50c JUNE 1966

Radio-Electronics

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HUGO GERNSBACK, Editor-in-chief

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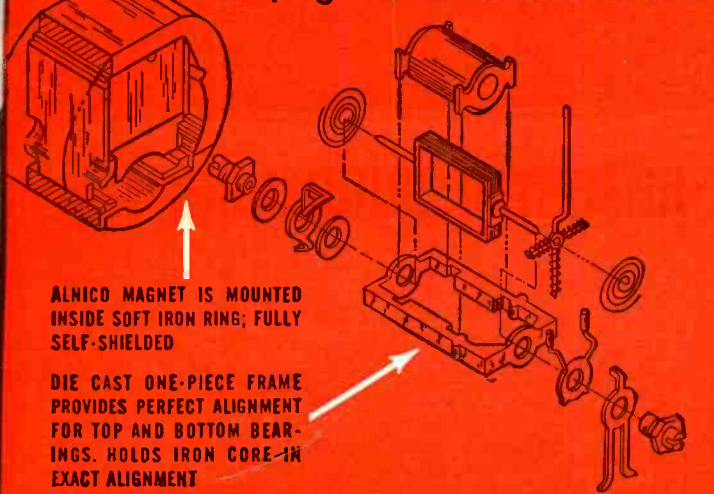

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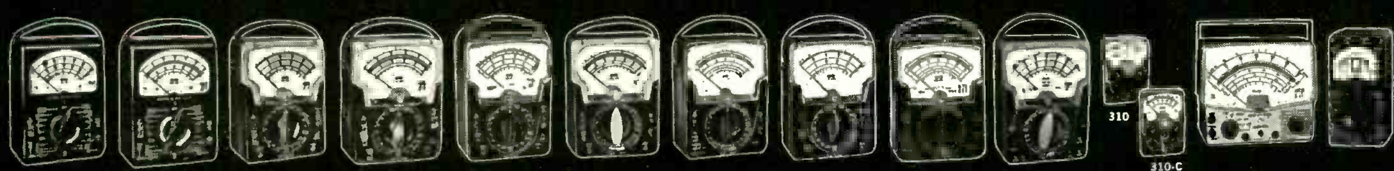

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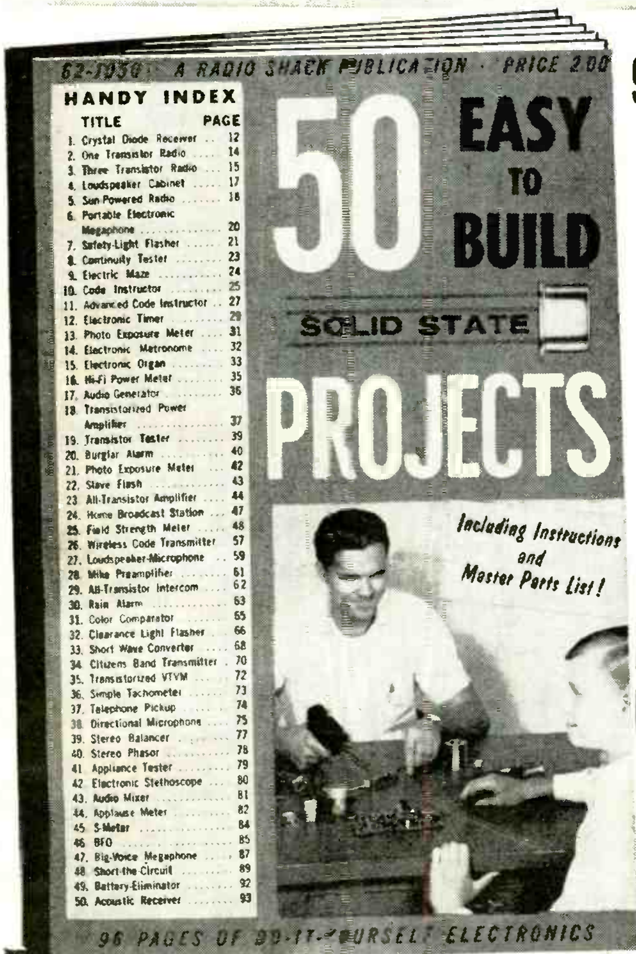

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Whither Consumer Electronics?

MICROELECTRONICS has reshaped the whole concept of electronic miniaturization. Where until recently the idea was to make electronic parts as tiny as possible and squeeze them into the narrowest practical space, microcircuits don't even *have* separate parts. In a microcircuit, the several circuit elements are all included on and in a single semiconductor chip—hence the name *integrated circuit* (IC).

Today's techniques of manufacturing ICs, in fact, make it possible to build several interconnected circuits on one chip or *substrate*. (This practice gives rise to the term *monolithic*—"one-stone"—*integrated circuit.*) As an example: The television IC introduced on page 26 does the job of two transistors and 24 associated parts, yet is hardly larger than one of the transistors. Physically, the TO-5 case that houses this new IC could just as easily enclose a half-dozen similar ones—such is the tinyness of an integrated circuit. This new technology portends some sweeping changes in electronic devices for consumer use.

Think how television may be affected. Picture an entire color receiver no thicker than this magazine. The screen is a single thin slice of specially treated phosphorescent material. The flat-screen deflection stages are deposited as integrated circuits right on the back of the screen (shielded from it, of course), along with IC video stages, i.f. amplifiers, sound section, sync—all the stages needed for television reception. The speaker is an electrostatic transducer; the i.f. and r.f. coils are replaced by self-resonant crystal devices that never need tuning; the bulky mechanical tuner is eliminated by electronic channel switching, capacitance-actuated by a finger touch. All is powered by light-activated cells illuminated by either daylight or house lights. Imagine this set mounted in a picture-frame cabinet with a built-in stand or a hook for hanging.

Dozens of other home-entertainment devices may be difficult to recognize after microelectronics has worked its magic. Consider a record changer whose entire amplifying system is mounted in the tone arm with the cartridge. Think of a tape playback amplifier mounted right inside the playback head shield. Or a phonograph on which the record doesn't rotate; instead, running around and around the record is a small self-propelled cube containing a stylus (which guides it in the groove), an amplifier, and a very efficient but tiny speaker—an entire record player in the palm of your hand.

Obviously, such devices are at the moment only ideas, but microelectronics makes them imminently feasible. Used until recently only in space electronics and computers, integrated circuits are now being manufactured at reduced costs and in quantities that make them practical for consumer-electronic devices. As they find their way into regular use, these microscopic circuits will affect the whole philosophy of design and servicing, and will call for an entirely new approach to troubleshooting.

Imagine a test instrument only 3 inches square and ½ inch thick. Two clips attach it to the antenna terminals of a television receiver, and a tiny internal battery powers it. It generates a single composite signal for troubleshooting an entire television set. An accessory, 4 inches square and very thin, connects through eight leads to test points in the IC "chassis" and displays clues that help show which IC is at fault. A companion generator of similar size and appearance is for troubleshooting stereo-FM receivers, and a third unit tests audio amplifier systems.

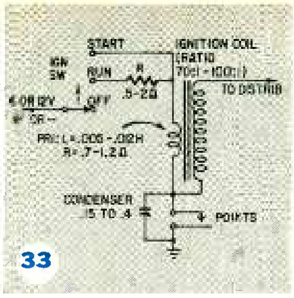
Imagine further a color-TV receiver, built of 22 microcircuits mounted on the back of a flat screen; assume it has some unknown trouble in one of the ICs. You clip a little test generator to the antenna input. The complex test signal passing through the color receiver actuates failure-sensing circuits that during manufacture were made a part of the various IC sections; a tiny solid-state indicator (also built in as part of each IC) lights up on the IC that is faulty, showing the technician which IC module needs to be replaced. Outlandish? Maybe. Or maybe not.

Whether you experiment with, design, build, repair, or merely enjoy electronic equipment, your future is unavoidably enmeshed with that of microelectronics. Superior reliability and rapidly decreasing cost will assure wide use of integrated circuits in consumer-electronic products. Your thinking and your methods of work will have to take this new technology into consideration.

—*Forest H. Belt*

Radio-Electronics

JUNE 1966 VOL. XXXVII No. 6
Over 55 Years of Electronic Publishing



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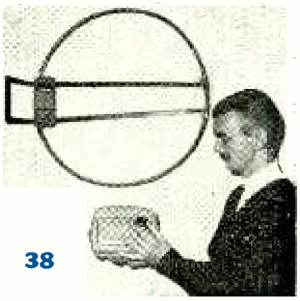
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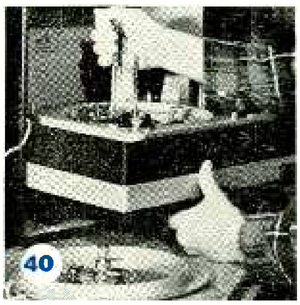
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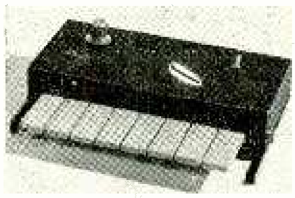
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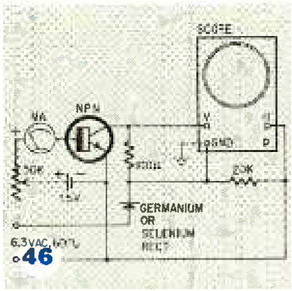

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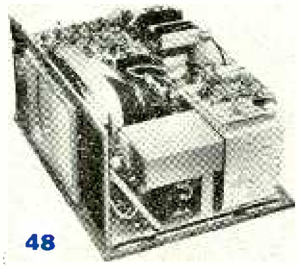
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***COVER FEATURE**


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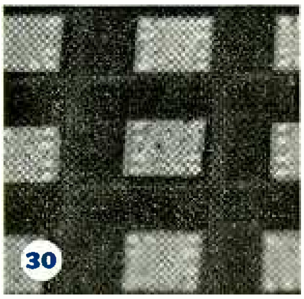
The hottest development in television this year—the introduction by RCA of a low-cost integrated circuit for the sound section of the new line of TV's!

PICTURE STORY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Microelectronics and solid-state devices are attracting such acclaim that R-E editors put together this illustrated description of how they are created!

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Radio-Electronics is indexed in *Applied Science & Technology Index (formerly Industrial Arts Index)*

NEWS BRIEFS

HOMEWORK TROUBLES? PICK UP YOUR PHONE, ASK THE COMPUTER

Having some kind of magical creature or thing always around to help out with sticky homework problems is certainly one of the most frequent day-dreams of a busy high-school student. Now the dream is real—or was, briefly—for six students in Catholic high schools in the borough of Queens, New York City.

Participating in a joint experiment conducted by IBM and the Catholic Schools Diocese of Brooklyn (N.Y.), the students punch up problems on pushbuttons in a box connected to an ordinary telephone. With the buttons they can tell an IBM 1710 computer 50 miles away in Yorktown Heights, N.Y. to add, subtract, multiply, divide or find a square root. The computer confirms what it has been told to do and instantly gives answers—*via a human voice*—from its prerecorded vocabulary.

The researchers emphasize that this takes only the drudgery, not the teaching power, out of homework. On the contrary, says Brother Austin David, F.S.C., data-processing consultant for the Diocese, "With routine but time-consuming operations . . . taken care of by the computer, students should be able to do more problems and get more practice in setting them up."

Students in the pilot experiment report the project a huge success, and, at this writing, are using the system daily.

Roger C. Greenhalgh, manager of technical planning for IBM's Advanced Systems Development Div., points out that personal services rendered by this sort of phone-linked computer are not necessarily limited to homework and scientific calculations, or even to voice-only responses. In the future, people may be able to receive pictures as well as sound from the computer, via their home TV sets.

Possible future domestic services: Automatic financial record-keeping, checkbook-balancing, reminders of financial obligations; recipe and household-information files; files of product guarantees and insurance coverage; appointment calendars that ring you at the proper time; instant almanacs and encyclopedias of information; home selection and purchase of goods, with automatic charge service.

PREDICT TRANSISTOR BREAKDOWN FROM EARLY LEAKAGE

Two research workers of the National Bureau of Standards, George T. Conrad, Jr. and Donald C. Shook, state that they have discovered a method for predicting whether transistors are likely to break down during the first several years of their life. The transistors were aged for 1,000 hours at a temperature of 100°C and were then checked. Early increases in leakage current were found to be consistently associated with transistor failure. Changes in leakage current were found to be correlated with the performance over several (simulated) years of life.

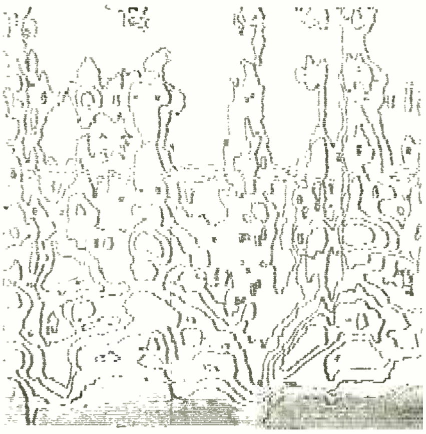
"HOTTEST" ELECTRONS FOUND ON FAR SIDE OF MOON

The Soviet Luna 10 spacecraft has reported electrons with energies 70 to 100 times more intense than cosmic rays on the far side of the moon. The Soviet press agency Tass stated that these electrons could be attributed to the "earth's magnetic tail," and went on to say, "Data have been obtained which may be interpreted as evidence of the existence in the near-lunar space of fluxes of electrons with energies of tens of thousands of electron volts."

According to Dr. Van Allen, of radiation-belt fame, the radiation observed by Luna 10 may well have been the comet tail of the earth. This tail sweeps across the moon when it is full—on the side of the earth opposite the sun—and may have been reinforced by a similar "comet-tail" effect due to the moon itself. The radiation intensity and energy reported by the Soviet Union satellite, Dr. Van Allen pointed out, is similar to that expected from electrons trapped in the earth's tail, and the moon was full on April 5, shortly after Luna 10 was launched.

VOICEPRINT'S FIRST ACCEPTANCE AS EVIDENCE IN COURT

The voiceprint, a sort of electronic analogy to fingerprints, was admitted as evidence in a perjury trial in Westchester County (N. Y.) Court over the objections of two defense lawyers. The trial was that of a suspended policeman charged with perjury in denying that he had warned a gambler of an intended raid.



The voiceprint (RADIO-ELECTRONICS, Aug. 1962, page 6) is a voice spectrogram, which indicates electronically the quality, loudness and duration of sounds or words uttered by the person whose spectrogram is being taken.

Speech is a randomly learned process, according to Lawrence G. Kersta of the Bell Telephone Laboratories, who developed the voiceprint technique. Therefore each individual develops his own approach to pronouncing a given sound. Further, voice quality is determined by the physical characteristics of the vocal cavities and by the structure and use of the vocal muscles.

Mr. Kersta testified that he had supervised 50,000 voiceprint identifications, and that his assistants had scored better than 97% accuracy in identifying voices. He himself, he said, could not remember making a single mistake in the 50,000.

WU COMBINES COMPUTER SERVICE WITH AUTOMATIC COMMUNICATIONS

The Western Union Telegraph Co. has opened the first of a series of real-time public-service computer centers. This marks the beginning of a plan to transform the company into a national information utility, serving business and government with an instant-re-

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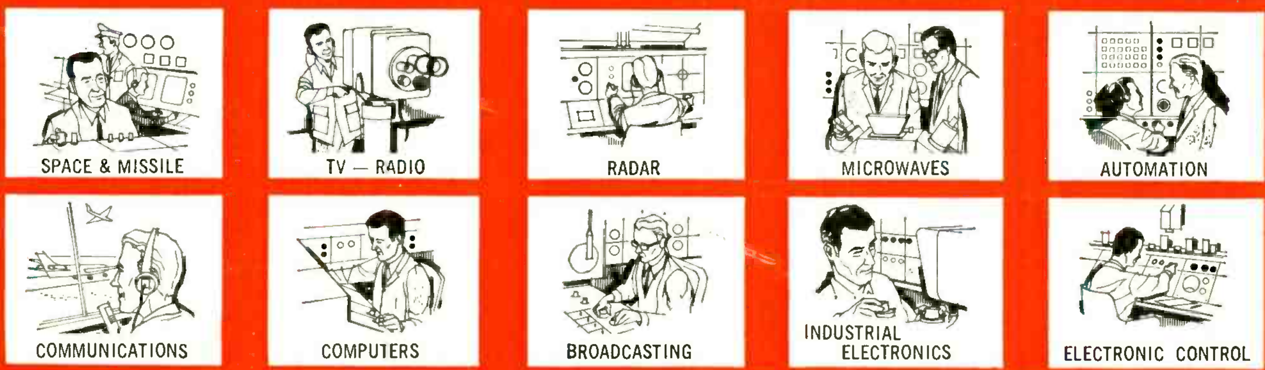

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NEWS BRIEFS continued

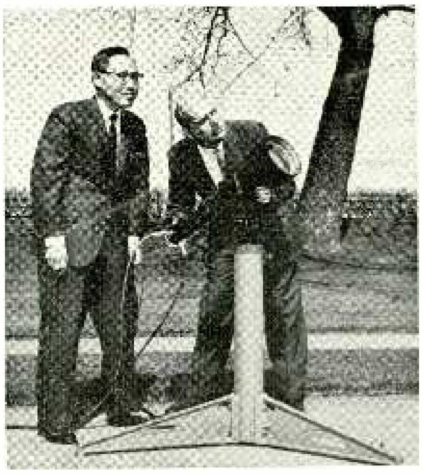
sponse network link with its coast-to-coast Telex system.

Western Union has an advantage in that it can combine a communications system with a computer-based information and data-processing service. Other companies offering similar services have to lease lines from outside concerns.

Western Union will first offer their own customers, or (a new feature) any subscriber to Bell's TWX, an improved telegraph service with which they can communicate direct with any Telex subscriber. Multiple-address messages will be handled automatically by the computer, as will delayed messages. Second, a time-shared data-processing system is offered. And third, an information system, in which the wide range of information stored on the computers' memory drums, will be available to inquirers.

COMPRESSED COMMUNICATIONS USE LASER BEAMS

Patent No. 3,243,592 was granted to two General Electric research scientists, Dr. Kiyo Tomiyasu and James R. Whitten, for a communications system that makes it possible to transmit at least 400 words on a laser pulse lasting a millisecond. Ten such pulses, or 4,000 words, can be sent per second.



The laser beam offers considerable advantages in line-of-sight communications between earth stations and spacecraft. It is not affected by many types of interference that block out radio signals, and may solve the re-entry-blackout problem for spacecraft entering the atmosphere.

The signal is digitally coded and modulates the laser beam in that form. The laser beam is received photoelectrically and the signals are returned to their original digital code form. END

Radio-Electronics

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CALENDAR OF EVENTS

International Instruments, Electronics and Automation Exhibition, May 23–28; Olympia Hall, London, England.

National Electronics Week, May 29–June 5; Civic Auditorium, San Francisco, Calif.

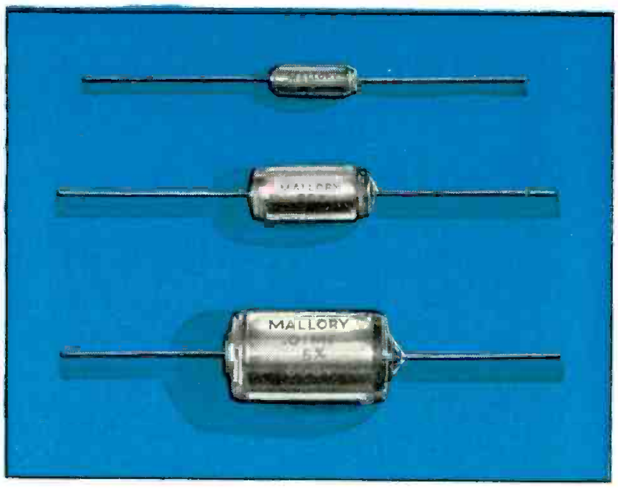
42nd Annual EIA Convention, June 7–9; Continental Plaza Hotel, Chicago, Ill.

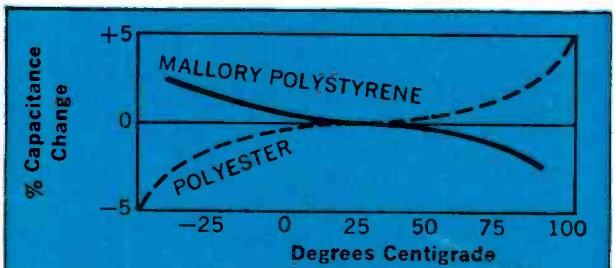
1966 IEEE Communications Conference, June 15–17; Sheraton Hotel, Philadelphia, Pa.

1966 Conference on Precision Electromagnetic Measurements, June 21–23; Boulder Labs, National Bureau of Standards, Boulder, Colo.

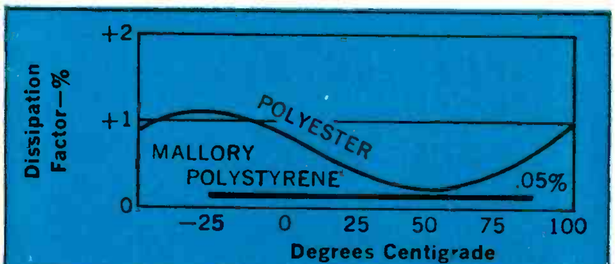
MALLORY Tips for Technicians

When you need a stable capacitor...

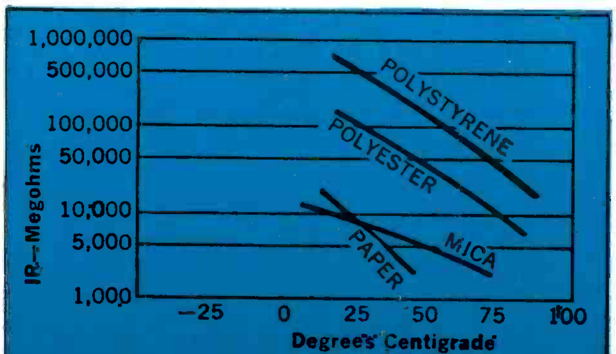




Capacitance vs. Temperature



Dissipation Factor vs. Temperature



Insulation Resistance vs. Temperature

Temperature makes most capacitors wander. For electrolytics, capacitance goes down when temperature gets colder, goes up when things get hot. But this usually doesn't cause trouble, because most electrolytic applications are in filtering—and as long as you have low enough AC impedance, you get the filtering you need. Where drift can bring problems is in tuned circuits, timing and differentiator circuits; here you've got a paper, film, ceramic or mica capacitor, in the fractional-microfarad range. If it changes value due to temperature variations or just plain old age, you're going to have some headaches.

Today's tip: when you need extra stability, try the *new* Mallory polystyrene capacitors. They're the most stable you've ever seen. They look different, and they act different. They're made of a unique kind of stretched polystyrene film and high purity aluminum foil, wound up in a compact roll and then fused together in a self-sealed case of solid clear plastic.

What's extra special about these new capacitors is the way they hold their original microfarad value while temperature varies all over the lot. Temperature coefficient is considerably lower than that of polyester film capacitors—under 150 parts per million per degree C. And it's negative—which means that instead of going up with temperature, capacitance goes down. This is the direction you need to change capacitance in order to compensate for the effect of temperature on the inductive part of a tuned circuit. From −10°C to +70°C, their *total* capacitance change is less than 1.3%. And brother, that's *stable!*

And that's not all. These little dandies don't grow old. They hold their characteristics month after month. You just connect 'em and forget 'em.

One more thing. Mallory Polystyrene Capacitors have the lowest dielectric loss in the business. Their dissipation factor (similar to power factor, a measure of efficiency as a capacitor) is extremely low . . . only 0.05%, which is a small fraction of that of other capacitors. And it stays at this low value over the whole temperature range. This means that they're high Q capacitors, ideal for tuned circuits. And their insulation resistance is way higher than polyester, mica or paper capacitors.

In case you were wondering how much dough you would have to lay out to get such wonderful capacitors—here's the best news of all. They are really low priced. You can get them in values from 5 pF to .01 mfd, all rated 600 volts, from your Mallory Distributor. See him soon—and ask for your copy of the 1966 Mallory General Catalog. Mallory Distributor Products Company, a division of P. R. Mallory & Co. Inc., Indianapolis, Indiana 46206.

50th ANNIVERSARY

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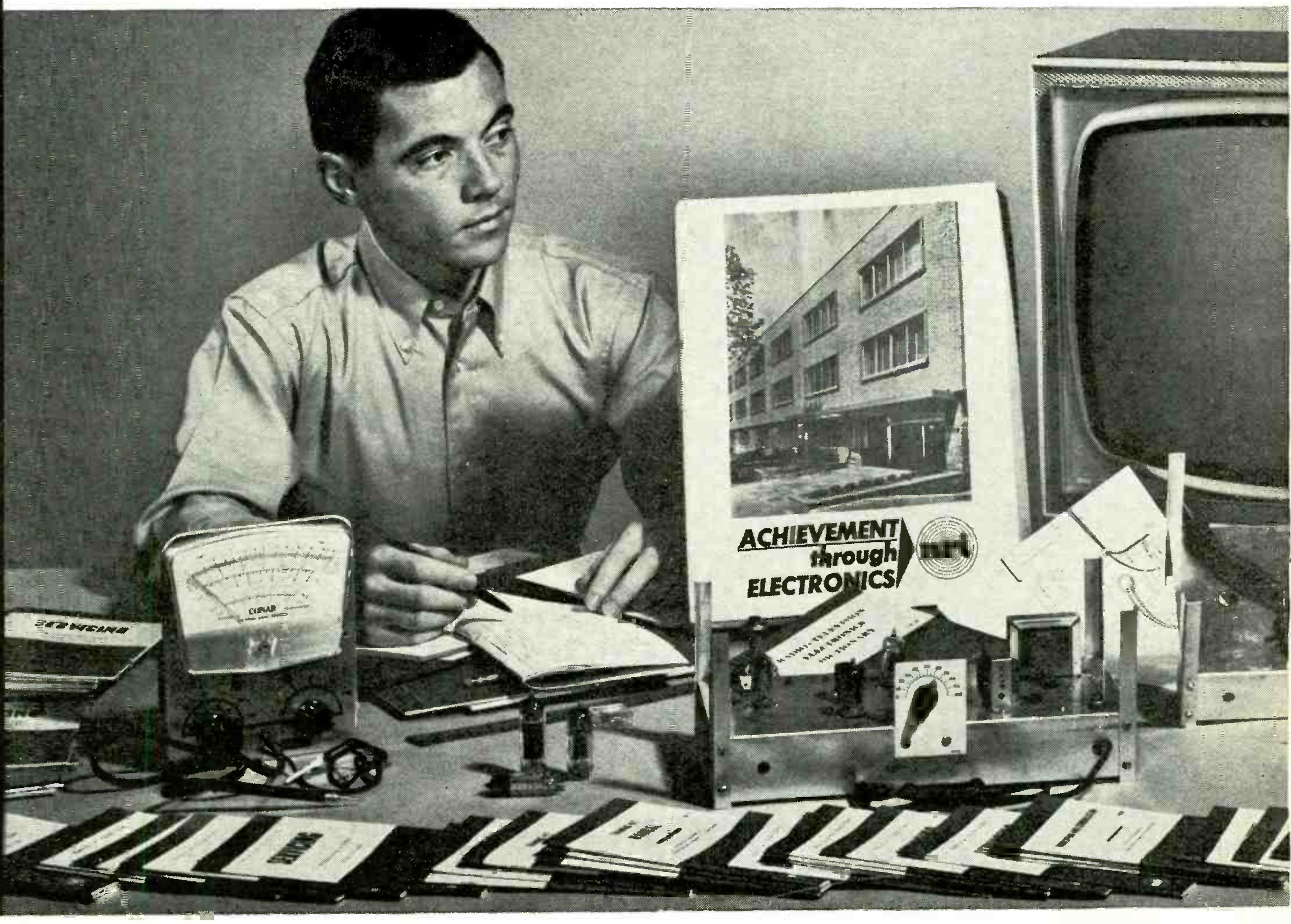

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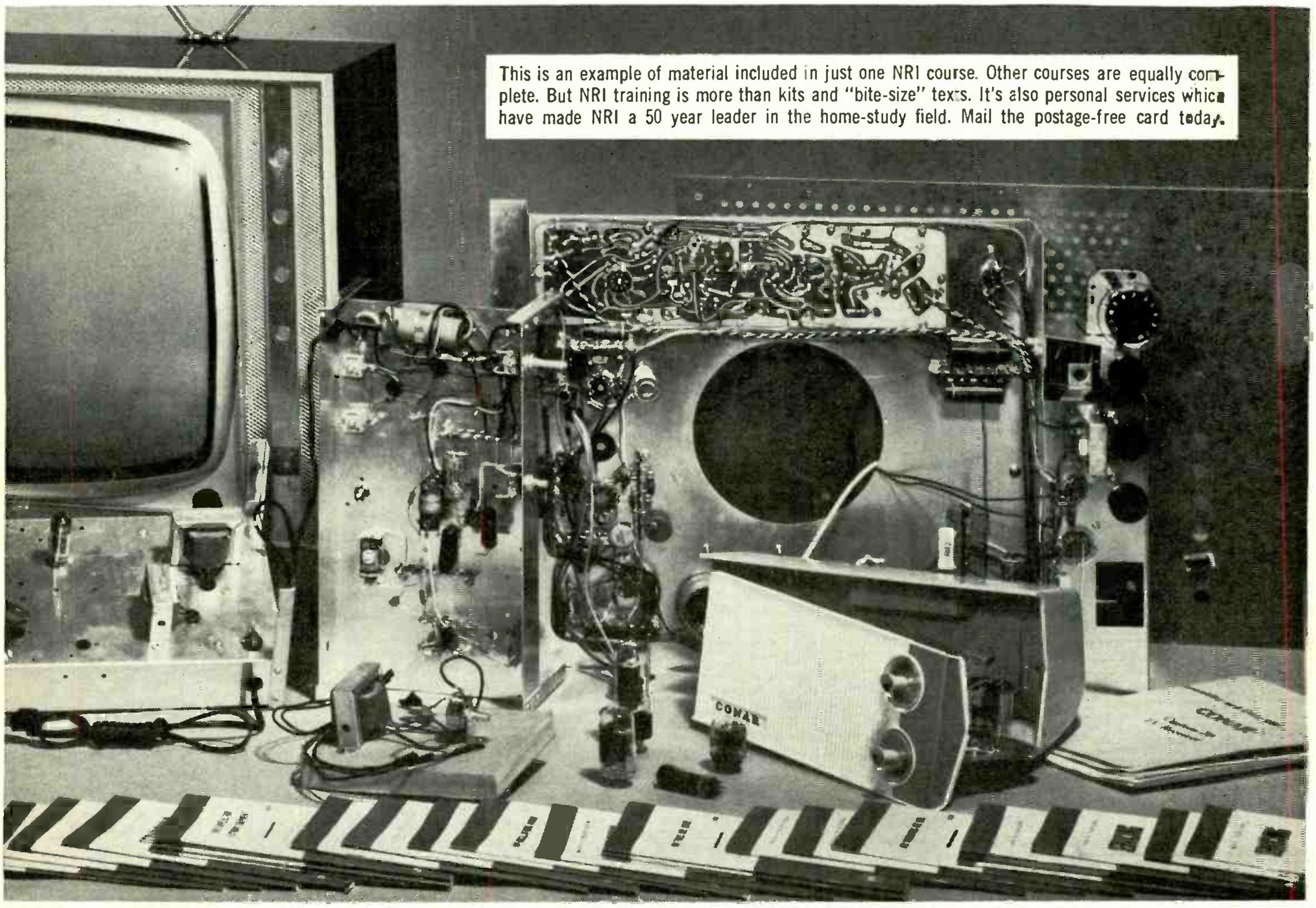

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Correspondence

WE LEFT THEM OUT

Dear Editor: P 48

I found to my dismay that you failed to include Wollensak in your HiFi/Tape Recording issue (March 1966). Our equipment is sold through hi-fi shops, department stores and retail outlets throughout the country. I can understand not including "every recorder under the sun," but I would argue that omitting Wollensak does not constitute a sampling of the "more widely available ones."

TOM C. NELSON
Division Publicist
3M Co.
St. Paul, Minn.

Sorry. We didn't learn in time that Wollensak makes a battery portable. But it sure enough does (see photo).

The model 4100 has a frequency response of 120 to 6,000 Hz ±3 dB, wow and flutter 0.35% rms, signal-to-noise ratio −45 dB, power output 250 mW. It's a cartridge machine, 1 hour per cartridge. Tape speed is 1⅞ ips, track width .06 in. It weighs 3 lb, and comes with mike, C-batteries, carrying case and a patchcord for recording from radio or phono.—*Editor*

AND WE LEFT THEM OUT, TOO

053

Dear Editor:

We enjoyed the article "Why Glow Lamps Glow" by Tom Jaski (February 1966 R-E) until we got to the references section.

General Electric is the largest producer of glow lamps in the US, and we have an excellent publication on glow lamps. Our *Glow Lamp Manual* contains a chapter on theory, chapters on circuits, and a chapter on glow-lamp ratings.

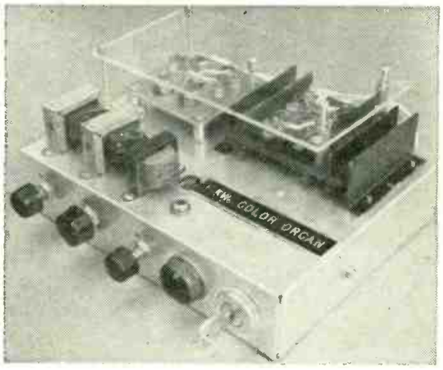
If any of your readers would like a copy, have them drop me a line.

CHARLES R. DOUGHERTY
Application Engineering—381
General Electric Co.
Miniature Lamp Dept.
Nela Park
Cleveland, Ohio 44112

APPLAUSE FOR R-E COLORGAN

Dear Editor:

I recently built the Colorgan featured in the October '65 issue of RADIO-ELECTRONICS. The unit works beautifully and has been the center of attention on several occasions.



I found it necessary to insert a 360K ½W resistor in series with the background control pot to get lamp cut-off with no signal input. I also found that 100W colored outdoor floodlamps seem to give the best display.

My compliments on an excellent article. This version of a Colorgan is by far the best designed of the several types I have built.

DANE E. ERICKSEN
San Bruno, Calif.

ELECTRONIC MUSIC: OPPORTUNITY FOR SERVICERS

Dear Editor:

Electronic music installations involve rather large investments. Breakdowns call for technicians with skill in high-fidelity repair and alignment. Often special projects are planned, demanding someone who can design and construct new apparatus.

North Texas State University is a good example. We have an installation consisting of the Moog Co. sound synthesizer, several tape recorders, mixers and other units. "Home" construction projects have included a sheet-metal reverberation unit, a complex tone generator among others.

Breakdowns, while not frequent, have occurred and, even more important, most of the people who use the lab can use instruction.

Similar situations exist at other schools and universities and are oppor-

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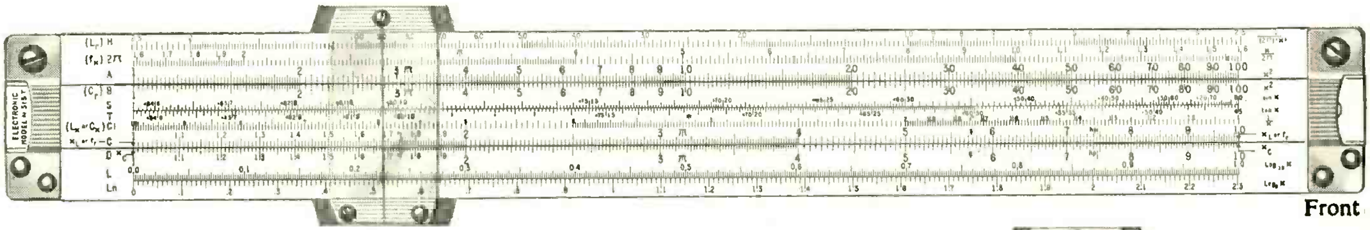
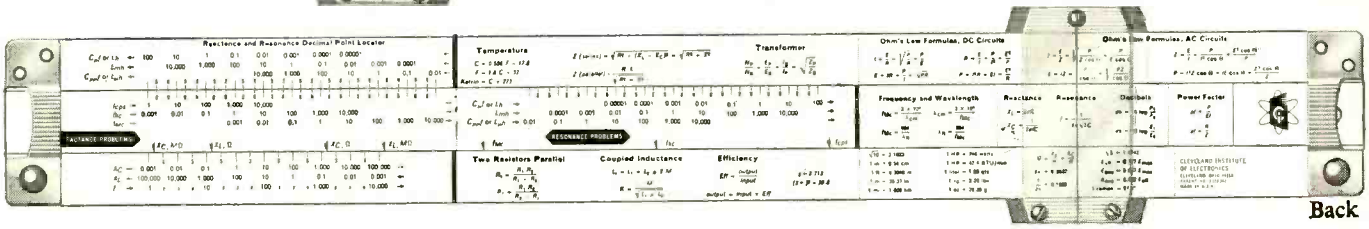
A New Electronics Slide Rule with Instruction Course



Front



Back

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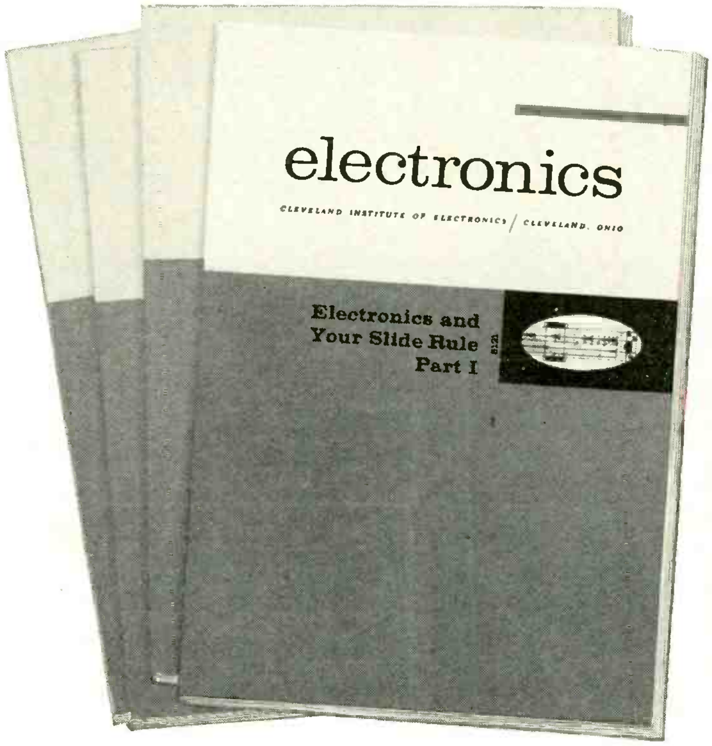

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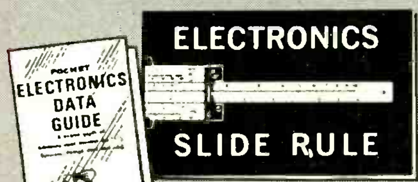

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tunities for enterprising audio technicians with an interest in music.

ROBERT C. EHLE
Research Assistant in Electronic Music
North Texas State University
Denton, Tex.

DON'T TRY THIS ONE!

Dear Editor:

On page 96 of your March 1966 issue you give information for making a simple solder pot. *It is dangerous.*

Copper dissolves in solder. The soldering process depends on that. As a result, the solder will eat a hole through the bottom or side of the copper solder pot in a few weeks, and somebody or something is going to be badly burned by hot solder.

I know, because some years ago I made a solder pot somewhat like that one; but I'm a suspicious guy, so nobody got hurt. I don't even trust my own work!

ROBERT M. VON RIEGERS
Quincy, Mass.

FIXED-BIAS GRID-RESISTOR CHANGE

Dear Editor:

A caution is necessary in applying the amplifier bias circuit on page 100 of the January issue. Since this circuit holds the cathode voltage independent of cathode current, the output tubes are operating under fixed bias. Therefore, the grid resistors for the output tubes must be no higher than the maximum specified for fixed bias. If a cathode-bias amplifier is being modified, the grid resistors might have to be changed.

CHARLES ERWIN COHN
Clarendon Hills, Ill.

TRANSISTOR INJECTOR WORKS FINE

Dear Editor:

I mounted the transistor signal injector (December 1965, page 94) on a piece of cardboard. It works very well, and it was cheaper than any similar factory-made device.

E. KIRSCH
Montreal, Que.

END

Build the 30/30 Transistor Stereo Amplifier

Here's a top quality, solid-state, 60-watt power amplifier that, says RADIO-ELECTRONICS' audio editor, turned up as "the best-sounding, best-measuring amplifier for less than $250." And it costs a *lot* less to build! Harmonic distortion 0.5% or less at full power and at any frequency. RADIO-ELECTRONICS' detailed plans make building it a cinch. No rare parts or critical adjustments.

Get all the details in the July issue of RADIO-ELECTRONICS

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More brains? More ambition?

No, just more education in electronics.

You know that two men who are the same age can work side-by-side on the same project, yet one will earn much more than the other.

Why? In most cases, simply because one man has a better knowledge of electronics than the other. In electronics, as in any technical field, you must learn more to earn more. And, because electronics keeps changing, you can never stop learning if you want to be successful.

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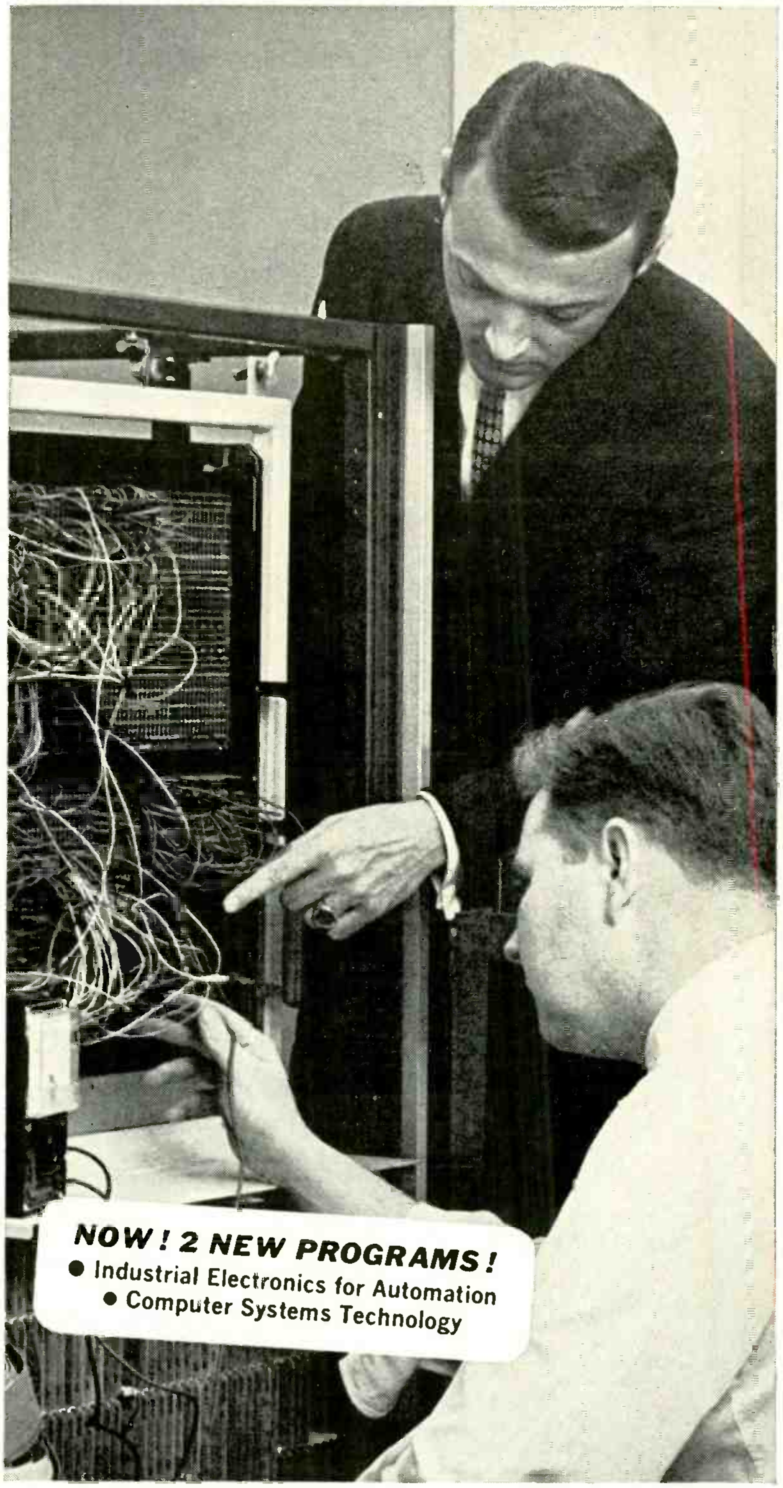

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16

WIFIJECH

While our LPV-TV series was undergoing development in Champaign, Ill., it was assigned the code name: WIFIJECH.

For good reason.

Its performance objectives were to surpass every competitive make—model for equivalent model!—in gain, directivity, response, V S W R, & F/B ratio.

Did the new LPV-TV come through?

—All the way! Its performance is the proof!

Now at your JFD LPV distributor.

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Write for LPV-TV brochure 1039.

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BY FAR—the best antenna for VHF COLOR performance because it combines...

- The electronic perfection of the patented frequency independent Log Periodic concept of the University of Illinois Antenna Research Laboratories.
- New capacitor-coupled Cap-Electronic elements that respond on the third harmonic mode for highest effective gain. More harmonically resonant elements mean higher signal-to-noise ratios, better ghost rejection, sharper directivity on high VHF band—where it's most needed, especially in color.*
- True dual-band directors separately tune to high and low bands for added gain and directivity on all channels.
- Flat frequency response (± ½ db across entire channel) for studio-quality color regardless of channel tuned.

New LPV-TV Log Periodic antenna series incorporates new capacitor-coupled element concept for improved response, especially in color, on channels 2 to 13.

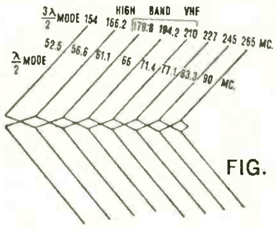

FIG. 1

Fig. 1 shows how a VHF log periodic with eight conventional V-dipoles might look. The resonant frequencies of the dipole elements in the low VHF band are indicated near midpoint of each dipole. The 3/2 wavelength resonant frequencies are indicated near the ends of each dipole. (Note that only three dipoles resonate at frequencies in the high VHF band.)

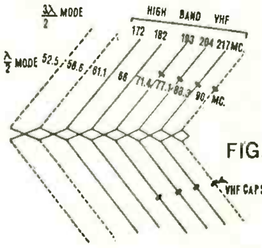

FIG. 2

However, by introducing parallel plate capacitors into the dipoles and by carefully adjusting the value of this capacitance and its position on the dipole, as shown in Figure 2, the resonant frequencies of the dipole can be shifted in the 3/2 wavelength mode. In this way, the dipole can be made to resonate at two desired frequencies: e.g., 88 and 216 mc.

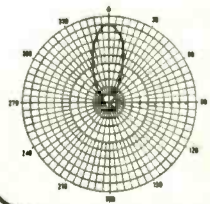

FIG. 3

Result: the active region in the high band extends over five of the eight original dipoles instead of three, as in Fig. 2, with a performance improvement of 66⅔%. The new capacitor-coupled dipoles also present more capture area on the low band than ordinary dipoles. Thus LPV-TV antennas offer, on both bands, higher and more uniform gain, lower side-lobe levels, narrower beamwidths, for vastly improved ghost rejection (see Fig. 3).

VHF – up to 50 miles
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3 Cell System (single-crossarm)
With electronic "ghost-killing" trap
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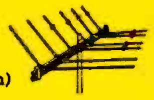

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FM – up to 40 miles
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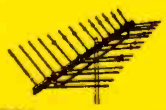

VHF – up to 150 miles
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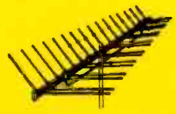

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SERVICE CLINIC

By JACK DARR Service Editor

Servicing Transistor Sets

EVERYBODY HOWLS ABOUT SERVICING transistor radios, and howls louder about transistor TV's. "Too little!" "Hard to fix!" "Can't get at 'em," and so on. Actually, we're just yelling to hear our voices —they're not all *that* hard to fix. We said the same things about printed circuits, and now they're everyday stuff.

Most of our trouble is wrong test equipment! We fixed radios with a wet finger and a screwdriver. When TV came along, we had to give that up. A lot of us old bull-heads for a long time kept getting burnt fingers, but we finally got to where we'd use a voltmeter! Now, we have to go back to an earlier technique to get information about transistor radio troubles.

Voltage readings are useful, yes. Not in the way we've been using them, though, as a first step to finding trouble. We can use the same principle but with a different instrument. Yes, you guessed it —the scope! If you can see a resemblance between this method and good old-fashioned signal tracing, you're right!

So, try this (good procedure for all kinds of transistor equipment): First, check the battery or power supply. (Standard Service Procedure No. 1.) In a radio, put the low-capacitance probe on the detector, with the set tuned to a station or to a signal generator. Any signal there? If so, then the front end, i.f., etc. are OK, and the trouble is past that point—between there and the speaker. We've got a start already!

Remember: we're not looking for perfect waveforms, or anything like that. All we need to know is, "Is there a signal there or not?" If you're using a signal generator, you'll see the 400-Hz sinewave modulation. If there's *any* signal at this point, then there ought to be *something* coming out of the speaker, if the audio stages are OK.

It's very easy to follow this signal through the audio stages. Just go from base to collector, and look for an increase in signal strength across each transistor stage. Exactly the same as going from grid to plate in tube circuits. You won't get the same amplitude increases you're used to in tube sets, but you'll still see the increase in height that means the stage is amplifying.

Typical peak-to-peak signal readings in this type of circuit, with an af amplifier stage, driver and output: af stage, base, 10 mV; collector 170 mV. Driver, 0.1 to 1.2 *volts*, and so on. Find a stage without gain, or without any signal at all in its output circuit, and there you are. Stop and make dc voltage measurements in *that* circuit, for you've found the trouble. You'll have only five or six parts to check, including the transistor.

Transistor i.f.'s are a source of many complaints. However, if you use the right method, they're just as easy. Of course, you can't make gain checks until you find out what killed the set and fix that. Just as in all radios, *never* try aligning one unless you can get a signal through it!

Put a crystal-detector probe on the scope and start in. Feed in an i.f. signal with audio modulation, and go from base to collector and so on. If any stage has a loss, or very low gain, it'll be easy to spot. (Try this on a set you know is working, so that you'll have an idea of about what signal level to expect in different stages.)

Transistor TV's are exactly like this. After all, they're still TV sets, aren't they? You'll find the same signals as in any other, and in the same places. As a beginning, look at the signal at the video detector with a low-cap probe. If you find video there, you know that the trouble must be past that point, in the video amplifier stages.

You'll probably find about 2 volts p-p signal at the detector. Check the gain through the video stages just exactly as if they were audio amplifier stages. You will wind up with a video signal at the CRT of about 100 volts p-p. The value varies a bit from one set to another, just as it does in tube sets.

Sync, sweep, audio—all the other functions are the same as before, and they can all be signal-traced with the scope. Troubles in the sweep circuits will be about as common as they have been in tube sets, and can be fixed with the same basic methods.

Horizontal sweep circuits have the same functions: oscillator with afc, output, damper, HV rectifier, etc. If there's

This column is for your service problems—TV, radio, audio or general and industrial electronics. We answer all questions individually by mail, free of charge, and the more interesting ones will be printed here.

If you're really stuck, write us. We'll do our best to help you. Don't forget to enclose a stamped, self-addressed envelope. Write: Service Editor, Radio-Electronics, 154 West 14th Street, New York 10011.

no high voltage and the breaker is kicked out, check the output stage for shorted transistors, diodes, etc. Measure high voltage with a HV probe, as you ought to; it's not a good idea to arc HV leads to chassis in transistor sets. The voltage spikes you cause might puncture a perfectly good transistor.

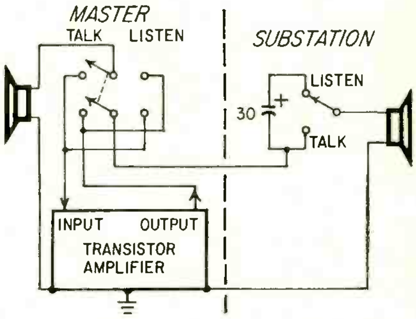
Some of the functions may look different, but they're just the same. The damper diode, f'rinstance, may be connected directly to the horizontal output transistor, on the "wrong side" of the flyback, but it does the same thing—damps yoke ringing. Incidentally, there's no boost voltage in transistor TV's, and no need for it, so don't worry about *that*.

So, if we use the old reliable service methods—find the trouble by checking *function, stage, circuit* and finally *parts*—we'll get along very nicely, thank you. It'll take us a little while to get used to the *appearance* of these little chassis, and find out where the parts are and what they look like; but after we do, we won't have any more trouble than we had before.

Transistor intercom overheated?

We had a little transistor intercom in our show window, and it got pretty hot. Now it works OK when the master calls the substation, but the "call" signal stays on, even with the set off. When it's on, the substation is continually calling the master.—A.D., Toronto, Ont.

It looks very much as if your 30-μF capacitor has shorted. These very-low-voltage electrolytic types can be pretty



delicate, and this is a more likely suspect than a transistor. The amplifier is obviously still working, since it works one-way very well.

Note that the remote's switch bypasses the 30-μF capacitor in the TALK position. So, if the capacitor is shorted, the remote "calls" all the time.

Reversible battery

I found a funny one recently, while checking a set of flashlight cells used in a table-model transistor radio. It had six cells; when I read the total voltage with a vtvm, I got 9 volts. Turning the set on made it drop to a bit less than 6 volts.

I measured the voltage across each battery; with the set off, they all read 1.5 volts. Turned the set on and one bat-

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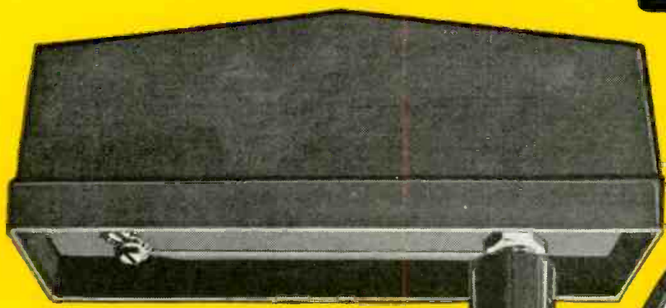
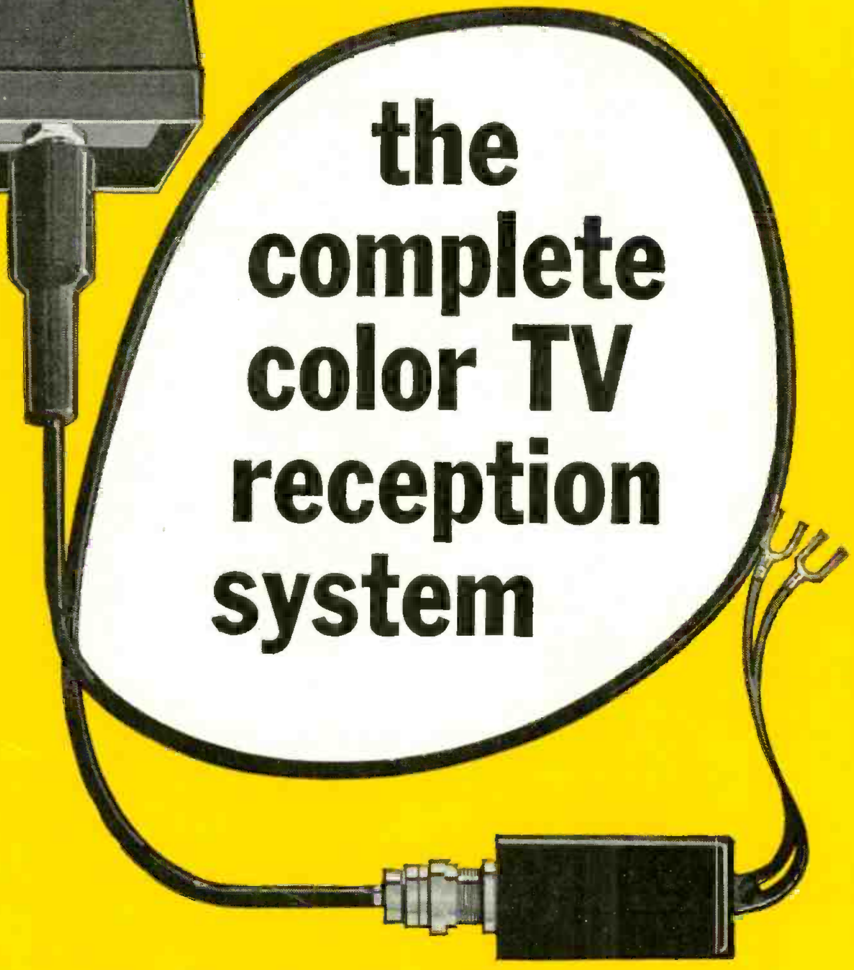
COLOR-KIT





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Circle 19 on reader's service card

tery all of a sudden read about 1.8 volts but the polarity was reversed! Wha hoppen?—B.G., Fayetteville, Ark.

This is perfectly normal. The cell that "reversed itself" is very dead! Actually, you shouldn't even bother to take an open-ciruit or no-load reading if you use a vtvm. The very high input resistance will give you a seemingly "normal" reading on a battery that is almost completely exhausted!

Always check batteries under full load; that is, with the radio turned on. With transistor radios, the load current is higher at full volume than at low volume; so, measure these with the radio playing at normal room volume.

The reversible cell was exhausted or faulty; it couldn't furnish its share of the total current. With all those healthy cells pushing current through it anyhow, it gave up and became a series resistor! Notice that the reversed voltage you read across it was actually higher than even its normal open-circuit voltage.

Measuring small dc voltages

What's the easiest way of measuring base bias on transistors? My eyes aren't as good as they used to be, and it's hard for me to tell the difference between 6.2 and 6.4 volts on a meter.—O.T., Birmingham, Ala.

The easiest way is to measure this voltage between the base and emitter on the transistor itself (meaning on the socket, of course). By doing this, you can set your meter down to its lowest range. If that's about 2 volts or so, the difference between 0.2 and 0.3 volts will be much easier to see.

Transistor phone pickup "one-way"

I'm using a transistorized phone pickup amplifier. It has lots of volume when the other party is talking, but on my end it's very weak! Is there a way I can make this amplifier more sensitive to get rid of this? Or, could I use a more powerful amplifier?—G.S., Maybrook, N.Y.

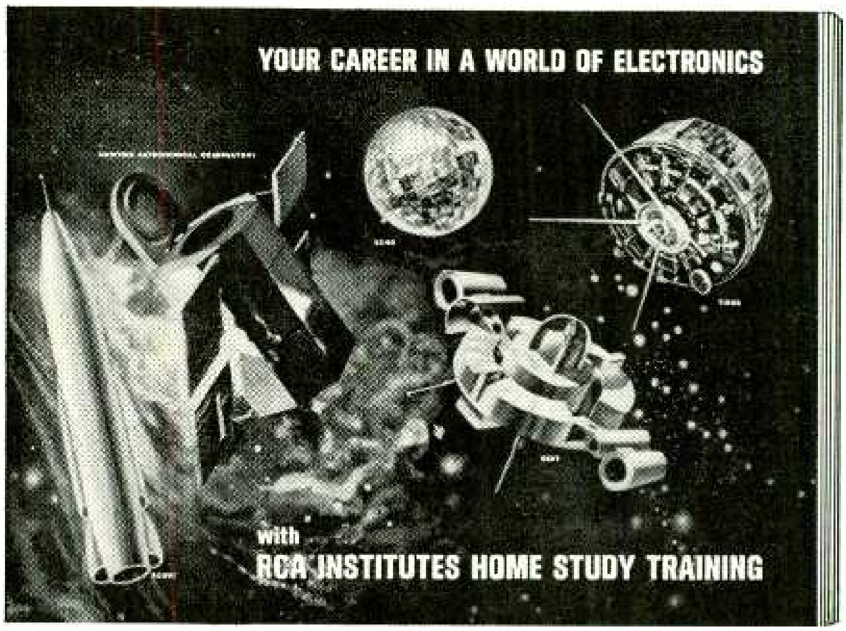
I don't think this trouble is in the *amplifier*, from the symptoms. If you'll notice, there is only one pickup coil. This is placed under the base of the telephone, and coupled magnetically to the incoming *and outgoing* signals.

So, your pickup should be the same for both *if* the signal levels are the same. It looks to me as if your incoming signal is quite a bit higher than the outgoing signal from your own phone.

Perhaps the incoming signal has just gone through a nearby repeater amplifier; your own mike signal, of course, has no amplification. This might account for the difference.

Try moving the pickup coil to different locations under the phone base, or inverting it, and see if that helps. END

Cut the time BETWEEN NOW



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THE IC COMES TO TV!

First integrated circuit in home TV sets replaces sound i.f., detector and preamp—contains a dozen transistors, a dozen diodes, over a dozen resistors

By George F. Corne, Jr.*

MICROELECTRONICS IS REALIZING A SPECtacular impact, growth, and influence in the electronics trade. The principal products, solid-state integrated circuits—an outgrowth of transistor technology—are complete electronic circuits (or systems) fabricated into a single microminiature unit. An entire amplifier system, for example, may be contained on a small chip of silicon material no larger than a match head. The microminiaturized unit usually contains all the necessary transistors, resistors and capacitors to operate as an amplifier system.

* *RCA Sales Corp., Indianapolis, Ind.*

In the center of the ring: RCA's TV-sound integrated circuit, between two transformer cans. It eliminates a third (interstage) can, and simplifies servicing and production tremendously. All 10 leads are accessible from either side of the circuit board for voltage checks and signal injection—the two main techniques you'll be using to troubleshoot this kind of circuitry. There's no need to reach the insides.

In the few years since they were introduced in 1958, integrated circuits have found their widest application in military and computer electronics. Those responsible for designing military electronics, especially in our space program, were quick to adopt solid-state integrated systems. The drastic reductions possible in size, weight and power requirements, together with exceptional reliability, make microcircuits ideally suited for such critical and important applications. Techniques of manufacture have been improved until integrated electronic circuits are now commercially available for a large number of applications—rf, i.f., video, audio, dc amplification, and logic switching.

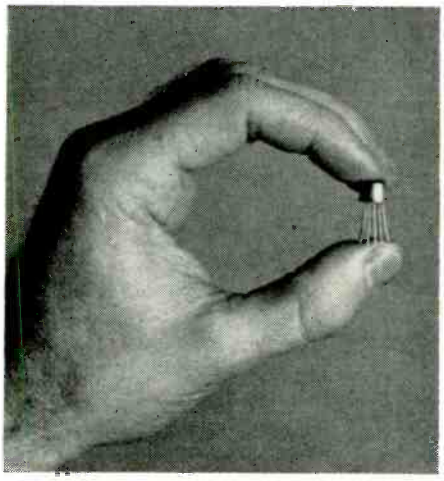


Fig. 1—That's all there is to it—one single TO-5 header and case, about 3/8 inch diameter, 3/8 inch high, with 10 wire leads.

In consumer use

In the early 1960's, leaders in the electronics industry couldn't agree whether integrated circuits would follow traditional evolution—military to industrial to commercial and home-entertainment equipment—or would bypass the industrial step. Some predicted integrated circuits would appear in home-entertainment products well before full saturation in industrial applications. But, even with this accelerated approach, most predictions were conservative and ventured the late '60's as the time integrated circuits would appear in consumer products such as television, hi-fi and radio.

The predictions were indeed conservative! Near the end of 1965, Admiral indicated in the trade press that microcircuits would soon appear in some of their home-entertainment products; they declined, however, to reveal exactly when or in what instruments. Shortly after that, in February, RCA Victor announced that several of their black-and-white and color television instruments to be marketed this year will use an integrated sound circuit.

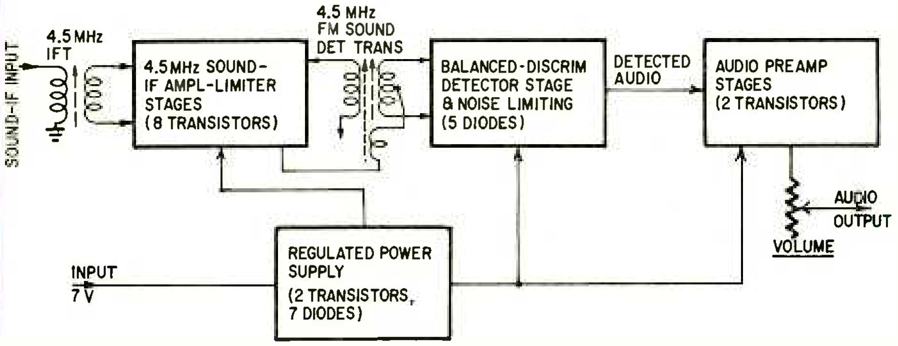


Fig. 2—The RCA IC sound circuit replaces these stages (though not the transformers).

A working IC

The tiny size of the RCA integrated circuit (IC) is shown in Fig. 1. It is actually a complete subassembly. That is, the little unit contains the equivalent of 12 transistors, 12 diodes, and a brace of resistors, and performs several functions: 4.5 MHz amplification, limiting, noise rejection, FM sound detection, and audio preamplification. Besides these multiple stages, the IC has two internal power-supply circuits for its own voltage regulation and distribution. All the functions are illustrated in the block diagram (Fig. 2).

Fig. 3—Typical sequence of TV sound stages. It's preserved even in the IC design.

Notice the similarity of functions in the IC to those performed by TV sound stages that use discrete components. A comparison of Figs. 2 and 3 suggests one of the main advantages of the IC over conventional tube circuits and components. The improved performance of the circuit represented in Fig. 2 can be achieved with the IC because the number of transistors and diodes necessary for this optimum is not limited by space or cost, as it is with discrete components. Notice the IC system has in it eight sound-i.f. amplifier and limiter transistors (for highest possible rejection of AM and noise). This thoroughness of design—carried further in the balanced diode discriminator stage with noise limiting, the two audio preamplifier stages, and the two power stages—would require prohibitive space and added cost if introduced other than by an integrated circuit. The same sound stages in older models used two transistors and 24 other assorted parts. In the conventional circuit using individual components, an even larger number of parts would be needed.

Inside the IC

The working schematic for RCA's integrated sound circuit (stock No. 118361) is detailed in Fig. 4, which is drawn to show signal flow from left to right. All components shown inside the dashed lines are contained in the IC. The only external components needed to complete this sound system are the tuned input transformer, certain bypass capacitors, and a tuned discriminator transformer. The power input is a positive 7 volts, obtained through a dropping resistor (bypassed with a Zener diode) from the B+ supply in the TV chassis. In the color-TV receiver, the 7-volt supply is taken from the emitter circuit of the audio output transistor.

The entire 12 transistors, 12 diodes, and 14 resistors are contained on a small silicon chip, hardly larger than the diameter of lead in a pencil. The microcircuit is much smaller than the TO-5 package case (Fig. 1) would indicate. Taking 4.5-MHz input at pins 1 and 2, the sound-i.f. section of the IC uses 8 transistors—connected as emitter-coupled amplifiers and emitter-follower circuits—to provide amplification and limiting for the sound-i.f. signal. Output at pin 5 is the amplified 4.5-MHz sound i.f., coupled to a tuned phase-shift transformer. Overall gain of the 4.5-MHz portion is approximately 75 dB.

All components associated with the sound discriminator circuit are inside the integrated-circuit block, with the exception of the transformer. In its drawn configuration, this stage looks like a ratio detector, but it isn't. Diodes D1 and D2 are formed in the IC chip in a special manner that causes the circuit to operate as an average-detector or a sampling type of balanced discriminator. This new type of discriminator provides a constant level of audio output over wide ranges of input signal strength. Diodes D3, D4 and D5 serve as rf filter capacitors and help limit impulse noise.

The balanced-detector network is followed by an audio preamplifier stage. Sound-signal output sufficient to feed an audio driver stage is taken from pin 9 of the microcircuit.

The two internal power stages (2 transistors, 7 diodes) regulate the 7-volt dc input at 4.2-volt and 2.1-volt levels to supply the amplifier–limiter and discriminator circuits. The IC draws 17 mA in normal operation, and will function over a 6–10-volt spread.

RCA's new KCS153X (12-inch transistorized black-and-white chassis) announced in March was the first television receiver to use an integrated circuit. The photo on this month's cover and the one on page 26 show the physical location of the IC in this particular chassis. The 4.5-MHz input transformer and the discriminator's phase-shift transformer are located directly above and below the TO-5 housing of the IC. Other monochrome chassis and at least one color chassis will use the 118361 or a similar unit.

Troubleshooting an IC

The coming of integrated circuits to home-entertainment equipment is of special interest to the service technician. The main concern here is: what's the best servicing procedure to determine the condition of an IC?

First, remember that you can't repair an integrated circuit. If an IC is found defective, the only solution is a new, *direct replacement*. However, integrated circuits have proven more reliable than transistors and tubes, and not many faulty ones are anticipated. Price of a replacement unit is expected to be less than $10, far less as production grows.

If a replacement is required, use

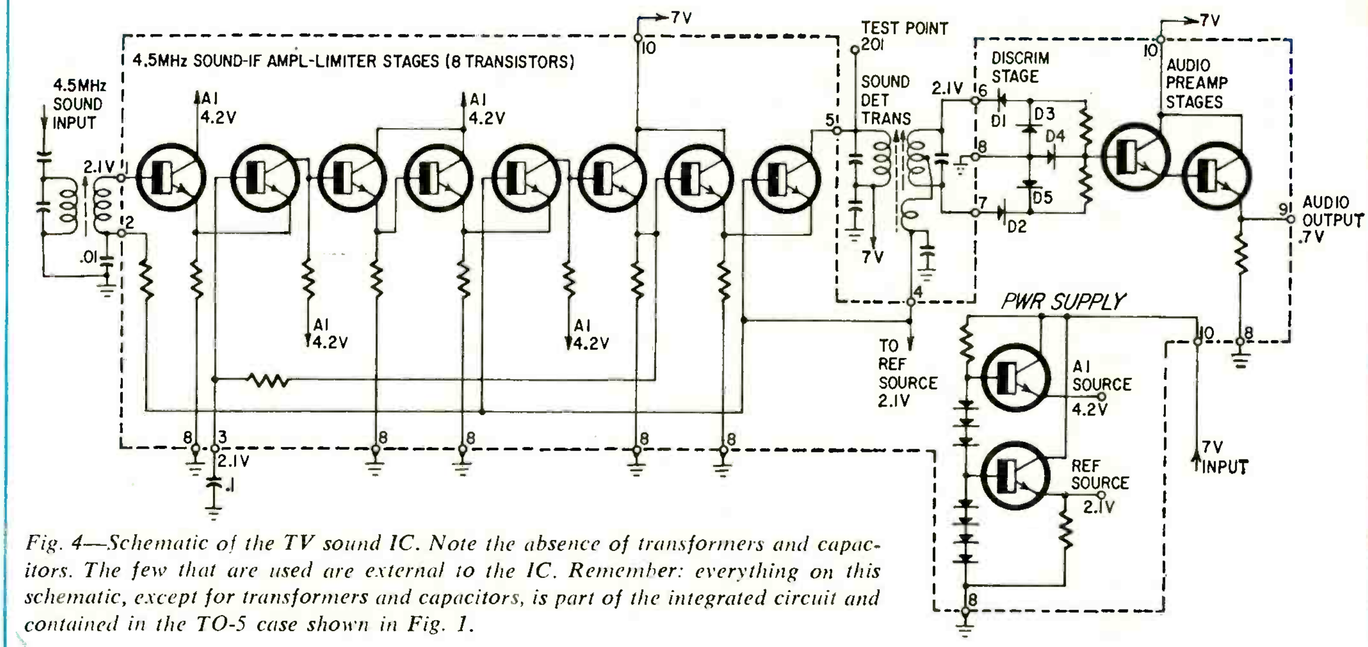


Fig. 4—Schematic of the TV sound IC. Note the absence of transformers and capacitors. The few that are used are external to the IC. Remember: everything on this schematic, except for transformers and capacitors, is part of the integrated circuit and contained in the TO-5 case shown in Fig. 1.

the same careful soldering techniques as with other delicate solid-state devices—including the usual precautions. To remove a faulty IC from the circuit, you can clip the individual leads, then remove the stubs one at a time from the holes in the printed board.

The integrated sound circuit is shown in Fig. 5 as it will probably appear in service data. The IC is separated into two triangle symbols for clarity of understanding signal flow. The basing diagram shows that the IC has 10 leads. Circuit connection of each terminal is identified by number on the schematic.

Two familiar methods can be used to determine proper operation of the IC: signal injection with a generator (or tracing the station sound) and dc voltage measurements at the IC terminals. It's usually best to use a combination of both procedures.

As an example of troubleshooting procedure, assume the symptom is that sound is missing. The servicing procedure might follow these steps:

1. Apply audio signal to pin 9 of IC to check audio stages following. *Result*: Good output signal.
2. Move generator to pin 6. *Result*: Good output.
3. Apply a modulated 4.5-MHz signal to pin 5. *Result*: Good output.
4. Inject 4.5-MHz signal to pin 1. *Result*: Weak or no output from speaker. Conclusion: Possible IC trouble.

Notice carefully the word *possible*. Before the IC can be definitely condemned, more tests are in order—for example, a visual check of solder connections to the IC terminals. Voltage measurements on pins 1, 2, and 3 may provide other clues. How's the secondary of the input transformer, and are the capacitors at pins 2 and 3 (C207 and C208) in good condition?

A good rule of thumb to remember when servicing integrated circuits is: Check the condition of all associated components before committing the IC to the scrap heap. Remember, the integrated circuit is known for its reliability and long life.

Signal injection or tracing is not limited to the sample case given above. The integrated circuit can be checked in its entirety by injecting a 4.5-MHz signal into the primary of input transformer, while checking discriminator output. Several signal-tracing approaches are possible—as in conventional television sound systems.

The IC service procedure, then, becomes more a matter of checking at input and output points—the same procedure good technicians now follow with ordinary stages. The only difference between servicing the IC and the conventional circuit is that many internal connections in the IC are not accessible for testing.

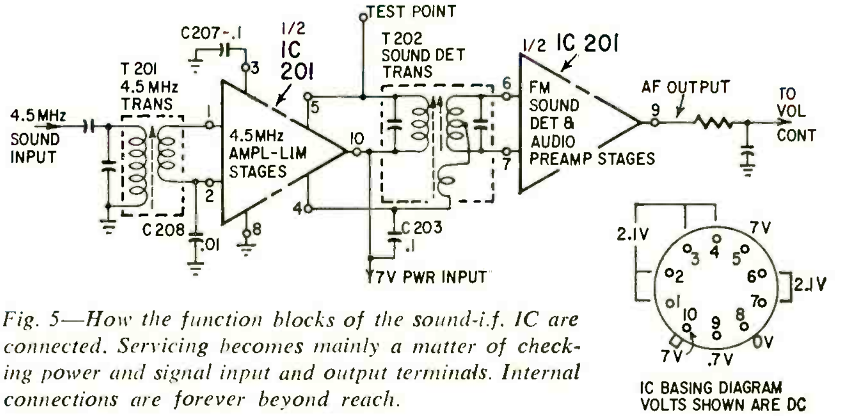
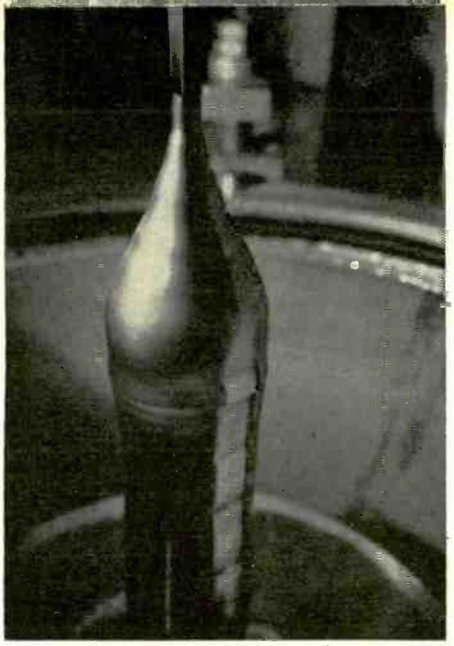


Fig. 5—How the function blocks of the sound-i.f. IC are connected. Servicing becomes mainly a matter of checking power and signal input and output terminals. Internal connections are forever beyond reach.

More to come

The reliability and reduced power requirement of integrated circuits are sure to stimulate designers to find further applications in other home-entertainment devices—radio, stereo amplifiers, tape recorders, garage-door openers, toys—possibly much sooner than was expected, judging from those early-'60 predictions. The initial step has been taken for revolutionary changes in products for the consumer's home, and a new dimension has been added to servicing. END



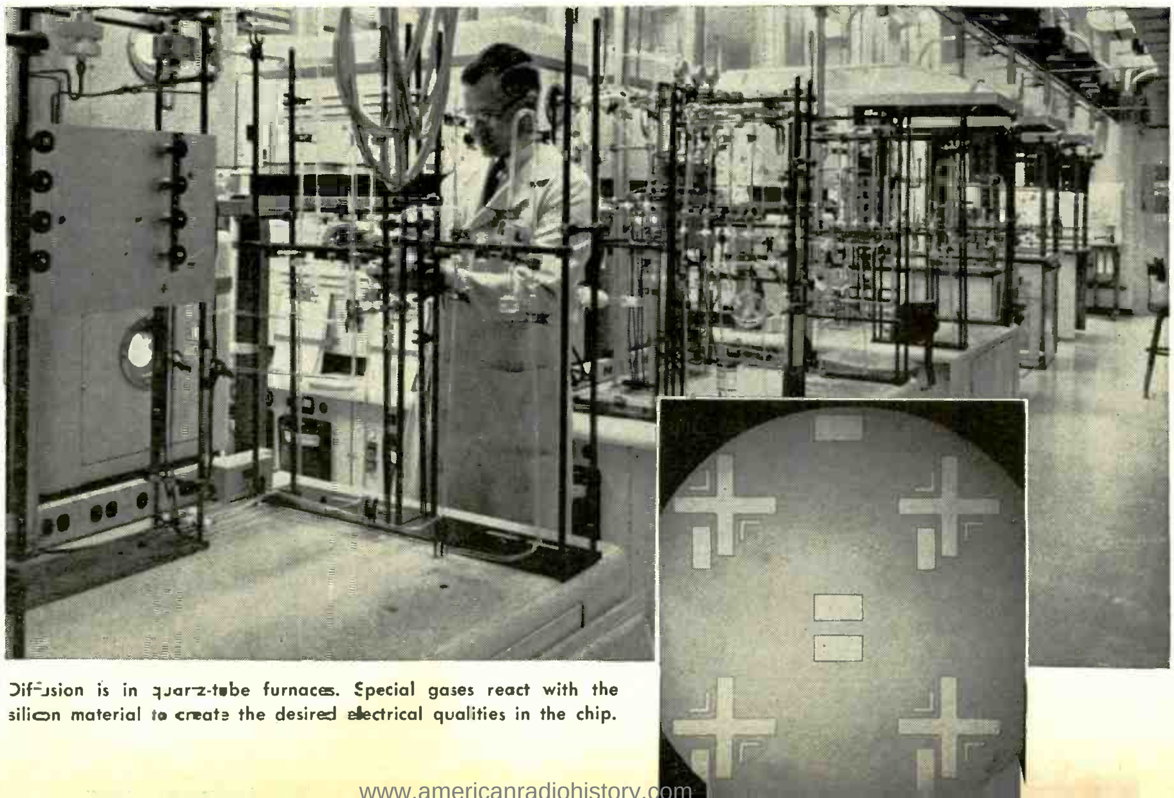
Photos courtesy Fairchild Semiconductor Div.

EVOLUTION OF AN INTEGRATED CIRCUIT

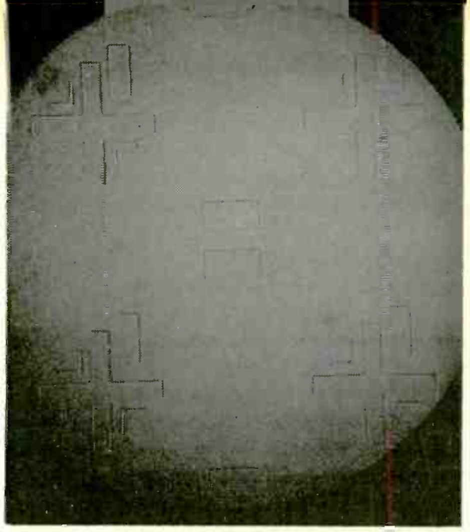
Microcircuits are probably the hottest news in electronics this month, especially since they are being introduced as low-cost items available through ordinary distribution channels. This accessibility should speed their use in consumer products and trigger a raft of experimenters' projects. Here is how IC's are manufactured in quantity—the best way to lower their prices.

Integrated circuit begins same as other semiconductors: ingot of monocrystalline silicon, "grown" at 1425°C (melt point) in oxygen-free atmosphere.

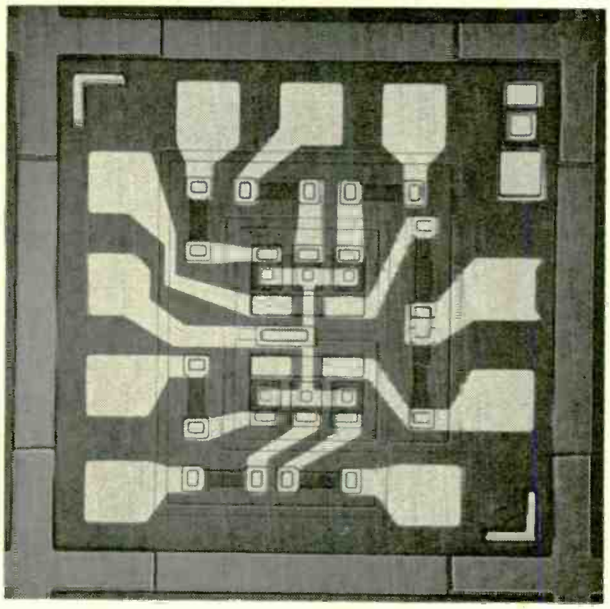
Slices of silicon are coated with a layer of photosensitive material and exposed to ultraviolet light passing through a mask. The patterns which are thus impressed on the silicon substrate form shapes which will then be etched away, leaving behind areas for the many diffusions that are part of the manufacturing process. Mask alignment is simplified by projection-type magnifying viewers shown being used here in IC production.



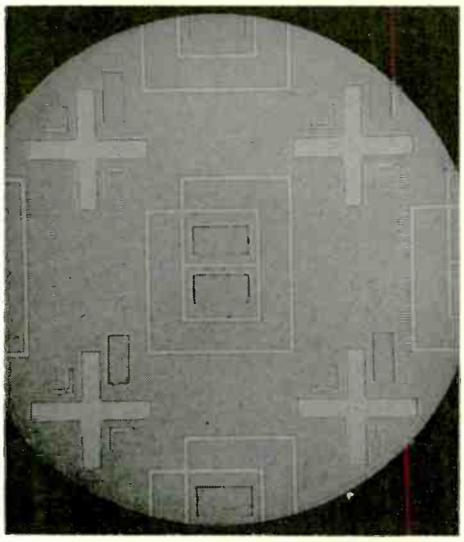
Diffusion is in quartz-tube furnaces. Special gases react with the silicon material to create the desired electrical qualities in the chip.



After the first diffusion, following step is to deposit a crystal layer over entire silicon slice. A smooth epitaxial layer is produced this way.

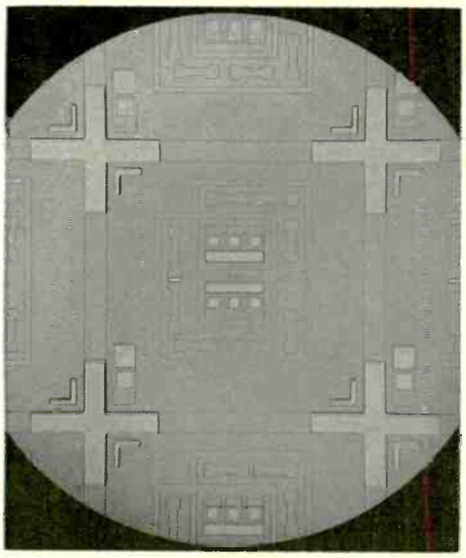


Metallic deposits over and among elements link IC components.

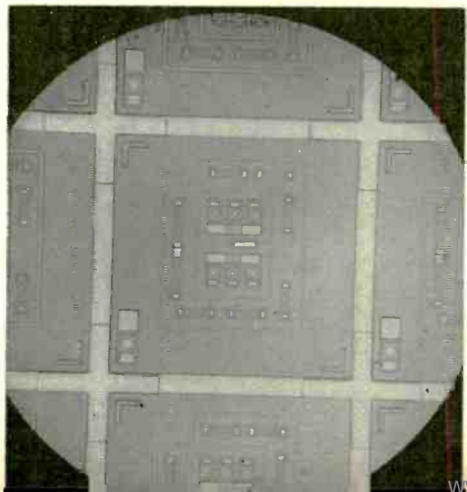


Next, isolation diffusions — to keep electronic signals from leaking from one segment to another—are developed in the integrated chip.

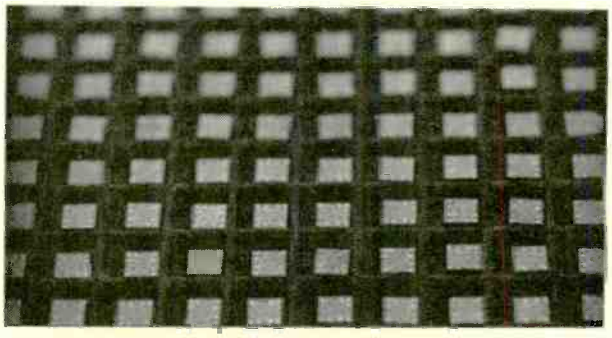
Evaporation apparatus like this is used for depositing interconnects.



Other diffusion steps develop a number of transistors, diodes, and resistors. Each element is an integral part of original chip.

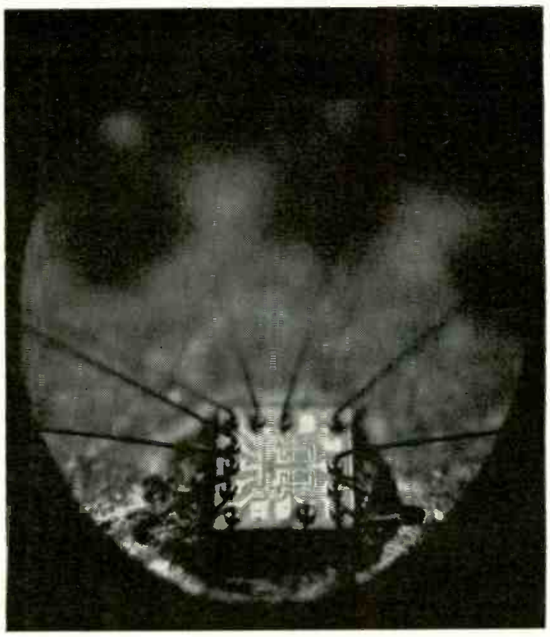


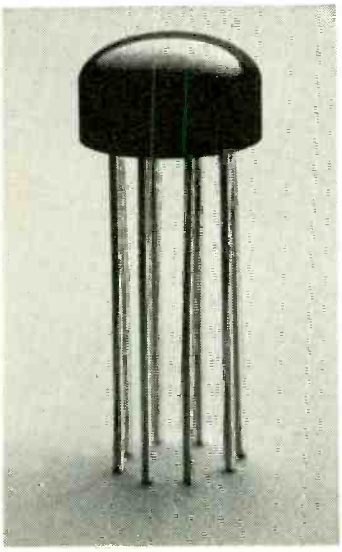
Still more steps are needed in the diffusion process to complete development of circuit portions. Result is a chip full of active elements.



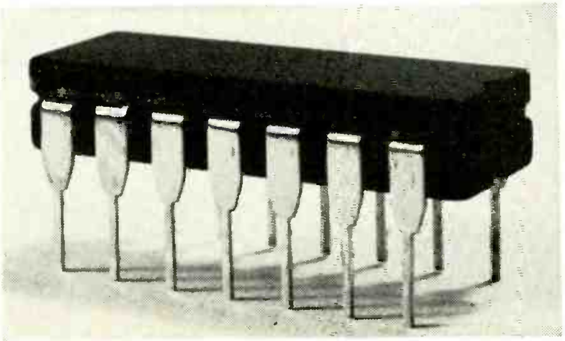
Finished chips rest in honeycomb-like carrier awaiting packaging.

Powerful microscope (above) for viewing, and special equipment for handling, make final assembly job easier for workers. IC chips (right) are soldered to headers, and thin connecting wires are welded from the bonding points on each integrated-circuit chip to the termination points on the headers. There are different shapes of headers, depending on what style of final packaging is to be used for the integrated microcircuit. Girl above is moving integrated-circuit chip into position for spot-welding the tiny wire leads to the bonding pads at the outer perimeter of the chip—a delicate task that requires of the assembly operator precision, especial care and coordination.





The familiar TO-5 transistor can is frequently used as housing for IC's. This packaging is ordinarily merely for convenience in mounting, since a typical integrated circuit chip is tiny in comparison; if there were room for leads, a dozen IC's could be enclosed in a single TO-5 package. The one pictured above is an epoxy-plastic housing placed over a ceramic base. In quantities, integrated circuits in these package types can be sold for considerably less than $5. The "dual-in-line" at right was developed for handling IC's whose lead requirements are greater than can be adapted easily to a package . . .



. . . of the TO-5 variety. The flat package is already finding considerable use in computers, and will undoubtedly be put into consumer products when microcircuits become available that need the additional connections. As you can see from the preceding photographs, the means for producing cheap microcircuits is already available. It now remains only for the designers to develop new IC's and ways to use them in consumer goods. END

20 Keys to Transistor Ignition

Answers to the most-often-asked questions about these popular accessories

By I. M. SALZBERG

TRANSISTOR IGNITION SYSTEMS ARE popular with all kinds of drivers—from the suburbanite who clocks only a mile or two each day between home and the railroad station, to the teen-age hot-rodder and professional race driver. A commercial system is now available even for motorcycles. Nearly every driver wants to know more about this relatively new ignition system. These are the questions *you* have asked about transistor systems in your letters to RADIO-ELECTRONICS.

1. Should I buy or build a transistor system?

If the transistorized ignition is your first, or even second, attempt at constructing an electronic device, the answer is definitely *buy*. Purchase a commercial unit and get a friend with some electronics background to help you install it.

If you have tinkered with various transistor circuits and know Ohm's law, you should have no trouble constructing a kit. If you want to save money, you can use the circuits described later in this article to construct your own.

2. Is a new, and often expensive, coil (transformer) required?

Not absolutely. However, a 400:1 coil is necessary to derive full performance from a transistor ignition system.

Perfectly satisfactory results can be achieved by using the old 100:1 coil now in your car.

3. Is there any difference between the most expensive and the least expensive commercially available units?

Yes. The least expensive units usually leave something to be desired in the way of performance or reliability.

4. How does a conventional ignition system work?

Assume that the points (see Fig. 1) are closed, allowing gradually increasing current to flow through the resistor,

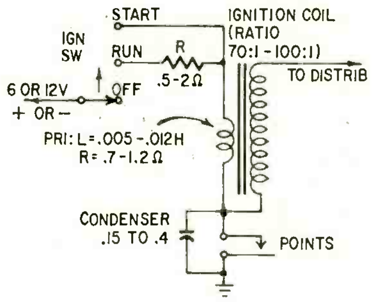


Fig. 1—Schematic of conventional ignition system, with actual typical circuit values.

transformer and points. This current generates a magnetic field in the transformer. When the points are opened, the sudden stoppage of current in the transformer causes the magnetic field to collapse quickly in the *primary* winding of the transformer. This rapidly collapsing primary field induces a high primary voltage which, through transformer action, creates a very high voltage to be fed to the sparkplugs. Then the points close again and current builds up another field around the coil, so another high-voltage pulse is generated when the points open.

The capacitor (condenser) acts as a temporary energy-storage device, thus partly protecting the points from arcing, and allowing the points to open faster (electrically). Without the capacitor, the points would fail after only minutes of use.

When you start the engine, the ballast resistor is shorted out to deliver a higher voltage to the coil and provide a higher spark voltage under starting conditions. When the engine is running, however, the generator (or battery) supplies full voltage and the resistor limits the current to a level the points can safely handle. The voltage at the sparkplug for a conventional ignition system varies anywhere between 10,000 volts (at about 4,500 rpm) and 28,000 (at 400 to 1,800 rpm).

5. How does a transistor ignition system work?

Simple—the transistor essentially takes the place of the ignition points in switching the large currents and high in-

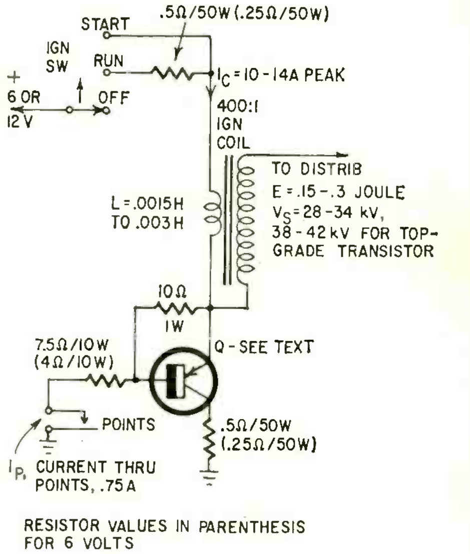


Fig. 2—Basic transistor ignition system, with typical values for parts and parameters.

ductive voltages. The points (Fig. 2) now control only the transistor, which requires only 1/15 the current and a very small voltage.

On several more expensive models, the points are completely eliminated. One system uses a magnetic switch—a magnet rotating on the distributor shaft near a stationary coil controls the transistor in synchronization with the engine. Another system uses a photocell. Vanes rotating with the distributor shaft interrupt light from a small bulb at the proper moment. These are, however, expensive

CHART 1. TRANSISTOR SPECIFICATIONS

Transistor	P_t Watts	BV_{CBO} Volts	BV_{CES} Volts	I_{Cmax} Amps	f_{ab} MHz	T_j °C	Cost $
1	100	110	110	18	10	100	11.30
2	100	100	80	15	.01	100	5.00–2.75
3	100	100	50	10	.01	100	2.35

and sometimes difficult to install in a car presently equipped with breaker points or the usual ignition system. For these reasons they are not covered here.

6. What can I really expect from a transistor ignition system?

a. Smoother idling (less engine wear, smaller carbon deposits, etc.)
b. Easier starting, especially in cold weather.
c. Less maintenance (points last four times as long and sparkplugs twice as long).
d. Better high-speed acceleration and gas mileage.
e. Increased mileage at all speeds. A hotter and longer spark can be expected to yield an increase of 1 to 5 miles per gallon.

Generally, the hot-rodder gets better performance, while the average driver gets increased reliability with less maintenance.

7. What should I look for when buying a commercial transistor ignition system?

Because of cost, let's exclude the magnetically or photoelectrically triggered units mentioned in Question 5. Most systems have three major components: the transformer or coil, the transistor, and the ballast resistor.

a. The transformer. Coils with turns ratios of 400:1 give optimum performance. A commercial unit should use this type of transformer.
b. The transistor. Of the many transistors on the market, some are more desirable in any given circuit. You may have a hard time determining the merit of various transistors. (Chart 1) Instead, study the system's output-voltage specifications. If they are within the limits in Chart 2, the transistor is acceptable. If possible, determine the temperature rating of the transistor (T_J, maximum allowed junction temperature). This should be higher than 85°C.
c. The ballast resistor. Its resistance determines how much energy is delivered to the sparkplug, and should be lower than 1 ohm—the lower the better.

Other considerations

a. Moisture protection. Moisture on a transistor may short it out or at least impair its ability to act as a switch. Thus it's wise to choose a system where the semiconductor is potted or otherwise protected from moisture. It is necessary to protect only the transistor.
b. Heat sink. It dissipates the heat generated in the transistor. A finned heat sink is desirable. If the unit is to be mounted under the hood, a heat sink is *necessary*.
c. Output voltage. Optimum output voltage for any transistor ignition should be between 28 and 40 kV for all driving conditions.

8. What determines the performance of an auto ignition system?

Three items:
a. Energy (E, in joules) delivered to the sparkplug.
b. Voltage (V_s) delivered to the sparkplug.
c. Transformer primary-field buildup time (T).

Let's examine these items.

The larger the spark, the more perfect is combustion. However, the points are able to handle at most only 6 amperes without their life being drastically shortened.

Voltage delivered to the plug is governed by the turns ratio of the transformer and the switching speed of the points (or transistor). Maximum switching speed is limited by the small arc at the points, which passes current and thus makes the points appear to open more slowly, as far as the circuit is concerned.

Field buildup time (T, seconds) is the time it takes current through the coil to rise to 63% of final value. As engine rpm increases, the time the points are closed becomes shorter and shorter. When the rpm reaches a value such that the time the points are closed approaches T, only 63% of the maximum possible coil current can be reached. This is why conventional ignition systems lose performance at high engine rpm—T is reached at approximately 2,000 rpm.

Now let's summarize: We need a small value of inductance (to keep T small), high primary current (to keep energy large) and high turns ratio (to keep spark voltage high). Maximum switch speed is also important and is often held down by an inferior transistor.

Chart 2's two middle columns compare performance factors for normal and transistor systems that use 100:1 ignition coils. Note the improvement in two of the three parameters (energy and secondary voltage). Remember that high-speed performance improves as T is made smaller.

9. Should I use my present transformer or buy a 400:1 transformer?

Columns 3 and 4 of Chart 2 compare the performance factors for two transistor ignition systems; one uses a 100:1 coil, the other a 400:1. All three factors are improved in the 400:1 system. The 100:1 coils are not designed to withstand the large currents in a transistor circuit. Thus a compromise current value was chosen—larger than for the normal system but smaller than in a transistor system with a 400:1 coil.

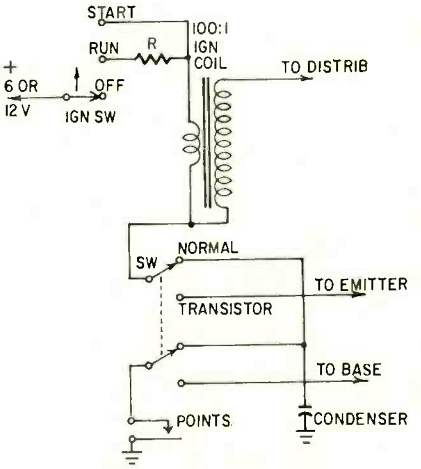


Fig. 3—"Chicken" switch, for transferring back to conventional system, is a wise precaution. Use it only with 100:1 coils.

A transistor system using the car's original 100:1 coil has a slight advantage—one of convenience rather than performance. It can be installed with a switch (Fig. 3) or jumpers to permit reverting to the basic "breaker" type operation in emergencies or when the car must be serviced by a mechanic who is not familiar with transistor circuits.

Caution: A 400:1 coil *must not* be used in a normal ignition system. Its primary resistance is so low that a large current (30-60 amps) would flow

CHART 2. COMPARISON OF PERFORMANCE FACTORS

	units	normal	transistor system	
coil current	amps	3	5	12
coil inductance (L)	henrys	.007	.007	.0025
switching rate	amps/sec	41,000	44,000	44,000
turns ratio		**100:1**	**100:1**	**400:1**
spark energy (E)	joules	.037	.088	.18
secondary volts (V_s)	kilovolts	28.6	31.0	44
coil time constant (T)	seconds	.0035	.004	.002

Note: The values are typical for all cars but apply precisely to a 1959 Oldsmobile.

through the points when starting. The points and probably the coil would be ruined. Notice also that Chart 2 shows a significant increase in all three performance factors. This improvement, coupled with all the other benefits, indicates that, regardless of what coil is used, a transistor system is better than the normal type.

Note also that the cost of a 400:1 transistor system is only $4 or $5 more. However, the convenience of a switching arrangement like Fig. 3 is not possible with a 400:1 coil (see caution above).

10. Are Zener diodes required to protect the transistor?

Definitely not—that is, as long as the voltage reflected to the primary of the transformer does not exceed the forward-voltage breakdown rating of the transistor. Good system design and careful choice of a transistor eliminate this expensive component.

11. Are heat sinks necessary for the transistor?

Yes. The area of the heat sink for this application depends on four major items:

a. Ambient temperatures. If the transistor is mounted in the engine compartment, ambient temperatures of 70° to 100°C can be expected. If mounted under the dashboard, under the seat or in the trunk, ambient temperature ranges from 40° to 60°C.

b. T_j or junction temperature rating of the transistor.

c. Shape and composition of the heat sink.

d. Power dissipation within the transistor. A transistor dissipates about 10 watts in a typical system.

Most transistor T_j ratings are 100°C or better, so an ordinary aluminum chassis with an area of about 31 square inches is satisfactory for mounting outside of the engine compartment. However, when the unit is mounted under the hood, ambient temperatures approach the upper safe operating limit of T_j and it is necessary to use an efficient heat sink.

12. Will vibration affect the performance of the transistorized system?

No.

13. How reliable is transistor ignition?

As reliable as its weakest link—the transistor. Careful selection of a transistor will yield a very reliable system that will last for the life of two or three cars.

14. Will the transistorized system work on both 6 volts and 12?

Yes. System component values will be different but equal performance can be obtained.

15. How does the performance of a system for a positive-ground battery compare with one for negative ground?

Once again: performance can be equal, but circuits are different.

16. What circuit should I use?

This depends upon how much performance and reliability you want and how much you want to spend. Let's draw a few circuits and explain the advantages, deficiencies and cost of each.

I consider the circuit in Fig. 2 the ultimate in point-triggered transistor ignition systems when a 400:1 coil is used with a top-quality high-speed switching transistor, such as the 2N1907 or 2N1908. (These transistors can handle 20 amperes and have an extraordinarily high breakdown voltage.) The maximum switch current through the points is approximately 750 mA, thus insuring long point life. The circuit is simple and will last at least 250,000 miles of driving. It is designed for a 6- or 12-volt negative-ground system. Sparkplug voltage is approximately 40,000 volts under all driving conditions.

The circuit in Fig. 2 is less expensive, when using slower-switching transistors like the 2N1100 and 2N1555 with the same 400:1 coil. The 30,000 volts at the sparkplug is still superior to the conventional system voltage in all driving conditions. The energy delivered to the plugs is about the same for both classes of transistors. The common-collector circuit has the advantage of having the base current flow through the coil thus adding to the collector current and increasing the energy output.

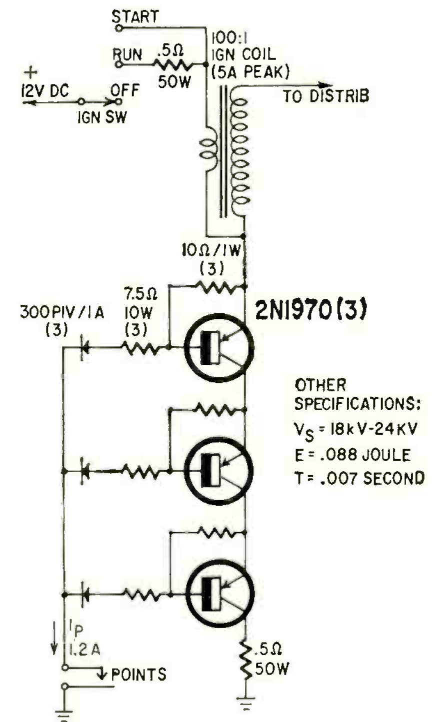


Fig. 4—A popular type of transistor ignition system. Three inexpensive transistors handle kick-back voltages from 100:1 coil.

Fig. 4 is a circuit that uses the 100:1 ignition coil presently in your car. The transistors must be chosen to withstand the very high induced voltages. The three diodes are to avoid a problem which will be covered in Question 18.

17. What weakness, if any, do commercial circuits have?

Two major weaknesses. Fig. 5 shows a common commercially produced circuit. Note that while the 400:1 transformer is capable of producing 40 kV, the Zener diode in the primary circuit limits the voltage. This Zener diode is rated at anywhere from 60 to 90 volts. This means that the peak voltage across the primary of the coil at any time can only be from 48 to 78 volts, depending on the unit purchased: 78 times 400 yields only 31 kV. Therefore, when buying a commercial unit that has a Zener diode, determine the Zener voltage, subtract 12 (for a 12-volt battery system) and multiply by the transformer's turns ratio. This will determine the maximum possible output voltage.

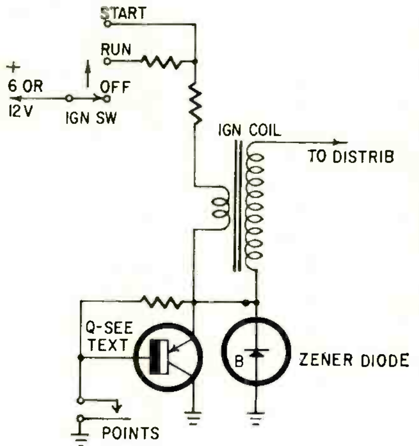


Fig. 5—Commercial transistor ignition unit.

The second weakness lies in the fact that the collector resistor is omitted. The purpose of this omission is obvious. The circuit is cheaper and the transistor can be mounted directly to a grounded heat sink without using mica insulators. This, *they say*, better dissipates the heat generated in the transistor. It does. *But*—in this circuit configuration—it is impossible to turn the transistor full on. If the transistor is not fully on (or shorted) a voltage drop appears across it which is anywhere from 10 to 20 times greater than the "fully shorted" (saturation) voltage. This means that the transistor dissipates 10 to 20 times more power, gets much hotter, and requires a more efficient heat sink. The net gain for the consumer is zero at best (heat can shorten the life of a transistor). For the manufacturer, it's cheaper.

18. What is the so-called "synchronization problem" with a two- or three-transistor circuit?

In a circuit where two or three transistors are in series (Fig. 4), one transistor may switch faster than the others. Then one semiconductor could be fully opened while the others still are almost a short circuit. The inductive voltage caused by the collapsing current in the coil is then applied to only one transistor, canceling all the advantage of having two or three transistors to double or triple the breakdown rating.

In circuits where multiple transistors are used, Zener diodes between emitter and collector as in Fig. 6 are required to protect them. Ordinary diodes used as shown in Fig. 4 also eliminate this problem and are less expensive than Zeners.

19. Should the sparkplug gap be changed after a transistor system has been installed?

Yes. The output voltage is higher. The larger the gap, the more efficiently and evenly the fuel is ignited. Fig. 6 shows approximate maximum settings for various voltages. Remember—leave yourself at least a 50% margin of safety for easy cold-morning starts and to compensate for normal plug wear and fouling. In general, .040 is a good setting.

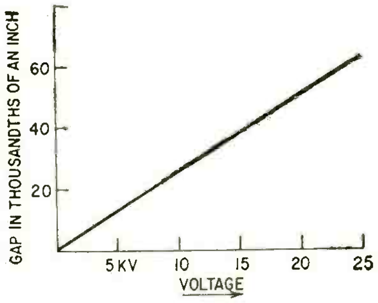


Fig. 6—What voltage it takes to jump a gap for a particular gas-air vapor pressure.

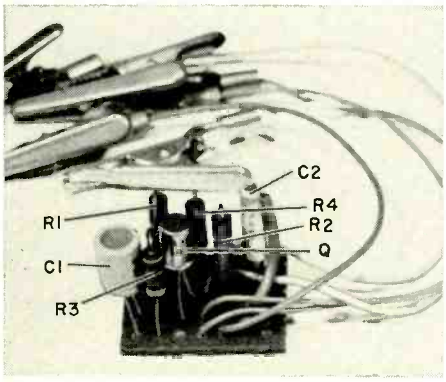
20. How should the points be set?

If the dwell angle is decreased (point gap setting increased) it has the same effect as increasing T (of Question 8). This lowers high-speed performance. If the dwell angle is increased, power dissipation in the transformer, resistors and transistors increases. If the components of the circuit can handle the increased power dissipation, then an increase in dwell is in order. If not, in most cases the old setting for a normal system can be used. END

Another "Transistor Line Transformer"

This one is the opposite number to the one in April—it steps impedance and voltage up instead of down

By R. M. MARSTON



Step-up "transformer" can be built on scrap of perforated phenolic board, foil-strip perforated board, Veroboard, such as the author used, or you can make a printed circuit. You can even wire up the entire unit on an ordinary solder-lug terminal strip.

STILL USING AN OLD-FASHIONED IRON-core stepup transformer to match that low-impedance pickup to the input of your amplifier? If so, hang onto it—it might have some value as an antique in another year or two!

Take a long, cool look at a simple shielded matching transformer. It makes a beautiful inductor: place it within a foot of a telephone and it will pick up conversations clear as a bell. Operate a light switch within 50 yards of it and you'll get a nice, big voltage kick across the secondary. That's just fine if you want to listen in to phone calls and light switches, but not so hot if all you want is a nice, simple amplifier system.

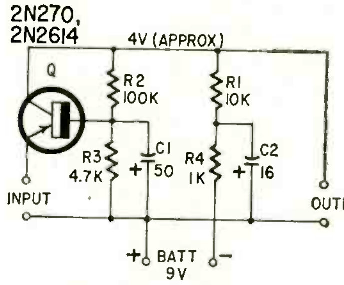
Near power lines, an unshielded transformer picks up so much hum and noise that all low-level signals get smothered. The normal way out of that trouble is to use a fully shielded transformer, with layers of Mumetal or steel wrapped around it. That costs money; I'm just a poor peasant who has to go without food for two days whenever I buy a new transistor. If I had to buy a shielded input transformer, I'd starve for a month.

So I use a solid-state "transformer." How does it work? Great. Take a look at the schematic. The unit is a conventional grounded-base amplifier. The low-impedance signal source is wired in series with the emitter and the output is taken off between collector and ground. With the component values shown, any source with an impedance of less than 25 ohms can be used.

The unit gives a large voltage gain. Emitter and collector currents are virtually the same; a current swing in the input will give a similar current swing in the collector load. Thus, the voltage gain of the stage works out, near enough at R_C/R_E, where R_C is the collector load and R_E is the emitter load. With the 10K collector load shown and a 5Ω pickup or speaker voice-coil wired in the emitter circuit, the voltage gain works out to 2,000 times! The output impedance of the unit is about equal to the value of collector load. Remember that the effective value of the collector load is reduced when you feed the output into a normal transistor amplifier, just as happens with a conventional transformer.

R2 and R3 are the base bias network; the top end of R2 is fed from the collector of Q; this gives dc feedback and stabilizes the average emitter current. C1 decouples the base and prevents ac negative feedback. The current drain of the unit is about 0.5 mA.

The unit can be powered with its own 9-volt battery or connected to a 9-volt supply in the unit with which it is used. R4 and C2 decouple the negative line and prevent instability when the supply is common with other equipment.

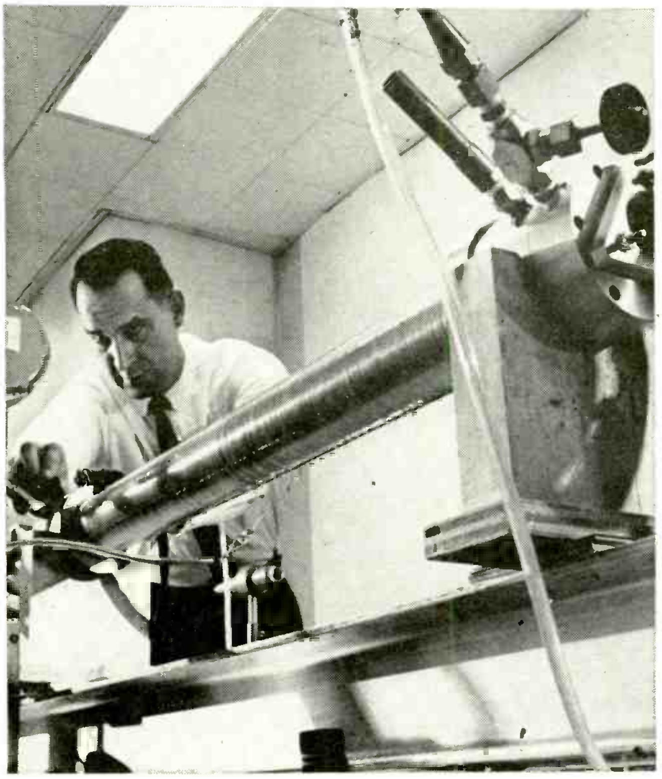


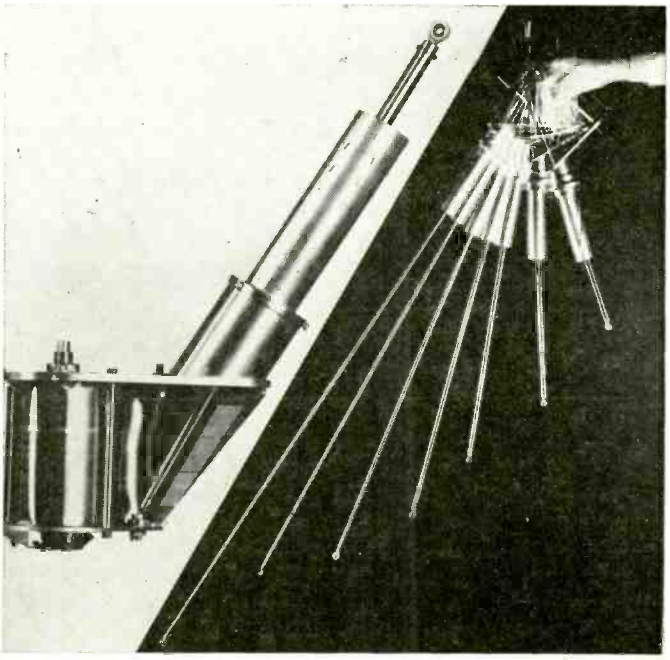
Circuit of impedance changer is uncluttered.

BATT—9-volt transistor radio battery, or well filtered 9-volt supply
C1—50 µF, 15 volts
C2—16 or 20 µF, 15 volts
Q—2N270, 2N2614 (RCA) or similar p-n-p germanium transistor
R1—10,000 ohms
R2—100,000 ohms
R3—4,700 ohms
R4—1,000 ohms
All resistors ½ watt, 10%
Perforated board or terminal strip for wiring; input and output connectors (phono jacks, etc.) to suit application

With this unit, you can use almost any collector load you want, and any supply voltage the transistor can take. All you have to do to modify the unit is to put in the collector load you want, connect the battery supply, and adjust the value of R2 until the collector potential falls to about half the supply voltage with no input signal. END

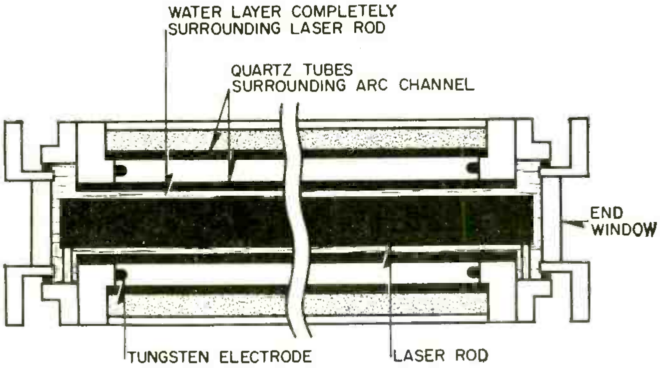
WHAT'S NEW





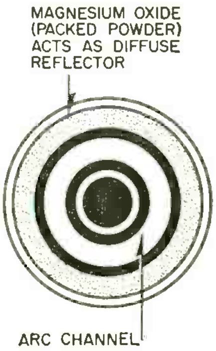
TUBES FROM STRIP AND BACK AGAIN: Prestressed steel strip, coiled flat on drum, spirals itself into rigid tube when drum is allowed to rotate. Self-generating tubing stores easily and compactly, is a natural for unattended antennas—as in air-dropped or satellite transceivers. Length can be controlled remotely by operating drum motor, so antenna can be tuned. Inset photo shows device which guides strip into tube as it unrolls. Storage reel depth equals strip width. Unit is made by Hunter Spring Division of AMETEK, Inc.

SIMPLIFIED SKETCH OF COAXIAL LASER PUMP

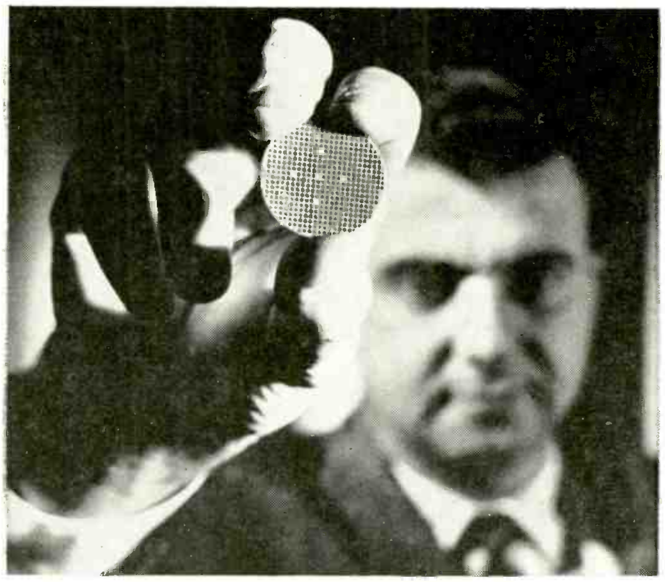


SIDE VIEW

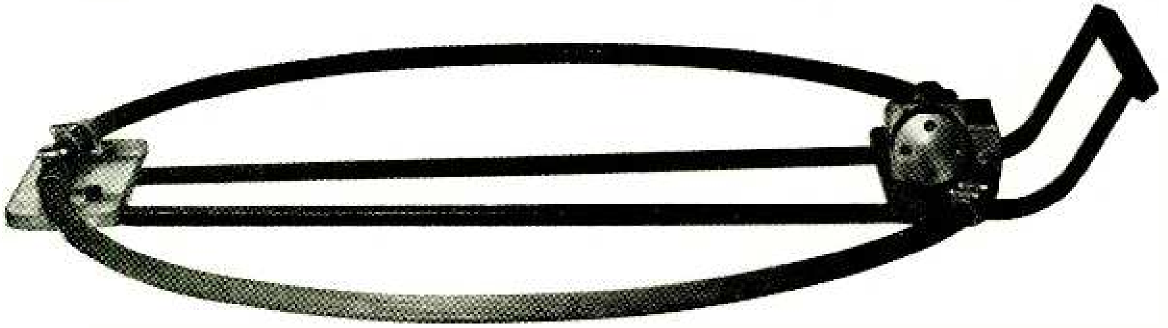
SUPER LASER IS FLASHED COAXIALLY by 100-megawatt arc. Sturdy quartz-tube "pump" excites neodymium-glass laser rod 3 feet long into emitting pulsed beam of coherent light. Special coaxial construction (see drawing) was needed to withstand tremendous shock of firing and to prevent shattering. Design literally wraps laser rod in blanket of intense light, with little loss by absorption or scattering, hence is more efficient than designs using reflecting cavities. Westinghouse scientists developed the laser pump.



END VIEW



440 INTEGRATED CIRCUITS on this 1.3-inch ceramic disc, each circuit containing 10 electrically separate components interconnected by metallized paths. 8,000 silicon "tiles" make up this mosaic, smallest of them having only twice the width of human hair. Disc comes from new manufacturing process developed by RCA. The ceramic base and isolation between components permit higher voltages than possible with present integrated circuits. That, and great ruggedness of ceramic substrate, open the way to high-frequency, high-reliability communications with microelectronics.



Locator drags easily from line attached to boat. Note round magnet on oscillator box, used to turn unit on and off.

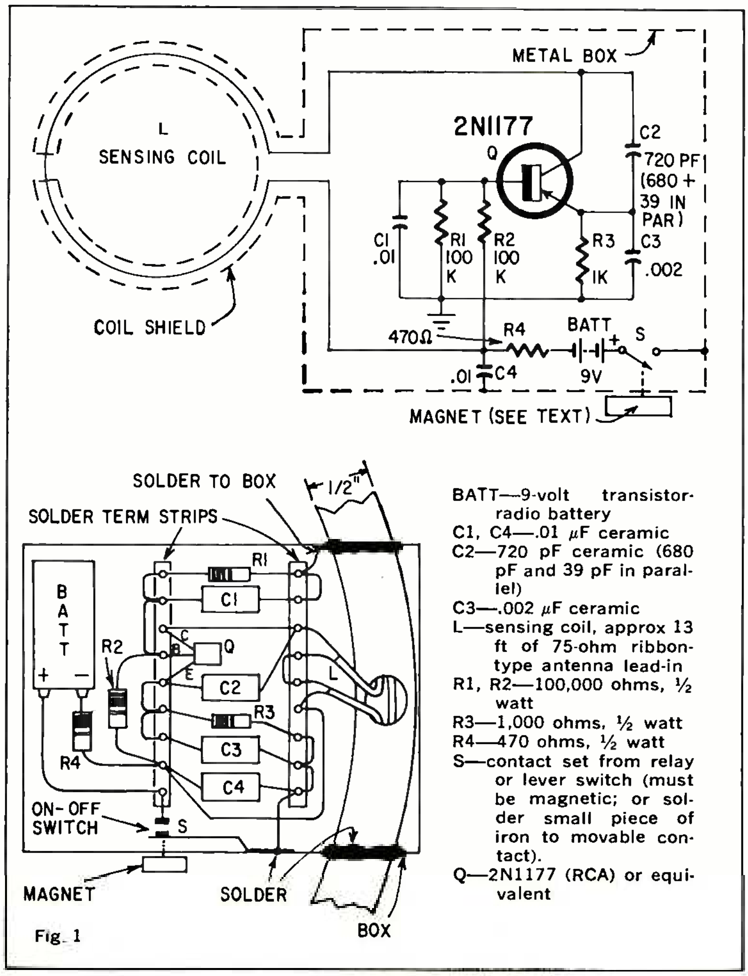
Underwater Metal Hunting for Fun or Profit

By OLLE KLIPPBERG

This low-cost detector finds lost motors, anchors—or treasure! It doesn't mind getting wet!

NOTHING STIRS THE IMAGINATION MORE than reading of ancient galleys that sank with great treasures aboard. I got the idea for this underwater locator from a friend of mine, a scuba diver, who asked me if I could construct an electronic device for a much less glamorous job: he wanted to hunt for a lost outboard motor. I tried a number of methods, and finally built a locator that really works well. You can build one that will do equally as well for you.

The treasure locator consists of a little transistor transmitter (Fig. 1) that is sunk into the water, with a tether to the boat. An ordinary transistor radio, outfitted with a beat-frequency oscillator (bfo), is used as a receiver. As a substi-



BATT—9-volt transistor-radio battery
C1, C4—.01 µF ceramic
C2—720 pF ceramic (680 pF and 39 pF in parallel)
C3—.002 µF ceramic
L—sensing coil, approx 13 ft of 75-ohm ribbon-type antenna lead-in
R1, R2—100,000 ohms, ½ watt
R3—1,000 ohms, ½ watt
R4—470 ohms, ½ watt
S—contact set from relay or lever switch (must be magnetic; or solder small piece of iron to movable contact).
Q—2N1177 (RCA) or equivalent

Fig. 1

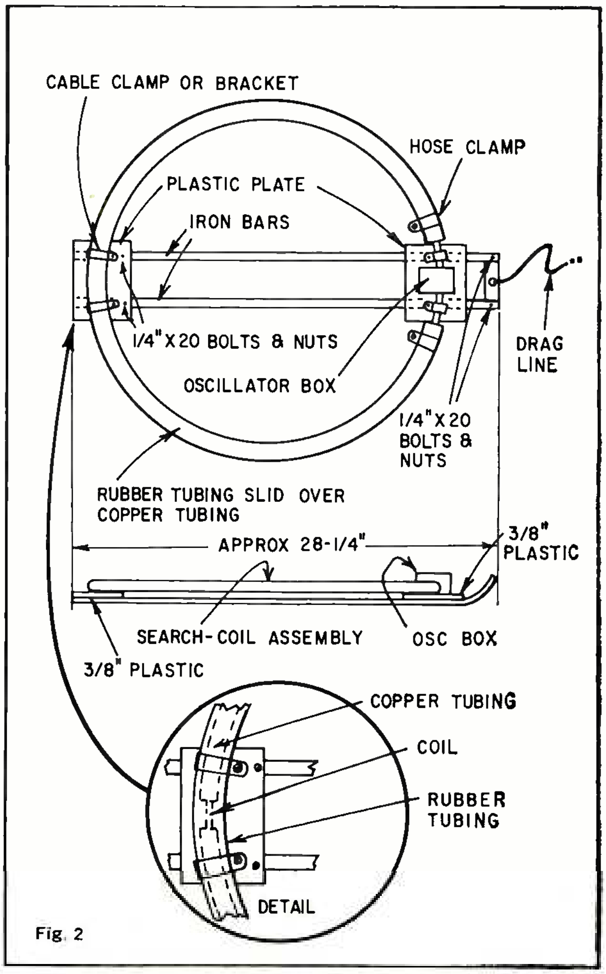


Fig. 2

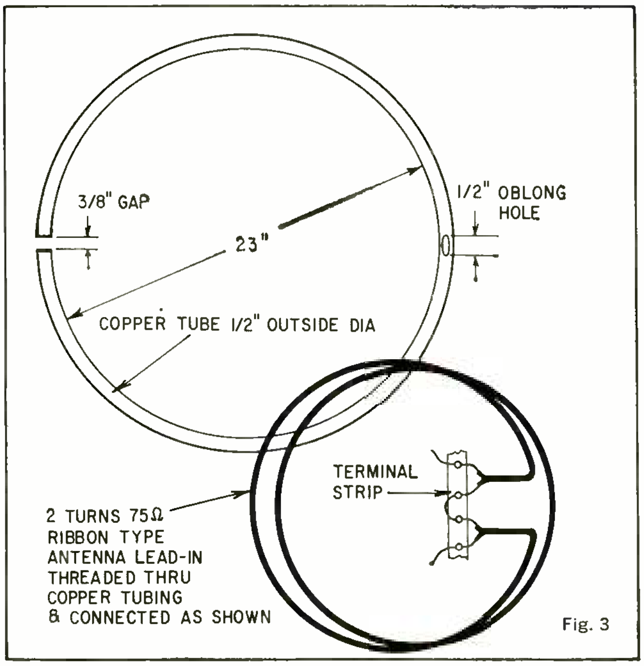


Fig. 3

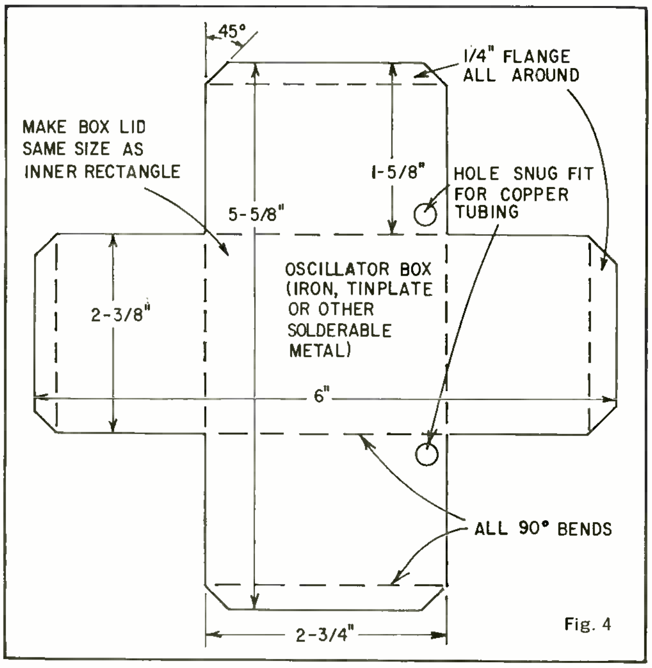


Fig. 4

tute for the bfo, you can couple back between two i.f. stages to make an oscillating i.f.

The transmitter operates at approximately 600 kHz. The signal is sent from the transmitter output coil to the receiver through the water, if the depth is not greater than about 30 feet. If you have to work deeper, connect an insulated antenna wire to the receiver and run it parallel with the tether down to the transmitter. There it can be connected to the same point as the drag line.

Any metal object near the transmitter coil will alter the coil's inductance, causing a shift in frequency. This frequency shift is registered in the receiver as a beat whistle in the speaker. To get the best results with the locator, the receiver should be tuned a little to one side of the null tone (zero beat). The field extends about 2 feet from the transmitter coil, which makes it possible to find objects covered with mud or slime.

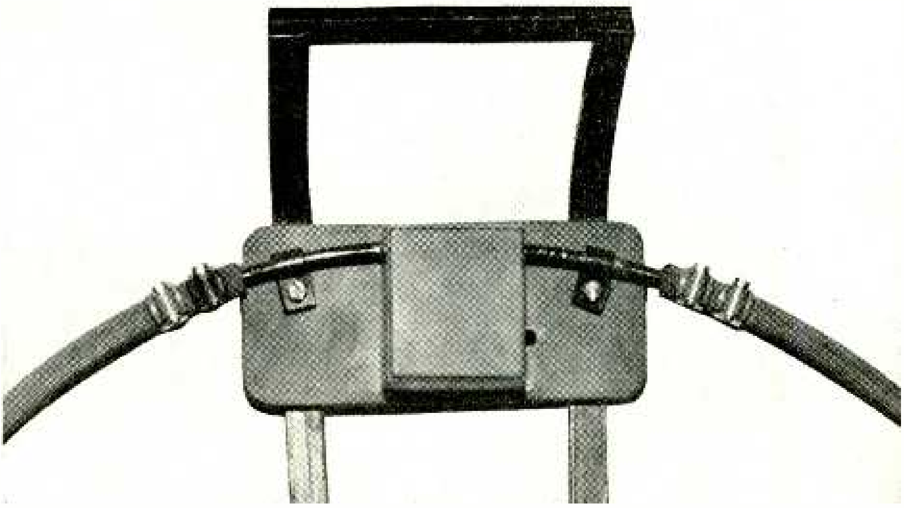
The frame of the locator, which must be dense enough not to be buoyant, is made of strap iron 29 x 9/16 x 3/8 inches (Fig. 2). [These dimensions seem odd because they were converted from nice, round metric-system numbers. You can round off the figures in inches, but think carefully before you do anything permanent with your hacksaw!—*Editor*] Drill holes for fastening the transmitter coil and for the cross bars where the drag line will be attached. Two acrylic or polystyrene plates are then mounted on the strap iron. The transmitter coil's shield is made of ½-inch copper tubing (Fig. 3). A hole approximately ½ inch in diameter is made in the tube and the coil threaded through it.

The coil is made of two turns of 75Ω cable, threaded through the copper tube (Figs. 1 and 3). They are connected so that all four turns are in series. A rubber hose is threaded over the copper tube (Fig. 2). Its inner diameter is a snug fit over the tube; its outer diameter is about ¾ inch. To make the coil assembly watertight, fasten hose clamps at the ends, as shown in the photo. Fasten the coil and box to the frame with cable clamps and screws with lockwashers.

The oscillator case was made of tinplated steel, 1-mm tinplate (approximately 3/64 in.), formed as shown in Fig. 4. After the box is bent into shape, solder it on all edges and solder the copper tube to it carefully so that everything will be absolutely watertight when the top is soldered on.

The wiring of the transmitter itself is supported on two 9-terminal solder-lug strips, as shown in Fig. 1. They should also be soldered to the metal of the box, to prevent leaks.

A relay contact leaf is used as a switch. A small flat piece of soft iron is glued to it. Normally, a magnet is kept on the outside of the box to keep the transmitter turned off. When you want to use the locator, remove the magnet. (It can be a magnet from an old loudspeaker.) The battery is an ordinary transistor radio battery. It should last several months. [An 8.4-volt mercury cell is better.—*Ed.*] When all is adjusted and tested, solder the cover on. Be sure everything is watertight. END



Detail of junction between oscillator box and search-coil tube. Completed assembly must be watertight, and should get two coats of good glossy enamel to prevent corrosion and make it easy to clean. The oscillator box is then mounted on a plastic support plate.

REPAIRING SOLID-STATE PHONOS

The low supply voltages and small size of transistors have resulted in some unusual circuits and layouts

By HOMER L. DAVIDSON

THE PAST 3 YEARS HAVE BROUGHT BIG change in small phonographs, just as in other home-entertainment products. The transistor has taken over, and new circuit designs and physical layouts have been developed to take advantage of the conveniences of solid-state devices. Lower voltages, far less heat and smaller size have made phono amplifiers more compact than ever before. As always, some of the new circuits call for new servicing techniques.

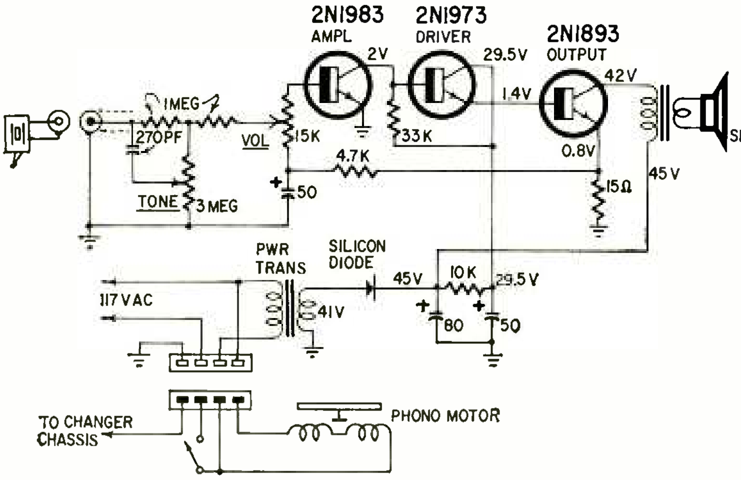


Fig. 1—One three-stage all-transistor phono amplifier is direct-coupled throughout and has fewer parts than the old traditional two-tube design. It can also be smaller.

Many manufacturers of portables use from three to ten transistors in the phono circuits. The first audio stage takes the output of the ceramic stereo cartridge. The volume control, and sometimes the bass and treble controls, are usually in that first stage. Most portables don't have a balance control. Balance of the left and right channels is most often controlled by dual volume controls.

The output stage may be single-ended or push-pull. A driver with an interstage transformer may be used, or R-C coupling. Some manufacturers, such as RCA, Westinghouse, and Silvertone, do not use output transformers. The voice coil is made with the correct impedance for a good match. In some RCA models, a choke coil is paralleled with the voice coil. Other models use output transformers, conventionally. Fig. 1 shows the circuit of a typical transistor portable. Figs. 2 and 3 show two transistor output stages.

Power supplies

Several methods are used to supply B+ voltage to the transistors. Some phono power supplies operate right off the ac line. Others use a stepdown transformer. Several use an extra winding around the phono-motor field to develop voltage for the amplifier.

At least one manufacturer (Admiral) has a phono operating directly from the ac line. A silicon diode rectifies the ac voltage. Another photo shows the power supply of an RCA model RP-219, with the ac coming from the field of the phono motor. The ac voltage in these supplies can be from 12 to 41 volts. In the stepdown-transformer supplies, full-wave or half-wave rectification is used.

Almost always, filter capacitors in these circuits have a very high capacitance (100 to 3,000 μF) with a low voltage rating. Capacitors like that aren't stocked by most radio and TV shops. The special phono motor with the separate ac winding must be ordered from the manufacturer. Of course, a separate small stepdown transformer could be used if only the power-supply winding of the motor shorts or opens.

The unusual power supply of a Westinghouse manual portable is shown in Fig. 4. This phono operates from the power line or from a 9-volt battery. The phono motor runs on dc. The power transformer produces about 9 volts ac, which is rectified by a silicon diode. A transistor is used as a voltage regulator in this circuit. The regulated −9.4 volts goes to the dc phono motor and to the transistor output stage. A dropping-resistor-and-capacitor network also supplies −8.7 volts to the amplifier and driver stages.

Chassis layout

The RCA R2-219 series has an unusual physical design. All components, including the etched circuit board, power transistors and power supplies, are mounted on the turntable chassis. To get at the etched board, you must lift off the turntable. The board is mounted upside down; only the foil shows. Four mounting bolts hold the board in place and also serve as feedthrough terminals for B+ voltages.

The four bolts fasten the etched circuit board to the power transistors and power supply and are insulated from the metal chassis. To get at the amplifier, simply remove six woodscrews, lift the Masonite changer-mounting board out of the cabinet, and turn the board over. Even the tone and volume controls are mounted on the metal turntable chassis.

All voltages and resistances are measured from the top. If any components must be replaced, unscrew the four nuts holding the etched circuit. Unsolder the wire clips from the board and mark the color-coded wires on the metal chassis. At this point, the board can be raised a few inches. Unhook the emitter and base leads from the power transistors, and the board will come off.

When replacing the board, be sure

the power-transistor wires are fitted onto the correct terminals. The left channel in one RCA portable was entirely dead because one of the emitter leads had come off. Also be sure to replace the star washers on the four chassis bolts. These fastenings *must* be tight; otherwise vibration from the turntable will make the etched board intermittent.

Tie the pickup arm down to the arm rest when you turn the chassis over.

A plug-in fuse, located underneath the turntable, protects the motor and amplifier. If the trouble is no sound or no turntable rotation, replace the fuse. Be sure the turntable screws are loosened so the changer base will float. Motorboating or boomy, ringing bass notes mean that speaker vibrations are being fed back to the pickup via the changer.

Troubleshooting

Simple transistor amplifiers generally don't cause much trouble. Most troubles can be laid to the power supply or output transistors, or to the stereo cartridge. If the whole amplifier is dead, check the silicon diodes in the power supply. They sometimes short. The low-voltage transformer supply doesn't cause as much trouble as the half-wave rectifier right off the ac line. In most cases the small fuse resistor will go at the same time as the silicon diode. Replace both with units of same ratings and physical dimensions. If there is no ac voltage on the rectifier, suspect the stepdown transformer or the ac winding in the phono motor.

If the amplifier has a loud 60-Hz hum, suspect the filter capacitors. Bridge a good capacitor across each filter, but remember that some of these capacitors are 1,000- and 2,000-μF units. You must use a substitute somewhere near those values. A 40-μF capacitor won't help. Also, check the working voltage of the capacitor. Supply outputs may vary from 9 to 125 volts.

Let's say, for instance, that the right channel is completely dead. First, check the stereo cartridge by feeding an audio signal into the wire coming from the right-side terminal of crystal cartridge. Simply touch the wire or terminal with a screwdriver blade which is touching your finger. If you hear a hum, that side of the cartridge is probably dead, since the amplifier is OK. If the right channel is intermittent, check the pickup arm by pressing it lightly down to the record. (Don't use one of the customer's good records for this!) Use only light pressure, then let up. An intermittent cartridge will go on and off when pressure is applied and removed.

If you get no sound with the screwdriver hum test, look for a short in the cable or at a phono plug. If there is no short, feed an audio signal into the first stage and to later stages until you find the trouble. Coupling capacitors can open and kill the signal. A shorted transistor can be spotted easily with voltage and resistance checks. Power output transistors give more trouble than low-signal ones. Intermittent sound or no volume may be caused by a defective speaker. Check the circuit board for bad connections (boards today are less troublesome than ones of a few years ago). Since there is no high voltage and no heat problem on the board, transistor amplifiers develop little trouble.

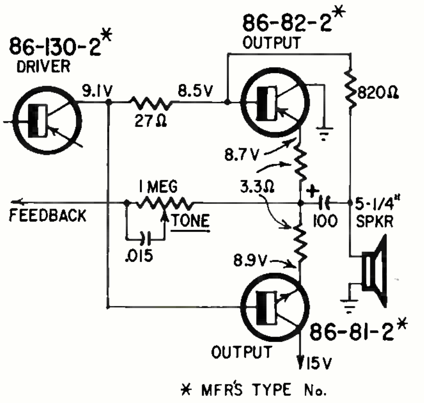
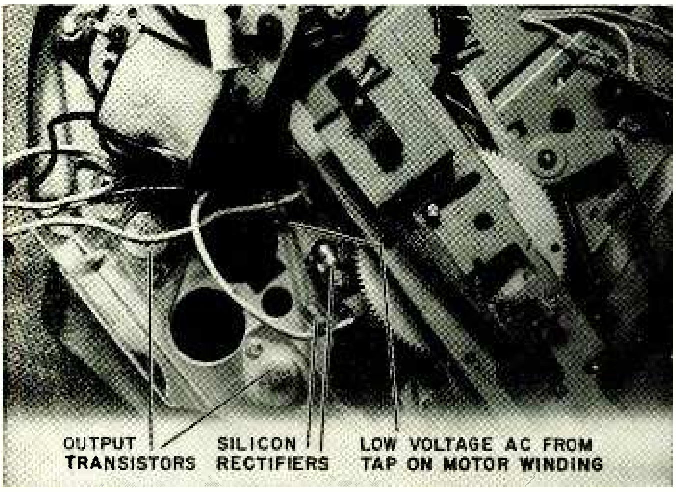
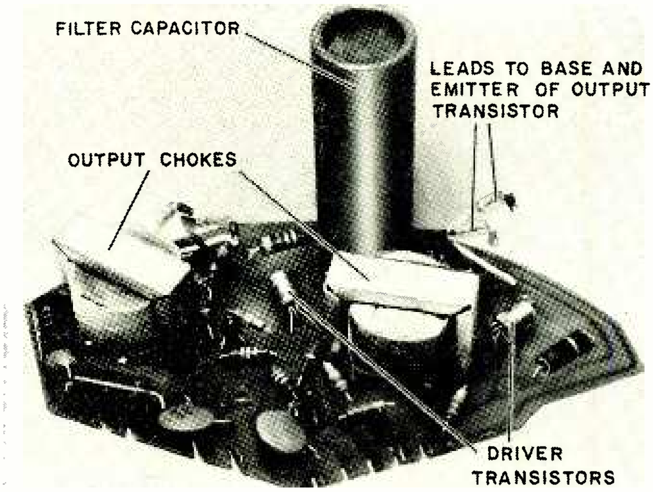


Fig. 2—This complementary-symmetry output circuit is in some Silvertone phonos.



RCA phono mounts output transistors right on changer base. Power is rectified from separate motor winding, combining functions.



Circuit board in some RCA phonos mounts on changer base. Some nearly identical chassis have output transformers, not chokes.

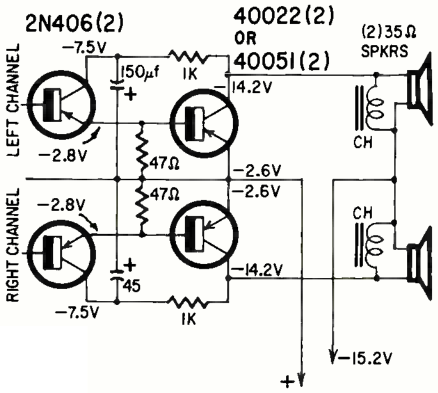
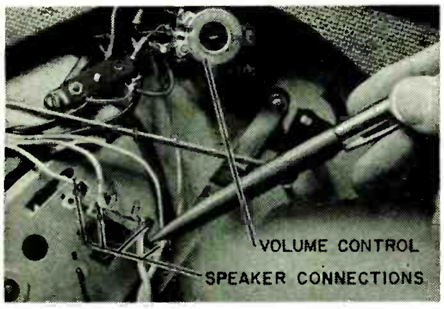


Fig. 3—Output stages of RCA phono amplifiers. Note low-resistance chokes across voice coils. Some similar RCA boards use transformers and different transistors.

Changer repair

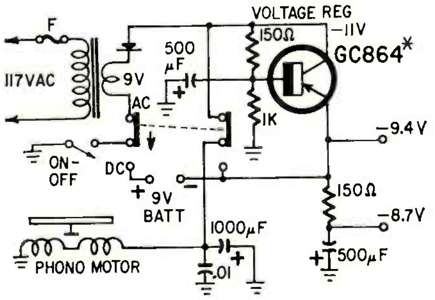
The most common complaint with a changer is slow speed, no speed, or that the arm doesn't work right. Look at the phono-motor bearings to see if they are properly oiled. If the armature is very dirty and the bearing oil is thick and gummy, clean the whole motor assembly. Take the motor apart and clean off the bearings and armature. You can tell by sound and feel when a motor is dry or sluggish. Push the idler wheel away from the motor shaft and start the motor. If the bearings make a noise, they are dry. If the motor turns slowly, or, when the motor is shut off, if the armature stops at once, clean and lightly oil the bearings.

If the turntable slows down after 30 minutes, suspect a shorted motor field. The motor-frame assembly will get very hot, if the field is shorted. Replace the motor. Another cause of slow



Even speaker connections and volume control are mounted directly on changer base in RCA phono in Fig. 3 and other photos.

speed is a hard, slick idler wheel. After several years of use, the edge of the tire becomes rounded. Put in a new idler wheel, or tighten the idler tension spring by snipping off a couple of turns.



* MFR'S TYPE No.

Fig. 4—This Westinghouse H99AC1 has a 9-volt dc phono motor, and can be used for ac-line or battery operation.

A slick or dirty turntable rim will also cause slow or uneven speeds. Clean it with alcohol and brush on a coat of liquid resin or other nonslip compound.

Check the set-down of the pickup arm on all three sizes of records. Check the cycling period and oil the record arm support; straighten it if it's bent. Last, clean off the turntable board and polish the cabinet. END

A Simple Electronic Siren

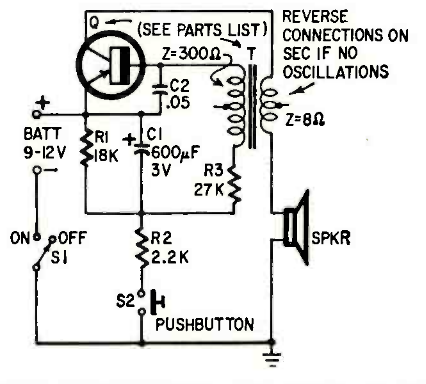
By HERB WHITE and JOHN R. LANGE, K9ARA

THIS SIMPLE ELECTRONIC CIRCUIT GENerates a very realistic sirenlike sound. It produces increasing-, then decreasing-frequency square waves when you push the button. The siren can be built for about $10. It'll make any child the envy of his playmates when they hear him coming on his wagon, pedal car or bicycle. The volume is adequate, but not high enough to disturb the neighbors.

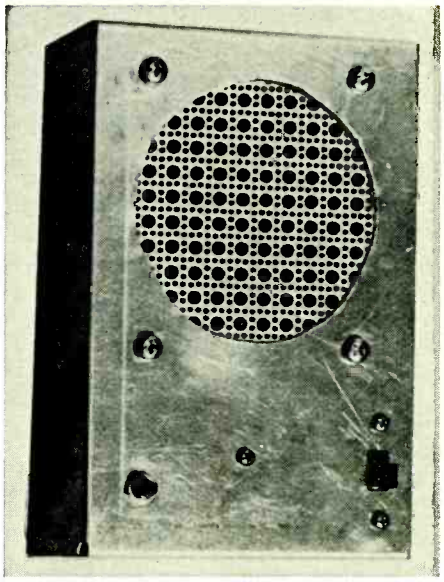
You can make a fine low-cost siren for volunteer firemen, policemen, or other emergency vehicle drivers authorized to have sirens by simply feeding the output of the siren circuit to a mobile PA amplifier.

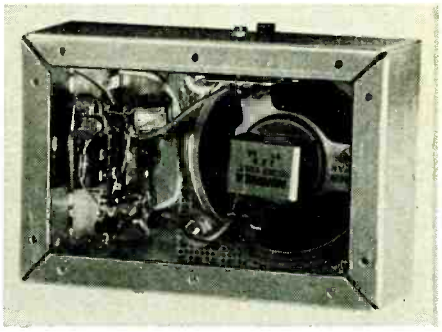
The circuit uses one transistor and a transistor portable-radio output transformer to develop feedback from collector to base. When the on-off switch is turned on, and the pushbutton pressed, the 600-µF, 3-volt capacitor charges up at a rate determined by the 2.2K resistor. The siren oscillates at a steadily increasing frequency up to a maximum determined by the values of C2 and base resistor R3. When the pushbutton is released, the circuit continues to oscillate at a decaying frequency rate determined mainly by the 600-µF capacitor and 18K emitter resistor. An on-off switch prevents battery discharge that might result from leakage back through the transistor.

The photo shows the siren mounted in a 2 x 6 x 4-inch aluminum chassis box



BATT—9-volt transistor radio battery, or any well filtered dc source up to 12 volts.
C1—600 µF, 3 volts
C2—.05 µF (any voltage)
Q—2N651 (Motorola), GE-2 (General Electric) or almost any 25-volt 150-mW p-n-p germanium transistor
R1—18,000 ohms
R2—2,200 ohms
R3—27,000 ohms
All resistors ½ watt, 10%
S1—on-off switch (any kind)
S2—spst normally-open pushbutton
SPKR—small PM speaker, 8 ohms impedance
T—transistor output transformer, 300- to 500-ohm primary, 8-ohm secondary; center taps, if any, not used (Stancor TA-21, Knight 62 U 358)
Aluminum chassis or box to suit application (see text); protection for speaker (see text); miscellaneous hardware





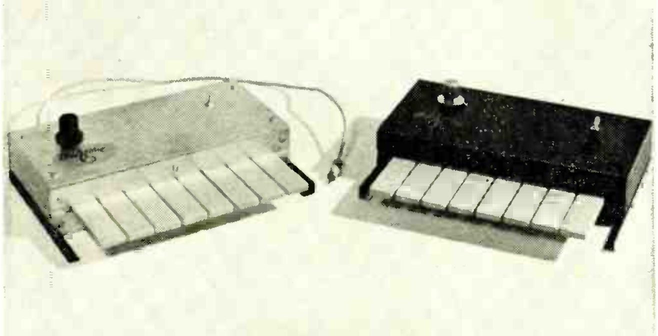
with a 3½-inch speaker mounted behind a piece of perforated aluminum sheet. A piece of polyethylene film can also be sandwiched between the speaker and the perforated aluminum to keep the speaker cone dry in case the unit is left outdoors.

Most of the circuit components are soldered to two terminal strips. A regular 9-volt transistor portable radio battery is clamped inside the case with two screws and a strap. Be careful to hold transistor leads with long-nose pliers while they are being soldered so that heat is conducted away before it gets to the body of the transistor.

If the siren does not oscillate when the pushbutton is pressed, reverse the collector and speaker connections on the low-impedance winding of the transformer.

The larger the speaker, the more realistic the sound. If you plan to use an amplifier, omit the speaker, and ground that transformer lead. Couple the output from the transistor's collector through a 0.1 to 10-µF capacitor, depending upon the input impedance of the amplifier. (0.1 is OK for inputs of 100K or higher; increase the value proportionally for lower impedances.) END

BUILD THE UNITONE



A Unijunction Transistor Organ

By JOHN F. CLEARY

A FULL-SIZE ELECTRONIC ORGAN IS RATHER FORMIDABLE. FOR a true musical instrument, with all the variety and flexibility of a pipe organ, you need a separate generator, or at least a separate divider stage, for every pitch. Those, together with tone blending and shaping networks, couplers, vibrato and tremolo, add up to a hunk of circuitry that uses wire by the mile.

But it all grows out of a simple beginning. This little "Unitone" is a real musical instrument. It makes sharp, reedy sawtooth waves tuned in a diatonic or chromatic scale (your choice). With optional filters, you can shape the sawtooth to produce a wide variety of tones—all much more interesting musically than a pure sine wave. The Unitone has a one-octave range—ample for many tunes and accomplishments.

And best of all, you can build it in an evening!

A simple unijunction-transistor oscillator (Fig. 1) is the heart of the Unitone. This relaxation type of oscillator works much like a neon-lamp oscillator, but it's more stable and generates its output at a lower impedance, which makes the oscillator less likely to be affected by varying loads.

Closing one of the playing keys causes timing capacitor C to begin charging at a rate determined by the value of whichever tuning resistor RT has been switched in by the key. When the voltage across C reaches a value high enough to trigger the unijunction, C dumps its charge through the low base-1-to-emitter resistance of the unijunction. When the voltage across C falls far enough, the high-resistance state of the unijunction is restored, and the capacitor begins charging again. This keeps on as long as the key is held down, at a rate determined by the supply voltage, the capacitance of C and the resistance of RT.

Throwing in different resistors (or different capacitors, but resistors are cheaper) changes the time rate, or frequency, and produces different pitches.

R2 provides a "movable octave." By adjusting R2, you can play in any key from C below middle C to C above middle C. Select values of RT according to the table, depending on what kind of scale you want. Then tune the organ by adjusting R1 with the help of a piano, tuning fork, pitch pipe or audio oscillator—or just your ears.

Set R1 to the middle of its range. Strike a middle C (261.6 Hz) on the Unitone keyboard against a known middle C. Adjust *R2* for zero beat (no periodic variations in loudness).

Now strike C above middle C on the Unitone (523.3 Hz) and beat it against the same note on the piano or whatever instrument you are using for tuning. This time, get your zero beat with *R1*.

Repeat both steps several times. Then leave R1 alone.

Once the Unitone is tuned, don't touch R1. You can now produce correct scales anywhere between C below middle C and C above middle C by changing R2.

Musical tone	Freq. (Hz)	RT values in ohms (5%) for: Chromatic scale	Diatonic scale	RT
C'	523.3			
B	493.9	1,500	1,500	RT2
A#	465.0	1,500	—	RT3
A	440.0	(1,500 + 150) = 1,650	(3,000 + 150) = 3,150	RT4
G#	414.9	1,800	—	RT5
G	392.0	1,800	(3,000 + 300) = 3,300	RT6
F#	370.0	2,000	—	RT7
F	349.2	2,200	(3,900 + 300) = 4,200	RT8
E	329.6	2,200	2,200	RT9
D#	310.5	(2,200 + 47) = 2,247	—	RT10
D	293.7	(2,000 + 470) = 2,470	4,700	RT11
C#	277.0	(2,000 + 470) = 2,470	—	RT12
C	261.6	3,000	(3,900 + 1,500) = 5,400	RT13

Construction and variations

For keying, use any sort of momentary-contact switch: pushbuttons, relay or telephone-key switch leaves, or mercury switches fixed to spring-return wooden keys. One of the simplest and cheapest methods is the one shown here: "thumbtack keying." The "exploded" photo and the drawings (Fig. 2) show its essentials. The keys are strips of ¼-inch wood about 1 x 5 inches. They are laid side by side, with metal pegs driven into the keyboard base to keep them apart. (The pegs can be 1-inch brads with their heads cut off after driving.)

About 2 inches from the inner end of each key is a crosswise slot, which rides on the metal edge of the keyboard frame and prevents the keys from sliding in and out. The edge also serves as a rocker pivot. An inch from the inner end, each key carries a little block of foam rubber or plastic—the spring.

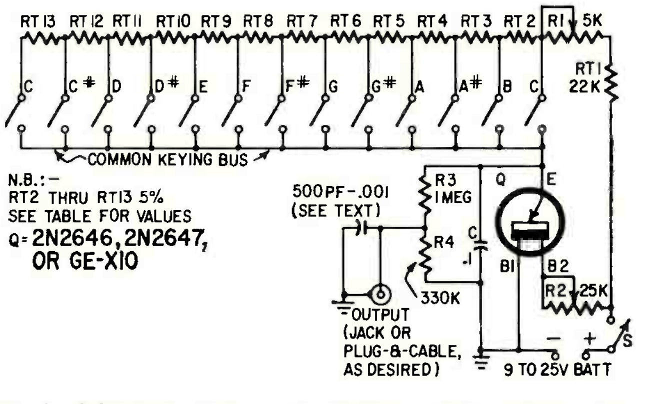
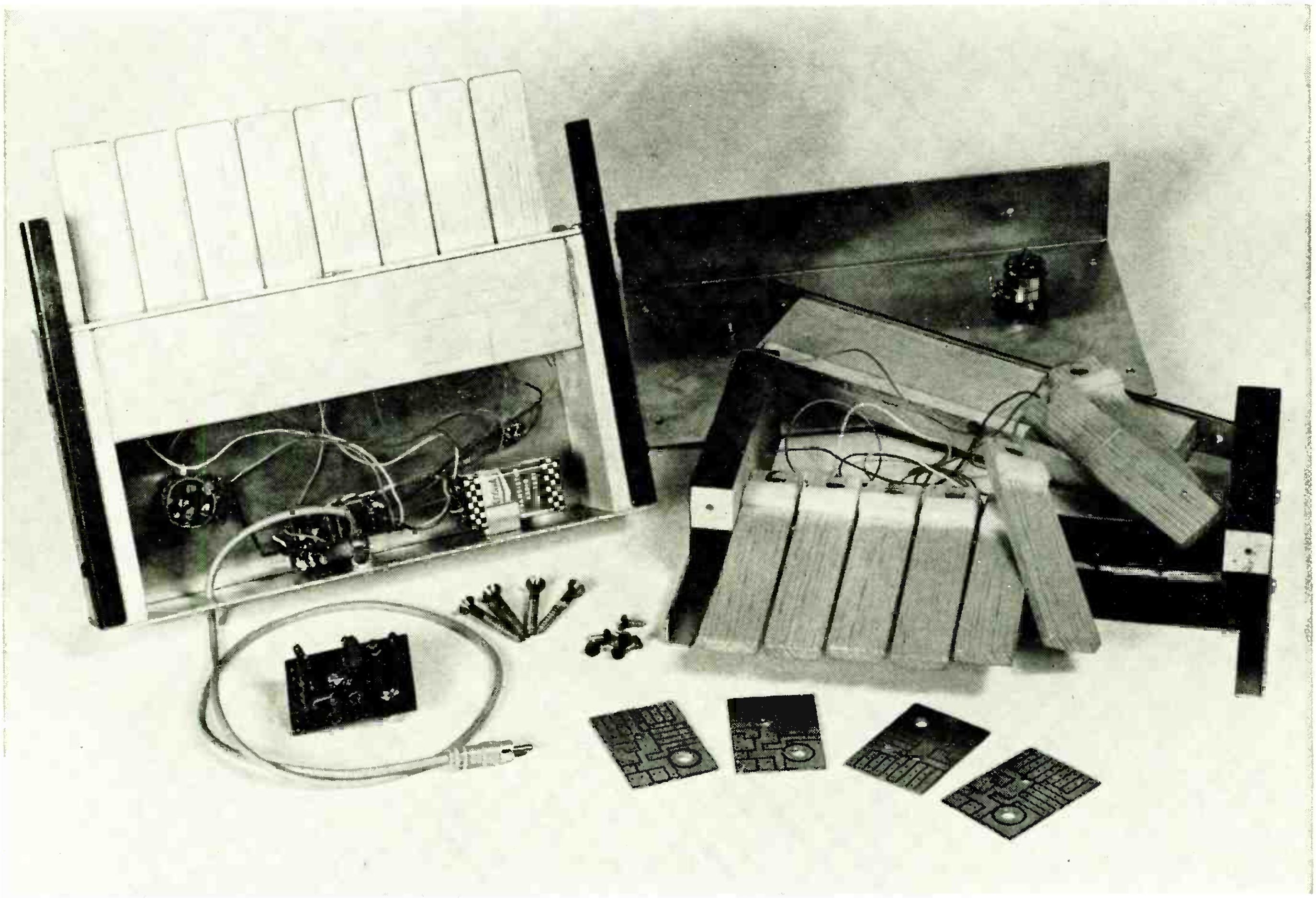


Fig. 1—Schematic of the entire Unitone. "RT" resistors determine note pitches; choose values from the table, according to whether you want chromatic scale (13 notes) or diatonic scale (8 notes). R2 sets range or key of instrument—affects all pitch.

BATT—9-volt transistor radio battery (or, for higher output, 22½-volt hearing-aid battery)
C—0.1 μF, 10 volts or higher
Q—2N2646, 2N2647 or X10 unijunction transistor (all G-E types)
R1—pot, 5,000 ohms, linear
R2—pot, 25,000 ohms, log taper
R3—1 megohm, ½ watt, 10%
R4—330,000 ohms, ½ watt, 10%
RT1—22,000 ohms, ½ watt, 10%
RT2–RT13—see table (all ½ watt, 5%)
S—spst toggle switch
Material for keys and console (see Fig. 2 and photos)



Detail views of Unitones. Patterned rectangles in foreground are etched circuit boards for oscillator and tuning resistors. Only one board is needed for each Unitone. Large hole is for pot R1. Unless you plan to turn out Unitones in quantity, you will find it easier to hand-wire one or two of the circuits on a perforated phenolic board.

A nickel-plated thumbtack pushed into the inner end is the keying contact as well as the connection to the key.

The keying bus, common to all keys, is a strip of aluminum foil pasted around one corner of the wood block that forms the top of the keyboard assembly. A thumbtack pressed into the back edge of the block, through the foil, is the connecting terminal for the unijunction emitter lead.

If you choose a *chromatic* scale (13 tones—a full octave with all sharps and flats plus the top note, one octave above the bottom note), you will want to make the keyboard long enough to accommodate 13 keys (12 separating pins), and choose the tuning resistors from the chromatic scale column of the table. If you want a *diatonic* scale, you will need only 8 keys (7 pins). A diatonic scale limits you to one musical key, so it won't be as much fun as a full chromatic scale, but it is simpler and cheaper.

The Unitone is a *monophonic* instrument, as contrasted with a polyphonic instrument. That means that you can play only one note at a time. If you press two or more keys simultaneously, only the higher note will sound.

To be able to play more than one note at a time, you need independent oscillators—as many oscillators as there are notes to be played simultaneously. That is why commercial electronic organs have separate oscillators for each note in an octave. (Some use a separate, stable oscillator for each pitch to be used, which usually means at least 60 independent oscillators, each of which must be separately tuned, like organ pipes. Others use 12 master oscillators, one for each note in an octave, and synchronized dividers to produce the lower octaves. Only the 12 master oscillators need to be tuned. Both systems have advantages.)

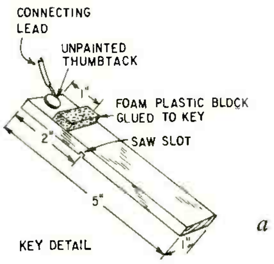
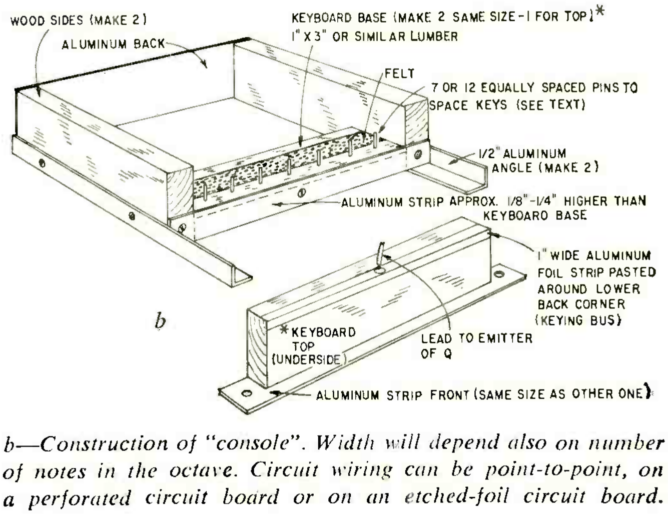
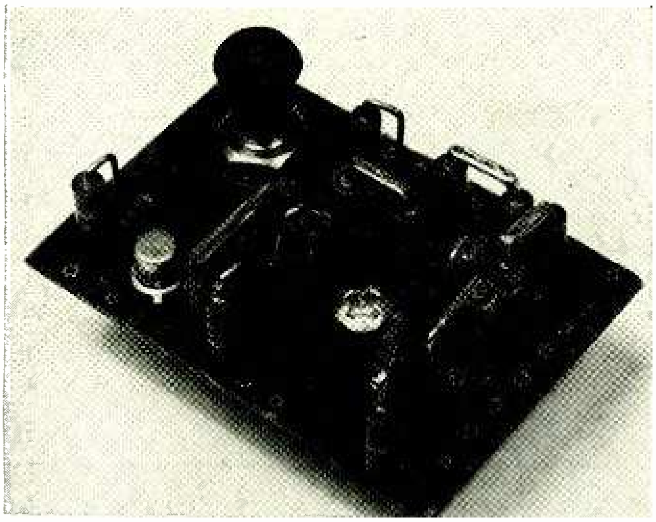


Fig. 2—Mechanical details of the Unitone. a—Construction of a single key (you will need 8 or 13, depending on the scale you choose).



b—Construction of "console". Width will depend also on number of notes in the octave. Circuit wiring can be point-to-point, on a perforated circuit board or on an etched-foil circuit board.



Wired circuit board for a Unitone. Unused holes are for remaining resistors to make up full 13-note chromatic octave. (Shown here is an eight-note circuit board incorporating only diatonic scale.)

Tone shaping

The output of the Unitone can go directly to a high-level (low-gain) input on any kind of amplifier. The audio stages of a table radio can be used. The raw sawtooth output of the Unitone is somewhat harsh. You may find the tone more pleasant if you filter out some of the higher harmonics by shunting a 500-pF to .001-μF capacitor across the output of the Unitone. Feel free to experiment with lower or higher values of capacitance. You can get special tone qualities by using broad (low-Q) resonant filters across or in series with the output. Clipping the sawtooth with diodes to make a squarish sort of wave gives a "woody" tone that suggests a clarinet. The more highs you filter out, the closer you get to a sine wave, and the duller and cleaner is the tone (sort of flutelike).

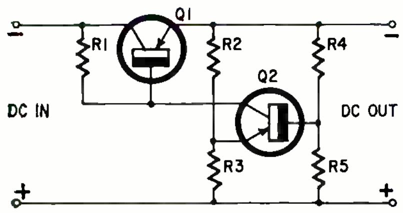
[For those of you who'd like to pursue this further, there are quite a few good books on electronic organs. One of the best is *Electronic Musical Instruments*, by Richard H. Dorf, published by Radiofile, 255 W. 84 St., New York, N. Y. 10024. Another good book is the *Electronic Organ Handbook* by H. Emerson Anderson, published by Howard W. Sams & Co., Inc., 4300 W. 62 St., Indianapolis, Ind. Try local book or electronic parts outlets before you mail-order.—*Editor*] END

See Sept. p 16

CIRCUIT QUIZ

By **MARVIN JACK MOSS**

Each of these circuits has one error that will keep it from working as it should—or from working at all. Can you name each circuit and find the trouble? Assume component values to be consistent with proper design of the circuit. Answers on page 92.



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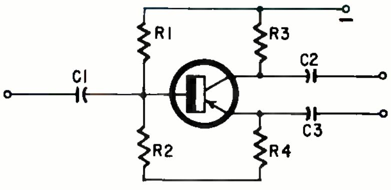

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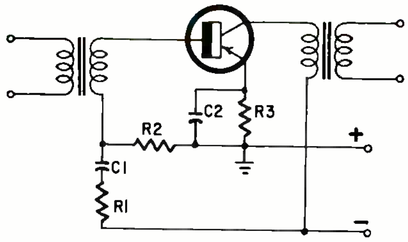

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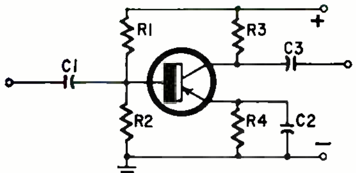

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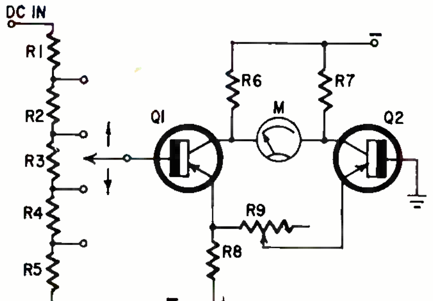

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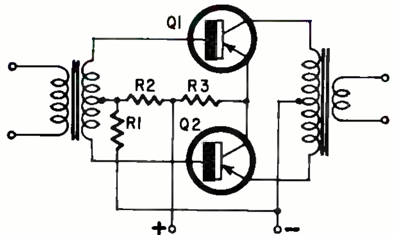

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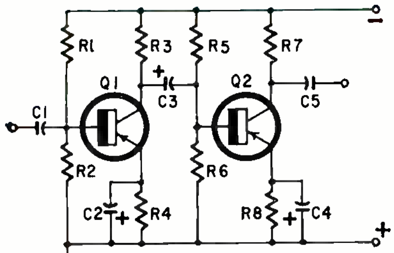

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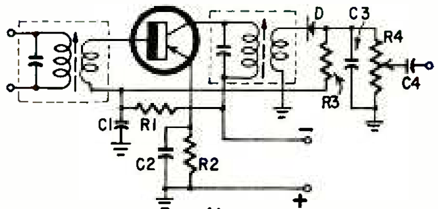

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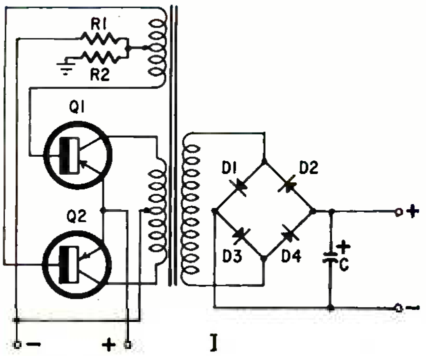

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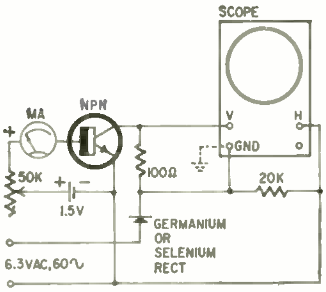


Fig. 1—Circuit for displaying the collector voltage current.

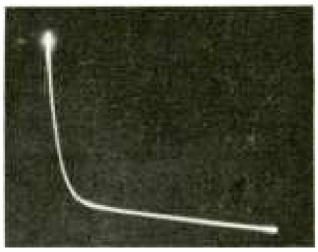


Fig. 2—Basic display on scope.

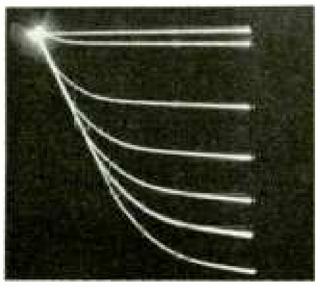


Fig. 3—I_c versus E_c, base current varied in 0.2-mA steps.

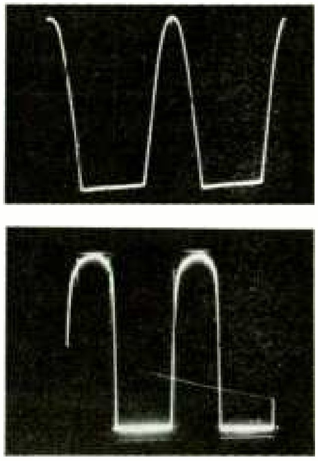


Fig. 4—Voltage applied to collector (top) and current in the collector circuit (bottom).

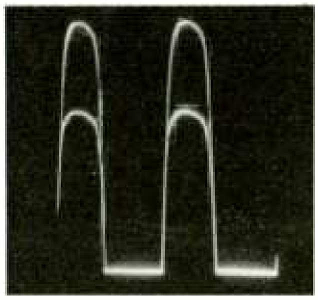


Fig. 5—Collector currents with 0.5 and 1-mA base currents (1-mA base-current waveform is the longer of the two shown).

TEST TRANSISTORS WITH YOUR OSCILLOSCOPE

How to test them or match them for precision performance in critical stages

By ROBERT G. MIDDLETON

THE SIMPLEST "FIRST-AID" CHECKS OF a transistor are usually made with an ohmmeter. If you read a fairly high resistance between emitter and base with the meter leads connected one way. and a low resistance the other way, and the same is true between collector and base. the transistor has passed its initial test.

The next important check is for *leakage* current. Now you're measuring the reverse current between collector and base. As an example of the procedure, the collector might be reverse-biased with a 6-volt battery in series with a microammeter. If the leakage current (I_{co}) with the base lead unconnected is not greater than specified by the transistor manufacturer, the second test is passed. When a transistor begins to go bad, a leakage test often shows it, while a simple ohmmeter test won't.

Oscilloscope tests

But for a really good picture of a transistor's performance, look at it with a scope. Fig. 1 shows an arrangement for electronically plotting the transistor's *collector characteristics*. Curves appear on the scope screen. Fig. 2 shows a typical curve. The *horizontal* axis is the *collector-voltage* axis. The *vertical* axis is the *collector-current* axis. The downward drop in Fig. 2 is called the *saturation region*. The horizontal, linear part of the curve is the useful part of the characteristic for class-A amplifiers.

Each time you change the base current by adjusting the 50K potentiometer in Fig. 1, another curve is displayed. What you get is a *family* of collector characteristics, like Fig. 3 (a multiple-exposure photo). Here, the straight line across the top is the zero-volt level; in other words, the collector sweep voltage is turned off to show the zero-volt reference level. The first curve below the zero-volt level in Fig. 3 is for zero *applied* base current ($I_b = 0$). This is the leakage characteristic of the transistor. A good transistor should show a leakage line that is almost parallel with the zero-volt level.

Note also in Fig. 3 how the curves begin to fall closer together as the base current is stepped from 0.2 to 1 mA. An ideal transistor would have all curves uniformly spaced from one base-current step to the next. For linear amplification. as in high-fidelity audio, for example, choose transistors with a nearly uniform characteristic spacing. Collector family characteristics are available from transistor manufacturers, and you can compare the characteristics of a particular transistor against the "bogey" (typical or average) specifications. For push-pull operation. select a pair of transistors with similar collector families.

Principles of scope test

Returning to Fig. 1, note that the vertical input terminals of the scope are connected across a 100Ω resistor. Thus, the vertical deflection is proportional to collector current.

The only reason for the rectifier is to avoid passing current through the collector circuit in the forward direction: this could overheat the transistor. The 20K resistor is used simply to swamp out the small reverse current through the rectifier, and thus avoid distortion in the pattern.

What are the voltage and current waveforms in the collector circuit? They are shown in Fig. 4, displayed with conventional sawtooth scope deflection. In other words, half-sine waves are applied to the collector. The exact waveform doesn't matter, because we are concerned only with sweeping the collector from zero volts to some suitable peak voltage.

The collector-current waveform (bottom, Fig. 4) is not a half-sine wave. Why? Because the collector resistance is nonlinear, as is clear from Fig. 2. This is a resistance curve. Resistance is simply the relation between voltage and current. As the base current (and hence the collector current) is increased, the current in the collector circuit begins to appear more like a half-sine wave, as seen in Fig. 5.

Type of scope

There are two good reasons for using a dc scope to test transistors. First, if you use an ac scope, the origin shifts

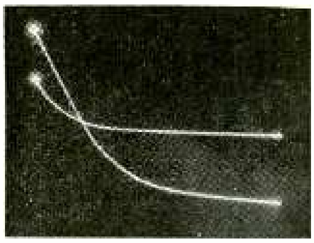


Fig. 6—Scope's inability to respond to dc shifts trace origin.

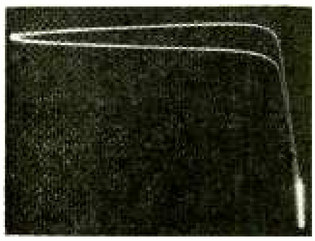


Fig. 7—Pattern looping caused by phase shift in ac-type scope.

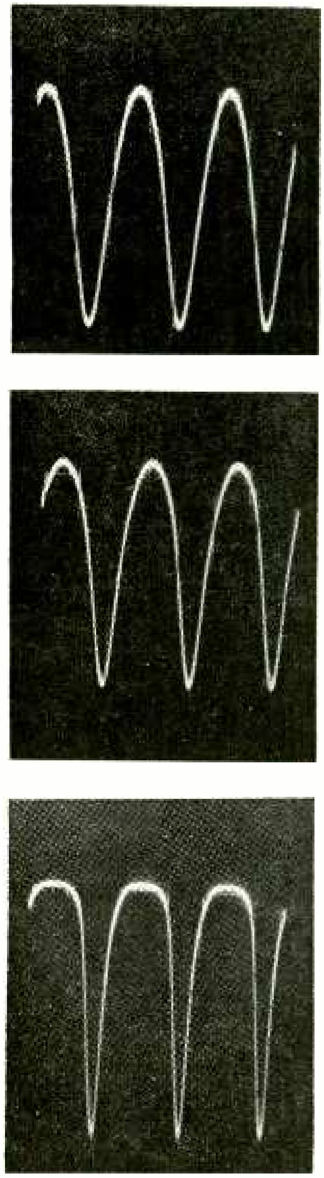


Fig. 8—Progressive distortion of collector waveform as base current signal drive is increased.

from one base-current step to the next, as in Fig. 6. With a dc scope, the origin is clamped and all curves start from the same point, as in Fig. 3. Secondly, an ac scope often causes looping in the pattern (Fig. 7). This is due to phase shift in the ac scope amplifiers, and can be very confusing at first. In theory, ac scopes don't have substantial phase shift at 60 Hz—but beware!

If you must use an ac scope, and you have phase shift, you can often eliminate it by installing larger grid-coupling, screen-bypass and cathode-bypass capacitors. That's because phase shift at low frequencies results from too-short time constants in the R-C circuits. The first difficulty—shift of the origin—remains, however, so it's best to use a dc scope in running collector-curve families if you plan to do a good deal of it.

The test arrangement shown in Fig. 1 is for the common-emitter connection of a transistor. Since the common-emitter configuration is the most common in audio amplifiers, this will be the most useful. If you want to run the collector family for the common-base configuration, just reconnect the transistor suitably in the test circuit. The same method can be used to run the emitter family in a common-collector test circuit.

Nonlinear distortion

Back in Fig. 3, note how the collector characteristics tend to become more closely spaced as the base current is increased. Just how does that affect nonlinear distortion in an amplifier? Fig. 8 shows the performance of the Fig. 3 transistor in a simple single-ended class-A amplifier. The amplifier was driven by an audio oscillator. The scope was connected across the output load.

The first photo shows how the top of the output sine wave tends to become rounded as the input drive is increased. As the drive is increased further, the top of the output waveform becomes seriously flattened and the bottom highly peaked. This is nonlinear or harmonic distortion. It is caused entirely by the nonuniform collector characteristics. Every transistor, no matter how good, will begin to show nonlinearity as the input signal is increased, or if bias currents are too large or too small. To improve the output waveform (at the expense of gain), we can add a negative-feedback circuit. Another approach is to use two transistors in push-pull, instead of a single-ended circuit.

Staircase test technique

To use this comprehensive test in a factory for incoming inspection, for example, we have to speed it up. The operator shouldn't need to adjust the base current in steps. One way is to use a staircase-wave generator in place of the 50K pot and 1.5-volt battery shown in Fig. 1. An automatic transistor curve tracer with a built-in staircase generator is shown in Fig. 9. The operator simply plugs in the transistor to be tested, and the complete family of characteristics is displayed simultaneously on the scope screen.

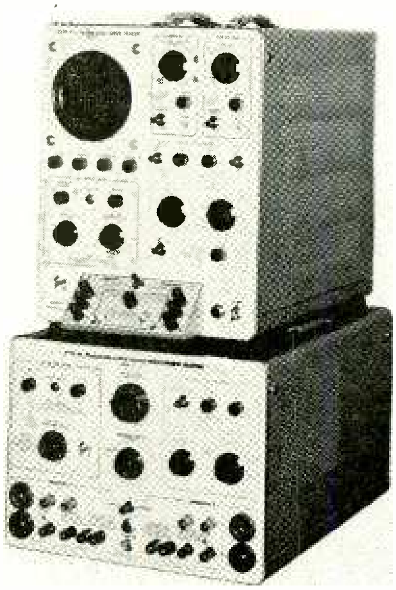


Fig. 9—Tektronix 575 automatic transistor curve tracer—with high-current adaptor.

Scope testing can display the switching time of a transistor, though it may occur in less than a microsecond. In addition to the analog display on the scope screen, digital readout is possible.

END

LEARNING TO LIVE WITH TRANSISTORS

Semiconductors share certain characteristics which, taken together, are almost a personality. If you want to get along happily with them, get acquainted with their quirks. Here are some, culled from various sources—including some engineers' bitter experiences.

Use a heat shunt when you solder, especially on small germanium transistors: long-nosed pliers or a small copper alligator clip around the lead being soldered.

Avoid bending leads sharply right at the transistor body. You may crack the seal.

Clipping transistor leads with scissors-type wire cutters can damage the semiconductor element. It's better to use "dikes" or fingernail clippers.

Don't disconnect transistors without first shutting off the circuit power.

Be certain that any device you use for checking transistors has a terminal voltage well below the transistor's ratings.

Use a collector supply voltage no higher than half of the transistor's collector-to-base breakdown rating. END

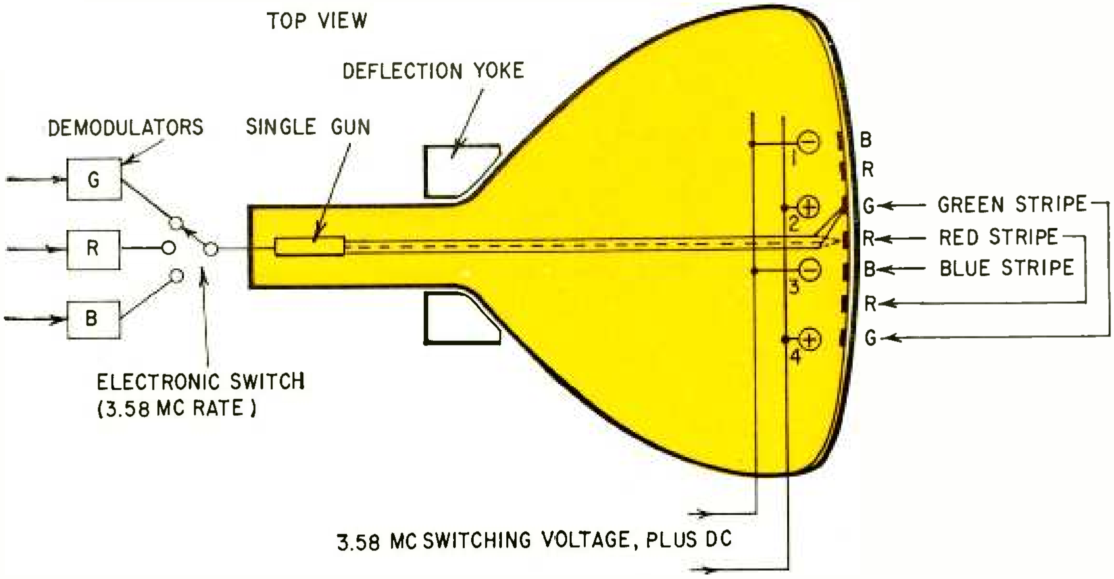


Fig. 1—Single-gun Chromatron, looking down at ends of stripes and wires (grid). High-voltage dc focuses beam to pinpoint; 3.58-MHz power superimposed on grid flips beam tip slightly left or right as it sweeps across, making it strike red, green or blue elements. Simultaneously, beam intensitiy is modulated by video.

All-Transistor Circuits for Chromatron Color

Solid-state color-TV receiver designed for the Chromatron beam-switching CRT

By PETER E. SUTHEIM
ASSOCIATE EDITOR

IN THE JANUARY ISSUE, WE DESCRIBED A VERY INTERESTING type of color-TV picture tube called the Chromatron, which shows a great deal of promise technically but almost none commercially! Though it has been around for some 15 years, no American manufacturer has chosen to exploit it commercially. Yet the tube continues to exist. Sets using it or a similar tube, the Colornetron, are being made and sold in Japan. And one major electronics firm, Fairchild Semiconductor Co. (division of Fairchild Camera & Instrument Corp.), has developed compact all-solid-state circuitry for use with an 11-inch Chromatron.

This article will describe that circuitry. We're going to assume that you are fairly familiar in a general way with how color TV works, and that you know some of the words

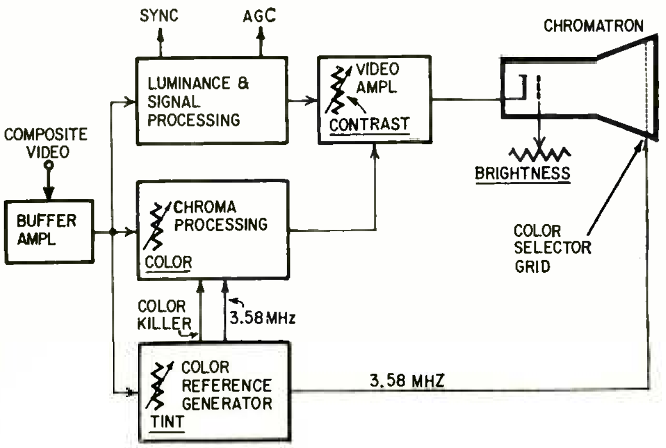


Fig. 2—Block diagram of signal-processing required for Chromatron shows that the chief difference from shadow-mask-tube circuitry is the direct application of 3.58-MHz reference (much amplified) to beam-switching grid in CRT. Also, all video information (chrominance as well as luminance) is applied to cathode.

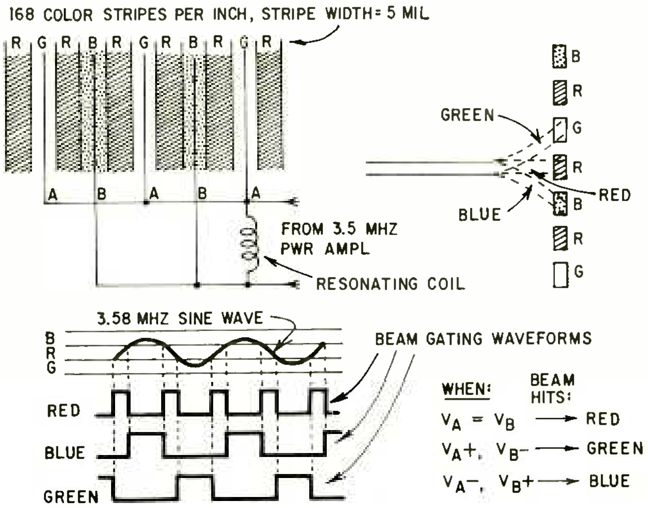


Fig. 3—How single modulated electron beam is switched to produce three colors. Lines lettered "A" and "B" are vertical wires in color-selecting grid. Beam strikes only red when A and B potentials are equal, is deflected to blue or green when potentials differ.

that are going to fly around in a few moments.

The Fairchild design is interesting for two reasons. First, it is the only completely solid-state color-TV circuit we know of: and second, the Chromatron requires circuits that are substantially different from the shadow-mask circuits. For instance, all convergence circuitry is gone, but instead there is a 10-watt push-pull 3.58-MHz amplifier!

The tuner, video i.f., video detector and power supply circuits are either relatively conventional or so similar to other transistor designs that we won't talk about them here. The video processing and beam switching circuits are the really interesting ones. An additional high-voltage source of 4.7 kV is required as a static potential on the color selecting grid, but that comes from the flyback rectifier via a simple resistive divider.

Fairchild has tried two ways of demodulating the composite video signal to get color pictures on the screen: the *chroma gate* system, and the *1, 2, 4 system*.

You'll recall that color information in the transmitted signal is carried on a 3.58-MHz amplitude-modulated suppressed-carrier subcarrier. The subcarrier is modulated along two axes in quadrature (90° apart in phase) called I and Q. The two modulation axes have different bandwidths, which has to do with the sensitivity of the eye to certain colors, but few if any commercial color sets take advantage of the wider bandwidth along the I axis. That simplifies circuit design.

Once the engineers decide on "equiband" operation (I and Q axes of same bandwidth), *any* pair of quadrature axes can be used as demodulation references. Most sets today use red-difference-signal (R − Y) and blue-difference-signal (B − Y) axes, which can be matrixed with the luminance (Y) signal to get the green-difference component (G − Y).

What the Chromatron circuits must do is make the single electron beam strike the correct color phosphor at the same instant the beam is being modulated with signal information corresponding to that color. Fig. 1 shows a schematic of the tube, and Fig. 2 shows the idea in terms of function blocks. The cathode of the electron gun is the input for all video information. In the chroma-gate method of processing, it is rapidly switched in proper sequence between red, green and blue information. At the same time, the tip of the electron beam is flipped to the correct color-phosphor stripe by a grid of vertical wires just behind the screen. (All this goes on, of course, at the same time as the regular horizontal and vertical scanning, and quite independently of it.)

Flicking the beam around from phosphor to phosphor at a rate of 3½ million times a second takes quite a bit of power, and that is the reason for the 3.58-MHz power amplifier. It generates a 10-watt rms sine wave. Fig. 3 shows how the phase of the sine wave corresponds to the switching at the Chromatron cathode.

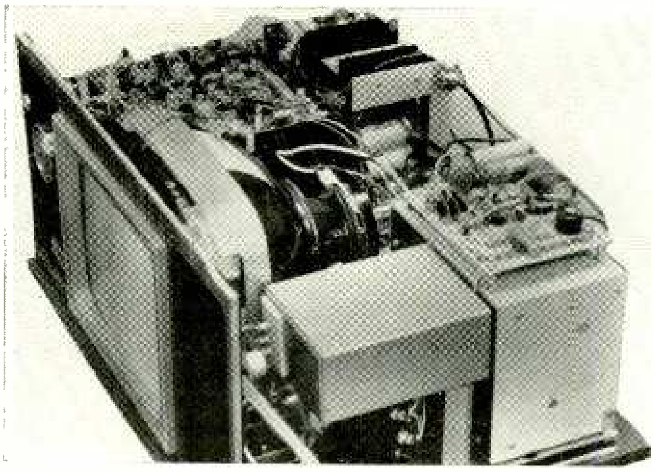
A full schematic of the chroma gate processing circuitry is given in Fig. 4, along with the 3.58-MHz power amplifier circuit. Those two circuits, properly synchronized by the 3.58-MHz oscillator and ultimately by the color burst signal sent from the transmitter, recreate the correct colors on the screen of the Chromatron.

In Fig. 4, three identical diode demodulators pick off the green, red and blue difference information from the 3.58-MHz subcarrier in much the same way as in conventional shadow-mask tube sets. The demodulators' outputs are direct-coupled through low-pass filters to buffer amplifiers Q20, Q21 and Q22. The circuits have different gains, corresponding to the difference between Chromatron drive requirements and the NTSC standard signal amplitudes.

The red-channel gain is made adjustable, because the red sampling period is narrower than that of the green or blue. (Note that there are twice as many red stripes on the Chromatron screen as green or blue ones; hence, red is struck more often, but for shorter times, than green or blue.) That narrower sampling period is affected more by the sloping rise of the gated signal than are the green and blue signals. The CHROMA GATE BIAS sets the dc level of the color difference signals (R − Y, etc.) that feed the sampling circuitry. Balance controls correct for slight differences between the dc levels of the three signals.

The signals go to the bases of sampling transistors Q27, Q28 and Q29. The emitter resistor of each transistor is switched to ground during the period that the electron beam in the Chromatron passes over the corresponding phosphor stripe. The blue and green gating transistors, Q24 and Q25, are driven from the 3.58-MHz reference signal. Drive for the red gate transistor, Q26, comes from the blue and green gates via an OR circuit. The RED GATE WIDTH control permits adjusting the width, or dwell, of the red sampling pulse. The black-and-white luminance signal, from the separate luminance processing circuitry, is amplified in Q23 and added to the sampled color-difference signals. The composite Chromatron video signal goes to Q30, which drives parallel-connected video output transistors Q31 and Q32. Two transistors are used in parallel because the wide bandwidth requires a low collector-load resistance, and, hence, large signal currents in the transistors.

Experimental color set designed by Fairchild for Paramount Pictures C6003 Chromatron. This is the set described in this story.



View of the insides of the Fairchild set. Chromatron in this design has 168 phosphor stripes per inch, each about 5 mils wide.

Color processing by 1, 2, 4

There's another way of looking at this whole business, which produces another approach to color processing. (It's a little like the difference of viewpoint that led to FM stereo being reproduced by both time division and matrixing. A lot of people were bewildered until someone explained to everybody's satisfaction that the two methods are really equivalent and arrive at the same point by two different roads.)

It turns out that the beam switching sequence shown in Fig. 3 amounts to a *sixth-harmonic sampling* of the colors with a sequence GRB-BRG-GRB. In the 1, 2, 4 scheme, amplitude-modulated components at the fundamental and the second and fourth harmonics of the 3.58-MHz color subcarrier are generated and combined to energize the color phosphors with the correct phases and amplitudes to give the right color.

A complete analysis of the process calls for a lot of hairy equations that drag in Fourier series and other morsels of engineering math, which we haven't space for. Most of you are probably aware that any periodic waveform, no matter how screwy it may look, can be broken down into a fundamental sine wave plus sinusodial harmonics of that fundamental, added together with particular phases and amplitudes. This is one of mathematician Fourier's great contributions to electrical engineering (although he developed harmonic analysis for a different purpose). Fig. 5 shows how various colors can be produced on the Chromatron by feeding the proper wave forms to its cathode. Anyone who has ever looked at the output of a harmonic-distortion meter with a scope will recognize those waves as being made up of the fundamental 3.58-MHz burst frequency (top of Fig. 5) plus harmonics of it.

By generating the correct harmonics (we already have the fundamental, from the 3.58-MHz crystal oscillator) and adding them in correct proportions and with the correct phases, we can get any color we want on the screen. By doing that in synchronization with the color information we get from the demodulated chroma signal, the colors will correspond to the ones in the original before the camera.

The circuitry that does this is quite complex (17 transistors compared to the 13 of Fig. 4, and many more tuned transformers), but Fairchild engineers feel it gives better color purity than does the chroma-gate circuit. However, they admit that the chroma-gate circuit is easier to align. Fig. 6 shows a functional diagram of the 1, 2, 4 color processing circuit; unfortunately, the schematic requires almost a full page and we just haven't room.

Some practical observations

Fairchild engineers agreed with many who observed the Chromatron in operation that its picture is brighter than that of the shadow-mask tube. They noted that best color ap-

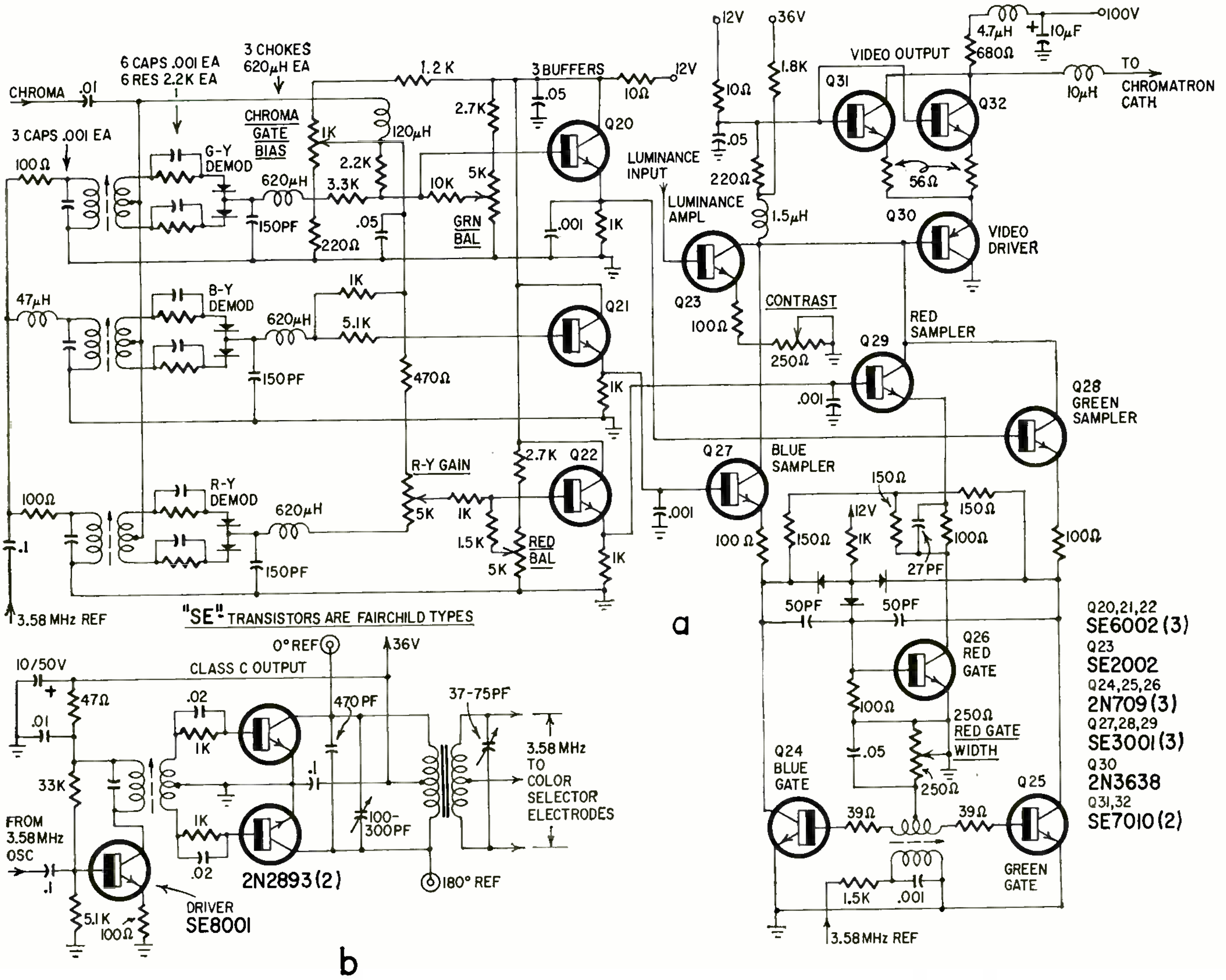


Fig. 4—Chroma demodulator and gating circuits (a); 3.58-MHz power amplifier (b). These determine how much of which color the Chromatron displays at any instant. They are locked in phase by 3.58-MHz crystal oscillator, which is locked to color burst.

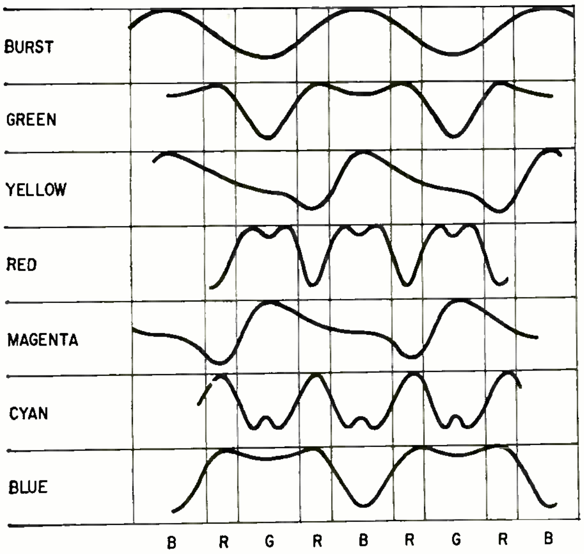


Fig. 5—Fundamental-plus-harmonic waveforms of 3.58-MHz signal can produce every kind of color on Chromatron screen; that's the basis of "1, 2, 4" system. To understand drawings, imagine that downward-going excursion of waveform produces more of whatever color the waveform happens to be "in" at the moment. Thus, for red, electron gun is driven hard every time beam crosses red stripe; in between, beam current is almost zero.

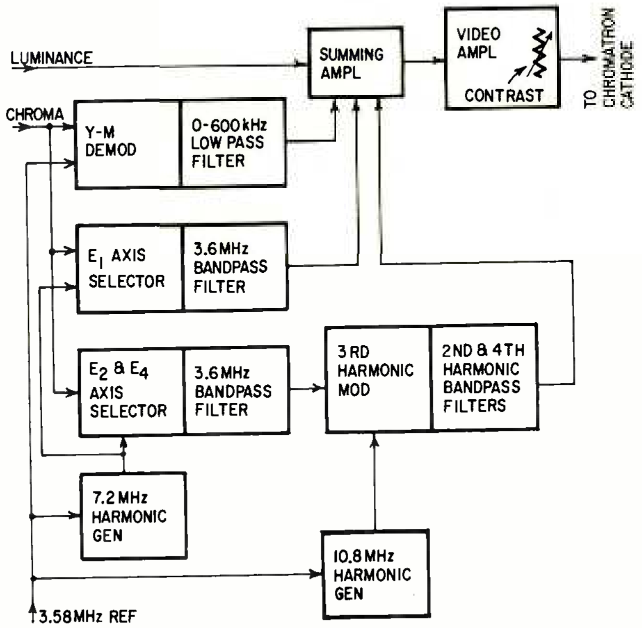


Fig. 6—Functional diagram of 1, 2, 4 processing system. "M" signal, referred to in "Y—M DEMOD" box above, is made up of equal amounts of red, green and blue information. Frequencies are rounded off to 3.6, 7.2 and 10.8 MHz for sake of simplicity.

pears at high brightness; the opposite is true of the shadow-mask tube. No convergence is necessary, which means that once the color-processing circuits are set up, the few remaining setup operations don't require a color test generator or a color program.

Contrary to what has often been reported, external magnetic fields *do* influence color quality in the Chromatron. They cause an effect that looks a little like poor convergence; it appears as a red "blush." Radiation of 3.58 MHz from the set or the Chromatron is not a problem.

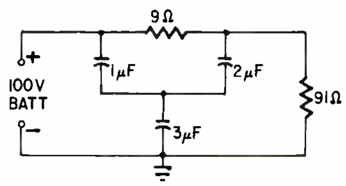
The prototype designed by Fairchild using the 1, 2, 4 color processing circuitry contains 66 silicon transistors in all, plus of course the Chromatron and a 1X2-B (tube) high-voltage rectifier. It draws 70 watts from the ac line. END

WHAT'S YOUR EQ?

Conducted by E. D. CLARK

How Many Volts?

In the circuit shown, it is assumed that sufficient time has elapsed to com-

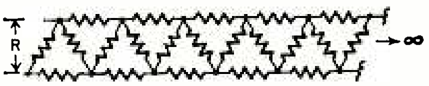


pletely charge the three capacitors.

Find the voltage across the 3-μf capacitor.—*Robert L. David*

Resistors Galore

The diagram shows an infinitely long triangular network of 1-ohm resis-



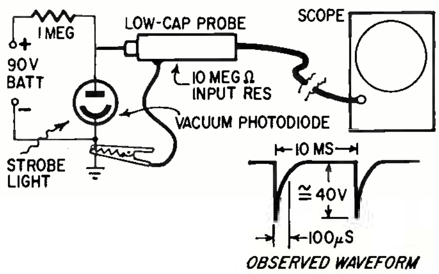
tors. What is the resistance (R) looking into the network?

Since the network cannot be broken down in pi or T junctions, existing textbook formulas for long attenuator networks do not apply here. However, with a little inqenuity and basic algebra, the problem can be solved.—*William Uhlenhoff.*

Phantom Power Source?

The photodiode circuit shown here was being tested in the lab. A strobe light was used as the light source, generating a pulse of 100 microseconds' duration every 10 milliseconds. Everything seemed normal until the 90-volt battery was disconnected. With the battery removed, the observed waveform did not disappear but, instead, nearly double in amplitude. This performance continued for several minutes before a significant amplitude decay was noted.

What is the mysterious source of power? (*Hint*: output disappears instantly on removing the battery if the scope is dc-coupled).—*G. Robert Wisner*



Three puzzlers for the student, theoretician and practical man. Simple? Double-check your answers before you say you've solved them. If you have an interesting or unusual puzzle (with an answer) send it to us. We will pay $10 for each one accepted. We're especially interested in service stinkers or engineering stumpers on actual electronic equipment. We get so many letters we can't answer individual ones, but we'll print the more interesting solutions—ones the original authors never thought of.

Write EQ Editor, Radio-Electronics, 154 West 14th Street, New York, N. Y. 10011.

Answers to this month's puzzles are on page 97.

50 Years Ago

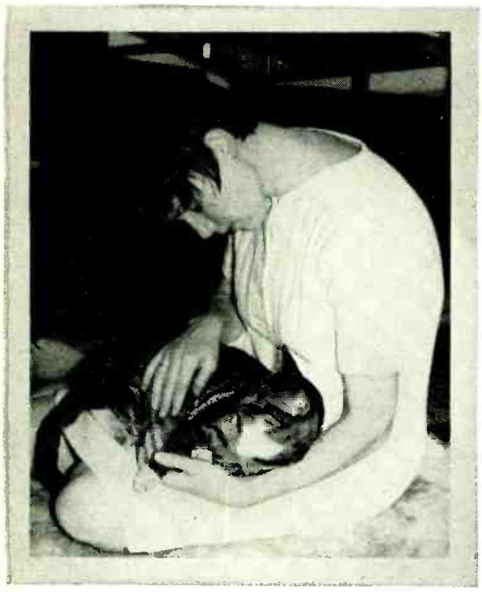
In Gernsback Publications
In June, 1916
Electrical Experimenter

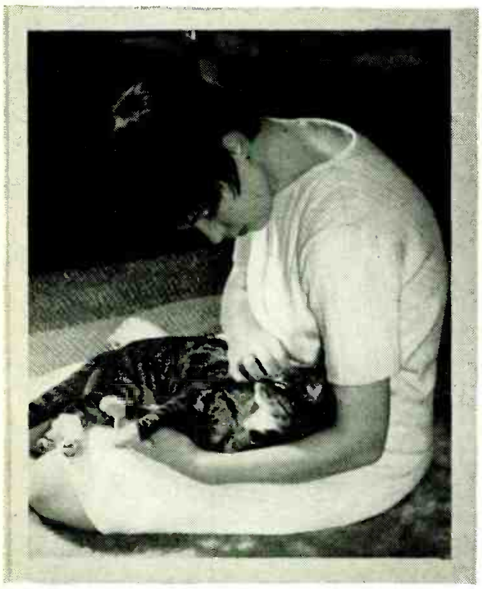
Wireless Music with Your Meals
Tesla's Early Work with Radio-Controlled Vessels
High-Speed Radio Telegraph
High-Voltage Battery for Audions
Signal Corps Uses Radio in Mexico

FLASH SLAVE MAKES BETTER PIX

By J. W. KORTE

Simple light-operated unit syncs auxiliary flash with camera flash. Works at any light level





These pictures show why you should use slave fill-in flash whenever you can. They were shot minutes apart, with everything the same except that the top one used a single flash at the camera, and the lower was taken with one slave unit as the principal source, and the camera flash as fill-in lighting at reduced intensity to kill the hard shadows.

HERE'S A CONVENIENT, EASY-TO-BUILD light-actuated remote flash unit. The transistors are not critical—low-cost general-replacement types are suitable. If you use a discarded B-C (battery-capacitor) flashgun, the other components can be bought for about $5. An optional test-lamp circuit checks continuity of the flashbulb and that it has been seated properly in its socket. Power comes from a 9-volt transistor radio battery.

Most B-C flashguns are suitable for this slave flash. The typical 100-μF capacitor, test lamp and test switch can be reused. Added parts are the two transistors, a selenium solar cell and resistors. The usual test bulb operates on about 60 mA (a No. 48 or 49 bulb will also work), which is low enough not to fire a flashbulb. Locate the test bulb at the back of the unit. That way, if a flashbulb pops off accidentally when you test the circuit, your eyes won't get the full flash.

The value of R1 depends on the transistors you use. Values from 470K to 1 megohm, or no resistor at all, were used in various test models (680K is the most common value). Use the value that makes about 6 mA flow through the flashbulb socket. Lower resistance increases the current flow and the unit's sensitivity to light, but of course discharges the battery sooner. Note that, because of C, the intensity of ambient light does not affect this current, unless the light level is changed so fast and so much that C passes a pulse.

To check that the circuit is operating correctly, without wasting a flashbulb, place a No. 40 pilot-light bulb in the flash socket. If the flashgun handles only the larger class-5 flashbulbs, get an inexpensive adapter for a class-3 flashbulb. A No. 40 pilot-light bulb will fit most adapters, or it will fit directly into most flashguns that accept class-3 flashbulbs.

The solar cell can be mounted on a pivot so that it can be turned to intercept as much light as possible from the camera flash.

Operation

Inserting a flashbulb in the socket connects the battery and energizes the circuit. (*The battery will be discharged if the bulb is left in without being flashed.*) If a 100-watt light bulb is switched on about 2 feet from the solar cell, or another flashbulb is fired up to 30 or more feet away, the slave unit will fire its flashbulb. If a No. 40 pilot-light bulb is in the flash socket for testing and the 100-watt bulb is switched on, the test light should momentarily light up brightly.

Any type flashbulb can be used. Preferably, use the same class flashbulb as you normally use in your camera flash. That way, you avoid confusion with different guide numbers and peaks. For making portraits, most bulb manufacturers recommend placing one flashbulb nearer to the subject, to the side and higher than the camera flash (about 70% of the camera distance is a good place to try.) Only this nearer "main light" is used to calculate the f-stop. The other bulbs do not materially increase the light, but they improve modeling and depth. When a portion of a very large area or a distant background is illuminated by the slave unit only, calculate by regular guide-number methods.

Camera and flashbulb timing

A brief analysis of flashbulb operation will explain why a slow shutter speed (around 1/25 second, or 40 milli-

BATT—9-volt transistor radio battery
C—100 μF, 9 volts or higher (can use capacitor from discarded B-C flash unit you're rebuilding as slave)
PC—silicon solar cell, 0.3-volt, 10 mA minimum output (International Rectifier S1M, Solar Systems 10-4L or equivalent)
Q1—p-n-p germanium general-purpose transistor (RCA replacement type SK3003, G-E replacement type GE-2 or any similar transistor will work)
Q2—p-n-p germanium power transistor in TO-3 case (RCA replacement type SK3009, G-E replacement type GE-3 or any similar transistor will work)
R1—680,000 ohms, ½ watt, 10% (tentative value—see text)
R2—10,000 ohms, ½ watt, 10%
R3—470 ohms, ½ watt, 10%
R4—100 ohms, ½ watt, 10% (optional, for test light)
S—spst normally open pushbutton (optional, for test light)
Old B-C flashgun, No. 48 or 49 pilot lamp (optional, for test light), miscellaneous hardware

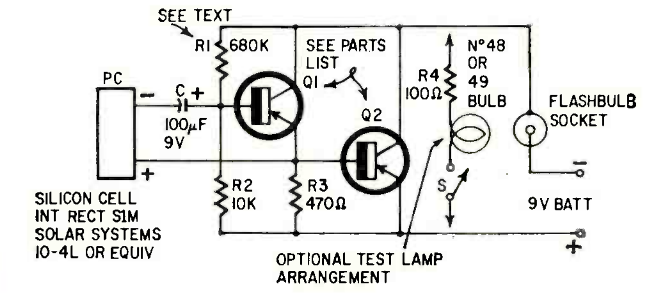


Fig. 1—Schematic of the flash slave. Small battery is sufficient for many flashes, and widely available, also.

seconds) is generally recommended. Action is stopped by the short duration of light from the flashbulb even though the shutter is open slightly longer. From Fig. 2, you can see that peak light occurs with class-M flashbulbs around 15 to 20 msec after the flash contacts are closed. Fresh batteries may cause the peak of light to occur up to 5 msec sooner; weak batteries, 5 msec later. It is not possible for the remote bulb to fire until some light-intensity increase is detected (around 5 or 10 msec with class-M bulbs).

M-synchronized shutter flash contacts close before the shutter blades open. X-synchronized shutter contacts close when the blades are fully open, and therefore require slower shutter speeds when used for flashbulb pictures. A little analysis of the information in Fig. 2 should indicate to you whether your camera synchronization and flashbulb

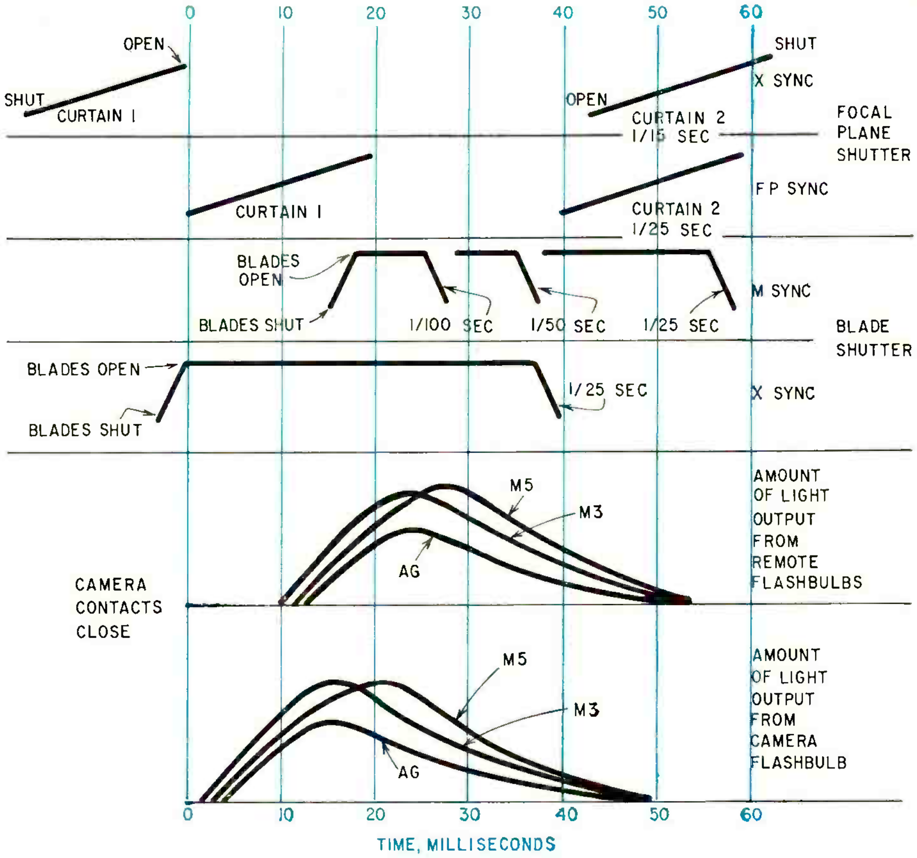
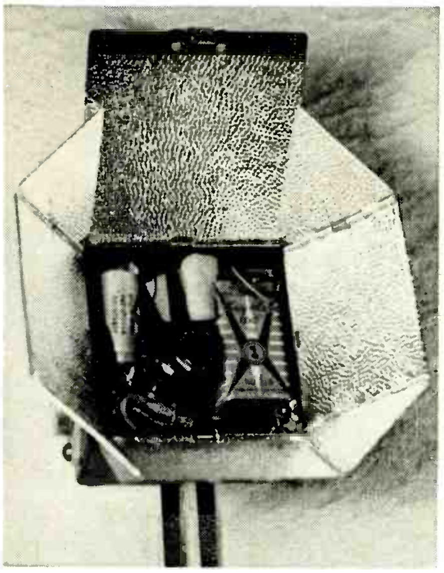
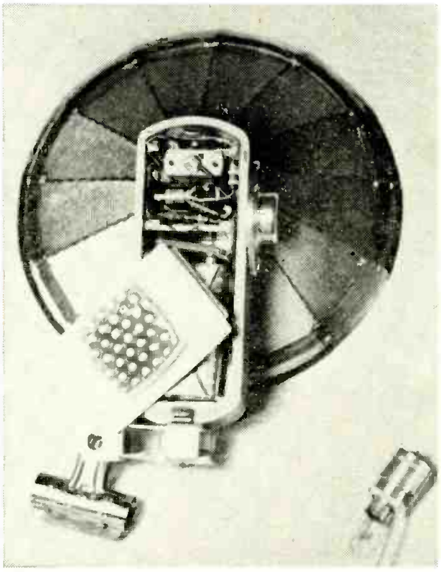


Fig. 2—Shutter actions at typical speeds related to light peaks from various flashbulbs.

class will allow faster shutter speeds. It'll be worth your while to run a few test shots at 1/50 second or faster speeds. One method is to illuminate only part of the picture with the camera flash, and part with the slave flash. Then you can check the relative illumination on the two parts at various shutter speeds. END





Most B-C flash units have plenty of space in and around them for mounting slave control parts. Here are author's two versions.

FEEDBACK, NEGATIVE AND POSITIVE

Readers comment on the March debate "The Wider the Band, the Higher the Fi?"

". . . I am violently opposed to Mr. Brociner's yardstick to stale . . . biological facts . . . (he) needs to recognize the newest trends in biophysical research. For I along with a few other 'nuts' can perceive certain types of information not readily discernible to the human ear."

H. Bernard Smith
Boulder, Colo.

"My own hearing extends only to about 12,000 Hz, and when I listen to sinusoidal tones from two high-quality tweeters I cannot distinguish the one that is rated at 18,000 from the one at 22,000. Yet I can easily distinguish when I listen to music from one or the other. It sounds cleaner and better from the 22,000 unit."

Ben O. Hicks
Malibou, Calif.

"No one that I know of has yet proved *conclusively* that wide bandwidth *alone* improves the quality of sound. Nonetheless, it seems reasonable that to be on the safe side, equipment should have as wide a range as possible until something is definitely proved."

William Sommerwerck
Baltimore, Md.

". . . as to an amplifier that can only reproduce sine waves from 20 to 20,000 Hz, forget it! It is not capable of high-fidelity performance.

"P.S.—For Mr. Brociner's information: the latest proof-of-performance on WGNB-FM (St. Petersburg, Fla.) showed a frequency range of 35 to 21,500 Hz within 1 dB at 0.3% harmonic distortion."

John H. Sherrod
Largo, Fla.

"It is amazing how many words can be devoted to this problem without coming to grips with its essence: is there a demonstrable difference in sound between units designed to the disparate philosophies?"

Dr. Lawrence R. Zeitlin
Assoc. Prof. of Industrial Psychology, City College of New York

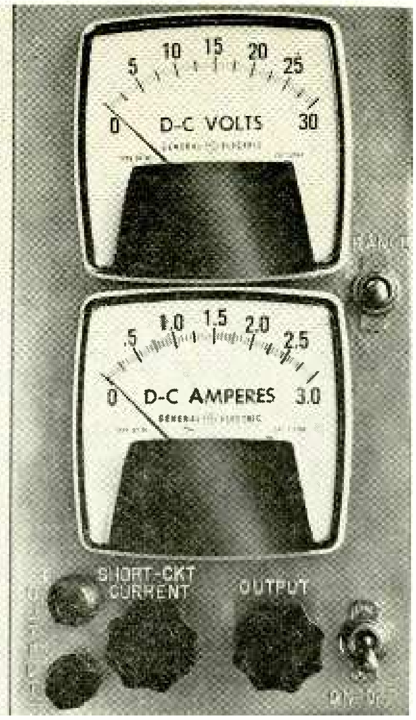
Whether by observation and logical deduction, or from an emotional "just in case" hunch, almost everyone felt that amplifier bandwidth should exceed the usually quoted limits of human hearing.

But one writer—Lawrence Zeitlin (last letter above)—proposed an experiment to determine whether humans can detect differences in sound reproduced through an amplifier of wider-than-audio bandwidth, and through an amplifier whose response is limited to the range of human hearing.

RADIO-ELECTRONICS *and Dr. Zeitlin will collaborate on a series of experiments to establish just that. We will present the results in a later issue.—Editor*

ALL-SILICON REGULATED POWER SUPPLY

Simple, stable bench supply has built-in short-circuit current limiting. Up to 2 amperes at 35 volts. Ideal for power-transistor experiments.



By DONALD H. ROGERS*

SILICON TRANSISTORS ARE GETTING cheaper all the time. They are now eligible for a lot of jobs for which they would have been too expensive only a year or two ago. Their ability to withstand high temperatures recommends them for power-supply work. Their low leakage also simplifies the design of stable dc amplifier circuits for regulating.

Availability of RCA's new 40251 silicon power transistor (rated at 117 watts dissipation at 25°C case temperature) for a series "valve," with the smaller 40250 to drive it, suggested a design for a series-regulated power supply for general lab use. Voltages up to 25 or 30 were required, at a current of up to about 2 amperes. Short-circuit protection was a must.

The circuit I developed (see diagram) can be built entirely from commercial components.

Dc supply circuit

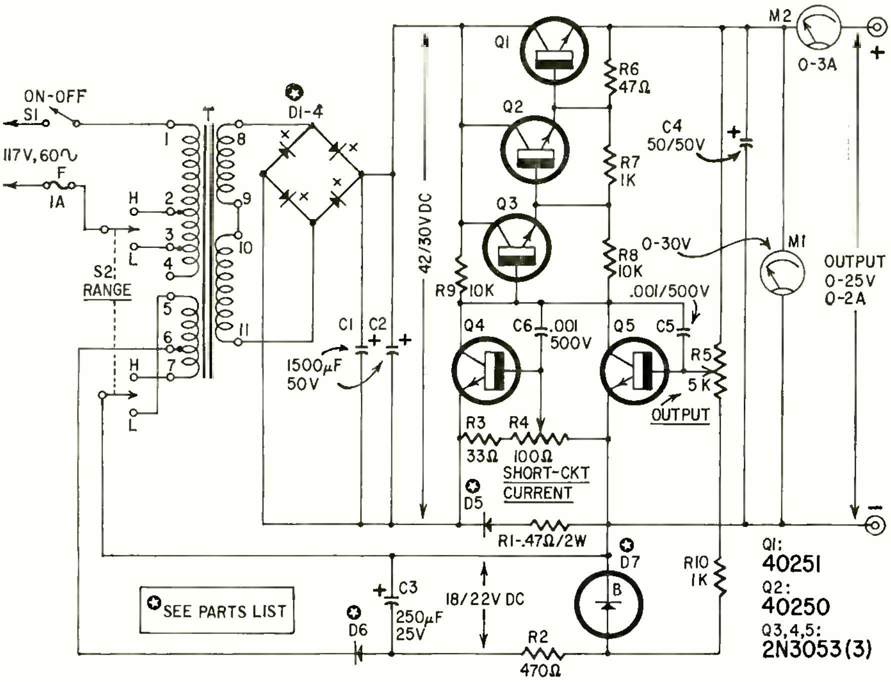
The power transformer is a multi-voltage job rated at 33 volts, 2 amps dc with a full-wave bridge rectifier and a capacitive load. The 2-ampere 200-piv rectifiers have a 100% safety margin in the bridge circuit, and 3,000 μF of capacitance does a lot of brute-force filtering before the regulator.

An unexpected virtue of this transformer is a completely independent winding which can be used to extend the primary in some low-voltage applications. This winding has been pressed into service here as an extra secondary driving a half-wave rectifier and filter to provide an outboard negative supply for the regulator reference.

One section of switch S2 is arranged to change the primary tap from terminal 2 to terminal 3 for lower output voltages, to reduce regulator dissipation. The other section of S2 changes the negative supply from terminal 7 to terminal 5 to keep its voltage from dropping at the same time. This insures that in either position of the switch there will be enough current through Zener diode D7 to keep its impedance to a low value.

Regulator circuit

Series-valve transistor Q1 is driven by Q2, which in turn is driven by Q3 for high current gain. Base-to-emitter resistors R6, R7 and R8 prevent the transistors from turning themselves on with leakage current under high load



Circuit of all-silicon supply. Low leakage and high temperature stability simplify design.

C1, C2—1,500 μF, 50 volts, electrolytic
C3—250 μF, 25 volts, electrolytic
C4—50 μF, 50 volts, electrolytic
C5, C6—.001 μF, 500 volts, ceramic
D1–D5—200-piv, 2-A silicon rectifier (Solitron 2A200 or equivalent)
D6—100-piv, 150-mA silicon rectifier (Solitron CER-68A or equivalent)
D7—Zener diode 400 mW, 12 V ±10%, 1N963-A
F1—Fuse 1 A, Slo-Blo
M1—30 V dc meter (General Electric series DO-91)
M2—3 A dc meter (General Electric series DO-91)
Q1—40251 (RCA)
Q2—40250 (RCA)
Q3, Q4, Q5—2N3053 (RCA)
R1—0.47 ohm. 2 watts (IRC BWH)
R2—470 ohms
R3—33 ohms
R4—100-ohm potentiometer, linear
R5—5,000-ohm potentiometer, linear
R6—47 ohms
R7, R10—1000 ohms
R8, R9—10K ohms
All resistors ½ watt, 10%, except as noted
S1—spst switch
S2—dpdt switch
T—Stancor RT-202 selenium-rectifier transformer
Heat sink—Carl Cordover type HSD-3B (Radio Shack catalog No. 27-076)
Chassis, terminals, knobs, miscellaneous hardware

**Manager, distributor products engineering, Jerrold Electronics Corp., Philadelphia, Pa.*

See Sept P 16

and temperature. Q5 is a dc amplifier coupled to Q3 by load resistor R9. It amplifies the difference between the 12-volt reference across D7 and that part of the output voltage which appears across R10 and the lower part of R5. It thus closes a negative feedback loop which maintains a constant output voltage. C5 prevents parasitic oscillations. C4 reduces the ac output impedance, and makes the supply insensitive to capacitive loads.

Current-limiting circuit

Overload protection is the job of transistor Q4. When a large enough output current is drawn through R1 and D5, Q4 turns on and reduces the base voltage of Q3 to zero, turning off the regulator and bringing the output voltage down to zero. The exact value of current at which this takes place depends on the setting of R4. C6 prevents parasitic oscillation.

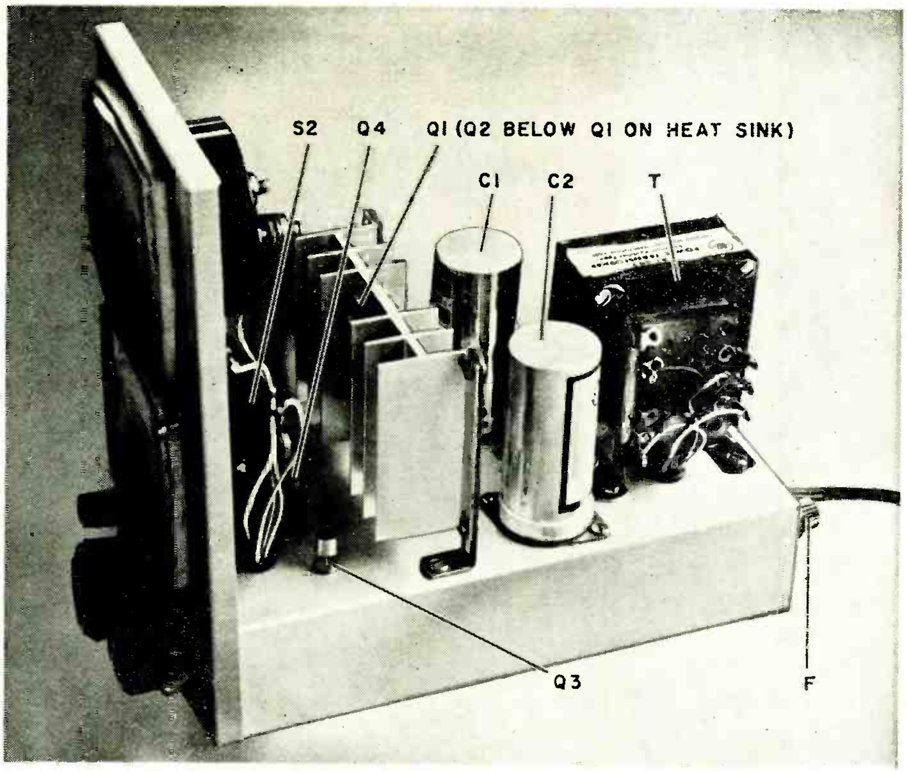
Silicon diode D5 is used instead of making R1 larger, because it develops a nearly constant voltage drop that matches the emitter-junction drop of Q4. It has a lower dynamic impedance than a resistor, and has less effect on the regulation of the supply.

All five transistor types were chosen for a high collector breakdown rating. With a short-circuit load, the full dc supply voltage appears across Q1, Q2, Q3 and Q4. At highest output setting and light load, nearly the full dc supply voltage appears across Q5. This voltage, which can reach about 46 at no load and high line, is well within their rating.

Power dissipation is no problem for any of the transistors except Q1, which is mounted with Q2 on a Carl Cordover Co. HSD-3B heat sink. Dissipation stays within rating for currents up to 2 amperes on the low-voltage range, and for voltages above 10 on the high-voltage range. Q1 is somewhat overdissipated for short-circuit currents above about 1.4 amperes on the high range, and such shorts should be cleared as soon as possible. Heat dissipating ability could be increased by painting the sink dull black, but this did not seem necessary for the service intended. Neither did it seem necessary to add another 40251 transistor in parallel with Q1.

Performance

Output voltages up to 25 are available on the high range at the full 2 amperes, and up to 35 volts at light loads. On the low range the capability is 15 volts at 2 amperes, and up to 25 volts at light loads. Within the appropriate range, the output changes less than 0.25 volt between no load and full load, or for a ±10% change from the nominal 117-volt line.

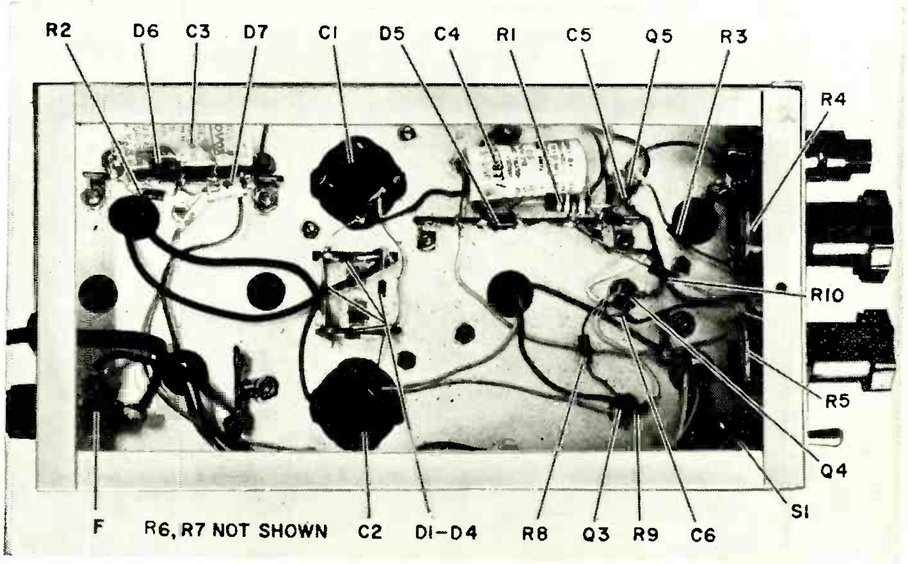


Heat sink, which mounts power transistors Q1 and Q2, is electrically common to chassis through mounting brackets. Therefore, Q1 and Q2 must be installed with mica insulating washers and flat and fiber shoulder washers (usually supplied with transistors). Q1 and Q2 cases must not touch heat sink electrically.

Ripple in the output varies from less than 20 mV peak to peak at light loads to a maximum of less than 100 mV p–p at full load, at maximum output setting. At low output the ripple measures less than 10% of these values.

The current limiter is set by turning it down until the output voltage starts to drop, and then backing it off just clear. When set for a 2-ampere load, it holds the short-circuit current down to 2.5 amp. It limits a 200-mA load to 300 mA on short circuit, and a 25-mA load to 50. Limiting occurs in about 2 milliseconds after a shorting the output through 4 ohms, at 10 volts (2.5 amps output current).

If the power supply is to be used extensively for low-current work, you may want to use a multi-range milliammeter at M2, with a range switch. If the supply is to be used at light loads and high voltages, you may wish to change M1 from a 30-volt to a 50-volt instrument. END



Size of chassis, dictated mainly by transformer and heat sink, leaves plenty of room for wiring. R6 and R7 are with Q1 and Q2 on heat sink.

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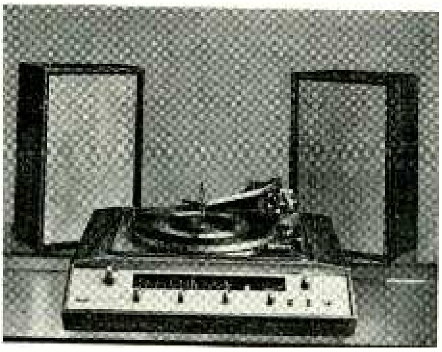
EQUIPMENT REPORT

Harman-Kardon SC-440 System

Circle 25 on reader's service card

ONCE UPON A TIME IT WAS EASY TO separate component systems from "pre-packaged" ones. Then a certain firm introduced a modular system, and soon every manufacturer of components also had a complete ready-to-play music system. Some are pretty good: others seem built to prove that a quality manufacturer can make something as badly as anyone.

Harman-Kardon was one firm that bided its time, coming out only recently with a complete system that does not give one the feeling that is has been hastily assembled to cash in on a new market.



Certainly, the most striking thing about this SC-440 is its appearance. The basic case is more than a mere box: it has the feel of sculptured beauty. The speakers are fitted with a handsome grille cloth with Velcro squares holding it and its mounting board in place. This has two advantages. First, it insures a resonance-free mounting for the grille assembly; second, it makes the grille cloth easy to change if you should care to do so.

The SC-440 is a complete stereo music system. It consists of three pieces: two speaker units, and an AM/FM stereo receiver and automatic record player.

These units are designed for shelf mounting or for use as furniture. Harman-Kardon has wisely tilted the control panel, so that the controls are easy to work—even if the system is on a knee-high shelf. At the same time, eye-level placement still leaves the knobs controllable.

All requisite controls are there, too. Bass and treble boost and cut are two knobs only. I see no need for separate channel controls on a system where you know the two speakers will be identical. Harman-Kardon's thinking has gone the same way.

Volume and channel balance are the other two control knobs. In addition, a loudness switch introduces a bass-boost circuit for low-level listening, and a speaker-defeat switch is used with the stereo headphone output jack on the lower right.

The source selector switch is interesting. It has a stereo-mono switch for FM and phono as part of it. Both FM and PHONO positions actually have two switch stops, one for mono and the other for stereo. An auxiliary input is provided (via rear-apron inputs); this is always in the stereo mode. The AM position feeds the signal to both speakers, since there is, of course, no stereo AM.

The record player sits atop the case. It is a stock Garrard AT-60 about which all we need to say is that rumble measured a highly satisfactory −31 dB unweighted. More important, rumble was not annoyingly audible during listening. Flutter and wow were also low to the ears, but weren't measured.

The cartridge supplied with this sample is the ADC-770. Again, only listening tests were made, indicating that this cartridge, tracking at 3 grams, treats records well and produces a bright but controlled sound.

The speakers are two-way systems with a sealed-box construction. The 10-inch high-compliance woofer and 3-inch tweeter are caulked into the box, assuring a tight air seal. A tweeter-level control allows tailoring high-end response over a wide range of room conditions.

Any complete package must be judged primarily on the sound it produces, rather than by measurements. After all, one buys such a unit to use as a unit, not to pull it apart and substitute this or that.

I first set up the SC-440 with the speakers on the floor. This is in violation of the instructions, which state that the speakers should be off the floor. Those instructions are valid! There is a great deal of bass boom on a resonant wooden floor. Happily, it completely disappears once the speakers are off the floor. Then, sound from any source is notable for a wide-range smoothness. The SC-440 immediately impressed me as being about the best compact I have yet heard.

Bench measurements showed ample reason for the superiority of sound. Overall amplifier frequency response at one watt is 15–55,000 Hz within 2.5 dB. Power is 10 watts at midband into an 8Ω load. Full bandwidth at −2-dB points extends from below 20 Hz to just over 20,000. This is not very *high* power, but it is more than enough (considering the power bandwidth) to do the job.

Power into 4- or 16Ω loads is reduced. Midband maximums are 6.5 watts at 4 ohms and 5.8 watts at 16 ohms. Power at frequency extremes is reduced proportionally. It is interesting that the speakers are 4 ohms. This would seem to suggest that we ought to run out of

power quite quickly, since 50-Hz power output into 4 ohms is limited to 5.2 watts. Listening tests could not confirm this; my comments on adequate audible power remain.

Amplifier signal-to-noise ratio is an excellent 100 dB at high-level inputs. IM distortion readings were 1.2% at 0.5 dB below full output. At maximum output IM measured 4%. At 1 watt it was 0.9%. While this is not terribly high IM, it is more than is really desirable. This IM is probably responsible for the slight edginess I hear from the speakers, rather than any fault of the speakers themselves. Again, I want to emphasize that this is not a serious fault; the SC-440 is, overall, an exceedingly fine-sounding system.

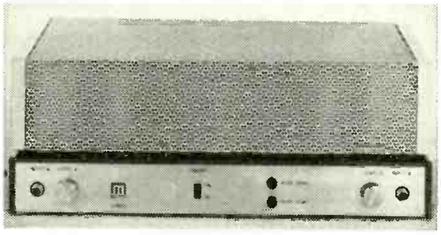
The FM tuner does not drift. It is extremely sensitive, capturing stations as well as some separate tuners with the best reputations. Audible tuner distortion is very low in mono or stereo reception. Stereo channel separation is entirely adequate, measuring 25 dB at 1 kHz for either channel.

The SC-440 lists for $399. That is not a great deal—for a component system. All the more reason to marvel at the *value* of this Harman-Kardon unit. Considering that high-quality sound is here mounted in attractive walnut enclosures (themselves worth a pretty penny) you soon come to realize that this SC-440 is a considerable achievement.—*Leonard Silke*

Mattes SSP-200 Stereo Amplifier

Circle 26 on reader's service card

THIS IS AN ALL-TRANSISTOR STEREO BASIC (power) amplifier. Its power output capability is greater than that of any other commercially available stereo power amplifier. And it offers performance equaled by no other similar component I know. That seems a powerful statement, but I sincerely mean it.



Consider: Power output into 8-ohm loads is 112 watts *per channel* at mid-band frequencies. At 20,000 Hz, power is 2 dB down; at 15 Hz it is 1.3 dB down. (No measurements were made at other values of load for lack of big enough noninductive power resistors.)

Mild capacitive loads have no apparent effect on the stability of the amplifier. A totally capacitive load does not alter the appearance of a 1-kHz square wave.

Frequency response is flat from a 15-Hz rolloff (down 3 dB at 10) to a −2-dB point at 45 kHz.

IM distortion, the bane of many transistor amplifiers, is impressively low. Witness these measurements (powers are equivalent sine-wave):

1 watt	0.32%
10 watts	0.18%
50 watts	0.14%
100 watts	0.18%
110 watts	0.20%

Note that this amplifier shows a little of the common rise in distortion at low power levels, usually attributed to crossover distortion in the output stage; but in the Mattes the total distortion, even at 1 watt, is extremely low.

The signal-to-noise ratio is 105 dB below 100 watts output. With that extraordinary figure, I still heard considerable noise when I first installed the amplifier in my system. A quick check revealed that it was not from the amplifier but from my preamp. That in spite of the fact that I have a *very* low-noise preamp. Nothing was amiss. The Mattes has phenomenal gain. That is why it is equipped with input-level controls. Simply turning them down a bit cured the problem completely, allowing me to operate the preamp's volume control at reasonable settings.

The manufacturer claims that the patented circuit used is nearly indestructible even under hideous abuse. I concur. I drove the amplifier to full output, kept it that way for a while, then laid a short across the output terminals. This would lay low most any transistor amplifier. Not the SSP-200. With the short removed, the amplifier recovered immediately. One transient overshoot, and it was back to full normal power.

A front-panel light will blink on under prolonged shorted-output conditions. It indicates that a circuit breaker is in action. Removing the short returns everything to normal. A second light across the power-input fuse tells you if it has blown.

Mattes has done a clever thing with the input connections. Each channel has two parallel inputs, one on the front apron of the amplifier, the other on the rear. Thus, connections are always easy.

An output switch adjusts the circuits for the speaker load. A position on this switch limits output power to about 12 watts. This is a safety feature for your *speakers*. When you are first setting up the system, put the switch in this position. That way, an accidental transient pulse from, say, inserting an audio plug while the amplifier is on will not tear the speaker cone out by the roots. (It is wise never to change any connections unless all equipment is turned off. This is true for any amplifier but with

100 watts it is imperative.)

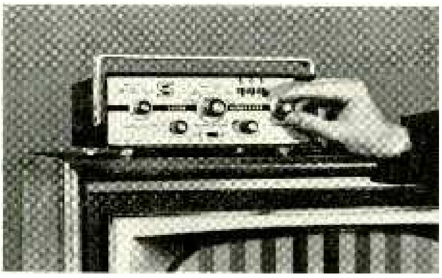
You'd expect that an amplifier with these specifications would make beautiful music. It does. This is as flawless a sound as it has been my pleasure to hear. That old saw about an amplifier one can see through has never been more true. I would have doubted that such power is necessary. Having heard it, I doubt no more. Incidentally, I tried this amplifier with ultra-low-efficiency full-range electrostatics. This is the *only* amplifier that has done these units justice.—*Leonard Silke.*

Price: $375

Seco Model 900 Solid-State Color Generator

Circle 27 on reader's service card

THE LATEST COLOR-BAR GENERATOR from Seco Electronics is the model 900. Using 17 transistors, 5 of which are unijunctions, and a Zener-regulated power supply, this instrument provides all the standard convergence patterns, plus the 10-bar keyed-rainbow color pattern and a "gray-raster" pattern for purity and gray-scale tracking adjustments.



The crosshatch pattern has 10 horizontal lines and 9 vertical lines. These are adjustable with the dot-size control. Vertical and horizontal bar patterns have the same number of lines each way as the crosshatch.

The 900 makes keyed-rainbow color bars, in what is the industry standard bar pattern now. A color-amplitude control from 0% to 200% is convenient for checking color-sync lock action of the TV set.

Rf output is continuously variable on channel 2, 3 or 4. The channel can be selected with a front-panel knob.

Countdown circuits and the color

oscillator are crystal-controlled. While the color crystal is the standard 3.563795 MHz, the countdown crystal is 190.080 kHz, for a good reason: This frequency can be evenly divided to give the 60-cycle vertical frequency. The horizontal sweep frequency is 15,840 cycles that way instead of 15,750, but that is still well within the range of the horizontal sync in TV sets.

If the horizontal and vertical frequencies are directly related, then the raster sweep will *not* be interlaced. This is intentional; transistor shaper stages are used to start and stop the horizontal-line pulses by triggering them with a 660-Hz pulse. Because of the deliberate "overlay" (lack of interlace), each horizontal line is scanned twice in each frame. This gives higher brightness and eliminates flicker or jitter from the patterns.

The countdown frequencies used in the 900 are divided down in highly stable unijunction circuits; these transistors are almost immune to temperature drift.

A convenient feature is the small (10-pF) trimmer capacitor across the 3.56-MHz crystal. Called the COLOR QUALITY control, it varies the crystal frequency very slightly, enough to let you eliminate crawl or "barber-pole" effect.

The CLEAR RASTER position on the PATTERN SELECTOR switch is very handy for checking purity and gray-scale tracking. This signal has no chroma modulation, but has both horizontal and vertical sync to hold it steady and make the set's agc work normally.

I was delighted with the nice long leads on this instrument, on both the rf output cable and gun-killer cable. They allow you to set the cabinet on the floor if you want to, or on top of the TV cabinet. The gun-killer switches are on the front panel. The cable has three colored clips and a ground clip.

Only 8½ by 10½ by 3½ inches, the cabinet is compact enough to let you see over it or reach the convergence board. The line cord is plenty long. All cables can be stowed in a handy compartment in the back of the case. A flat metal handle can be turned under for use as a prop, setting the front panel at a convenient angle.

The stability of this instrument is excellent. Patterns are steady, and the fine lines make for easy convergence. The only criticism I have is the omission of numbers on the channel-selector knob. However, since you're supposed to be watching the TV screen while tuning, this isn't terribly important. I set the 900 up and used it on several TV sets, and it works very well.

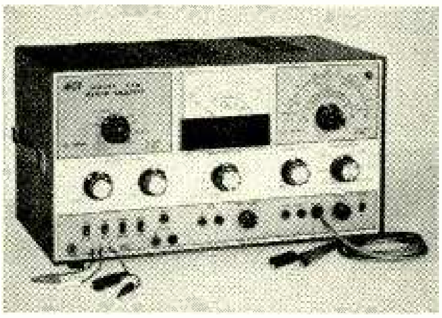
A well-written instruction book, complete with service data and schematic, comes with each Seco 900. Included in the book is some good material on how to use the generator in setting up color TV's, plus some details on the various circuits you'll find in different makes. The book is very useful, *if you read it!—Jack Darr.*

Price: $129.50

B & K 970 Radio Analyst

Circle 28 on reader's service card

A NEW RADIO ANALYST, MODEL 970, HAS been ushered in by B & K. The 970 combines several of the features of the model 960 Transistor Radio Analyst and adds some new wrinkles of its own.



The analyst supplies dc for testing any transistor radio, and up to 5 amperes at either 6 or 12 volts for testing car radios. For radios requiring a tapped power source, the 970 provides an adjustable tap—simply connect the tap to the BIAS terminal on the front panel and adjust the bias.

The 970 uses an in-circuit test for defective transistor stages similar to that used in the 960. Connect the defective radio to the built-in power supply and adjust the panel meter with COARSE and FINE controls until the meter pointer reads in the blue square designated as the in-circuit calibrate point. Then touch the base of a suspected transistor with the "Dyna Trace" probe. If, when the probe touches the base, the meter moves upscale out of the blue square, the stage is good. If there is no change in the meter reading, either the transistor or the dc circuits of the transistor are open.

What really happens in this test is that the probe inserts either a negative or positive voltage at the base (depending on whether the front-panel switch is set for p-n-p or n-p-n).

If the stage is working, current in it will increase. This is reflected in the total current drain of the radio and thus will be indicated on the calibrated meter scale. A 2.2K resistor is connected internally in series with the probe to limit the additional bias on the circuit.

Out-of-circuit transistor tests are available too. Small clips on short captive leads connect the transistor to be tested into the metering circuit. Or, for plug-in type transistors, a front-panel socket parallels the clip leads. Switches select either n-p-n or p-n-p, and small-signal or power transistors. Another switch selects leakage or dc-beta measurements.

Something new in the 970 is an AM and FM signal generator. This generator tunes 250 to 2,000 kHz, 10 to 11.2 MHz, and 88 to 108 MHz. The first band is AM only, the second is both AM and FM and the third is FM only. Both AM and FM on the 10-MHz band is a good feature, since it permits an AM rejection test for FM radios without changing connections. The FM (which, incidentally, is not common in service signal generators) is useful for an audible or scope check of the detector output.

The 400-Hz audio used for modulation is also available separately for tests in the audio output and percentage of modulation are adjustable with a front-panel control.

Finally, the B & K Radio Analyst also has vom functions. The voltage ranges are 2, 20, 200 and 500 volts with a sensitivity of 10,000 ohms per volt. Ohms scales are $\times 1$, $\times 10$ and $\times 100$. The ohmmeter section is self-powered, and this turns up one of the few, the very few, objections I had to the 970. The ohmmeter supply voltage is taken between a 15-volt source and ground. If you are using the signal generator and have the ground from that cable connected to the set you are testing, and attempt to read a resistance in the radio, the meter pointer dives violently backward. So, when checking resistance, be sure that no ground from the 970 is connected to the set you are testing—other than the internal supply used to power the radio. Its positive and negative terminals both float ungrounded.

You can clear just about everything but a test speaker, soldering iron and a few hand tools off your bench, set the 970 on it and have all you need for repairing radios.

My first job with the 970 was an FM converter used with a regular auto radio for receiving FM broadcasts. A quick check at the mixer test point by injecting 10.7 MHz from the 970 gave ample output at the detector. Switching the 970 to the 88–108-Mz band and adjusting the radio dial, I found that with full rf output from the 970 there was only a weak, noisy sound signal at the detector. That I could get audio at all, though, indicated that the FM oscillator was working, and suggested an rf amplifier or mixer fault.

I hooked up the Dyna Trace probe and checked at the base of the rf transistor. The meter reading went up, as it should. Then I checked at the base of the mixer and there was no change. This indicated trouble in the mixer. With the 970's ohmmeter, I found a dead short between base and emitter of the mixer transistor. Snipping the base lead of the transistor did not remove the short, so I knew the trouble was in the circuit itself. It turned out to be a 1-pF capacitor connected between base and emitter whose leads had accidentally touched together.

Just one case, but it does show how the 970 can be used to localize the trouble to a particular stage. Then, with the built-in vom, the trouble can be ferreted out and pinned down to the exact part.—*Wayne Lemons*

Price: $199.95 END

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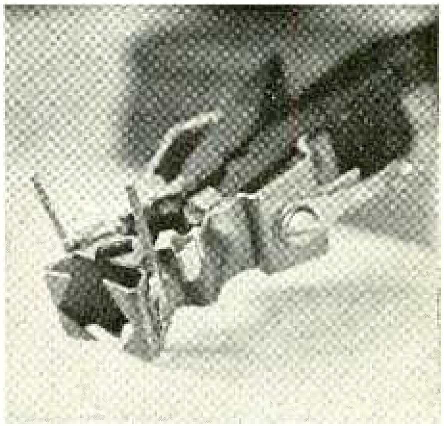
ANTENNA TEST CLIP

You can make bench antenna test clips more useful by soldering pins and push-on clips to the jaws. Most new portables use push-on lugs to connect the tuner to the antenna terminals on the rear cover. When the back is off, connect the test clip to the set by pushing the up-



right pins into the connectors on the tuner lead. The upright pins are solderless-wrap connectors from a discarded printed circuit. The connector clips are for older sets with round pins on the tuner input cable. They are from a 7-pin (old style) wafer socket. Take the plastic handles off while soldering or you will melt them.—*Steve P. Dow*

Getting to Know More About Circuit Operation

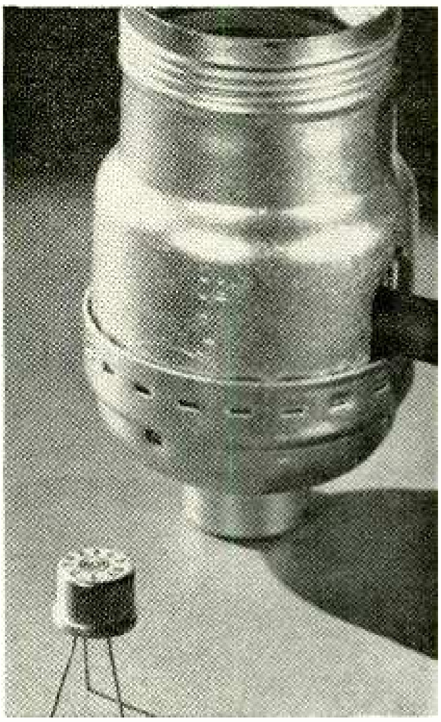
Find out what really happens when a carrier gets phase- (or frequency-) modulated by another wave. Vectors tell the story! They're one key to knowing more about how circuits work.

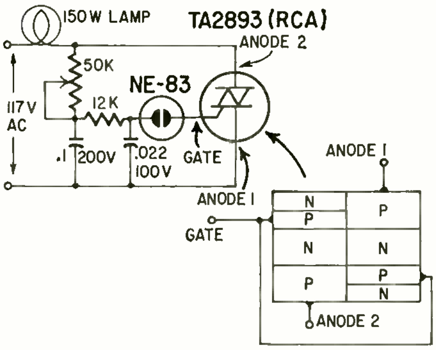
All in the July issue of RADIO-ELECTRONICS

NEW SEMICONDUCTORS, MICROCIRCUITS & TUBES

SPRING RAINS DOWN NEW DEVICES AT IEEE EXHIBIT

Dozens of semiconductor makers scrambled for the attention of some 64,000 visitors to the Institute of Electrical and Electronics Engineers International Convention in New York City in late March.





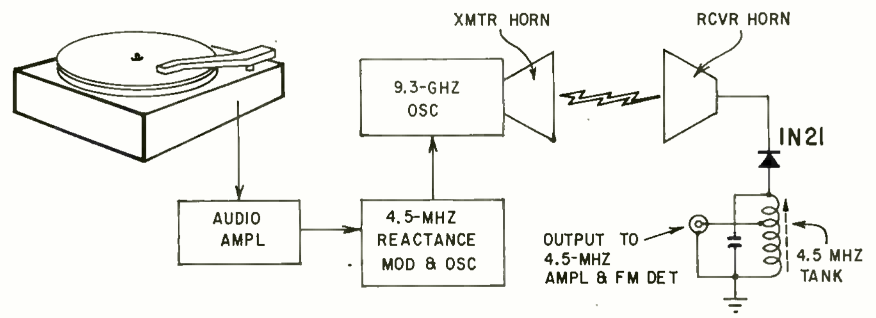
The new developments in semiconductor devices alone would fill several columns this size. And tubes are not forgotten; one of the most stimulating new items is a tiny microwave triode from G-E. But more about that later.

RCA stole the show, for many, with a continuously variable light-bulb dimmer built into an ordinary light socket. The secret of this hyperminiaturization is a tiny, efficient new sensitive-gate "Triac"—a three-lead, eight-element semiconductor switch that passes *both* halves of an ac waveform when it's properly triggered. The principle of operation is roughly like that of an SCR—the big difference being, of course, the bipolarity of the Triac, which amounts to having two SCR's in parallel back-to-back.

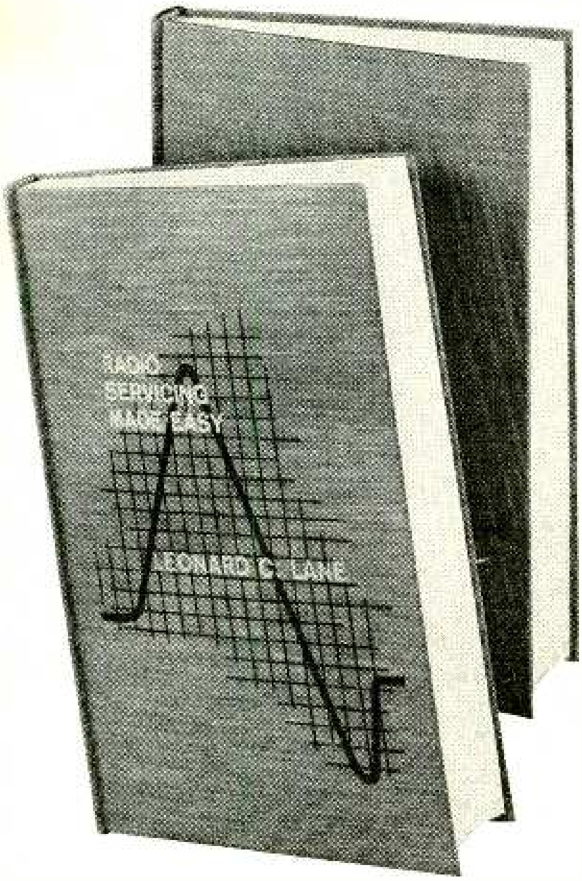
The circuit that was built into the socket has only six components, not counting the lamp itself, or any rf-interference-suppressing parts, which are optional. The schematic here shows the circuit, and the photo shows the Triac, RCA type TA2893, next to the socket that contains the dimmer.

For experimenters, RCA has brought out three experimenter kits, which let hobbyists build up to 14 different SCR circuits using thermistors and photocells as sensors. Speed controls for food mixers, power tools, model trains and cars are among possible projects; timers and delay switches, battery chargers, light dimmers, light- or heat-actuated heating controls are other possibilities. They'll be available through RCA distributors. The basic kit costs about $10. A circuit manual and add-on kits are available, too.

Big news for manufacturers—and ultimately for servicers—is RCA's introduction of linear integrated-circuit (IC) chips for TV and radio applications. Our cover story this month tells you all about one such chip, which fills the jobs of TV sound-i.f. amplification, FM detection and audio preamplification. The entire IC itself—including all resistors and semiconductor devices—is about the size of a typewritten letter "o", according to RCA, and it's built into a (compara-



Sound-modulating system used by G-E to demonstrate X-band triode (page 77).



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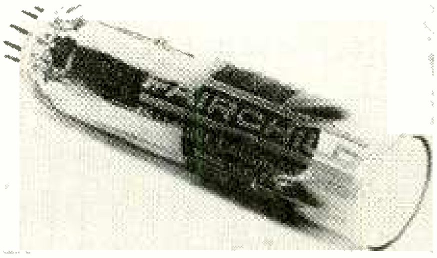
tively huge) TO-5 transistor package.

General Electric came up with an X-band microwave (10 gigahertz, or GHz) triode—yes, a tube, and of a comparatively "ordinary" kind (not a magnetron or klystron). Possible applications include hand-held intruder-finders, prowler-seekers, or any sort of situation where you want to set up an invisible screen of energy which, when disturbed, sounds an alarm.

To demonstrate the tube, G-E coupled its output to a small waveguide horn, set up 10 feet from another small horn. Inside the second horn was a microwave diode detector. The microwave energy between the two horns carried a 4.5-MHz subcarrier, which in turn was modulated by sound from a portable phono.

The winning feature of this tube (which G-E describes as "lima-bean-sized") is the simple circuitry it makes possible. Power supplies can be ordinary, nonregulated designs, compared with the expensive high-voltage regulated supplies required by other methods of microwave generation. This metal-and-ceramic tube takes about 2 to 3 watts dc input at 180 volts, and 6 volts for its heater. Output at 9.3 GHz was about 40 mW.



From Fairchild's DuMont Electron Tubes division comes a cathode-ray tube 1 inch in diameter, 3.2 inches long, with a spot size of .007 inch. The face is quite flat, and the usable face diameter is about 0.8 inch. It's designed to work with low beam-acceleration voltage, which improves deflection sensitivity. END

TRANSISTORS UNSCRAMBLED

Get strange, unexpected results from transistor circuits? Maybe you're thinking tubes!

By CARL H. BABCOKE

HAVE YOU EVER BEEN PUZZLED BY THE performance of transistors in some circuits? Did you ever add a one-transistor amplifier to a crystal radio and get no more volume than without the amplifier? Ever measure the total gain of two cascaded 40-dB transistor audio stages, find it to be 65 dB, and wonder where the 15 dB went? If so, you may be using vacuum-tube logic. Comparing tubes and transistors is like comparing apples and peaches; there are similarities, but don't expect the pies to taste alike.

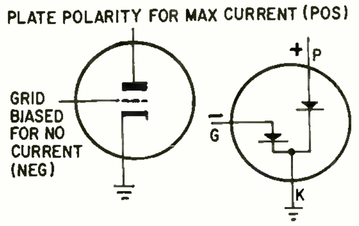


Fig. 1—In normal operation, a tube's plate current would be practically unlimited if the grid weren't biased negative to hold it down. As far as dc in the rest of the circuit is concerned, a tube looks like two diodes connected as shown.

What hard-working, self-respecting tube would be undecided whether to act as a variable resistor, a thermometer, an amplifier, a switch, a matching transformer, or a fuse? Transistors are often that fickle. Yet they have a reputation for being dependable. Let's examine some transistor foibles to find reasons for this apparent paradox.

The transistor base is customarily considered equivalent to a tube grid, the emitter to a cathode, and the collector to a plate. This assumption is harmless enough if you do not expect their characteristic actions to be equivalent, too. There are important differences.

Polarity of operating voltages is one of the most confusing differences between tubes and transistors. A tube grid is normally more negative than the cathode; considered as a diode, the grid-cathode combination is always reverse-biased for minimum current between the

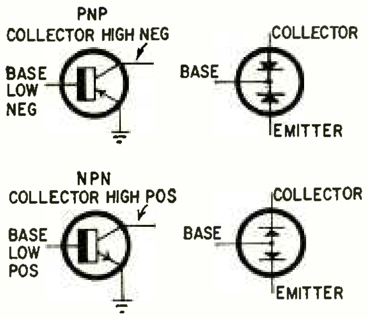


Fig. 2—The two "sexes" of transistors. Both behave like two diodes connected in series, back to back. Collector current doesn't flow at all (in theory) unless the base–emitter diode is forward-biased.

two elements. The plate voltage is of such polarity as to cause maximum cathode–plate current. Note the diode equivalent in Fig. 1. Polarity is just the opposite for a transistor: the base is forward-biased for maximum base–emitter current (Fig. 2), while the collector is always reverse-biased for minimum collector–emitter current. The concept of a transistor as two diodes in series is helpful in visualizing normal current flow. As you'll also see in Fig. 2, transistors are made in two polarities, p-n-p or n-p-n. If you think in terms of tube theory, you can't see how transistors could ever work, for the collector is at the wrong voltage for substantial current to flow.

How does it work?

Visualize a transistor as an electronic sandwich with the "bread" of p-type material and the "meat" of n-type (Fig. 3). The shapes of the "slices" are

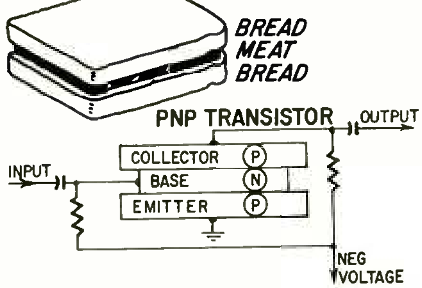


Fig. 3—A junction transistor is built like a semiconductor sandwich—two p-type (or n-type) layers of bread around an n-type (or p-type) slice of meat.

seldom similar, and they may be thick or thin, or may blend gradually from one to the other. Current between collector and emitter must go through the solid material of the base; there is no other path. With the collector reverse-biased, it seems very unlikely there will be much current. There must be more to understand.

Take a look at Fig. 4—three backyards in a transistor "community." Imagine the positive carriers as boys and the negative ones as girls. In the eternal fashion of man with maid, the boys start from their emitter backyard to visit the girls in their base backyard. The road is easy and all downhill (because of forward-biasing BATT1), so they develop quite a momentum. When they arrive at the base, and before they stop to embrace the girls, they look beyond—into the collector backyard next door. Through the fence (caused by reverse-bias BATT2) they see the prettier (higher-voltage) girls and most of these high-speed Casanovas keep right on going over the fence to join the collector girls. The higher their momentum (higher-current trip from emitter to base), the more of them reach the collector.

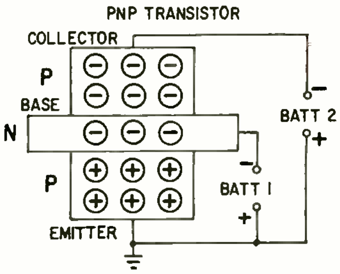


Fig. 4—Community life in Solid State: how current flows in a transistor.

In a transistor, collector current flows as the result of base current. The *direction* of electron flow is as in any circuit, from negative power-supply terminal to positive, but the *cause* of electron flow is as described in this analogy—it is caused by the *carriers*. This analogy thus applies to n-p-n types as well as p-n-p. Only a small part of total current through the emitter–base junction flows through the *external* base circuit. Since a small input (base) current can control a much larger output (collector) current, amplification is possible.

In a tube, the grid bias opposes the electron flow to the plate; if this voltage

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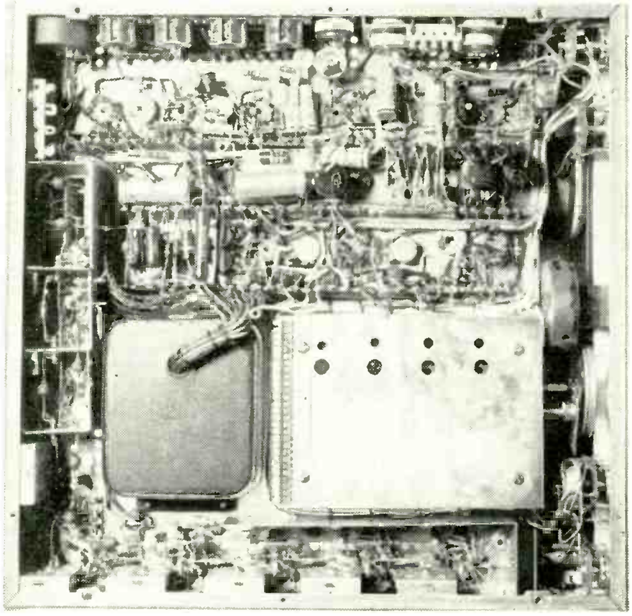

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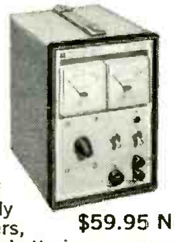

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were removed, plate current would be much greater. Just the opposite is true with a transistor: collector current would be zero (except for tiny leakage) without forward bias on the base to pull carriers on through.

Learn transistor characteristics

One way to learn about transistor action is by plotting forward-bias voltage, collector current, ac gain, and input-impedance curves on graphs. Transistors have low input impedance, so use a low-impedance audio oscillator to supply signal. You can breadboard the circuit of Fig. 5 for experiments.

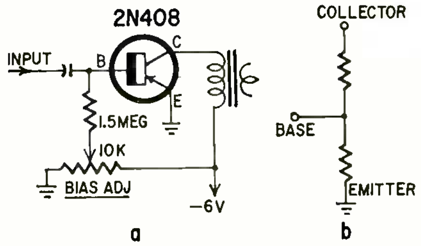


Fig. 5-a—This circuit you can try turns out to work even with no obvious bias source. Fig. 5-b and the text tell why.

As a first trial, vary the bias pot in Fig. 5 and watch the readings change. But wait, something is wrong; nothing much has changed! The forward bias changes very little as you rotate the pot. In fact, with the arm at ground, the transistor still amplifies and has about .09 volt dc on the base.

Where is the base voltage coming from? Rectified ac from the generator? No, for the dc remains when the generator is turned off. For an answer, imagine the transistor as two resistors (Fig. 5-b). High collector voltage forces a little leakage current to the base. The path through the emitter to ground has high-enough resistance to develop some forward bias. Moral: if you want to make sure the collector is completely cut off, place a low-resistance path from base to emitter.

In the circuit of Fig. 6-a, all readings change normally as you vary the bias pot. You can chart the characteristics, as in Fig. 6-b. If a little forward bias gives some gain and collector current, a lot more should be even better—true? Sorry, but *not* with many transistors. Above a certain point, gain starts down again, even while collector current continues to increase. This maximum-gain point is fairly sharp and unmistakable.

An interesting sidelight here is that both sides of the gain curve can be used for agc. Transistor radios usually use the left side of the curve, for it gives less current drain and easier control. This is called "cutoff" bias. The right side of the curve is called "saturation" bias and is often used in transistorized TV receivers because the lower input impedance broad-bands the tuned circuits on strong signals and gives less cross-modulation distortion.

Gain and impedance

Measure actual signal gain in this circuit with the bias pot set at the maximum-gain point. If you are accustomed to tube gains of 10 to 100, you may be surprised—the gain is 1,388 or 63 dB. Why? The transformer secondary was not connected to anything, and measured impedance is 40,000 ohms. Parallel it with a 40K resistor, and the gain drops to half. Make the load impedance 10K, and the gain goes down 12 dB. Obviously, the higher the collector load impedance, the higher the gain.

Consider a transistor with high internal leakage: most of the supply voltage is dropped across the emitter and collector resistances and very little is left for the transistor. The result is low gain and high distortion.

According to the analysis of Fig. 6, high collector impedance gives high gain. See if this also works with resistance-coupled stages, using the circuit of Fig. 7. Start with the collector resistor at 15K and the bias pot set for maximum gain, then increase the value of collector resistor and notice the effect on gain. Surprise! Gain went down, not up. The chart in Fig. 7 tells the story: as the collector voltage dropped below 0.2 volt, gain dropped radically.

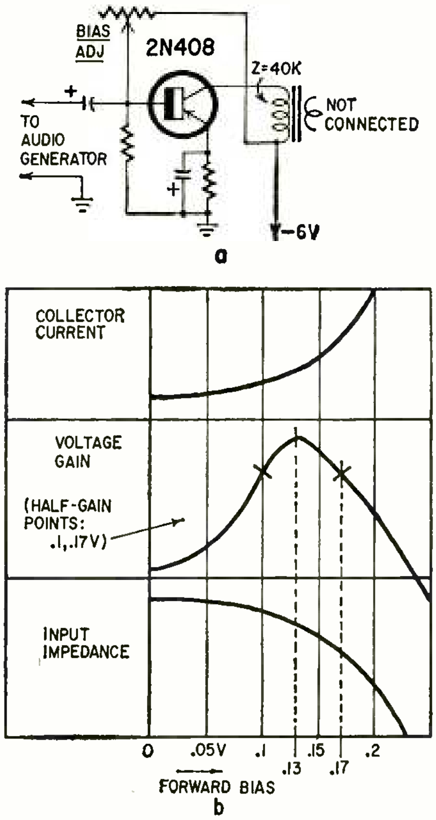
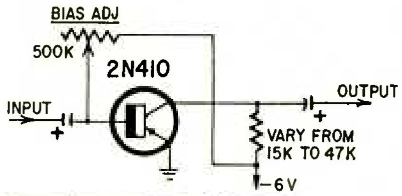


Fig. 6-a—This is a very-high-gain amplifier. Things work pretty much according to theory here. In (b), curves show what happens to collector current, gain and input impedance as bias is pushed up.

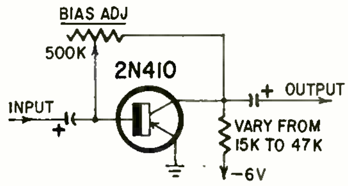
Make one little change (Fig. 8) and try it again. This time the gain actually rises a little. Dc feedback from the collector has stabilized gain by automatically decreasing the forward bias when the collector voltage goes down.



COLL RES	BASE VOLTS	COLL VOLTS	GAIN
15K	-.15	-1.3	45dB
22K	-.15	-.2	38dB
33K	-.14	-.08	16dB
47K	-.13	-.06	11dB

Fig. 7—High collector resistance doesn't always mean high gain. When drop across collector load is too great, transistor "starves".

This simple change has made the circuit almost immune to parts variations, voltage changes and temperature variations. But the conclusion to draw from these experiments is this: Supply voltage, matched to a high collector resistance and adequate forward bias, must be sufficient to keep collector–emitter voltage above 1 volt.



COLL RES	BASE VOLTS	COLL VOLTS	GAIN
15K	-.140	-3	41.5dB
22K	-.135	-2.6	42dB
33K	-.126	-2	43dB
47K	-.120	-1.5	43dB

Fig. 8—Slight circuit change makes a world of difference. Note that gain changes insignificantly with a variation of more than 3 to 1 in collector load resistance. The secret? Dc feedback from collector to base via the bias resistor.

Sometimes a collector-impedance problem sneaks up on our blind side. Cascade two identical amplifiers as shown in Fig. 9. Gain of the second one tests at 40 dB. What would you expect the gain of the first to be? If you say 40 dB, you are still thinking about tubes. The first measures only 24 dB, for the low input impedance (slightly over 2K) of the second stage loads down the collector impedance of the first, and thus reduces its gain.

Low input impedance can also cause frequency-response problems if

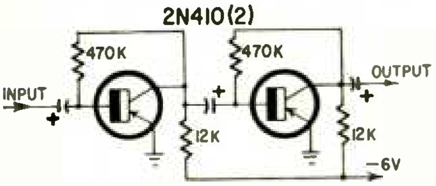


Fig. 9—If the gain of each stage measured by itself is 40 dB, will the two, cascaded, amplify 80 dB? No! The gain of the first stage in this circuit is only 24 dB.

high-impedance tape heads, microphones, and phono cartridges are connected directly to a transistor. This raises the question of how best to raise transistor input impedance.

Input impedance rises with less forward bias, but so does distortion. Degeneration or negative feedback is probably the best method of raising input impedance, but it does so at the expense of gain. Fig. 10 shows typical methods. Gain of the circuit in Fig. 10-a will be 18 dB greater when the emitter resistor is bypassed, but input impedance will be only 2K instead of 16K.

Why doesn't an amplifier help the volume of a simple crystal set? The low impedance of the transistor base loads down the tuned circuit through the diode. The Q goes down to almost nothing, and the transistor gets little audio to amplify. Possible improvements: tapped coil for impedance matching, or two stages—an emitter follower that doesn't load the detector, plus a high-gain amplifier.

Dangers to transistors

Transistors are heat-sensitive. But, how much does a moderate amount of heat change performance? The transistor in Fig. 11 was held between thumb and forefinger. The forward bias dropped to half, collector current went up, but gain stayed about the same. When a small soldering iron was held near the transistor, the change was greater, as you can see from the chart in Fig. 11. An overloaded transistor runs away to destruction; the overload causes heat which increases collector current which causes more heat which causes more collector current . . . and so on. A resistor in the emitter lead can prevent this thermal runaway; higher collector current causes a bias decrease between emitter and base because of the polarity of voltage that develops across the emitter resistor.

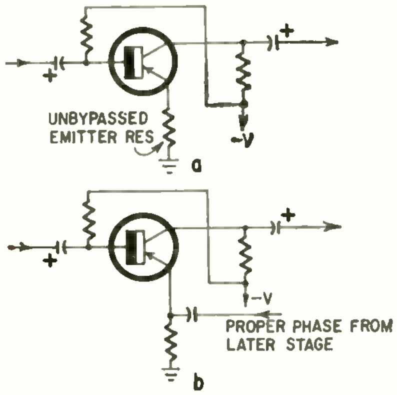
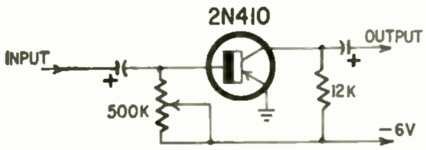


Fig. 10—Two ways of boosting input impedance, both with negative current feedback in series with the emitter. An unbypassed emitter resistor (a) is the simplest way, but limited by the gain of the transistor. Feeding back a signal from a later stage, as in (b), is very common.



	FORWARD BIAS (BASE)	COLL VOLTS	GAIN
NORMAL-TEMP	−.135	−2.6	42dB
FINGER-WARM	−.07	−.5	42dB
WARM	−.04	−.04	ALMOST NO OUTPUT

Fig. 11—What happens when a transistor is heated? The chart tells the story, and most transistor circuits have to be compensated against the effects of heat.

Transistors also fail because of excessive inductive pulses from transformers or chokes which momentarily exceed the voltage rating. Solid-state diodes and transistors do not have a tube's ability to withstand temporary surges. Varistors or Zener diodes can be used in parallel with transistors to clip such peaks before they rise to dangerous levels.

Summary of rules

Here are some rules for obtaining best gain with transistors:

1. Forward bias must be optimum, neither too high nor too low.
2. Collector impedance must be kept as high as is practical (considering Rule 3), which is:
3. Collector voltage must be sufficient, generally above 1 volt.
4. There must be as little negative feedback or degeneration as possible.
5. Input and output impedances must be matched.
6. Internal or external heat must be kept low.

For circuits in which you want characteristics other than high gain, making these compromises does not invalidate these rules.

Compare tubes with transistors all you wish, but remember transistors have rules of their own that are different from any other electronic component. You break their rules at your own risk.

Transistors can either be predictable and dependable or capricious and self-destructive. It all depends on the circuit in which they are used more than on the transistor itself. END

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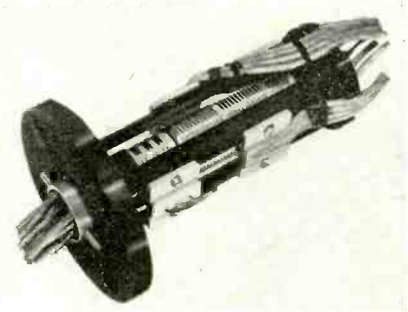
Hz = Hertz = cycles per second; kHz = kilocycles; MHz = megacycles

SLIP-RING ASSEMBLY, *CAY-150,* provides up to 50 shielded circuits at 2 amps maximum. For gyro test stands, unit operates at noise figure of less than .006Ω at 300 rpm and less than .002Ω at 10 rpm



at currents of 50 mA. Power circuits can be provided to carry up to 10 amps. Special switching circuit will actuate electronic counters.—**Airflyte Electronics**

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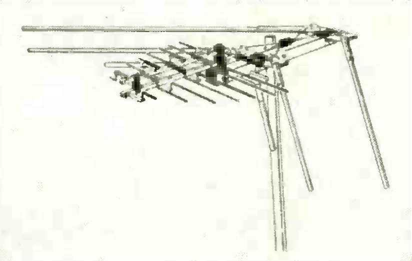

UHF/VHF/FM ANTENNA KIT, *model AA-157.* Single lead-in wire. Gold Protecto finish. Snapout construction, kit includes one 5-ft. mast, six 3½-in. insulators, two 7½-in. standoffs, three 1¼-in. snap-on insulators, antenna splitter.—**Olson Electronics, Inc.**

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3-SPEED STEREO TAPE RECORDER, the *Continental 420,* has multiplay and sound-on-sound facilities. Four-track recorder has ganged stereo controls, cardioid moving-coil stereo mike, modulation indicator, 4-digit tape counter with automatic reset. Up to 16 mono playing hours; to 8 hrs stereo from single 7-inch reel. At 7½ ips response is 40–18,000 Hz; 3¾ ips, 60–15,000 Hz; 1⅞ ips, 60–10,000 Hz—all ±3 dB. 17 x 10 x 9 in., 22 lb. Unit comes with 3 patch cords, demonstration tape, empty reel.—**Norelco**

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30-WATT STEREO AMPLIFIER KIT, *model AA-14,* has identical but separate preamplifiers and power amplifiers using 17 transistors and 6 diodes, producing 30 watts IHF music power. 20 watts continuous power at ±1 dB from 15–60,000 Hz. 6-position source switch. Solid-state power supply with electronic filter for regulation within 10%; outputs accommodate 4, 8, 16-ohm speakers; channel separation of 45 dB or better. Can be

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wall-mounted vertically or horizontally. Also available in walnut veneer or metal cabinet. 10¾ x 3 x 12 in.—**Heath Co.**

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FM STEREO GENERATOR, the *MX11 Channelizer,* eliminates need for complicated dB formulas, setups or multiplex theory. Slide switches align, troubleshoot, service FM multiplex receivers in minutes. Stereo signal available on rf carrier adjustable from 95–105 MHz or as

composite stereo without rf from stereo jacks on front panel for injection into detector. Two built-in speaker meters measure signal output of each channel of receiver and actual separation as LOW, GOOD, or HI from meter or in actual dB. Built-in 8-ohm speaker loads so speakers may be disconnected without damaging receiver, avoiding listening to 1,000-Hz note.—**Sencore, Inc.**

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AUTO REVERBERATION SYSTEM, the *Verba-Mite VX-700.* All solid-state; 12-volt negative ground. Adhesive

foam tape mounted no-drilling needed. 10,000-hour pilot light. 6½ x 3¼ x 1⅝ in., 1½ lb.—**Kinematix, Inc.**

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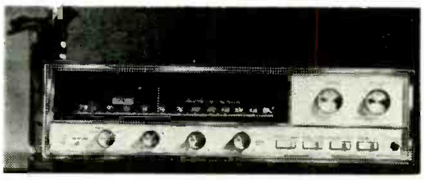
ALL-SILICON FM STEREO RECEIVER, *model S-8800.* 130 watts of music power at 4 ohms and 100 watts at 8 ohms. Same FM tuner circuitry as in *S-3300.* FM sensitivity 1.6 μV, IHF. Dual agc system. Noise-gated FM stereo/mono



switching. FM stereo indicator light. Distortion 0.1% at 10 watts or less. Power: 12–35,000 Hz at 1% distortion. FM signal-to-noise: 70 dB. FM detector: 800 kHz peak-to-peak. FM stability ±10 kHz. 40 silicon transistors, 14 silicon diodes and rectifiers.—**Sherwood Electronic Labs**

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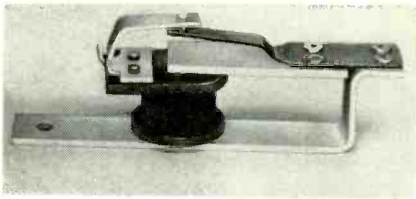

AC/DC BUZZER, *type 302,* for experimenters, hobbyists, students, manufacturers for use in warning and signaling applications, as well as games and toys. Voltage: 1.5–3 volts ac or dc. Power: from flashlight batteries or from center tap of 6.3-volt filament transformer winding. Booklet with buzzer describes 20 projects. —**Caringella Electronics Inc.**

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AC/DC STEREO PORTABLE TAPE RECORDER, the *Aiwa TP-1002.* 13 transistors, capstan drive, separate volume controls, 2 speakers (one detachable), pushbutton controls with fast tape forwarding, ac bias record/erase system, pilot-light ac indicator, 5-in. reels, 3¾ and 1⅞ ips. Two dynamic microphones (one

with on–off switch), 2 earphones, ac cord, batteries, take-up and supply reel with tape and storage bag.—**Selectron International Co., Inc.**

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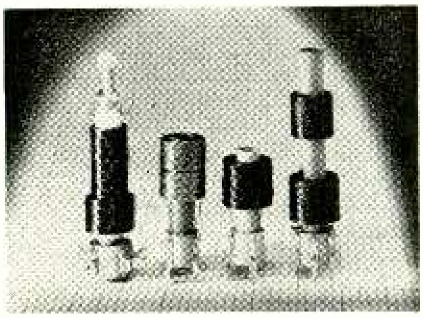

COLOR-TV LINEARITY COILS, replacements for more than 25 makes. *Models 6347, 6348*—red/green convergence. *Model 6349*—horizontal oscillator and waveform. *Model 6350*—focus coils.—**J. W. Miller Co.**

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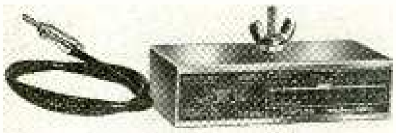
CONVERTER, the *Monitor*, built-in power supply, solid-state circuitry. Current drain 1/5000 amp, or 200 times less than a flashlight bulb. Converts ordinary



domestic or foreign car radio into powerful marine-band receiver. Comes with battery, instructions, calibration chart.—**Pearce-Simpson, Inc.**

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PORTABLE TAPE RECORDER, *model 300*, features *Reverse-A-Track*, which records forward and reverse by turn of single lever. 1⅞ and 3¾ ips. Records 3 hours on ½-mil tape at 1⅞ ips; 6 hours on ¼-mil tape. Standard 4-in. reels or smaller. Remote-control dynamic cardioid microphone. 60–10,000 Hz at 3¾ ips. 6 type-C batteries and/or external ac. 3 x 9 x 10 in., 6½ lb.—**Concord Electronics Corp.**

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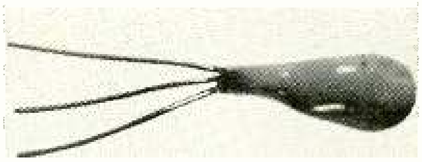
LINEAR OUTPUT THERMISTOR DEVICE, parts *44201* (0–100°C), *44202*



(−5–+45°C), part *44203* (−30–+50°C), *44204* (30–100°F). Linear resistance changes of as much as 127 Ω per degree C, linear deviations of 2 parts per 1,000 from 0 to 100°C. Composite thermistors are interchangeable.—**Yellow Springs Instrument Co., Inc.**

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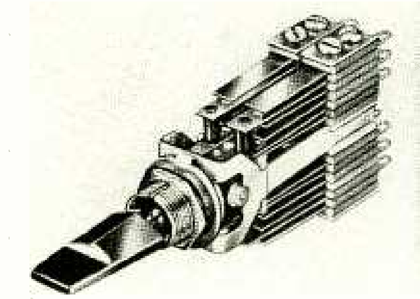
MULTIPLE-CIRCUIT LEVER SWITCH, *series 41000* **Telever LT Switches,** feature spring-loaded detent, occupy only 2⅝-in. behind panels, can be mounted on 1 1/16-in. centers. 2- or 3-position styles, choice of locking or nonlocking positions, up to 8pdt switching. Standard palladium crossbar welded contacts for up to 3-amp ac noninductive current



loads (200-watt maximum power rating). For heavier current loads, several sizes of fine silver contacts are available. Decorator-styled black paddle knobs.—**Switchcraft Inc.**

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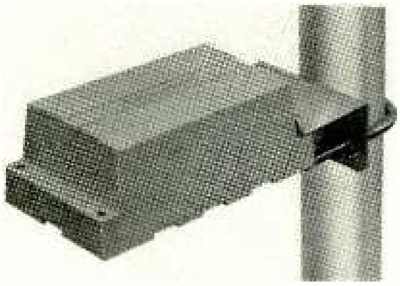
TWO NEW ANTENNA COUPLERS. *Model CA-314* couples 3 separate antennas (vhf, uhf, FM) on same mast with single downlead. A preamp can be used on vhf antennas because circuitry is ac-passive. Can also be used inside as a



splitter. *Model CA-312* couples a low-band (channels 2–6 and FM), a high-band (channels 7–13), and a uhf antenna to permit a single downlead. Both models packaged with 5-way mounting bracket. —**Winegard Co.**

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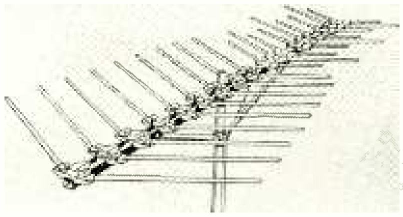

COLOR ANTENNA, the *LVL Vector-Log*. Five models for vhf-TV and FM. Stock No. 18-0159WX: 75 mi., 5 elements, 5 lb; 18-0160WX: 100 mi., 7 elements, 7 lb; 18-0157WX: 125 mi., 10 elements, 10 lb; 18-0158WX: 150 mi., 15 elements, 13 lb; and 18-0161WX: 175 mi., 18 elements, 16 lb.—**Lafayette Radio Electronics Corp.**

Circle 61 on reader's service card

SSB RADIOTELEPHONE, *CH-25-M*, claimed to be first solid-state, single-sideband transceiver to receive FCC type-acceptance. Range: 1.6–15 MHz. 6 channels available. Power output: 100 watts PEP. Transmitter monitored by automatic load control, receiver by wide-range automatic gain control. Power supplies can be had for 115 and 230 volts ac,

50–60 Hz, or 12, 24, 32 Vdc. Typical power drain on 12 volts dc is .15 amp receive and 15 amp transmit. Matching antenna coupler can be mounted on back or used as remote.—**Kaar Electronics Corp.**

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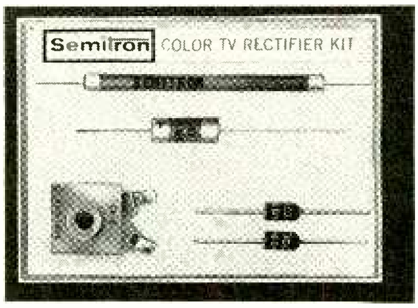

COLOR-TV RECTIFIER KIT, the *Universal.* Contains focus, booster and convergence rectifiers and two power-supply rectifiers. Suitable for replacements in sets such as Admiral, Emerson, G-E, Magnavox, Motorola, Philco, Zenith, etc. Kit includes copy of *Semitron Semiconductor Replacement and Interchangeability Guide.*—**Semitronics Corp.**

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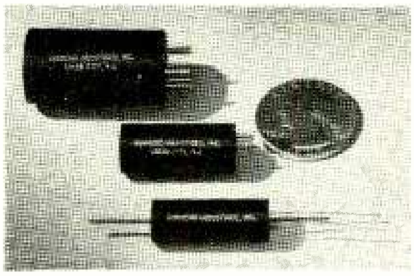
ENCAPSULATED REED RELAYS, available from 0.25 to 0.5 amp at maximum of 300 volts in form A or C. *Model DRM-138:* 0.437 x 1 in. high, 4 pins for



PC boards. *Model DRM-139:* 0.375 x 1⅛ in. with 4 axial leads. *Model DRM-140:* 0.750 x 1¼ in. high, standard 7-pin layout for 7-pin miniature tube socket or PC board.—**Diamond Industries, Inc.**

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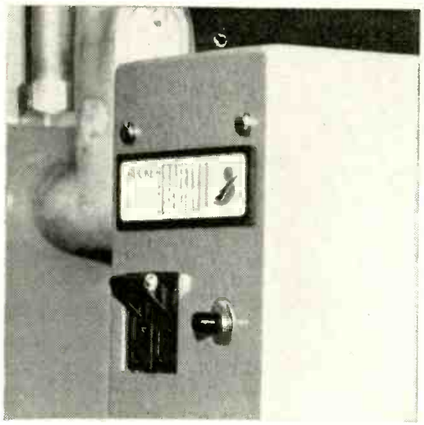
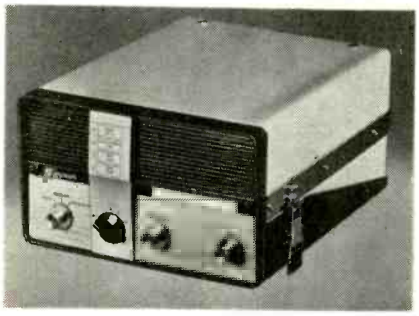
DIFFERENTIAL CIRCUIT BREAKER, *model E102*, the *Rucker Electrical Safety Sentry* for ground-fault protection. Protects against faults in home appliances, swimming pools, and home and industrial tools. Current balance protection: 110–130 volts; 50–60 Hz; 0–50 amps; sensitivity to earth leakage currents: 50 mA. Earth resistance: 2,400 ohms. Trips in 50 msec at 50 mA. Maximum overcurrent protection: 50 amperes. Tem-



perature range: −40 to +150°F. Humidity: to 100%. 7¼ x 4¼ x 3 ¾ in.—**Electronics Div., Rucker Co.**

Circle 65 on reader's service card

35-WATT MARINE RADIOTELEPHONE, the *Simpson 35,* operates on 4 marine channels, connecting to 12-volt dc systems. Hybrid receiver for low-drain transmitter standby; power plug; quick-



release any-position mounting cradle; preset automatic noise limiter. Included: 8 crystals, microphone, center-loaded antenna with folding deck mount.—**Simpson Electronics, Inc.**

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TRANSCEIVER, *model BB-10,* type-accepted for use on low-power industrial radio service channels. Power requirements: 12.5 Vdc: receiver, 3.9 amps; transmitter, 6.2 amps. 115 Vac: receiver, 48 watts; transmitter, 90 watts. Range: 26–28 MHz, crystal controlled by oven. Superheterodyne receiver with cascode rf amplifier, 2 i.f. stages, crystal-controlled. 15 watts rf power to antenna. 4½ x 6½ x 9 in., 11 lb.—**General Radiotelephone Co.**

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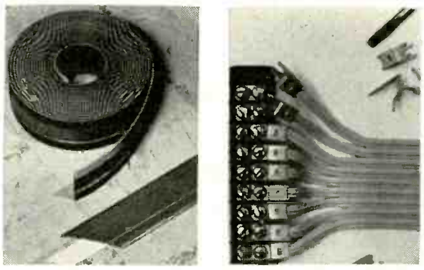
FLAT CABLE SYSTEM, *Scotchflex No. 550,* with foam adhesive backing. 22-



gage stranded wire cable, 2 to 24 conductors.—**3M Co.**

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GUITAR AMPLIFIERS, *Baronet 808* and *Baronet 810,* same specs except the 810 has tremolo. 5-watt solid-state amplifier, 9-in. oval speaker in luggage case 10 x 14 x 5 in., 8 lb.—**Perma-Power Co.**

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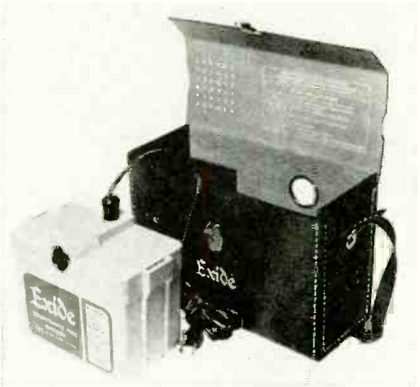
12-VOLT POWER SUPPLY, *Personal Power Pack,* delivers 12 Vdc for



radio, TV, portable tools. Consists of Exide type EMF-2 battery and EMFC-2 charger in vinyl case. Provides up to 1,000 hours of TV viewing. 9¾ x 6½ x 3⅜ in., 10 lb.—**Exide Industrial Marketing Div.**

Circle 70 on reader's service card

COMPACT VACUUM CONTROLLERS, optical meter-relay type, available in choice of 3 pressure ranges; 0–100 microns Hg, 0–1,000 microns Hg and 0–20 Torr. Solid-state. Internal relays rated at

5 amps, 115-volt noninductive load. Contactless control—set pointers adjustable across entire direct-reading pressure scale. Panel space 4 x 4¾ x 6½ in.—**Hastings-Raydist, Inc.**

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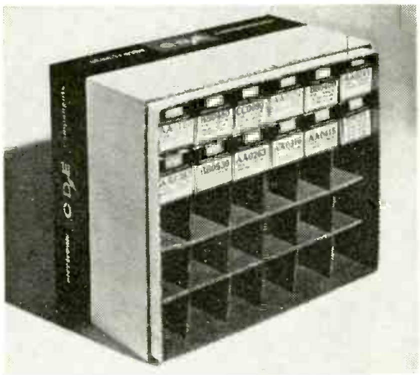

TWIST-PRONG CAPACITOR ASSORTMENT has 12 twist-prong capacitors with wide application range; will replace over 100 most popular types. Packaged in stock module.—**Cornell-Dubilier Electronics Div.** END

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NEW LITERATURE

All booklets, catalogs, charts, data sheets and other literature listed here are free for the asking with a Reader's Service number. Turn to the Reader's Service Card facing page 82 and circle the number of items you want. Then detach and mail the card. No postage required!

TAPE HEADS CATALOG, 10 pages, grouped by: erase heads, record/playback heads, combination heads. Tubular reference form.—**Michigan Magnetics, Inc.**

Circle 73 on reader's service card

CATALOG, AM-661, 4 pages, describes line of amateur fixed-station and mobile antennas, mounts and accessories.—**Mark Products**

Circle 74 on reader's service card

BOOKLET, "How to Adjust and Maintain Relays," 20 pages, pocket-size, contains information on relay terminology, what tool to use, maintenance, adjustment of armature assembly, tensioning, gaging, current values and timing for all types of relays.—**P. K. Neuses, Inc.**

Circle 75 on reader's service card

INSTRUMENT RECTIFIERS, 4-page sheet gives complete color code, specifications of standard types, dimensions, rectifying efficiency, temperature effects.—**Conant Labs**

Circle 76 on reader's service card

CLIPS CATALOG No. 300, plus price sheet. 10 pages, universal-punched, of complete line of alligator, test and battery clips.—**Mueller Electric Co.**

Circle 77 on reader's service card

BROCHURE, "Leader in Solid State Technology." 8 pages with photos, describing what to look for in an amplifier, various models and specs. —**Acoustech, Inc.**

Circle 78 on reader's service card

CATALOG of *DieKut StikOns*, new line of drafting symbols for layout and master drawings. They are printed on adhesive-backed matte acetate film; accurate to ±.001 in. 12 pages—**Bishop Industries Corp.**

Circle 79 on reader's service card

SHORT-FORM CATALOG, 1 page, has specs on Gaussian noise generators, solid-state and tube type.—**Elgenco, Inc.**

Circle 80 on reader's service card

CRYSTAL OSCILLATORS, 4-page manual for specifying and ordering oven and non-oven oscillators from 1 Hz to 100 MHz.—**Hill Electronics, Inc.**

Circle 81 on reader's service card

Write direct to the manufacturers for information on the items listed below:

"TAPE TABULATOR FOR THE TIMING OF CLASSICAL REPERTOIRES," 40-page pocket booklet. Lists individual running time of best-known classical works so you can calculate exact amount of raw tape needed to record depending on tape speed of your recorder.—Send 25¢ to **Martel**, 2356 S. Cotner Ave., W. Los Angeles, Calif., Att.: Tape-Timer END

Circle 115 on reader's service card

CIRCUIT QUIZ

These are the answers. Quiz is on page 45.

A. A voltage regulator such as this would not regulate very well without some sort of reference voltage. In this case, a logical choice for a reference would be a Zener diode placed between the emitter of Q2 and the positive line return. Resistor R3 would no longer be needed.

B. No current can flow through the splitload phase inverter if there is no ground return for the base and emitter resistors, R2 and R4.

C. This transformer-coupled audio amplifier will operate in class B unless capacitor C1 is removed and connected in *parallel* with R2. R1 would then be connected to the junction of R2, C1 and the input transformer.

D. One little item that some of us fail to notice occasionally is the polarity of the supply we connect to our transistor circuits. The RC-coupled amplifier here uses a p-n-p transistor, so the collector should be negative.

E. If you used this circuit as a balanced-bridge meter amplifier, you'd have some difficulty in setting the meter to zero with no dc input. By moving the emitter of Q2 to the right end of R9 and connecting R8 to the wiper of R9, you can balance the circuit.

F. This could be a conventional push-pull audio amplifier, except that Q2 is in the circuit upside down. Its collector should go to the output transformer and the emitter should connect to the emitter of Q1.

G. Here is a two-stage RC coupled amplifier. Depending upon circuit values, voltages at the terminals of Q1 and Q2 could very widely. However, if we assume that the two stages are biased identically and that the potential between collector and emitter is several volts, then the collector of Q1 will be several volts more negative than the base of Q2. Thus, capacitor C3 is in backwards, which can make it pass high leakage currents. This will change dc bias levels, causing highly distorted output or damage to Q2.

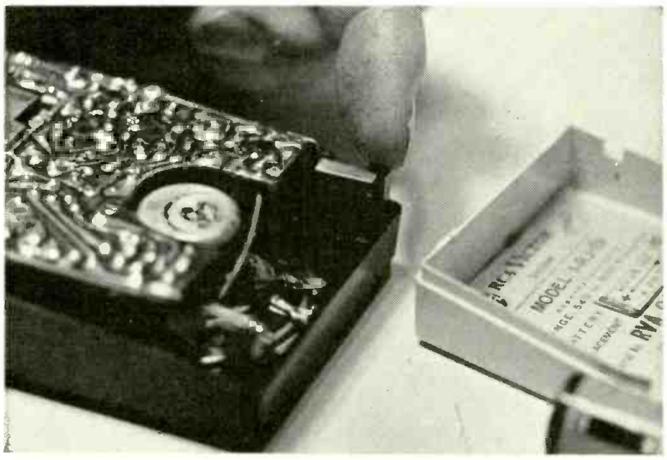
H. This typical i.f. amplifier stage for a radio will overload easily, since with an increase in the signal fed to detector diode D, the avc voltage would be *negative*. This would tend to forward-bias the stage and *increase* its gain. Oscillation might result. The way to check this would be to reverse the diode, putting a positive (reverse-biasing) avc voltage on the transistor.

I. This is the familiar dc-to-dc converter used so often today. This particular unit would hardly be acceptable, though for there will be no output. Diodes D1 and D3 short the transformer on one half cycle and D2 and D4 short it on the other. To obtain dc of the polarity indicated, you must reverse diodes D1 and D2. As it is now, Q1 and Q2 probably would not even oscillate, because the shorted output loads the circuit very heavily. END

TECHNOTES

REPAIRING A BAD BATTERY CONNECTION

I had let a dead battery remain is a small pocket transistor radio and one of the battery holder terminals was badly corroded. I cleaned it with a pocket knife and sanded it down. But the end would not hold the battery. So I cut a 1-inch piece



of brass from a leftover door weatherstripping. (Any flexible brass or copper would have done.) I drilled a small hole in one end for the wire, and soldered the brass piece over the old battery connection. Do not get solder where the batteries will touch.—*Homer L. Davidson*

ADJUSTING MVB-TYPE HORIZONTAL OSCILLATORS

A "G-E Service Talk" bulletin reports that technicians are trying to correct horizontal instability and off-frequency oscillator operation by adjusting the stabilizer coil only. This is wrong, because it does not really correct the trouble and leaves the oscillator unstable.

If there is trouble, the first step is to find what's causing it and repair or replace the proper parts. *Then* adjust the stabilizer coil and horizontal hold control according to the correct setup procedure.

This is the procedure for all General Electric AB, W, X and Y chassis:

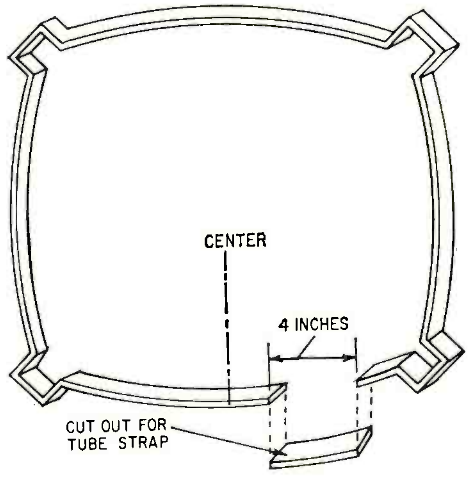
1. With back off and power on, tune the set to a weak signal and adjust controls for normal operation.
2. Ground test-point (TP) VI (first triode grid).
3. Connect a 1,000-ohm resistor from TP VIII to TP IX (in parallel with stabilizer coil).
4. Adjust horizontal hold control until picture just floats back and forth across the screen. Leave the hold control in this position.
5. Remove the resistor from TP VIII and IX. Adjust the stabilizer coil, turning the core toward the circuit board, until the picture again just floats across the screen. Leave the stabilizer coil in this position.
6. Remove the jumper from TP VI and ground. The picture should lock in. If it doesn't, repeat the procedure.

Never adjust the stabilizer coil alone to set the horizontal frequency.

REPLACING OBSOLETE 16-INCH CRT's

Picture tubes 16ATP4, 16AZP4 and 16BUP4 are no longer being made and will not be available when present stocks are exhausted. They can all be replaced with type 16BYP4, which has tension-band implosion protection instead of the bonded-plastic implosion plates. This calls for a minor alteration in the plastic cabinet.

Remove about 4 inches of the plastic rib that surrounds the picture tube. This lets the clamp on the tension band fit



properly into the cabinet. The drawing shows what to cut out. Side cutters do nicely.—*G-E Service Talk, Vol. 7, No. 6*

BUILT-IN ANTENNA CONNECTIONS ON PHILCO "N-LINE" COURIER TV's

In cases of poor reception on uhf *and* vhf channels, check the built-in antenna lead connections. In some sets, the uhf and vhf antennas were interchanged, connecting the wrong antennas to the tuners. External antenna operation is not affected.—*Philco TV Service Bulletin TV7-64* END

TRY THIS ONE

THREADED SPACERS FROM NUTS & TUBING

If you need threaded spacers or standoffs, here is a simple way to make them. Take some brass tubing, available in hobby shops. Force the tubing over two nuts, one at each end, and solder. Use solder sparingly. To use nuts with different-sized threads, get standard nuts for the smaller size and "small" nuts for the bigger size. These will usually be near enough to the same size to fit the same tubing.

I prepare the tubing by cutting it to length, deburring and filing the end square, and then forcing into the end of the tubing a hex Allen-head wrench which is just a little large. After that, pushing in the nut is a cinch.—*Tom Jaski*

TURN POWER TRANSISTOR INTO PHOTOCELL

A high-output photocell can easily be made from discarded power transistors. Just cut into the case with a hacksaw and peel it off with a pair of longnose pliers. Remove rough edges with a fine file. Be careful not to damage the photosensitive surface, a grayish material within a ringlike structure. Connect leads to the base and emitter. If the transistor is p-n-p, the base will be connected negative and the emitter positive.

One transistor (a 2N255) produced 0.1 volt at 120 microamps when held 3 inches away from a 60-watt lamp. In direct sunlight the output was much higher. This type of photocell has an advantage over many others in that it can be mounted with screws or bolts through the transistor case flanges.—*Albert Koehler*

NONMAGNETIC "STEEL WOOL"

The metallic particles around the electronics workshop from filing and drilling can cause plenty of trouble. Don't add more by using steel wool to shine instrument panels or clean things.

A material called Scotch Brite, from 3M Co., is nonmagnetic and nonconductive. It will not affect variable capacitors by getting between the plates or make a meter stick by getting between the pole pieces. A pad can be cut

Circle 122 on reader's service card

smaller with a pair of scissors or sheet-metal snips without ruining them.

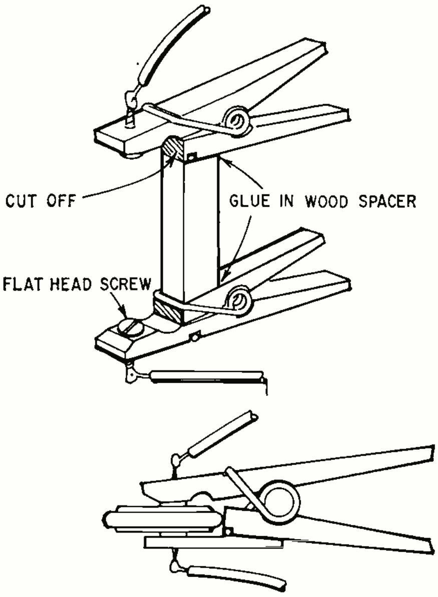
Keep some in the tube caddy too. It will help remove stubborn spots from the face of a dirty CRT.

Since it does not rust, shred or load up with the abraded material it can be used many times.

Strips can be cut to polish commutators, act as nonskid pads.—*Elmer C. Carlson*

CLOTHESPINS AS BATTERY HOLDER

To charge different sizes of rechargeable batteries this handy rig will take the place of several standard battery holders, which never seem to fit precisely anyway. Saw off two clothespins as shown, glue them to a spacer block ⅝ inch shorter than the battery length. Then add small woodscrews and solder wires to the screws.



For the small flat cells cut off only one clothespin, glue on a flat piece of wood and add screws and wire.

In the same way, you can make a quick connector for TV antennas or for auto batteries used in experiments (use two clothespins per terminal).—*Tom Jaski* END

WHAT'S YOUR EQ?

These are the answers. Puzzles are on page 51.

How Many Volts?

Neglecting leakage currents in the capacitors, we see that the resistive voltage divider produces 91 volts on the top plate of the 2-μf capacitor. (Fig. 1)

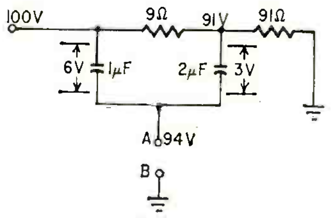


Fig.1

We'll use the Thevenin's Theorem approach to the solution of the problem. Calling the 3-μf capacitor the load, temporarily disconnect it and determine the voltage between points A and B. The 9 volts across the 2-μf in series with the 1-μf produces 6 volts across the 1-μf and 3 volts across the 2-μf. Therefore, the voltage between points A and B is 91V + 3V = 94V. (Fig. 1)

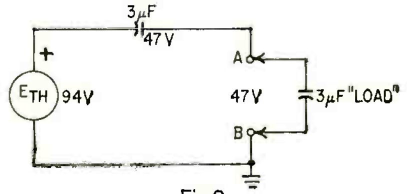


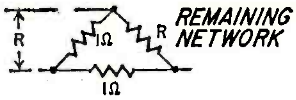
Fig.2

Looking into the circuit at A and B, we see 1-μf in parallel with 2-μf, with power supplies considered a short circuit. Fig. 2 shows the Thevenin's equivalent.

By inspection, 3-μf in series with 3-μf across 94 volts equals 94/2 = 47V.

Resistors Galore

Since the network is infinitely long, the first two resistors can be temporarily removed without changing the resistance value of the remaining network (still R ohms).



The first two resistors are now reconnected as shown in the equivalent-circuit diagram. Solving for the series-parallel resistive circuit, we get:

$$R = \frac{R1R2}{R1 + R2} = \frac{1\,(1 + R)}{1 + (1 + R)}$$

This forms a quadratic equation:

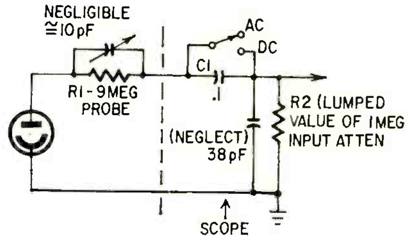
$$R^2 + R - 1 = 0$$

Solving for R:

$$R = \frac{-1 + \sqrt{5}}{2} = 0.618 \text{ ohm.}$$

Phantom Power Source?

The scope's ac coupling capacitor (C1—0.1 μF) supplies the power. It is initially charged by the 90-volt battery. With the battery removed, the photodiode, with its high internal impedance, has only the 10 megohms of the scope's probe and input as a load. The low duty cycle of the light pulse results in very little average current being drawn from C1.



EQUIVALENT CKT

The time constant of the input circuit (R1, R2 and C1) is extended from its calculated value of 1 second to 100 seconds—thanks to the 1% duty cycle of the strobe light. When the scope is switched to dc, the not-so-mysterious power source (C1) is shorted and circuit operation stops immediately. END

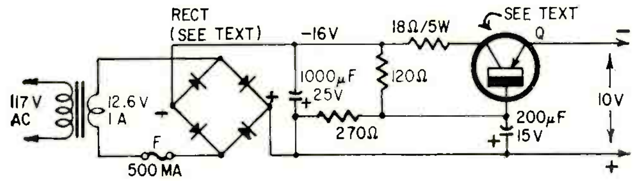
Radio-Electronics Adopts Hertz

RADIO-ELECTRONICS is now using the term *hertz* in place of cycles in all references to frequency. Hz, kHz and MHz, abbreviations for hertz, kilohertz and megahertz, are replacing cycles, kc and mc in all recently edited material.

NOTEWORTHY CIRCUITS

BATTERY ELIMINATOR FOR 9-VOLT SETS

The little 9-volt batteries used in many transistor sets are notorious for their short life and many readers have requested circuits for battery eliminators. This diagram was developed from the circuit of a commercial model described in *Radioschau* (Vienna, Austria). Minor changes have been made in some parts values to insure that the circuit can be duplicated with ease. The rectifier bridge may be made up of low-cost silicon rectifiers such as the 1N3193. The transistor used was a 0C74. You can use a General Electric GE-2, RCA SK3003, Semitron JR15 or any similar transistor.



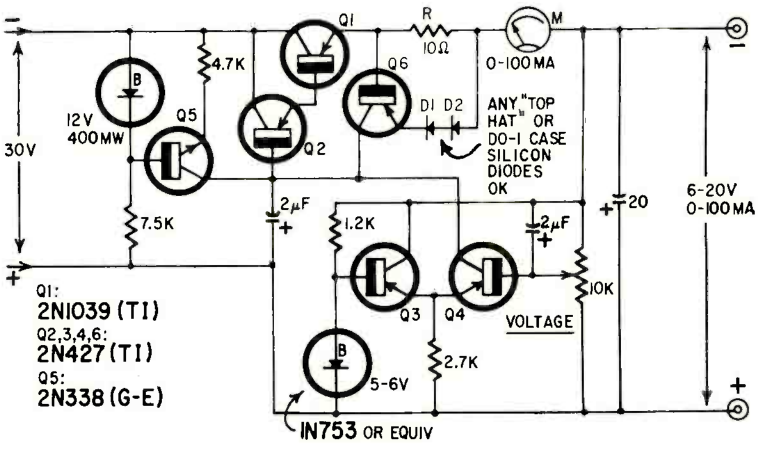
REGULATED POWER SUPPLY HAS SHORT-CIRCUIT PROTECTION

This power supply regulator has a range of 6 to 20 volts dc at up to 100 mA. Ripple is only 1 mV at 12 volts and 100 mA. Its large-signal output impedance is 0.9 ohm from 0 to 100 mA.

Transistor Q1 is a conventional series regulator, which passes the load current. Q2, a current amplifier for Q1, increases the feedback loop gain. Q3 and Q4 make a differential amplifier. The reference voltage at the base of Q3 is developed across the 5–6-volt Zener diode, which is driven into its Zener region by a voltage derived from the regulated output. This minimizes output ripple.

To reduce ripple further, Q5, a pre-regulator, is used. With its circuitry, Q5 produces a practically ripple-free constant-current source to feed the base of Q2 and the collector of Q4.

Q6 is a short-circuit protector. It is normally off because of the 1.2 volts of back-bias developed across silicon diodes D1 and D2. (The leakage current of Q6 keeps the *diodes* forward-biased to produce the reverse bias on Q6.) When sufficient load current is drawn, the drop across 10-ohm resistor R cancels the 1.2 volts of reverse bias and turns Q6 on. When Q6 is fully on it robs Q2, and hence Q1, of base current, which limits the load current to 120 mA under short-circuit.—*Phillip Cutler*



[The 30-volt source can come most economically from a 25.2-volt 1-ampere filament transformer, such as Knight (Allied Radio) 61 U 421, and a bridge rectifier made up of four 100- or 200-volt silicon rectifiers rated at 500 ma (plenty) or higher, such as 1N1692 or -1693, 1N3193, etc. One of many encapsulated bridge assemblies will also do well.—*Editor*]

END

SCHOOL DIRECTORY

NEW BOOKS

GRAPHICAL CALCULATORS AND THEIR DESIGN, by Norman Crowhurst. *Hayden Book Co., Inc., 116 W. 14 St., New York, N. Y. 10011. 7½ x 10½ in., 96 pp. Cloth, $5.95*

Mr. Crowhurst breaks down graphical calculators into three types: the slide rule, the nomogram or alignment chart, and the graphical chart, and covers each in detail. In each case, and especially that of the slide rule, he describes some unexpected and interesting types and applications. The style is clear and excellent.

RECEIVING TUBE SPECIFICATIONS & SUBSTITUTIONS. *TechPress Inc., Brownsburg, Ind. 6 x 9 in., 138 pp. Paper, $1.95*

Contains specifications for more than 2,000 American and foreign tubes, listed in two ways—under types (diodes, triodes, etc.) and by type number. Also includes a list of similar types (equivalents or near-equivalents).

ELECTROMAGNETIC THEORY, by Ernst Weber. *Dover Publications, 180 Varick St., New York, N. Y. 10014. 5¼ x 8½ in., 590 pp. Paper, $2.75*

A reissue, at a popular price, of the book originally called "Electromagnetic Fields, Theory and Applications." A complete mathematical treatment of the subject.

END

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18**	.26	.45	.60	.70
35	.60	.80	1.15	1.30

Amps	300 PIV	400 PIV	500 PIV	600 PIV
.75*	.12	.14	.18	.21
3	.25	.28	.35	.40
15	.90	1.30	1.40	1.65
18**	.85	1.25	1.85	2.50
35	1.90	2.25	2.50	2.90

Amps	700 PIV	800 PIV	900 PIV	1000 PIV
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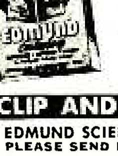

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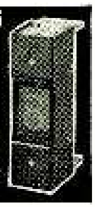

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1A7	1.75	6AW8	1.35	6W6GT	1.02	12W6	1.33
1AX2	.95	6AX4	.96	6X4	.59	13GF7	1.75
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1LA4	1.95	6B4	5.95	6Y6GA	.90	14A7	2.25
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1U4	1.05	6C4	.64	7B5	3.00	14Q7	2.25
1U5	.98	6C5M	1.95	7B6	1.90	14W7	2.25
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2A3	3.75	6CG7	.75	7C5	1.25	19	1.00
2A5	2.50	6CG8	.95	7C6	2.75	22	1.15
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3CB6	.82	6D6	2.50	7K7	3.05	30	1.50
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4BZ7	1.45	6E5	2.25	7W7	2.49	35Y4	1.62
4CB6	.82	6F4	3.20	7X6	1.35	35Z3	1.54
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5AN8	1.55	6F6G	1.95	7Y4	2.35	36	1.50
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5AT8	1.44	6GK5	1.66	8AU8	1.63	39/44	1.25
5AZ4	2.00	6HZ8	2.38	8BQ5	1.18	41	1.50
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5BR8	1.50	6J6A	.70	8FQ7	.99	43	2.75
5CG8	1.19	6J7	1.88	8GJ7	1.38	45/2A3	3.75
5J6	1.05	6J7G	1.75	8GN8	1.59	46	.95
5U4	.59	6J8	2.50	8JV8	1.59	47	3.50
5U8	1.19	6K6GT	.93	10DE7	1.14	48	4.00
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5X8	1.30	6L6G	1.15	12AH7	1.99	50	1.75
5Y3	.61	6L6GC	1.50	12AT6	.59	50C5	.85
5Y4	1.45	6L7M	2.58	12AT7	.74	50L6	1.10
5Z3	1.54	6N7M	.90	12AU6	.65	50X6	2.10
5Z4	3.00	6P5	2.50	12AU7	.74	50Y6	2.25
6A7	3.05	6Q7	2.05	12AV6	.56	50Y7	2.25
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6AB4	.80	6S8GT	1.60	12AX7	.87	55	2.75
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6AC7	1.75	6SD7	1.49	12BH7	.96	58	1.95
6AF3	1.05	6SF5	.98	12BQ6	1.35	59	3.50
6AG5	1.03	6SF7	2.40	12BR7	1.08	70L7	2.00
6AG7	2.25	6SG7	1.69	12BY7	1.09	71A	1.25
6AH4	1.10	6SH7	1.50	12K7	2.49	75	2.60
6AK5	.80	6SJ7GT	1.49	12K8M	2.95	76	1.75
6AL7	2.40	6SJ7M	1.65	12L6	1.13	77	2.00
6AM8	1.15	6SK7	1.60	12L8	.50	78	1.75
6AN8	1.43	6SK7M	1.58	12Q7	1.50	80	1.75
6AQ7	1.33	6SL7GT	.80	12SA7	1.48	83	1.48
6AR5	.89	6SN7GT	.90	12SC7	1.50	83V	3.00
6AS5	.95	6SQ7GT	1.33	12SF7	1.98	5881	3.00
6AS7	3.15	6SR7	1.50	12SG7	1.72	6146	2.75
6AT6	.72	6SS7M	1.15	12SH7	1.50	6336	4.75
6AT8	1.25	6T8	1.20	12SJ7	1.50	6550	4.00
6AU4	1.28	6T9	1.46	12SK7	1.40	807	.95
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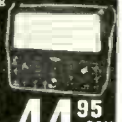

Circle 132 on reader's service card

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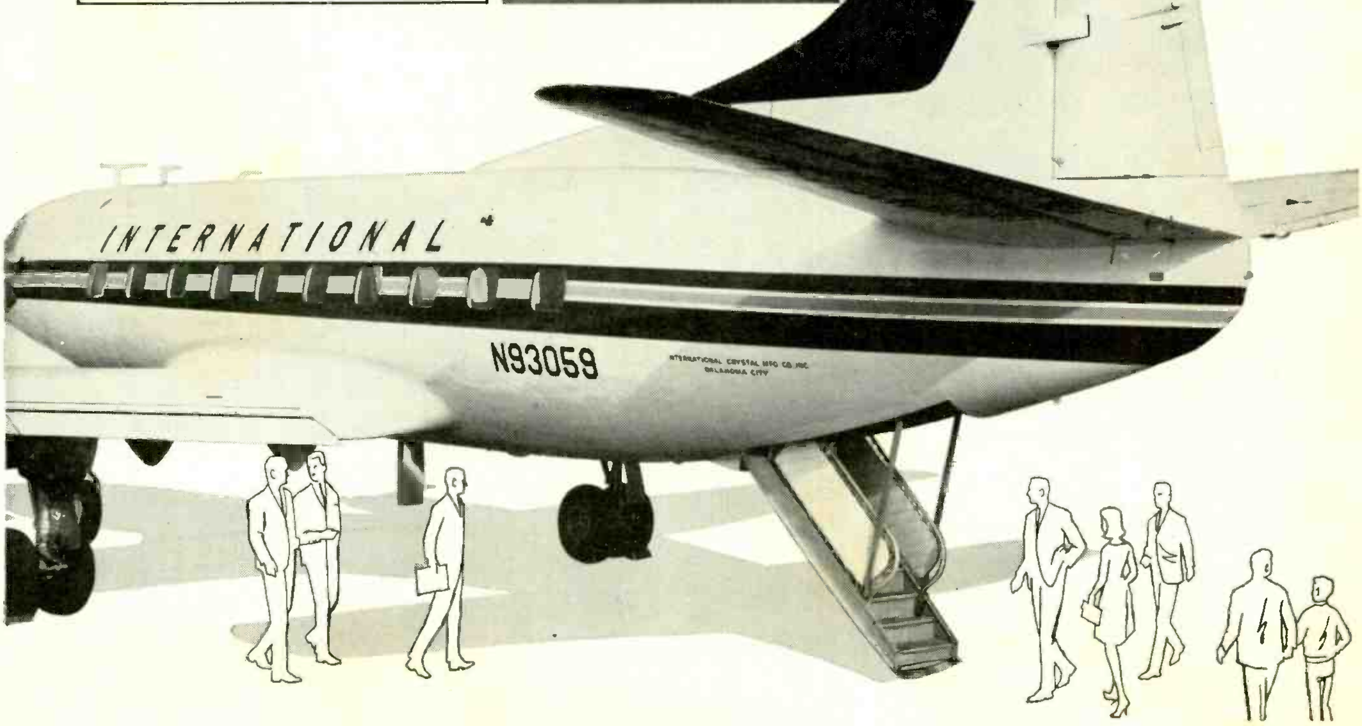

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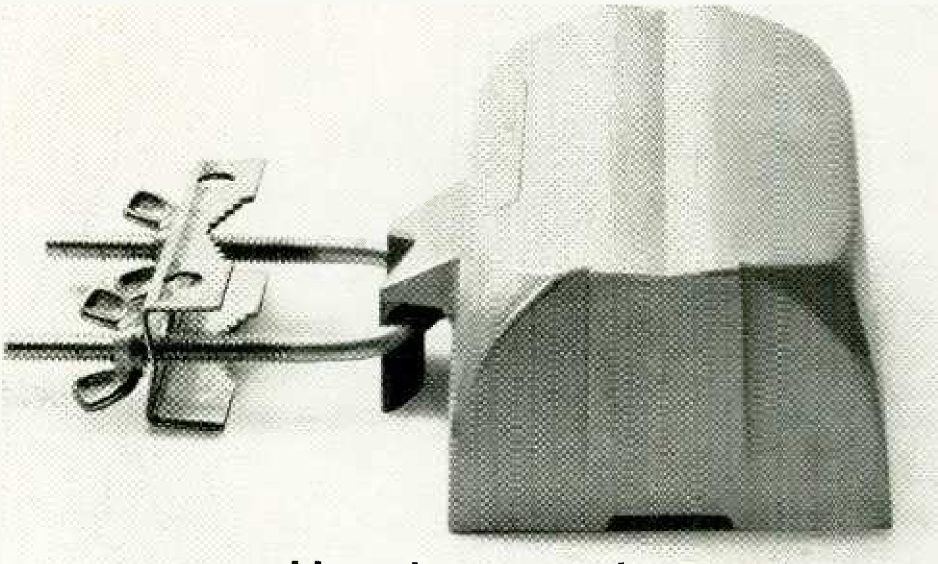

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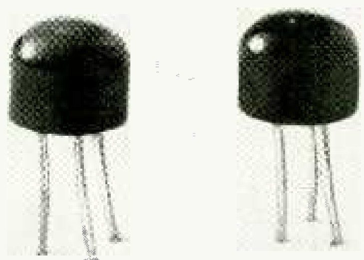

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