual inspection, other innovations involve new alloys or internal structures, and are evidenced by better performance with less heat, lower noise, and fast warmup.

Design Problems

In its primary mode of operation, a conventional or space-charge control tube is an amplifying device that depends on the control of a stream of electrons emitted by a cathode and collected by an anode or plate. The electron stream is regulated by one or more grids located between the cathode and plate. With d.c. potentials applied to the plate and grids, a steady-state plate current flows whose magnitude is determined largely by the geometry of the structure and the applied voltages. The plate current can be varied as desired by superimposing a signal voltage on the control grid.

A tube is a good amplifier if a small input signal at the control grid produces a much larger output at the plate. The figure of merit, called mutual conductance, is expressed by the relation, $G_m = \mu / R_p$ where G_m is mutual conductance, μ is amplification factor, and R_p is dynamic plate resistance.

A good tube will obviously have high μ and low R_p, where μ is determined by the effectiveness of the grid in shielding the cathode from the plate. Closer spacing of grid wires will increase μ, and so will *increasing* the separation between the grid and the plate. Dynamic plate resistance (R_p) depends on the geometry of the tube elements. It can be reduced by using a large cathode and by *reducing* the spacing between tube elements. The ability of a tube to perform at v.h.f. or u.h.f. depends largely on its transit time and interelectrode capacitances. Transit time must be short and is reduced by close spacing of electrodes. Interelectrode capacitances, which must also be small, increase in proportion to the size of the electrodes and their proximity to one another.

Ingenuity is needed to assure that measures devised to improve one factor do not adversely affect another.

Studies show that 50 to 80 percent of all receiving tube failures are accounted for by open heaters, shorts, arcing, and gas; with open heaters far in front. While it is unlikely they will ever be entirely eliminated, the average life of a vacuum tube has been greatly increased during the past several years by attacking these common causes of failures.

Heaters

Heaters are made from fine tungsten wire, either coiled or folded, and are usually coated with aluminum oxide for insulation. They burn out in use from recrystallization and embrittlement of the metal due to successive heating and cooling. Recently, a new technique was discovered based on altering the over-all crystalline structure of tungsten through the addition of a small amount of rhenium. Heaters made of this material will give thousands of hours of service without any deterioration when operating at the high temperature that is necessary.

A second great stride in reliability is the so-called "dark heater." Although each manufacturer has his own process and methods are confidential, dark heaters in general are formed by coating the wire with an overcoating of a substance that will improve heat emissivity. As a result, a dark heater can be operated at a lower temperature while still giving the same performance (*i.e.*, supplying the same amount of heat to the cathode) as an unprocessed heater operated at a much higher temperature.

The reduced temperature made possible by the use of a dark heater retards recrystallization of the tungsten and thus increases heater life. Reliability studies now in progress indicate that heater failures due to the heater material itself can be virtually eliminated by the techniques described. The failures that still occur in tubes with improved heaters are mostly attributed to faulty workmanship.

Cathodes

Receiving tube cathodes are usually high-purity nickel sleeves in which heaters are encased. Purity is necessary because extraneous elements cause operating difficulties. Copper, for instance, sublimes in a vacuum at relatively low temperatures, creating electrical leakage paths between tube elements where resistance should be very high. Sulphur causes poisoning of the cathode coating and is very harmful to electron emission.

Tungsten, on the other hand, is sometimes added to the nickel cathode to improve its heat strength, and to lessen the possibility of shorts caused by the cathode bowing at high temperatures.

Electron emission is provided by coating the cathode with a mixture, usually of barium and strontium oxides, which gives high efficiency at relatively moderate heat. The coating was traditionally applied by spraying or dipping and thickness was impossible to control with great accuracy. Recently, however, a new film-casting process has been developed whereby emitting materials are produced in the form of self-supporting films of any desired thickness from about 0.25 to 40 mils, to a tolerance of 0.1 mil. They are wrapped around the nickel sleeves to form so-called "sarong" cathodes.

This technique provides an extremely accurate and uniform chemical and mechanical emitting surface. It has resulted in better control over electrode spacing, contributing to more uniform current density over the entire cathode area and thus giving consistent tube characteristics and a lower noise figure. The closer spacing made possible by the small tolerances increases efficiency and allows lower heater power.

An instant-heating cathode to be used in conjunction with transistorized equipment has been developed by the *Amperex Electronic Corp.* Known as the "harp cathode" (Fig. 2), it consists of a large number of parallel, closely spaced oxide-coated tungsten wires wound on a rigid frame. This design lends itself to variations of each of the three dimensions, so that it can be made long or short, thin or thick. A typical harp-cathode tube, the type 8408, also contains a frame grid and provides power output of 6 watts at 500 mc. Harp cathodes warm up in less than ½ second. They need a current of several amperes at a voltage of 1.1 to 1.6 volts, and this is usually supplied by means of a push-pull transistor oscillator.

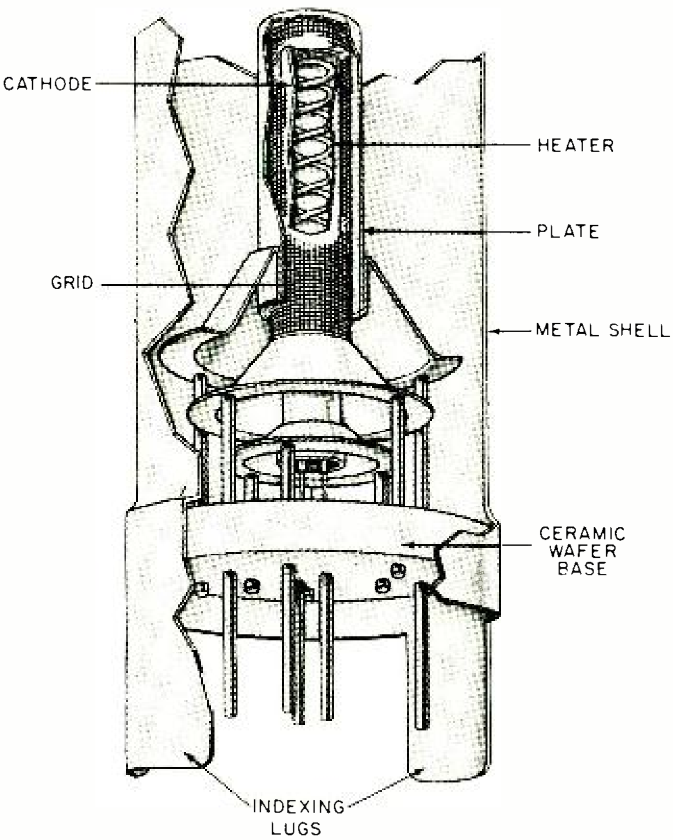


Fig. 1. Cutaway view of a typical nuvistor miniature tube.

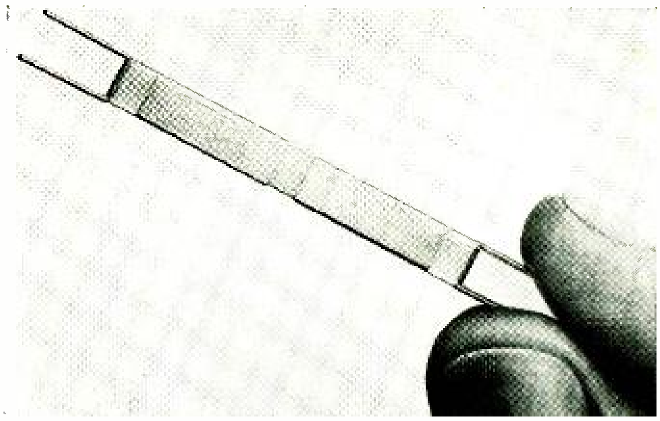


Fig. 2. Because this instant-heating cathode warms up in less than ½ second, it is being used with transistorized equipment.

Grids

Any relative motion between the various elements making up the tube structure will change the geometry of the system and cause a change in anode current, in the same manner as a fluctuation of the potential on one of the grids. Changes in anode current resulting from such mechanical movements cause undesirable microphonics. If the movement of tube elements is great enough, two elements may touch, producing a temporary short and a spike of impulse noise.

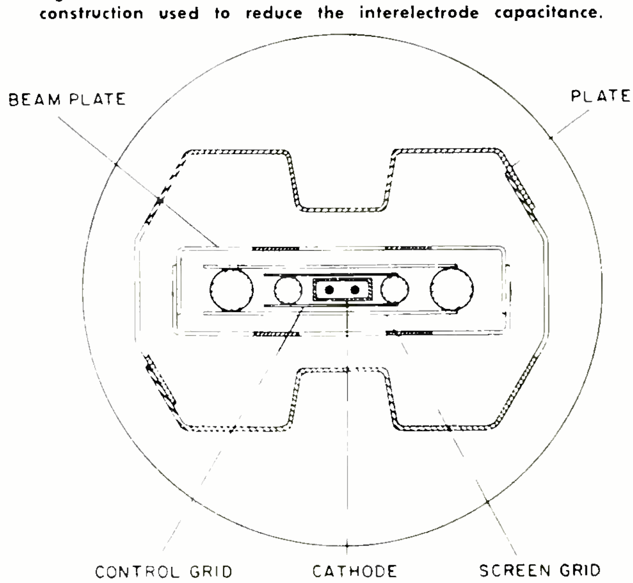
While it is virtually impossible to eliminate all microphonics, notable improvement has resulted from frame-grid construction techniques. These structures make use of a rectangular grid frame that is designed for greater stiffness in all directions. The greater rigidity makes it possible to wind grid wires much closer together without danger of shorts. Frame grids also permit notable improvement in amplification factor and mutual conductance. Closer winding of grid wires (up to 500 wires per inch, with positional accuracy of ±5 microns) provides greater isolation of the plate from the cathode, thus increasing μ. At the same time, R_p is reduced by closer spacing of tube elements, made possible by greater rigidity.

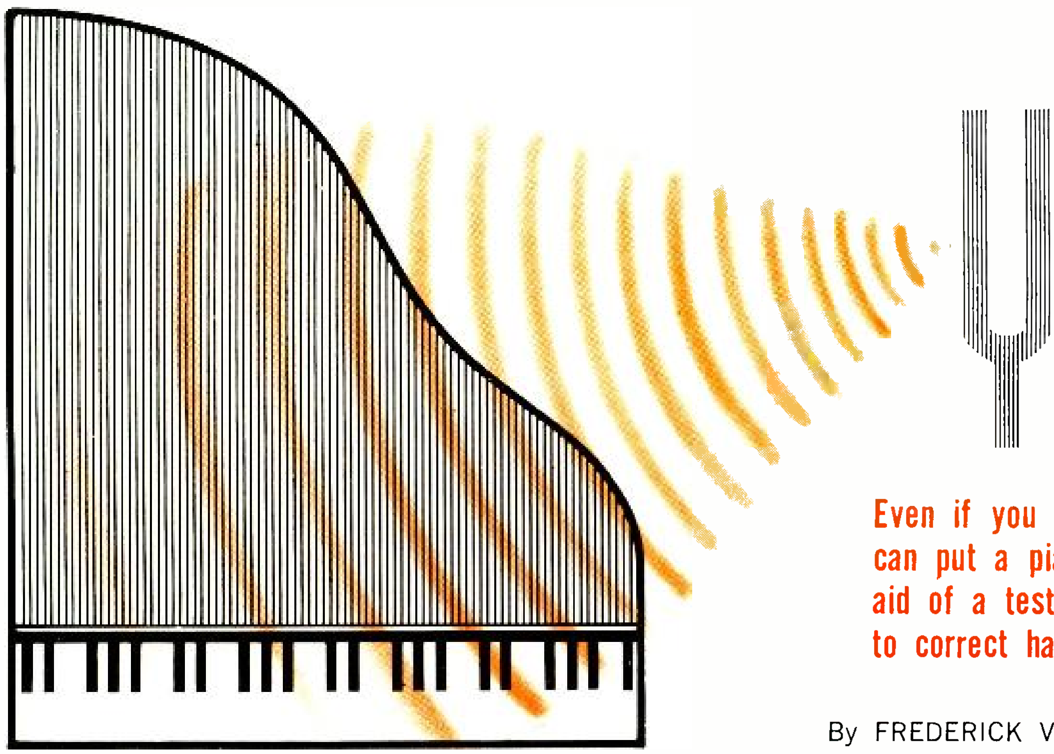
The use of frame-grid tubes has permitted a striking reduction in the number of amplification stages needed in the i.f. systems of modern television receivers. The function of the i.f. system is to amplify the video signal from the mixer to provide adequate output at a bandwidth great enough to retain picture detail. Linearity is needed to prevent undesirable cross-modulation. Although four or five tubes, such as type 6AU6 ($G_m = 4450$), were needed to achieve the desired result in early sets, it is now practical to reduce the i.f. stages to two. Modern tubes designed for this kind of service include frame-grid types 6JK6 ($G_m = 18,000$) and 6JL6 ($G_m = 15,500$). Another frame-grid tube especially suited for use as a wide-band amplifier is type 8233 ($G_m = 45,000$).

Anodes

The anode, or plate, of a tube must be a good thermal conductor to permit the dispersion of heat evenly over the entire surface. If hot spots develop, radiated heat may damage other elements. Hot areas (*Continued on page* 90)

Fig. 3. Cross-section of one new tube shows the unique plate construction used to reduce the interelectrode capacitance.





Even if you lack a trained ear, you can put a piano "on key" with the aid of a test instrument that tunes to correct harmonic and beat note.

By FREDERICK VAN VEEN / General Radio Co.

PIANO TUNING—THE ELECTRONIC WAY

GOOD piano tuners, it seems, are becoming increasingly scarce—so scarce, in fact, that it's not unusual to find a tuner "booked solid" for several weeks in advance, especially just before a holiday. This state of affairs, coupled with the renewed popularity of the piano, may interest many piano owners in the art of piano tuning. If there is electronics in your background and especially if there are certain types of electronic instruments that are available for your use, piano tuning can be simplified to the point where you need not be afraid to do something about the clinkers coming from that old piano.

Basic Tuning Procedure

Tuning a piano, as almost everyone knows, is basically a matter of adjusting the tension of the piano wires so that the notes occur at the frequencies assigned to the equally tempered scale. The tuner, after calibrating one note against a tuning fork or other standard, strikes that note together with a note 2/3, 3/2, or 3/4 of the reference note's frequency, in such combinations that the second, third, or fourth harmonic of the second note should nearly equal the second or third harmonic of the reference note. ("Nearly," rather than "exactly," because of the compromises of the equally tempered scale.) The tuner adjusts the second note for the proper beat frequency and then uses that note as a reference for another, and so on in a "knight's tour" of a central octave. This octave is then used as the reference for all other notes on the keyboard.

The actual adjustment of wire tension involves use of a special wrench, which fits over the square ends of the pins to which the wires are attached. The long handle on such a wrench provides the necessary leverage and sensitivity of adjustment.

Throughout most of the keyboard, there are three strings per note. The usual procedure involves tuning the center string of each note and then setting the adjacent strings to unison. (The idea is to avoid creating stress unbalances that might damage the piano.) While tuning the first string of a two- or three-string note, tuners use rubber wedges to "damp out" the companion string or strings. Sometimes a long strip of felt is tucked along an octave or so, ribbon-candy style, to damp the "outside" strings of three-string notes.

Wrench, wedges, a strip of felt, and a tuning fork or two are the basic tools of the trade, plus one of the excellent handbooks covering the mechanical aspects of tuning and the proper care of a piano (*e.g.*, "Piano Tuning and Allied Arts" by William B. White). The piano is a delicate, expensive instrument, and you should not try to tune a piano for the first time without reading such a handbook. The results of such an attempt could be catastrophic.

Recognizing the Beats

Assuming that one is familiar with the basic procedure and with the mechanical aspects of tuning, the most difficult part for the inexperienced tuner is usually recognition of the beat frequencies in the presence of the much louder fundamentals. To one who has been tuning pianos for years, the beats are as clear as church bells. This ability to recognize the proper beats, even at the high and low ends of

Table 1. Filter frequencies for the standard tuning sequence. The values are for the central octave, after tuning C_4 with respect to a tuning fork or other standard. A plus sign in the middle column indicates the note should be tuned above zero beat; minus sign indicates tuning to be below zero beat.

NAMES OF TONES Ref.—Tuned	NO. OF BEATS PER SECOND	FREQ. AT WHICH BEATS ARE HEARD (cps)
C_4—F_3	+0.6	523
C_4—G_3	−0.9	784
G_3—D_4	−0.7	587
D_4—A_3	−1.0	880
A_3—E_4	−0.8	660
E_4—B_3	−1.1	988
B_3—$F\#_3$	−0.8	740
$F\#_3$—$C\#_4$	−0.6	554
$C\#_4$—$G\#_3$	−1.0	831
$G\#_3$—$D\#_4$	−0.7	622
$D\#_4$—$A\#_3$	−1.0	932
$A\#_3$—F	−0.8	698

the keyboard, is probably the piano tuner's most valuable asset.

Lacking a trained ear, one can call on some electronic help to filter out the fundamentals and pass only the desired harmonics. The filter must be tunable, of course, and must cover the audio range. Such a filter is the *General Radio* Type 1232-A Tuned Amplifier and Null Detector (see "A Tuned Amplifier and Null Detector with One-Microvolt Sensitivity" by A. E. Sanderson in the *General Radio Experimenter*, Vol. 35, No. 7, July, 1961), with a tunable frequency range from 20 cps to 20 kc., low noise level, small size (8″ x 6″ x 7½″), and battery operation. The only other equipment needed, beyond the usual piano-tuning implements, is a microphone connected to the input of the filter and a pair of high-impedance headphones connected to its output.

For each note pair struck, it is necessary to set the frequency control on the filter to pass the desired harmonics. Table 1 lists these frequency settings for the entire central-octave tuning sequence. Note that for all pairs except the first, the tuned note is adjusted for a beat frequency on the flat side of zero beat. The octaves on either side of the central octave can easily be tuned to the central octave. A_2 (110 cps), for instance, can be tuned so that its fourth harmonic is at zero-beat with the second harmonic of A_3, with the filter set at 440 cps. Such straight-octave tuning can be used for all but the extremely high and low ends of the keyboard, where one must call on "expanded-third" or other techniques described in the handbooks. By noting the harmonic relation of any prescribed note pair, one can easily determine the frequency at which beats should be heard, and set the filter frequency accordingly.

Using a Counter

If one has access to a frequency counter, each note can be tuned directly to its proper fundamental as indicated by the counter, without recourse to harmonic techniques. A tuned filter is once again needed, between the microphone and the counter. Accuracy of direct-frequency measurement is limited to ± 1 cps, a fairly significant percentage at the low end of the keyboard. With a "universal counter," one can switch to period or multiple-period measurement and thus gain more than enough precision. The period of A_0 (27.50 cps) for instance, is 0.036364 second. A counter with a 100-kc. time base indicates this as 3636 for a single-period measurement, 36364 for a 10-period measurement.

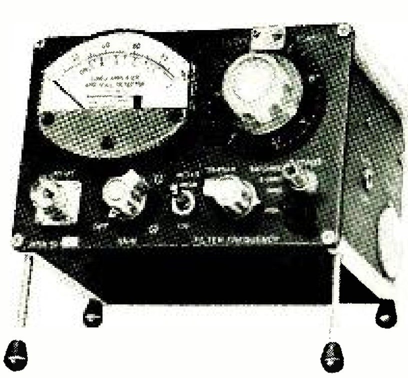
Since period measurements are made in terms of time rather than frequency, a conversion table must be used. Table 2 gives period indications for the entire keyboard. The five digits given are as they appear on a "universal counter" with a 100-kc. time base, set for single- or multiple-period as noted. The five digits given will be found to offer far more precision than the "settability" or frequency stability of the average piano justifies.

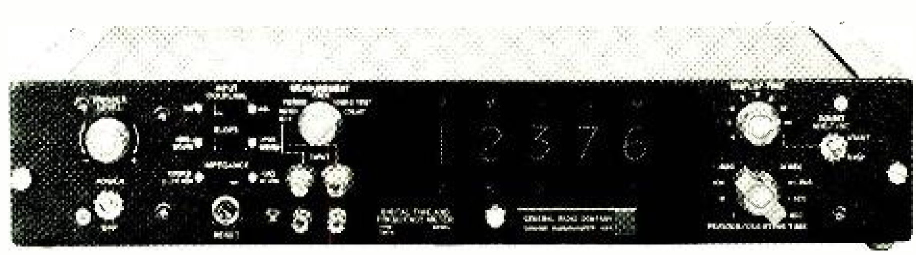
The counter can probably best be used as a check on tuning adjustments made by the usual harmonic procedures. The tuned filter is really all that is needed to do a first-class job, and it is doubted that much time is saved or accuracy gained by a top-to-bottom tuning by period measurement.

Tuning pianos with the aid of a tuned filter offers several obvious advantages: accuracy of tuning, convenience, low cost (assuming one has access to the instrument in the first place). Also, after listening to the beats through the tuned filter, one soon develops the "piano-tuner's ear" and can, if he chooses, do the job in the old-fashioned way. ▲

	NOTE	FREQ.	PERIOD		NOTE	FREQ.	PERIOD
10 period	A_0	27.500	36364	100 period	F_4	349.23	28634
	$A\#_0$	29.135	34323		$F\#_4$	369.99	27028
	B_0	30.868	32396		G_4	392.00	25510
	C_1	32.703	30578		$G\#_4$	415.30	24079
	$C\#_1$	34.648	28862		A_4	440.00	22727
	D_1	36.708	27242		$A\#_4$	466.16	21452
	$D\#_1$	38.891	25713		B_4	493.88	20248
	E_1	41.203	24270		C_5	523.25	19111
	F_1	43.654	22907		$C\#_5$	554.37	18038
	$F\#_1$	46.249	21622		D_5	587.33	17026
	G_1	48.999	20409		$D\#_5$	622.25	16071
	$G\#_1$	51.913	19267		E_5	659.26	15167
	A_1	55.000	18182		F_5	698.46	14317
	$A\#_1$	58.270	17161		$F\#_5$	739.99	13514
	B_1	61.735	16198		G_5	783.99	12755
	C_2	65.406	15289		$G\#_5$	830.61	12039
	$C\#_2$	69.296	14431		A_5	880.00	11364
	D_2	73.416	13623		$A\#_5$	932.33	10726
	$D\#_2$	77.782	12856		B_5	987.77	10124
	E_2	82.407	12135	1000 period	C_6	1046.5	95557
	F_2	87.307	11454		$C\#_6$	1108.7	90196
	$F\#_2$	92.499	10811		D_6	1174.7	85128
	G_2	97.999	10204		$D\#_6$	1244.5	80354
100 period	$G\#_2$	103.83	96313		E_6	1318.5	75844
	A_2	110.00	90909		F_6	1396.9	71587
	$A\#_2$	116.54	85807		$F\#_6$	1480.0	67568
	B_2	123.47	80991		G_6	1568.0	63776
	C_3	130.81	76447		$G\#_6$	1661.2	60197
	$C\#_3$	138.59	72155		A_6	1760.0	56818
	D_3	146.83	68106		$A\#_6$	1864.7	53628
	$D\#_3$	155.56	64284		B_6	1975.5	50620
	E_3	164.81	60676		C_7	2093.0	47778
	F_3	174.61	57271		$C\#_7$	2217.5	45096
	$F\#_3$	185.00	54054		D_7	2349.3	42566
	G_3	196.00	51020		$D\#_7$	2489.0	40177
	$G\#_3$	207.65	48157		E_7	2637.0	37922
	A_3	220.00	45454		F_7	2793.8	35794
	$A\#_3$	233.08	42904		$F\#_7$	2960.0	33784
	B_3	246.94	40496		G_7	3136.0	31888
	C_4	261.63	38222		$G\#_7$	3322.4	30099
	$C\#_4$	277.18	36077		A_7	3520.0	28409
	D_4	293.66	34053		$A\#_7$	3729.3	20815
	$D\#_4$	311.13	32141		B_7	3951.1	25309
	E_4	329.63	30337		C_8	4186.0	23889

Table 2. Frequencies (in cps) and periods for the equally tempered scale. The five digits in the "Period" column are the readings on a "universal" counter with a 100-kc. time base, set for single- or multiple-period measurement. These figures may be read as "period in microseconds" for the 10-period measurements. For 100-period measurements, period figures are ten times the values in microseconds. For the 1000-period measurements, figures are 100 times the values in microseconds.





A universal counter can be used for direct indication of period of piano notes.

◀ Tuned amplifier and null detector.

JOHN FRYE

In addition to the ignition system, the modern car has a number of "noise makers" that may require suppression.

NON-IGNITION NOISE SOURCES

BARNEY clumped noisily into the service department carrying a relative signal-strength meter in his left hand and a pair of grass-clippers, very ostentatiously, in his right.

"See these?" he demanded of Mac, waving the sharp points uncomfortably close to his employer's nose. "You'd never guess these clippers were a TV service tool, now would you? But they were all I used to clear that weak-reception complaint."

"Let's hear about it," Mac said resignedly. "I'll get no peace until I do."

"Well, when I put the signal-strength meter on the antenna, I found signals were away down, especially on the higher channels. Suspecting a broken lead-in, I went outside to look; and I nearly flipped when I found morning glory vines planted directly beneath the lead-in and the motor control wires and climbing both clear to the top of the tower. The owner explained he thought the bare wires looked ugly running up alongside the house and he had deliberately planted the morning glories there to hide them.

"I had him watch Channel 13 while I climbed the tower and stripped away the runner twined closely around the lead-in. He said every time a chunk of vine came down the picture strength went up; and when I finished, the picture was the best he had ever seen it. That's the sort of odd-ball situation a technician encounters very rarely, but he's gotta realize such things can happen. Say, that reminds me! Remember about a month ago we were talking about suppressing ignition interference without impairing engine performance?"

"Yes, and I've been intending to get back to the subject. What about it?"

"I was browsing through some literature from the *Champion Spark Plug Company* at Homer's garage the other day, and they made quite a to-do about the bad effects of reversing ignition-coil primary connections. The polarity of the spark-plug terminal should be negative with respect to the block; but if the coil primary connections are hooked up incorrectly, the terminal becomes positive. Under these conditions you need 35-45% more voltage to fire the plug. Hard starting and rough engine idle often result. It also figures that adding resistor suppression to such a reversed system would aggravate the condition and make you think the car wouldn't tolerate suppression, when all you really needed to do was reverse the coil polarity."

"Is this condition very common?"

"I read an estimate someplace that a third of all the cars on the highway today have reversed primary connections, but Homer and other mechanics with whom I've talked think that's way too high. They say you encounter the condition just rarely enough to make you overlook the possibility when you shouldn't."

"I suppose you could touch the high voltage probe of a v.t.v.m. or v.o.m. to the plug terminal and determine if it were negative by watching which way the meter kicked when the plug fired."

"Yeah, but there's another quick-and-dirty method. You pull off a plug wire and arrange the connector about a quarter-inch away from the plug terminal. Then you insert the point of a wooden pencil into this gap while the motor is running. If the spark flares and turns orange on the *plug* side of the pencil point, the coil is correctly wired. If the flare and orange tint is toward the connector, reverse the coil primary connections."

"That's good addenda to our discussion of ignition-noise suppression," Mac applauded; "but now let's talk about suppressing other kinds of noise. Ordinarily, ignition interference is strong enough you don't realize the other noise is there until you get rid of the ignition racket; then it comes in annoyingly clear, the way the unnoticed ticking of a clock seems to build in volume as the house quiets down.

"The battery-charging system is usually the worst offender, especially in cars employing a d.c. generator instead of an alternator. Arcing between the brushes and the commutator segments of the generator armature and between the contact points of the voltage-regulator relays produces the interference. The generator produces a high-pitched musical whine that doesn't stop instantly when the ignition is shut off at fast idle. The pitch changes with motor speed. The first thing to do is make sure the commutator is perfectly round with the mica properly undercut, the segments are clean, and the brushes are in good condition. There's no point in creating unnecessary interference to be suppressed.

"The voltage regulator puts out a haphazard, ragged rasping sound that also continues briefly after the ignition is cut off a rapidly turning motor. A .5-μf. high-current coaxial capacitor (such as *C-D* #NFF-0558) should be installed right at the generator 'Arm.' terminal. Then .1 or .2-μf. high-current coaxial capacitors (*C-D* #NFF-315D or equivalent) should be connected to the 'Bat.' and 'Arm.' terminals of the voltage regulator. An ordinary capacitor should *never* be connected to the 'Field' terminal of the voltage regulator. Instead, a special filter, consisting of an .002-μf. capacitor in series with a 5-ohm resistor can be installed between the 'Field' terminal and ground. All wiring between the generator and the regulator should be shielded; and all shielding, including the cases of the coaxial capacitors, should be well grounded. So should the frame of the generator, all generator shields, and the voltage-regulator case.

"Probably the easiest way out is to use a universal low-voltage suppression kit, such as the *Sprague* Type SK-1 'Suppresikit[R],' which includes all the capacitors and the filter I have just mentioned together with the shielded wiring and a coaxial capacitor for the ignition-coil primary. Detailed instructions show you how to install it."

"Isn't a tunable generator filter sometimes a help?"

"Yes, in a few cases a parallel-tuned trap inserted in the generator output lead and tuned to the receiver frequency will take out the last bit of generator noise. For the CB band, this could consist of eight spaced turns of #10 wire wound on a 1" form and tuned with a 30-pf. compression-type mica capacitor. The capacitor is adjusted for minimum noise in the receiver with the engine running."

"How about alternators on modern cars? Do they give

HOBSON'S CHOICE?
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If, in 1631, you went to rent a horse from Thomas Hobson at Cambridge, England, you took the horse that stood next to the door. And no other. Period. Hence, Hobson's Choice means No Choice.

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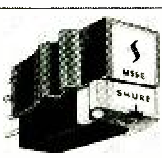
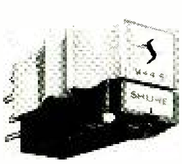
Since then, Shure has developed several models of their Stereo Dynetic cartridges—each designed for optimum performance in specific kinds of systems, each designed for a specific kind of *porte-monnaie*.

We trust this brief recitation of the significant features covering the various members of the Shure cartridge family will help guide you to the best choice for you.

THE CARTRIDGE	ITS FUNCTION, ITS FEATURES...	IS YOUR BEST SELECTION
 V-15	The ultimate! 15° tracking and Bi-Radial Elliptical stylus reduces Tracing (pinch effect), IM and Harmonic Distortion to unprecedented lows. Scratch-proof. Extraordinary quality control throughout. Literally handmade and individually tested. In a class by itself for reproducing music from mono as well as stereo discs.	If your tone arm tracks at $1\frac{1}{2}$ grams or less (either with manual or automatic turntable)—and if you want the very best, regardless of price, this is without question *your* cartridge. It is designed for the purist . . . the perfectionist whose entire system *must* be composed of the finest equipment in *every* category. Shure's finest cartridge. $62.50.
 M55E	Designed to give professional performance! Elliptical diamond stylus and new 15° vertical tracking angle provide freedom from distortion. Low Mass. Scratch-proof. Similar to V-15, except that it is made under standard quality control conditions.	If you seek outstanding performance and your tonearm will track at forces of $\frac{3}{4}$ to $1\frac{1}{2}$ grams, the M55E will satisfy—beautifully. Will actually improve the sound from your high fidelity system! (Unless you're using the V-15, Shure's finest cartridge.) A special value at $35.50.
 M44	A premium quality cartridge at a modest price. 15° tracking angle conforms to the 15° RIAA and EIA proposed standard cutting angle recently adopted by most recording companies. IM and Harmonic distortion are remarkably low . . . cross-talk between channels is negated in critical low and mid-frequency ranges.	If you track between $\frac{3}{4}$ and $1\frac{1}{2}$ grams, the M44-5 with .0005" stylus represents a best-buy investment. If you track between $1\frac{1}{2}$ and 3 grams, the M44-7 is for you . . . particularly if you have a great number of older records. Both have "scratch-proof" retractile stylus. Either model under $25.00.
 M7/N21D	A top-rated cartridge featuring the highly compliant N21D tubular stylus. Noted for its sweet, "singing" quality throughout the audible spectrum and especially its singular re-creation of clean mid-range sounds (where most of the music really "happens".) Budget-priced, too.	For 2 to $2\frac{1}{2}$ gram tracking. Especially fine if your present set-up sounds "muddy." At less than $20.00, it is truly an outstanding buy. (Also, if you own regular M7D, you can upgrade it for higher compliance and lighter tracking by installing an N21D stylus.)
 M99	A unique Stereo-Dynetic cartridge head shell assembly for Garrard and Miracord automatic turntable owners. The cartridge "floats" on counterbalancing springs . . . makes the stylus scratch-proof . . . ends tone arm "bounce."	If floor vibration is a problem. Saves your records. Models for Garrard Laboratory Type "A", AT-6, AT-60 and Model 50 automatic turntables and Miracord Model 10 or 10H turntables. Under $25.00 including head shell, .0007" diamond stylus.
 M3D	A best-seller with extremely musical and transparent sound at rock-bottom price. Tracks at pressures as high as 6 grams, as low as 3 grams. The original famous Shure Dynetic Cartridge.	If cost is the dominant factor. Lowest price of any Shure Stereo Dynetic cartridge (about $16.00) . . . with almost universal application. Can be used with any changer. Very rugged.

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HIGH FIDELITY PHONO CARTRIDGES . . . WORLD STANDARD WHEREVER SOUND QUALITY IS PARAMOUNT

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CIRCLE NO. 217 ON READER SERVICE PAGE

much trouble in causing interference?"

"Very little. With brushes riding on smooth copper slip rings, there's no arcing as long as these rings are kept clean and the brushes make good contact. Now and then a defective diode rectifier can cause intermittent noise. Most alternators are factory-equipped with a special capacitor to protect the rectifiers and suppress radio noise. No other capacitor should be substituted for it. The alternator voltage regulator contains only one relay instead of the three used in a generator-type regulator, and a .1-μf. bypass capacitor across the contacts will quiet it."

"I saw a Field Service Bulletin from *General Motors* saying a few cases of CB radio noise had been encountered with 1-D Series 'Delcotron®' alternators. The suggested cure was to connect a metal-cased .5-μf. capacitor between the 'R' terminal lead and ground. The capacitor lead was simply spliced to this lead and the splice taped. The case of the capacitor was firmly grounded to the alternator case. It was suggested you be darned sure you didn't connect the capacitor to the 'F' terminal lead."

"Fine!" Mac said. "Once you've quieted the charging system down, you may begin to hear sender units for the oil pressure, temperature, and fuel gauges. The oil-sender puts out a low-pitched clicking whose frequency varies with oil pressure. A .1-μf. coaxial capacitor inserted in the lead coming out of the sender and going to the gauge will quiet it. Gauges with rheostat-type senders will give a hissing, crackling sound when they are jarred or the car is rocked with the ignition on. Give them the same treatment as the oil-sender. Incidentally, don't forget new cars may have a miniature voltage regulator tucked away at the rear of the instrument cluster that uses vibrating points to regulate the voltage for thermal-type fuel and temperature gauges to approximately 5 volts. This can be a source of interference, but a .1-μf. capacitor can usually be installed across the output without removing the regulator."

"Accessory motors quite often make noise," Barney offered, "but they're easy to spot and to cure. For example, if you hear a noise only when the heater blower is running, you know you can connect a bypass capacitor from the hot wire to ground right at the motor and stop the racket. The same goes for other motors used in a car."

"About all that's left is wheel and tire static," Mac reflected. "This takes the form of an irregular popping or rushing sound heard only in dry weather at fairly high speeds. When you touch the brakes, the sound disappears. The first thing to do is to install static collectors in the front-wheel hubs or make sure collectors already present are making satisfactory electrical contact with the spindles."

"I know a case where a collector was really producing noise," Barney interrupted. "The cotter key holding the spindle nut from turning was not properly tucked in, and a split end was touching the static collector once each revolution. It made a rhythmic clicking sound in the radio that varied with the speed."

"That's another of those morning-glory-vines-climbing-the-lead-in cases," Mac said with a grin. "It doesn't happen often, but it can be a headache when it does. If rolling noise persists, the next thing to do is to put graphite anti-static powder in the tires with a special applicator. A final resort is to ground the brake shoes with flexible braid."

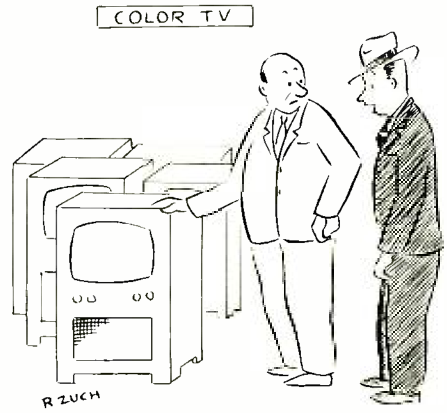
He paused, and Barney could see him raking his mind for any noise-suppressing ideas he had overlooked. Finally the older man continued.

"Practically never will all these measures be needed in one installation. I've deliberately tried to talk about noise sources in their usual order of magnitude: ignition, charging system, gauges and motors, tire static, etc. My thought was that a technician should be able to go right down the list until the receiver was quiet enough to suit him. But I know from experience that individual cars do not always follow this classic pattern.

"The best way is to *identify* the source of the loudest interference and quiet it. Then proceed to the loudest remaining interference and stop that. At each step the over-all noise level will be dropping, and when you are satisfied with the reception, quit. That way you will not be wasting equipment and effort on units that are actually not producing any objectionable noise."

"But how do you know when you've reached the quitting point?"

"Well, when you begin to hear the noise from every passing car much louder than the normal background noise in the receiver or when a weak FM station temporarily disappears every time you meet another car, you're about there," Mac said. "At that point, noise emanating from your car will seldom be the limiting factor in your reception." ▲



"Is it an Ektachrome or a Kodachrome set?"

EW Lab Tested

(*Continued from page* 18)

microphone by comparison to our standard, whose response is known over the 20 to 15,000-cps range. This technique, although subject to some errors with microphones of different directional properties, gives a reasonable approximation of the true response of a microphone, and correlates well with listening tests.

The response curve of the SK-46 velocity microphone proved to be exceptionally smooth and flat, within ±4 db from 22 to 10,000 cps. The output falls at a 12 db/octave rate above about 9000 cps. The exceptionally good bass response is the result of the close speaker-to-microphone spacing. At greater distances, the low-frequency response starts to fall off at a much higher frequency. This is characteristic of velocity microphones and is shown in the manufacturer's published response curves for the SK-46. Our measurements substantially confirmed the manufacturer's ratings, except that we found the response above 6 kc. to be somewhat better than the published values. The curves accompanying the microphone showed the free-field response falling off below 1000 cps at a 2 or 3 db/octave rate. Most public-address and recording applications will result in a response somewhere between the "close-talking" and "free-field" conditions.

We made tape recordings with the microphone, comparing the sound to that from other comparably priced dynamic microphones. It has a pleasingly clean, natural sound, with no detectable coloration as long as the sound source is a foot or more from the microphone. Closer spacing adds noticeably to the bass response, with male voices becoming boomy under close-talking conditions. The output from the SK-46 was sufficient to drive the high-impedance inputs of typical home tape recorders, even when it was wired for 200 ohms impedance.

The rejection of side response was superior to that of any of the cardioid dynamic microphones we have tried. In fact, it was possible to hold the microphone within a foot of the loudspeaker which it was driving without getting acoustic feedback, even at relatively high gain settings, as long as it was carefully oriented to take advantage of its directional properties.

The *RCA* SK-46 is an excellent-quality ribbon microphone, with sound quality in all ways comparable to that of any microphone in its price class, as well as to many more expensive microphones. In situations where acoustic feedback is a problem, its outstanding directional properties make it especially valuable. It sells for $49.50. ▲

26 Heathkit® Values...There Are

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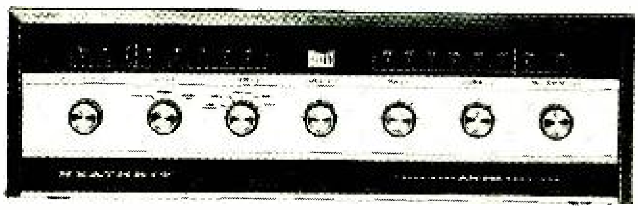
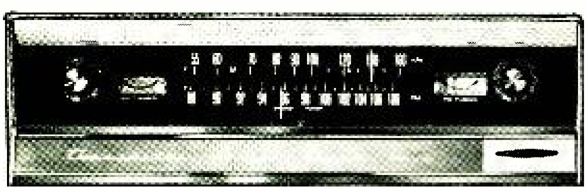
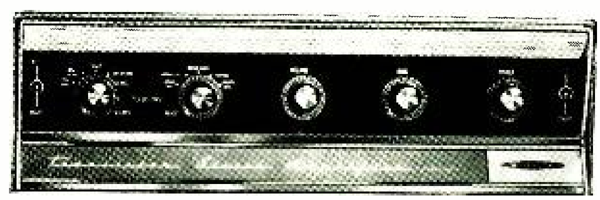
HEATHKIT Stereo/Hi-Fi Kits



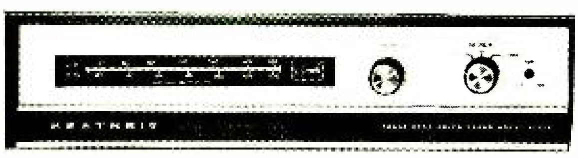
All-Transistor, AM/FM/FM Stereo Receiver AR-13 . . . $195.00—43 transistor, 18 diode circuitry for cool, instant, hum-free operation, plus the quick, uncompromising beauty of "transistor sound." Compact, yet houses two 20-watt power amplifiers (33 watts each, IHF music power), two preamplifiers, and a wide-band AM/FM/FM Stereo tuner. Attractive new "low-silhouette" walnut cabinet. Just add 2 speakers for a complete stereo system. 34 lbs.



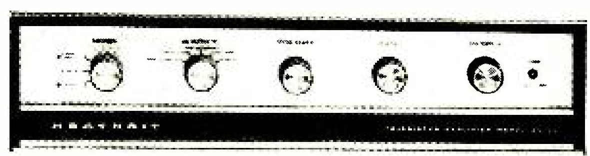
Deluxe All-Transistor, AM/FM/FM Stereo Tuner AJ-43 . . . $119.95—Up to the minute AM, beautifully quiet FM, thrilling natural FM Stereo . . . all reproduced in the exciting new dimension of "transistor sound." Features 25-transistor, 9-diode circuitry, automatic switching to stereo, AFC, stereo phase control, filtered outputs for direct, beat-free stereo recording, and handsome tan vinyl-clad steel cabinet. 19 lbs.



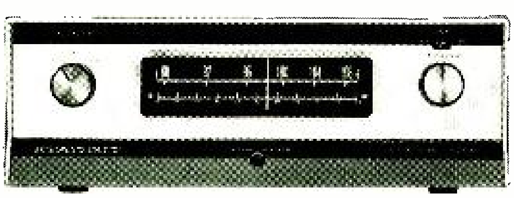
Matching Deluxe All-Transistor 70-Watt Stereo Amplifier AA-21 . . . $139.95—Enjoy the quick, unmodified response of every instrument, each with its characteristic sound realistically reproduced. No compromising! Enjoy 100 watts of IHF music power at ± 1 db from 13 to 25,000 cps. Enjoy cool, instant, hum-free operation from its 26-transistor, 10-diode circuitry. Simple to assemble. 29 lbs.



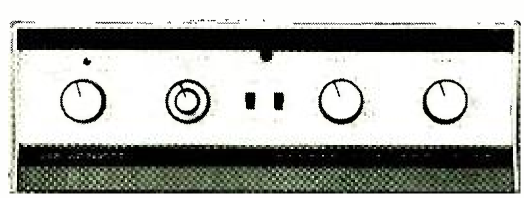
Low-Cost All-Transistor AM/FM/FM Stereo Tuner AJ-33 . . . $99.95—Features 20-transistor, 10-diode circuitry for cool, "hum-free" operation and longer life, built-in stereo demodulator, AFC for drift-free reception, stereo broadcast indicator light, filtered outputs for direct, beat-free stereo recording, concealed secondary controls to prevent accidental system changes, and "low-silhouette" walnut cabinet. 17 lbs.



Matching All-Transistor 40-Watt Stereo Amplifier AA-22 . . . $99.95—Produces a full 66 watts IHF music power at ± 1 db from 15 to 30,000 cps. Quick, clean, unmodified "transistor sound." 20-transistor, 10-diode circuitry for cool, instant, trouble-free operation and long life. 5 stereo inputs for versatile performance. Concealed secondary controls. Handsome "low-silhouette" walnut cabinet. 23 lbs.



New FM/FM Stereo "Tube-Type" Tuner AJ-13 . . . Only $49.95! Easy to own! Only 3 simple controls to operate. Features built-in FM stereo circuitry, stereo indicator light, automatic frequency control for drift-free reception, flywheel tuning, lighted slide-rule dial, external antenna terminals, preassembled, prealigned "front end," and new mocha brown, beige & black color styling. Matches the AA-32 Amplifier. 16 lbs.



New 16-Watt "Tube-Type" Stereo Amplifier AA-32 . . . $39.95! An inexpensive way to start a modern stereo system in your home. Operates with magnetic as well as ceramic phono cartridges; delivers full power (20 watts IHF) within ± 1 db from 30 to 30,000 cps; has full-range controls, 4 stereo inputs, 2 four-stage preamplifiers, 2 push-pull power output stages; plus new mocha brown, beige & black color styling. Matches the AJ-13 tuner. 15 lbs.

MORE

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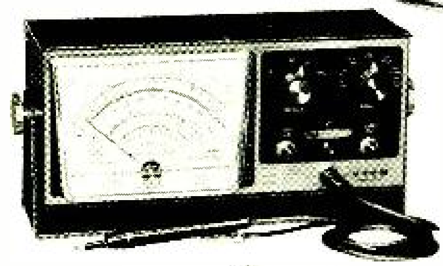
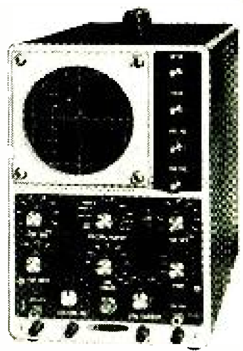


IM-13 $32^{95}

Deluxe "Service Bench" Vacuum Tube Voltmeter IM-13 . . . $32.95—Measures AC volts (RMS), DC volts, resistance & db. Separate 1.5 & 5 volt AC scales for high accuracy; "gimbal" mounting bracket for easy bench, shelf or wall mounting; meter tilts to any angle for best viewing; smooth vernier action zero & ohms adjust controls; large, easy-to-read 6" 200 UA meter; and single AC/Ohms/DC test probe. 7 lbs. Assembled IMW-13 . . . $49.95.

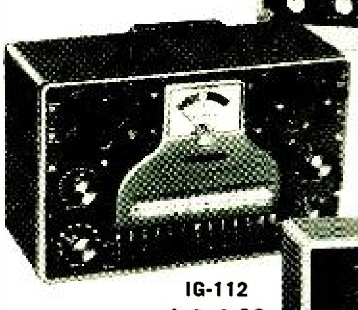


IO-12 $76^{95}

Extra Duty Wide-Band 5" Oscilloscope IO-12 . . . $76.95—Boasts professional styling & features at low cost! Has 5 mc bandwidth for color TV servicing, famous Heath patented sweep circuit—(10 cps to 500 kc), push-pull vertical & horizontal amplifiers, and two circuit boards & wiring harness for quick, easy assembly. Other features include positive trace position controls, peak-to-peak calibration reference, automatic sync circuit, Z-axis input, 5UP1 CR tube, and a husky power supply. Excellent linearity with lock-in characteristics allow stable waveform presentations at upper frequency limits. 24 lbs. Assembled IOW-12 . . . $126.95.

IG-82 $51^{95}

Professional Sine-Square Wave Generator IG-82 . . . $51.95—Ideal for any application in service and general laboratory work. Less than .25% sine wave distortion. Less than .15 microsecond square wave rise time. Sine & square wave output available simultaneously. Covers 20 cps to 1 mc in 5 bands. Features exact frequency calibrating system for proper dial tracking. 13 lbs.



IT-21 $44^{95}

Quality Heathkit Tube Checker IT-21 . . . $44.95—Simplifies servicing . . . eliminates guesswork! Tests all tube types, including new Compactron, Nuvistor, Novar and 10-pin miniatures. Features multicolored "Bad-?-Good" meter scale; and constant tension, free-rolling roll chart mechanism. Individual tube element switches protect against obsolescence. Has color-coded wiring harness for fast, easy assembly. Compact size with handy carrying handle make it ideal for field use. 12 lbs.

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New! Heathkit FM Stereo Generator IG-112 . . . $99.00—Produces all signals required for trouble-shooting & alignment of multiplex adapters, FM tuners and receivers. Generates mono FM or composite stereo FM signals. Switch selection of 400 cps, 1000 cps, 5000 cps, 19 kc, 38 kc, plus 65 kc or 67 kc SCA test signals for complete alignment capability. Simple to assemble and operate. 10 lbs.

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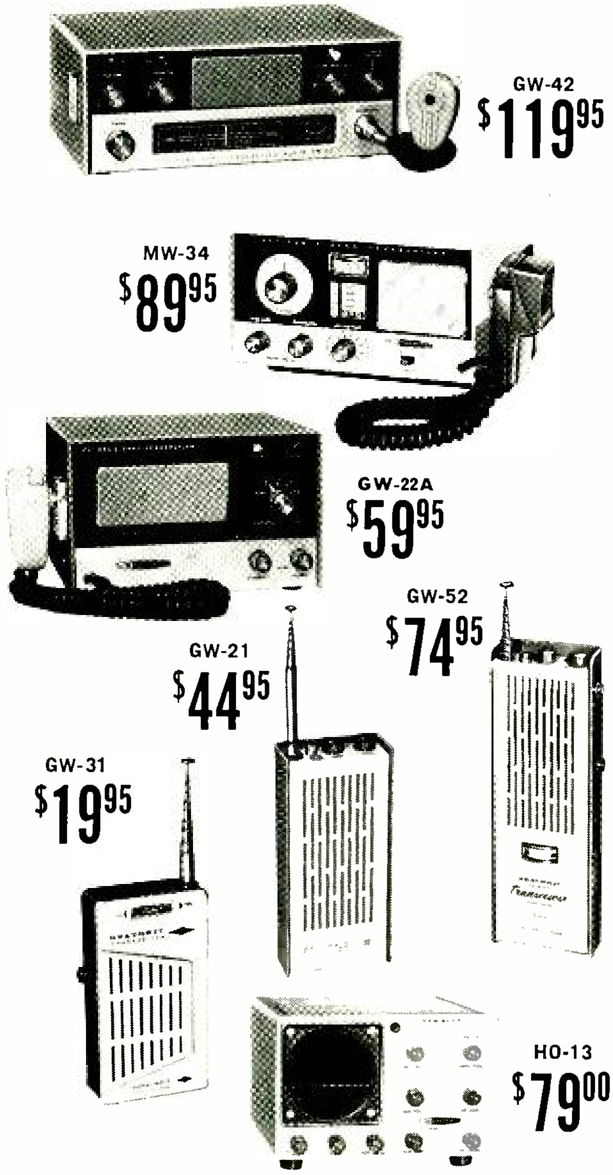
Heathkit Audio Generator Kit IG-72 . . . $41.95—Produces near-perfect sine wave audio signals. Less than .1 of 1% distortion between 20 and 20,000 cps. Output level and frequency accurate to within ± 5%. Switch selected output frequencies, 10 cps to 100 kc. Large 4½" 200 UA meter calibrated in volts and decibels. Output attenuator operates in steps of 10 db, and is calibrated in 8 full scale meter ranges. 8 lbs.



Citizen's Band Kits

Deluxe "Master Station" Transceiver GW-42 . . . $119.95—Operates "mobile" or "fixed" with built-in 3-way power supply. Other deluxe features include 5 crystal-controlled transmit & receive channels, built-in 4-tone selective call circuitry, all-channel receiver tuning, tuning meter, adjustable squelch, switchable automatic noise limiter. Complete with AC & DC power cables, PTT microphone, and crystals for 1 channel (specify). 23 lbs.

New Versatility! 2-Way Citizen's Band Radio MW-34 . . . $89.95—Provides 5 watts of input power for reliable communications from boat to boat, car to boat, car and home. Features 5 crystal-controlled transmit-receive channels (one transmit crystal on front panel); variable receiving tuning with spotting switch; 3-way power supply (6 or 12 V. DC or 117 V. AC); RF stage for superb reception; and attractive black, white, & blue Heathkit marine styled cabinet. 19 lbs.

5-Channel Citizen's Band Transceiver GW-22A . . . $59.95—Low cost! Ideal for business or personal communications. 5 crystal-controlled transmit & receive channels; superheterodyne receiver with RF stage; built-in squelch & automatic noise limiter; PTT crystal microphone; and crystals for one channel (specify). GW-22A (117 v. AC, less selective call). GW-22D (6 or 12 v. DC, less selective call) . . . $64.95. 14 lbs. GW-32A (117 v. AC, with selective call) . . . $84.95. GW-32D (6 or 12 v. DC, with selective call) . . . $89.95. 15 lbs.

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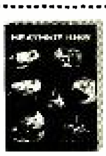

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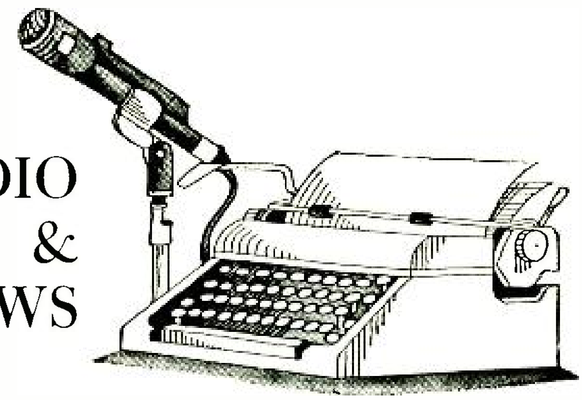
RADIO & TV NEWS



At the present writing, we are aware of seven different color-TV systems proposed by various countries around the world. Recently, we heard about an eighth. The latest approach comes from Dr. N. Mayer of the Institut fur Rundfunktechnic, Munich, Germany.

This new method came as a result of the delay, until April 1965, in the selection of a color-TV system for use in Europe. During previous discussions, principal criticism of the NTSC system revolved around the susceptibility of the chromatic subcarrier to amplitude-dependent phase distortion due to multi-path reception.

In conventional NTSC reception, the reference burst occurs at the black level while the chrominance signal rides up and down dependent on the luminance signal amplitude. If the phase distortion is dependent on the level, then the phase of the chrominance signal will change with respect to the color burst with signal level changes. This will produce color changes on the received picture. If, on the other hand, the reference burst were to ride up and down on the luminance signal, together with the chrominance signal, then the relative phase between burst and the chrominance would not be easily altered.

Dr. Mayer then proposes a system that he calls NTSC+Additional Reference Transmission (ART) that uses a new subcarrier having the same frequency as the color burst but the phase of the *I* chromatic signal. Although this new system has a somewhat different circuit than conventional NTSC, Dr. Mayer claims that his new method will be compatible with conventional NTSC receivers but that the ART color system will be immune to differential phase distortion (up to 40°) and therefore less susceptible than ordinary NTSC to multipath reception distortions.

This system will be discussed at the next European color TV meeting.

Rare Earth Red

Because of the low efficiency of the red phosphor under cathode-ray excitation, the blue and green phosphors of most present-day color CRT's have to be operated at low brightness levels to keep the gun ratios at acceptable limits. This has kept the over-all brightness at the screen of the CRT at a reduced level, necessitating viewing in low ambient light.

If the beam current of the three guns were increased in an effort to make the color picture brighter, the red phosphor sometimes exhibited a shift in color towards orange so that true red could not be experienced at high beam currents and other colors containing red would be distorted.

In an effort to make brighter color pictures, *Sylvania* has introduced a new rare-earth red phosphor (europium) that overcomes the limitations of the older red phosphors so that color CRT's using it are about 40% brighter than those currently used. This new red phosphor does not change color at the higher beam currents, and therefore all three guns can operate at a higher level, producing a higher brightness color picture.

The new phosphor came from an interest in laser experiments and has now sparked the search for rare-earth green and blue phosphors which may lead to even brighter color-TV pictures.

Sensitivity

Have you ever wondered just how sensitive a detector could be made if someone really made the effort? Well, down at the National Bureau of Standards, someone has done just that.

They are in the midst of a search for an attenuation measurement system having accuracies on the order of .0001 db and for a detector that would not be a degrading factor in the measurement.

The detector that was developed has a sensitivity of 36 picovolts (36×10^{-12} volts, or 36 micromicrovolts) and capable of responding to a signal 210 db below 1 volt. This value, obtained with a 30-second integration time, is only 17% greater than the theoretically possible 29.9 picovolts attainable with this circuit.

In the old ham days, it was said that a sensitive receiver could hear two wires being rubbed together in AC4-land (Tibet to the uninitiated). Looks like it might happen real soon. ▲

H.F. Transistors

(Continued from page 52)

of the device has been optimized to enhance its switching characteristics. However, a transistor listed as a switching device also makes a good amplifier.

Transistors that are specified as amplifier devices have an f_{max} which is higher than f_T for like reasons. A comparative chart of f_T and f_{max} for a 2N741 amplifier transistor is shown in Fig. 6.

If f_{max} is known, the maximum available gain at frequencies between f_{max} and f_{α}, may be found using Fig. 1.

An example may be helpful. Suppose a transistor is being considered for an r.f. amplifier at 50 mc. Probably the first and most important consideration is gain at the operating frequency. Assume you locate a high-frequency transistor that looks attractive price-wise, but the only high-frequency parameter given is an $f_{\alpha b}$ of 400 mc. First, use Fig. 7 to find f_T. Possibly h_{fbo} and h_{feo} are not known, so assume $h_{fbo} = 1$. The value obtained for f_T from Fig. 7 is 320 mc.

Since nothing is given about f_{max}, or power gain, assume f_{max} approximately equals 1.3 f_T, or 416 mc. Using this value of f_{max}, find the power gain at 50 mc. using Fig. 1. The result is 18.5 db, which means that the transistor is capable of providing about 18.5 db power gain at 50 mc.

By now some readers may feel that so many approximations have been made that perhaps this entire article has been a waste of time. However, the approximations have been made in the interest of greatly simplifying the determination of expected high-frequency performance when only a limited amount of information about the transistor is available. Further, the assumptions made will often be as accurate as the parameter given since individual transistors may vary as much as 100% from typical parameters given in some cases. ▲

GLOSSARY OF SYMBOLS

Symbol	Definition
h_{fb}	Common-base a.c. forward current gain (alpha)
h_{fbo}	Value of h_{fb} at 1 kc.
h_{fe}	Common-emitter a.c. forward current gain (beta)
h_{feo}	Value of h_{fe} at 1 kc.
$f_{\alpha b}$	Common-base current-gain cut-off frequency. Frequency at which h_{fb} has decreased to a value 3 db below h_{fbo} ($h_{fb} = 0.707\ h_{fbo}$)
$f_{\alpha e}$	Common-emitter, current-gain cut-off frequency. Frequency at which h_{fe} has decreased to a value of 3 db below h_{feo} ($h_{fe} = 0.707\ h_{feo}$)
f_T	Gain-bandwidth product. Frequency at which $h_{fe} = 1$ (0 db)
G_e	Common-emitter power gain
f_{max}	Maximum frequency of oscillation. Frequency at which $G_e = 1$ (0 db)

Capacitance Transducers

(Continued from page 40)

electrode of an electrical capacitance. The electrode is coated with a thin film of insulating material of constant thickness, such as Teflon or polyethylene, to provide a suitable dielectric. When the sensing probe is immersed in the electrically grounded vessel, the conductive fluid within forms the second electrode, or ground plate. Hence, the capacitance increases in direct proportion with an increase in plate volume around the insulating layer, which may readily be computed to yield a direct level indication. To obtain accurate readings, the undesirable capacitance effect between the walls of the vessel and the insulated electrode above the level of the conducting fluid must be negligible compared to the capacitance through the insulated coating to the fluid itself. For this reason, the dielectric material must be kept relatively dry above the liquid level. To further avoid measurement errors, the dielectric constant of the insulating material must be appreciably independent of temperature.

The principle of indicating and controlling level by capacitance electrodes may be satisfactorily applied to the measurement of dry granular materials or powdered solids contained in bulk storage bins. One commercially available inventory control system consists of a flexible steel probe (insulated with polyvinyl material), signal detector, transmitter, and indicating meter. The capacitance probe is securely mounted in the storage container which serves as the grounded electrode, to sense changes of electrode capacitance as the material being measured rises and falls along the probe. These capacitance variations, which are proportional to the level or volume of the material, are relayed to the detector which converts the information to d.c. where it is displayed on the indicator scale as a percentage of the maximum height of the material. Since the actual level is affected by the density of the material, the reading may be converted into equivalent weight. This system is also suitable for multi-probe gauging of several bins by means of a selector switch to provide an accurate, instantaneous determination of the quantity of material contained in each bin.

In the pulp and paper industry, capacitance measuring instruments are widely used in automatic processing systems to continuously measure and control the amount of moisture contained in sheet materials. Since the efficient production of paper requires that a uniform product be maintained with a specified moisture content, it is necessary to avoid over-drying or under-drying during the final processing.

A unique arrangement is shown in Fig. 7, in which the transducing element utilizes the fringing capacitance between two plates and eliminates the direct capacitance. In this configuration, the capacitance transducer consists of two active electrodes (A and B) and a grounded shield electrode, which are enclosed in a suitable metal housing packed with insulating material. The dielectric material is the fast-moving sheet of paper which travels across the stationary transducer so that the electrodes are placed in close proximity to the surface of the paper sheet. Since the dielectric constant of water is approximately equal to 80 while that for dry paper is close to 2, the effective dielectric constant for the combined materials will vary between these limits. Thus, very small variations in the moisture content of the paper produce relatively large changes in the measured capacitance of the transducer.

The operation of this device depends on the effect of the dielectric fringe field at the edges of the active electrodes, which produces capacitance changes as the moisture of the paper sheet varies from a wet to a dry condition. To eliminate the effect of the direct electrostatic field, a grounded shield electrode is placed between the plates so that any stray capacitance effects have no influence on the active elements. In Fig. 7, the measuring bridge is driven by an oscillator which also furnishes a reference signal to the phase-detector circuit in the converter unit. As the sheet of paper moves past the electrodes, an error signal is produced which is detected, amplified, and applied to a two-phase servometer. Phasing is such that the motor will drive the slide-wire contact (R_B) in the proper direction required to reduce the error signal to zero. The displacement of the slide-wire contact is directly proportional to the capacitance of the sensing element, and hence to the moisture content of the paper sheet. To provide a visual representation of amplitude, the input signal is mechanically linked to the indicator scale which is calibrated in percentage of moisture deviation. The control signal also actuates process controllers which regulate the temperature of a drying chamber through which the moving sheet of paper passes. By this means, moisture content is controlled and maintained within reasonably close limits.

Capacitance transducers, by virtue of their small size, weight, and rugged construction, offer a high degree of accuracy and dependability which are required for industrial use. Furthermore, the infinite resolution obtained with these devices favors the use of capacitance-measuring equipment in modern process instrumentation and control systems. ▲

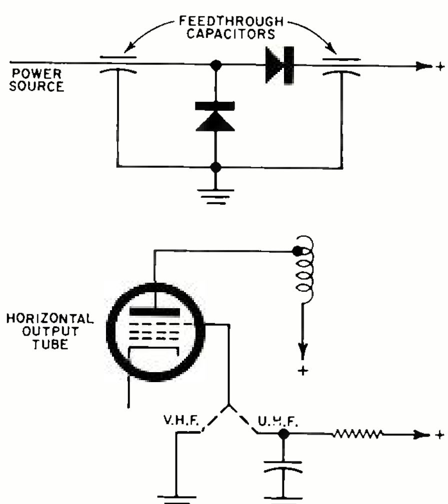
REDUCING U.H.F. TV INTERFERENCE

A COUPLE of minor irritations can be removed from your u.h.f. TV set with some changes suggested by *RCA.*

For some reason, as yet undetermined, silicon and other efficient solid-state rectifiers produce a form of oscillation. These oscillations are radiated by circuit wiring and picked up by the u.h.f. input circuits. They appear on the screen as drifting bars of varying shades and widths and, at times, can extend over the lower half of the screen with the top half normal.

At other times, there can be up to four sets of light and dark bars covering the entire screen. This is most noticeable at low modulation levels.

The problem can be alleviated by the upper circuit shown in the sketch. The feedthrough capacitors at the cathode of each rectifier in the "B+" supply are used to bypass the radiation to ground. These feedthrough capacitors can also be used as a convenient tie point for the silicon rectifiers.



The second irritation is the so-called "snivet" interference that looks like c.w. interference on the screen. The suppression circuit for this type of interference is shown in the lower portion of the sketch. By operating the suppressor grid of the horizontal output tube at a positive voltage, these oscillations either disappear or are moved outside of the TV spectrum.

The level of this bias voltage is critical. Best results are found in the 40- to 50-volt range. Below 30 volts, snivets may still be present while above 70 volts, tube efficiency is impaired. Over 90 volts, both width and high voltage are drastically reduced. In v.h.f.-only sets, the suppressor grid can be grounded. ▲

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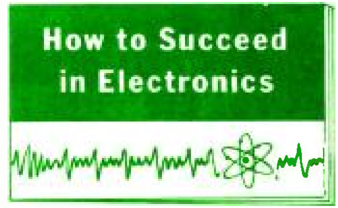

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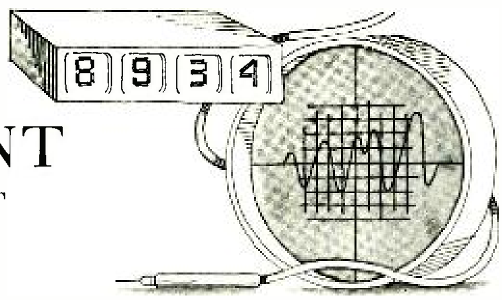
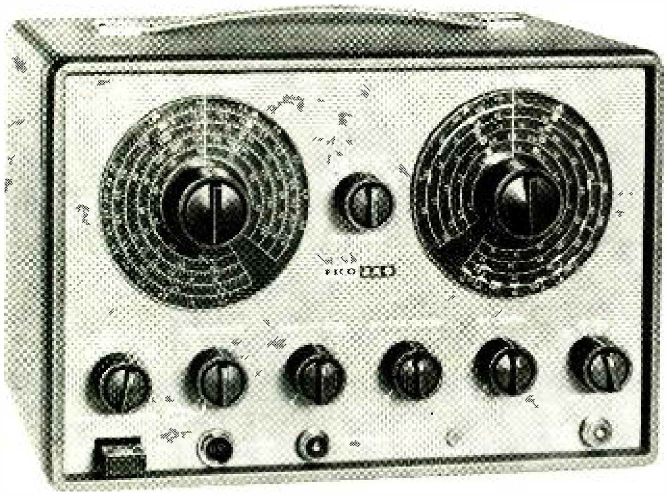


Eico 369 TV/FM Sweep-Marker Generator

For copy of manufacturer's brochure, circle No. 65 on coupon (page 19).



TRYING to re-align a high-quality FM tuner without a sweep signal generator is very time-consuming; re-aligning a TV set without such an instrument is well-nigh impossible. Such a generator will permit the entire r.f. and i.f. response curve to be viewed on a scope. Hence, the effect of any of the many alignment adjustments can be seen instantly. Not only do we need to know the shape of the curve, but exact frequencies along the curve must also be known. Therefore, a marker generator must be used along with the sweep signal generator that traces out the curve shape. Both sweep and marker functions are combined in a single instrument, the *Eico* Model 369 generator.

One problem crops up when trying to mark a sweep-response curve of a receiver. Let's assume we are trying to adjust one of the trap circuits in a TV i.f. amplifier. Since the marker signal is located where response is at a minimum, the marker is attenuated by the trap and it may not be visible at all.

Because of the post-injection-marker technique used in the Model 369, markers are not affected by circuit response. The instrument feeds only the required sweep signal to the input of the circuit being aligned or tested. At the output end of the circuit, a cable picks off the demodulated signal and feeds it to a mixer stage inside the generator. Here, a sample of the sweep signal is combined with the marker-generator and demodulated signals, and the markers are added to the response curve. This combined signal is then fed to the oscilloscope for viewing (see the block diagram below).

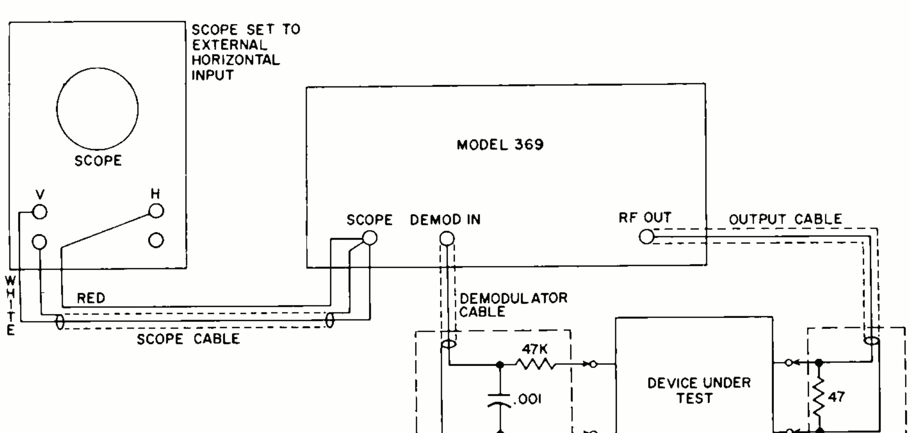
The sweep circuit is completely electronic and uses a controllable inductor for frequency modulation. A sine wave of current applied to the control winding of this inductor results in a sinusoidal change of inductance. As this inductance is in the frequency-determining circuit of the sweep oscillator, the frequency of this oscillator is varied sinusoidally above and below a center frequency. When a sine-wave timing signal is applied to the horizontal input of the scope along with frequency response at the vertical input, a linear display of amplitude *vs* frequency appears on the scope.

The sweep generator has five overlapping ranges from 3.5 to 216 mc. All ranges are fundamentals and tuning is simplified by a 6:1 vernier dial and an expanded scale that occupies nearly all of the entire circular tuning dial.

Retrace blanking is used so that two overlapping response curves are not seen. This is accomplished with a blanking tube that conducts during the negative alternations of the 60-cps sweep. As a result, the sweep oscillator is cut off completely due to a high negative grid bias and the removal of its "B+" during this period of time. A three-stage a.g.c. circuit keeps the level of the swept signal constant over its entire frequency range, even with maximum sweep width (20 mc.).

The independent marker generator, with its own expanded-scale circular dial, covers from 2 to 60 mc. on fundamentals, and 60 to 225 mc. on harmonics. As a check of marker-generator accuracy, a 4.5-mc. crystal is supplied. When plugged into the front-panel socket, it turns on a fixed-frequency marker oscillator that produces crystal-controlled markers every 4.5 mc. Both crystal marker and variable marker can be used to mark a response curve simultaneously. The crystal is also used for sound-circuit alignment of TV receivers.

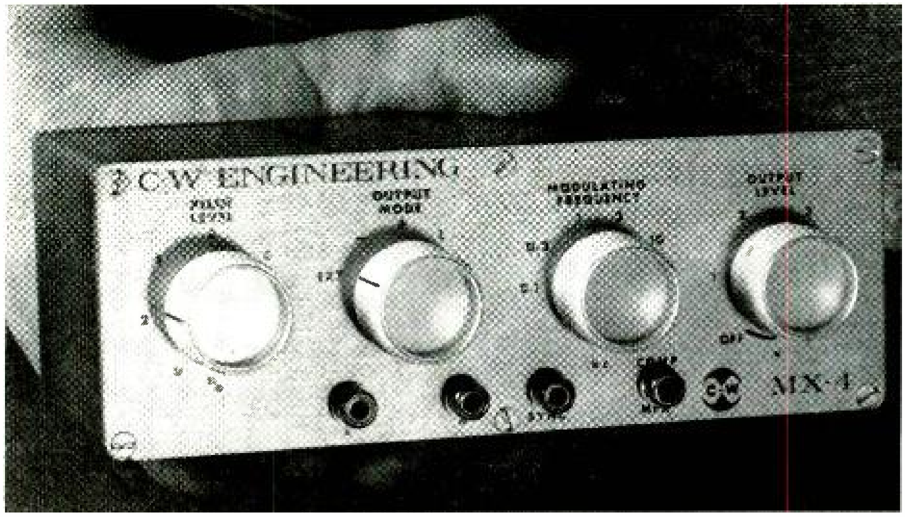
The instrument is available either in kit form at $89.95 or factory-wired at $139.95. A very informative instruction manual accompanies the generator. ▲



C-W Engineering MX-4 Stereo Signal Generator

For copy of manufacturer's brochure, circle No. 66 on coupon (page 19).

THE Model MX-4 by *C-W Engineering* is used to simulate an FM radio station's stereo signals. It can be used to service FM-stereo tuners and receivers from the detector through output stages, as well as stereo multiplex adapters. Its tunable audio oscillator can be used for on-the-spot frequency-response checks. In addition, the generator can be used for new equipment stereo demonstrations on the sales floor.



This battery-operated instrument is fully transistorized, portable, and rugged. It uses a heavy printed-circuit board in an anodized extruded aluminum case. With its leather case it is small and light enough to be carried in a tube caddy, allowing service on home and business custom stereo installations.

The 19-kc. pilot subcarrier is generated in a crystal-controlled pilot oscillator (see diagram). This assures pilot subcarrier stability. A front-panel control varies the pilot subcarrier amplitude from 0 to 12% modulation. Technicians can then measure and adjust "trip level" of stereo alarm circuits. A 19-kc. "sync" jack will provide oscilloscope synchronization.

The multiplex subcarrier doubler-amplifier is used to generate the 38-kc. multiplex subcarrier. This stage doubles the crystal-controlled 19-kc. signal, assuring multiplex subcarrier stability. Balance of the 38-kc. subcarrier is obtained with an internal balance control.

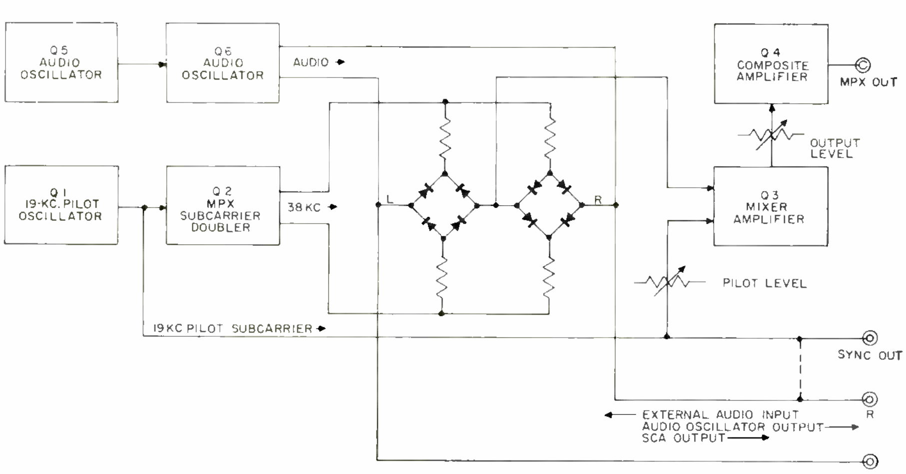
Modulation is selected with an "Output Mode" control. The MX-4 can be modulated with L+R, L−R, L-only, and R-only internal audio signals, or an external stereo signal. When switched to internal modulation, the audio oscillator provides 100-cps, 300-cps, 1-kc., 3-kc., and 10-kc. tones.

"L" and "R" jacks provide audio output terminals to use the unit as a portable audio oscillator. Since the audio oscillator has a constant output voltage, the generator can be used for frequency-response tests from 100 cps to 10 kc. When using external modulation, the "L" and "R" jacks are the input terminals for an external stereo source.

A sixth position of the "Modulating Frequency" control produces the 67-kc. signal used to align 67-kc. filters in

multiplex circuits and in Subsidiary Communications Authorization Equipment (SCA). SCA-equipped FM stations broadcast "commercial-free" background music on a 67-kc. subcarrier.

Output from the diode-ring modulator (L−R signal on 38-kc. multiplex subcarrier) is applied to the mixer amplifier, with the 19-kc. pilot subcarrier. The mixer output is a composite multiplex signal (see oscilloscope photograph). The L+R, pilot, or multiplex subcarrier signals can be separately switched out of the composite signal.



A composite amplifier boosts the output signals, and provides a low output impedance. The output level is continuously variable from 0 to 5.0 volts. The output can directly modulate an FM r.f. signal generator.

The unit operates from one 9-volt battery, assuring hum-free, completely portable operation. Minimum battery life is 65 hours. The MX-4 is stable over variations from 7.5 to 13.0 volts.

Technicians and engineers alike will find the 48-page instruction book clear and concise, yet thorough. The book covers the theory of multiplex stereo, the operation of the generator itself, measuring techniques that are employed, and maintenance instructions for the generator. In addition, a good many sample receiver, tuner, and adapter schematics are included to acquaint the technician with typical multiplex equipment.

The Model MX-4 is compact, measuring 7" x 2½" x 3", and weighs just 30 ounces. It is available directly from the manufacturer at a price of $194.50. This price includes a leather carrying case for the unit. ▲

Waters Model 343 Frequency Meter

For copy of manufacturer's brochure circle No. 67 on coupon (page 19).

THE *Waters* Model 343 frequency meter is a completely transistorized portable device for the measurement of the frequency of repetitive waveforms in the range 20 cps to 50,000 cps. Readout is an analog indication on a 3½" d'Arsonval meter. The meter is calibrated from 0 to 100 and switched multipliers of 1, 2, 5, 10, 20, 50, 100, 200, and 500 are provided. Accuracy is better than ±2% of full scale.

The unit is useful for such jobs as setting the frequency of variable-frequency oscillators within its range, reading the output of magnetic pickups of tachometers, flowmeters and the like, or any other transducer which produces an electrical output for a cyclic occurrence.

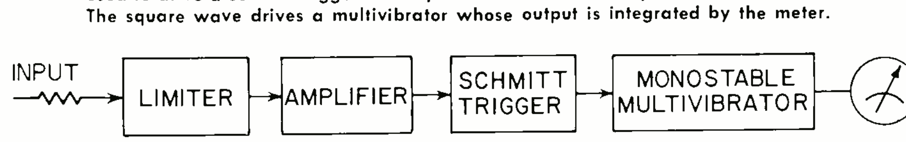
The input impedance is 47,000 ohms nominal to a pair of standard *GR* banana jacks spaced ¾ inch. Input signal voltage range is 50 millivolts to more than 200 volts r.m.s., a.c. peak plus d.c. not to exceed 600 volts. A d.c. output is provided for operating a high-impedance recorder, the output being 1 volt nominal for full-scale indication on any range of the instrument.

Power for the instrument is supplied by a 6-volt manganese-alkaline lantern battery. This voltage is internally regulated in the instrument by a 4.05-volt mercury battery, and a position on the front-panel switch indicates whether the 6-volt battery is within its useful life period. This life is approximately 1000 hours while the life of the reference battery for the voltage regulator is greater than approximately 10,000 hours of operation.

Input to the unit through a capacitor and 47,000-ohm resistor is limited by a pair of diodes (see diagram). The output from this limiter is amplified and squared up by a two-transistor amplifier. This signal drives a Schmitt trigger which creates a constant-amplitude square wave. The leading edge of the square wave is differentiated and is used to trigger a monostable multivibrator. The monostable multivibrator creates a standard-area pulse for each cycle of the input signal and these pulses are integrated in the meter movement. The pulses are filtered to provide a d.c. level for the recorder output of the frequency meter.

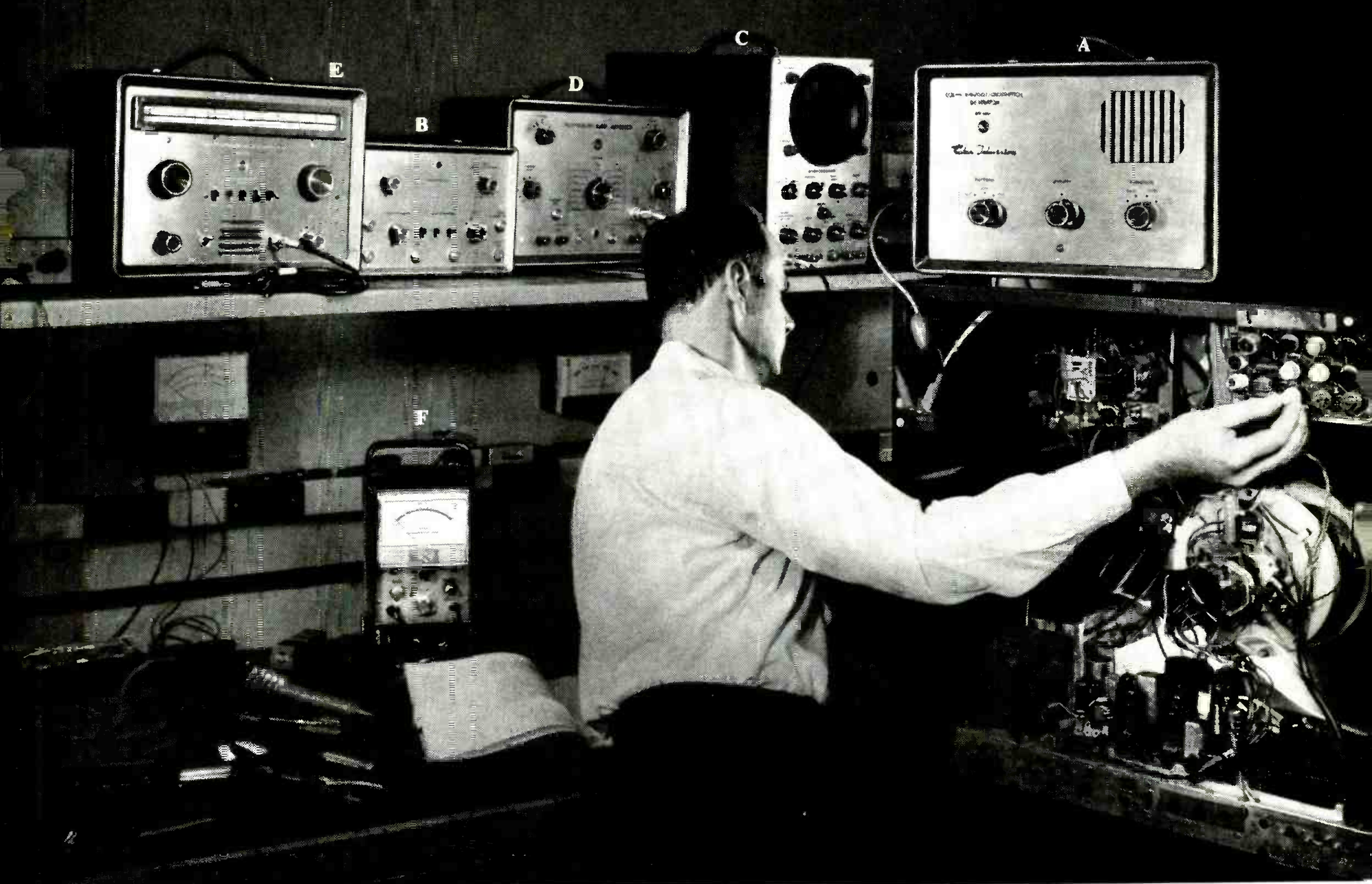
Dimensions of the unit are 4¾" wide, 9" high, 11" deep, and the weight is 12 lbs. The device is operable within specifications from −20°C to plus 55°C. It is priced at $239.95. ▲

Block diagram of the Model 343 frequency meter which illustrates the operating principles involved. Any repetitive waveform from 20 cps to 50,000 cps is applied to the instrument through an RC circuit. This waveform is highly limited by a pair of diodes, then it is applied to a 2-stage amplifier. The output is used to drive a Schmitt trigger which produces a constant-amplitude square wave. The square wave drives a multivibrator whose output is integrated by the meter.



Color-TV servicing is profitable

GET THE MOST OUT OF IT WITH COLOR-TV TEST INSTRUMENTS FROM RCA—PIONEER OF COLOR TV



Making last-minute convergence adjustments on a color-TV receiver with an RCA WR-64A Color-Bar/Dot/Crosshatch Generator.

(A) RCA WR-64A COLOR-BAR/ DOT/CROSSHATCH GENERATOR

Low-cost, lightweight, portable instrument that provides all essential Color-TV test patterns:
• *Color-bar pattern:* ten bars of color for checking phase and matrixing, and for automatic frequency and phase alignment.
• *Crosshatch pattern:* thin sharp lines for adjusting vertical and horizontal linearity, static and dynamic convergence, raster size, and overscan.
• *Dot pattern:* small dots to facilitate accurate color convergence.
$189.50* with output cables

(B) RCA WR-70A RF/VF/IF MARKER ADDER

For use with a marker generator and a sweep generator. Used for RF, IF, and VF sweep alignment in color and B&W TV receivers.
• Choice of four different marker shapes
• Provides very high-Q markers of high amplitude and narrow bandwidth
$74.50* complete with cables

(C) RCA WO-91A 5-INCH OSCILLOSCOPE

A wideband scope for checking colorburst signals and general troubleshooting.
• Dual bandwidth: 4.5 Mc at 0.053 volt rms/in. sensitivity; 1.5 Mc at 0.018 volt rms/in. sensitivity.
• Continuously adjustable sweep frequency range: 10 cps to 100 Kc
$249.50* including direct/low capacitance probe and cable, ground cable, and insulated clip.

(D) RCA WR-69A TELEVISION FM SWEEP GENERATOR

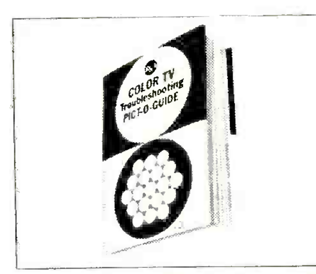
For visual alignment and troubleshooting of color and B&W TV receivers, and FM receivers.
• IF/Video output frequency continuously tunable from 50 Kc to 50 Mc.
• Sweep-frequency bandwidth continuously adjustable from 50 Kc to 20 Mc on IF/Video and FM; 12 Mc on TV channels
$295.00* including all necessary cables

(E) RCA WR-99A CRYSTAL-CALIBRATED MARKER GENERATOR

Supplies a fundamental frequency RF carrier of crystal accuracy for aligning and troubleshooting color and B&W TV receivers, FM receivers.
• Most-used IF and RF frequencies indicated on the dial scale
• Sound and picture carrier markers available simultaneously
$256.50* complete with output cable and phone tip

(F) RCA WT-115A COLOR PICTURE TUBE TESTER

Designed specifically to test color-TV picture tubes, either in or out of the set. Tests each gun for emission quality, inter-electrode leakage and shorts.
• Large sensitive meter with separate 3-color scales
• Provision for accurate adjustment of cut-off point for each gun
$89.50* with cable, carrying case and socket assembly



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RCA **The Most Trusted Name in Electronics**

Noise Figures

(*Continued from page* 35)

being unimportant. Generally, *average* noise figure will be within a half db of *spot* noise figure in 2-meter converters, while the variation will be, respectively, larger and smaller in 50-mc. and 432-mc. units.

Practical Considerations

The minimum noise figure of which a converter is capable is established by its tube line-up. All that is important is that a given converter be adjusted to deliver the best noise figure of which it is capable. This is what manufacturers do during final factory alignment. If the noise figure of the converter in an actual installation is to approach factory performance, however, it is essential that the source (antenna system) into which the converter looks be the same as the source for which it was adjusted. In other words, a converter fresh out of the shipping carton, in perfect adjustment, can perform poorly if the antenna and feed system do not have the same terminal impedance as that of the factory noise source.

Before any adjustments are made to a new low-noise commercial converter, the antenna system should be studied. Is the s.w.r. close to unity? Is antenna system loss contributing more to poor noise performance than the converter itself? The author has seen many amateur v.h.f. installations and concludes that most could be dramatically improved by the simple expedient of cleaning up the antenna system.

The quest for good noise performance begins with the antenna which, in most classical designs, will have a moderately high feedline terminal impedance—300 and 450 ohms are quite common. It is the *usual* practice to make a balun transformation at the antenna and to feed the system with coax. This is an unfortunate approach. The ideal technique is to mount the converter in a weatherproof enclosure at the antenna (this is the method used in most major space-tracking systems). Next best is to feed the antenna with open-wire line, preferably some multiple of an electrical half-wavelength long. The balun transformation (to the usual 50-ohm converter input impedance) should be made at the *converter end of the line.* Revising the antenna feed system along these lines will have the same effect as lowering converter noise figure by some number of decibels . . . about 2.5 db if the original 2-meter feedline was a hundred feet of RG-8U, more if the line was RG-58 or RG-59. Since this change in system has a beneficial effect on *transmitting* as well as receiving performance, it is highly recommended.

The final pruning of the antenna, feedline, and balun should be done with the transmitter and s.w.r. bridge. Measure the length of the sensing element of the s.w.r. bridge from the input fitting to the output fitting. Now make a cable of RG-8U of sufficient length so that the total of the bridge-sensing element plus cable is 26⅝" from fitting to fitting, which equals an electrical half-wavelength at 146 mc. Connect a good 50-ohm resistive dummy load to the s.w.r. bridge output and tune up the transmitter for the lowest s.w.r., which should be very, very close to unity. Disconnect the dummy load and connect the antenna without retuning the transmitter. If the antenna proper, feedline, and balun are all properly cut and tuned, the s.w.r. will be no higher than 1.2, any higher value indicating the need for reworking the system.

For any frequency other than two meters, the technique of making half-wavelength tuned lines is to divide 325 by the frequency, which equals the length of RG-8 or RG-58 cable in feet. For the main open-wire feeders, an electrical half wave, in feet, will be about 470 divided by the operating frequency.

With the antenna system cleaned up, the next step will be to adjust the converter for best noise figure permitted by the particular tube line-up. (At two meters, this will be between 2 and 2.5 db for a converter using 7077, 416B, 6299, or 7588 tubes and a half db higher for nuvistors, 417's, and similar triodes. Bearing in mind the difficulties in absolute measurement, these figures are mentioned not for purposes of comparison, but as an indication of the probable performance of a properly adjusted converter.) There are several methods of making the adjustment for best noise figure, all predicated on the use of a shot-noise generator to achieve a critical mismatch. It has been observed in many tests, however, that optimum noise figure can be obtained by a rule-of-thumb procedure which requires no test equipment whatsoever.

The receiver used with the converter should be tuned to the frequency at which most operations will take place. The a.v.c. is disabled and the gain is adjusted for quarter-scale "S" meter reading on noise. Peak the r.f. stages of the converter on antenna noise, then re-tune the receiver to a frequency 2% lower than the first converter frequency; for example, if the converter were tuned to peak at 145 mc., then the receiver should be adjusted to receive 145 minus 2.9 mc. or 142.1 mc. Re-peak the converter antenna coil or capacitor on noise, but do not re-adjust any other tuning controls; the converter noise figure will now be best at the initial, higher frequency. ▲

BATTERY CHARGER USES AN SCR

By ROBERT G. DALE

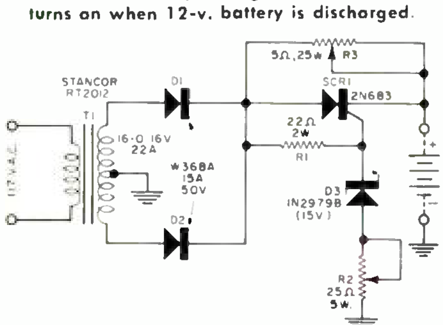
THE SCR battery charger shown in the circuit offers many advantages over most present inexpensive chargers. The SCR will automatically turn the charger off when the battery reaches full charge. If the battery is left connected to the charger for a period of time and the battery potential decreases, the charger will automatically turn on and bring the battery up to full charge. The charger also has provisions for selectable trickle charging during SCR off time.

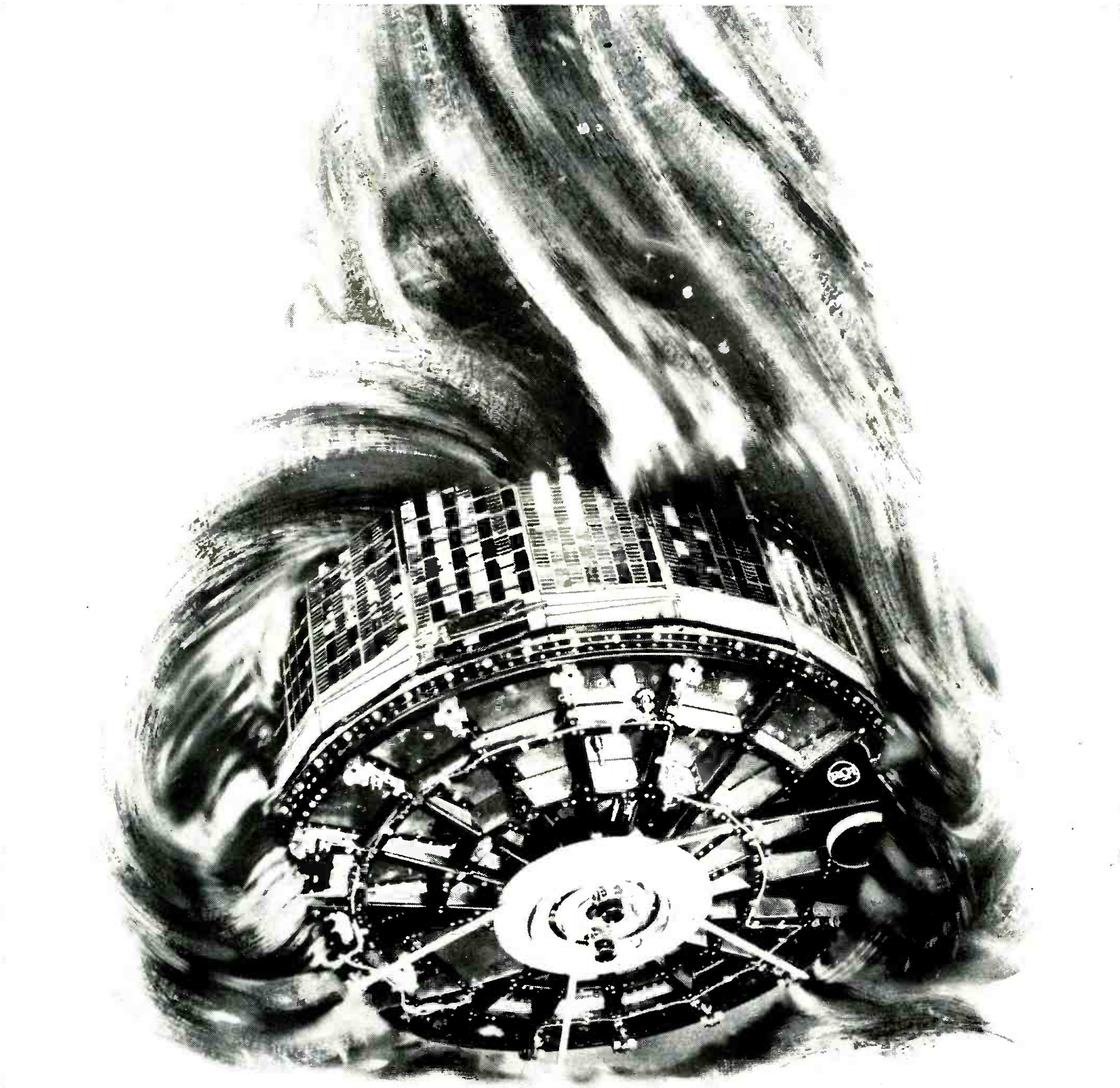
The SCR is a semiconductor device having two operating conditions. One is a blocking, or off, condition and the other is a conducting, or on, state. In the blocking state, no current will flow through the device, therefore the battery would not be charging. In the conducting state, current flows through the device to the battery. The SCR must have a small positive voltage applied to its gate terminals, with respect to the cathode, in order to turn the device on. When the SCR gate and cathode are at the same potential, the device will not conduct and would not charge the battery.

T1, a low-voltage, high-current transformer, has its output rectified by *D1* and *D2* to deliver the d.c. current to the battery through the turned-on SCR. The SCR is turned on by the gate voltage through *R1* produced by the combination of *D3* and *R2*. Zener diode *D3* performs the gate-switching action. When the battery reaches the same voltage as the clipping voltage of *D3* and *R2*, the gate will be at the same potential as the cathode. The SCR will not conduct under these conditions, thus stopping the charging action.

R2 is used since the zener has a tolerance on its clamping voltage. *R3* is the trickle-charge path when the SCR is not conducting. It can be set for any desired charging rate and if lower rates are desired, its value should be increased. ▲

This SCR battery charger automatically turns on when 12-v. battery is discharged.





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DESIGN OF SIMPLE "Q" METER

By DAVID H. SANDROCK

Requiring only an external r.f. source and a v.t.v.m., this handy little device can be used to determine various values of L,C, and "Q".

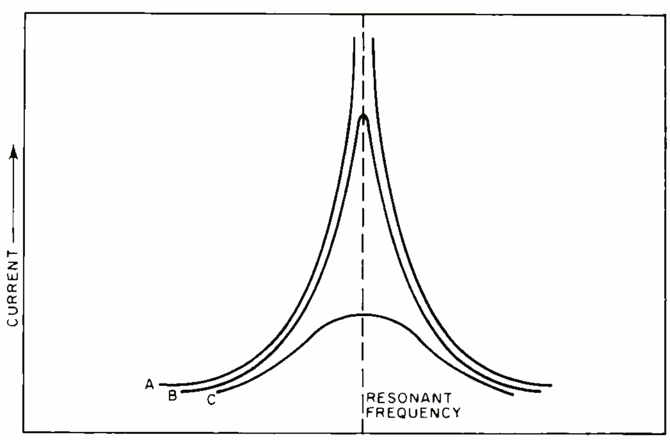


Fig. 1. Current through a series-resonant circuit (A) with zero losses, (B) very low losses, and (C) with high losses.

BESIDES measuring the "Q" of a resonant circuit or inductor, a "Q" meter may also be used to measure inductance, capacitance, distributed capacitance of a coil, and the reactance of an inductor or capacitor.

The instrument to be described in this article will measure capacitance between 1 and 450 pf. directly, although its range can be extended to higher values. Inductance measurement range is from 1 μh. to 12 mh., with this range capable of being extended. "Q" can be determined over a range from approximately 10 to 200, and the useful frequency range is from 100 kc. to 30 mc.

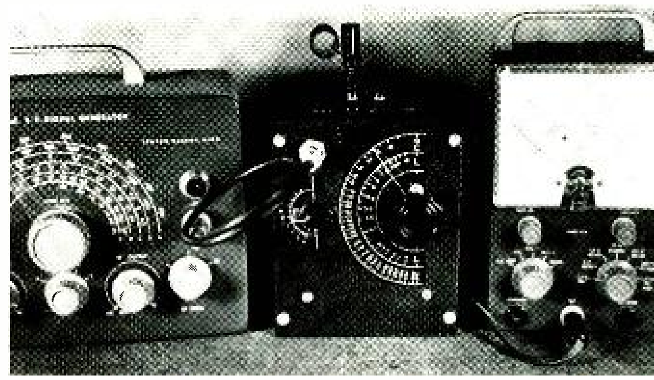
An external r.f. generator and v.t.v.m. are required although a 20,000-ohms-per-volt multimeter may be used in place of the v.t.v.m., but with a loss of about half sensitivity.

Theory of Operation

The shape of the curve of current through a series-resonant circuit is determined by the ratio of the reactance to the series resistance, as shown in Fig. 1 and Fig. 2A. This ratio is called "Q", and the higher the "Q", the less are the losses in the resonant circuit.

This "Q" meter measures the r.f. voltage across the capacitor of a series-resonant circuit (Fig. 2B). The actual v.t.v.m. used is a diode (*V1A* in Fig. 3) which will detect any r.f. voltage present. As the shunt capacitance of the diode is in parallel with the main capacitor *C3* when it is calibrated, it can be neglected in all measurements.

Differential amplifier *V2* has its input isolated from r.f.



External r.f. source and v.t.v.m. complete the "Q" meter.

by *R1*. The output of this circuit is proportional to the difference between its two inputs. The contact potential developed by *V1A* is bucked out by that developed by *V1B*. As the two diodes are matched, equal contact potentials are developed, and the differential amplifier will indicate zero as long as no signal rectification takes place in *V1A*. Power supply variations also have a negligible effect as they are applied equally to each half of the amplifier. Any small differences that do exist in either the diodes or the amplifier can be balanced out by adjustment of potentiometer *R8*.

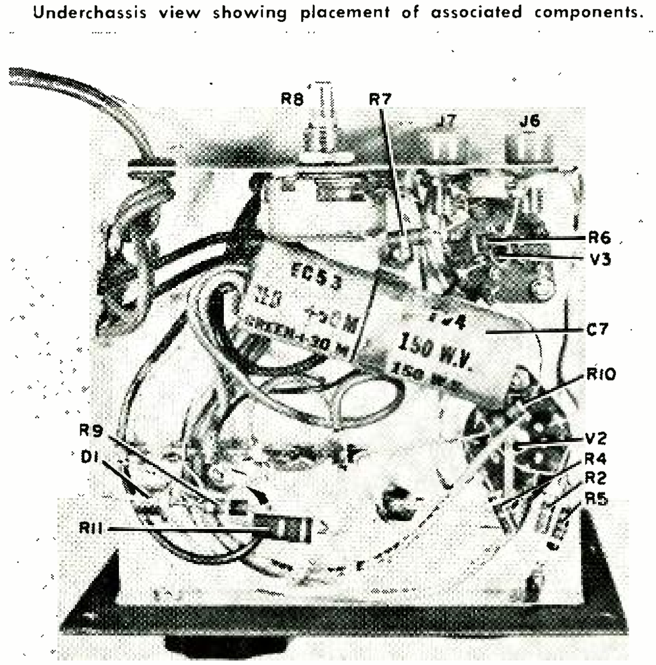
Construction

The instrument is housed in a 4x5x6-inch utility cabinet. A sheet metal chassis is formed and bolted to the front panel as shown in the photographs. Placement of parts on this chassis is not critical, and any convenient layout may be used. As it is not necessary to adjust the balance potentiometer (*R8*) often, it was placed on the rear apron of the chassis. Because the power consumption is so low (less than 5 watts), no power switch was used. In any case, it is a good idea to leave the device turned on for a long period of time for maximum stability.

For the device shown, a broadcast-band superhet tuning capacitor of approximately 15 to 467 pf. was used for the main capacitor *C3*. Any variable capacitor with this approximate value may be used. If the maximum capacitance is not high enough, two sections may be paralleled. Remove any trimmers to obtain a low minimum capacitance.

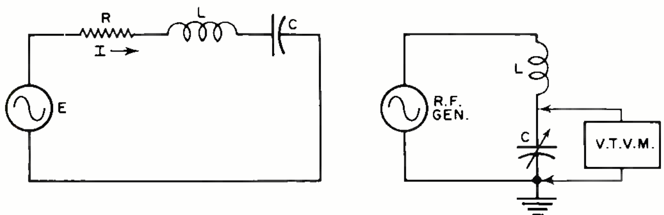
A small bracket to hold V1's socket and associated termi-

Underchassis view showing placement of associated components.



nal strips should be mounted as near to the terminal of the variable capacitor as possible to reduce stray capacitance and lead inductance. Capacitor $C2$ should be mounted with the shortest leads possible between $J2$ and $J5$. This is necessary for proper operation at the higher frequencies. The minimum spacing between the vernier capacitor $C4$ and the main capacitor should also be used. The vernier capacitor is not absolutely necessary, but its use makes some measurements easier and more accurate. Be sure to leave enough room for a reasonably sized dial. About 2″ radius will give a large enough dial for good accuracy. For the dials, black cardboard marked with a lettering pen using white drawing ink may be used. After calibration, the dial should be sprayed with a plastic protective coating.

If desired, a vernier dial can be used to eliminate the need for the vernier capacitor, as such a dial can be read to less than 0.5 pf. The use of such a dial would require that a calibration chart be made for the capacitance and inductance readings. As this is not as convenient as a direct reading dial, it was not incorporated in this particular unit.

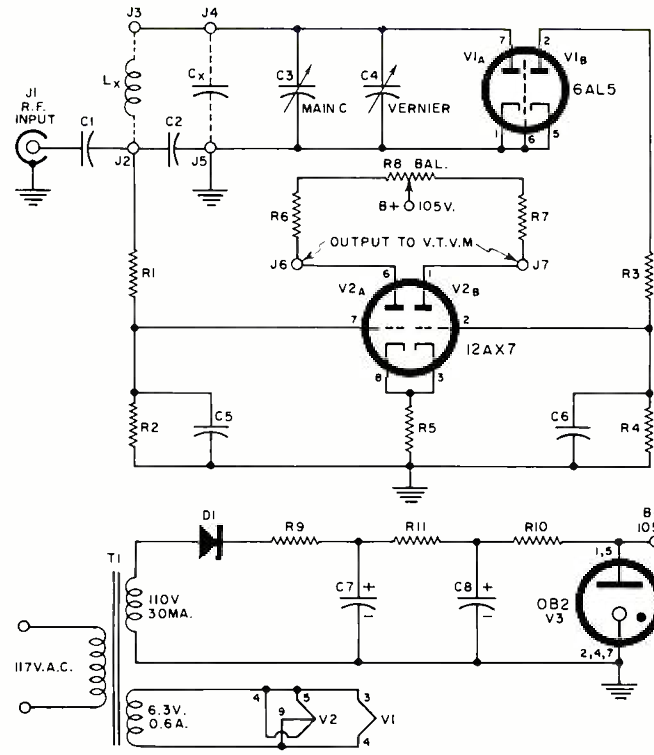


(A) (B)

Fig. 2. (A) Amount of series resistance determines "Q" of series-resonant circuit. (B) Basic circuit of "Q" meter.

The dial pointer for the main capacitor is made from a thin sheet of clear plastic. Scribe a fine line on the reverse side and fill this line with ink of a color that contrasts with the dial. Glue the pointer to the knob.

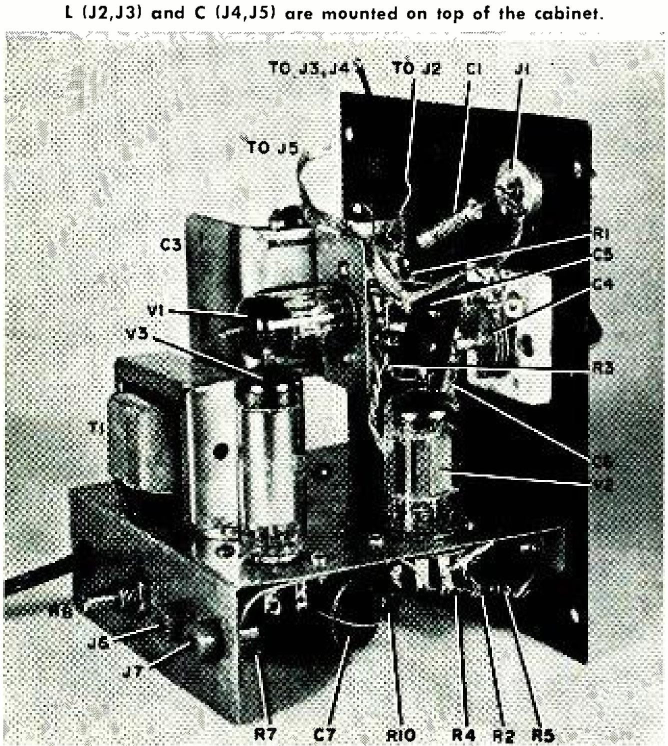
The standard coil (L_X), used for calibration of the capacitor, consists of 100 turns of #30 enameled wire on a form ¾″ in diameter. The wire is closewound with no overlapping turns.



R1,R2,R3,R4—3.3 megohm, ½ w. res.
R5—4700 ohm, ½ w. res.
R6,R7—220.000 ohm, ½ w. res.
R8—50.000 ohm pot
R9,R10—100 ohm, ½ w. res.
R11—4700 ohm, 1 w. res.
C1—.01 μf., 100 v. capacitor
C2—.005 μfd., 500 v. disc ceramic capacitor
C3—15-467 pf. tuning capacitor
C4—3-15 pf. vernier capacitor
C5,C6—0.1 μf., 100 v. capacitor
C7,C8—30-50 μf., 150 v. elec. cap.
J1—BNC panel connector (UG-625/U)
J2,J3,J4,J5—Banana jack
J6,J7—Insulated jack/post
D1—130 v. r.m.s., 30 ma. silicon or selenium rectifier
T1—Instrument trans. 6.3 v. @ 0.6 amp, 110 v. @ 30 ma.
V1—6AL5 tube
V2—12AX7 tube
V3—0B2 tube

Fig. 3. Circuit and parts list for the "Q" meter. To use device, external r.f. source and v.t.v.m. are required.

Chassis of "Q" meter is neat and clean. Jacks for unknown L (J2,J3) and C (J4,J5) are mounted on top of the cabinet.



The finished coil will be about 1.1″ long. The ends of the wire should be looped through two small holes drilled in each end of the form to hold them in place. A heavier wire should also be looped through these holds, and the coil ends soldered to it. Spray the coil with plastic or varnish to protect the fine wire. For convenience, the coil can be mounted on a double banana plug. Inductance should be about 100 μh.

Capacitor Calibration

The frequencies used for calibration must be accurately known. Zero beating the signal against known broadcast-band stations (which must be within 20 cycles of assigned frequency) will yield high accuracy. For required frequencies above the broadcast band, the second harmonic can be used.

Plug in the instrument and allow it to warm up. Connect the v.t.v.m. and signal generator. Connect the standard coil to "L" terminals $J2$, $J3$. Set main and vernier capacitors to minimum. After the "Q" meter has warmed up, adjust the balance potentiometer $R8$ for zero indication on the v.t.v.m. Adjust the signal generator for a peak indication and note the frequency. Calculate the minimum capacitance from $C = 25,400/(f^2L)$ where C is the capacitance in pf., f is the frequency in mc., and L is the inductance in μh.

Fully close the vernier capacitor plates, find the resonant frequency, and again calculate the capacitance. The average of the difference between these two capacitances will be used as the vernier zero capacitance. Calculate the resonant frequency for this capacitance from $f = 159/\sqrt{LC}$ where f is the frequency in mc., L is the inductance in μh., and C is the capacitance in pf.

Apply this frequency and adjust the vernier for a maximum indication. Mark this point as zero on the vernier dial.

Calculate the resonant frequency for capacitance increments of one pf. to a maximum of plus and minus 3 pf. or higher, resonate as before, and mark these points. The half pf. values can be interpolated with reasonable accuracy.

The same procedure is used to calibrate the main "C" dial with the vernier set to its zero position. Recommended calibration points are every 5 pf. from the minimum capacitance up to 100 pf.; every 10 pf. from 100 to 200 pf.; and every 20 pf. thereafter. The intermediate 5 and 10 pf. points can be interpolated and marked on the dial.

The "L" scale can now be calculated and marked on the dial. For a frequency of 7.9 mc., the capacitance required to resonate with 1 μh. is 406 pf. The "L" scale 1.0 is marked at this capacitance. Using this same frequency, capacitance values required to resonate with inductances from 1 to 12 μh. are calculated and marked on the dial. Recommended intervals are in steps of 0.1 from 1 to 2; 0.5 from 2 to 10; and 1 from 10 to 12.

This range can be multiplied by use of the proper frequencies, with frequencies and multiplication factors of 7.9 mc. = × 1; 2.5 mc. = × 10; 790 kc. = × 100; and 250 kc. = × 1000. A small chart with this information can be attached to the "Q" meter case.

These frequencies were chosen for calibration ease. The 250 kc. and 2.5 mc. frequencies can be checked against WWV, while a 790-kc. broadcast station can be used to check the 790 kc. and 7.9 mc. frequencies.

Slide-rule accuracy is quite sufficient for all necessary calculations. An easier method is the *Allied* "R.F. Resonance and Coil Winding Calculator," or reactance charts such as in *Allied Radio* "Data Handbook" or several other reference books. These methods will also give the required accuracy.

For "Q" readings, the voltmeter scale must be calibrated with known voltages. The "L" terminals are shorted, and a low frequency (10 kc. to 100 kc.) is applied to the input. Adjust this input voltage for a convenient voltmeter reading such as 1.0 or full scale. Reduce the input voltage by 3 db or .707 times its original value. Note the v.t.v.m. reading. This is the value to be used for the −3 db points for "Q" measurements. Each different scale to be used for "Q" measurements must be so calibrated, as the diode rectifier is nonlinear.

To measure capacitance up to 420 pf., connect the unknown capacitor across the "C" terminals, set the "C" dial to the lowest capacitance reading, and adjust the input frequency for resonance. Remove the unknown capacitor and adjust the "C" dial for resonance. The difference between the two readings is the unknown capacitance.

To measure capacitance above 420 pf., connect the unknown to the "C" terminals, and resonate with the "C" dial set to its minimum reading. The capacitance is $C_x = (25{,}400/f^2L) - C_{min}$. The inductance used here can be any convenient, previously measured value, or the standard coil.

To measure inductance, the unknown inductance is placed across the "L" terminals, and with r.f. applied, the "C" dial is adjusted for resonance. The inductance is given by $L = 25{,}400/f^2C$. If the dial has been calibrated in inductance values and the proper frequency applied for a given range, the inductance will be indicated directly on the "L" dial.

To measure distributed capacitance, resonate the coil at a convenient frequency with the "C" dial. Call this value of capacitance $C1$. Again resonate at exactly twice the frequency. This capacitance is $C2$. The distributed capacitance is given by the following: $C_o = (C1 - 4C2)/3$. This will not work with values of C_o below about 1 pf. unless the distributed capacitance of the standard coil (about 1 pf.) has been taken into consideration during the "C" dial calibration.

There are two methods of measuring "Q" with this device: frequency variation and capacitance variation. The frequency variation method requires that the r.f. source be accurately calibrated and flat over the range used. For this method, resonate the coil at a known frequency, f_o, then increase the frequency to a value of f_1, such that the output drops to .707 times the peak value. Decrease to a frequency f_2 such that the output again drops to .707 times the peak value. Then "Q" $= f_o/(f_1 - f_2)$.

The capacitance variation method uses a fixed frequency and the capacitance is varied from its original value of C_o to obtain the .707 points with capacitances $C1$ and $C2$. "Q" $= C_o/(C1 - C2)$.

In both of these methods, use the calibrated values for peak reading and the .707 points as determined under "Q" calibration.

To determine reactance, the following formulas are used after the inductance or capacitance has been determined: $X_L = 2\pi fL$ and $X_c = 1/2\pi fC$ where X_L is the inductive reactance in ohms, X_c is the capacitive reactance in ohms, f is the frequency in mc., L is the inductance in μh., and C is the capacitance in μf.

As the ground terminal of the v.t.v.m. is connected to one plate of the differential amplifier V2, the v.t.v.m. case will be about 75 volts above ground. Don't let the two instruments touch, or the signal will be shorted out. As the maximum short circuit current is only 0.6 ma., no shock hazard exists. ▲

ELECTRONIC CROSSWORDS

By DONALD W. MOFFAT

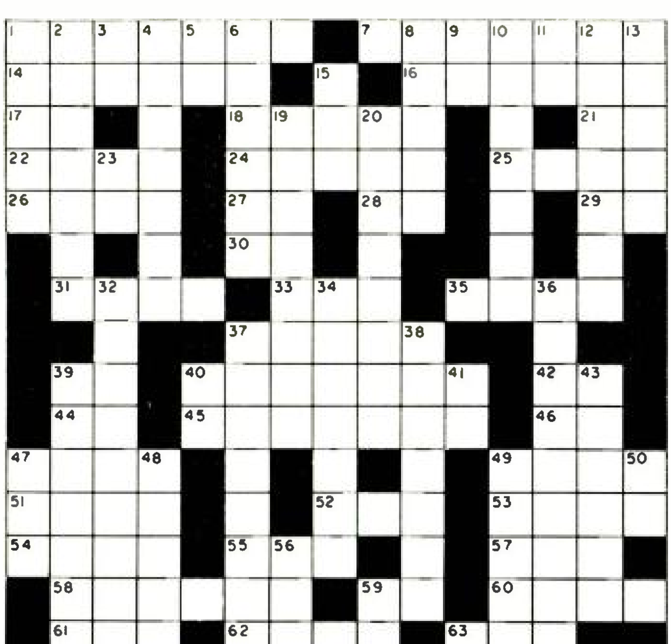
(*Answer on page* 101)

ACROSS

1. Shunted.
7. Tube with region of negative resistance.
14. Service a piece of equipment.
16. Describes tuning with no error.
17. We two.
18. Straight lines extending from the center of a circle to the circumference.
21. Familiar gas used in some pilot lights.
22. Waveform resulting from sudden changes in d.c. level.
24. Common contraction.
25. Unit of weight in the metric system.
26. Reproduces audio faithfully.
27. ....switch connects radar alternately to transmitter and receiver.
28. It pays off at 65 (abbr.).
29. Normal adverbial suffix.
30. Voltage gain.
31. Standard of measure.
33. Peruvian coin.
35. Long periods of time.
37. Water vapor.
39. Universal pronoun.
40. Resistance to change of velocity.
42. Its capital is Pierre (abbr.).
44. In the manner shown.
45. Where young ones get started.
46. Equals power (formula).
47. Cloudlike mass around nucleus of a comet.
49. Covet.
51. Exclamation.
52. Voltage between base and collector.
53. Instruction to the printer.
54. Famous English spa.
55. Cover.
57. Atmosphere.
58. Move unsteadily.
59. You and I.
60. Daughter of Baptista.
61. Wielders of the blue pencil (colloq.).
62. Small, hand-propelled missile.
63. Poetic shortening of preposition indicating time.

DOWN

1. Transmits current to armature.
2. FM center frequency.
3. Symbol for plate current.
4. Causes each cycle to have lower amplitude than previous cycle.
5. American military man.
6. Corrections.
8. Prepare a manuscript for publication.
9. Mode of conduction in a waveguide.
10. Getting distance to a target.
11. Diameter, taking wall thickness into account.
12. Mr. Duck and others.
13. Unfriendly opponent.
15. Lyric poem characterized by lofty feeling.
19. Bypasses lightning to ground.
20. Add a non-conductor.
23. Filament voltage (symbol).
32. Operates without human intervention.
34. Unit of magnetic force.
36. Required.
37. Got close to.
38. Unexplainable in scientic terms.
39. Disassociate.
40. Location.
41. Affirmative (esp. nautical-arch.).
43. Direct away.
47. Front of truck.
48. Residue of fire.
49. Inventor of tunnel diode.
50. Symbol for element used in new solid-state filters.
56. Man's name.
59. Associated with mass (abbr.).



D.C. Current Probe

(Continued from page 43)

range of environmental conditions.)

Incidentally, since the synchronous detector preserves the polarity of the signal, the feedback is always negative. This would not be the case if a simple amplitude detector were used.

The feedback technique also provides a convenient means for switching measurement ranges. The actual output current which corresponds to full-scale deflection of the meter is 50 ma., but the feedback current required in the sensing coils to balance out a 1-ma. current in the measured wire is only 5 μa. By placing a current attenuator on the range switch, the feedback current is reduced enough to match the current to drive the meter. A voltage attenuator, also on the range switch, reduces the a.c. input proportionately so that the loop gain of the instrument is the same on all ranges.

Another interesting aspect of the circuit design of this instrument concerns the technique for doubling the 20-kc. drive signal to 40 kc. As shown in Fig. 6, doubling is performed in the unbypassed common-cathode circuit of the twin-triode oscillator tube. The cathodes "follow" the most positive grid and, as a result, the cathode circuit pulsates at a 40-kc. rate. The cathode signal, after suitable amplification, is used as the synchronous detector gating signal.

The 40-kc. signal also is passed through a phase-shift network and then applied to the output circuit of the probe bridge. This signal bucks out any residual 40 kc. appearing in the bridge output that results from unavoidable small imbalances in the bridge. Control of the network output therefore serves as a zero-set control for the instrument.

Precautions to Observe

As is true of all laboratory instruments, certain precautions must be observed with the current probe to maintain instrument accuracy. Most important is to guard against actions which could affect the magnetic properties of the probe. The probe should not be subjected to any mechanical shocks which could fracture the cores since fractures introduce air gaps in the magnetic circuits which affect performance. The probe jaws should be kept clean, easily done with an eraser, so that no air gap exists where the jaws close together.

Although the jaws are insulated and can withstand voltages up to 300 volts on bare wires, it is recommended that the probe be used on insulated wires.

The instrument readings are little affected by the presence of a.c. with the measured d.c., provided that the a.c. peak value is less than full scale (limit 4 amps peak on 10-amp range).

One further precaution deserves special comment: if there is any residual magnetism in a conductor, the instrument may read 2 to 3 ma. even when no current flows in the wire. Ferrous wires should, therefore, be avoided during measurement as these are most likely to have residual magnetism. Many transistors use ferrous leads, so measurements in transistor circuits should be performed beyond the point where the transistor leads connect into the circuitry. If this is not possible, re-zeroing the instrument, with the transistor circuit turned off, will buck out the reading from the residual magnetism.

A de-gausser is built into the instrument to demagnetize the probe in the event that it has been exposed to heavy currents or high magnetic fields.

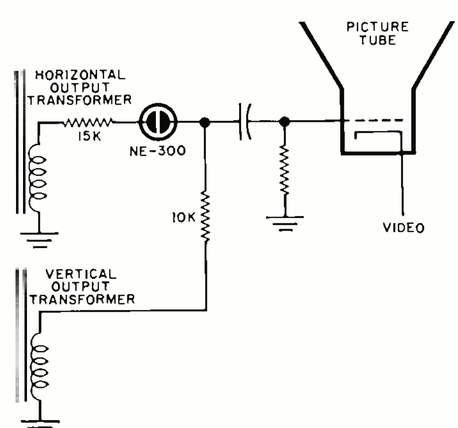
With proper care, a d.c. current probe retains its calibration for long periods and the instrument may be used with confidence for making accurate measurements in a wide variety of situations. ▲

WHITE-BAR BLANKING

Picture tube blanking as used in the late model Westinghouse TV receivers is shown in the accompanying illustration. The circuit was specifically designed to eliminate the white bar sometimes seen on the left of the screen during fringe-area reception. This bar is produced by excessive transmitter or receiver high-frequency compensation in the sync circuits, in the interests of sync stability.

During flyback time, a negative pulse is produced at the secondary of the horizontal output transformer. Ordinarily, this pulse could be used to blank the picture tube, but because of ringing in the flyback transformer, the total signal cannot be used. In the circuit shown, the 15,000- and 10,000-ohm resistors in series with the neon lamp and transformers reduce the amplitude of the negative pulse. The neon lamp will then fire only on the peak negative excursion and will be coupled to the picture-tube control grid.

Vertical blanking pulses are taken from the secondary of the vertical output transformer. ▲

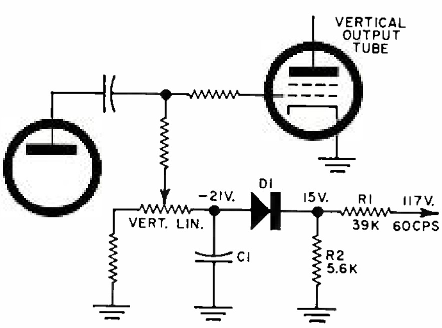


STABILIZING VERTICAL HEIGHT

WHEN there is a change in line voltage, many TV sets exhibit an annoying change in vertical height. Many control circuits have been used to stabilize the vertical sweep during these voltage changes. One of the latest, shown in the sketch, is used in the new *Westinghouse* TV sets.

In a normally operating receiver, the vertical output tube is biased to operate on the linear portion of its characteristic curve. If the bias changes, the picture may appear distorted because of the non-linear operation of the tube. When the line voltage changes, the vertical tube bias will also change.

A simple circuit that automatically adjusts the bias to changing line conditions is shown in the sketch. When the a.c. power is applied to the set, it is also applied to diode *D*1 through voltage divider *R*1 and *R*2. The voltage divider reduces the line voltage to approximately 15 volts. The negative output



from the diode is filtered by *C*1, and applied to the vertical output tube control grid through the linearity control and its associated resistors.

When the line voltage goes up, the set's "B+" also goes up, causing the vertical output tube to conduct more, thus increasing picture height. Similarly, a decrease in line voltage decreases the picture height.

However, in the new vertical height stabilization circuit introduced by *Westinghouse*, as the power-line voltage goes up, rectifier *D*1 produces a greater negative voltage. This voltage is applied to the vertical output tube, increasing the bias and thus reducing the height of the picture.

If the line voltage should go down, then the negative voltage being applied to the vertical output tube is reduced, increasing the picture height.

If the vertical height is properly adjusted at nominal line voltage, then variations around that line voltage will not drastically change picture height. ▲

Tube Innovations

(*Continued from page* 55)

also give rise to the evolution of gas, causing "gassy" tubes.

The plate, in addition, should have good heat emission qualities to prevent inordinate temperature rise.

These several factors are provided by an alloy called "copper-cored aliron," which consists of a layer of copper sandwiched between two layers of aluminum-clad steel. The copper provides good thermal conductivity, while the aluminized steel offers a dark surface that is a good heat radiator. Tubes with greater plate dissipation can be constructed in smaller envelopes through the use of this material.

A definite plate area is needed for a given plate dissipation, and thus presents a design problem where v.h.f. or u.h.f. operation is contemplated. Spacing must be close to reduce transit time, and a large plate tends to increase undesired interelectrode capacitance. Fig. 3 shows one solution to the complex problem of locating elements for optimum performance. The electrodes are kept close together, especially the cathode and grids. The plate is designed so that the beam deflection plates will direct the electron stream to an active part of the plate which is close to the other electrodes. The remainder of the plate which is needed for the required dissipation is mounted further away. By designing the tube in this manner, a rigid construction is obtained with low interelectrode capacitance and good power output at higher efficiencies.

Nuvistors

The *RCA* "nuvistor" is a new approach to receiving tube design. Elements are spaced close together, employing a type of construction not uncommon in transmitting tubes, in which all the electrodes are supported from a common base with a minimum of insulating material in between. The elements are mounted on a ceramic base wafer, and the assembly is enclosed in a metal shell. The use of metal and ceramic materials with no glass permits operation at higher-than-usual temperature. Plate area is small and the tube is simply allowed to run hot. Transit time and interelectrode capacitances are small, however, and most nuvistors are capable of u.h.f. operation.

Nuvistors are made with mutual conductance of about 15,000. They are quite rugged and are capable of good performance under conditions of severe shock, high temperature, and extreme altitudes.

A typical nuvistor (Fig. 1) measures only 0.8 inch over-all in length, from the top of the cap to the bottom of the indexing lugs, with little more than ½ inch above the chassis. It is only 0.435 inch in diameter at the widest part. Nuvistor heater power requirement is low, being only 135 ma. at 6.3 volts. Plate voltage is typically 110 volts. However, a nuvistor has been designed which operates with only 24 volts on the plate, giving low-noise in the lower u.h.f. region, making it suitable for u.h.f. TV use.

Compactrons

A different approach is found in the *G-E* line of "compactron" tubes which have all-glass envelopes and 12-pin bases. They come in two diameters—1.188 inches and 1.563 inches—and range in bulb height from 1½ inches to 3¾ inches.

Most compactrons are multifunction tubes, usually designed for specific applications. The 30AG11, for example, contains two high-μ triodes and two diodes, and is intended for FM stereo multiplex service. The 33GY7 contains a high-perveance diode and a beam-power pentode, and is meant for use as the damping diode and the horizontal-deflection amplifier in television receivers. The 6AR11 contains two twin pentodes for television i.f. amplifier circuits.

Combining several tubes in a single, large envelope has several advantages. The initial cost is less than the sum of the tubes replaced, numerous jumpers are eliminated, leads can be shortened, and more compact circuitry is possible. Because of increased bulb size, operating temperature is lower. The extra pins allow greater than usual versatility in design. Two pentodes, for instance, can be combined in a single envelope without sharing common connections. *General Electric* reports an average life expectancy of 5¼ years for compactron tubes as compared with 2¾ years for conventional vacuum tubes.

Looking Ahead

A further step, still in the experimental stage, is the "circuitron" developed by *Sylvania*. These devices combine integrated circuits consisting of both active and passive components in a single envelope. In this way, multivibrators, class-A amplifiers, logic circuits, and similar functions are available in a single, self-contained package. A complete flip-flop circuit, for example, has been built into a conventional 9-pin miniature envelope—the size of a 12AU7. It includes seven resistors, three capacitors, two triodes, and two diodes. The passive circuit elements are built on substrates positioned on the header.

As circuits and functions become more standardized, there is reason to believe that an increasing tendency will prevail to simplify circuitry by placing elements such as resistors and capacitors inside the tube envelope. ▲

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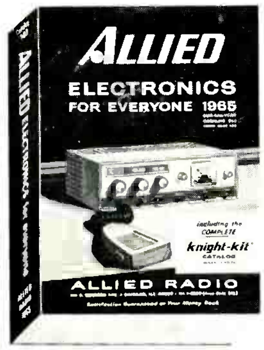

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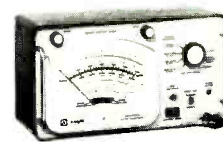

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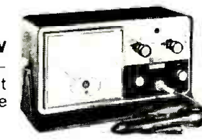

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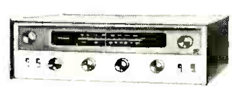

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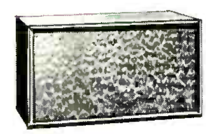

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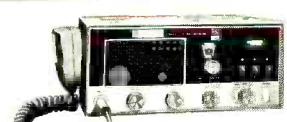

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NEW PRODUCTS

Additional information on the items covered in this section is available from the manufacturers. Each item is identified by a code number. To obtain further details, simply fill in the coupon appearing on page 19.

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

DECADE RESISTANCE STANDARD

1 **General Resistance, Inc.** is now offering a new high-precision decade resistance standard featuring ±.0025% accuracy and low reactance (less than 0.1 phase angle at 10 kc.).

The Model RDS-615 contains six dialable decades with individual controls and numeric dis-

plays for each decade. The resistance standard covers the range from 1 ohm to 1,111,110 ohms. A calibration chart noting the accuracy of each decade and each resistor is included with each RDS-615, assuring calibrated accuracy of ±5 parts per million.

The instrument is available as a rack-mounted unit measuring 19" w. x 7" d. x 3½" h. or in an optional walnut case.

LAB/INDUSTRIAL TUBE TESTER

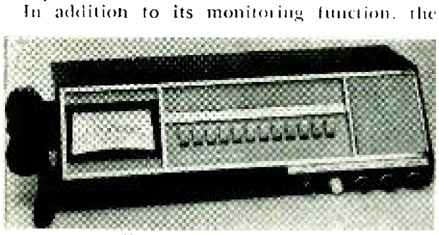
2 **The Hickok Electrical Instrument Company** is now marketing the Model 580 tube tester which features a complete range of test potentials that permits setting test conditions directly from the tube handbook without reference to the roll chart.

The circuit is completely solid-state and features a transistorized gas test circuit which permits measurement of gas effects down to 0.05 μamp. Other features include four μmho ranges, leakage that can be read directly on the meter, sensitivity to 50 megohms, push-button test of dual tubes, and plate, grid, and cathode jacks which permit access to these elements under test conditions.

AUTOMATIC HEART MONITOR

3 **Fisher Berkeley Corporation** is now offering the "Ektacom" automatic heart monitor which automatically monitors the hospital patient's heartbeat and, if the rate rises above or falls below limits that the doctor has established, sounds an alarm at all nurse's stations and over the patient's door.

In addition to its monitoring function, the



new system allows the nurse to both listen and talk to the patient. The system is designed primarily for use with post-operative patients and cardiac cases.

LIGHT-CONTROL UNIT

4 **International Resistance Company** is distributing a new line of full-range lighting controls for commercial, industrial, or residential applications.

The "Capri" fits standard-depth wall boxes and is installed in the same manner as an ordinary switch. Models are available for controlling incandescent lamps only or both incandescent and fluorescent lamps. A built-in voltage synchronizer switch allows complete circuit break when the control is in the "off" position. A toroidal core filter eliminates radio and TV interference and protects the semiconductor components.

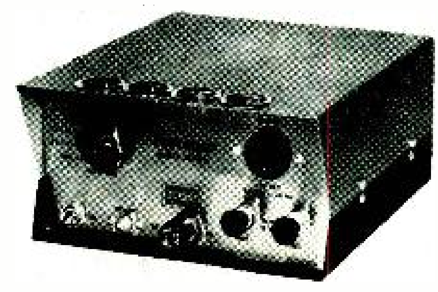
An aluminum alloy mounting bracket dissipates heat from the control through the faceplate, protecting the rectifier from excessive heat and insuring longer life and greater reliability.

The Model D-6 is designed for residential 600-watt incandescent applications while other models are available for up to 72 40-watt tubes.

COMPACT INVERTER

5 **Cornell-Dubilier Electronics Division** is now marketing a compact, modern inverter for powering portable TV sets from a 12-volt battery. The 12TV12 is suited for automotive, marine, house trailer, and camp applications as a source of a.c. power independent of power lines.

In addition to operating portable TV, a special switch tap is provided for radio receivers,



dictating machines, phonographs, shavers, and other transformer-operated equipment with a 75% to 100% power factor not requiring more than 120 volts.

For remote installations, a special remote-control head is available. Other accessories include an input fuse for battery protection, dashboard mounting kit, and a lead kit.

MULTI-PEN RECORDER

6 **Rayflex Division of Phillips-Eckardt Electronic Corp.** has introduced the "Polypen," a new multi-pen recorder available with as many as five pens that traverse the full paper width.

The unit features ball-point pens to overcome the liquid ink hindrance to portable operations. Paper is loaded and unloaded at the top of the unit, which also offers a convenient open writing space for making immediate notations on the recording chart.

Designed for use in the field, in the lab, or in permanent installations, it can be used as a readout device for analytical research and process instrumentation, direct recording of d.c. voltages, and analog recording (with appropriate transducers) of physical, chemical, and electrical properties.

TRANSISTOR U.H.F. CONVERTER

7 **JFD Electronics Corporation** is now offering a new series of transistorized u.h.f. converters covering channels 14 to 83.

The Models CR1-J and CR2-J are completely solid-state converters having a tuner noise figure of only 11.5 db. Frequency drift is not more than 250 kc./sec. Both units have illuminated horizontal slide-rule scales and a logarithmic calibration scale on the channel dial to facilitate channel location.

The Model CR1-J is designed for local area and suburban use and has one transistor in the oscillator circuit and a mixer diode. The CR2-J converter has two transistors—one each in the oscillator tuner and i.f. amplifier stage—and is designed for fringe area applications.

RUDDER-POSITION INDICATOR

8 **Heath Company** has added a new rudder-position indicator to its line of marine electronics equipment in kit form.

The MI-11 continuously shows rudder position up to 40° both port and starboard and simplifies close maneuvering at the dock. Although designed to be used on either single- or dual-engine boats, it is particularly useful on dual-engine craft since it permits compensation for current and wind by adjusting the engines rather than the rudder to maintain proper heading. As a result, rudder drag and excessive fuel consumption are eliminated.

The kit comes complete with 25 feet of connecting cable and a 36" phenolic linking shaft for direct physical connection to the rudder shaft. The meter unit is housed in an aluminum case with gimbal mounting bracket for ease of installation in any position. The unit will operate from either 6- or 12-volt storage battery, with a nominal current drain of approximately 300 ma.

NEW CARDIOGRAPH

9 **Sanborn Company** has developed a new lightweight cardiograph which is designed to make the recording of heart action a quick, simplified procedure that can be done even in the presence of relatively severe amounts of electrical noise or interference.

The 500 "Viso-Cardiette" isolates noise from the heart signal to a degree never before achieved; has operating controls logically ar-

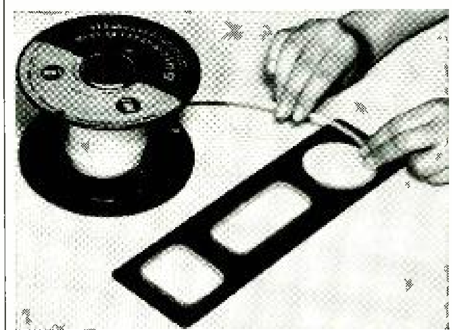
ranged by frequency of use; the locations of patient connection points color-coded to a pictorial diagram directly on the instrument's top panel; simplified chart roll reloading without threading or alignment; and modular plug-in electronic circuits which permit instrument servicing by substituting a new section in two minutes or less.

The instrument utilizes all present-day transistor and solid-state circuitry principles useful in a sensitive chart-recording device of this type.

STRIP GROMMETS

10 **Illumitronic Engineering Corp.** now has available strip grommets in cut or continuous lengths which are adaptable to any shape or configuration where grommets are used.

Trade named "Gromstrips," the U-channel de-



sign feeds around cut edges, grips surfaces, reduces abrasion and noise, and remains intact under vibration.

Five sizes are said to replace hundreds of stock grommet sizes, reduce inventory, and eliminate waste. Standard continuous length packs are 50, 100, and 500 feet polyethelene, nylon, or Teflon.

DUAL-VOLTAGE POWER SUPPLY

11 **Buckeye Stamping Company** has developed a low-cost, high-stability dual-voltage power supply specifically for prototype transistor circuit design and experimentation.

The Model PS-100 is tailored for breadboarding into experimental circuit designs and provides both positive and negative voltages by means of individual controls. Up to 300 ma. can be drawn from two outputs simultaneously. The output voltage range is from 0 to ±15 v. with 10% adjustability.

The regulation against load is 1% change in output voltage for 0 to 300 ma. change in output current. The regulation against the line is ±1% change in output voltage for ±10% change in line voltage. Ripple and noise are less than 5 mv. at 15 volts and 300 ma. output.

The unit measures 7" x 5" x 4" and weighs 2½ pounds.

INSULATION TESTER

12 **Giannini Scientific Corporation** has developed a non-destructive insulation tester, a small-sized, rack-mounted or portable instrument specifically designed to measure insulation or dielectric resistance and leakage values for such small and large electrical and electronic components as capacitors, generators, transformers, relays, motors, wiring, switches, solenoids, and a wide variety of other vital system parts.

The tester offers built-in protection for the operator and also prevents damage to the tested component by incorporating circuits which cut off the high voltage when breakdown threatens.

SQUARE-WAVE GENERATOR

13 **Du Mont Laboratories'** Scientific Instrument Department is now in production on a transistorized square-wave generator with nanosecond rise and fall times and extremely wide operational frequency range.

Designated the "Fairchild Type 791," the new solid-state instrument keeps rise and fall times constant throughout all frequencies from 7 cps to 10 mc. inclusive. A coincident trigger output is provided in addition to the square-wave output. Its timing may be phased to either the rising or falling edge of the square wave to permit alignment of video systems having minimum inherent delay. The repetition rate of the trigger output is the same as the frequency of the square wave.

A front-panel switch provides a choice of either 600-ohm or 50-ohm output impedance.

PHOTOELECTRIC KIT

14 **Edmund Scientific Co.** has packaged a low-cost photoelectric control in kit form which can be used to construct 19 separate light-actuated mechanisms.

The kit includes three T-4 cadmium-sulfide photoconductors measuring ½" in diameter by ½" long; a mounting bracket; a **Sigma** a.c.-d.c. relay (rated 2 amps resistive load); and a 22,000-ohm, 1-w. resistor. Accompanying the parts is a 52-page booklet explaining in detail the steps for constructing the 19 different circuits. Featured are plans for building annunciators, volume controls, lightmeters, tachometers, counters, and other light-actuated electronic devices.

A.C. DECADE VOLTAGE SOURCE

15 **Idalec Electronics Corp.** has announced the availability of the Model 200 a.c. decade voltage source, an easy-to-dial unit which provides digital readout to 999 volts in one-volt increments and output accuracy of ±0.5%.

The unit can be used for the recalibration of a.c. meters, transformer testing, voltage comparison, nulling, design of rectification circuits, and other applications requiring an accurate, easily adjusted a.c. voltage source. Input, at 117 volts, can be any frequency from 60 through 1000 cps. Output is adjusted in three decades by front-panel rotary switches which provide in-line window display of the voltage setting in units, tens, and hundreds of volts.

LIGHT-ACTIVATED PHOTOSWITCHES

16 **Sarkes Tarzian, Inc.'s** Semiconductor Division has announced a line of light-activated photoswitches which are capable of handling substantial amounts of a.c. power without further amplification. The 200-ma. devices are designed for card and tape readout, relay replacement, counting and sorting, SCR triggering, and appliance control. They are electrically isolated from the trigger source but can be activated with light intensity as low as 100 footcandles at 5 volt bias and 2500 K color temperature.

Spectral response is from 3500 to 12,000 angstroms with maximum response at 8000 angstroms. Voltage ratings are available from 20 to 400 volts on p.i.v. and v.b.o.

TRANSISTORIZED INVERTER

17 **Terado Corporation** has recently added the "Galaxy" inverter to its line of power supplies. This new solid-state unit changes the

regular 12-volt storage battery current of a car or boat to 117-volt filtered a.c. A manual frequency and output voltage control is provided.

Capacity of this inverter is 150 to 175 watts to operate tape recorders, record players, hi-fi equipment, portable TV sets, lights, and low-powered home appliances.

The unit is housed in a heavy gauge copper-clad case with carrying handle. It measures 10¾" x 6" x 6" and weighs 10½ pounds.

SUBMINIATURE CIRCUIT BREAKER

18 **Airpax Electronics Incorporated** has developed a subminiature electromagnetic circuit breaker, the APL, to provide an overload device housed in the smallest possible package.

Current ratings are from 50 ma. to 20 amperes. It operates in circuits up to 240 volts r.m.s., 60 to 400 cps, and to 50 volts d.c. A minimum of 10,000 operations is guaranteed. The units are available in three delay characteristics.

The breaker measures from the top of the bar handle to the bottom of the hook terminals 2.605 inches max. 1.5 inches wide, and .625 inch thick.

LINEAR VIDEO VOLTMETER

19 **Ballantine Laboratories** is now offering the Model 311G linear video voltmeter, a general-purpose instrument for use over a wide range of both voltage and frequency.

The instrument has a frequency range of 10 cps to 6 mc. and features a 1% accuracy full-scale deflection from 40 cps to 1 mc. The 3-db bandwidth is 2 cps to 10 mc. The voltage range is 1 mv. full-scale to 300 volts full-scale in 12 ranges and can be used up to 1000 volts or 10,000 volts with optional accessories.

The instrument is available in both portable and rack versions.

HI-FI—AUDIO PRODUCTS

TAPE RECORDER LINE

20 **Ampex Corporation** has recently added the 2000 series of tape recorders to its line of home machines. The new series includes the Model 2070, a self-contained portable recorder/reproducer; the Model 2080, a tape deck in a walnut base; the Model 2050 unmounted tape deck; two speaker systems, Models 2010 and 2011; and the Model 2001 microphone.

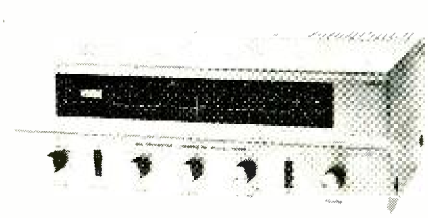
Both the tape decks and the machine provide for recording and playback at 7½, 3¾ and 1⅞ ips. Guaranteed minimum performance at 7½ ips is 50-15,000 cps ±3 db.; at 3¾ ips 50-9000 cps ±4 db; and 50 to 5000 cps ±4 db at 1⅞ ips.

Each model in the line records 4-track stereo & mono and plays 4-track stereo and mono, half-track mono, and full-track mono. Reel capacity is 7 inches.

SOLID-STATE STEREO TUNER

21 **Kenwood Electronics, Inc.** has recently introduced the Model TK-500 solid-state FM-stereo tuner which features a newly developed protection circuit which automatically guards against widespread transistor damage due to a short circuit.

An all-new front-panel design includes automatic relay switching to proper mode, showing



instantly the reception of FM-stereo broadcasts. The unit also features an automatic relay switching adapter, interstation muting circuit, SCA noise eliminator, stereo and tape recorder output, and 24 transistors.

Power consumption is 10 watts at 50-60 cps, 110-120 volts.

WEATHERPROOF SPEAKERS

22 **Oxford Transducer Corporation** has announced the availability of two new weatherproof paging and talkback speakers, the OP-6 and OP-8. The new design assures high efficiency and maximum penetration in high ambient noise level areas, according to the company.

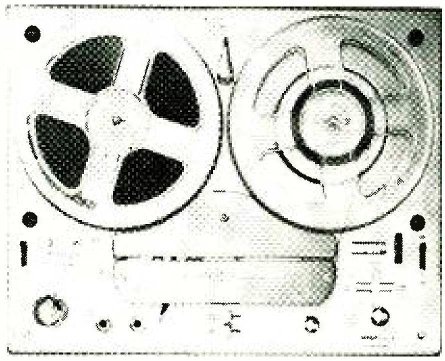
The units feature an integral close-coupled inner horn and diaphragm that eliminates conventional phasing plugs and insures perfect impedance match to the outer bell. Both models are molded from "Implex A" which is impervious to weather, salt water, oil, acids, and temperature extremes.

The units are available with built-in 70- or 25-volt constant-voltage transformers with a 15-ohm tap. They can also be supplied without transformers.

STEREO TAPE RECORDER

23 **Tandberg of America, Inc.** is now offering the Model 71B, a 3-speed, 4-track self-contained stereo tape recorder/playback unit.

The unit features an FM-multiplex filter, precision laminated heads, built-in matched speakers, power amplifiers, preamplifiers, pause con-



trol switch, a 4-pole asynchronous motor, two built-in cathode-follower outputs, speaker selection for slide-projector synchronization, and center-channel output for language lab use.

Frequency response at 7½ ips is 30-20,000 cps, wow and flutter is .15%, signal-to-noise ratio is at least 55 db while crosstalk rejection is better than 60 db.

100-WATT BOOSTER AMPLIFIER

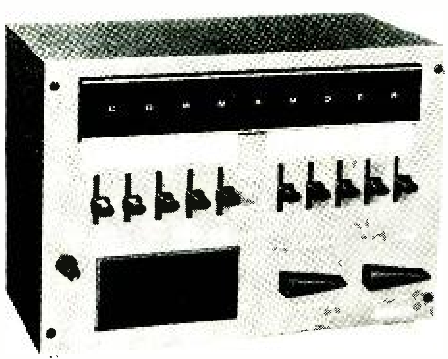
24 **Bogen Communications Division** has introduced a high-performance 100-watt booster amplifier designed for continuous applications which require full power at high and low frequencies.

The Model MO100A provides 100 watts of output from 25 to 10,000 cps at less than 5% distortion. It is usable at slightly reduced wattages for an even wider frequency range. The amplifier can be used as a modular building block in creating inexpensive industrial power sources for unusual voltage-frequency-wattage applications. Completely isolated secondary windings of the output transformer make possible series connection of two or more of the units.

Outputs are 25- and 70-volts balanced and center-tapped and 16-ohm balanced.

P.A./INTERCOM SYSTEM

25 **Harman-Kardon Incorporated's** Commercial Sound Division is now marketing the "Powrcom" series which includes the Model MPC-10 ten-station master consolette, an optional ten-station switchbank which fits directly into the MPC-10 to expand it to 20 stations; an RPS-1 remote station with full facilities for low-level paging, talkback, and call origination; an



SWB-1 switchbox that provides call origination for any loudspeaker in the sound system; a trim panel for mounting the MPC-10 into a standard 19" rack or console; and the JB-14 junction box for interconnection between the master consolette and the speaker lines.

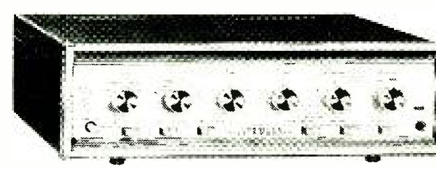
UNDERWATER SPEAKER

26 **LTV University,** division of **Ling-Temco-Vought, Inc.** has introduced the Model MM-2PPS underwater speaker which is completely waterproofed, hermetically sealed, and impervious to underwater environment. The housing is so designed to make flush mounting installation in existing light niches easy. Frequency response is 100 to 10,000 cps with a full-range power capacity of 30 watts. According to the company, the unit will distribute sound throughout a pool up to 30 x 30 feet.

80-WATT STEREO AMPLIFIER

27 **Sherwood Electronic Laboratories, Inc.** is now marketing the S-5500IV, a stereo preamp, control center, and power amplifier in one unit. Designed to be used in home music systems with tape decks, phonographs, and tuners, the new unit features a front-panel stereo headset jack and speaker disabling switch. There is also an integrated powered center channel for the operation of a middle-channel speaker or mono extension speaker systems.

Frequency response of the amplifier is 20-20,000 cps ±½ db. Each channel provides 40 watts of music power or 36 watts continuous at 1½% IM distortion. The 80 watts of music power is suited to driving modern low-efficiency speaker systems. Speaker outputs are for 16, 8, and 4 ohms. The unit also includes 12 db/octave



scratch and rumble filters, tape-deck playback preamps, and a pair of low-impedance outputs for tape recording.

TRANSISTOR STEREO RECORDER

28 **Concord Electronics Corporation** has recently introduced the Model 884, a fully transistorized stereo tape recorder. Featured in the new unit is an A/B monitoring switch which consists of four separate record/playback transistorized preamps, allowing tape to be monitored instantaneously while recording, with a simple panel switch.

In addition, the 884 has a push-button interlocked control and a built-in sound-on-sound switch. Three tape speeds are featured with up to 24 hours of recording possible at 1⅞ ips on a single 3600-foot reel of tape. Separated 7" speakers, a 15-watt stereo amplifier, and two illuminated vu meters are also included.

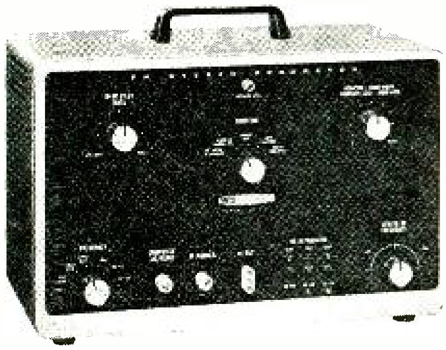
Frequency response at 7½ ips is 40-16,000 cps ±1.5 db. Signal-to-noise ratio is better than 60 db.

FM-STEREO GENERATOR KIT

29 **Heath Company** has recently introduced a new FM-stereo generator, the Model IG-112, in kit form.

This completely self-contained instrument generates an audio or composite stereo signal for multiplex adapter adjustments or an r.f. carrier modulated by these same signals to produce an on-the-air signal similar to those transmitted by an FM station. Instant selection is featured for either right or left channels as well as a special "phase" test for accurate adjustment of stereo subcarrier transformers. No balancing is required for equal right and left channel modulation.

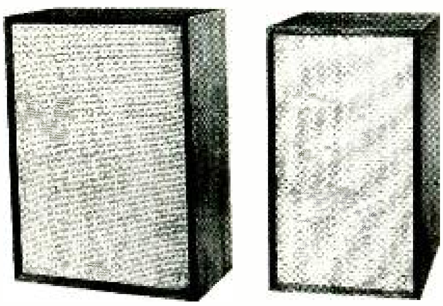
Switch-selected frequencies for modulation or separate use include 400, 1000, 5000, 19,000, 38,000 cps and two special SCA frequencies at either 65 kc. or 67 kc. A crystal-controlled 19-kc.



(±2 cps) pilot signal, adjustable in level from to 10%, is provided to check the lock-in range of stereo receivers.

COMPACT SPEAKER SYSTEMS

30 **Sonotone Corporation's** Electronic Applications Division has announced two new speaker systems, the Model SE-880 (enclosure



with double 8" speakers), and the Model SE-80 (enclosure with single 8" speaker). Housed in hand-rubbed oiled walnut enclosures, the new systems are compact in size and designed to be used for either bookshelf or floor systems. Both are constructed of 3/4" non-resonant panels. The cabinets are lined with "Tufflex" acoustical material.

Response of the SE-880 is 20,000 cps with a power rating of 40 watts, 80 watts peak. Impedance is 8 to 16 ohms. The enclosure is 11" x 24" x 17½". The SE-80 has a system response of 45-20,000 cps, a power rating of 20 watts, 40 watts peak, and an impedance of 8 ohms. It measures 11½" x 20½" x 12½".

TRANSISTORIZED MONO RECORDER

31 **Midwestern Instruments, Inc.** has added the Model 1021 to its "Magnecord" line of tape recorders. Designed for any mono recording application, the tape transport of the new machine is built on a precisely machined rugged die casting to guarantee stability of the tape driving elements. Differential-band braking is used to insure gentle tape handling. A unique single solenoid system is used to actuate the brakes to insure that the braking action on the reels is synchronized.

The electronics are solid-state with regulated power supply and built-in transformers for impedance matching to console or speech equipment. Connectors are standard for broadcast and commercial equipment as are the input and output impedances and levels.

Tape speeds are 3¾ and 7½ ips. The head complement is full-track erase, full-track record, and half-track playback. The transport will accept reel sizes up to 8" in diameter.

CB-HAM-COMMUNICATIONS

MOBILE TWO-WAY RADIOS

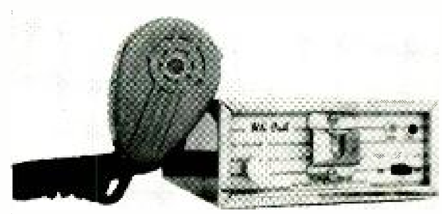
32 **Aircraft Radio Corporation** has recently added two mobile radio units to its line of communications equipment.

The "Cambridge" is an AM or FM dash-mounted mobile unit which operates in the 25 to 174 mc. band. Output is 5 watts on AM or 15 watts on FM. The unit has a fully transistorized receiver, modulator, and power supply. The circuit operates on 12 v. d.c. in the AM mode and 6/12 v. d.c. and 12 v. d.c. in the FM mode.

The second unit, the "Reporter," is an AM dash-mounted mobile unit which operates in the 118-136 mc. band. Output is 1.5 watts and the unit can be used as a base station if desired. Up to 6 crystal-controlled channels are available.

AUTOMATIC TONE-SIGNAL DEVICE

33 **Utica Communications Corporation** is now offering the "Uti-Call," a fully automatic tone signal device. The equipment is always on standby while the microphone remains in its clip. By removing the microphone from the clip, the station is automatically monitoring the



frequency. Keying of the microphone button emits a tone which will activate the receiver of the station called.

The unit can be used on most CB, AM and FM business radio equipment. It is also available in a model that will activate the horn in a vehicle for 1 second when the operator of the receiving station has switched to "horn" position upon leaving the car.

FULL-COVERAGE HAM RECEIVER

34 **Hammarlund Manufacturing Company** has just released an all-new amateur receiver, the HQ170A-VHF, with built-in coverage of 160

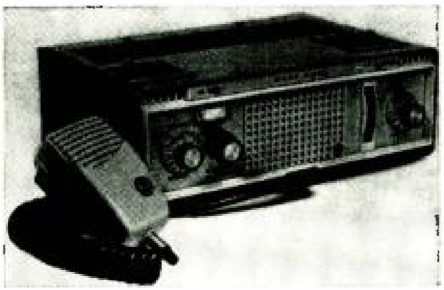
through 2 meters. Separate nuvistor front ends for both 2- and 6-meter bands are complemented by 9 tuned circuits to insure sharp front-end sensitivity and rejection of unwanted signals.

Sensitivity is 0.3 μv. for a 10 db S/N ratio on 6 and 2 meters, i.f. rejection on 2 meters is better than 70 db. The unit is said to have excellent electrical and mechanical stability and expanded vernier tuning.

ULTRA-SLIM MOBILE CB

35 **RCA** Electronic Components and Devices has announced a new two-way CB radio featuring simplified operation and ultra-slim design for small cars.

The "Mark Nine" incorporates a combination meter that indicates the strength of both the transmitted and incoming signals. A new "spotting" switch permits precise manual tuning of



the receiver without the use of receiver crystals. It also permits the user to spot quickly the proper crystal-controlled transmit frequency to respond to an incoming call.

The unit is housed in a rugged metal cabinet which measures only 3½" high x 11¼" wide x 3" deep. Weight of the entire unit, including the ceramic microphone, is 9 pounds. The unit operates on 117 volts a.c. Separate d.c. power supplies for 6- or 12-volt mobile operation are available as optional equipment.

AUTOMATIC RADIO PAGING

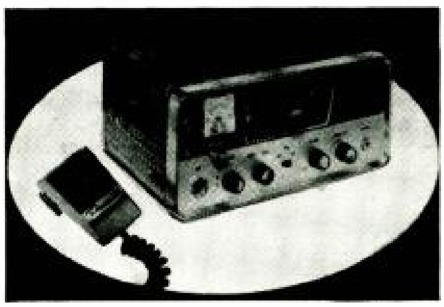
36 **General Electric** Communication Products Department has developed a pocket-paging unit "Message Mate" which permits the selective calling of a specific individual for whom the message is intended without other pocket units listening in.

Designed to work in conjunction with PBX switchboards, the new system permits direct one-way voice messages from any plant telephone to men equipped with the FM pocket pagers. Once the voice message arrives at the PBX, electronic reeds code the transmission and guide the voice to the desired receiver. There is no intermediate operator, and no special equipment is needed at the individual phone. The person originating the call merely dials the radio number of the call's recipient. A beep signal is heard on the signalled pocket receiver, the wearer pushes a button, and then hears the voice message.

CB TRANSCEIVER

37 **Regency Electronics, Inc.** has added the "Romper" to its line of CB transceivers.

The unit provides 8 crystal-controlled transmit and receive frequencies, seven of which are internal. The eighth crystal is plugged into a socket recessed in the front panel. This arrangement allows great flexibility because the operator can insert a crystal tuned to any of the 23 broadcast frequencies he desires.



The transceiver has a dual power supply operating from 117 volts a.c. or 12 volts d.c. The circuit uses ten tubes and 5 diodes. Seven dual-purpose tubes provide 17 tube performance.

A ceramic element microphone with a frequency range of 350 to 3500 cps is included as standard equipment.

AUDIO COMPRESSOR/CLIPPER

38 **Control Radio Labs** is now offering a transistorized audio compressor-clipper-amplifier for use with CB, ham, and commercial radio-telephone equipment. Known as the "Hi-Gainer," the unit offers both compression and clipping in a single package. No internal connections to the transmitter are required. The device is completely self powered by a 9-volt battery. According to the company, the unit allows 100% modulation with normal speech.

The "Hi-Gainer" is designed for use with both mobile and base-station equipment.

AMATEUR STATION KIT

39 **Conar Instrument** is now offering a low-cost novice package consisting of a 3-band high-gain receiver, a 25-watt transmitter, a code key, and an ARRL manual.

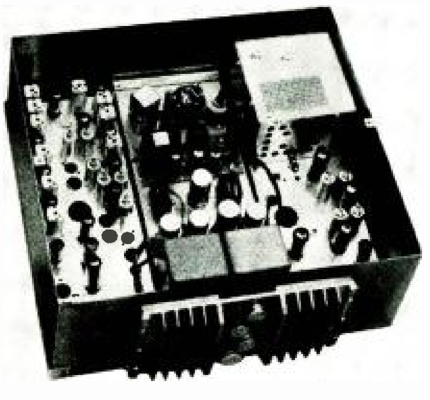
This special combination "station" features transformer operation in both units, easy construction, guaranteed parts and service, and attractive styling. The complete station can be built in just a few evenings.

The receiver provides coverage of the 80, 40, and 15 meter bands, vernier tuning, two i.f. stages, two audio stages, built-in speaker, separate b.f.o., antenna trimmer, variable i.f. gain, headphone jack, and reception of AM, c.w., and SSB. The transmitter features a pi-network output, 3" panel meter, crystal control, and coax output.

75-WATT MOBILE UNIT

40 **Industrial Radio Corporation** has introduced a 75-watt mobile unit as a companion to its 75-watt base station marketed last year.

The "Premiere" Model TM/501L-M mobile provides extended range with a conservative 75 watts output. Both high- and low-band models



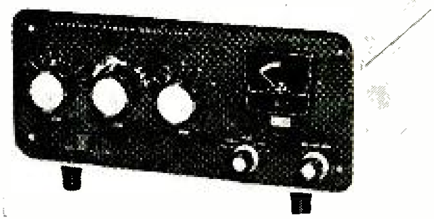
are in production. The transmitter, receiver, and power supply are assembled on separate chassis strips with special attention being given to cool operation and easy maintenance. The chassis is wired for plug-in addition of continuous tone squelch. Standby drain is 2.5 amps.

KW. LINEAR AMPLIFIER KIT

41 **Heath Company** has recently added the SB-200 kw. linear amplifier to its deluxe series of amateur gear.

This completely self-contained desk-top unit provides 1200 watts p.e.p. SSB, and 1000 watts c.w. in a high-efficiency grounded-grid input circuit for operation on the 80 thru 10 meter bands.

Features include a pre-tuned cathode input circuit for maximum efficiency and low distortion, solid-state power supply designed for operation on either 120- or 240-volt power sources, circuit-breaker power-supply protection, two



572B/T-160-L final amplifier tubes, fan cooling, complete shielding for stability and TVI protection, and built-in s.w.r. meter and antenna relay.

SQUARE HALO ANTENNA

42 **Cush Craft** is now offering a square halo antenna for use on the Citizens Band and 6 meter amateur band. Known as the "Squalo," the antenna is a full half-wave, horizontally polarized, omnidirectional unit with 360 coverage without deep nulls.

For mobile operation the antennas are equipped with rubber suction cups for car-top mounting. Fixed-station units are also available for the 10 through 40 meter ham bands.

SSB TRANSCEIVER FOR 2-18 MC.

43 **Stoner Electronics** is now in production on a transistorized SSB transceiver which is designed to provide dependable communications in the 2-18-mc. band. The SSB-100 uses only three transistor types throughout with four crystal-controlled channels selectable throughout the 2-18 mc. frequency range.

The circuit is fully protected against overload. Full operational usage is obtained with a minimum number of controls and adjustments. The unit is powered from a 12 volt d.c. source. The transceiver measures 14" x 5½" x 11" and weighs 12 pounds.

S.W. CONVERTER FOR CARS

44 **Autovox Corporation of America** is now offering an all-transistor short-wave converter, Model OC-401, which is designed to be used with any AM car radio.

The converter operates on all conventional car battery systems and provides reception of

nine short-wave bands (13, 16, 19, 25, 31, 41, 49, 60, and 90 meters). It measures 7-1/16" x 1⅜" x 2⅜" and can be mounted under the dashboard of most standard cars.

MANUFACTURERS' LITERATURE

SCR RATING CHART

45 **International Rectifier Corporation** has published an 11" x 17" wall chart that provides the basic rating information on nineteen different standard, JEDEC, and epitaxial silicon controlled rectifiers.

The rectifiers listed span the current range from 3 to 150 amperes and voltage range (p.r.v.) from 50 to 1300 volts, as well as those with flag terminals and dual-control leads and those exhibiting fast turn-off and higher p.r.v. characteristics.

RECORDED CARTRIDGE TAPES

46 **3M Company** is offering copies of a new catalogue which lists the more than 1500 individual selections now available in cartridge albums for the firm's Revere stereo tape cartridge system.

Selections listed cover a broad range of tastes

ING?

IF YOU'RE A REGULAR SUBSCRIBER TO THIS MAGAZINE, BE SURE TO LET US KNOW YOUR NEW ADDRESS AS SOON AS POSSIBLE.

from popular, jazz, and classical music to original cast recordings of Broadway shows from a wide variety of labels.

PRECISION FILM RESISTORS

47 **Campbell Industries, Division of Clarostat Manufacturing Company, Inc.** lists complete specification on an entire line of precision metal film and deposited carbon resistors in a new six-page catalogue just off the press.

Included are eight types of metal film resistors, including two for military applications under MIL-R-22684, and 16 deposited carbon types with ten applicable to military projects under MIL-R-10509B and -E.

CAPACITOR ASSORTMENTS

48 **Cornell-Dubilier Electronics** has published a 4-page, two-color brochure which describes the capacitor assortment now available to service technicians. The following kits are covered in the brochure: tubular electrolytics, miniature electrolytics, molded Mylar bypass, dipped paper Mylar bypass, 100-volt Mylar film wrap, 600-volt Mylar film wrap, ceramics, and dipped mica capacitors. The assortments are offered in six-drawer cabinets.

GLASS CAPACITORS

49 **Westinghouse Electronic** Capacitor Department has announced publication of a new brochure (93-160) outlining the applications and rating of glass capacitors designed specifically for circuits requiring the ultimate in stability, reliability, and low drift.

In addition, graphs display the operating-range characteristics of capacitance, insulation resistance, dissipation factor, and "Q" factor for the glass capacitors. Also included is a list that cross-indexes military designations with the firm's catalogue numbers.

LABORATORY INSTRUMENTS

50 **Ballantine Laboratories** has published a new 12-page, short-form catalogue which illustrates and describes the firm's complete line of laboratory vacuum-tube voltmeters, a.c.-d.c. linear converters, calibrators, wideband amplifiers, direct-reading capacitance meters, and a line of laboratory a.c. voltage standards 0 to 1000 mc.

SILICON RECTIFIER STACKS

51 **Tung-Sol Electric Inc.** has published a 12-page catalogue covering medium-current silicon rectifier stacks in ratings from 65 to 290 amperes. Detailed specifications are given on single-phase center tap assemblies, single-phase bridge assemblies, three-phase bridge assemblies, and six-phase star assemblies.

The catalogue contains photographs, graphs showing output current as a function of ambient temperature, outline drawings with mechanical dimensions, and a selection chart.

SOLID-STATE DEVICES

52 **Semiconductor Specialists, Inc.** is offering a 24-page illustrated stock and price list featuring the newest semiconductor devices for off-the-shelf delivery.

This distributor's listing includes zener diodes, high-voltage subminiature rectifiers, flangeless package and multiple-cell rectifiers, silicon power semiconductors, low-level integrated choppers, matched diode pairs and quads, microminiature transistors, etc.

The list is intended for design, procurement, circuit, and component engineers who require prototype or production lot quantities.

PC PROCESSING EQUIPMENT

53 **Calumet Manufacturing Company** has prepared a 52-page technical catalogue describing nitrogen burst processing equipment for preparing photographic masters in printed circuitry and microminiaturization work.

The equipment is available for glass plates or film capable of holding process densities as close as ±.02 density units on continuous tone materials and similar consistency on high-contrast materials.

The catalogue also contains descriptions of temperature control equipment plus technical cameras and lenses for precision photography.

INVERTER-TYPE SCR'S

54 **Westinghouse Semiconductor Division** describes fast-switching inverter-type silicon controlled rectifiers in a four-page bulletin (7964) now available.

The bulletin covers the characteristics and applications of a line of inverter-type SCR's rated 4.7, 16, 55, and 110 amperes r.m.s. Each unit is available in forward biasing voltages from 50 to 600 volts.

GLASS CAPACITOR DATA

55 **Corning Glass Works,** Electronic Products Division has published a four-page bulletin on glass capacitors which provides electronic designers with a means of comparing electrical performance of glass capacitors with ceramic, mica, paper, paper plastic, paste electrolyte tantalum, and solid electrolyte tantalum capacitors.

Seven test procedures are covered, with capacitance changes listed for each capacitor type under each procedure.

MASS SOLDERING TECHNIQUES

56 **Hollis Engineering, Inc.** is offering copies of a new booklet entitled "Reliable Mass Soldering Techniques" written by Howard W. Wegener, president of the firm.

The objective is to up-date all facets of automatic soldering and discuss factors contributing to quality assurance in soldering printed-circuit boards. Topics covered include: soldering, automatic soldering, eliminating icicles, oil/solder mix, the correct solder, fluxes, plating, plated-through holes, eyelets and, component lead staking.

TWIST-PRONG ELECTROLYTICS

57 **Cornell-Dubilier Electronics** is offering copies of a new 96-page "Twist-Prong" electrolytic capacitor reference which has been designed to solve the major problems facing the service technician with electrolytic replacement —immediate availability of a proper electrical replacement.

The reference details recommended replacements for every rating in current use. Items are classified by capacity/voltage ratings.

AUDIO PRODUCT CATALOGUE

58 **Sonotone's** Electronic Applications Division is now distributing a new product catalogue covering a complete line of OEM, distributor, and consumer products in the hi-fi and electronic field.

The 16-page publication (SAH-76) illustrates in detail the firm's line of ceramic and crystal cartridges, replacement needles, tonearms, ceramic microphones (including low-impedance types) and learning-lab headset/microphone units. It also covers speakers and new speaker enclosure systems as well as rechargeable flashlight battery cartridges.

ELECTRONIC DIMMING CONTROLS

59 **Hunt Electronics Co.** has prepared an 8-page brochure on electronic dimming controls and systems which pictures and describes an extensive line of dimmer units for home, office, store, church, school, restaurant, factory, and outdoor installations.

Both electronic and mechanical specifications are given along with a complete product selection chart for specifying the correct control for the job.

HI-FI SPEAKER BROCHURE

60 **Jensen Manufacturing Company** is distributing a six-page, two-color brochure which provides complete specifications and prices on the "Delta Series" of 12" and 8" unitary loudspeakers.

Each speaker is illustrated with an actual photograph and a cutaway drawing to show construction.

TAPE CRITERIA

61 **The 3M Company** is offering copies of a technical data sheet entitled "Tape Considerations for Continuous Loop Recording" which outlines the differences between reel-to-reel tape recording transports and continuous-loop transports that govern tape selection.

The bulletin describes a continuous-loop tape cartridge and discusses tension and friction and outlines magnetic coatings and lubricant coatings to meet the requirements.

Bulletin No. 40 in the company's "Sound Talk" series is the publication in question.

HEAT-SHRINKABLE TUBING

62 **ITT Surprenant** has announced availability of a leaflet describing its line of heat-shrinkable tubing.

The "Formtite" tubing is said to conform to almost any shape and is suitable for insulating terminals and pigtails, for jacketing wires to form cables, for providing identifying markers, for shockproofing tool handles, and for leakproofing hydraulic fittings and plumbing. ▲

PHOTO CREDITS

Page	Credit
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27, 30 (bottom right)	Sylvania Electric Products Inc.
28, 29, 30 (top left)	Motorola Inc.
30 (top right), 32	General Instrument Corp.
30 (bottom left)	Zenith Radio Corporation
41	The Hewlett-Packard Co.
55 (Fig. 2)	Amperex Electronic Corp.
57	General Radio Company
74	Eico Electronic Instrument Co., Inc.
75	C-W Engineering
76	Waters Manufacturing, Inc.

Answer to Electronic Crosswords

(Appearing on page 87)

B	R	I	D	G	E	D	■	T	E	T	R	O	D	E
R	E	P	A	I	R	■	O	■	D	E	A	D	O	N
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ELECTRONICS
MARKET PLACE

COMMERCIAL RATE: For firms or individuals offering commercial products or services. 60¢ per word (including name and address). Minimum order $6.00. Payment must accompany copy except when ads are placed by accredited advertising agencies. Frequency discount: 5% for 6 months; 10% for 12 months paid in advance.

READER RATE: For individuals with a personal item to buy or sell. 35¢ per word (including name and address). **No Minimum!** Payment must accompany copy.

GENERAL INFORMATION: First word in all ads set in bold caps at no extra charge. Additional words may be set in bold caps at 10¢ extra per word. All copy subject to publisher's approval. **Closing Date:** 5th of the 2nd preceding month (for example, March issue closes January 5th). Send order and remittance to: Martin Lincoln, ELECTRONICS WORLD, One Park Avenue. New York, New York 10016

FOR SALE

TRANSISTOR Ignition coils, components, kits. Advice Free. Anderson Engineering. Wrentham 5, Mass.

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$100.00 WEEKLY Spare Time selling Banshee TS-30 Transistor Ignition Systems and Coils. Big Demand. Free money making Brochure. Slep Electronics, Drawer. 178ZD, Ellenton, Fla. 33532.

GOVERNMENT Surplus Receivers, Transmitters, Snooperscopes, Parabolic Reflectors, Picture Catalog 10¢. Meshna, Nahant, Mass.

TRANSISTORIZED Products importers catalog. $1.00. Intercontinental. CPO 1717, Tokyo, Japan.

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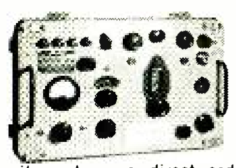
FREE Catalog
OF THE WORLD'S FINEST GOV'T. SURPLUS ELECTRONIC BARGAINS

TS-147B/UP MICROWAVE SIGNAL GENERATOR



Portable unit designed for testing and adjusting Radar, Beacon, and Communication systems operating in the frequency range of 8500 to 9600 MC. Provides either F-M or CW test signals of known power level & frequency. This unit contains a direct-reading freq. meter and a power-level meter which measures power referenced to one Milliwatt (DBM). Used to measure both the freq. and power level of the input and output signals. Spectrum width, frequency change, recovery time, and standing wave ratio. Also can be modulated externally Operates from 115 V. 50-1600 cy.; less cables, plugs, adapter, pick up horn. Size: 11¼ x 18¾ x 12¼".
TS—147B/UP Test Unit, as Photo — Used: **$99.50**
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RT-82/APX-6 RADAR IDENTIFICATION SET —
Receiver-Transmitter covering freq. range of 950-1150 MC. I.F. Freq. 59.5 1.5 MC. (Can be converted to 1296 and 1220 Bands.) With Tubes. (30) 6/6J6, 1/6A56, 1 5687, 1/3E29, 3/6AL5, 1/5Y3, 2 3B24, 3/6AL5, 2 12AU7, 7 6AK5, 1/2C42, 1/2C46, 1 1B40, 1/1N-43, 1/1N-25. Digit Counters, Tuners for Trans.-Freq., Rec.-Freq. and LO Freq. Operates from 24 Volts DC & 115 Volts 400/800 cycle. Shpg. Wt.: 45 lbs. Price — Used· **$16.95**

BC-348 RECEIVER
BC-348R RECEIVER — AM 6 Bands 200-500 KC and 1.5 to 18 MC. Crystal phasing, antenna align., beat oscillator & audiogain controls, vernier and speed tuning, output jacks for phones and speaker. With Tubes: 3/6K7, 1/6J7, 1/6C5, 1/6K6, 1/6B8, & 1/6F7. Voltage required: 24 Volts 2 A. & 220 VDC 70 MA. Size: 18 x 10½ x 9½". Wt.: 38 lbs. Used $89.50
AC POWER SUPPLY — In cabinet with speaker when purchased with Receiver $20.00
DM-28 DYNAMOTOR — 24 VDC for Rec. Used 6.95
FT-154 Shockmounting for Rec. Used 2.75
PL-103 Plug — for Receiver. Used 1.50

Address Dept. EW • Prices F.O.B., Lima, O. • 25% Deposit on C.O.D.'s • Minimum Order $5.00
SEND FOR BIG FREE CATALOG!

FAIR RADIO SALES
2133 ELIDA RD. • Box 1105 • LIMA, OHIO

CIRCLE NO. 181 ON READER SERVICE PAGE

IGNITION! Transistor. Coil, ballast $7.95. Free Parts Lists. Transfire, Carlisle 2, Mass.

RESISTORS precision carbon-deposit. Guaranteed 1% accuracy. ½ watt 8¢. 1 watt 12¢ 2 watt 15¢. Rock Distributing Co., 902 Corwin Road, Rochester 10, N.Y.

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COPYRIGHTED theory gravitation caused by pushing radiation from stars. Important spaceage implications. $1.00 refundable. Carnahan, 4407 Ave. H, Austin, Texas.

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CAPACITORS disc ceramic. 50 assorted $1.00. Hi-Q, NPO, N-750. O. M. Farnsworth, 88 Berkeley St., Rochester 7, N.Y.

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FCC LICENSE in six weeks. First class radio telephone. Results guaranteed. Elkins Radio School, 2603C, Inwood. Dallas, Texas.

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CASH Paid! Sell your surplus electronic tubes. Want unused. Clean radio and TV receiving, transmitting special purpose. Magnetrons, Klystrons, broadcast types. Want military and commercial lab/test equipment. Want commercial Ham Receivers and Transmitters. For a Fair Deal write: Barry Electronics, 512 Broadway, New York, New York 10012 (Walker 5-7000).

PAY cash for tubes, test equipment, TS, URM, UPM prefixes. Commercial lab test equipment, need klystrons, magnetrons, broadcast & power & industrial tubes, ground equipment, PRC, GRC, etc.. For best deal write Bob Sanett, 616 S. Holmby, Los Angeles, Calif. BR 9-1275.

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IMMEDIATE DELIVERY
FULLY GUAR'NT'D NEWEST TYPE
AMERICAN MADE FULLY TESTED

750 MA-SILICON "TOP-HAT" DIODES
LOW LEAKAGE FULL LEAD LENGTH

PIV/RMS 50/35 .05 ea	PIV/RMS 100/70 .09 ea	PIV/RMS 200/140 .12 ea	PIV/RMS 300/210 .16 ea
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ALL TESTS AC & DC & FWD & LOAD
SILICON POWER DIODE STUDS

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

D.C. AMPS	300 PIV 210 RMS	400 PIV 280 RMS	500 PIV 350 RMS	600 PIV 450 RMS
3	.40	.45	.55	.65
12	1.10	1.35	1.50	1.70
35	2.35	2.55	3.00	3.50
50	3.50	4.20	5.25	7.00
100	3.75	4.60	5.65	8.00

"SCR" SILICON CONTROLLED RECTIFIERS "SCR"

PRV	7 AMP	16 AMP	25 AMP	PRV	7 AMP	16 AMP	25 AMP
25	.50	.85	1.20	250	2.30	2.65	3.10
50	.85	1.20	1.40	300	2.60	3.00	3.40
100	1.35	1.80	2.20	400	3.00	3.40	4.15
150	1.60	2.10	2.65	500	3.75	4.25	4.75
200	1.75	2.40	2.90	600	4.00	5.00	5.25

Money Back guarantee. $2.00 min. order. Orders F.O.B. NYC. Include check or money order. Shpg. charges plus. C.O.D. orders 25% down.

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AN/ARN-7 RECEIVER

Frequency range 100 Kc to 1750 Kc in 4 bands. Aircraft navigational instrument comprising superhet receiver and additional circuits. Complete with tubes. exc. cond. $29.50
Accessories for above. available.

AN/APR-4Y FM & AM RADIO RECEIVER

High precision lab instrument, suitable for monitoring and measuring frequency and relative signal strength of signals from 38 to 4000 Mc., in 5 tuning unit ranges. For 110 V 60 cycle AC operation, built-in power supply.
LIKE NEW, SPECIAL $79.50
TN-16, TN-17, TN-18, TN-19 and TN-54 Tuning Units for above in stock. P.U.R.

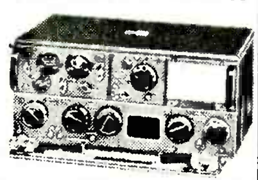
SCR-522 2-METER TRANSMITTER-RECEIVER

Terrific buy! VHF Transmitter-Receiver, 100-156 Mc. 4 channels. Xtal-controlled. Amplitude modulated voice. Complete with all 18 tubes, top rack and metal case. LIKE NEW!
SPECIALLY PRICED .... P.U.R.
SCR522 as above. exc. used $32.50

AN/ART-13 100-WATT XMTR

11 CHANNELS
200-1500 Kc
2 to 18.1 Mc

$79.50 EXC. USED
complete with Tubes



Famous Collins Autotune Aircraft Transmitter. AM CW. MCW. Quick change to any of ten pre-set channels or manual tuning. Speech amplifier/clipper uses carbon or magnetic mike. Highly stable, highly accurate VFO. Built in Xtal controlled calibrator. PPS11s modulate 813 in final up to 90% class "B." A Real "HOT" Ham buy at our low price!
AN/ART-13 XMTR. as above. In LIKE NEW condition. with all tubes and crystal $89.50

0-16 Low Freq. Osc. Coil for ART-13 .... 7.95
24V Dynamotor for ART-13 .... 11.95
We carry a complete line of spare parts for above.

SCR-274 COMMAND EQUIPMENT

ALL COMPLETE WITH TUBES

Type	Description	Used	Like NEW
BC-453	Receiver 190-550 KC	$14.95	$18.95
BC-454	Receiver 3-6 MC	15.95	19.50
BC-455	Receiver 6-9 MC	13.95	19.50

BC946 Receiver 550-1500 Kc Complete with all tubes. Brand New, in original packing $44.95
1.5 to 3 MC. Receiver Brand New $19.95

110 Volt AC Power Supply Kit for all 274-N and ARC-5 Receivers. Complete with metal case. Instructions .... $.8.95
Factory wired. tested. ready to operate $12.50
SPLINED TUNING KNOB for 274-N and ARC-5 RECEIVERS. Fits BC-453, BC-454 and others. Only .... 49¢

2.1 to 3 Mc Transmitter, Brand New $12.95
BC-457 TRANSMITTER—4-5.3 Mc. complete with all tubes and crystal. BRAND NEW $10.75
Like New $7.95
BC-458 TRANSMITTER—5.3 to 7 Mc. Complete with all tubes and crystal.
BRAND NEW $12.95
Like New $7.95
BC-696 TRANSMITTER 3-4 Mc Complete with All Tubes & Crystal. Like New $11.95
BC-456 Modulator .... USED 3.45 NEW 5.95
ALL ACCESSORIES AVAILABLE FOR ABOVE

MICROPHONES Checked Out, Perfect

T-17 Carbon Hand Mike.
Exc. Used $4.45 .... Brand New $7.95
RS-38 Navy Type Carbon Hand Mike.
Exc. Used $3.95 .... Like New $5.75

HEADPHONES Checked Out, Perfect

Model	Description	EXC. USED	BRAND NEW
HS-23	High Impedance	$2.79	$4.95
HS-33	Low Impedance	3.15	5.45
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TELEPHONICS—600 ohm Low Impedance HEADSETS. BRAND NEW. PER PAIR $3.95
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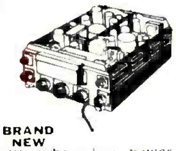
Earphone Cushions for above—pair .... .50

WE BUY FOR CASH

your surplus Military Electronic Equipment
WRITE—WIRE—PHONE

FAMOUS BC-645 TRANSCEIVER

15 Tubes 435 to 500 MC



Can be modified for 2-way communication. voice or code. on ham band 420-450 mc. citizens radio 460-470 mc. fixed and mobile 450-460 mc. television experimental 470-500 mc. 15 tubes (tubes alone worth more than sale price!): 4—7F7, 4—7H7, 2—7E6, 2—6F6, 2—955 and 1—WE-316A. Now covers 460 to 490 mc. Brand new BC-645 with tubes, less power supply in factory carton.
Shipping weight 25 lbs. SPECIAL! $19.50

PE-101C Dynamotor. 12/24V input $7.95
UHF Antenna Assembly 2.45
Complete Set of 10 Plugs 5.50
Control Box 2.25

SPECIAL "PACKAGE" OFFER:
BC-645 Transceiver. Dynamotor and all accessories above. COMPLETE. BRAND NEW.
While Stocks Last $29.50

BC-344 RECEIVER. 150-1500 Kc., continuous tuning. 4-band. for 115 V 60 Cycle AC. Excellent used. perfect working order. complete with tubes. $79.50

BC-342 RECEIVER. 1.5 to 18 Mc. AC Only. Like New. complete with all tubes $79.50

BC-348 SUPERHET RECEIVER 200 to 500 Kc and 1.5 to 1800 Mc. Voice Tone. CW. Self-contained dynamotor for 24 V DC. Exec. Used. Checked out $89.50
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Original Tech. Manual for above .... $ 3.15
AC Power Supply for above. wired $12.95
12-Volt Mobile Dynamotor Power Supply, NEW .... $ 5.50

BC1206-C BEACON RECEIVER

195 to 420 Kc. made by Setchel - Carlson. Works on 24-28 volts DC. 135 Kc. IF. Complete with 5 tubes. Size 4" x 4" x 6". Wt. 4 lbs. LIKE NEW ... $10.95
USED. less tubes $4.95

234-258 MC RECEIVER AN/ARR-2

BRAND NEW 11-tube UHF Tunable Receiver with schematic. Only a few at this low price!
Complete with tubes. Exc. used $5.95 .... $8.88

ARB/CRV 46151 NAVY AIRCRAFT RADIO RECEIVER 190 to 9050 KC in 4 bands: 190-550, 550-1600, 3-6 Mc, 6-9.050 Mc. 6-tube super with local and remote tuning. band change. Complete with tubes and dynamotor. like new $39.50
As Above. brand new $59.50
Power Supply, 110 V AC wired .... $ 8.95

ARC-3 RECEIVER!

Complete with All tubes Exc. Used $21.50
Like NEW $33.50

Crystal-controlled 17-tube superhet. tunes from 100 to 156 MC., AM., on any 8 preselected channels. 28-volt DC power input. Tubes: 1-9002. 6-6AK5. 1-12SH7, 3-12SG7. 1-9001. 1-12H6. 2-12SN7. 1-12SL7, 1-12A6.
110 V A.C. Power Supply Kit for above 15.00
Factory Wired and Tested 19.95

ARC-3 TRANSMITTER

Companion unit for above tunes 100 to 156 MC on any 8 pre-selected channels. 9 tubes. crystal controlled, provides tone and voice modulation. 28V DC Power input. Complete with all Tubes: 3-6V6, 2-832A, 1-12SH7, 1-6J5, 2-6L6. Exc. Used .... Only $18.95
Like new condition $28.50
ARC-3 PUSHBUTTON CONTROL BOX $5.95

Type	Input	Output	Excellent Used	BRAND NEW
DM-32A	28V 1.1A	250V .05A	2.45	4.45
DM-33A	28V 5A	575V .16A		
	28V 7A	540V .25A	4.45	7.50
DM-34D	12V 2A	220V .080A	4.15	5.50
DM-35	12V	625V .225A	—	19.50
DM-36	28V 1.4A	220V .080A	1.95	2.95
DM-42	28V 23A	515/1030/2/8 MA 215/260	—	12.50
DM-43	28V 23A	925V .220A 460V .185A	—	7.95
DM-53A	28V 1.4A	220V .080A	3.75	5.45
PE-73C	28V 20A	1000V .350A	8.95	14.95
PE-86	28V 1.25A	250V .050A	2.75	3.85

(DYNAMOTOR VALUES:)

DM-37 DYNAMOTOR. Input 25.5 V DC @ 9.2 A. Output 625 V DC @ 225 Ma. BRAND NEW. Each $3.25

SCHEMATIC DIAGRAMS For most equipment on this page. each 65¢

Please include 25% Deposit with order—Balance C.O.D., or Remittance in Full. 50c Handling Charges on all orders under $5.00. All shipments F.O.B. Our Warehouse. N.Y.C. All Merchandise subject to Prior Sale and Price Change.

G & G RADIO SUPPLY CO.
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SCR-625 MINE DETECTOR

Complete portable outfit in original packing, with all accessories. Brand New $32.50

VICTOREEN RADIATION DETECTOR

$2.25 Model 506 BRAND NEW, actual value $49.50 SPECIAL, WHILE THEY LAST

LM FREQUENCY METER

Crystal calibrated modulated. Heterodyne. 125 Kc to 20,000 Kc. with Calibration book. Complete, like new $79.50
LM Frequency Meter as above, completely checked out, with tubes and crystal, less calibration book. Exc. Used, clean $34.50

BC-221 FREQUENCY METER

Equipped with original calibration charts. 125 Kc to 20,000 Kc with crystal check points in all ranges. Excel. Used with original Calibration Book, Crystal, and all tables. CHECKED OUT!
Unmodulated $89.50 Modulated .... P.U.R.

BC-221 1000 Kc Crystal Brand New $8.95
BC221 FREQ. METER CASE, aluminum, with volt. reg. supply. Shock mounted. BRAND NEW $2.95

BC-906 FREQ. METER—SPECIAL
Cavity type 145 to 235 Mc. Complete with antenna. Manual and original calibration charts included. BRAND NEW. OUR LOW PRICE $13.88

LORAN APN-4

FINE QUALITY NAVIGATIONAL EQUIPMENT

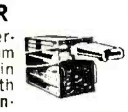
Determine exact geographic position of your boat or plane. Indicator and receiver complete with all tubes and crystal.
INDICATOR ID-6B/APN-4, and RECEIVER R-9B/APN-4, complete with tubes, Exc. Used. $69.50

NEW! APN-4A Receiver-Indicator as above, changed to operate same as APN4-B for improved performance .... NEW $88.50
Shock Mount for above $2.95

INVERTER POWER SUPPLY for above APN-4. INPUT: 24 V DC. OUTPUT: 115 V AC, 800 cycles. Like New $22.50

12-Volt Inverter Power Supply for above APN-4. Like New. .... P.U.R.
We carry a complete line of replacement parts and accessories for above.

LORAN R-65/APN-9 RECEIVER & INDICATOR

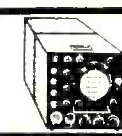


Used in ships and aircraft. Determines position by radio signals from known xmitters. Accurate to within 1% of distance. Complete with tubes and crystal. IN LIKE NEW Condition $79.50
Used, with all parts, less tubes, crystal and visor .... Special $29.50

INVERTER POWER SUPPLY for above APN-9. INPUT: 24 V DC. OUTPUT: 115 V AC. 800 cy. Like New $22.50

12-V. Power Supply for APN-9, like New P.U.R.
Shock Mount for above $2.95
Circuit diagram and connecting plugs available.
We carry a complete line of replacement parts and accessories for above.

APN-12 3-INCH SCOPE

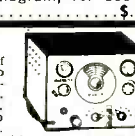


Has vertical and horizontal sweep with focus and intensity controls. coaxial antenna changeover motor. Complete with 11 tubes and 3JP1 CR Tube. For 115 V. 400 cycle AC and 24 V DC. Circuit diagram included. LIKE NEW. $14.95

TS100AP 'SCOPE. exc. used. like new, with all tubes, crystals and CR tube $42.50
As above, BRAND NEW $69.50

BC-929 3-Inch Scope, with all tubes, BRAND NEW $14.95
Conversion instructions, with diagram, for 100 V AC operation .... $.65

TS-16/APN TEST SET

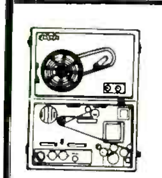


For aligning and calibration of radio altimeters. May be used to check calibration of count or circuits and modulator sweep freq. and bandwidth of transmitter. Audio-oscillator range: 340 to 7250 cycles. 24 V.DC input. Complete with tubes. connecting cables, instruction summary. **BRAND NEW** $19.95

EE-8 FIELD PHONES

Checked out. perfect working order. Complete with all parts. Excellent Condition.
LIKE NEW! Each $14.50

TG-34A CODE KEYER



Self-contained automatic unit, reproduces code practice signals recorded on paper tape. By use of built-in speaker, provides code-practice signals to one or more persons at speeds from 5 to 25 WPM.

Like New, Tested $29.50

Set of 15 Reels, Army Code Practice Lessons, BRAND NEW, original packing .... P.U.R.

CIRCLE NO. 152 ON READER SERVICE PAGE

TUBES

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

RADIO & TV Tubes—33¢ each. Send for free list. Cornell, 4215-W University, San Diego, Calif. 92105.

BRAND New Tubes, World's lowest prices on Radio, TV-industrial-special purpose tubes. Write for free parts catalog. United Radio, Newark, N.J.

BEFORE you buy receiving tubes, test equipment, Hi-fi components, kits, parts, etc. . . . send for your giant free Zalytron current catalog, featuring Standard brand tubes: RCA, GE, etc.—all brand new premium quality individually boxed. One year guarantee—all at biggest discounts in America! We serve professional servicemen, hobbyists, experimenters, engineers, technicians. Why pay more? Zalytron Tube Corp., 469-W Jericho Turnpike, Mineola, N. Y.

7" TV test tube—$6.99. Tubes—6146—$2.95; 6211 (12AU7 equiv.) 39¢, 3 for $1.00. Germanium diodes, tested, equiv. 1N34, 1N60 etc., 30 for $1.00. Tophat silicon rectifiers, 750 MA—1000 piv 75¢. Transistors, tubes, resistors, condensers etc., bargain priced. Free catalog. Arcturus Electronics, Dept. ZD, 502-22nd St., Union City, N.J. 07087.

ELECTRONIC TUBES—Top Brands SOLD at substantial savings! (Minimum Order $15.00) Authorized GE Distributor. Send for FREE Buyers' Guide for all your Tube Requirements. TOP CASH PAID for your excess inventory (New ONLY—Commercial Quantities). Metropolitan Supply Corp., 443 Park Avenue South, New York, N.Y. 10016. 212-MU 6-2834.

PHOTOGRAPHY—FILM, EQUIPMENT, SERVICES

MEDICAL FILM—Adults only—"Childbirth" one reel, 8mm $7.50; 16mm $14.95. International W, Greenvale, Long Island, New York.

SCIENCE Bargains—Request Free Giant Catalog "CJ" —148 pages—Astronomical Telescopes, Microscopes, Lenses, Binoculars, Kits, Parts, War surplus bargains. Edmund Scientific Co., Barrington, New Jersey.

CIRCLE NO. 167 ON READER SERVICE PAGE

EMPLOYMENT INFORMATION

FOREIGN Employment. Construction, other work projects. Good paying overseas jobs with extras, travel expenses. Write only: Foreign Service Bureau, Dept. D, Bradenton Beach, Florida.

REPAIRS AND SERVICES

TV Tuners Rebuilt and Aligned per manufacturers specification. Only $9.50. Any Make UHF or VHF. We ship COD Ninety day written guarantee. Ship complete with tubes or write for free mailing kit and dealer brochure. JW Electronics. Box 51B. Bloomington, Indiana.

METERS—Multimeters Repaired and Calibrated. Free estimates—Catalog. Bigelow Electronics, Box 71-F, Bluffton, Ohio.

RCA Test Equipment, Authorized Repair & Calibration Center, Nationwide. Edwin Bohr/Electronics, Box 4457, Chattanooga, Tennessee 37415.

GOVERNMENT SURPLUS

JEEPS $64.50, boats $6.18, typewriters $4.15, airplanes, electronics equipment, thousands more, in your area, typically at up to 98% savings. Complete directory plus sample Surplus Market-letter $1.00. Surplus Service, Box 820-K, Holland, Michigan.

JEEPS — $62.50, Transmitters — $6.18, Typewriters — $4.15, Walkie-Talkies, Oscilloscopes, Multimeters. Typical Surplus Prices. Exciting Details Free. Enterprises, Box 402-B7, Jamaica 30, N.Y.

TECHNICAL manuals for surplus electronics. Stamp for list. Books, Box 184, Riverdale, Maryland.

CLASSIFIED ADVERTISING ORDER FORM

Please refer to heading on first page of this section for complete data concerning terms, frequency discounts, closing dates, etc.

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25
26	27	28	29	30
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_______ Words { @ .35 Reader Rate } = $ _______
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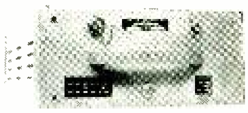
WORD COUNT: Include name and address. Name of city (Des Moines) or of state (New York) counts as one word each. Zone or Zip Code numbers not counted. (Publisher reserves right to omit Zip Code if space does not permit.) Count each abbreviation, initial, single figure or group of figures or letters as a word. Symbols such as 35mm, COD, PO, AC, etc., count as one word. Hyphenated words count as two words. EW-964

GREGORY ELECTRONICS

Reconditioned FM 2-Way Radio Savings

**THIS IS A PARTIAL LIST—
WRITE FOR NEW
FALL '64 EXPANDED CATALOG**

We bought a large quantity of 2-way radio units from a state police network AND FOR LIMITED TIME ONLY WE OFFER THIS NEW LOW PRICE!



LINK 6000 NW SERIES

25-50mc 20F3 Emission. Fully narrow banded (Tx and Rx). 12 volt. 50 watt. Complete with all accessories, less crystals and antenna. . **$128**

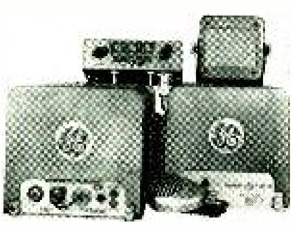
Add $40 for crystals, tuning and brand new antenna —ready to go on your frequency. also available in dual frequency Tx & Rx add $30 for tuning of second frequency.

RCA 148 to 172 mc

CMC20 6/12 volt, 20 watt, complete with all accessories less crystals and antenna. Wide band **$118**

Same unit fully narrow banded, transmitter and receiver **$158**

Add $35 for crystals, tuning and antenna. Ready for Installation.



30-50mc MOBILES

GE 2-Piece Unit—6 volt or 12 volt
4ER6—4ET5 30w 30-40mc 40-50mc . . . **$ 88**
1ER6—4ET6 60w 30-40mc 40-50mc . . . **$108**
Complete with all accessories except antenna and crystals.
Equipment can be crystalled and tuned to any frequency in the 30-50mc band.
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Complete with all accessories including antenna and crystals. Fully narrow banded (Tx & Rx) and tuned to your frequency with in the 30-50mc range.

We Buy Late Model Equipment for Cash —Write; Wire or Phone!

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CIRCLE NO. 185 ON READER SERVICE PAGE

LEEDS & NORTHRUP KELVIN-VARLEY VOLTAGE DIVIDER — 20,000 ohm 0.1% accuracy, ratio 1:10,000 0.01%. Has 2 ratio dials (1,000 & 100) & ratio slidewire dials (0-100). Part of calibrator for fire control computor. Kelvin-Varley network is an enclosed assembly complete with panel & can be used separately as voltage divider, heart of Wheatstone bridge, or as an accurately calibrated variable resistance or potentiometer. Has 100-0-100ua Galvonometer with three sensitivity ranges. Aluminum case 18"x10"x12". Shipping weight 37 lbs. Good condition. Lab checked out **$49.50**

MN-26C BENDIX RECEIVER 150-1500KC in 3 bands, two RF amp. 112.5KC IF. BFO & Audio amp. Xlnt for "DX", Foreign & American broadcast. With 11 tubes & schematic. Used good **$14.95**

HIGH VOLTAGE PROBE—50KV for VOM or VTVM with 500 meg high voltage resistor. Xlnt for TV service men. Worth $12.00 BRAND NEW **$2.95**

Send money order or check with order—Please include postage—Excess promptly refunded. Minimum COD $10.00 with 25% Deposit.

Write for Bulletin #40 — Loads of Bargains

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2430 So. Michigan Ave.
Chicago, Illinois 60616
Dept. 975
Phone CAlumet 5-1281

TAPE AND RECORDERS

RENT Stereo Tapes—over 2,500 Different—all major labels—free brochure. Stereo-Parti, 1616—E. W. Terrace Way, Santa Rosa, California.

SAVE 30-60% Stereo music on tape. Free bargain catalog/blank tape/recorders/Norelco speakers. Saxitone, 1776 Columbia Road, Washington, D.C.

RENT 4-TRACK STEREO TAPES—When you narrow it down it has to be TRIMOR—Goodbye to partial satisfaction—Service and Dependability our keynote—ALL LABELS and TITLES—No Deposit—Postpaid both ways. Write for FREE BROCHURE and TAPE CATALOG. TRIMOR Company, Dept. TR, P.O. Box 748, Flushing, New York 11352.

TAPEMATES MAKES AVAILABLE TO YOU—ALL 4-TRACK STEREO TAPES—ALL LABELS—POSTPAID TO YOUR DOOR —AT 40% COMBINED SAVINGS. FOR FREE BROCHURE WRITE TAPEMATES CLUB, 5280-E W. PICO BLVD., LOS ANGELES, CALIF. 90019.

WINDSOR Tape Club members HEAR BEFORE THEY BUY. Free "samplers" of new releases. Save on tape purchases.—All major labels. Free brochure. Windsor Tape Club, Dept. E, Windsor, Calif.

BEFORE renting Stereo Tapes try us. Postpaid both ways—no deposit—immediate delivery. Quality—Dependability—Service—Satisfaction—prevail here. If you've been dissatisfied in the past, your initial order will prove this is no idle boast. Free Catalog. Gold Coast Tape Library, Box 2262, Palm Village Station, Hialeah, Fla. 33012.

SARKES Tarzian's Galaxie tensilized Mylar: 1800'/1.69, 2400'/2.79, 3600'/3.89. Postpaid. Free all-components, tape catalog. Pofe, 1716-EW Northfield, Muncie, Indiana.

PROFESSIONAL Crown Imperial tape recorder—10½ inch reels—full track head—3 speed—2 channel preamp—A-1 shape—$200. TELEFUNKEN M251E Condenser microphone with power supply—like new—$175. SHURE Studio ribbon microphone—good shape—model 333—$65. Edward B. Vogt, Apt T-1, Jardine Terrace, Manhattan, Kansas.

HIGH FIDELITY

LOW, LOW quotes: all components and recorders. Hi-Fi, Roslyn 9, Penna.

HI-FI Components, Tape Recorders, at guaranteed "We Will Not Be Undersold" prices. 15-day money-back guarantee. Two-year warranty. No Catalog. Quotations Free. Hi-Fidelity Center, 1797 (L) 1st Avenue, N.Y., N.Y. 10028

HI-FI components, tape recorders, sleep learn equipment, tapes. Unusual Values. Free Catalog. Dressner, 1523 Jericho Turnpike, New Hyde Park 10, N.Y.

FREE! Send for money saving stereo catalog #E9W and lowest quotations on your individual component, tape recorder or system requirements. Electronic Values, Inc. 200 West 20th Street, N.Y., N.Y. 10011.

FREE—$1.00 Value "Miracle" Record cleaning cloth with every quotation on HIFI EQUIPMENT. Our "ROCK BOTTOM" prices on NAME BRAND amplifiers—tuners—taperecorders—speakers—FRANCHISED—59 YEARS IN BUSINESS. Write for this month's specials—NOW! Rabsons 57th St., Inc., Dept. 569, 119 W. 57th St., New York, New York 10019.

BOOKS

AUTHORS! Learn how to have your book published, promoted, distributed. FREE booklet "ZD," Vantage, 120 West 31 St., New York 1.

1,000,000 BOOKS! Bargains! Catalog—dime. Treasure-Site, 6990 Aberdeen, Upper Darby, Pa. 19082.

AIRCRAFT RADIO

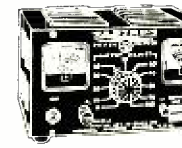
WANTED Aircraft Radio Sets—Collins: 51R3-51X—51Y—51V—51Z, Bendix: T-21; R21; DFA-70; RA-18C; MK-7; GSA-1, Test Sets: ARC—Boonton—Collins—Hewlett-Packard. Highest prices paid. J. Lee, Box 105, New Haven, Conn.

MAGAZINES

AMERICANS—Subscribe to Canada's Hobby and Service Magazine—"Electron". Exciting Ads, Stimulating articles $5.00 one year. Box 796, Montreal 3, Canada.

"TABTRON" AC & DC POWER SUPPLIES!

**Model T201A
Lab Supply $50
0 to 20VDC at 10Amps
Filtered**



STEPLESS 320° VARIABLE • "VARIAC ®" RATED 330 WATTS • PINPOINT VOLTAGE CONTROL • DW RECTIFIER XFMR for F.W.B. • 4 SILICON 18A DIODES in F.W.B. • TWO LARGE METERS V&A 5WAY BINDING POSTS • COMPUTER ELECTROLYTICS • FILTERED RIPPLE 0.1% at 2AMPS • 3% at 10Amps! COMPACT 5H9W6D • CIRCUIT BKR. OUTPUT PROTECTED • INPUT FUSED 115VAC 50 to 500Cys • T1610R BATTERY CHGR! PLATER $42 SAME SPECS, NON-FILTERED 0 to 16VDC at 10Amps IDEAL "NI-CAD" BATTERY CHARGER • Q225L CONVERTER DC to AC 12VDC INPUT to 115VAC/225 WATT SQ WAVE 60CYCLES. Q225L $40

See Distributor or Write Dept. EW9

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Six Church St. N.Y. 6, N.Y., U.S.A.

"TAB" ★ SCR's ★ TRANSISTORS ★ DIODES!!!

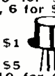
750MA — SILICON DIODES

Piv/Rms 50/35 .05	Piv/Rms 100/70 .09	Piv/Rms 200/140 .12	Piv/Rms 300/210 .16
Piv/Rms 400/280 .20	Piv/Rms 500/350 .24	Piv/Rms 600/420 .32	Piv/Rms 700/490 .40
Piv/Rms 800/560 .48	Piv/Rms 900/630 .55	Piv/Rms 1000/700 .70	Piv/Rms 1100/770 .75

Sil. Pressfit 18A upto 100 Piv ....4 for $1
Micro or MuSwitch CSD 35Amp/AC-DC . . 3 for $1

Full Leads Factory Tested & Gtd! U.S.A. Mfg.

PNP 50Watt/15Amp HiPower TO36 Pckg! 2N441, 442, 277, 278, DS501 up to 50 volts/VCBO $1.25 @, 5 for $5
2N278, 443, 174 up to 80v $3 @ 2 for $5.
PNP 10Watt/3A-2N155,156,235,242,254, 255, 256, 257, 301, 351: ¢35 @, 4 for $1
PNP Signal up to 350MW TO5, ¢25 @, 6 for $1
NPN Signal IF, RF, OSC, TO5, OV5, ¢25 @, 6 for $1
PNP 2N670/300MW ¢35 @, 4 for $1
PNP 2N671/1Watt ¢50 @, 3 for $1



Silicon PNP TO5 & TO18, Pckg ¢25 @, 5 for $1
TO36, TO3 Pckg Mica Mtg Kit 5 for $1
Power Heat Sink Finned 80 Sq $1.25 @ 5 for $5
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2N1038 4/$1, 1039 3/$1, 1040 2/$1, 1041 $1
2N538, 539, 540/3Amp ....2 for $1
Zener 50/60V Auto Ignition $1
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Kit Zeners 400Mw to 10W Asstd ......3 for $1

"TAB" TERMS: Money Back Guarantee! Our 18th year. $2 Min. order F.O.B. N.Y.C. Add shpg charges or for C.O.D. 25% Dep. Prices shown subject to change.

111-WS, Liberty St., N.Y. 6, N.Y.
Send 25¢ Phone: REctor 2-6245 *for Catalog*

CIRCLE NO. 225 ON READER SERVICE PAGE

INVENTIONS WANTED

INVENTORS. We will develop, help sell your idea or invention, patented or unpatented. Our national manufacturer clients are urgently seeking new items for outright cash sale or royalties. Financial assistance available. 10 years proven performance. For free information, write Dept. 42, Wall Street Invention Brokerage, 79 Wall Street, New York 5, N.Y.

HELP WANTED

NEW JERSEY Salesmen. Sales Engineers. Accumulate substantial extra income with little effort, performing your usual sales calls. Pengad Travel Agency will show you how. Telephone N.J. 437-3900, N.Y. 964-8133, or write P. O. Box 86, Bayonne, N.J.

EDUCATIONAL OPPORTUNITIES

LEARN While Asleep, hypnotize with your recorder, phonograph. Astonishing details, sensational catalog free! Sleep-Learning Association, Box 24-ZD, Olympia, Washington.

LEARN while asleep. Remarkable, scientific. 92% effective. Details free. ASR Foundation, Box 721, Dept. e.g., Lexington, Kentucky.

NOW Amateur Radio license correspondence classes! Free details, write Valley Schools, Dept. K-11, Box 608, Aurora, Ill. 60507.

MUSIC

FOR continuous music without commercials, build a sub carrier adapter for your FM receiver. Standard parts. Text with schematics $3.00. Wired adapters $75.00. Music Associated, 65 Glenwood Road, Upper Montclair, N.J.

GET IT from GOODHEART!

ALL-BAND SSB RCVR BARGAIN: Hallicrafters R-45 ARR-7, 550 kc to 43 mc continuous: Voice, CW, MCW, aligned and modified now also modified to include PRODUCT DETECTOR, 2 RF, 2 IF stages, S-Meter, Xtl w 120/230 v 50/60 cy pwr sply. Hot and SHARP & **works like a charm!** FOB Los Ang. **199.50**

Same less SSB, fob San Antonio **179.50**

TIME PAY PLAN: Any purchase totalling $160.00 or more, down payment only... **10%**

ARC-5 Q-5'er Revr 190-550 kc w/85 kc IF's, 3 Ant. posts: Loop DU-1 (see below) or ordinary. Electrically checked, aligned, OK grtd. w/spline knob, tech. info. 10 lbs. **14.95**

LM FREQ. METER generates AM or CW to align revrs or tells unknown freq. to align oscillators or xmtrs. 125 kc to 20 mc w accuracy approx. .01%, self-calibrated w 1 mc xtl osc. w/harmonics beyond 20 mc, itself an xlnt exact-signal source. Our HONEST OPINION: Next to a multimeter, it's the most valuable tool for ANY radio hobbyist or serious lab. Exc. cond., electric. checked, OK grtd., w/matching-serialized calib. book, plug, dwgs & much tech. info. 15 lbs. **57.50**

Same exc. condition. Calibration books have dogeared edges but grtd readable **42.50**

GRTD CONDITION TELETYPE right off operating line, all w SYNCH motors. No pwr splies. Clean, oiled, no rust. We will send you any repair parts you need FREE except window glass if you specify part Nos., so get the books too.

Mod. 15 send revc plus hi-base Typing Reperforator plus #14 Trans-Distr. all in operator's console cabinet w paper storage, etc. Made of panels which open out on piano hinges for ready access to all machines **175.00**

Same except machine is Mod. 19 ...... **195.00**

Mod. 14 Trans Distrib with cover **37.50**

Books (TM11-): #352 on Mod. 15 **$7.50.** —2222 on #14 TD. **$8.50.** —2223 on #14 Typing Reperf. **$9.00.** —2216 on Mod. 19. **$12.50.**

ARC-3. ARC-27. ART-13 TECH. MANUALS each **10.00**

TEKTRONIX SCOPES grtd OK & gorgeous, w/books: #514A or #514D: DC to 10 mc; sensit. 30 mv cm; sweep calib. uv cm; calib. deflection **395.00**

#514AD **450.00**

#524D: For TV station engineers **550.00**

GERTSCH RATIOTRAN PT-5R AC Voltage Divider .001% accurate, 50/10,000 cy, 5 decades plus final interp. slidewire, rack mtg ... **175.00**

w ST-200 Xfrmr & sw. to reverse polarity **200.00**

Measurements Corp. Model 80. General Radio #1021A series. General Radio #805-C. Navy LP. TS-413/U. etc. STANDARD SIGNAL GENERATORS GALORE! All completely checked out and certified OK ready to use. ASK FOR LIST! Also LINE VOLTAGE REGULATORS, Regulated Power Supplies. etc. & etc. TELL US YOUR NEEDS!

LEEDS & NORTHUP: Kelvin Varley Volt. Divider .01%, 20K ohms, 4-digit .. **49.50**

#4760 4-dial .1% DC Wheatstone Bridge .. **100.00**

#2310-(*) pointer galvan. for above **27.50**

WESTON #440 pointer galvanometer **37.50**

#5430A, similar above, galvo built in **125.00**

#4725 5-dial DC Wheatstone Bridge .05% **275.00**

#2430-c Lamp & Scale galvo for above ... **150.00**

RUBICON galvo very similar to above **125.00**

#5365 Power Cable Fault Bridge + Rheost. **275.00**

PLENTY MORE WONDERFUL MATERIAL! Ask for your needs! We ALSO BUY your excess mdse.

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CIRCLE NO. 243 ON READER SERVICE PAGE

USED ELECTRONIC EQUIPMENT

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GENERAL RADIO 1217A Pulser & pwr supply .... $ 95.00
RUTHERFORD B3-2 Dual Pulser, 20 nsec RT, to 1 mc prr 495.00
ELECTRO PULSE 2140A Dual Pulser, 20 nsec RT, 10 cps to 100 kc prr 275.00
ELECTRO PULSE 3450A Pulser, 30 nsec RT, 20 cps to 1.6 mc prr 175.00

RECORDERS

AMPEX FR400, 1/2 in. magnetic tape, 30,000 bps storage @ 75 in/sec with read-write amps and controls in 6' rack, IBM computer format-7 level heads $1,500.00
BRUSH BL262 and 550 amplifiers, two channel electric or ink oscillograph 225.00
BERKELEY 1452 Digital Recorder 1 print/sec, 7 digit 150.00

MULTIMETERS

FLUKE 103 VAW meter, AC, 1.5-600 vrms, .0015-30 amps, .002-1800 watts $195.00
MILLIVAC MV73B, 10 mv-1000 v, 1 ua-10 a, AC/DC/Ohms 49.00
EPSCO DV813, Digital Meter, AC/DC/Ohms, 4 Digit, 0.1%, 100 Samples/sec. 195.00

OSCILLOSCOPES

DUMONT 304A DC to 300 kc .... $ 95.00
DUMONT 324 DC to 300 kc-cal. sweep 125.00
FEDERAL ITT 1770, 17" display scope mounted in 6 ft. rack 95.00
HEATH 0-10 AC amplifiers, 5 in. CRT 35.00

Representative listing above—we invite your inquiries for test equipment. All reconditioned and sold on 30 day money back guarantee. F.O.B.

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Dept. EW. 1043 Fern. Escondido. Calif.
Phone 714-746-1327

PATENTS

INVENTIONS: Ideas developed for Cash Royalty sales. Raymond Lee, 2104G Bush Building, New York City 36.

EQUIPMENT

HEAR Aircraft, Tower Emergencies, weather. Portable 9 Transistor AM-FM-VHF Aircraft receiver. Beautiful Black with Gold Trim. $26.50. Free Details. Transco, Box 13482, North County Station, St. Louis 38, Mo.

INFRA Red Receiver, type B, new surplus, made by Eastman Kodak, $38.50 each, postpaid, Cash with order. List of surplus panel and portable meters for stamp. Hanchett, Box 1898, Riverside, Calif.

FREE Electronics Catalog. Tremendous bargains. Electrolabs. Department C-106E, Hewlett, N.Y. 11557.

STAMPS

OLYMPICS TOKYO 1964 Stamps, Souvenir albums, First Day Covers. Free list over 150 items. Advance orders insure low prices. The Oriental Interpreter, Home Acres 132, Clyde. N.Y. 14433.

CELEBRATE With Us: Canada centenary offer; 100 Different $1.00. Free with lot valuable foreign errors worth many dollars extra. Bileski, Station B, Winnipeg. Canada.

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BORROW $1,233 Airmail! Repay $54 for twenty-nine months. State licensed. Postal Finance, Dept. 15-R, Kansas City 1, Kansas.

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I Made $40,000.00 Year by Mail Order! Helped others make money! Start with $10.00—Free Proof. Torrey. Box 3566-N, Oklahoma City 6. Oklahoma.

AMAZING Mail Order Profits using proven methods. Research, 3207-H Southern Hills, Springfield. Mo.

HOW And Where to Raise Capital. Details Free. Financial, Box 785-H. Springfield, Mo. 65801.

HIGHLY WEEKLY EARNINGS! Address-mail letters featuring real merchandise. Get $10 with every order—keep $8 profit. Supplies furnished. Free particulars. Modern Merchandising, Box 357. Oceansde, N.Y.

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FREE Book "990 Successful, Little-Known Businesses." Work home! Plymouth-717J, Brooklyn 4. N.Y.

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MISCELLANEOUS

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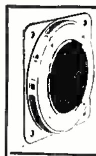
SAVE $200 to $2,000 on European automobiles delivered at low, low factory tax-free prices by using our direct shipment plan. Delivery guaranteed, references available. Tourist and Military deliveries available in Europe. Information on all models and makes Eurauto. Postbus 333. Rotterdam, Holland.



HI-FI SPECIAL! 4" SQ. ELECTROSTATIC TWEETER

Made by Lorenz. ITT, for Grundig. Never before offered. A natural for hi-fi enthusiast. Buy 2 for stereo. Illustration resembles tweeter in stock. Includes hookup. **$1.00 ONLY**

FREE! FREE!

$25 WORTH OF • Transistors • Diodes • Rectifiers • Knobs • Condensers • Coils, etc. **PLUS $1** ANY 1.00 ITEM FREE

Include 25¢ for handling

BOTH FREE WITH ANY $10.00 ORDER

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- 50 1-WATT RESISTORS, popular values, asstd, 5% too . $1
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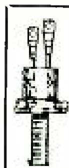
- 4 TRANSISTOR TRANSFORMERS, worth $25 . . . . $1
- 40 WORLD'S SMALLEST RESISTORS, 5% too, 1/10W . . $1
- $25 PARTS SURPRISE, wide assortment of parts $1
- 100 ASST HALF WATT RESISTORS, 5% too $1
- 60 HI-Q RESISTORS, 1/2, 1, 2W to 1 meg, 5% too $1
- 10 RCA PHONO PLUG-n-JACK SETS, tuners-amps $1
- 50 TERMINAL STRIPS, asst 1-to-10 lug types $1
- 50 COILS & CHOKES, rf-if, osc-peaking, etc $1
- 10 TRANSISTOR ELECTROLYTICS, 5mf to 100mf $1
- 40 PRECISION RESISTORS, 1/2, 1, 2W, 1% $1
- 60 TUBULAR CONDENSERS, to .5mf to 1KV $1
- 40 DISC CONDENSERS, 27mmf to .05mf to 1KV $1
- 60 TUBE SOCKETS, receptacles, audio, plugs $1
- 30 POWER RESISTORS to 50W, to 24K ohms $1
- 50 MICA CAPACITORS to .01mf, silvers too $1
- 10 TANTALUM ELECTROLYTICS, $15.00 value $1
- 35 2-WATT RESISTORS, popular asstd. values, 5% too . $1
- 30 SPRAGUE 'YELLOW MYLAR' CONDENSERS to 1mfd . $1



TRANSITRON SCRs

TESTED SILICON CONTROLLED RECTIFIERS

BRAND NEW LOWEST PRICES

PRV	7 Amp	15 Amp	25 Amp
50	1.00	1.25	1.50
100	1.50	1.95	2.25
150	1.75	2.25	2.75
200	1.95	2.75	2.95
250	2.25	2.95	3.25
300	2.69	3.19	3.50
350	2.95	3.50	4.25
400	3.25	3.95	4.50

3-TRANSISTOR SUBMINIATURE AMPLIFIER
• Only 3"x2"x3/4" • Wired • Printed Circuit • W/Transistors **1.95**

FACTORY TESTED **SEMI-KON-DUCTORS**

- 1 2N718 NPN SILICON PLANAR, 1W freq mw $1
- TEXAS 3N35 TETRODE 150MC SILICON transtr, TO5 . $1
- 3 2N255 POWER TRANSISTORS or equal, TO3 case . . . $1
- 4 2N112 EQUALS, if, osc, TO22 case $1
- 20W SILICON MESA, 2N1648, TO10 transistor $1
- 2 1N429 TYPE ZENER REFERENCES, 6 volts $1
- 3 2-WATT SIZE zener references, axial leads, 1V $1
- 6 UPRITE ZENER DIODES, silicon, assorted voltages . . $1
- 2 TRANSITRON 2N341, 1-watt, npn, silicon, TO8 . . . . $1
- 4 CK721 TRANSISTORS, new aluminum case, pnp $1
- 10 NPN SWITCHING TRANSISTORS, 2N440 equals $1
- 6 SYLVANIA 750 MIL 400V TOP HAT rectifiers $1
- 10 RAYTHEON CK722 TRANSISTORS, pnp $1
- 1 85W 2N424 TYPE SILICON NPN MESA transistor . . . $1
- 15 PNP TRANSISTORS, asst types and cases $1
- 15 NPN TRANSISTORS, asst types and cases $1
- 1 2N706 EPITAXIAL PLANAR silicon npn 500mw 300mc . $1
- 2 500-MC MESA TO18 CASE TRANSISTORS, pnp $1
- 3 20W TRANSISTORS TO5 case, 2N1038, 'n heat sink . . $1
- 5 GENERAL ELECTRIC 2N107 PNP TRANSISTORS $1
- 3 CBS—20-WATT TRANSISTORS, pnp, stud, 2N1320 . . . $1
- 4 GENERAL ELECTRIC 2N170 PNP RF TRANSISTORS . . $1
- 15 UPRIGHT SILICON DIODES, worth $40 . . . . $1
- 2 'MESA' 4-WATT TRANSISTORS, npn, silicon, TO5 . . $1
- 2 25-AMP SILICON STUD RECTIFIERS $1
- 10 PNP SWITCHING TRANSISTORS, TO5 case $1
- 25 GERMANIUM DIODES, 1N34, 1N48 equals $1
- 25 EPOXY RECTIFIERS, axial lead, 750 mil, untested . $1
- 25 TOP HAT RECTIFIERS, 750 mil, untested $1
- 25 TRANSISTORS, audio, switching, rf, untested $1
- 3 300-MC TRANSISTORS, like 2N1264, TO5 case $1
- 10 30-MC TRANSISTORS, TO5 case, with shield $1

50-WATT TRANSISTORS • Gold plated • T036 case • Untested **3 for $1**

6 AMP 1000V SILICON STUD RECTIFIERS .... **2 for 1.49**

1 AMP 700V EPOXY RECTIFIERS, SILVER AXIAL LEADS .... **5 for 1.00**

10 WATT STUD ZENERS $1.49 ea

5V	14V	42V	70V	100V
6V	20V	45V	80V	110V
12V	24V	60V	90V	124V

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200,000 OHMS PER VOLT

NEW AND THE FIRST

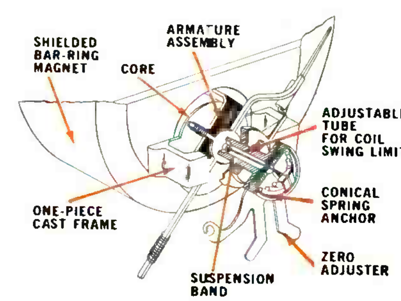
$99.50
SUGGESTED U.S.A. USER NET

TRIPLETT

Model 630-NS
VOLT-OHM-MICROAMMETER

TRIPLETT SUSPENSION MOVEMENT

no pivots . . . no jewels . . .
no hair springs . . . thus ***NO FRICTION.***



FACTS MAKE FEATURES

1. 200,000 OHMS PER VOLT D.C. for greater accuracy on high resistance circuits. 20,000 OHMS PER VOLT A.C.
2. 5μa SUSPENSION METER MOVEMENT. No pivots, bearings, hairsprings, or rolling friction. Extremely RUGGED. Greater sensitivity and repeatability.
3. 62 Ranges, usable with frequencies through 100 Kc. Temperature compensated. 1½% D.C. ACCURACY, 3% A.C.

Low voltage ranges and high input impedance make the 630-NS especially useful in transistor circuit measurement and testing. Input impedance, at 55 volts D.C. and above, is *higher than most vacuum tube voltmeters.*

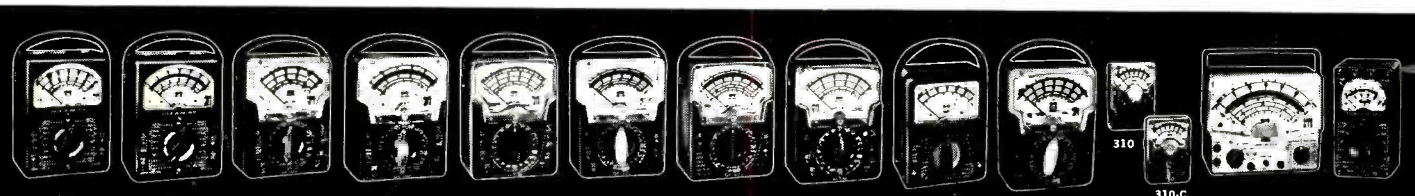
The unit is designed to withstand overloads and offers greater reading accuracy. Reads from 0.1μa on 5μa range. Special resistors are rigidly mounted and directly connected to the switch to form a simplified unit. Carrying cases with stands are priced from $9.90.

TRIPLETT ELECTRICAL INSTRUMENT COMPANY, BLUFFTON, OHIO

62 RANGES

D.C. VOLTS	0-0.6-3-12-60-300-1200 at 100,000 Ohms/Volt. 0-0.3-1.5-6-30-150-600 at 200,000 Ohms/Volt. 0-0.150 at 60μa
A.C. VOLTS	0-3-12-60-300-1200 at 10,000 Ohms/Volt. 0-1.5-6-30-150-600 at 20,000 Ohms/Volt.
DB	-20 to 77 in 10 ranges.
D.C. MICRO-AMPERES	0-5 at 300 MV. 0-60-600 at 150 MV. 0-120 at 300 MV.
D.C. MILLI-AMPERES	0-6-60-600 at 150 MV. 0-1.2-12-120-1200 at 300 MV.
D.C. AMPERES	0-6 at 150 MV. 0-12 at 300 MV.
OHMS	0-1K-10K-100K (4.4-44-440 at center scale)
MEGOHMS	0-1-10-100 (4400-44,000-440,000 Ohms center scale)

OUTPUT: Condenser in series with A.C. Volt ranges.



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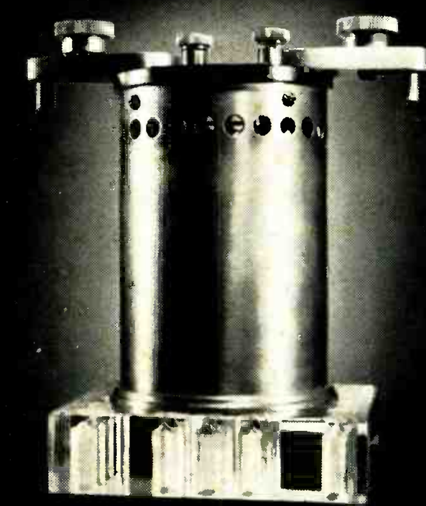
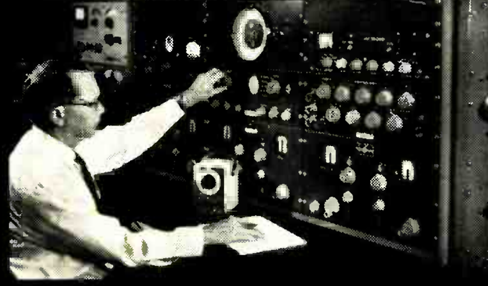
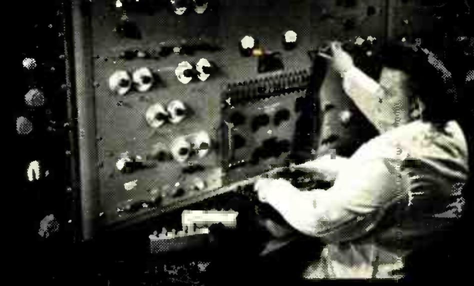
RCA Calibration Center's Resistance Standard — accuracy 0.0002%.



RCA Frequency Standard being used to calibrate an oscillator.

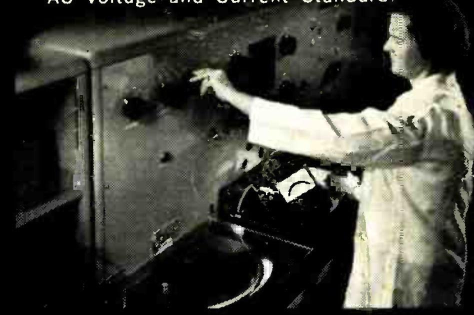


Recertifying Calibration Tubes on the RCA Static Characteristic Standard.



Calibrating portable Standard Cell on the RCA Primary Voltage Standard.

Voltmeter being calibrated on the RCA AC Voltage and Current Standard.



RCA ELECTRON TUBE RELIABILITY BEGINS HERE

DEPENDABLE PERFORMANCE IS THE END RESULT

No reliability program for receiving tubes can be better than the test instruments and equipments it employs.

That's why RCA maintains the extensive Calibration Center in its Harrison, N. J., tube manufacturing plant (see photos above). The Center's responsibility: to assure that all measuring instruments and equipments, used in tube development from initial design through volume production, are accurate within rigidly specified limits. Here is how this is accomplished:

1 The Calibration Center's own equipments are calibrated by standards (voltage, resistance, capacitance, frequency) whose values are regularly checked against standards of the National Bureau of Standards.

2 Measuring instruments used in all research, design, development and application laboratories are calibrated directly from the Center's equipments.

3 Sets of Calibration Tubes, selected to cover every type and family of tubes, are measured in the Calibration Center and used by the Center's personnel to periodically verify the accuracy of all factory tube-testing equipments.

4 Sets of Control Tubes, evaluated under the supervision of the Calibration Center, constantly monitor the repeatability of factory tube-testing equipments.

Our Harrison Calibration Center is another example of the effort we make to assure the specified and dependable performance of every receiving tube that bears the emblem of RCA... performance that benefits you through customer satisfaction.

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