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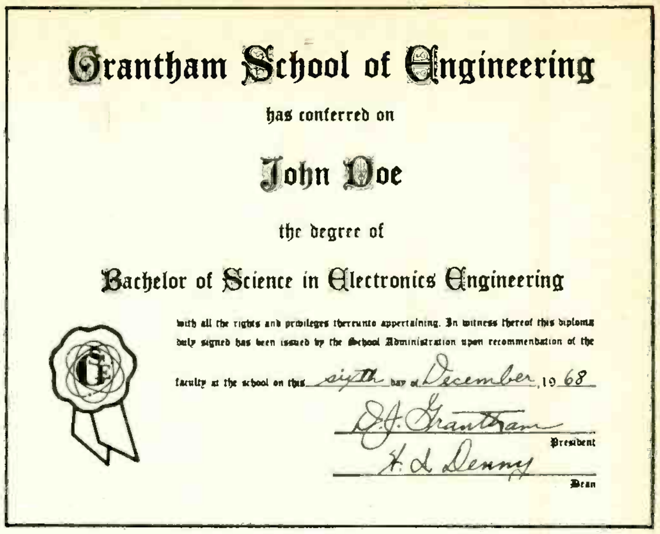
Become an electronics engineer

The Grantham educational program in Electronics Engineering is designed to upgrade technicians to engineers, mostly by home study. In this program you can acquire an extensive knowledge of engineering and earn your BSEE Degree – for greater prestige, better pay, and more security.

In America's race to the moon and outer space, *more and more* engineers are needed. By becoming an electronics engineer, you can move into the forefront of technology and engineering, and be an important part of this exciting age. You can help make things happen and be properly rewarded for doing so.

The demand for engineers continues to increase; electronics engineers are needed in the space program and in many other military and domestic projects. In a recent survey conducted by the Engineering Manpower Commission of the Engineers Joint Council, it was found that engineering employment in the electrical and electronics industries is expected to increase by 40% in ten years. The need for engineers is increasing faster than the population as a whole. The survey report indicates that in the next decade, employers expect to need almost *twice as many* new engineering graduates as are likely to be available.

If you have the desire to be an engineer, the determination to stick to your objective, and a reasonably good aptitude for mathematics and technology, the Grantham educational program can produce the wanted results for you. But make no mistake about it, to become an electronics engineer requires work. You must be willing to do that work; otherwise you can never reach your objective, regardless of what course of instruction you may choose.



Grantham School of Engineering

has conferred on

John Doe

the degree of

Bachelor of Science in Electronics Engineering

with all the rights and privileges thereunto appertaining. In witness thereof this diploma duly signed has been issued by the School Administration upon recommendation of the faculty at the school on this sixth day of December 19 68

President

Dean

The Grantham program in Electronics Engineering consists of eight home-study "sections" and two weeks of attendance at the School in Hollywood. There are 80 lessons in the first home-study section, and 70 lessons in each additional section, for a total of 570 home-study lessons. The two-week attendance in Hollywood is required after completion of Section 5. Upon completion of the two weeks in Hollywood, you are awarded the ASEE Degree, and then upon completion of Section 8 you are awarded a Diploma in Electronics Engineering. Finally, upon earning 24 required semester-hour credits in English, Business, etc. (in other colleges) and transferring these credits to Grantham, you are awarded the Degree of Bachelor of Science in Electronics Engineering (the BSEE).

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NEW & TIMELY

Volume 40 Number 4 RADIO-ELECTRONICS April 1969

CONSOLE UPDATES OLD SWITCHBOARD

MORRISTOWN, N.J.—The familiar telephone switchboard cluttered with patch cords has been phased out of service for long-distance calls here with a computer-like electronic console developed by Bell Labs.

The system, shown under test, automates many of the operator's functions, providing her with a visual display of the called and calling number, plus information necessary for billing. The system is similar to the electromechanical consoles replacing switchboards throughout the Bell System, but is more flexible. Controlled by a stored program, the console automatically records in its memory a number of details about a long-distance call. This first system to be installed will service all telephones in 11 nearby communities.

FCC PLANS RFI RULE REVISIONS

WASHINGTON, D.C.—The boom in consumer and industrial devices that generate radio-frequency interference (RFI) has a prompted Federal legislation authorizing the FCC to regulate the manufacture, import, sale, shipment or use of any potential RFI devices. Earlier Federal regulations restricted the FCC only to control of radio-frequency equipment use. The proposed FCC rules, which will influence companies previously unaffected by Federal regulations, require type approval, acceptance or certification prior to the sale or shipment of rf devices.

RESOLUTION DOUBLED IN COLOR TV TUBE

CHICAGO—A new TV color tube designed largely by computer is claimed to have twice the resolution of similar tubes by Admiral Corp. The 79-square-inch design is being used in a recently introduced 12-inch portable.

Spacing for the phosphor dot triad is 0.025 inch, compared to 0.056 inch in similar-size tubes made by Admiral's competitors.

Other features of the new tube are a temperature-compensated shadow mask for proper alignment between electron beam and phosphor dot, and a low-voltage focus system. The focusing feature utilizes voltages in the 400–500 range to maintain picture sharpness despite voltage changes in the home.

LOOKING AHEAD

by DAVID LACHENBRUCH
CONTRIBUTING EDITOR

Toward color-fast TV

An important new color television battle may be shaping up toward an eventual decision by the FCC: Should station signal tolerances be tightened or television receivers made more elaborate and expensive?

This prospect now seems probable on the basis of significant discoveries in field tests by an all-industry engineering committee charged with investigating "the disturbing lack of uniformity among color television pictures." The field tests, in Chicago, used closed-circuit and off-the-air material from three television stations received on four "top-of-the-line" color sets, all with automatic chroma control (ACC), made by four leading manufacturers.

The tests revealed that variations in the transmitted signal permitted by FCC specs produced different results on different receivers. In a preliminary report, the committee chairman, K. Blair Benson of CBS, drew these conclusions:

(1) "Signal specifications related to hue and saturation permit wide excursions, some of which subjectively are quite objectionable, depending upon the home receiver design.

(2) "Receivers may be affected by variations in burst timing, duration and amplitude. The degree of variations in picture quality is dependent upon the circuit design.

(3) "Transmission can introduce phase errors

(continued on page 4)

1200 ELECTROCUTIONS IN HOSPITALS ANNUALLY

Electronic and electrical instrumentation in hospitals helps save thousands of lives daily, but a recent computer study by a major insurance company has revealed it also takes some 1200 lives each year in the US through accidental electrocutions.

The figures, attributed to Dr. Carl W. Walter, a Boston surgeon, were reported at a recent meeting on reliability and medical instrumentation. The majority of the hospital patients killed were undergoing routine diagnostic test or treatment.

As reported in an issue of *Electronic News,* the causes of hospital accidental electrocutions appear to be growing in complexity as the instrumentation use increases.

A major problem is linking incompatible instruments simultaneously to a patient, creating an ac current loop that causes fibrillation—erratic beating—of the heart. Poor circuit design contributes to dangerously high leakage current from some equipment on the market, and the problem is compounded by untrained hospital personnel who "wire" patients into a ground loop easily completed when a faucet or other equipment is touched.

Approval by Underwriters Laboratory is not a requirement for hospital instrumentation, the *Electronic News* report noted. Companies are increasing safety by using isolation transformers, self-destruct fusing devices and separate-ground three-wire power cables.

(continued on page 4)

IN THIS ISSUE

Would you believe computerized cars are already here? Read Fred Holder's article on electronics in today's automobile and find out what's on the road.

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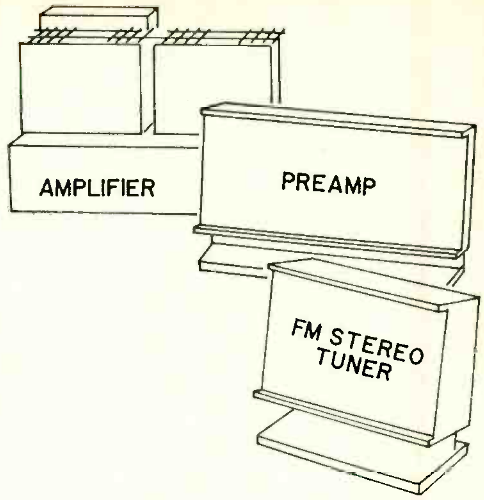
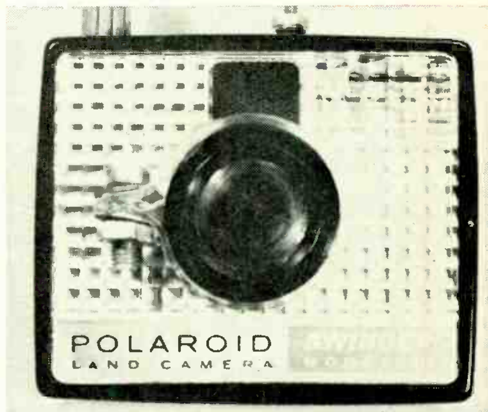


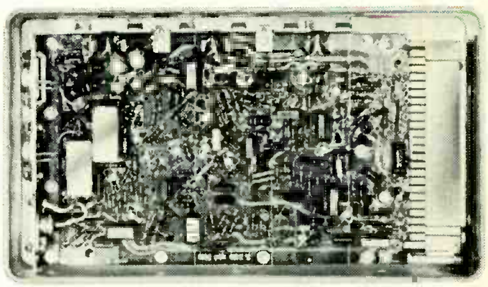
On the cover is a complete stereo hi-fi system. This month we show how to build the power amplifier. The preamp is in May and the FM tuner in June.

see page 41



Need a scope camera? You can convert a Polaroid Swinger into a good one. Total cost including camera is $20.

see page 52



Electronic fuel injection is just one of the latest developments in automotive electronics. See what else is new.

see page 48

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New & Timely

WILL IT BITE?

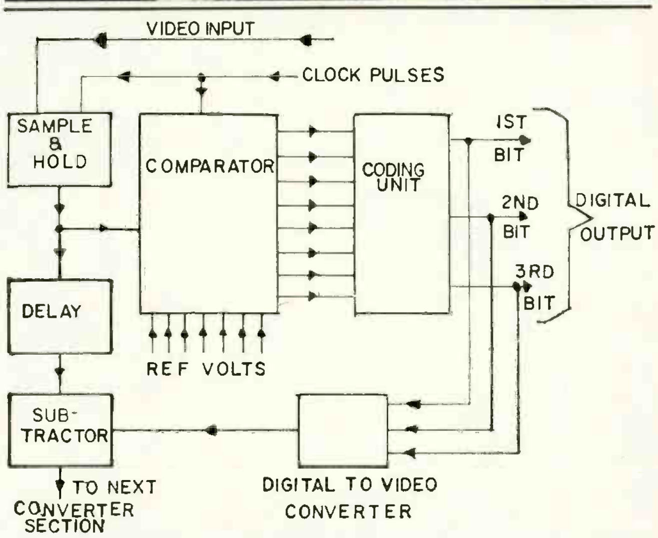
No, but it'll stay dry while carrying telephone signals underground. "It" is a cable whose wires have been encapsulated in a mixture of petroleum jelly and plastic. The inexpensive mixture was concocted at Bell Labs for use in the Bell System's program to reduce the number of aerial telephone wires. The waterproof cable is being field-tested in several states.

H-FI WATTAGE WAR

NEW YORK, N.Y.—Would you prefer 40 watts of hi-fi stereo power or 120 watts? Unfortunately for the consumer, an amplifier can be rated with *both* wattages. The problem faced by the hi-fi industry became apparent at a recent press briefing in which the Institute of High Fidelity and the Electronic Industries Association rejected a proposal that Federal amplifier rating standards be established.

Industry representatives showed how misleading ratings can be: Under IHF standards, a 40-watt amplifier (20 per channel) would be rated at rms continuous power with 1% total harmonic distortion (THD). But, since the 1000-Hz tone used for the continuous-power rating bears little resemblance to music, the amplifier wattage could be jumped to 100 watts peak music power without exceeding 1% THD. Want more power? Just switch to EIA's rating system, which tolerates a 5% distortion level. Now the 40-watter's volume control can be cranked up for a EIA peak music-power rating of 120 watts.

An IHF board member declared the hi-fi industry "has the technical background to police itself," but views on wattage ratings seem as far apart as ever. One major manufacturer is reportedly using test standards established by the IEEE.



LOOKING AHEAD

(continued from page 2)

which, while not seriously objectionable in the field tests, were quite noticeable. Undoubtedly, in less rigorously maintained stations, these variations can be larger and very objectionable . . . The appropriate allocation of the source of variation among transmitters, propagation and receiver is not clear.

Particularly in connection with variations in the color burst, Benson urged "a careful weighing of the economics of signal specification changes vs more elegant receiver design." More field tests are planned, primarily for further study of the role of phase errors in color variations on home receivers.

At the committee's direction, other color uniformity studies are being conducted simultaneously in the fields of color film characteristics, standardization of studio monitors and phosphors, video tape equipment, camera colorimetry and development of test-signal standards to evaluate and control overall performance of the color sys-

(continued on page 6)

DIGITAL TV TRANSMISSION DEVELOPED

LONDON—British Broadcasting Corp. engineers have developed equipment that enables TV signals to be transmitted with digital techniques. The method, called pulse code modulation (PCM), samples a video signal at regular intervals and converts the sample into pulses that represent a binary code. PCM techniques have been adopted for data transmission over telephone lines in this country.

The BBC system being studied samples a 625-line, 5.5-MHz TV signal approximately 13 million times a second. The bit rate, or number of pulses per sample, must be seven or eight bits for high-quality pictures. Prototype equipment using six bits permits 64 brightness levels, which is sufficient except for certain scenes. The BBC converter shown in the diagram is a series-parallel design in which the three most significant digits are extracted by a parallel converter, and the three least significant digits by another converter in series with the first. Before being sent to the second converter, the three most significant digits are reconverted to analogue form and subtracted from the original signal.

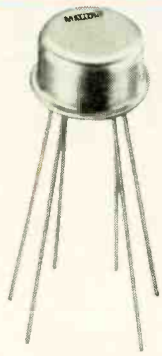
Chief advantage of PCM for TV transmission is its immunity to small signal changes that can raise havoc with complex color signals. With PCM, pulse shape can vary considerably before becoming unrecognizable at the receiving end. The system was described in the magazine *Electronics Australia*.

(continued on page 6)

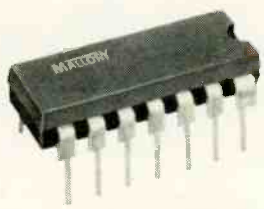
IN THIS ISSUE
Is the transistor on the way out? Why did news of a new glassy semiconductor cause rumbles on the stock exchange and front-page headlines throughout the country? Fred Shunaman's article tells the story behind the headlines.

MALLORY Tips for Technicians

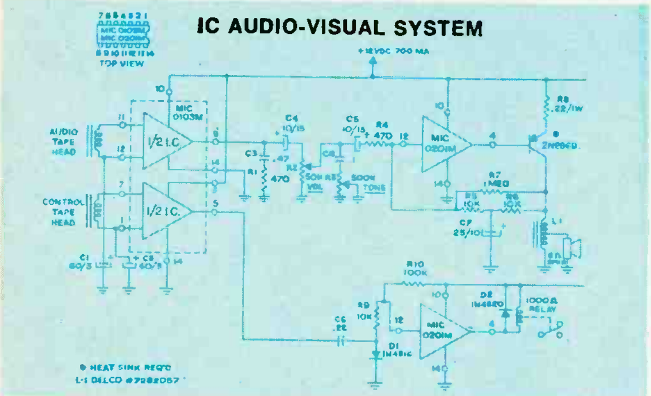
IC's..for automatic control of slide or film projector systems.



Typical TO5 IC Package



Typical Plastic Encapsulated IC



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We joined 3 low-cost integrated circuits, a discrete audio power amplifier and a 2-channel tape player. Result: a new method to automatically control slide or film projector systems.

Audio messages are recorded on one channel and the control signal (tone burst) on the other channel. At the end of a message, channel 2 gets the keying tone burst and activates a relay driver circuit. This advances the projector to the next scene.

A Mallory MIC0103 dual channel IC preamp provides audio and keying signal amplification and equalization.

Channel 1 output feeds a Mallory MIC0201 driver amplifier which drives the audio output stage. The audio driver/output stage provides about 3.5 watts output at less than 10% distortion for input signals of 10 mv or less. Up to 2.5 watts, distortion is less than 5%.

Frequency response for the audio amplifier is flat from 100 Hz to 8 KHz. Tone is controlled by potentiometer R3 and capacitor C6, and provides enough treble cut for most applications. Tape is equalized by resistor R1 and capacitor C3. These components give about 14 db of high frequency attenuation to compensate for recording emphasis.

The projector is controlled by components C8, R9, R10, D1, D2, a 1000 ohm relay and a Mallory 0201 driver amplifier IC. The IC is biased off by the resistor network (R9 and R10) in conjunction with diode D1. Incoming signals are peak-detected to bias on the IC which activates the relay. Resistors R9 and R10 control the threshold at which the IC turns on. The threshold will vary according to system requirements.

With the values shown, an 0.5 mv 3KHz output from the tape head will activate the relay. The relay driver IC should be sufficiently biased to keep it off until the keying signal is obtained. Otherwise, excessive dissipation will occur within the IC. Diode D2 protects the IC output device when the relay is de-energized.

Total circuit power consumption is 12 Vdc at about 700 ma. Power can easily be provided by a filament transformer and rectifier system.

For detailed descriptions and analysis of the integrated circuits in this application, write for Application Notes 1 and 2, to Mallory Distributor Products Company, a division of P. R. Mallory & Co. Inc., Indianapolis, Indiana 46206.

DON'T FORGET TO ASK 'EM—*"What else needs fixing?"*

Circle 10 on reader service card

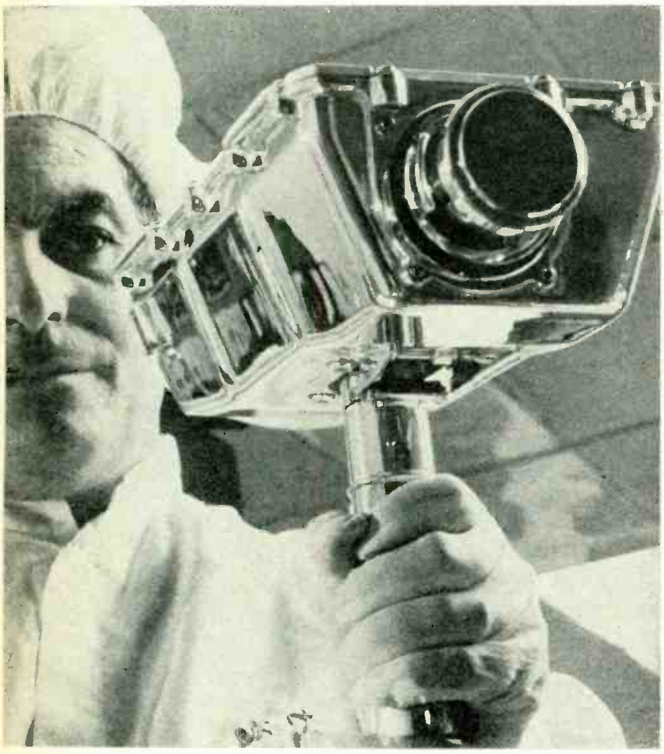
LUNAR TV CAMERA

BALTIMORE, MD.—This TV camera is going to the moon with the Apollo astronauts. It's one of 17 built for NASA by Westinghouse, and uses a secondary electron conduction (SEC) imaging tube for extreme low-light sensitivity. A cable from the spacecraft provides the 6½ watts of power needed. Camera can "see" scenes invisible to the human eye, yet will not bloom when exposed to extremely brilliant images. Integrated circuits are used extensively.

LASER ART UNSAFE

NEW YORK, N.Y.—Health Department officials here decided public eye safety came before modern art when they shut down an entry in a competitive museum exhibit. The work, a rectangular plastic-panel construction, uses several mirrors to bounce a laser beam from one panel to another. The Health Department said a safer method of viewing the exhibit than a Plexiglas window would be required.

(continued on page 15)



LOOKING AHEAD

(continued from page 4)

tem from original scene to the picture viewed in the home.

Vhf–uhf tuning 'equality'

One FCC proceeding involving TV set design is already under way. It concerns an old problem, familiar to everyone who lives in an area with numerous uhf stations: the relative difficulty of tuning the uhf band, as compared to the vhf.

The commission says it has no quarrel over the quality of uhf tuners, only with the relative ease of tuning. Under the authority of the all-channel law, which requires uhf tuners in all sets sold, the FCC has proposed to decree tuning "parity" between both bands. It thinks uhf stations are at a disadvantage when two separate tuning knobs must be used—the vhf selector with detents, the uhf with a continuous-tuning radio-type dial. The FCC would like to see all uhf channels marked on the dial as vhf channels are.

This leaves set manufacturers in something of a dilemma, since it's a matter of giving 83 uhf channels tuning equality with only 12 vhf's. (This equal treatment may be difficult and costly.) Nevertheless, the commission probably will establish rules to provide for more nearly equal ease in tuning, giving the industry a considerable amount of lead time to make the changeover.

Electronic tuning in '69

One of the most promising methods to bring about vhf–uhf tuning equality appears to lie in all-electronic varactor (variable-capacitance) diode tuning, using such methods as pushbuttons or a potentiometer control to change the tuner's resonant frequency electronically, with no moving parts in the tuner itself.

Diode TV tuning has become increasingly popular in Europe, where, it is estimated nearly 50% of all sets made in 1969 will use it. However, because of closer spacing between stations in the U.S., European tuning varactors have not been considered selective enough for use here.

Tuner and set manufacturers here now are giving top priority to development of all-electronic tuners. It's

(continued on page 12)

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National Electronic Associations did. They checked out the new TV training package being offered by ICS. Inspected the six self-teaching texts. Followed the step-by-step diagrams and instructions. Evaluated the material's practicality, its fitness for learning modern troubleshooting (including UHF and Color).

Then they approved the new course for use in their own national apprenticeship program.

They went even further and endorsed this new training as an important step for anyone working toward recognition as a Certified Electronic Technician (CET).

This is the first time a self-taught training program has been approved by NEA.

The surprising thing is that this is not a course that costs hundreds of dollars and takes several years to complete. It includes no kits or gimmicks. Requires no experience, no elaborate shop setup.

All you need is normal intelligence and a willingness to learn. Plus an old TV set to work on and some tools and equipment (you'll find helpful what-to-buy and where-to-buy-it information in the texts).

Learning by doing, you should be able to complete your basic training in six months. You then take a final examination to win your ICS diploma and membership in the ICS TV Servicing Academy.

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Which leads to the fact that this new course is far below the cost you would expect to pay for a complete training course. Comparable courses with their Color TV kits cost as much as six times more than the $99 you'll pay for this one.

But don't stop here. Compare its up-to-dateness and thoroughness. Find out about the bonus features —a dictionary of TV terms and a portfolio of 24 late-model schematics.

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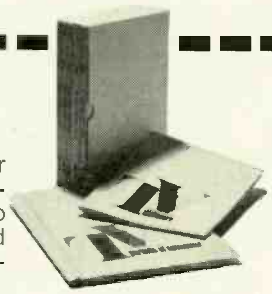

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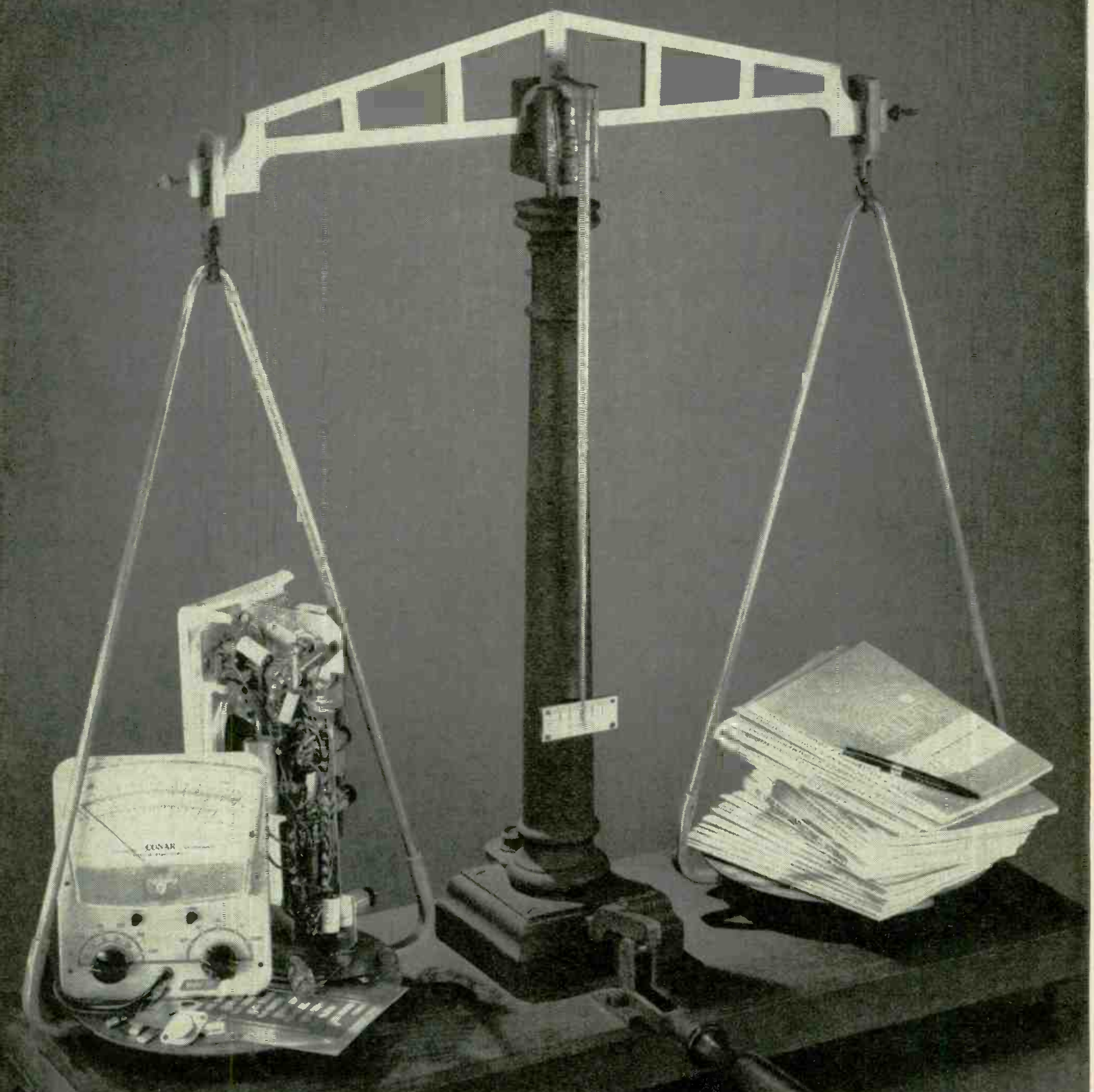

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Ask any teacher, job counselor, engineer, technician or prospective employer about the need for practical application of theory in Electronics. He'll tell you Electronics is as much a "hands on" profession as dentistry or chemistry. That's the way you learn at home with NRI. You put to work the theory you read in "bite-size" texts, using designed-for-learning lab equipment you build with professional components. You introduce defects into circuits, do experiments, until the "why" of circuitry and equipment operation comes clear through demonstration. You gain experience with transistors and solid-state designs as well as conventional tube circuits.

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NRI has trained thousands

L. V. Lynch, Louisville, Ky., was a factory worker with American Tobacco Co., now he's an Electronics Technician with the same firm. He says, "I don't see how the NRI way of teaching could be improved."

G. L. Roberts, Champaign, Ill., is Senior Technician at the U. of Illinois Coordinated Science Laboratory. In two years he received five pay raises. Says Roberts, "I attribute my present position to NRI training."

Ronald L. Ritter of Eatontown, N.J., received a promotion before even finishing the NRI Communications course, after scoring one of the highest grades in Army proficiency tests. He works with the U. S. Army Electronics Lab, Ft. Monmouth, N.J. "Through NRI, I know I can handle a job of responsibility."

Don House, Lubbock, Tex., went into his own Servicing business six months after completing NRI training. This former clothes salesman just bought a new house and reports, "I look forward to making twice as much money as I would have in my former work."

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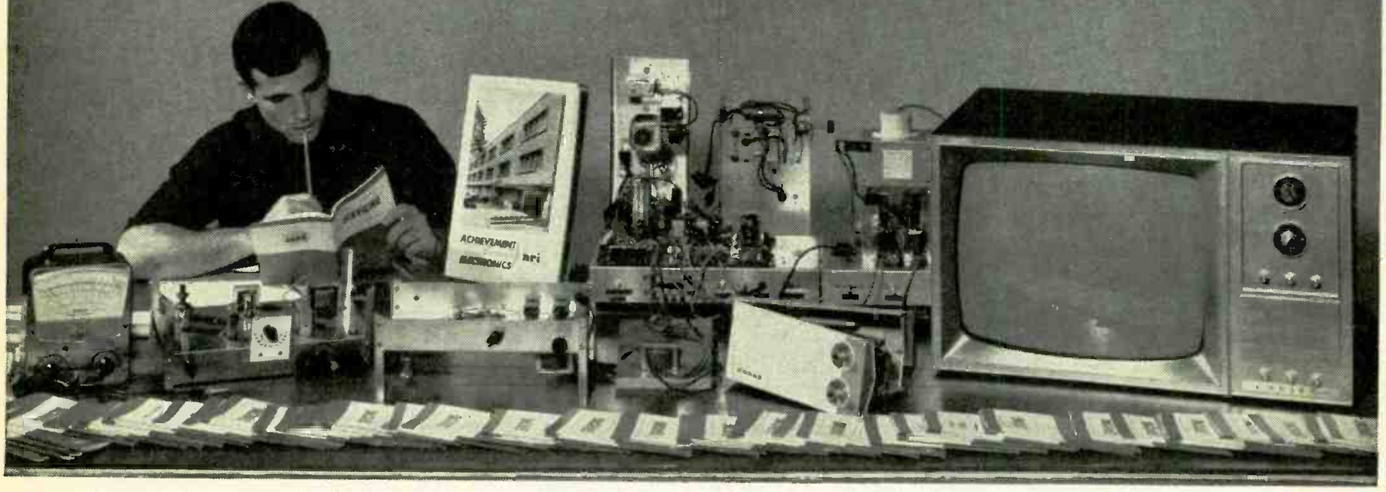

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LOOKING AHEAD

(continued from page 6)

certain that at least one manufacturer will introduce a diode-tuned TV set in the mid-1969 model changeover, while several others will have them in time for this year's Christmas selling season. These new devices, appearing first only on higher-priced color sets, may use new and interesting channel-selection devices. One manufacturer is expected to solve the problem of tuning equality with a signal-seeking pushbar control similar to those used on some auto radios.

Home movies on color TV

A 23-inch television set that also can show 8mm home movies is due for introduction in the next few weeks. It will be offered by Sylvania, which one year ago premiered its Scanner Color Slide Theater, a color set which shows 35mm home slides on its screen. The color movie theater is expected to incorporate an Eastman Kodak film-transport mechanism, but use TV scanner techniques instead of optical projection.

IC's in consumer products

The number of active integrated-circuit elements used in consumer electronic products—television, radio, phonographs, tape recorders, etc.—will exceed receiving tubes by 1971, and discrete semiconductors by 1975. That's the projection of Motorola Semiconductor Products. Motorola says 78% of all active components in consumer electronic products built this year will be discrete semiconductors, while 18% will be tubes and 4% will be IC's. Discrete semiconductors' share will remain at 78% in 1970, Motorola forecasters think, but IC's will gather a 9% share at the expense of tubes, which will decline to 13%.

They still watch

You may think people have given up on television, but it's just not true. Analyzing rating surveys, the Television Bureau of Advertising has found that the average family watched more television than ever in 1968—5 hours and 48 minutes per week, or 6 more minutes a week then in 1967. The study credited new color sets for much of the increase.

Meanwhile, color has passed something of a landmark. As 1969 started, the NBC research department reported that almost one-third of all television-equipped households—19.2 million of them—had color sets. The total number of color sets as of Jan. 1 was about 20.1 million. The number of sets is higher than the number of color households because some homes have two color sets, and some sets are in hotels, bars, offices, etc.

Fax via FM

There's increasing talk about public facsimile transmission these days, and most of it centers on the use of television stations as origination points. RCA has been conducting experiments in transmitting material during the vertical blanking interval between TV frames.

A New York firm, Comfax Communications Corp., now indicates that it plans to use FM stations for fax transmission, utilizing their subcarriers when they are not broadcasting in stereo, without interfering with regular programing. Comfax plans initially to confine its FM fax transmissions to specialized nonpublic uses—bank signature verifications, intracity transmittal of business documents—but it also claims it has a system which would make it possible to send newspapers to the home via the relatively narrow bandwidth of an FM subcarrier. R-E

(continued from page 6)

STATE TO COMBAT NOISE POLLUTION

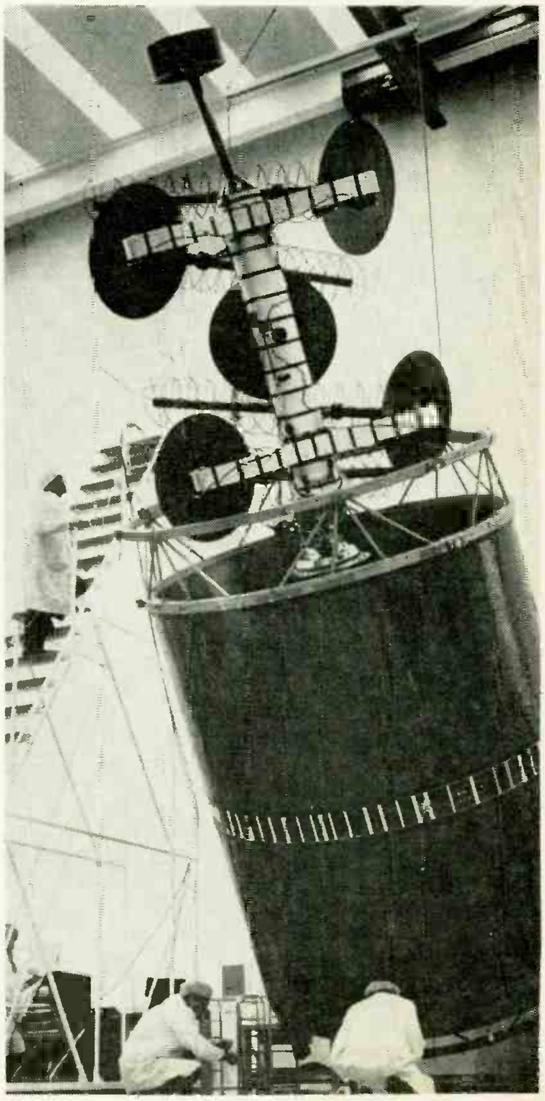
STAMFORD, CONN.—Instruments like this are being used in a new program to combat noise on Connecticut highways. Data obtained will help to formulate laws controlling highway noise.

The devices contain sensitive microphones and sound-level meters that track and record noise levels from vehicles.

The builder, CBS Labs, is also developing an instrument for the state that will provide instantaneous photographs and chart readings of noisy vehicles. The suitcase-size instrument will use a split-screen camera and calibrated microphone to establish legal evidence against operators of noisy vehicles.

GIANT SATELLITE READY

The largest and most powerful communications satellite ever to be launched is shown undergoing final tests at Hughes Aircraft Co. The 1600-lb satellite is as tall as a two-story building and has a communications capability equivalent to 10,000 two-way telephone channels. Signals from the cluster of antennas on top of the satellite can be picked up by ground stations. The satellite is being launched for the Defense Department.



REPAIR LICENSE BILLS

Legislation that would require licensing of TV service techs is being introduced in the State Legislatures of New York and Pennsylvania. The New York bill would establish an advisory board to set license requirements and standards. Similar legislation sponsored by a Pennsylvania service association would additionally require service technicians to provide a statement showing all parts placed in a set, an itemized list of all charges, and name and address of repairer. **R-E**

Correspondence

COMPLAINT DEPARTMENT

I wish to voice a formal protest to someone. Those little "earphones" that come with transistor radios are undoubtedly the most uncomfortable, ill fitting, unsanitary, low quality, always tangled listening devices ever made. Surely we consumers deserve better.

KEN GREENBERG
Chicago, Ill.

No one says you must use those little thingamabobs Ken. Just find a pair of good quality, comfortable headphones, fit an appropriate plug and use them. Only one point to remember, those good quality phones may cost more than the radio you're going to use them with.

ONLY A GUITAR AMPLIFIER

The Go-Go Guitar Amplifier in the November 1968 issue is just about what I've been looking for for some time. However, you state it is not hi-fi. How un-hi-fi is it? I am planning to build a stereo system with a reverb section and this is the first circuit I have run across that incorporates most of my requirements. I am primarily interested in FM stereo and records.

One thing I like about this circuit is that it is designed around the HEP solid-state components. I find them much easier to get than some of the parts you usually list in your construction articles.

By the way, I'm sure you didn't actually use a No. 313 lamp as shown in this unit. The lamp is rated at 28 volts and 170. Placed across the line as shown it would go off in one quick flash.

Do you have any plans for an FM tuner in the near future? I would like to see a solid-state tuner with an IC i.f. circuit.

DAVID C. SEARTZ
Aurora, Colo.

From the tone of your letter Dave, you want higher-fi than this guitar amplifier can deliver. Remember, it is

Circle 16 on reader service card

CORRESPONDENCE
(continued from page 15)

only a guitar amplifier. But if you can wait a couple of months longer you'll find a three article series with complete details on a hi-fi system that is really something. First we'll publish the premap and it's got an IC circuit. Then there's a power amplifier with two, 120-watt channels. Last there's an FM tuner that's just out of this world. Now how's that for keeping you on the edge of your seat.

FREQUENCY, MUSIC, AND HEARING

Dear Sir:

On page 22 of your October issue you suggest reopening discussion of the necessary bandwidth of high-fidelity amplifiers as related to the bandwidth of the human ear.

Actually, the extra bandwidth seems unavoidable, if amplifiers of low harmonic and intermodulation distortion are to be obtained. With practical tubes and transistors there is always nonlinearity of characteristic and appreciable values of feedback. $(-A\beta)$ are needed to bring distortion and desired percentage levels. These magnitudes of $A\beta$, when added in amplifiers having reasonable audio bandwidth, lead to wider bandwidths than are necessary to cover the audible range.

Mathematically, the gain with feedback can be expressed as

$$A' = V_o/V_s = A + \frac{V_hV_s}{1-A\beta}$$

where the harmonic distortion fraction V_h/V_s is seen to be reduced by the factor $1/(1-A\beta)$. Thus the desirability of large $(-A\beta)$ magnitudes. At the same time the upper bandwidth limit (half-power frequency), $\omega_2{}^1$ with feedback, becomes

$$\omega_2' = \omega_2 (1 - A\beta)$$

when ω_2 is the bandwidth limit with no feedback.

Thus if we want to reduce the harmonic distortion from 6% ($V_h/V_s = 0.06$) to 0.6% by making $[1 - A\beta)] = 10$, then $\omega_2' = 10\omega_2$ and we have expanded the upper bandwidth limit, perhaps from 10 kHz to 100 kHz.

Along with this comes the necessity to now control the phase shift out to 100 kHz, as well.

Of course, for high-fidelity we must reduce the harmonic distortion to a percent or less—then the bandwidth just comes along. **R-E**

J. D. RYDER
Professor
Department of Electrical Engineering
Michigan State University
East Lansing, Mich.

In the Shop . . . With Jack

By JACK DARR

Calibrate for Peak-to-Peak volts

A scope is a *comparison* instrument—you need some kind of standard or known voltage. You then compare the pattern amplitude with the amplitude of the standard. In TV service, you compare the p–p pattern amplitude to that given on the schematic. You also compare the waveshape, but we're only talking about p–p voltages at the moment.

To read p–p voltage, feed in a *known* voltage and set the vertical-gain control of the scope to show a pattern of a certain height. Then you know a pattern of the same height is at the same p–p voltage. You can then go to the TV set and read any p–p voltage you want by comparing it to the known standard voltage.

For example, Fig. 1 shows a scope screen with a vertical line on it set for an amplitude of 4 inches. You get this by turning the horizontal gain all the way off. (It's easier to read, and there are other advantages, as we'll see in a minute.) Let's say we want to read a horizontal output tube's grid-drive signal. The schematic says it should be 175 volts p–p.

Let's feed in an ac voltage at 200 volts p–p, and adjust the vertical gain to make a 4-inch line. Now each of the thick lines is 50 volts p–p. If your scope doesn't have the lines on the graticule, you can mark the distance on the screen with a grease-pencil and divide it into four equal parts. Half the distance (2 inches) is 100 volts p–p; 3/4 of the distance is 150 volts p–p, and so on.

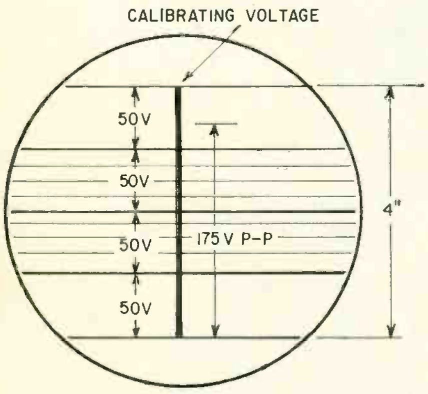


Fig. 1

"Yeah," somebody says, "but I haven't got a source of 200 volts peak to peak!" Care to bet? All you need is an ac voltage. First read it with a fairly good ac voltmeter, then multiply this voltage (an rms value) by 2.8, which will give you p–p.

You can get a 200-volt p–p calibration by using the 70-volt filament setting on a tube tester. (If you want to be precise about it, 71.5 volts rms = 200 volts p–p.) You do *not* need a very accurate reading in most cases. In the grid-drive measurement, we need to know: "Is there *enough* grid-drive signal here?" Or, "Is this signal *at least* 175 volts p–p?"

This can be done. Calibrate the scope on the 70-volt setting, 200 volts p–p. Now move the probe over to the grid of the 6JS6 or whatever it is. The only thing you must *not* do is change the *vertical gain* setting of the scope. Look at the amplitude of the drive signal. You should have a vertical line (even with the bottom calibration mark) that comes up about halfway between the last two marks, or the 150- and 200-volt lines. You can move the vertical *centering* control to make the bottom end of the line sit on the mark.

Most readings don't have to be *too* accurate. You don't have to know whether the grid-drive voltage is 175 volts p–p or 176 volts. You must know, "Is it 175 volts, or less than 100 volts, etc.?" This would be far enough out of the ballpark to cause trouble, and you'd go back to the horizontal oscillator.

Your tube tester is a good source of calibration voltage. For instance, the 5-volt filament setting is very close to 14 volts p–p; 10 volts is 28.2 volts p–p, and so on. You can plug a tube-socket test adapter into one of the tube-check sockets, and hook the scope to the filament terminals. Use an octal adapter, for example, and set the tube tester for a 6V6, etc. The filaments will then be connected to pins 2 and 7.

Can you use a low-capacitance probe on the scope and get the same results? Sure. Just put the probe on the scope, and use it when you make

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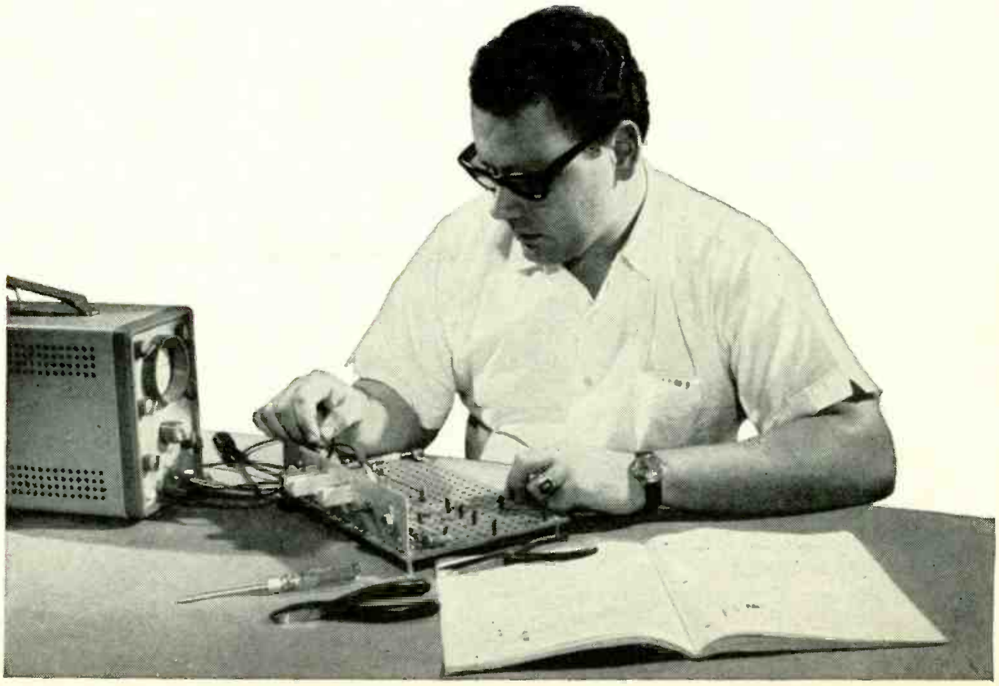

Performing transistor experiments on programmed breadboard—using oscilloscope.

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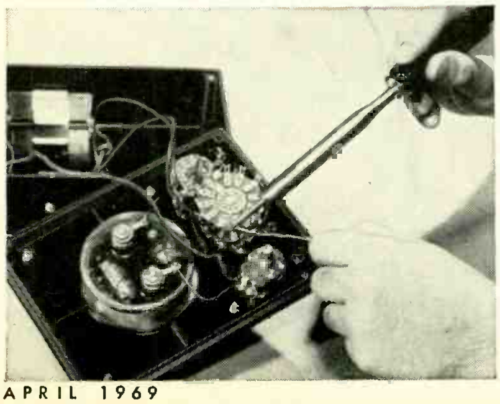
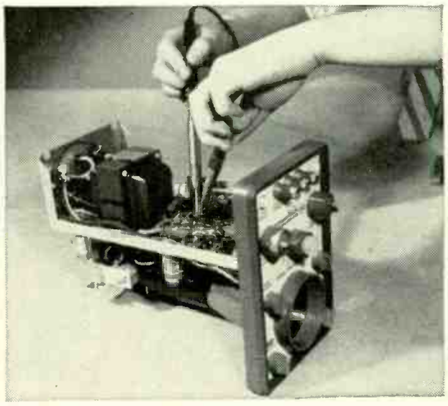
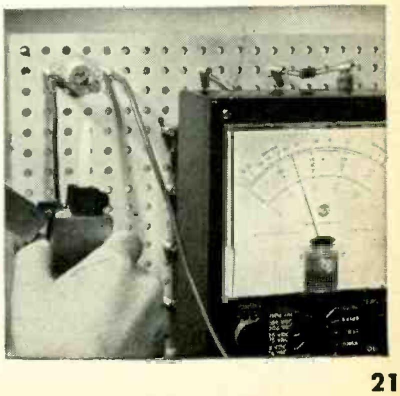
Construction of Multimeter.





Construction of Oscilloscope.

Temperature experiment with transistors.



IN THE SHOP
(*continued from page 17*)

the calibration. Touch the probe tip to the filament connections, set the gain control for the line height you want and there you are. Here's what you have: A 10-volt p–p signal *at the probe tip* makes a 2-inch, 3-inch, etc. vertical line on the screen. So, *any* 10-volt p–p signal at the probe tip will make a line of the same length on the screen. You don't have to worry about the probe's voltage-divider action, etc.

Cutting the horizontal gain to zero makes the scope easier to read, and helps in other ways. If you have a waveform with a long, thin spike like Fig. 2 on it, you may not even *see* it. It's so thin and fast that it makes a very weak trace. By cutting the horizontal sweep, the spike is

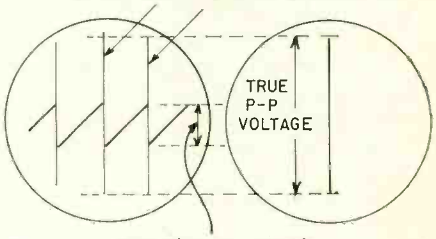


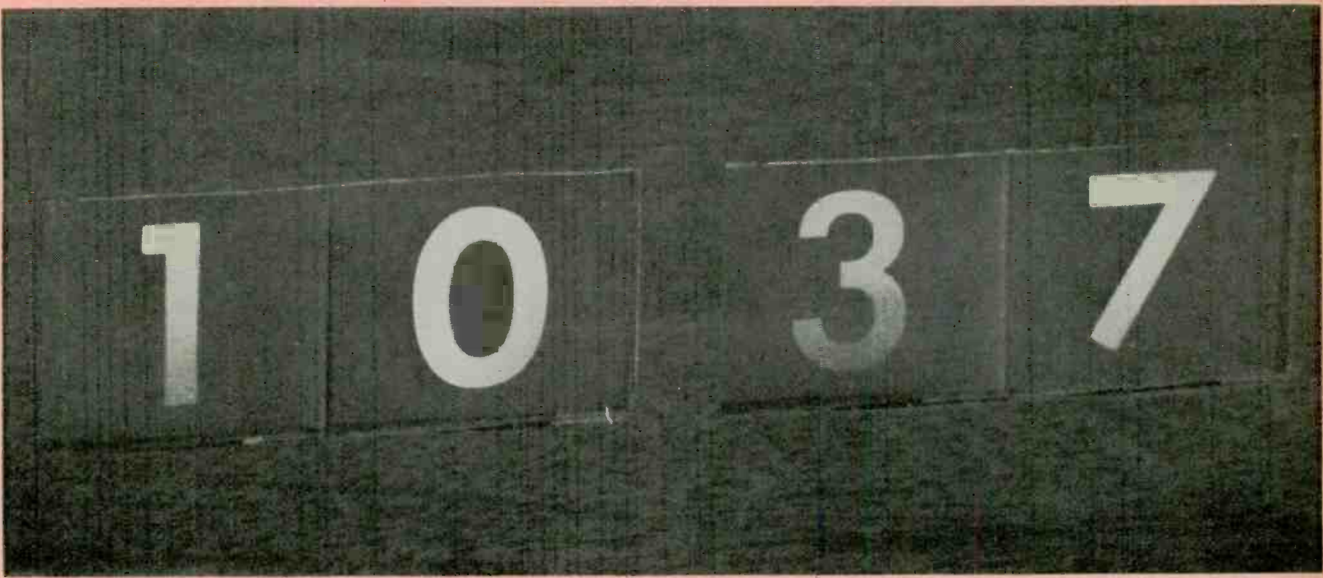
Fig. 2

scanned repeatedly, and becomes bright enough to see easily. This will show up spike and pulse waveforms that can otherwise be hard to read accurately. You might think the sawtooth part of the wave in Fig. 2 was the actual p–p voltage, but the spikes are at least three times higher.

You shouldn't touch the vertical gain control—the continuously variable control. If your scope has a step control (×1, ×10, and ×100), as most do, you can use this as a divider. For instance, set it to ×1, apply a 100-volt p–p signal and calibrate for a 4-inch deflection (or whatever you want). Then by turning the step control to ×10 (increasing the gain of the vertical amplifier 10 times), you will be able to read the same deflection for a 10-volt p–p signal. Going on up to ×100, you'll see the same deflection for a 1-volt p–p signal.

This works in the opposite direction, too. For example, if you want to read a 1000-volt p–p pulse and you have a 10-volt p–p calibrating voltage, set the step control on the ×100 (highest gain) range. Now ×10 will read 100 volts and ×1 will read 1000 volts for the same deflection. You've reduced the gain of the vertical amplifier by 10 or 100. To keep from getting confused on how this works, try it on the calibrating voltage. **R-E**

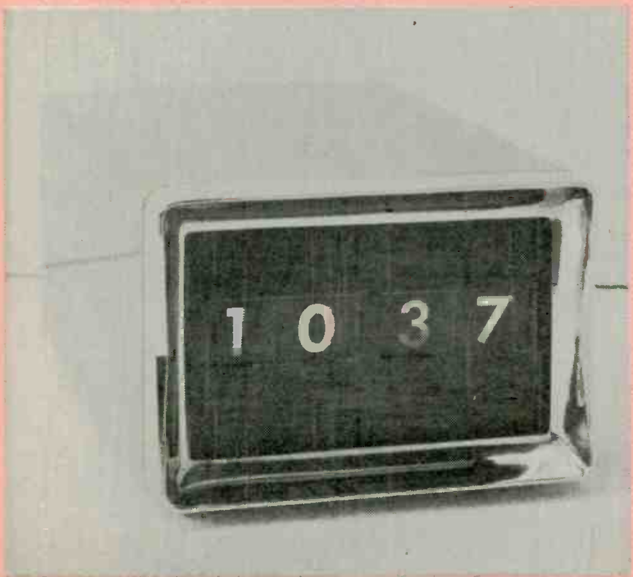
This is not a construction article. However, if you would like to see a complete "Build-It" story on this project drop a card to the editor. If readers show enough interest we will ask Mr. Plavcan to prepare an article with complete construction details for you.



A $200 IC DIGITAL CLOCK

IC's and numerical readouts combine to make a digital clock

by A. B. PLAVCAN

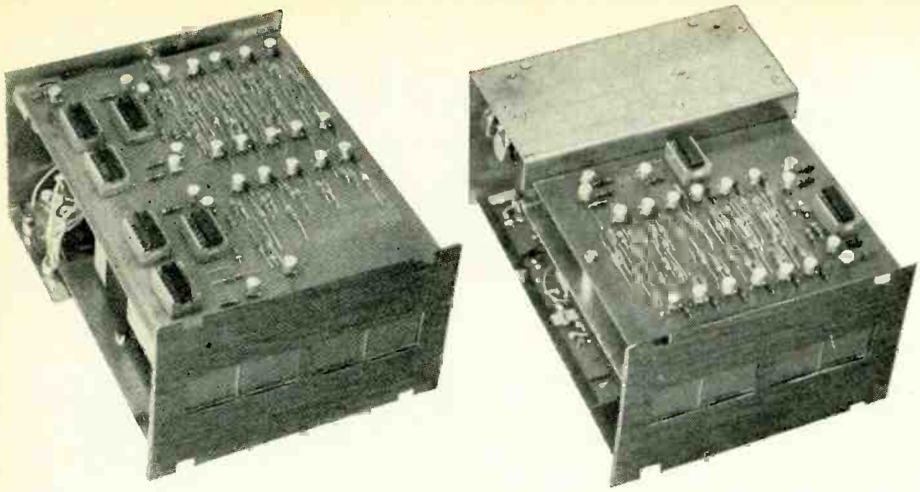


INTEGRATED CIRCUITS, LONG A LUXURY OF THE MILITARY, are rapidly finding their way into consumer oriented products. Prices have dropped within the reach of the average builder and experimenter. Here's a tale of how I've used these IC's (integrated circuits) to build a digital electronic clock.

This clock is designed around SN7492 IC counters (made by Texas Instruments) and diode transistor logic. It is a standard 12-hour clock that uses the 60-Hz line frequency as its main timing source. It features 115-volt ac operation, compact design, low current drain (less than 100-ma on the 115-volt line), and simple time set.

The layout is rather straightforward and not critical. The redundant circuitry lends itself well to printed-circuit techniques. I used sockets for the IC's to allow for easy replacement (should it become necessary) and as an aid to troubleshooting. Low-cost 2N5183 transistors are used wherever possible to keep costs down.

Operation is relatively simple. The 60-Hz line frequency is divided in IC1 and IC2 to 1 Hz (Fig. 1). This then becomes the reference count for all future timing. It



Inside the clock case. Two circuit cards carry most of the components. Space is tight, but a little planned cramming makes it all fit nicely. IC's are all in sockets to make replacement, if necessary, easy.

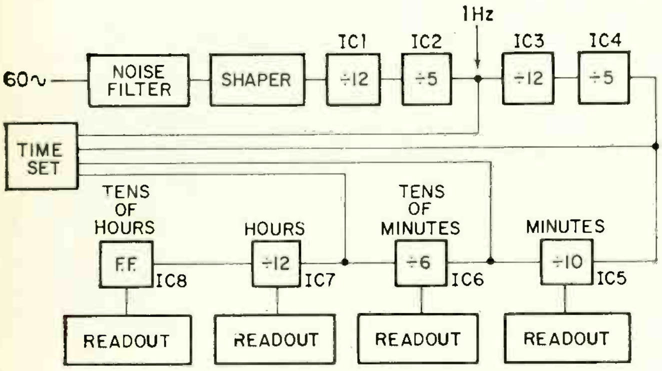


Fig. 1—Basic block diagram of the clock. It shows the order in which signals from the 60-Hz line are turned into timing pulses that operate the readout modules.

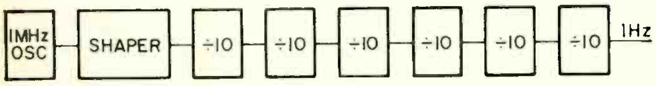


Fig. 2—For more accurate timing use a 1-MHz crystal oscillator and divide its signal down to tell time.

is further divided to produce the minutes and hours in the readout. Time accuracy is dependent on line-frequency stability. If greater accuracy is desired, additional IC's can be added as shown in the block diagram of Fig. 2. *If this is done, divide-by-ten units must be used.*

With the crystal-controlled 1-MHz oscillator shown in Fig. 2, the clock will be accurate to about 30 parts-per-million. This should be more than ample.

The 60-Hz signal input (Fig. 2) passes through a noise filter to prevent line noise, motors, switch transients, etc. from triggering the input divider. The signal then goes on to the shaper circuit (Fig. 4). The 0.1 μF capacitor across the 10,000-ohm resistor is a "speed-up" capacitor. It decreases the rise time of the leading edge (which becomes the trailing edge on the output) to provide better triggering for the divider. The diode clips the negative peaks of the sine wave to prevent V_{BE} breakdown. The shaped signal is now ready to divide down.

If SN7492 IC's are not available, SN7493 four-bit binary counters can be used instead. Basic operation is as follows.

If the reset lines (pins 2 and 3) are grounded, the counter will divide-by-16 (Pins 1 and 12 must be jumpered.), since each flip-flop divides-by-two and there are four flip-flops with no reset to inhibit the count (2^n where n is the number of flip-flops). But we're not interested in dividing by 16. We want to divide by 5, 6, 10, or 12. We can force this counter to divide by any of these numbers very easily. We'll need a truth table to do this. A truth table simply tells us the state of each flip-flop after each count.

Let's say we want to divide-by-five. The truth table (Fig. 9) shows us that after the fifth count, output "A" is high (1), output "B" is low (0), output "C" is high (1) and output "D" is low (0). Our four-bit binary requires both reset lines (pins 2 and 3) to be high (1) to reset to zero. We see that output "A" and output "C" are high (1). So if we connect output "A" (pin 12) to pin 2 and output "C" (pin 8) to pin 3, the counter will divide by five. When the count reaches five, the counter will reset to zero and repeat the count. Follow the same procedure for the other dividers. The SN7492 IC's I used follow the same procedure, even though the truth table (Fig. 8) is a little different. You'll notice that the four-bit binary consists of four J-K flip-flops and a NAND gate (NOT AND). If you took two SN7493 IC's and added a NAND gate as shown it will perform the same function as the SN7493 four-bit binary. You can also use separate J-K flip-flops and build up the dividers. The divide-by-five and divide-by-six require only three flip-flops each. Follow the same procedure as above. One advantage of the SN7493 is that the $\overline{Q}$ function is

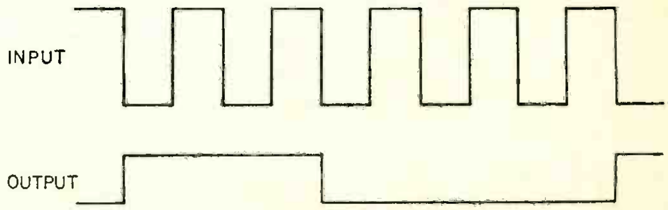


Fig. 3—This is what you'll see on a scope screen if you look at divide-by-six. Negative pulse triggers flip-flop.

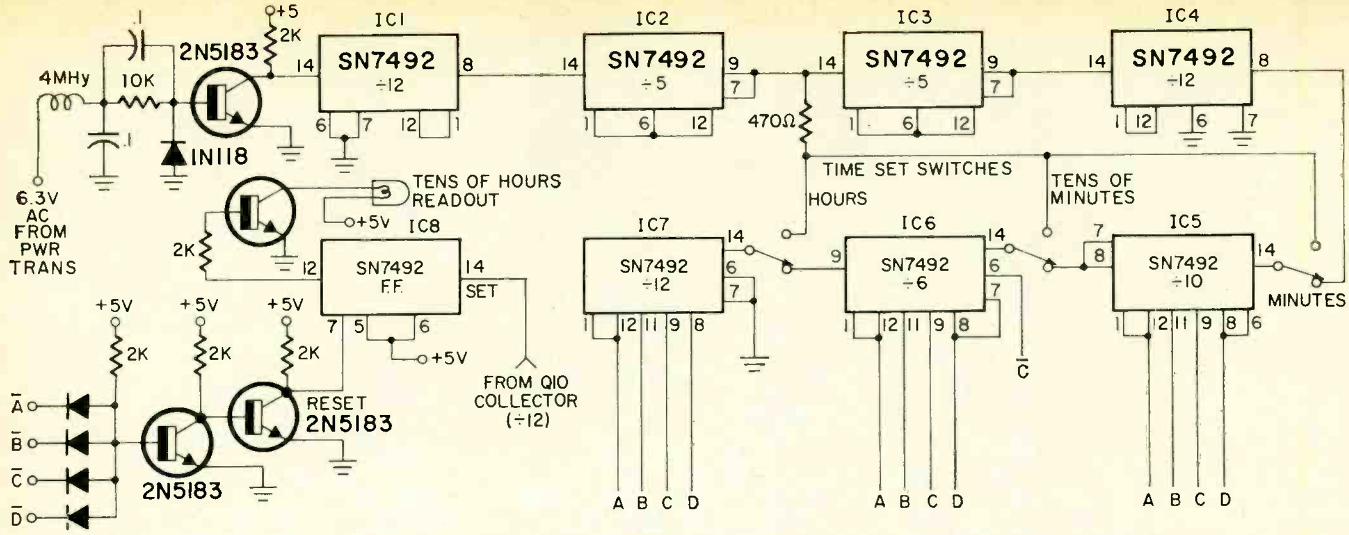


Fig. 4—Here we have the major portion of the clock circuits. All labeled circuit lines in this Figure connect to the matching points in Figures 5-a. and 5-b.

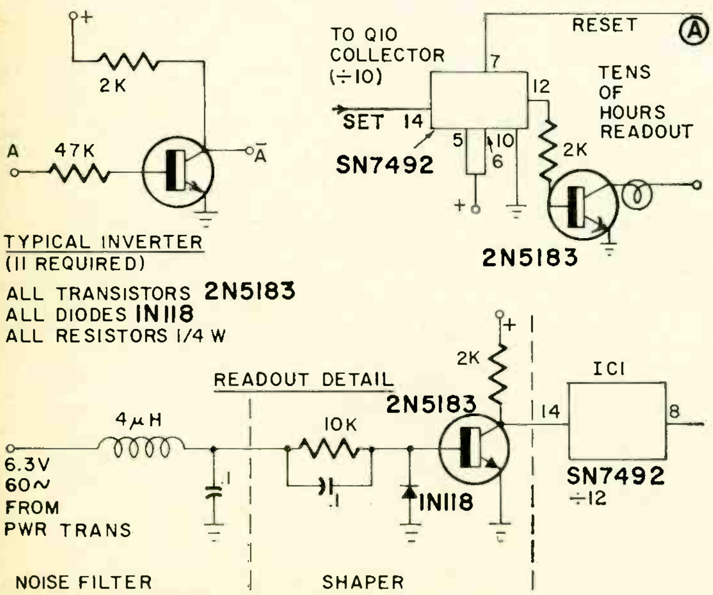
brought out to a terminal. You can eliminate all the inverters that are required for the SN7492 and connect instead to the Q terminals.

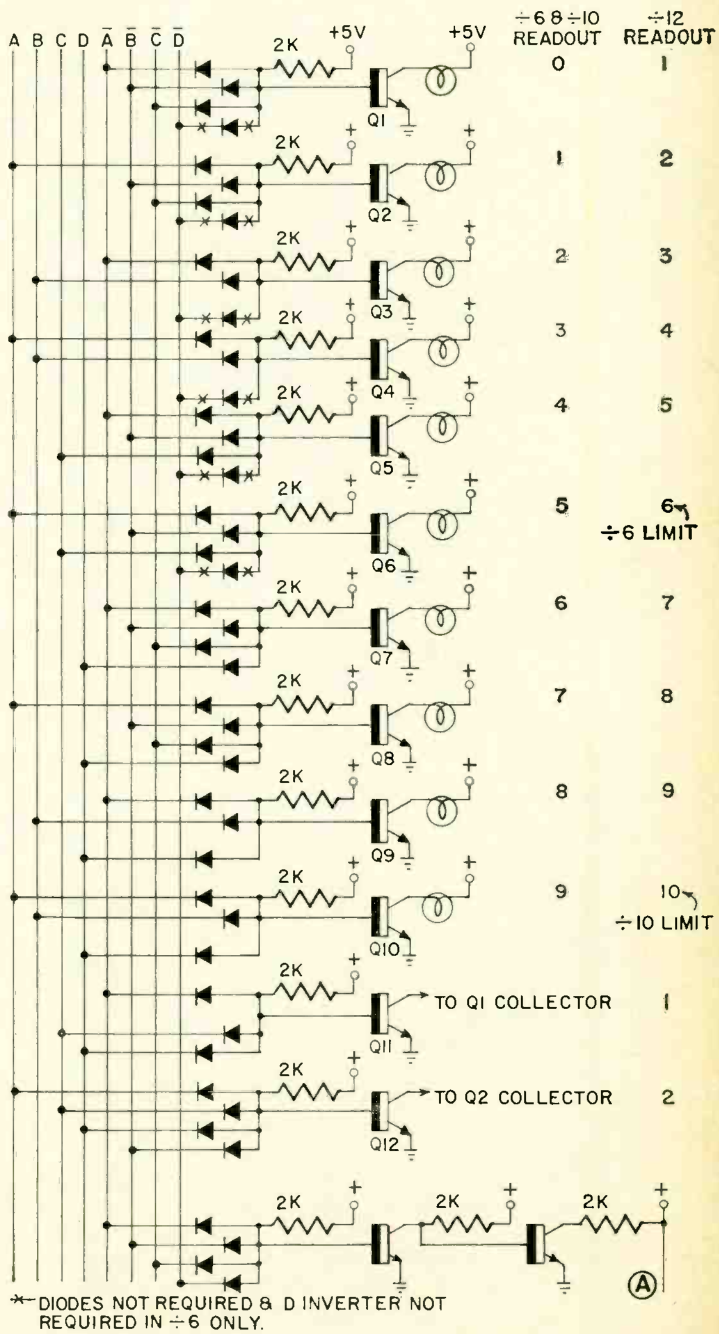
I used printed circuitry for all of the layout. Copperclad board is readily available at reasonable prices. I suggest you use masking tape to lay out the work instead of the dry-transfer material available. It tends to work a bit easier for the beginner. Use large ground areas in your layout too. Masking the layout is a little tedious, but the results are worth the effort. It eliminates a jungle of crossing wires and is easier to service.

After your printed-circuit boards are ready, it's time to start mounting the parts. Before you start, I suggest you check all parts electrically. A bad diode can cause an awful lot of unnecessary troubleshooting.

If you do end up with a troubleshooting problem, a scope and signal generator are musts. Simply insert a 1-MHz signal in place of the 60-Hz input. The scope can now be used to check each divider counter. Sync the

Fig. 5-a—(below) Details of typical inverter and readouts are depicted here. Fig. 5-b (right) is the diode-transistor logic to operate readouts. Like points interconnect.





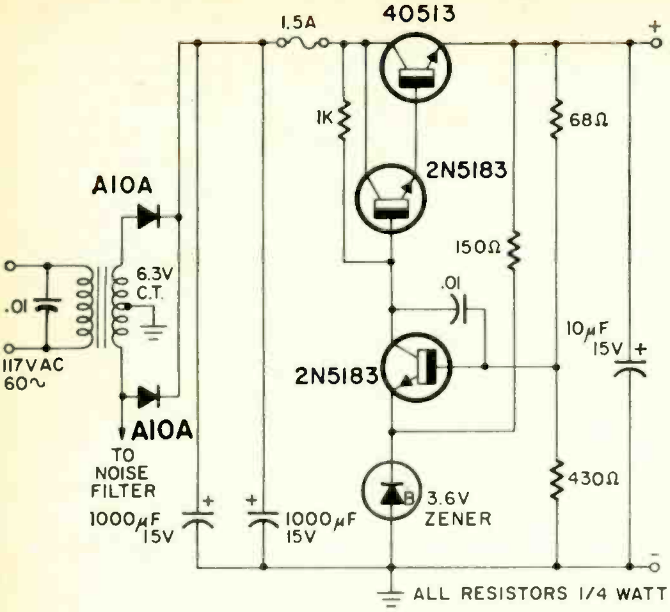


Fig. 6—(left) A simple power supply delivers 5-volts at 1 ampere to power the clock. Fig. 8—(right) is the Truth Table for the SN7492 IC.

SN7492
TRUTH TABLE

COUNT	A	B	C	D
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	1	0	0	0
7	1	0	0	1
8	1	0	1	0
9	1	0	1	1
10	1	1	0	0
11	1	1	0	1

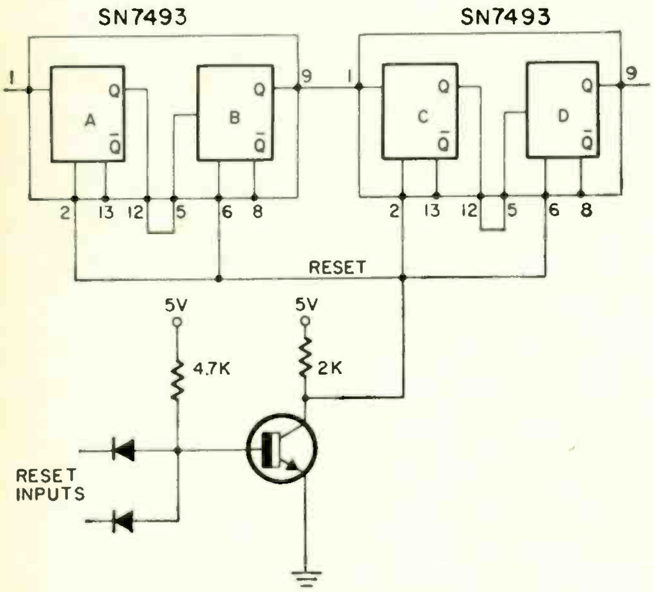


Fig. 7—(left) Details hookup for using SN7493 binary counters. Fig. 9—(right) is the Truth Table for the SN-7493 IC's.

SN7493
FOUR BIT BINARY COUNTER
TRUTH TABLE
JUMPER PIN 1 AND 12

COUNT	OUTPUT D	C	B	A
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
10	1	0	1	0
11	1	0	1	1
12	1	1	0	0
13	1	1	0	1
14	1	1	1	0
15	1	1	1	1

scope externally on the output of the counter under test (see Fig. 3).

The readout decoding follows the truth table (Fig. 8) and uses simple germanium diode-transistor logic to reduce the circuitry and cost. With germanium diodes and silicon transistors, if any diode input is grounded the transistor is off. All diode inputs must be high for the transistor to turn on. A 0.3-volt (typical) voltage differential exists between diode on and transistor off. This noise immunity is similar to the counters.

The 5.0-volt power supply shown in Fig. 6 is more than adequate to power the clock. It has a low ripple and good regulation to provide uniform illumination of the readouts and stable power for the IC's. The 6.3-volt readout bulbs work very well with 5.0 volts. Also, the reduced voltage insures longer bulb life. Use a good heat sink on the power pass transistor.

I used Texas-Instruments SN7492 divide-by-twelve IC counters throughout. They were purchased at a third of their usual cost from an electronic surplus store. But close examination will show that other divide-by counters could also be used. For example, divide-by-ten counters can be substituted and "strapped" to divide-by-five, divide-by-six, divide-by-ten. The only exception is IC7. It must be a divide-by-twelve in this particular design. IC8 need only be a set-reset flip-flop.

Another saving can be realized in the readout. The ones shown are made by Industrial Electronic Engineers of Van Nuys, Calif., and are fairly expensive. Radio-Shack has an edge-lighted unit that will work equally well.

The time set switches are the "make-before-break" type. This is a must to eliminate switching transients from flase triggering while setting the time. Rotary switches were used, since pushbutton make-before-break are not available.

To set the time after turning the clock on, let each readout run a complete cycle with the time-set switches to clear each counter. Then set the time.

IC's are here to stay, at least for a little while. Here's your chance to get familiar with them and have a useful timepiece for years to come. **R-E**

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GET BETTER PERFORMANCE

Add Electronic Ignition

by **BENNETT C. GOLDBERG & RAYMOND G. WILKINS**

DURING RECENT YEARS A NUMBER of articles have appeared describing transistorized automobile ignition systems. The majority of these systems (manufactured units and construction projects) had malfunctions after a few thousand miles of engine use due to exceeding germanium power transistor capabilities and poorly designed circuits.

The detrimental effects on germanium transistors occur with continuous operation at junction temperatures of 100°C. Temperatures in the engine compartment can range from +70° to +110°C or higher on hot summer days.

Silicon transistors

To beat the temperature problem, two transistor ignition systems were developed: a negative-ground system for American automobiles, and a positive-ground system for some foreign automobiles. A reliable high-voltage silicon power-switching transistor, having excellent beta with large collector currents at cold and hot temperature extremes, was selected. Silicon transistors have fast switching times and a junction temperature range in excess of +125°C with the proper heat sink.

These units were "worst case" designed for high reliability and laboratory-tested at ambient temperatures −55° to +125°C.

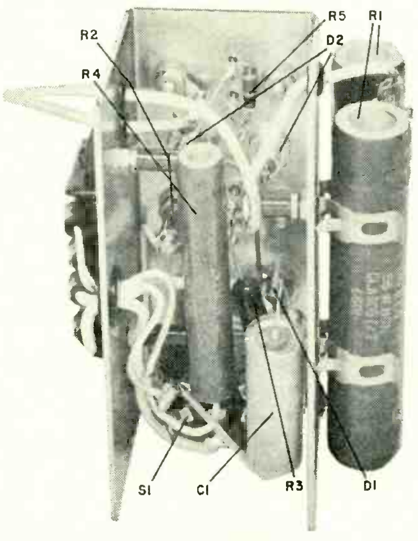
The negative-ground system has been in operation in a 1963 6-cylinder 85-h.p. Ford Falcon and a 1965 8-cylinder 325-h.p. Chevrolet. The systems have exceeded 10,000 miles without malfunction.

Circuit operation

On the negative-ground system (Fig. 1), current flows through R3 to the base of Q1 when the ignition breaker points are closed. This saturates the transistor and current flows through R4 to the base of Q2. Transistor Q2 then saturates and its collector current flows from the +12-volt battery terminal through ballast resistor R1 and transformer T1. Energy equal to ½ LI^2 (where L is the inductance of the transformer primary and I is the current flowing in the transformer primary) is stored in the T1's primary.

When the points open, Q1 no longer receives base drive, turning it off, and Q2 is cut off when it loses base drive from R4. Energy is stored in T1's primary until it reaches the breakdown voltage of Zener diode D2. This flux change in the transformer builds up a voltage in the secondary. The secondary voltage is the ignition pulse which jumps the spark plug. Ballast resistor R1 sets the primary current to the required amount. Zener diode D2 limits the voltage across transistor Q2 to a safe 100 volts.

During normal running, the battery is fully charged to 14–15 volts.



Inside the ignition system there's plenty of room to fit all parts without cramming.

Under these conditions, the ballast resistor is set to give a peak coil current of approximately 12 amps. When the car is starting, the battery voltage drops to 8–10 volts because of the starter load. This reduced battery voltage could mean less coil current and therefore a weak spark.

Therefore diode D1 is added to bypass the ballast resistor during engine cranking. This maintains the desired peak coil current and a full spark.

On the positive-ground system (Fig. 2), when the points are closed current flows through R3 to the base of Q1. This saturates the transistor, and current flows through R1, Q1, R4, R5, R6 at the primary of the transformer T1. When the points open the transistor no longer receives base drive. Current flow through the transistor is interrupted, and the operation is the same as the negative-ground system, including R1, D1 and D2.

Construction

The unit is built in a 2½ x 2½ x 5-inch aluminum box. The heat sink for D1, D2, Q1 and Q2 is the outside top of the box (see photo), D1, D2, Q1 and Q2 must be electrically insulated from the heat sink and ground. This is done by mounting the components with their insulating hardware and applying silicone grease on the metal surface. The grease aids in conducting the heat away. Arrangement of the components inside the box is not critical except D2 should be mounted near Q2.

Capacitor C1 (negative-ground system) should be the same value as the capacitor in the distributor next to the ignition breaker points. It may be placed inside the box or at terminal TB-6. The original breaker-point capacitor may be used later after the transistor ballast-resistor R1 is adjusted. This adjustment will be dis-

Silicon transistor ignition system can give your car a new lease on life—

To Your Car

cussed in more detail later.

Do not remove the capacitor in the positive-ground system. The time constant of R3 and the capacitor is small and has little effect on the input trigger pulse.

Ignition coil T1 is mounted on the engine firewall as close to the distributor as possible. Number 14 wire was used in all external wiring to the coil, ignition switch and starter. It is important that good grounds be used and all connections are secure.

The ignition-system package was mounted on the engine firewall. It could be mounted in another convenient location, preferably away from the exhaust manifolds. Tests had indicated it was not necessary to mount the package near the radiator or fan, thus simplifying installation.

The change-over arrangement from a conventional system to the transistor ignition is simple. To operate in the conventional mode, S1 is placed in position 2 and the center high-voltage distributor lead is plugged into the conventional coil. To operate in the transistor mode, place switch S1 to position 1 and plug the center high-voltage distributor lead into the transistor coil.

Here is a seven-step sequence for adjusting your negative ground transistor ignition system:

- With the transistor ignition system bolted to the firewall, connect wires to the positive and negative terminals of the transistor coil (**no wires to other terminals**).
- Place S1 in position 1.
- Start and run engine with normal ignition system until battery is fully charged. (Note: No connections have yet been made between the car's electrical system and the terminal strip.)
- With the engine running, connect a jumper wire with a 15-amp dc ammeter and ballast-resistor R1 (set to 1 ohm) in series between TB-4 and the positive terminal of the battery.
- Connect TB-5 to ground and adjust ballast-resistor R1 for a current reading of 12 amps. This will set R1 to the correct value,

PARTS LIST (Negative Ground)

R1—1-ohm 100-watt adjustable resistor Clarostat VK100NA or equal
R2—680-ohm ½-watt ±10%
R3—100-ohm 5-watt ±5% Clarostat VPR5F or equal
R4—10-ohm 20-watt ±5% Clarostat VPR-20H or equal
R5—47-ohm ½-watt ±10%
C1—22 µF 600-volt ignition-point capacitor (see text)
CR1—1N1199 50-volt, 12-amp silicon diode
CR2—1N3005 100-volt, 10-watt Zener diode
Q1—2N4901 pnp silicon transistor (Motorola)
Q2—2N3772 npn silicon transistor (RCA)
T1, S1, MISC—See positive ground
TO-3 Power Transistors, 2 req.

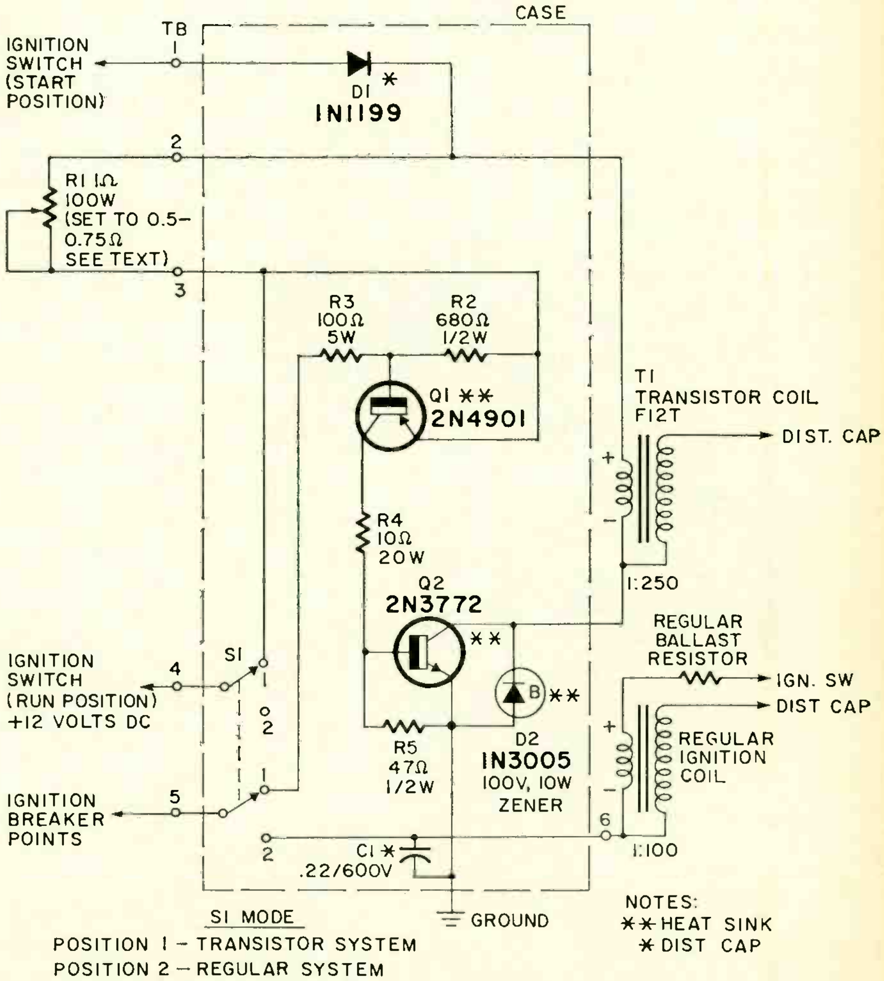


Fig. 1—This circuit is the one to use if you are building an ignition system to use with a negative-ground car. This includes almost all American made automobiles made in recent years. If you have a car with a positive-ground system try the circuit in Fig. 2.

which should be 0.5–0.75 ohm.

- Stop the engine, remove jumpers, etc., and connect wires to all terminals; remove the distributor capacitor (negative system only), and place it in the transistor box or at TB-6.
- Place the center high-voltage lead from the distributor to the transistor coil. Make sure switch S1 is in position 1. Your car will now start and run in the transistor mode.

This is the adjustment procedure for positive-ground systems:

- Bolt the transistor ignition system to the firewall. Connect a wire from TB5 to the negative terminal of transistor coil T1 and the positive terminal to frame (no other wires to terminals).
- Place S1 in position 1 (transistor ignition mode).
- Start and run engine with normal ignition system until the battery is fully charged.
- With the engine running, connect a jumper wire in series with an ammeter to TB2 and the negative terminal of the battery. (Set resistor R1 to 1 ohm.)
- Connect TB3 to the positive terminal of the battery or auto frame, and adjust ballast resistor R1 for a current of 12 amps. The value of R1 should now be between 0.25 and 0.5 ohm.
- Stop the engine and remove the jumpers, meter, etc., and connect wires to all terminals as shown in Fig. 2. (Do not remove the distributor capacitor.)
- Place the center high-voltage lead from the distributor to the center hole of the transistor coil. Switch S1 to position 1. **R-E**

PARTS LIST (Positive Ground)

R1—1-ohm 100-watt adjustable Clarostat VK100NA or equal
R2—47-ohm 1-watt ±10%
R3—7.5-ohm 5-watt ±5% Clarostat VPR5F or equal
R4, R5, R6—1-ohm 10-watt ±5% Clarostat VPR10F or equal
DR1—1N1199, 50-volt, 12 amp silicon diode
CR2—1N3005 100-volt, 10-watt Zener diode
Q1—2N3772 npn silicon transistor (RCA)
T1—Transistor ignition coil, 1:250T, Mallory F12T
S1—dpdt 15-amp 125-volt toggle switch, Arrow-Hart 82609
MISC—Barrier terminal block, Cinch Jones 6-142. Mini-Box 2½ x 2½ x 5", Bud CU-3004A. transistor mounting kit, Motorola MK-15. (For TO-3 power transistor, 1 req.)

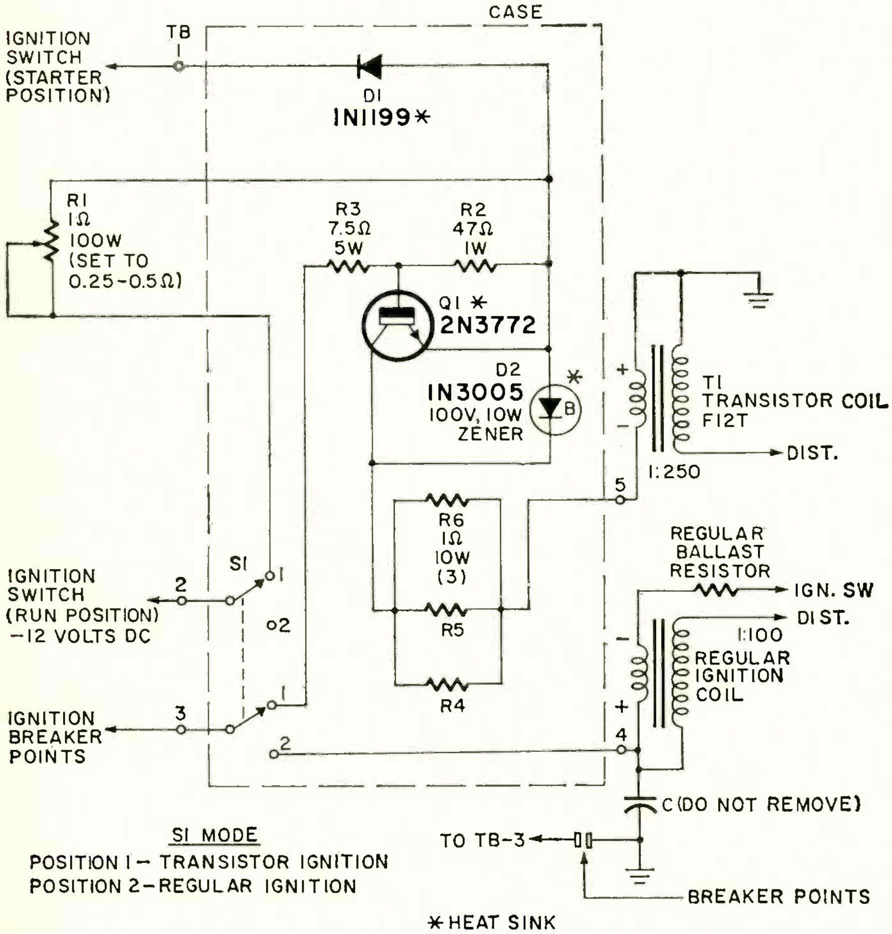
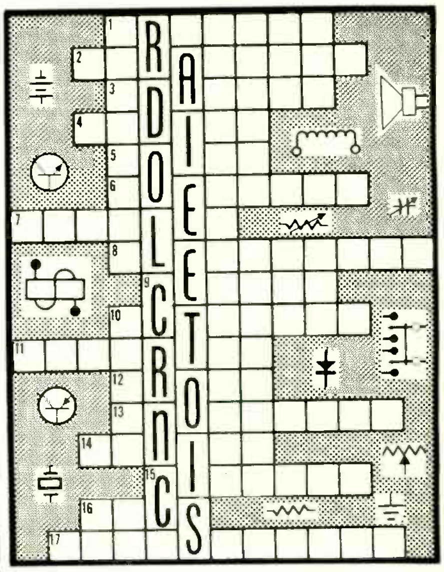


Fig. 2—Here's a circuit for an ignition system for a positive-ground car. This covers many European makes and some older U.S. models. Note that in this version, circuit ground floats. If your car has a positive ground, the positive battery terminal will be connected to the frame of the car. A glance under the hood is all you need.

R-E PUZZLER

by EDMUND A. BRAUN

Try this "only-across-word" puzzle based on electronic terminology. Each word is connected to the one above and below by a single letter. It should be fairly easy to get a perfect score except perhaps for someone who thinks "Heaviside layer" is the problem of the obese, or that "microhms" are similar to bacteria! Got a pencil? Ready? GO!



1 A circuit which is etched instead of wired.
2 Speech disguiser.
3 Device to change terminal arrangement of a jack, plug, socket, etc.
4 Three-electrode vacuum tube invented by Dr. Lee de Forest.
5 In TV, wavy effect observed when scanning parallel lines.
6 Unit of radioactive exposure.
7 Excursions above and below the average peak amplitude.
8 In vacuum tubes, cathodes, grids and plates.
9 Alkaline metal used in phototube cathodes.
10 Relay part converting electrical energy into mechanical motion.
11 Device that changes ac to dc, or vice versa.
12 Color of resistor band denoting number 1.
13 Process to improve appearance or corrosion resistance of metal surfaces.
14 Metal alloy used for speaker magnets.
15 Complete path of an electric current.
16 Discharges of electricity from one point to another.
17 RF noises due to natural activity, such as thunderstorms.

Check your answers with the solution on Page 93

CURE COLOR TV GREMLINS

Circuits that feed signals to the color CRT can be headaches. Here's the answer

By **MATTHEW MANDL**
CONTRIBUTING EDITOR

THE INPUT CATHODES, GRIDS AND screen grids of a color picture tube, not only combine the color (chrominance) signals with the black-and-white (luminance) signals, but control the relative intensity of each.

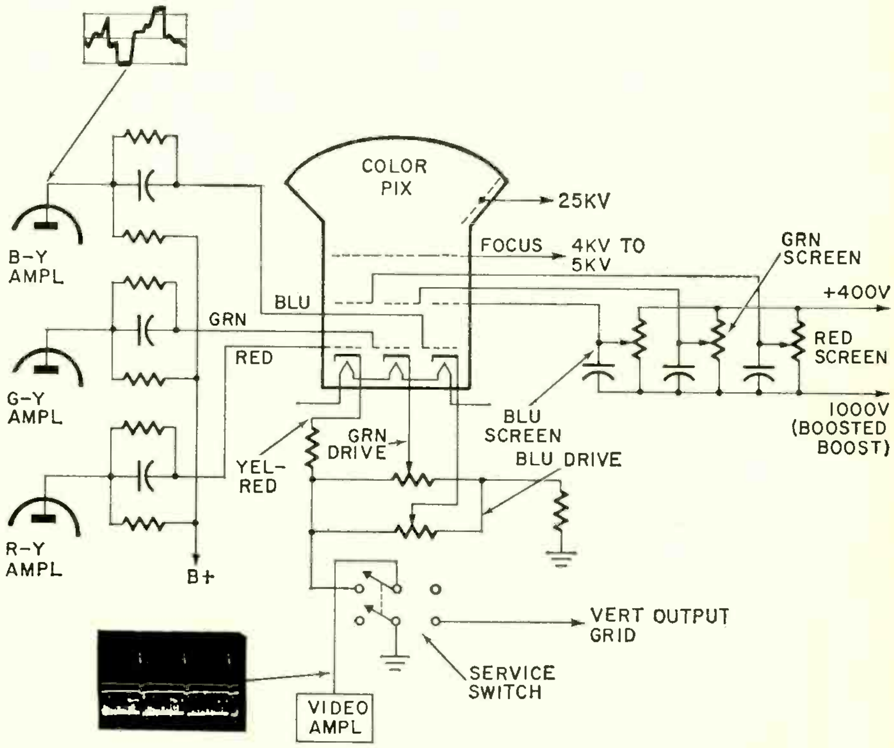
For good color reception, critical adjustments to get the proper balance are a must. The three-gun color CRT has three times as many input circuits as a black-and-white CRT. As a result, servicing problems are also more frequent and demanding, and a basic understanding of how the input circuits work helps speed troubleshooting and adjustments.

Typical input system

A typical input system for the larger-screen color sets is shown in Fig. 1. The luminance (Y) signals are applied to the cathodes. Generally, there are only blue and green drive controls. They are set to balance out with the fixed red-level drive. On some later receivers a red drive control has been added for more precise adjustments (RCA's CTC-31 chassis is an example).

A service switch permits gray-scale adjustments. It kills the vertical sweep (either by grounding some element in the vertical output section or opening a circuit), and removes the video signal input.

Color signals from the output amplifiers are applied to the individual control grids, as shown in Fig. 1. Each screen grid has an individual control for varying voltage and controlling beam acceleration. Voltage



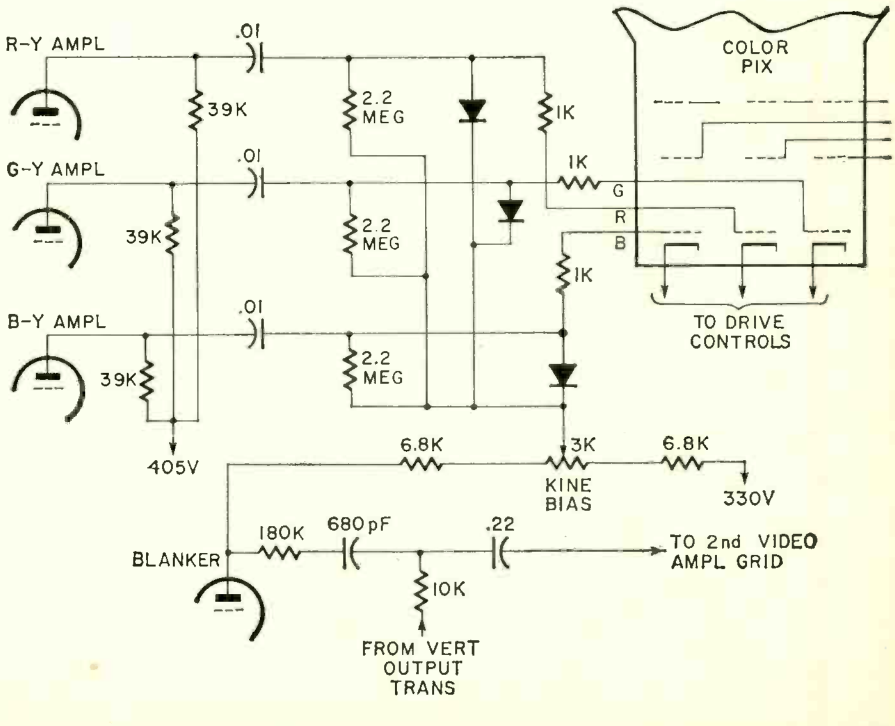


Fig. 1—(Top right) Typical input system for larger-screen color sets. The blue and green drive controls are set to balance out with the fixed red-level.

Fig. 2—(Bottom right) Bias control system is in the blanker anode circuit of this set and affects the amount of voltage applied to the color CRT grids.

may range from 400 to a 1000 (obtained from the boosted boost-voltage circuit).

A color-CRT bias control system is usually incorporated in the color amplifiers, output to the control grids. In some instances a three-position switch sets three brightness levels. On other occasions the bias control may be a potentiometer, as shown in Fig. 2. Here, the bias control is in the blanker anode circuit and affects the amount of voltage applied to the color CRT grids. Since the color amplifier anodes feed the control grids, a voltage change will affect bias and hence brightness. The blanker prevents the 3.58-MHz burst from getting to the picture tube.

Trouble symptoms

Improper colors are what you see if one of the color amplifier tubes goes bad. This also prevents black-and-white reception, since white are also dependent on a mixture of the three color signals. A scope check at the anodes of the color amplifier tubes helps localize the circuit not producing an output signal. The color signals are distinguished by positive and negative pulse-type combinations (as shown in Fig. 1), in contrast to the standard composite video signal present at the output of video amplifiers.

Also make sure the control settings haven't been tampered with. Many set owners try to make improvements themselves and eventually throw the controls pretty far off normal. In one such instance the owner insisted the color tube was defective because he could only get a black-and-white picture. It was difficult to convince him that if a color set produces a good black and white picture, the tube *has* to be good, because each gun must be working properly. In addition, convergence and purity must be good to prevent color contamination.

For total loss of color, check the settings of the color (chroma) and tint controls, as well as the color-killer threshold control. Improper antenna orientation can also kill colors completely.

Control adjustments

The screen-grid controls provide good white high-lighted areas in black-and-white reception during bright signal levels. Set the cathode drive controls (also called *background* controls) for good dark-gray tones in the darker signal levels. Tracking should be good for all brightness levels. Adjustments are called *gray-scale tracking*, or *temperature* adjustments.

Set the bias switch or control for low brightness and the screen controls to a minimum. Put the service switch into the SERVICE position to kill vertical sweep. Shunt the green and blue control grids with separate 100,000-ohm resistors and advance the red screen control until a red horizontal line is visible. (If you don't get the red line, turn up the bias control or switch for increased brightness.)

Repeat this procedure by shunting the green and red control grids with 100,000-ohm resistors and adjusting the blue screen control to produce a visible blue horizontal line. Repeat this procedure for green.

Now return the service switch to NORMAL and turn up the bias switch or control for normal brightness. Alternately adjust the drive controls during black-and-white picture reception for good reception in dark-scene areas.

If you run into trouble during gray-scale tracking, check voltages and component values in the cathode and screen-grid circuits. With the receiver off, check for smooth and uninterrupted resistance changes in each pot.

Because poor results are also caused by improper purity adjustments, check them as a matter of routine when servicing. Purity relates to the fact that the red gun must direct the electron beam within the picture tube to the red phosphors only, the blue gun to the blue phosphors, and the green gun to the green phosphors. To do this, purity magnet rings on the picture tube neck shift the three beams into proper position.

Make initial purity adjustments with only the red gun working, because a red field on the screen of the tube is easier to judge for purity. Once you get a pure red field the blue and green are usually pure too. If not, slight readjustments of the purity magnet will do the trick.

To set up purity the green and blue picture-tube control grids are shunted to ground with 100,000-ohm resistors and the tabs of the purity magnet set together. Spreading these tabs apart usually increases the strength of the purity magnet (see Fig. 3).

Next, loosen the yoke and slide it as far toward the tube base as possible. Then rotate the purity magnet slowly and spread the tabs apart until you see a uniform red area at the tube center. Next move the yoke forward until the entire screen is a uniform red without corner shadows.

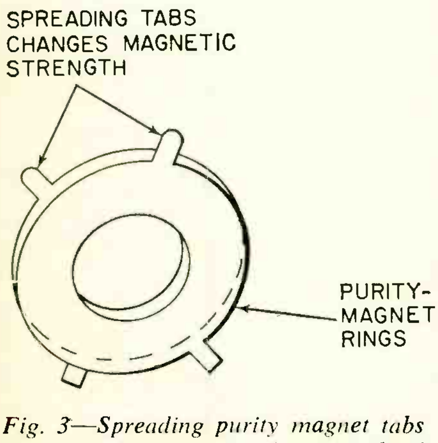
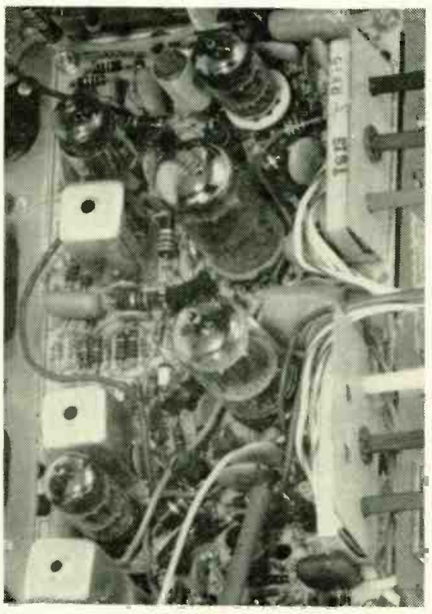


Fig. 3—Spreading purity magnet tabs apart usually increases the strength of the magnet.



Closeup of color circuitry that feeds the color CRT in Sylvania color TV set.

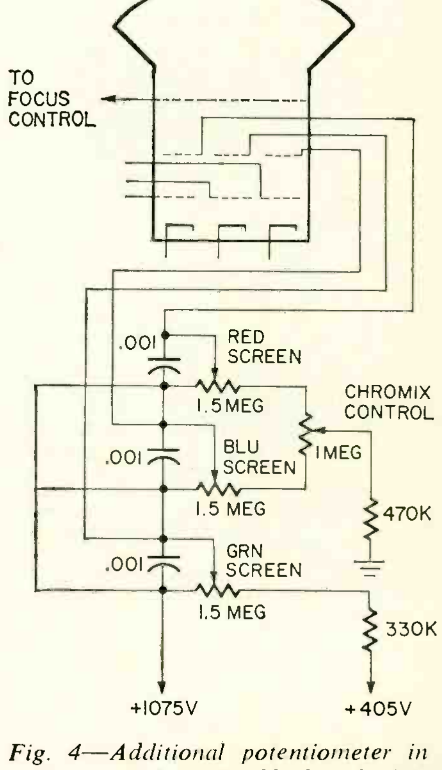


Fig. 4—Additional potentiometer in screen controls varies black-and-white picture tints.

(The purity magnets adjust for center-screen uniform field and the yoke placement affects edge purity.) Purity can now be checked for the green and blue screens by shunting the red and blue control grids with the 100,000-ohm resistors for the green field, etc.

With all three guns in operation, check for a pure white screen. The yoke may have to be repositioned slightly if there is some edge impurity.

Circuit variations

While Fig. 1 is typical for many color receivers, there are circuit variations. The Silvertone chassis 529-72130, for instance, has an additional potentiometer in the screen controls as shown in Fig. 4. It permits a slight tint variation in black-and-white pictures by unbalancing the red, blue and green levels which produce pure white. Thus, the CHROMIX control permits shading the b-w picture from slightly brownish to bluish if desired. If the screen controls are turned up too high, the CHROMIX control has little effect. So in this chassis good gray-scale tracking is particularly important.

With the circuit shown in Fig. 1 any variation of the drive controls in the cathodes affects tube bias and individual brightness of the color guns. With a more positive cathode, the grid becomes relatively negative and reduces beam current and brightness. In the G-E HC chassis color receiver the relative bias of the grids is adjusted instead of the individual cathodes as shown in Fig. 5.

The three cathodes are common and cathode voltage is changed with a common brightness control. Once it is set for the desired level, you get color drive (brightness) balance by adjusting the blue and green brightness controls individually. With the circuit in Fig. 5, the red bias is at a set level and the blue and green controls can vary above or below the set red level for proper balance.

Gray-scale tracking and purity adjustments are similar to those described earlier. Individual bias at each grid can be read with a vtvm between grid and cathode. Voltage between cathode and ground depends on the setting of the brightness control. A variation of more than 40 volts is the normal.

If you run into trouble, check for low voltages (135 volts at the video amplifier plate feed and brightness control, and 280 volts at the other end of the control). There should be a smooth voltage change at the variable arm of the blue and green brightness controls. Erratic voltage changes as the controls are slowly advanced calls for check of resistance changes. **R-E**

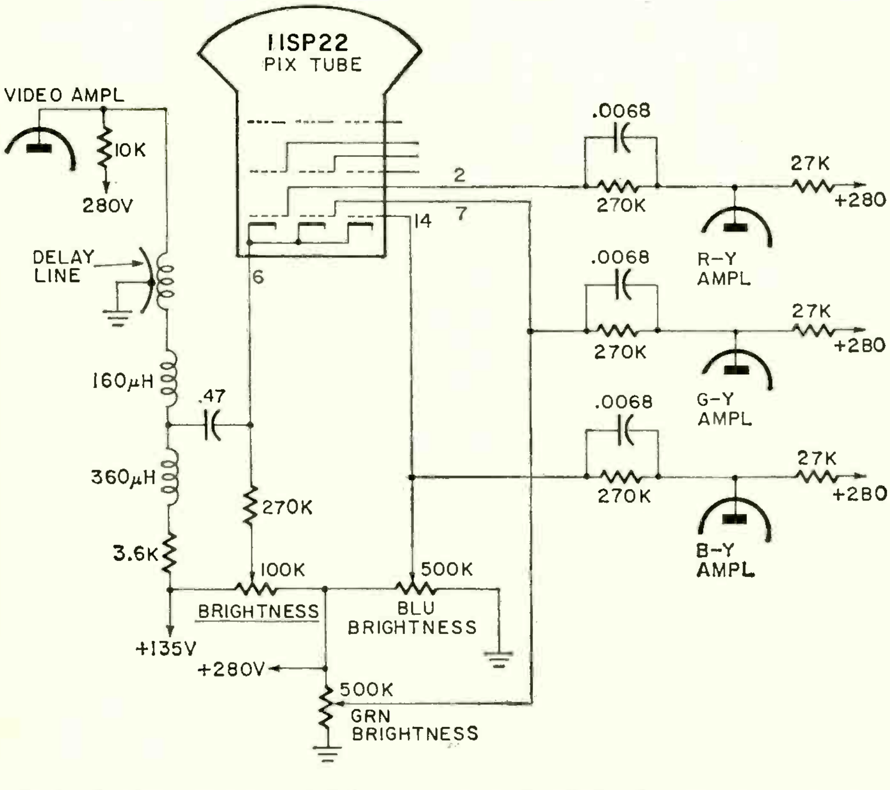


Fig. 5—In this circuit the red bias is at a set level and the blue and green controls can vary above and below the set red value. This permits easily setting up the correct color balance on the CRT.

CREDIT CARD SNOOP

ARE YOU A CREDIT-CARD SHOPPER? IF so, don't be surprised if a department store sales clerk pops your card into a mysterious box and begins pressing buttons. What's happening? Your credit is being checked in about 1/30 sec, and one of four lights hidden from your view on a card reader (foreground below) can tell the clerk how good your account is.

Credit-card authorizing system can be used with a few card readers (foreground) in small stores or with dozens of readers in giant department store chains via a central computer.

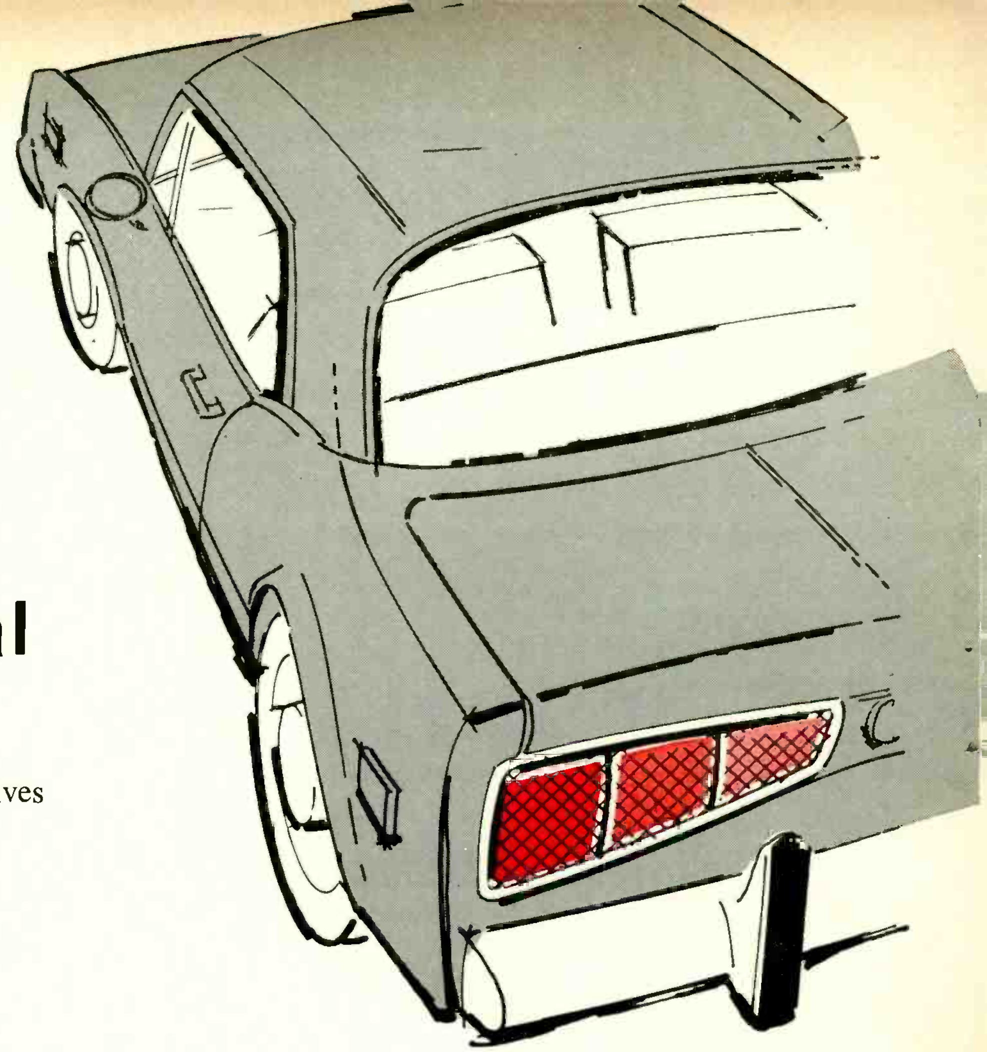
If you haven't paid your bill in months, a light may indicate the central credit office should be called for sales authorization. For most shoppers, however, a "go" light will save tedious minutes waiting for a credit search of the store's files.

National chain stores with 1 million credit cards in circulation figure some 50,000 of these cards are bad risks. This new authorizing system, developed by Digital Data Systems Corp., is being rented to retailers—large or small—to stop losses from fraud and bad debts.

Sales-counter card readers are tied to the computer-like central processor and credit-office console. To keep the size and costs of the system down, integrated circuits were used extensively. The card-reader circuit board shown here, for example, contains more than 20 IC's, and the system uses medium-scale-integration IC's developed at Texas Instruments that replace several regular IC's. **R-E**

For your car

1---2---3 Sequential Turn Signal



Reliable solid-state unit works with minimum wiring changes. Gives your car that modern look

by JAY NUNLEY

THIS SOLID-STATE CIRCUIT WILL TURN ON YOUR REAR TURN-signal lamps, provided you have three on each side of your car, in a 1-2-3 sequence after the fashion of the late-model Thunderbirds and the Cougars. Sequential turn signals add a touch of style to your car and may provide a degree of added safety in that they point out the direction of the intended turn more dramatically than a simple on–off flash. If you want sequential turn signals (and have the necessary lamps on the rear of your car), this circuit will do the job reliably with an absolute minimum of modifications to your existing wiring.

The circuit was designed with the average driver in mind. That is the driver whose desire for sequential turn signals is not sufficiently strong to compel him to make major alterations to his car. He would not want to install additional wires, modify his turn-signal switch (which is buried inside the steering wheel hub), or undergo other great difficulties in performing installation. Furthermore, he would want to be able to convert back quickly to the original system, for safety's sake, in the event the sequential system failed.

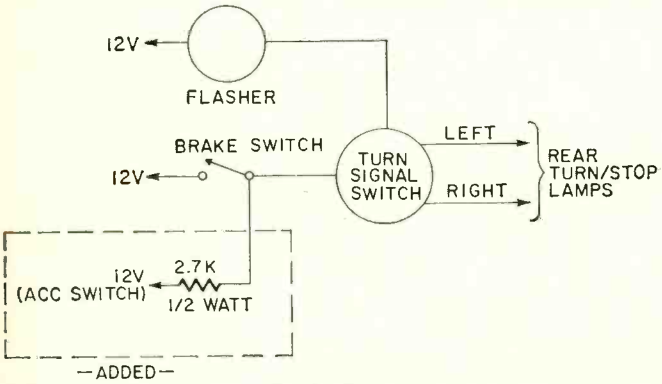
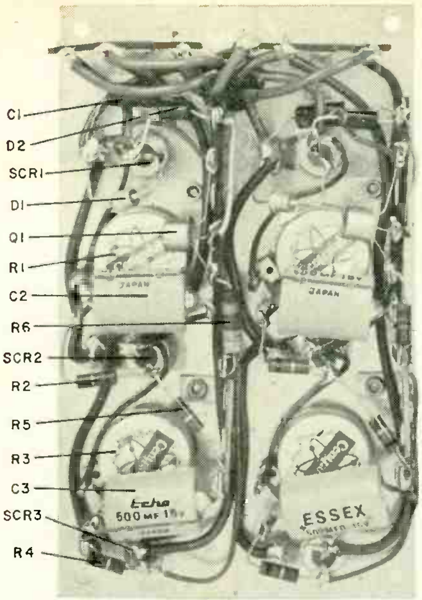


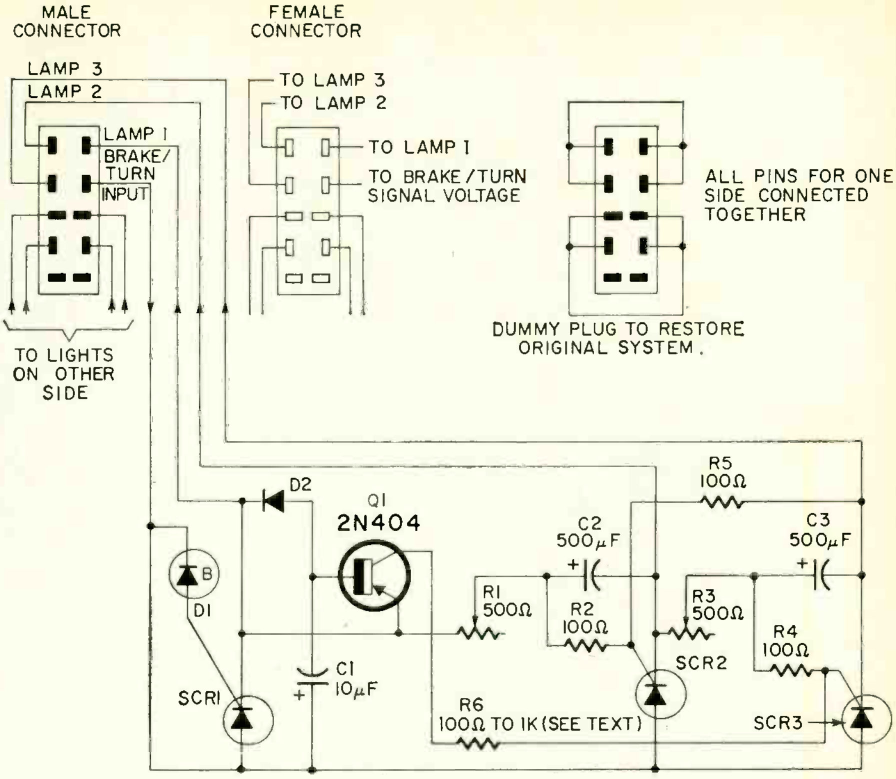
Fig. 1—Basic automobile brake/turn-signal lamp system. Flasher interrupts 12 volts at regular rate when the turn switch is on, and brake-switch line is disconnected.

Operation

Except for the portion in the dashed-line box, Fig. 1 shows the basic idea of a car's brake/turn-signal lamp system. When the turn-signal switch is in the center position, all lamps are connected to the brakeswitch line. Step on the brake and 12 volts is applied to all lamps. When the turn-signal switch is flipped in one direction or another, the brake-switch line is removed from the signaling side and 12 volts is applied to the lamps on that side through the flasher, which interrupts the 12 volts at a more-or-less regular rate. The side which is not signaling continues to be connected to the brake-switch line. We will ignore the tail lamps, which are actually lower-wattage filaments in the same bulbs as the brake/turn-signal lamps and which remain unchanged.

At the rear of the car we have only two lines coming in for the brake/turn-signal lamps, one for the right side and one for the left. If the brake is applied, we want all lamps to go on together without the sequential effect; if the turn signal is applied, we want the sequential effect. Since 12 volts is applied in either case, we must find a way of distinguishing a brake signal from a turn signal. The 2.7K resistor shown in the dashed-line box in Fig. 1 does the trick. In effect, it applies an "attenuated" 12 volts to the lamp wires around the brake switch. This attenuated 12 volts gets through only to the side or sides selected by the turn-signal switch to receive the brake signal and thus identifies the times when the lamps are to go on all together.





The photo above shows parts layout inside the turn-signal box. The parts in the uncoded half duplicate those noted. Fig. 2—One side of the sequencing circuit, which must be duplicated for other signal side. Lamp 2 has ¼-sec delay.

Figure 2 is the schematic diagram of the sequencing unit. Only one side is shown; two such circuits must be built for a complete sequential system. For the time being, ignore Q1, D2, C1, R5 and R6, which have to do solely with the brake mode. When the turn-signal switch is flipped to signal a turn, 12 volts is applied to the anodes of the three SCR's and to the cathode of D1. The Zener voltage of D1 is exceeded, and so current is passed to the gate of SCR1, turning it on immediately. This lights lamp 1 and applies 12 volts to C2 through R1. There is a delay while C2 charges to a voltage sufficient to trigger the gate of SCR2. Then SCR2 is turned on, lamp 2 lights, and 12 volts is applied through R3 to C3. After a delay, SCR3 is turned on and lamp 3 lights. Now, all three lamps are on, the car's flasher is properly loaded and, after a delay, opens, turning off the lamps and the SCR's. Incidentally, the SCR's *must* be turned off externally, since once triggered into conduction they remain on as long as there is a minimum holding current through them. The flasher remains open for a brief period, then closes, whereupon the sequence described above is repeated.

The turn-on delays of lamps 2 and 3 are provided by the RC time constants of R1–CE and R3–C3. The values chosen yield about ¼ second maximum. R1 and R3 are adjustable to compensate for differences in components so that an evenly spaced sequence may be obtained, and to allow the constructor to select the sequencing speed which has greatest esthetic appeal. R2 and R4 are used to give an elevated turn-on point for the gates of SCR2 and SCR3. If the delays obtained with maximum settings of R1 and R3 seem too short, which may be the case if the gates of SCR2 and SCR3 are unusually sensitive, the delay may be increased by increasing the values of R2 and R4.

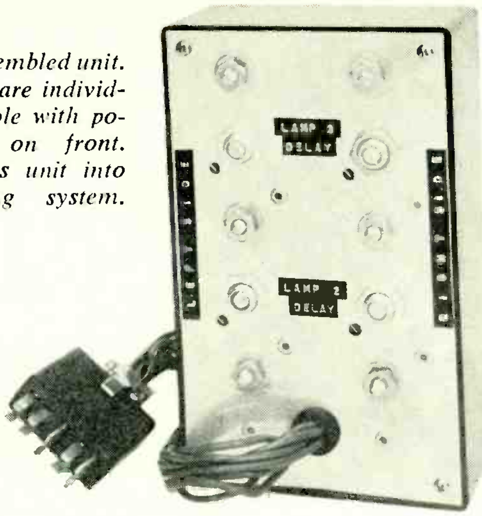
Notice that the circuit does not require a ground connection. The necessary ground (negative) returns are provided through the lamp filaments which, when cold, have a resistance of less than an ohm. Placing the lamps in series with the cathodes of the SCR's has the advantage of providing pulsed operation of the SCR gates, which promotes SCR longevity. The instant the SCR's turn on, their cathodes rise to 12 volts, so the potential between gate and cathode is zero and gate current is terminated.

The front turn-signal lamps are in no way part of this circuit. They are connected in series with the car's flasher, and go on when the flasher closes per original design. The only effect the sequential system has on the front turn-signal lamps is that their on period will be a little longer than before, since they remain on while the rear lamps go through the 1-2-3 sequence. Then the front lamps go off when the rear lamps are turned off by the flasher. The effect is very little different from the original.

As stated previously, when the brake pedal is pressed we want the rear lamps which are not engaged in signaling a turn to go on simultaneously without sequencing. To do this, the circuit obtains information from the brake/turn-signal line during the lamps-off period. When the turn-signal switch selects the brake-switch line, but the brake switch is not closed (brakes not applied), 12 volts is routed to the sequencer circuit through the added 2.7K resistor (Fig. 1). The value of this resistor is chosen so that it limits the current to a level below the holding current of the SCR's; hence the SCR's and lamps are off. The 12 volts sees a path to ground through D1, the gate and cathode of SCR1, and the filament of lamp 1. But D1 has a reverse breakdown of 10 volts, so 10 volts appears at the input of the sequencer circuit. This 10 volts charges C1 through D2 and the filament of lamp 1.

When the brake pedal is pressed, the brake switch bypasses the 2.7K resistor and applies 12 volts to the input of the sequencer. Instantly SCR1 and lamp 1 are turned on and, since it is tied to the cathode of SCR1, the emitter of Q1 becomes 12 volts positive. The negative end of C1 is blocked by D2 from discharging directly through SCR1 and so C1 discharges through the base and emitter of Q1 and SCR1. This discharge of C1 briefly turns on Q1 and the collector of Q1 becomes positive. Positive voltage from the collector of Q1 goes through R6 to the gate of SCR3, turning it and lamp 3 on. When SCR3 is on, gate voltage is routed to SCR2 through R5, turning on SCR2 and lamp 2. The delay between turn-on of lamps 1, 2 and 3 is small and all appear to light simultaneously.

During turn-signal operation, the 2.7K resistor is out



Here's the assembled unit. Lamp delays are individually adjustable with potentiometers on front. Plug connects unit into car's lighting system.

of the circuit and so C1 is not charged during the lamps-off period; hence, Q1 is not turned on and the 1-2-3 sequence takes place. In brake mode, there is a minimum off time required to charge C1 as determined by the RC time constant of the 2.7K resistor and C1. This turns out to be something in the neighborhood of 0.03 second. Therefore, if the brake pedal were released and reapplied in less than 0.03 second, C1 would not be charged, Q1 would not be turned on, and the lamps would turn on sequentially instead of simultaneously. But brake pedals, because of their weight and the inertia of the mechanism they are attached to, cannot be released and reapplied in 0.03 second.

Construction and installation

The two circuits, one for the right side and one for the left, can be built on the same or separate chassis; they are independent of each other. The SCR's are efficient and don't require expensive finned heat sinks; mounting the studs of the SCR's through the metal of the chassis with appropriate electrical insulating hardware will suffice. The studs of the SCR's are the anodes and will be at +12 volts, so must be kept from contact with any conducting parts of the car.

The SCR's are the most expensive parts in this circuit, but the cost can be justified on the basis of expected reliability. Just about any SCR's that will handle 3 amperes or more at 12 piv or more will do, and they needn't all be the same. Minimum holding is a critical parameter and it's a parameter you cannot buy on specification off the shelf. Manufacturers specify some minimum current at which the SCR will remain on, but they generally don't specify the lower current limit below which the SCR will turn off. The current through the 2.7K resistor is less than 5 milliamperes, and I find that this is below the holding current of nearly all SCR's in the 3-ampere forward-current range. But occasionally you will find an "eager" SCR, one that wants to stay on clear down to 1 milliampere or less. If this happens, the drop across the 2.7K resistor will be large, C1 won't charge during the lamps-off period, and in brake mode the lamps will be on sequentially. One way around this is to increase the value of the 2.7K resistor, but then the charging time of C1 would be increased. Best bet is not to use an "eager" SCR in this circuit; save it for an ac application where minimum holding current is not important.

The value of R6 depends on the leakage current of Q1 and to a larger degree on the sensitivity of SCR3's gate. Start with a value of 470 ohms, which will work in many cases. However, if you find that the unit refuses to sequence in turn-signal mode, that is, all lamps flash on and off together, increase the value of R6 in 50- or 100-ohm increments until the defect is corrected. On the other hand, if the unit sequences properly in turn-signal mode but also sequences when the brakes are applied, reduce the value of R6 until the defect is corrected.

Terminate the sequencer unit with a male connector capable of carrying about 9 amperes for the input and 3 amperes for each of the lamps. Contacts can be paralleled for added current-carrying capability. In your car, each of the rear lamps will have two wires going to it, one for the low-wattage "tail" lamp filament and one for the higher-wattage brake/turn-signal lamp filament. If you can't determine which is which, cut one and turn on the car's parking lights. If the "tail" lamp is out you've cut the wrong one and will have to splice it back together and cut the other one. Wire the lamps and the brake/turn-signal line to a female connector as shown in Fig. 2. Lamp 1 is the one nearest the center of the car. Then prepare a dummy male connector as shown in Fig. 2. If the sequencer circuit fails, disconnect the sequencer circuit connector and install the dummy connector in its place. This restores the original system. However, the SCR's should be extremely reliable in a noninductive switching application of this type, and long, trouble-free operation of the unit is to be expected.

If your car has fewer than three brake/turn-signal lamps on each side (as many cars do), and you want sequential turn signals badly enough to install additional lamps, remember that you must also change the existing flasher unit up under the dash of the car. Flashers are designed to work with a certain lamp load and if you increase the load by adding lamps, the flasher will operate so rapidly that the sequencer circuit won't get a chance to go through its 1-2-3 cycle.

If your foot is not on the brake pedal and you flip the turn-signal switch for a turn, the turn signal will flash on and off once without sequencing, after which the turn signal will sequence 1-2-3 on all subsequent flashes. The reason for this is that C1 has been charged by the 2.7K resistor in the brake-switch circuit just prior to its being switched out of the circuit by the turn-signal switch. This doesn't happen if your foot is on the brake pedal when you flip on the turn-signal switch because when SCR1 is on, C1 can't charge up. This small idiosyncrasy is scarcely noticeable, and avoiding it would involve circuit complications not worth the trouble.

If you connect the 2.7K resistor to 12 volts through the accessory side of the ignition switch as shown in Fig. 1, then if you apply the brake pedal when the ignition switch is off, the brake lights will sequence on both sides and remain on until the pedal is released. The reason for this is that when the ignition switch is off, 12 volts is removed from the 2.7K resistor and C1 won't charge. If this bothers you, it can be overcome by connecting the two ends of the 2.7K resistor to the two terminals on the brake switch, actually a simpler installation. This keeps 12 volts on the 2.7K resistor at all times, even when the ignition switch is off, but it also puts a slight drain on the battery at all times, even when the ignition switch is off. The drain is slight indeed, and it would take many weeks of this drain to discharge a fully charged battery. Because of the action of D1, the drop across the 2.7K resistor is only about 2 volts, so the drain is only about 800 microamperes. Even if D1 or C1 were shorted, the drain would be less than 5 milliamperes. Still, I have a deep-rooted aversion to walking away from my car knowing there is a closed circuit in it somewhere drawing current; so I show the connection to the accessory switch which is turned off when the car is left standing. **R-E**

COVER STORY

BUILD—R-E EXCLUSIVE

125 WATTS PER CHANNEL STEREO AMPLIFIER

By KENNETH F. BUEGEL

THIS ARTICLE IS THE FIRST OF THREE that will give details on how to build a complete state-of-the-art stereophonic high-fidelity system that is the ultimate in quality and performance.

The three parts are the power amplifier—it delivers 125-watts-per channel into a 4-ohm load and is burn-out proof; the stereo preamplifier—built around three IC's to reduce its complexity and improve its performance; and a most unusual FM stereo tuner—it uses variable-voltage-diode tuning and enables you to mount the front end up at the antenna for maximum sensitivity and selectivity.

This article will describe the power amplifier and it's power supply. When you build the preamp (next month) it draws operating power from this amplifier. So here we go. Off to a new dimension in high-fidelity stereo sound.

In an earlier era of high fidelity sound, all speakers were highly efficient devices for transforming electrical signals into audible sound, and amplifier powers seldom exceeded to 20 watts.

Keeping pace with the recording process speaker manufacturers extended the range of frequencies linearly reproduced. At first the trend was towards larger cabinet volumes to increase the usable bass range. But it soon became evident that few people wanted the huge speaker cabinet volumes associated with high-fidelity sound.

Speaker manufacturers were aware of the trade-offs in making a small cabinet volume adequately reproduce the lower frequency sounds —simply reduce the efficiency of the speaker in the middle and upper ranges. This was in direct contrast to boosting the low-range efficiency by tuning a larger cabinet volume.

The advent of stereo accelerated the advance of low efficiency speakers until today relatively few new installations are the larger cabinet volumes. Of course this lowered efficiency has forced an increase in amplifier power to maintain realistic levels of room volume. Fortunately, transistor amplifiers came along to replace the tube designs.

Early designs became notorious for their sudden death if a speaker output was shorted for even an instant. Manufacturers responded with a rash of protection circuits, almost all of which depended on limiting input current to the output transistor stages. One method of protection limits driving current to the output stages.

Examining Fig. 1, we see that increasing current flow through R4 will cause a larger voltage drop across R4. At some current flow, the base-emitter voltage of Q1 and Q2 plus the forward voltage of D4 and the voltage across R4 will exceed the Zener voltage of D5. Increases in drive current only increase the Zener current.

Unfortunately, this theory is not too practical. Variations in the base-emitter voltages of Q1 and Q2 and the Zener voltage of D5 combine to allow substantially higher current flow at increasing temperatures. Most designs of this type require a thermal

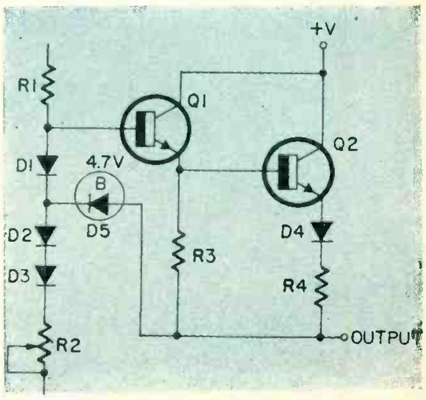


Fig. 1—Increasing current flow through R4 will cause a larger voltage drop across R4 to protect the amplifier.

cutout switch to eventually remove all input power.

An ideal protective circuit should sense only the current flow and must not be affected by heat sensitive parameters. This amplifier incorporates such a circuit. The schematic of Fig. 4 illustrates its operation.

Let's assume that the driving voltage at Q5's base becomes more positive. Q5 and Q6, connected as a Darlington pair, transmit this drive signal to the output terminals. Note that the same output voltage appears at the bottom end of R15 and at the emitter of Q4.

Transistor Q4 will not conduct and remove drive current until its base is about 0.55 volt more positive than its emitter. Let's calculate the output required to reach this state.

For a 125 watt output into a 4 ohm load:

$$P_o = \frac{E^2_{RMS}}{R_L},\ E_{RMS} = \sqrt{P_o \times R_L} = \sqrt{500} = 22.3V$$

$E_{PK} = E_{RMS} \times 1.41$, $E_{PK} = 22.3 \times 1.41 = 32.6V_{PK}$ $\left(\text{Base voltage of Q4}\right)$

$$I_{PK} = \frac{E_{PK}}{R_L} = \frac{32.6}{4} = 8.15A_{PK}$$

$I_{PK} \times R18 = 8.15 \times 0.33 = 2.72V$ drop across R18

Q4 emitter voltage $= (2.72 + 32.6)\frac{1000}{1000 + 68} = 33.1V$

Note that the base of Q4 is 0.5 volt more positive than its emitter and Q4 is *near* conduction. The same voltage, minus the voltage drop across R18, is applied to the emitter of Q 4. For negative signals Q7 limits drive current to Q8 and Q9.

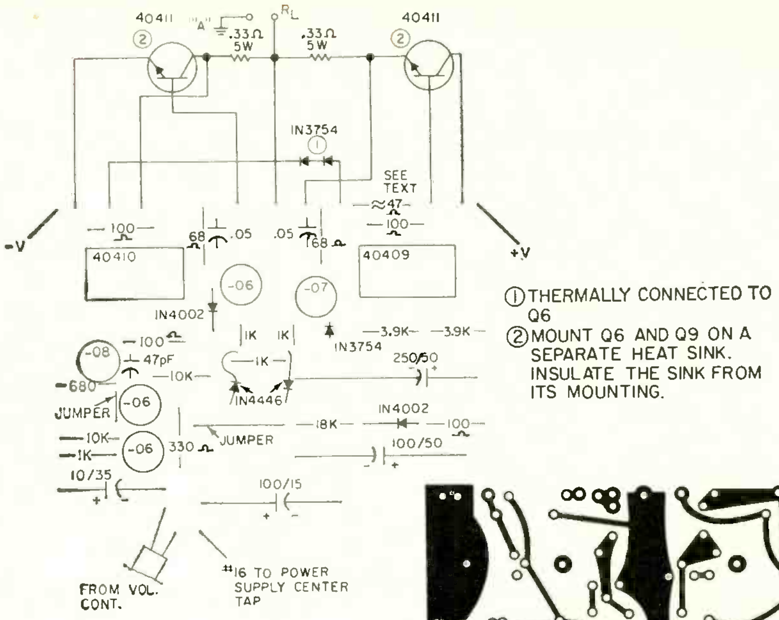
Now let's see what happens with shorted output terminals. First of all, Q4's emitter will be held at ground potential. Also, no current can flow through D6 and all voltage drop across R18 is applied to the base of Q4.

With a voltage drop of 0.55 volt across R18, the current flow is 0.55V ÷ 0.33 or 1.67 amp. The output current available is far less during shorted conditions than normal operation. The measured heat sink temperature actually drops when a short is applied to the output.

Of course, R18 may be changed to limit the output power to any lower level desired. Use the following formulas to calculate R18.

$$E_{PK} = \sqrt{2P_oR_L},\qquad I_{PK} = \sqrt{\frac{2P_o}{R_L}}$$

$$R18 = \frac{E_{PK} + 0.55}{0.934\, I_{PK}} - R_L$$



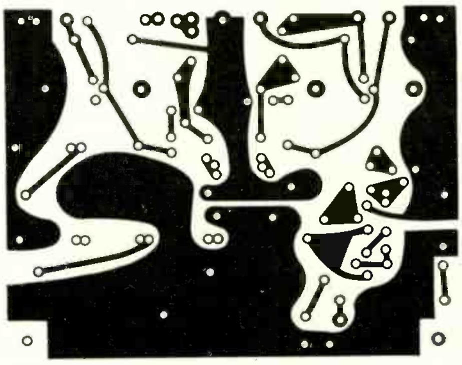


Fig. 2—Parts layout on the printed circuit board is detailed above. It also shows how the circuit board connects to the rest of the circuit. The foil side of the board (right) is half actual size.

No matter what output level is chosen, the short circuit output current will always be less than full power output current. No adjustments are required to set the current and circuit operation is entirely automatic.

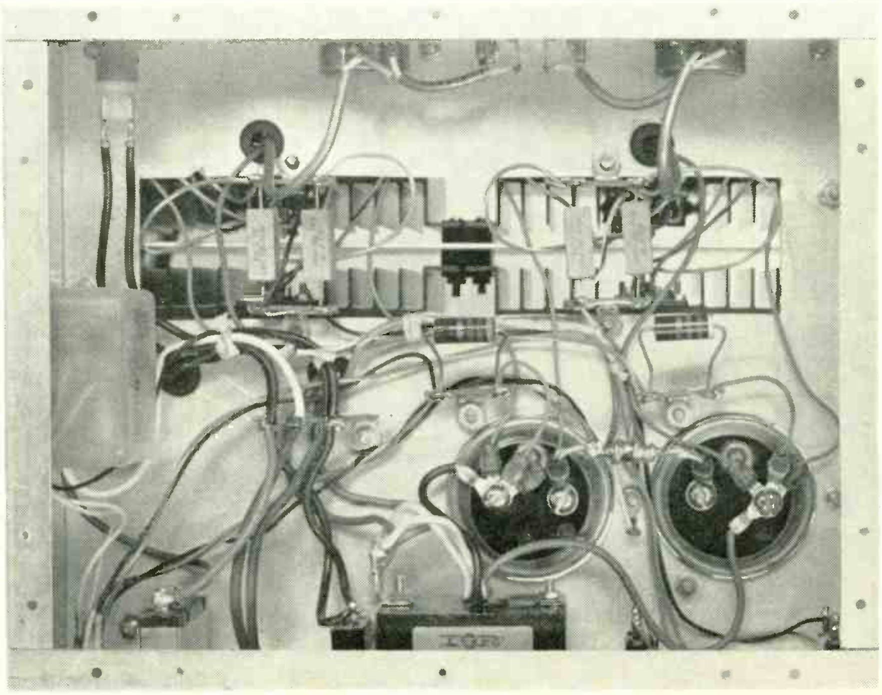
The power supply

The power supply in this amplifier will be used to power the preamp too. It is a simple, unregulated setup containing little more than a transformer, bridge rectifier and a couple of filter capacitors (see Fig. 3).

The transformer listed is one of the best buys available and substituting components offers little economy until power levels of less than 20-watts-per-channel are reached.

Several features of this amplifier require detailed explanation. First of

Under the amplifier chassis there is plenty of room for the components that are not mounted on the circuit boards. Do not crowd. This amplifier dissipates a lot of power.



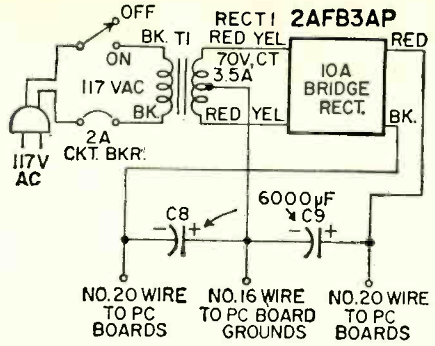


Fig. 3—Here's the power supply for the amplifier. All components used in the amplifier supply are used for both channels.

all, internal feedback eliminates the need for a control to set the dc output level of the amplifier. Looking at the schematic (Fig. 4) note that the base of Q1 is returned to ground through R3. The emitter of Q1 must be at 0.55-volt positive. Plus 50 volts is applied to the upper end of R5 and the current flow is just over 2.7 mA.

Less than 1 mA of this current flowing through R6 will bias Q3 into conduction. When Q3 conducts the resulting voltage drop across R9, R10, R11, D2 and D3 will bias the base of Q8 negative. The resulting voltage drop across R19 in turn places Q9 in conduction. As Q9 conducts, the output terminal which is also the right end of R8, becomes negative with respect to ground. Thus Q2's base is more negative than Q1's base.

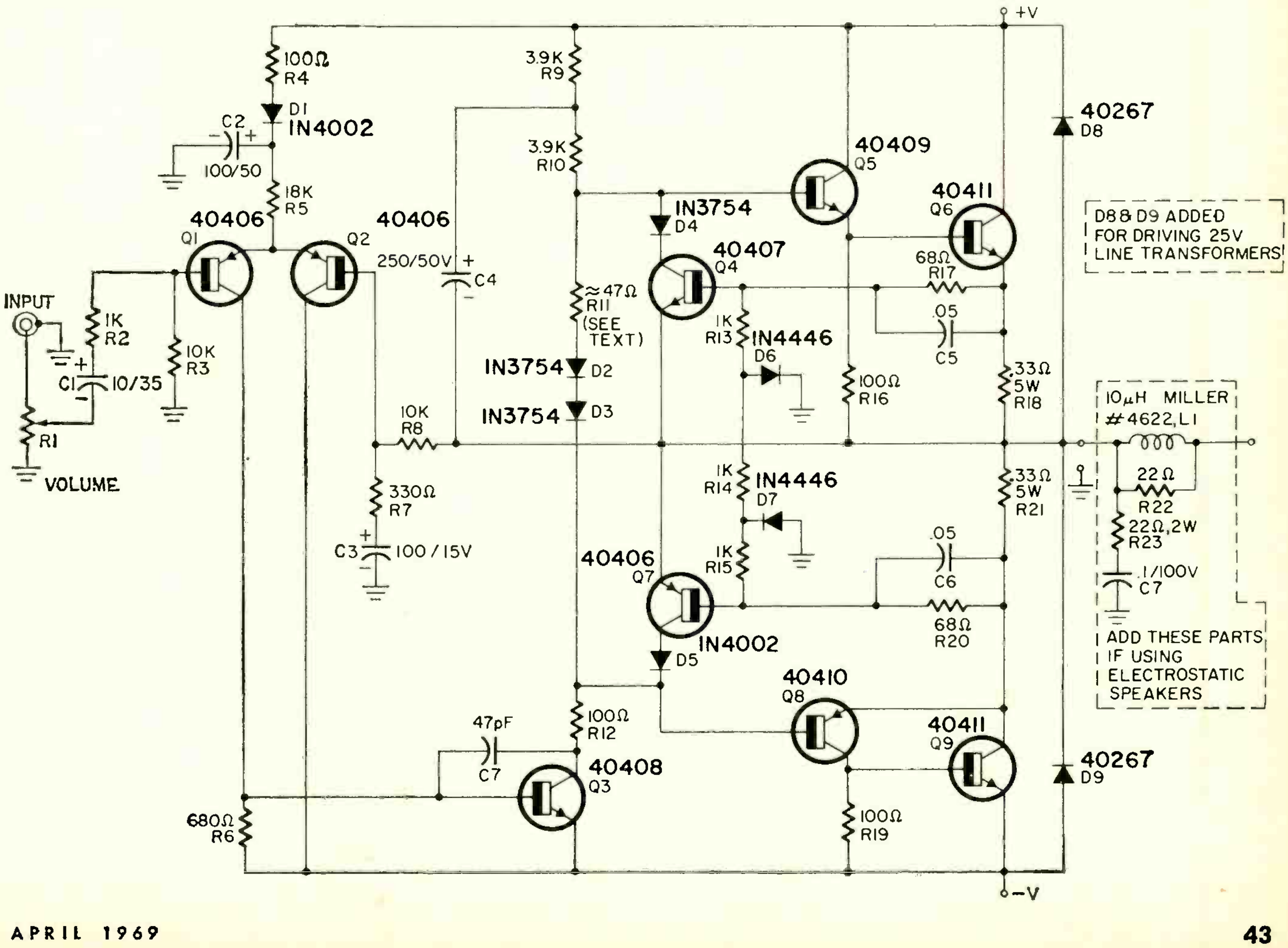
Since Q1 and Q2 emitters are connected, the current flow through Q1 decreases, thus reducing the bias developed across R6. Q3 now conducts less heavily and reduces the drive signals to Q8 and Q9. The cumulative action of this negative feedback is always in a direction which returns the output terminal to ground potential.

PARTS LIST

(two sets of parts are needed for stereo unit)

All resistors ½-watt 10% unless noted
R1—volume control, log taper (10,000 ohms for transistor preamp; 100,000 ohms for tube preamp)
R2, R13, R14, R15—1000 ohms
R3, R8—10,000 ohms
R4, R12, R16, R19—100 ohms
R5—18,000 ohms
R6—680 ohms
R7—330 ohms
R9, R10—3,900 ohms
R11—approximately 47 ohms (see text)
R17, R20—68 ohms, 5%
R18, R21—0.33 ohm, 5 watts
R22—22 ohms
R23—22 ohms, 2 watts
Capacitors
C1—10 µF, 35 V (Mallory MTR10D35 or equiv.)
C2—100 µF, 15 V (Sprague TVA 1310 or equiv.)
C3—100 µF, 15 V (Mallory MTA100B15 or equiv.)
C4—250 µF, 50 V (Sprague TVA 1312)
C5, C6—0.05 µF, 20 V disc ceramic (Centralab UK-20-503 or equiv.)
C7—0.1 µF, 100 V paper (see text)
C8, C9—6,000 µF, 50 V (Sprague 36D602G050 BB2A. Allied Radio catalog No. 43F 5066 $3.52 ea.)
Other components
D1, D5—1N4002
D2, D3, D4—1N3754 (RCA)
D6, D7—1N4446 (G-E)
D8, D9—40267 (RCA)
L1—10 µH (Miller 4622 or equiv.)
Q1, Q2, Q7—40406 (RCA)
Q3—40408 (RCA)
Q4—40407 (RCA)
Q5—40409 (RCA)
Q6, Q9—40411 (RCA)
Q8—40410 (RCA)
T1—Power transformer, Pri. 117 VAC, Sec. 70V Ct @ 3.5 A (Triad R-82B or equivalent)
RECT 1—Full-wave bridge rectifier, 300 piV, 10 A (International Rectifier 2AFB3AP)
Heat sinks for 40411—Wakefield NC402K (Allied Radio #60C6506)
Heat sinks for 1N3754—Wakefield 255 (Allied Radio #60F6545)
Etched and drilled circuit board No. DLA-1 $3.75 each, postpaid from
Transitek Co.
P.O. Box 98205
Des Moines, Wash. 98016

Fig. 4—The full circuit for the amplifier is shown here. Remember this is only a single channel. Two of these circuits and one power supply circuit (Fig. 3) must be built to form one complete amplifier. It delivers 125-watts-per-channel.



Of course, like any other feedback system, the error can never be reduced to zero. In this circuit the error is always less than 0.1 volt. With an 8-ohm speaker this results in a dc power dissipation of less than .002 watt.

The dc gain of the total amplifier is very nearly unity since C3 prevents any voltage division between R7 and R8 at very low frequencies. Capacitor C3 has a reactance of 330 ohms at 5 Hz, the point at which voltage gain is down 6 db from a 1 kHz reference value.

Resistor, R4, diode D1, and capacitor C2 prevent a very annoying "thump" when the amplifier is turned off. Let's see what would happen without these parts in the circuit. At turn off the supply voltages start to decrease due to the quiescent current drain of the output stages. As the positive voltage decreases Q1's emitter and collector currents also drop.

A reduction in Q3's bias means that the voltage drop from R9 through D3 will also be less, resulting in a more positive drive to Q5 and Q6. The increased current flow through Q6 means an even heavier load on the positive voltage remaining. This effect is regenerative and similar, in its effect, to dumping the positive charge in the 6,000-μF capacitor directly across the load.

With D1 in the circuit, C2 stores a charge for the emitter currents of Q1 and Q2. The power supply capacitor will discharge faster than C2. No audible transients exist at either turn on or turn off.

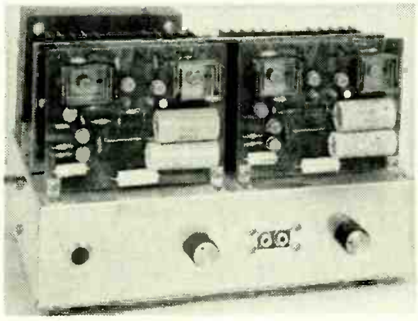
A regulated supply for this amplifier would be quite expensive since the output impedances, at dc, would have to be less than 0.02 ohm before the performance would be equivalent to what is now exists.

There are two reasons why this low impedance is needed. First, to prevent the large currents drawn from one channel from changing the output voltage of the supply, and thus, coupling a signal into the other channel. Second, to present an extremely low source of ripple current. The same effects are present in the connection of C4.

Note that one end of C4 is connected to ground through the load; the other is connected to the junction of R9 and R10. Any ripple voltage at the positive supply terminal is attenuated by a factor of 300 before it reaches the base of either Q5 or Q8. Since the ripple voltage across the power supply capacitors is solely a function of the load current, the ripple rises as the output increases—but always remains *at least* 50 db below the output voltage. The rejection from one channel to another is sufficient that one channel may be driven to full power output and the separation at 10 Hz will exceed 65 db.

Ripple on the negative supply results in a slight variation in collector to emitter voltage of Q1. Collector current, however, is not dependent on collector-emitter voltage in common-emitter amplifiers such as Q1. Consequently this ripple can not induce any voltage change across R6. Since the ripple peaks are in phase for both the positive and negative supplies their effects, small as they are, tend to cancel each other. Total hum and noise output is less than 500 mv with an 8-ohm load.

The values shown for R18 and R21 limit the output power to 125 watts for an 4-ohm load. Operation at higher powers are possible but require forced air cooling of the heat sinks. At 125-watts output power is current limited. An output power of 100 watts is available to an 8-ohm load. Although a 16-ohm load can be supplied with 60 watts per channel the output power is now becoming voltage limited since the supply voltages must be greater than the peak to peak excursions of the output voltage.



This is what the assembled amplifier less the protective cover looks like. Like it?

This amplifier is stable under all conditions from short to open circuit loading on the output terminals, without signal or heavily overdriven, during normal operation, turn on or turn off situations.

Construction techniques

Using the specified parts, both amplifier channels and the power supply neatly fit onto an 8 x 10 x 2½-inch chassis. A soft aluminum chassis is not only easier to work with, but also will not transfer magnetic fields from the transformer into sensitive input circuits.

The first construction step is mounting components to the printed circuit boards. A half size layout of the board is included (Fig. 2) for the convenience of constructors who may wish to make their own boards. Be sure to mount R4, D1, and R5 first since C4 and C2 obstruct the board entry. Use a small soldering iron and rosin core solder. If you should accidentally fill a hole with solder, heat the area while inserting a toothpick through the hole. Insert each component, bend the leads outwards slightly to hold it in place, then clip the lead about 1/16-inch above the copper. Solder the leads for a few components at a time. Keep your iron tip wiped clean. After each board is completed attach small angle brackets to the two corners. These brackets should not touch the copper foil; a separate No. 16 wire returns the circuit board to the power supply ground.

Remove the transformer shells and attach ½" aluminum angles to provide mounting feet.

Mount each 40411 transistor to a heat sink. Insulate the heat sinks from ground. This technique substantially improves heat flow out of the transistor and also reduces collector capacitance to ground. On two of the heat sinks a small bracket is used to mount D2 and D3. These diodes provide thermal compensation for the output transistors and their cases should make good thermal contact to the heat sink.

Mount all heat sinks to a 1/16-inch aluminum plate about 4 x 9.75 inches. Fasten this plate to the chassis with angle brackets placed at each end. After all assemblies are ready to mount, position them carefully. In particular, be especially careful of parts placement on the back of the chassis. The locations of the power supply capacitors should be examined carefully to avoid any interference with the output terminals.

An adequate vertical flow of air must be provided for the heat sinks. A large 2 x 8-inch slot is "nibbled" out beneath the heat sink mounting plate. If a bottom plate is used, provide a number of large holes to complete the air flow path. Use ⅝-inch high mounting feet on the chassis.

Test before using

After completing assembly, a few simple tests are in order. Temporarily connect a 100 Ω pot set to minimum resistance in place of R11. Connect a 50-watt light bulb in series with the ac line cord. Leave the output terminals unloaded and set the input level controls to their minimums. Apply power to the unit. Measure the voltage across each supply capacitor (C1 and C2). This reading should be nearly 48 volts and a dc voltmeter connected across each output should read less

(*continued on page 85*)

Throbbing Vibrato

by JACK JAQUES*

ADD THIS VIBRATO TO THE GUITAR amplifier described last November and you'll have given that amplifier new life. In simple terms the vibrato makes the sound pulsate—come and go at a controlled rate. This pulsating rhythm adds real life to otherwise "flat" or "dead" music. Also, with a little educated knob twisting, you can create some unusual sound effects.

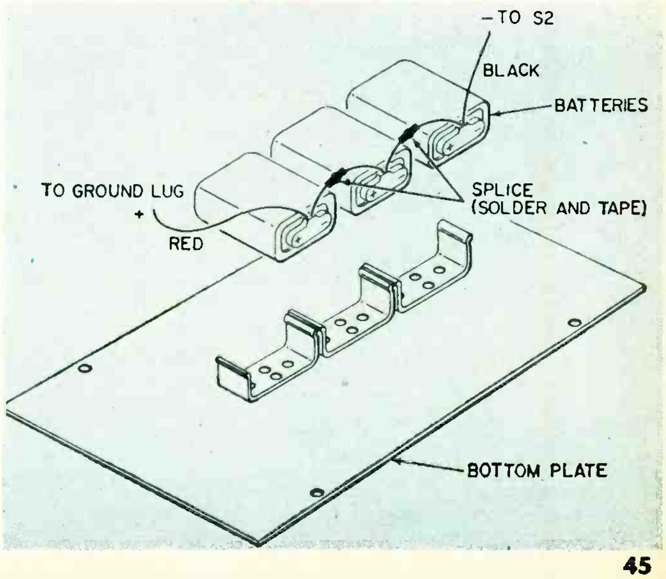
While vibratos are most commonly used with guitars and accordians, the sound of many other musical instruments can be greatly improved. For example, the reed type electric chord organ can be greatly enhanced by adding a vibrato. For instruments that do not lend themselves to a special pickup, try using a standard high-impedance microphone.

If you take a look at the vibrato circuit you'll see that it consists of one transistor, one FET, 2 potentiometers, a battery power supply, input and output jacks, and the various resistors and capacitors needed to complete the circuit. The unit delivers an overall gain of 6 to 8 dB, and its high-impedance output is ample for driving most power amplifiers to full output.

In the circuit transistor Q1 is connected as a twin "T" oscillator that produces a sine-wave of approximately 6 Hz. This signal is applied to the source (S) of FET Q2, where it amplitude modulates any incoming signal applied to the gate (G) of Q2 through input jack J1. The amplitude of this modulation can be varied by the DEPTH control R4, to create either a light or a deep vibrato effect. The vibrato rate (frequency) is adjusted with RATE control R11, or may be turned off with switch S1 for normal sound.

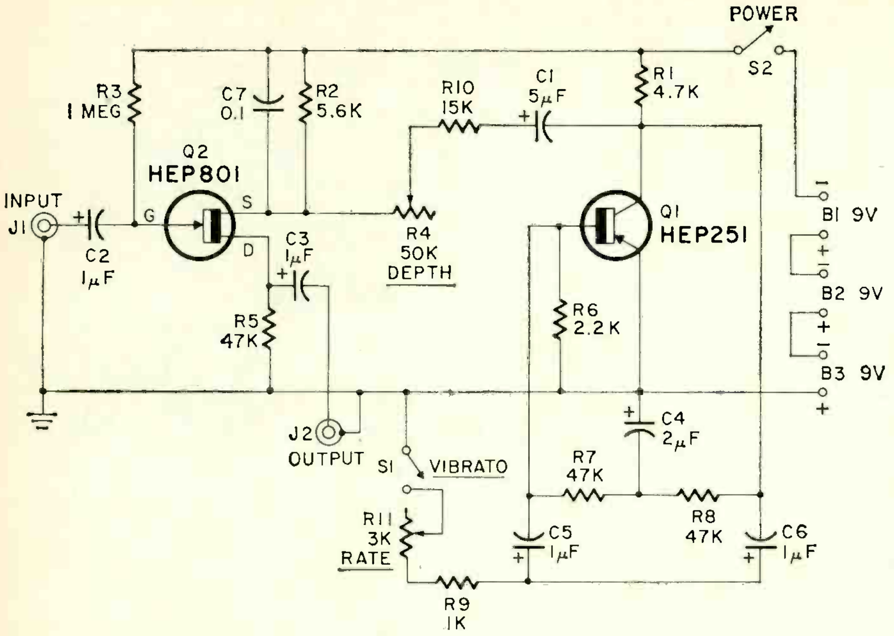
Operating the vibrato is easy. Connect any high-impedance microphone or pickup device to input jack J1. Connect output jack J2 to the high-impedance input of any amplifier system. Place the VIBRATO switch and the POWER switch in the ON position. Adjust potentiometer R4 and R11 to approximately midrange. Then play single notes or chords on the musical instrument being used and adjust the RATE and DEPTH controls to obtain the desired effect. When operated this way, Q2's gain is effectively used, and you'll find it handy if you are using a low-power amplifier.

Complete construction details can be found in the diagrams, although parts layout is not critical. Cut the perforated board to size and carefully drill the three mounting holes. Next insert the push-in terminals where indicated. Then wire in all

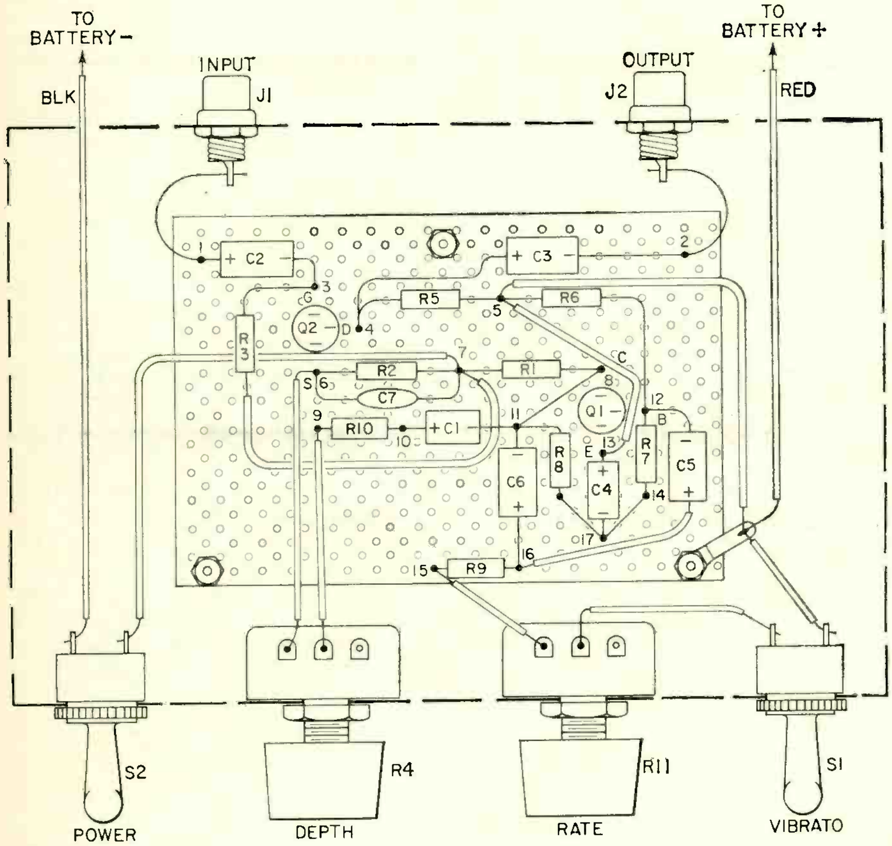


The three series-connected 9-volt batteries must be secured so there is no possibility of their coming loose and damaging other components. Too, replacement should be simple and easy. Use battery clips and holders bolted to the bottom cover plate as shown.

* HEP Technical Manager
Motorola Inc., Phoenix, Ariz.



A simple, yet effective vibrato circuit. It was designed especially for use with the R-E/HEP guitar amplifier and other instruments in this series but can be incorporated in other electronic musical instruments. Vibrato effect is produced by a 6-Hz twin-T oscillator that modulates the amplitude of the signal in the source circuit of the input transistor. Input and output impedances are high.



Physical layout of parts in the vibrato. Observe polarity of the electrolytics. The numbered circles represent the push-in terminals used as tie-points. Thin insulated hook-up wire is used throughout. The perforated-board chassis is suspended from the top of the case on three screws. These are visible in the head photo. Controls and switches are mounted on the front of the case; jacks are on the rear.

parts. Watch out for battery and capacitor polarity and you're home.

If you've followed along you now have a completed guitar amplifier, an inverter for outdoor operation, a mixer and a vibrato. Next time we'll present a 50-watt booster amplifier to add real power to your music system. See you then. **R-E**

PARTS LIST

B1, B2, B3—9-V mercury battery (Eveready E146X or equiv.)

Capacitors—25 volts or more

C1—5 μF, electrolytic

C2, C3, C5, C6—1 μF, electrolytic

C4—2 μF, electrolytic

C7—0.1 μF

J1, J2—phono jacks

Q1—HEP251 pnp transistor

Q2—HEP801 n-channel FET

Resistors—½-watt 10% unless noted

R1—4,700 ohms

R2—5,600 ohms

R3—1 megohm

R4—50,000-ohm potentiometer (Mallory U35 or equiv.)

R5, R7, R8—47,000 ohms

R6—2,200 ohms

R9—1,000 ohms

R10—15.000 ohms

R11—3,000-ohm potentiometer (Mallory U8 or equiv.)

S1, S2—spst toggle switch

Miscellaneous parts

Chassis, 5" x 7" x 2"

Chassis cover, 5" x 7"

Perforated terminal board 2⅝" x 3¾" (Keystone 1753 or equiv.)

Push in terminals (18) (Keystone 1499-FT or equiv.)

Battery clips (3) (Keystone 72 or equiv.)

Battery holders (3) (Keystone 79 or equiv.)

Transistor sockets (2)

Knobs (2)

Terminal lug

Machine screws, 6-32 x ¾" (3) (for terminal board mounting)

Machine screws, 4-40 x 3/16" (6) (for battery holder mounting)

Nuts, 6-32 (9)

Nuts, 4-40 (6)

Rubber feet (4)

SERVICE 2000 A.D.

By JACK DARR
SERVICE EDITOR

OVER THE YEARS THIS MAGAZINE HAS MADE MANY PREdictions about the marvelous electronic devices of the future. A lot of them have already come true. One thing has been rarely mentioned, though. Who's going to fix them? They *will* be built, and they will work, but not indefinitely. Materials being what they are, and fabrication processes what they are, *some* devices are going to fail.

Our ecology is already highly automated, not only in industry but in our homes. As machine complexity increases, so do the numbers of the men who keep them running; the service technicians. While it *might* be technically possible to build the eternal machine, using to the fullest the principles of redundant circuitry and massive overrating of parts, there would still come a time when even these were exhausted and the machine would stop. Simple economics would make this approach a bit impractical as well. A home TV set would be a 30-foot cube, even with miniaturization. And the *price?*

Any extrapolation into the future must be based on the past. In the early 1930's, a radio was made with all parts "plug-in". It was widely advertised as "ending the need for expensive radio servicemen!" But it made practically no impression, and vanished inside a year. We can make a close guess about the design of the future TV receiver. Very thin, of the "picture-on-the-wall" type; miniaturized, with sections made in separate modules: tuner, i.f., sweeps, power supplies, etc. When trouble happens, any module can be replaced. But a skilled technician will still be needed to find out *which* module to replace! If the modules are plugged in or wired in, there will still be another chance for trouble. Don't tell me that even in 2,000 AD there will be plugs that *always* make perfect contact, and that the intermittent solder joints will have disappeared forever! I won't believe it!

Another oft-mentioned possibility is the "throwaway" unit, so cheap that it will be possible to discard it instead of repairing it. We've got the beginnings of this today, in the $3.95 transistor radio needing a $10 repair job.

Miniaturization will be no problem; this too is with us now. As sets get smaller, so will the tools. Today's technician repairs tiny sets under a magnifying glass. Future technicians may use binocular microscopes and micromanipulators just as casually.

How about the test equipment of the future? Will it be a large machine, something like the cartoons of today's computers, which—hooked to the defective set—flashes a few lights and says in a bored, metallic voice, "C97 has 12,563 ohms leakage, R176 has changed value and Q97 has a base–emitter short. Replace! *CLICK!*" Probably not. That is, not unless *all* future TV sets are *exactly alike!* We have just such automated test units in use today, but they are in factories, testing one model of one make only. Their inherent inflexibility makes them impractical for general service work.

Future test equipment will look different; be smaller, more accurate, and be more stable, perhaps, but it must still measure the same basic quantities! Volts, ohms, amperes, frequencies, these won't change. The highly specialized robot testers will see greater use in the automated factories, of course, but not in the service shop. There will always be different models and makes; the principle of planned obsolescence is firmly implanted in our economy, and will be with us for a long time. Human nature isn't going to change a lot, even if the machines do. So, the test equipment of 2000 AD will still have to have enough flexibility to deal with TV sets of all sizes and shapes and makes, just as it does today, and that means measuring the basic quantities: volts and ohms and the like.

So spare me the gloomy predictions of the disappearance of the independent electronics technician, please. Increased automation of everyday devices will create an immense demand for the services of men trained in the basic principles of electronics; this is happening today. If I may do a bit of personal predicting and extrapolation, I can see this need growing by leaps and bounds. Electronics is a major factor in life today; it will be even more important in 2000 AD when there will be automatic controls on everything from the vacuum cleaner to the airliner, and all of these will be electronic!

Cities will spread, even as they're doing now. Even with fast transportation, it will take a housewife a long time to take a defective unit back to the company for repair, or an equally long time for a repairman to cross the city to fix it. So, the "neighborhood technician," simply because he's in the neighborhood, will always find enough work to keep him in business. With more and increasingly important household equipment automated, the availability of service technicians will be even more vital in the future. Any breakdown of household appliances is an emergency to the householder, and she'll still want help, and fast.

I can see one major change: the electronics repair business won't be concentrated exclusively on home-entertainment products, but cover all the electronic controls and devices in the home of the future. This is already apparent, as more and more men use their basic knowledge of electronics to work with equipment other than radio and TV. After all, the average electronic control is absurdly simple—an SCR, or a few tubes, a relay, etc.—compared to the complexity of a TV receiver. The repair business will divide up into *mechanical* and *electronic;* this is showing up today. An ordinary electronics technician can't install a set of piston rings in his car, but neither can the average mechanic repair a transistor ignition system. He simply hasn't the basic knowledge of electronics he'd need to repair it.

As to the robot testers, no machine can duplicate the *diagnostic* ability of the human brain. In 2,000 AD, as now, diagnosis will be the most important part of the process. No machine can take a set of scattered, apparently unrelated facts and reach a valid conclusion from them; a human brain can, and does, thinking nothing of it. (This is an unfortunate simile, for this is exactly what the brain does that the machine can't—*think!* Intuitive thinking is the tool we use—the machine can use logic of a sort, but it cannot think!)

The repairman will always be with us, and of far greater importance to the economy than today. Even now, if all repair activity stopped, everything would come to a grinding halt inside a week! What would it be like if present automation were increased by a factor of 1,000, as it undoubtedly will be? Try to imagine the number of skilled technicians needed to keep all these things in working order! **R-E**

ADVANCES IN AUTOMOTIVE ELECTRONICS

Computerized cars are here. Learn how the newest devices work

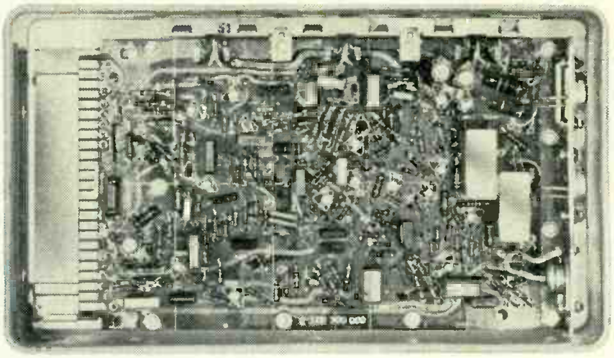
by **FRED W. HOLDER***

IN THE "EARLY DAYS" OF AUTOMOTIVE ELECtronics, several gadgets such as transistorized ignition and tachometers were developed by electronic buffs and small firms. The auto makers were reluctant to become involved with these gadgets because they had time-tested mechanical systems in production. A change to an electronic counterpart was not economically feasible.

Today, readily available, low-cost, solid-state components and space-saving integrated circuits have reversed this trend. The auto industry is now developing sophisticated, computer-controlled systems such as Volkswagen's electronic fuel-injection system and Ford's electronic speed control and anti-skid systems.

In addition, solid-state electronics is helping to improve such minor items as the electric fuel pump. Let's take a look at some of these new electronic innovations to see how they work.

*Supervisor, technical writing, Bendix Field Engineering Corp.



■ ELECTRONIC FUEL INJECTION

Volkswagen's electronic fuel-injection system, furnished as standard equipment on all 1968 fast- and square-back models, was developed through the joint efforts of Volkswagen and Robert Bosch GMBH of Germany. The prime purpose of the system is to increase engine efficiency enough to meet the exhaust emission requirements of the United States. The result is improved performance with little increase in cost.

The heart of this new system is an electronic control unit (or computer) that constantly monitors engine requirements and environmental conditions. It uses the information gathered to determine the correct amount of fuel needed by the engine at any given instant. Figure 1 is a simplified diagram of the Volkswagen system.

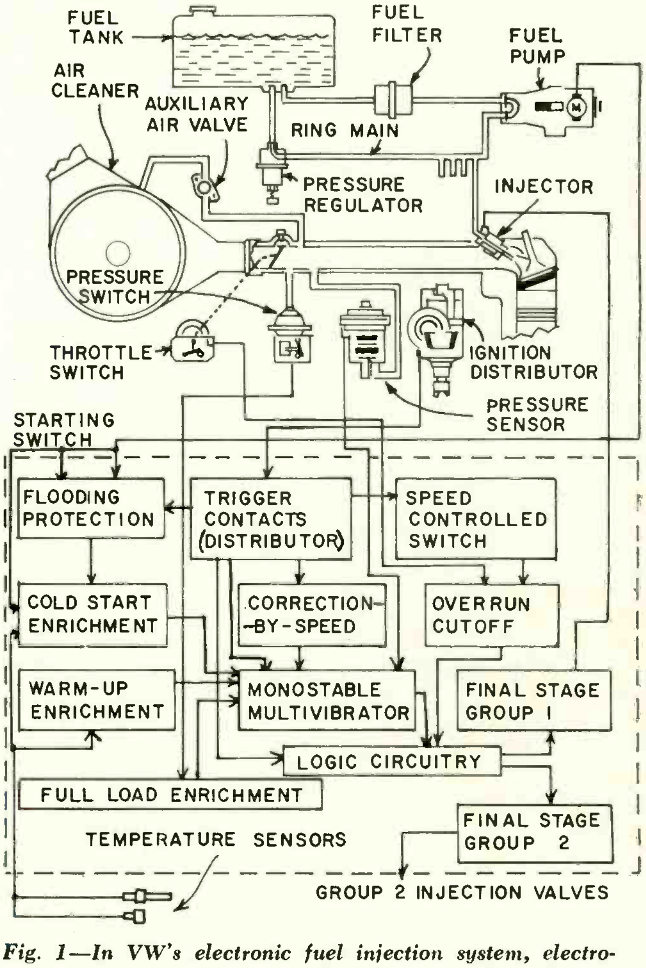


Fig. 1—In VW's electronic fuel injection system, electromagnetic injector valves are held open 8–12 msecs by logic-controlled pulses generated in control unit (dotted lines).

Fuel is drawn from the tank through a filter by an electric fuel pump and forced into the ring main for distribution to all injector valves. A pressure regulator maintains a constant 28 psi in the ring main by allowing surplus fuel to flow through the regulator and back to the fuel tank.

Next, the electromagnetic injector valves are opened and held open by a pulse from the control unit. This pulse varies in width from 8 to 12 msec. The duration of this pulse is governed basically by two factors: engine speed and load conditions.

Engine speed and timing information are furnished by two sets of contacts located in the lower part of the ignition distributor. Signals from these trigger

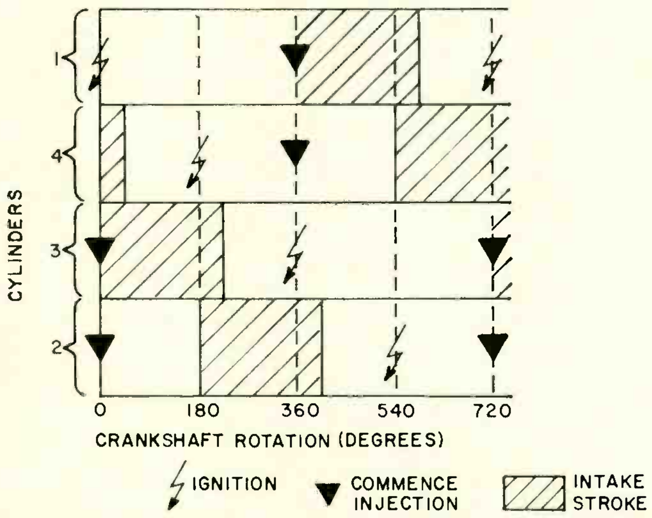


Fig. 2—Timing diagram shows relationship between injection and intake stroke of VW system. Sensors and logic circuits determine engine requirements as driving conditions change.

contacts are used in the control unit by a speed-controlled switch, the flooding-protection circuitry and a monostable multivibrator circuit.

Load condition information is furnished to the control unit in the form of a voltage signal from the pressure sensor located on the intake manifold. Other factors such as information from the cold-start circuit, the warmup enrichment circuit, the full-load enrichment circuit and the correction-by-speed circuit combine with the pressure sensor signal to establish the output pulse duration of the multivibrator.

When the control unit receives a trigger signal from one of the trigger contacts, the multivibrator switches to the unstable state for the appropriate time period determined by operating conditions. The output pulse is gated in the logic circuitry with the trigger signal and a signal from the overrun cutoff circuit.

Gating of the multivibrator pulse with the trigger signal excludes unwanted injections that could be triggered by contact bounce. The signal from the overrun cutoff circuit has no effect except when the throttle valve is closed and engine speed is above 1800 rpm.

Under these conditions, a signal is generated that inhibits the gate and cuts off fuel to the engine. As engine speed drops to 1250 rpm, the signal changes to enable the gate to switch on the fuel again so that a smooth transfer to idling operation is assured.

The logic circuitry also determines which final-stage amplifier is to receive the pulse from the multivibrator. The final-stage amplifier for group 1 drives the injectors for cylinders 1 and 4, while that for group 2 drives the injectors for cylinders 2 and 3. Each injector group has a separate trigger contact in the distributor. Fuel is injected to both cylinders of a group at the same time (Fig. 2).

To understand the operating sequence illustrated in Fig. 2, the reader must realize that this is a gasoline injection system in which the fuel is injected ahead of the intake valve rather than directly into the cylinder.

▪ AUTOMATIC SPEED CONTROL

The automatic speed-control system available as an option on the 1969 Ford and Mercury automobiles is almost entirely electronic. This system, mentioned in a November 1967 RADIO-ELECTRONICS article, was developed by the Automotive Electronics Division of Bendix Corp. In addition to the switching circuits located in the steering wheel, the system comprises three separate assemblies: (1) a variable-reluctance speed sensor, (2) a vacuum-actuated throttle actuator and (3) an amplifier, which actually is more of a computer than an amplifier.

As shown in Fig. 3, a variable-reluctance sensor is

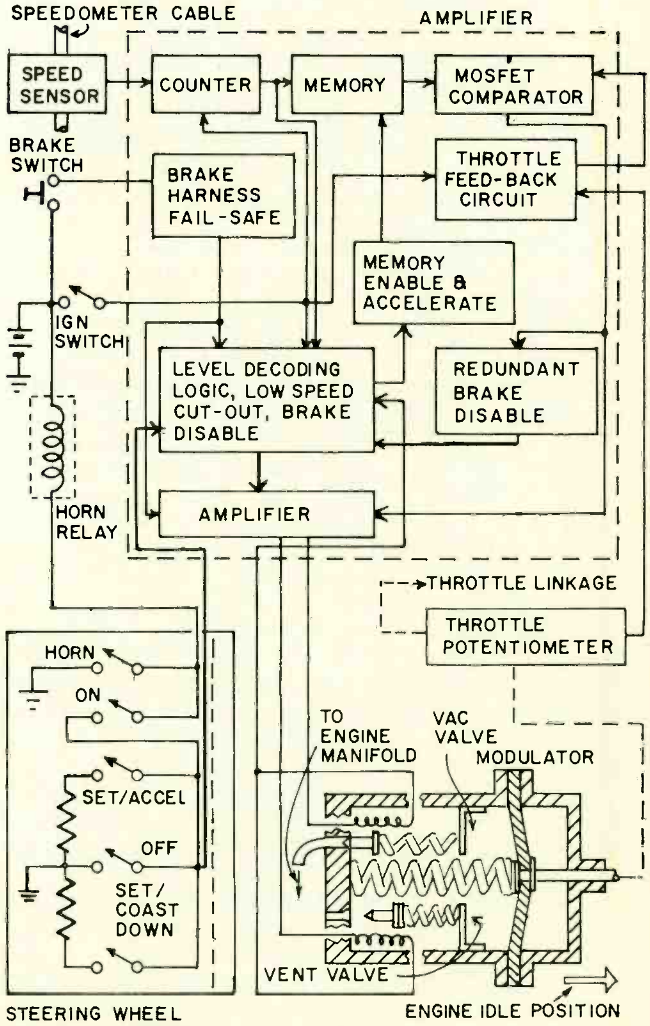


Fig. 3—Automatic speed control system—optional on 1969 Ford cars. Command speed is stored in a "memory" capacitor; a MOSFET comparitor detects changes, activating throttle.

connected in series with the speedometer cable and driven at the same speed as the speedometer. Because the gear ratio between the drive wheel and the speedometer cable is fixed, the sensor output frequency is proportional to vehicle speed. The sensor signal drives an energy-storage-type electronic counter that produces a dc voltage level proportional to the frequency of the input signal. This dc voltage level from the counter drives through a memory circuit into a high-impedance input of a MOSFET (metal oxide silicon field effect transistor) comparator.

The vehicle operator can impress a command speed signal on the memory circuit by momentarily depressing either the set–accelerate pushbutton or the set–coast-down pushbutton. The impressed signal represents the instantaneous speed of the vehicle.

After a command speed signal is impressed across the memory, any variations in vehicle speed will be reflected at the input to the comparator. This occurs because the memory circuit is a low-leakage capacitor connected between the counter output and the high-impedance input of the comparator. The commanded-vehicle-speed voltage level from the counter is stored in this memory capacitor. As a result, only changes in voltage from the counter are reflected to the input of the comparator.

A feedback potentiometer, mechanically connected to the throttle-linkage arm, provides a signal voltage that represents throttle position to the other input of the MOSFET comparator. The throttle feedback voltage passes through a feedback circuit that increases the magnitude of the signal when the throttle is moving. The purpose of the feedback circuit is to prevent too rapid movement of the throttle when vehicle speed is greatly below command speed, while at the same time allowing greater sensitivity of the comparator to the feedback signal as the vehicle attains command speed.

The resultant error signal from the comparator is amplified and used to control a vacuum modulator comprising solenoid valves which, in turn, control pressure on one side of the diaphragm of the vacuum modulator and actuator. These solenoid valves are electrically actuated needle valves positioned against ports in the pressure chamber of the vacuum modulator. One valve, which is normally open, allows atmospheric pressure to enter the chamber when it is de-energized. The other valve, which is normally closed, opens to allow a vacuum to be drawn in the chamber when it is energized.

The amplifier that drives these solenoid valves is designed so that an increasing signal will close the atmospheric valve. A further increase in signal strength will energize the vacuum valve and allow a vacuum to be drawn in the chamber. The diaphragm is urged forward by a spring. The reduced pressure in the chamber will allow atmospheric pressure to move the diaphragm and compress the spring. By controlling the chamber pressure, the diaphragm can be positioned at any point between the limits of its stroke. This diaphragm controls the throttle linkage.

When the brakes are applied, the brake switch closes and provides a signal through the brake harness fail-safe circuit to the logic circuit. The logic circuit is so designed that when the brake signal is received it will deactivate the speed control system. The system will not reactivate again until a command speed signal is ordered. The brake harness fail-safe circuit will shut down the system as if the brake switch were actuated should the brake harness malfunction.

As mentioned previously, if the set–accelerate button is momentarily depressed, the vehicle speed is memorized and maintained. If, however, the button is kept depressed, the vehicle will accelerate at a constant rate (about 2 feet per second per second) regardless of vehicle speed or terrain. Releasing the button enters the new speed into memory. The same conditions exist if the set-coast-down button is kept depressed, except that the vehicle slows down.

■ ANTI-SKID BRAKES

The effect of an anti-skid braking system can be simulated by a skilled driver with a conventional braking system if he pumps the brakes rapidly during panic stops. Maximum braking effort cannot be realized under these conditions, however, because the wheels are rapidly locked and unlocked. An anti-skid system should keep the wheel brakes applied at the most effective torque without permitting the brakes to lock. It is important that the brakes do not lock because the static friction created by a tire rolling at a slower speed than the vehicle is considerably greater than the sliding friction of a skidding tire.

Maximum braking effort, therefore, may be obtained by proportioning the rotation of the wheels in relation to the forward velocity of the vehicle. According to the Bendix Brake and Steering Division, such a system can best be implemented by an electronically controlled, vacuum-actuated control mechanism.

The Auto-Linear skid-control braking system to be

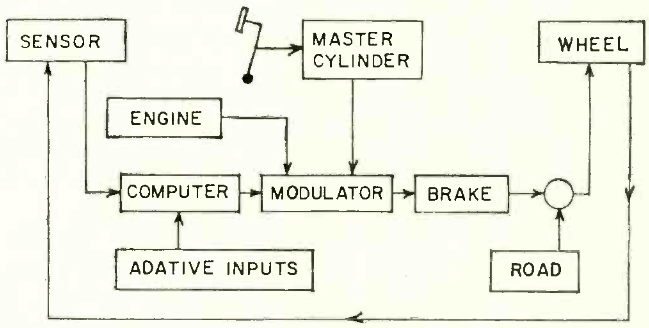


Fig. 4—A computer in this Bendix braking system determines rate of change of wheel speed, comparing it to predetermined settings. Modulator then sets pressure for best breaking.

available as an optional item on the 1969 Thunderbird and Continental Mark III uses this concept. The Ford system results from a joint development effort between Ford and Kelsey-Hayes.

The most ideal system would provide individual speed sensing and pressure modulation for all four wheels. During the development of their adaptive braking system, Bendix has found that individual front wheel–rear axle control gives the best tradeoff between braking performance and system cost, while retaining steerability for evasive maneuvers, lane changes, etc.

They found, for example, the stopping distance from speeds of 40 mph on a slick surface was reduced by 35% with four-wheel control; a reduction of 15% was obtained with only rear-axle control.

On the Ford system, each end of the rear axle is equipped with a sensor that provides an electric speed signal to a 5- by 7-inch computer. The computer compares the wheel velocity signal with a predetermined program and generates control signals to operate actu-solenoid in the pressure modulator. The solenoid actuates a valve to admit air to the front side of the modulator diaphragm. The resulting movement of the diaphragm allows a piston in the actuator cylinder to close a valve in the hydraulic system and isolate the brake master cylinder. Pressure in the rear brake line is reduced by this action. When the solenoid is de-energized, vacuum is restored to the front side of the diaphragm allowing the diaphragm to move forward, restoring hydraulic pressure to the rear brake line. The system can repeat this cycle about five times a second.

The Bendix adaptive braking system works somewhat similar to the Ford system just described. Fig. 4 illustrates the functional flow of information within the Bendix system. Wheel speed intelligence from the sensor is input to the computer where it is differentiated electronically to obtain a rate of change of wheel speed. The resulting signal is compared to a predetermined program and control signals are generated to control modulator valves.

These valves adjust the vacuum-powered modulator so that the correct brake pressure for maximum braking effort is applied to the wheel cylinder. This modulator is similar to the one used in the Bendix automatic speed-control system. During operations, the master cylinder is isolated so that there is no brake pedal movement.

When the car has braked to about 5 mph, the adaptive braking system cuts out to allow the normal manual braking system to take over.

■ SOLID-STATE FUEL PUMP

The Bendix solid-state fuel pump is mechanically similar to other electrical fuel pumps in that a magnetic field created by a coil actuates the pump plunger. Coil current of these pumps is normally controlled by reed switches or some other mechanical device. As shown in Fig. 5, the power transistor in the Bendix pump serves as a solid-state switch to complete the circuit of the main coil between B+ and ground.

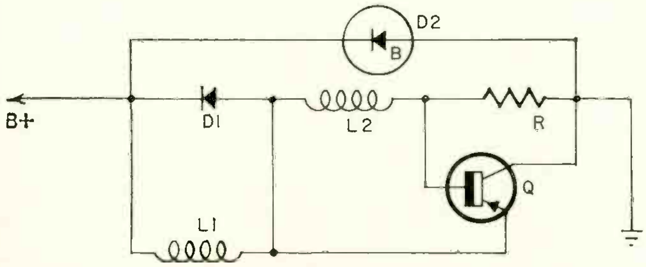


Fig. 5—Bendix solid-state fuel pump operates a plunger electromagnetically. Main-coil L1, energized through Q1, retracts plunger; L2's back emf then drives the base of Q1 to cutoff.

When electrical power is applied to the pump, the transistor acts like a short circuit, applying full voltage to the main coil, L1. The magnetic field created by the coil causes the plunger to move against the spring toward the inlet of the pump. Some of the fuel between the now-open plunger check valve and the foot valve is transferred to the outlet side of the plunger. As this sequence occurs, the voltage across L1 is dropping rapidly with increased current so that a current flows through signal coil L2.

When the plunger has reached maximum retraction, the change in voltage across L1 is no longer sufficient to maintain the field of L2. The resulting

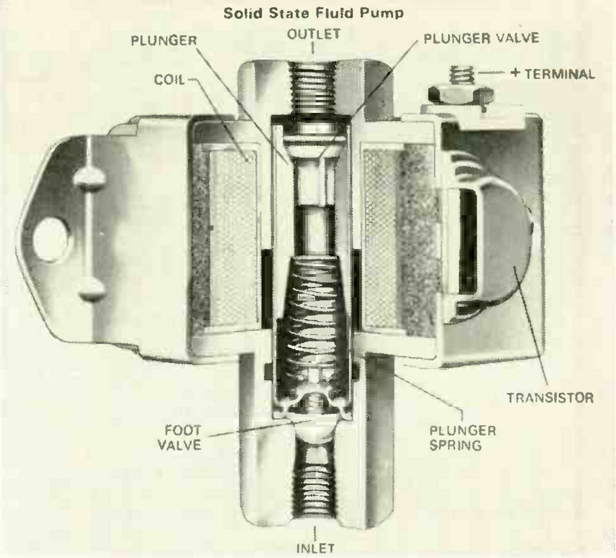


Fig. 6—Cutaway of Bendix fuel pump shows main coil with the signal coil (L2) wound around it. Coupling between the coils activates the plunger through the power transistor.

back-emf generated within L2 drives the base of the transistor to cutoff. The transistor then turns off the coil and the spring pushes the plunger toward the outlet. The plunger valve closes. Fuel on the outlet side of the plunger is forced into the discharge line. New fuel is pushed by atmospheric pressure through the foot valve. At this point, the back-emf from L2 has been expended and the transistor is again turned on. The cycle is repeated. During the turnoff phase of L1, diode D1 shunts the back-emf generated by L1. Zener diode D2 provides overvoltage protection for the circuit.

■ IN THE FUTURE

Industry forecasts show that increasing electronic applications for automotive use will continue for many years. According to reports, several items are being tested by the automotive industry.

Another item currently under development is an IC speedometer-odometer. Several systems are under consideration. According to an article in *Electronic News* (June 19, 1967), the one that appears nearest production uses a variable-reluctance pickup with a counter. In this system, the pickup mounts on a front wheel and generates about 60 pulses per minute for each mile per hour of vehicle speed. These pulses would be applied to a monostable multivibrator to drive a milliammeter calibrated in mph. A system similar to the speed sensor and counter circuit used in the Bendix speed control system might be satisfactory.

An announcement in *Electronic News* (Aug. 5, 1968) said that Ford Motor Co. research engineers are planning to evaluate two new electronic control systems: (1) automatic headway control (AHC) and (2) Minigap. A vehicle equipped with AHC transmits an invisible beam at the car ahead. Taillights of that car reflect the beam to a receiver. (It sounds like infrared radar.) A computer then adjusts brakes and throttle automatically to insure a safe following distance is maintained. Minigap, on the other hand, electronically links a string of cars together into highway caravans following a special lead car. With this system, the driver hooks up, then relaxes. Sounds like Greyhound —"Leave the driving to us." **R-E**

BUILD $20 SCOPE CAMERA

Simple camera modification enables you to keep permanent records of experiments

by DALE E. COY

MOST EXPERIMENTERS HAVE AN OSCILLOSCOPE, yet nothing is quite so rare as the experimenter with an oscilloscope camera to keep a permanent record of the results of his experiments. One reason for this is the cost—a commercial camera designed for scope photography will make a $400-$1200 dent in the wallet, and can only take pictures of the scope screen. Much as we appreciate the value of this piece of equipment, few of us can justify the expense.

This article describes the construction of a simple, inexpensive scope camera which, like Superman, is often disguised as a mild-mannered camera for all the ordinary uses. You can buy a Polaroid Swinger for about $15. or the Big Swinger for around $20. Conversion to a scope camera will cost another $5.

Three things are required to convert these cameras for scope photography; modifying the shutter, adding a supplementary lens; and a method for mounting the camera to the scope.

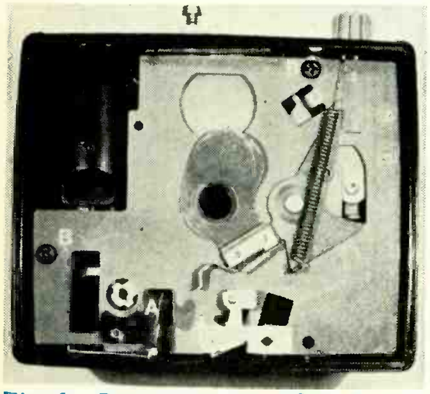


Fig. 1—Rear of the modified shutter. (A) is battery contact, (B) marks two screws holding shutter together. Lens opening is in the center of the plate.

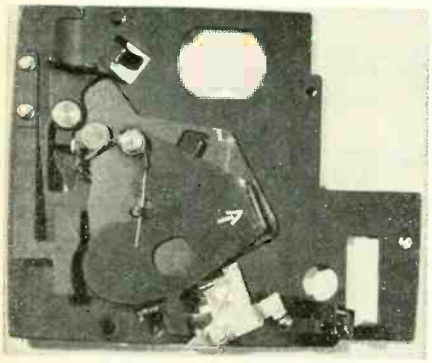


Fig. 2—Inside view of modified shutter. The tiny arrow points to bend made in shutter to provide a "bulb" position.

Shutter modifications

The shutter mechanism for these cameras has one fixed speed of about 1/200 second, which is much too fast for scope photography. An added "bulb" position is needed. With this type of action, the shutter will open when the shutter button is pressed, and will stay open as long as the button is held down. Since most scope photos require exposure times between 1 and 10 seconds, this is an easy shutter action to use. As an added bonus, the shutter mechanism does not have to be cocked between exposures, so multiple exposures may be made on each piece of film to place more than one trace on the picture.

To get to the shutter, first open the back of the camera and remove the battery compartment. Three small Phillips-head screws hold the lens-shutter housing to the rest of the camera. Two of them are chrome, and the other is black. Removing all of them lets the front of the camera drop off. Place the front housing on a clean cloth so the lens will not be scratched. Remove the plastic rear cover plate and the flashbulb ejector from the back of the shutter housing. You should now see something like Fig. 1.

Although Fig. 1 shows the completely modified mechanism with the shutter open, it also illustrates the next operation. Remove the two screws at B. Grasp the tab at C with needle-nose pliers and pull gently upward until the plate snaps free. Then slide the plate out from under the battery contact at A, and turn it over.

Figure 2 shows the inside of the shutter, as modified. The only change needed is to bend the end of the shutter leaf upward. Make the smallest bend you can with needle-nose pliers. Then file the bent part down so that about 1/16 inch extends upward.

Modify the plastic shutter housing next. Locate the spot on top of the housing as shown in Fig. 4, and drill and tap for the stop screw to be used. This screw must be at least ¾ inch long (thread length), and no larger than No. 4. If you can find a No. 2 or 3 screw this long, it is even better. Carefully drill and tap the hole so the screw will lie flat, as shown in Fig. 3. Since the top of the housing is angled, the hole will also have to be angled. Now insert the screw, and make sure it does not bind against the

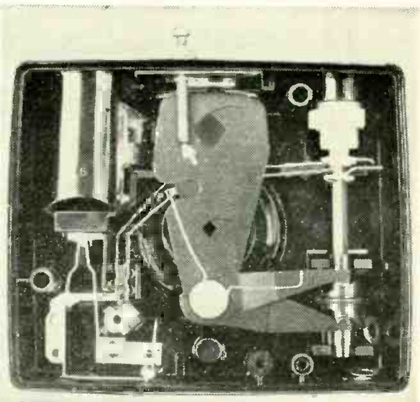
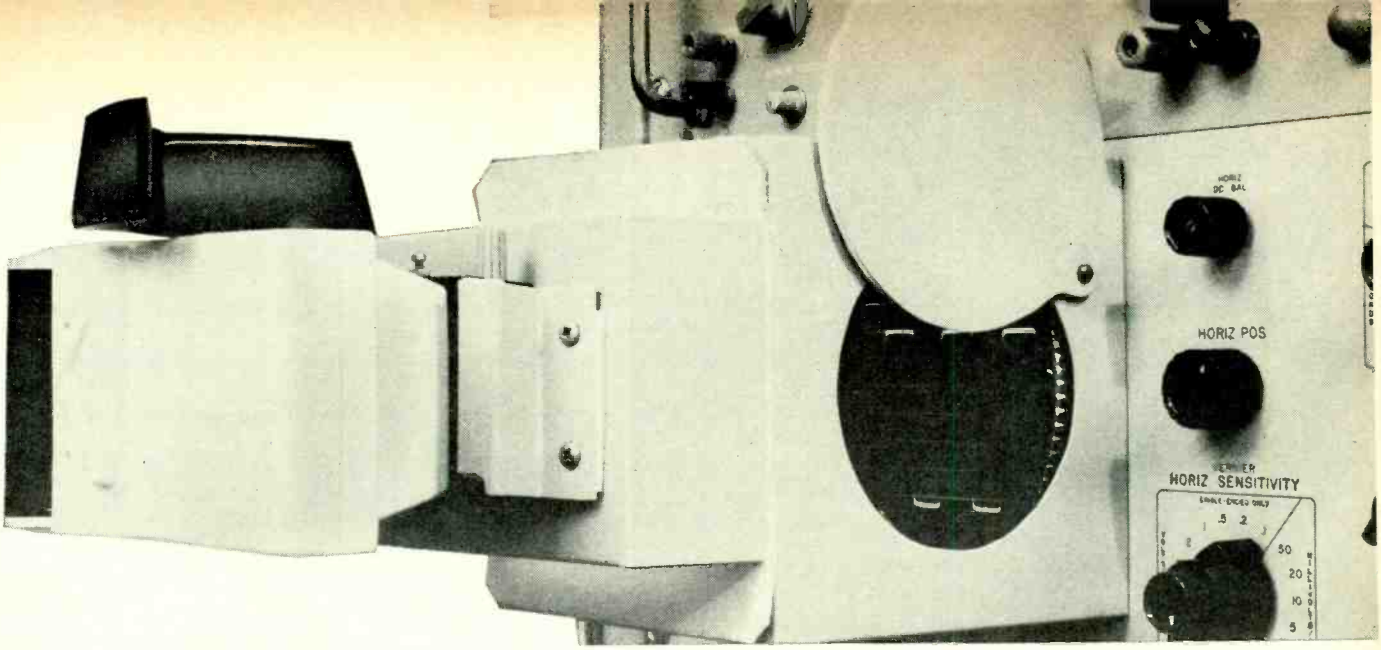


Fig. 3—Modified shutter housing. Added screw (arrow) stops the shutter leaf. The screw should lie flat and must be at least ¾" long (thread length).



sliding blades as the red "brightness" knob is turned.

Put the pieces back together, pressing in at C (Fig. 1) to snap the plate back on. Install the screws. Press the shutter release a few times

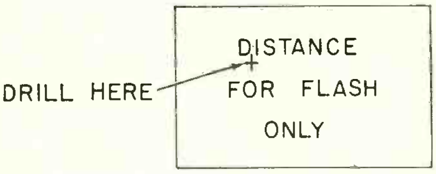


Fig. 4—Drill and tap for the stop screw between the D and I in DISTANCE.

to check for binding inside. If there is some scraping or binding, take the shutter apart again. Binding may be corrected by one of three methods: (1) filing the threads off the stop screw where it is inside the housing, (2) filing some more off the bent part of the shutter leaf, or (3) using thin shims or washers between the metal plate and plastic housing under the two screws at B in Fig. 1.

A few trial assemblies will correct any binding. When the shutter is assembled and working properly, hold the shutter release down and adjust the stop screw so that the shutter is fully open. For this operation, the red knob should be fully clockwise (away from the "darken" end).

This completes the hard part of the modification. You may want to mark the stop screw, or install a nut on the screw so that it can always be turned in to the same depth. By removing the screw and replacing it with a shorter screw (¼ inch or less), the shutter is returned to its usual operation and the camera will work normally.

Polaroid Corp. jealously guards the lens specifications for these cameras. A rough measurement shows, however, that the Swingers have f/16 lenses with a focal length of about 100 millimeters. Most lens measurements are traditionally made in millimeters (mm). There are about 25.4 mm to the inch, so the focal length of 100 mm means that the distance from lens to film is just shy of 4 inches. A supplementary lens is needed to let us focus the camera from a distance of something less than a foot, and to fill the picture with the image of the scope's CRT. Optics is a complicated subject, but since "rough" figures are all we need, we can use a "rough" formula:

$$S = \frac{(\text{Lens Focal Length}) \times (\text{Object Height})}{\text{Film Height}}$$

In this formula, the object height is the height of the part of the CRT screen we want to photograph. The film height is the top-to-bottom measurement of the film image (about 54 mm for the small Swinger and 73 mm for the Big Swinger). The value "S" is *both* the focal length of the supplementary lens we need, and the distance from the front of the camera to the CRT.

The object height chosen is usually not the diameter of the CRT because the pattern to be photographed usually does not go all the way to the top of the tube. Instead, a slightly smaller height is chosen.

To simplify the problem, Fig. 5 is a graph from which the correct supplementary lens may be chosen. The other necessary information is the diameter of lens needed. For the Swingers, the supplementary lens should be at least 20 mm in *diameter*, with the most convenient diameter for mounting about 28 to 30 mm. The best place to obtain lenses is probably Edmund Scientific Co. You can obtain

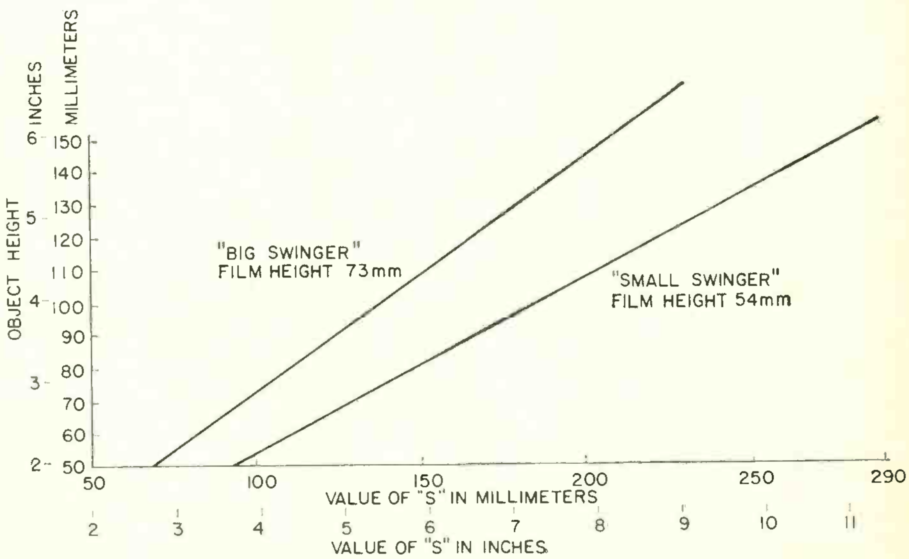


Fig. 5—Graph showing value of "S" (the focal length of the supplementary lens required and the focusing distance of the lens combination) for the 100-mm Swinger lenses. The actual focusing distance will usually be about 10% less than indicated on the graph.

their free catalog by writing to 300 Edscorp Building, Barrington, N. J. 08007. The catalog lists a wide variety of planoconvex and positive meniscus lenses with prices around $1, and a lot

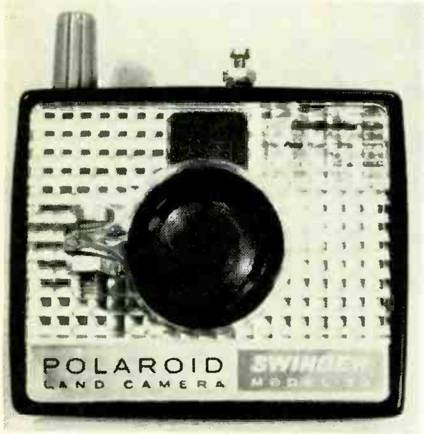


Fig. 6—Front of the modified camera. A plastic cable clamp holds supplementary lens in place. The added stop screw is on the top just to the right of center.

of other interesting gadgets. Their minimum order is $2, so when you order your lens, also order a 2¼ x 3¼-inch piece of ground glass (No. 2143 for 50¢) for use in focusing.

Mounting the lens on the front of the camera is probably the easiest task of all. It may be simply taped to the camera lens tube or clamped on with a plastic cable clamp, as show in Fig. 6.

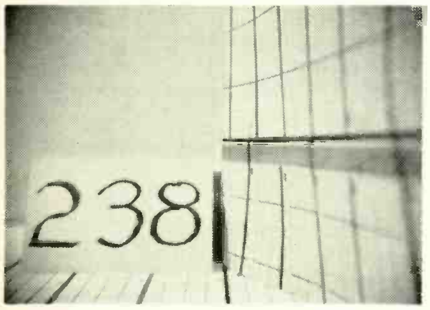


Fig. 7—Test of the camera with a 238-mm supplementary lens. Camera focuses at slightly less than 9 inches and covers a field approximately 4 x 5 in.

Mounting the camera

Before mounting the camera, we must find the exact distance at which the lens is in focus. With the supplementary lens in place, install a piece of ground glass (or a piece of clear plastic sandpapered on one side) in the back of the camera, where the film is located. Open the shutter, and move the camera until the image of some object (for instance, a ruler) is in focus on the ground glass. Then carefully measure the distance from the front of the camera to the object. This is the distance that the front of the camera must be mounted away from the oscilloscope. An alternate method of measurement is to take a picture of a test chart as shown in Fig. 7.

The actual distance from the front of the camera to the CRT should be slightly less than the distance measured, because the scope image is actually formed on the *inside* of the CRT. For most oscilloscopes, the image formed is actually about ¼ inch *behind* the front panel.

The scope mount is made from aluminum chassis and boxes, as shown in the head photo. Since scopes vary in size and style, the final design may not match the picture shown, which is for a 5-inch Hewlett-Packard scope. The mount is held in place by the oscilloscope bezel, located inside the box. The mounting screws pass through the bezel and through the mount, and are fastened to the front panel. The box is painted flat black inside to prevent reflections. Viewing holes with sliding covers are provided in each side, so that the screen may be seen. The covers are closed before the picture is taken. The piece of felt between the two boxes shown also covers a slot which may be used for viewing. The camera is fastened to the second box by two angle brackets bent from aluminum. The lens projects through a hole cut in the box.

When the mounting is finished, check the focus by using a piece of ground glass inside the camera as outlined above. If the image of the scope trace is in focus, the camera is complete. Small adjustments in focus may be made by adding felt pads between the camera and the mounting, if the distance was made too short.

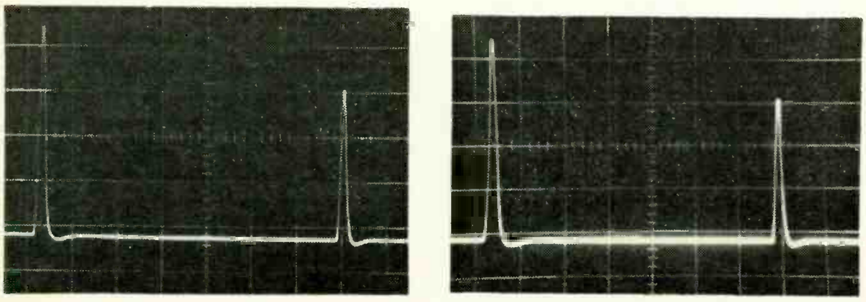


Fig. 8—Comparison of waveform photos (left) taken with a $500 professional oscilloscope camera and (right) $20 Swinger modified for scope photographs.

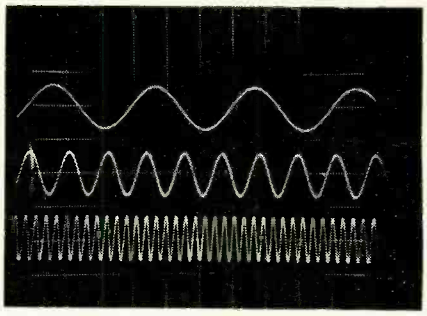


Fig. 10—Multiple exposure made by changing scope's input and trace position. This is an easy way to display waveforms when comparisons are required in the lab.

Using the camera

Using the oscilloscope camera is simple. Just set up the picture on the screen, close the viewing ports and hold the shutter open for a few seconds. Generally, exposure times will run between 1 and 10 seconds. Many things affect this exposure time, including the design of the oscilloscope, the frequency of the signal displayed and settings of the scope controls. The advantage of using Polaroid equipment is the ability to change exposure times and to see the results in just a few seconds. Because of the wide variation in setups, more specific exposure data cannot be given here. Shooting one roll of film with your equipment will make you an expert.

The scope camera may be used to make a permanent record of your experiments, to record transients and to photograph events which happen too fast or too slow for the eye to detect on the oscilloscope screen. Its versatility is limited only by your imagination. Samples of the work done by this camera are shown in Fig. 8 and 9. Quality compares favorably with equipment costing 20 to 30 times as much. For most pictures, the "darkness" control (red knob) on the camera should be set fully clockwise for the brightest picture. For extreme sharpness, you can rotate this control counterclockwise a bit, although this will cause an increase in the exposure time needed.

This inexpensive scope camera is simple to build and performs well. If you are reluctant to do the camera modification yourself, most camera repair shops will do it for a few dollars. By removing the supplementary lens and the stop screw, the camera is returned to service taking snapshots. This kind of bargain is hard to pass up. **R-E**

ABC'S OF TRANSISTORS

VDR's and Thermistors

by SYLVANIA TECHNICAL STAFF

Take a look at all the newest semiconductor devices. There are VDR's, thermistors, FET's, VVC's and more

EVERY SO OFTEN YOU'LL HAVE TO TEST voltage dependent resistors (VDR's) and thermistors and then decide whether or not they should be replaced. First let's take a look at the VDR.

Physically, the VDR appears as in Fig. 1-a and Fig. 1-b. Don't be fooled by the appearance of the unit in Fig. 1-b. It may look like a precision resistor but it isn't. The electronic symbols for the VDR are in Fig. 1-c. VDR's are used to present a high impedance to small applied voltage and as the voltage increases the VDR's resistance decreases and allows more and more current to flow.

The VDR is used to cut pulse-peak variations by providing in a high resistance when the voltage is low, and a low resistance when the voltage is high. In the vertical circuit of a TV set it is used to provide a low resistance to the large vertical pulse during trace time, and during retrace its increased resistance allows the retrace voltage to maintain its full amplitude for fast retrace. The VDR in the video supply provides a form of regulation and filtering action in a voltage divider network.

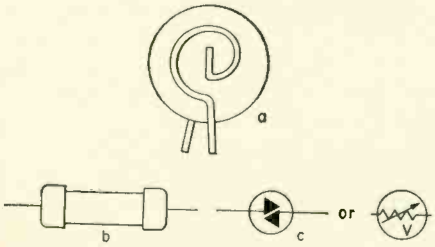


Fig. 1-a and b—Drawings of two types of VDR's used in TV and other circuits. Two electronic symbols are shown at c.

$$\text{MAX RTG} = \frac{\Delta E @ 10\,I}{E @ I}$$

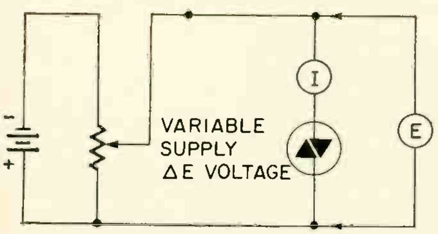


Fig. 2—VDR test setup. Rating is ratio of change in applied voltages required for a current change of 10.

Automatic degaussing circuits in color sets use a VDR in conjunction with a thermistor to allow heavy current to flow through the degaussing coils. As soon as the temperature of the thermistor rises, the voltage across the VDR falls, its resistance increases, and current flow through the coils is effectively stopped. Most VDR's will carry 10 times more current when the voltage applied is increased one to two times over a specified range.

An ohmmeter reading will tell you very little about a VDR since VDR's have such wide variation in resistance. Out-of-circuit readings will be in the megohm range. If the unit has failed it will probably fail in the open mode. Often, the easiest way to verify operation is to substitute a new VDR in place of one whose operation is questionable.

Factory tests for a VDR call for a variable dc supply near the VDR voltage rating. One milliamp of current is made to flow and a voltage reading taken. When the voltage is increased until 10 milliamperes flow, the two voltages are from 1.5 to 2, as shown in Fig. 2. The rating ratio provides the change in voltage (ΔE) required to produce a change in current magnitude of 10.

Thermistors

Most thermistors used in TV chassis have a negative temperature coefficient (NTC). Their characteristics are used where less resistance is required as a circuit comes up to temperature. (Fig. 3) One common application is to use a thermistor in series with tube heaters to protect them during heater warmup. They are also used in the vertical output transistor amplifier to maintain constant vertical sweep voltages over the temperature range of the set. Color TV's use a thermistor to develop a voltage while still cold to divert ac to the degaussing coil circuit.

A typical thermistor value when cold is 120 ohms and when hot about 20 ohms. Two ohmmeter measurements are needed to check a thermistor—the hot and the cold resistance readings. If these readings fall in the expected range the part is usually con-

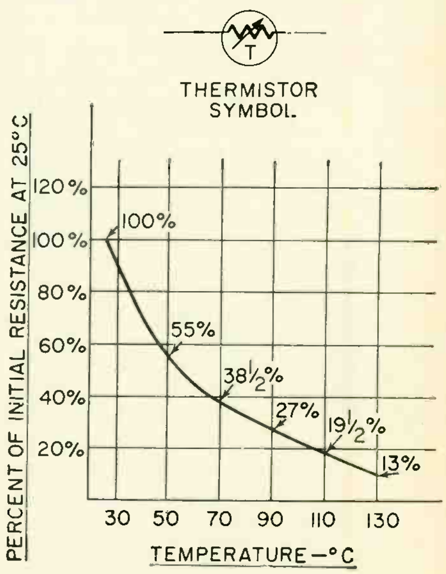


Fig. 3—Thermistor curve. Resistance drops as temperature rises.

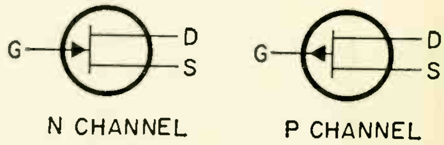


Fig. 4—Symbols for junction-type FET's. N-channel and p-channel types.

sidered good. Some thermistors have hot and cold values well into the megohm range.

When they fail, most thermistors increase in resistance. In a TV set this can cause slow warmup of series-string tubes, changes in vertical height with temperature or continuous degaussing in a color set.

The field-effect transistor

Appearing in new electronic circuitry is a new transistor type—the field-effect transistor or FET (see Fig. 4). Advantages include a high-impedance input, high-frequency response and low noise level. There is excellent input–output isolation, which is a common shortcoming of most transistors. There are two basic types: junction FET's and insulated-gate FET's.

The basic operation of the junction FET (JFET) can be described as an electrostatic field control of current flowing through a semiconductor (see Fig. 5). The input signal provides a controlling field to the gate terminal to regulate the flow of electrons from drain to source. If the gate bias is reversed with respect to the drain source, current is reduced. If gate bias is of forward polarity, drain-source current increases. The gate bias thus varies the depletion region, reducing the channel conduction size and increasing the resistance of the channel to current flow.

With a small gate voltage we can control a large source-drain current, so we have the ingredients of an amplifier. In Fig. 5 a high-impedance transformer secondary applies a small rf signal to a JFET. As shown, an oscillator signal is injected at the current-source terminal to use the stage as a superheterodyne rf–oscillator mixer.

The gate terminal must never be completely forward-biased or the source-drain current will flow into the gate circuit.

Insulated gate FET

This type FET has the gate junction insulated from the current-drain material by glass. This prevents drain current from flowing into the gate circuit as it did in the JFET. The principle of operation is the same as the JFET except that a higher input impedance is obtained and the dc polarity of the input signal may vary. To set up a dc operating condition, a positive polarity is applied to the drain terminal (Fig. 6). The substrate is connected to the source, and both are at ground potential so the channel electrons are attracted to the positive drain and a dc source-drain current is obtained.

Silicon controlled rectifiers

The Silicon Controlled Rectifier (SCR) is similar to the vacuum-tube thyratron. When a voltage is placed across the anode and cathode a trigger voltage applied to the gate causes the semiconductor layers to suddenly decrease in resistance and heavy current can flow. This continues even after the gate trigger voltage is removed and as long as the cathode-anode voltage remains.

A typical SCR application is as a switch to turn on a stereo indicator lamp in an FM set. In this circuit the 19-KHz subcarrier signal, which is present only during stereo reception, is used to turn on the SCR so that the

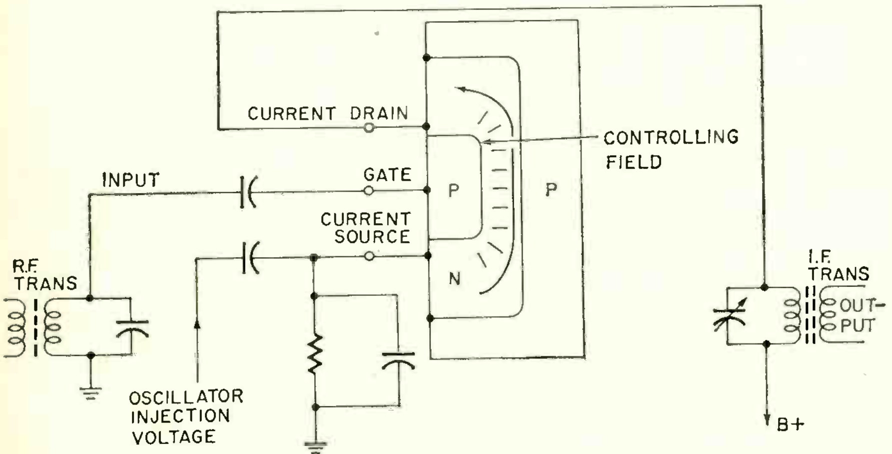


Fig. 5—With its inherent high input impedance, the junction field-effect transistor makes an ideal rf or i.f. amplifier. A large current between drain and source can be controlled by a small voltage on the gate. When an rf voltage of a different frequency is fed to source, the FET maks a good heterodyne mixer.

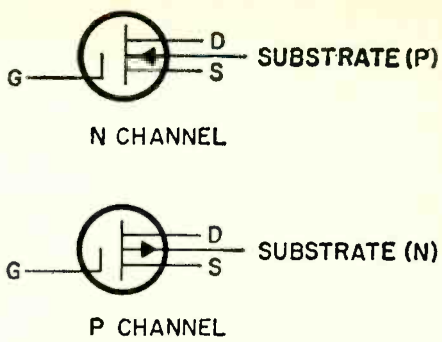


Fig. 6—Electronic symbols for the IGFET or insulated-gate FET. This type has a higher input impedance than the JFET and does not load down a signal source.

6.3 volts ac can operate the lamp. When stereo reception stops, the trigger voltage is removed and the anode-to-cathode current is shut off after the first pass of the ac voltage through zero.

Varactor diodes

A varactor or variable-reactance diode is a pn junction semiconductor device in which the junction capacitance varies in relation to the junction voltage. When biased in the reverse direction, a varactor diode can be represented by a voltage-sensitive capacitance in series with a resistance. This nonlinear capacitance and low series resistance permit the device to perform frequency-multiplication, oscillation and switching functions. It is the result of a very high impurity concentration outside the depletion-layer region and a relatively low concentration at the junction. Very low noise levels are possible in circuits using varactor diodes because the main current across the junction is reactive and random-noise components are absent.

A practical application of the varactor diode is shown in Fig. 7. The circuit permits automatic frequency control by applying an afc voltage to the cathode of the varactor diode.

A fixed bias voltage is maintained on diode SC2 by resistors R38 and R40. The diode remains in a reverse-biased condition while afc voltage variations cause slight capacitance changes, maintaining a constant oscillator frequency.

Clamping and rectifying diodes

Rectifying diodes are often used as polarity switches, rectifiers and overload limiting devices. One application is as a source of dc restoration in a TV set and bias for brightness control (see Fig. 8).

In this circuit SC202 rectifies a flyback pulse so that positive pulses forward-bias the diode and pull elec-

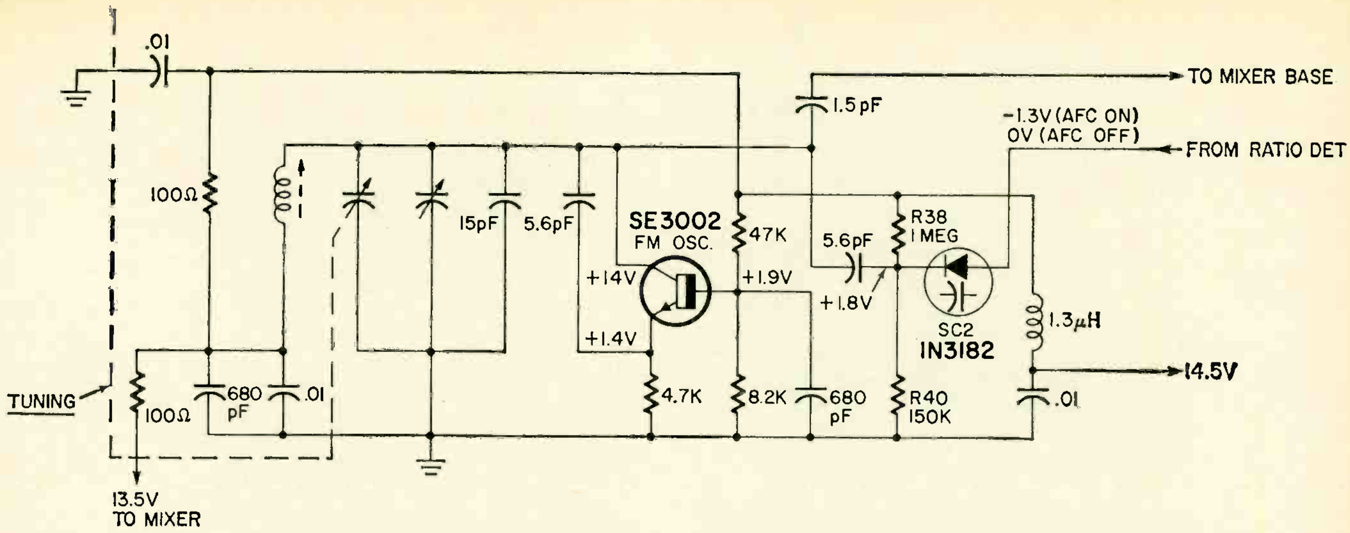


Fig. 7—In this FM afc circuit, the capacitance of the back-biased varactor is across the oscillator tank. Mistuning or drift causes the FM detector to develop a negative correction voltage on the varacator anode. This changes the effective oscillator capacitance in the direction that restores the oscillator to the correct operating frequency.

trons up from ground. This negative charge is drained off to ground through the BRIGHTNESS control. Depending on the control setting, the adjusted bias is applied to the grid of the video output stage and sets its conduction level. This establishes video plate voltages and in turn the CRT cathode bias.

In series with the voltage developed by the brightness circuit is another voltage developed by rectified flyback pulses and video signal. The flyback pulse provides positive-going pulses to turn on SC204 and remove electrons from the video output grid. This is done at a level determined by the flyback pulse amplitude. When a negative polarity video signal is present, the average dc bias on the grid of V7 varies to match and the corresponding conduction change and adjusts CRT cathode bias. The CRT bias is therefore dependent upon the average video signal level.

A receiver may use a clamping diode circuit to reduce the gain of an i.f. section when very strong signals are received. Normally the diode is reverse-biased until a large signal causes the diode to conduct.

When the diode conducts, it loads the transformer and gain drops considerably. To troubleshoot this circuit, make sure the diode is reverse-biased under no-signal conditions. The anode of the overload diode should be negative with respect to the cathode by a volt or more with no signal. A shorted diode causes a severe gain reduction under any signal condition. An open diode results in distortion when very strong signals are received.

Another application of the clamping diode is in a vertical oscillator circuit (see Fig. 9). This is a multivibrator type circuit with vertical triggering applied at the cathode of the vertical oscillator and across a diode. The diode is forward-biased to allow the tube to conduct normally. When sync pulses are applied to the diode, negative-going pulses bias the cathode and serve to trigger the tube out of the cutoff portion of its cycle. Positive-going pulses are grounded by virtue of forward-biasing the clamping diode. The diode will keep the cathode potential of V13-a from ever going positive, but will allow negative excursions resulting from sync pulses. **R-E**

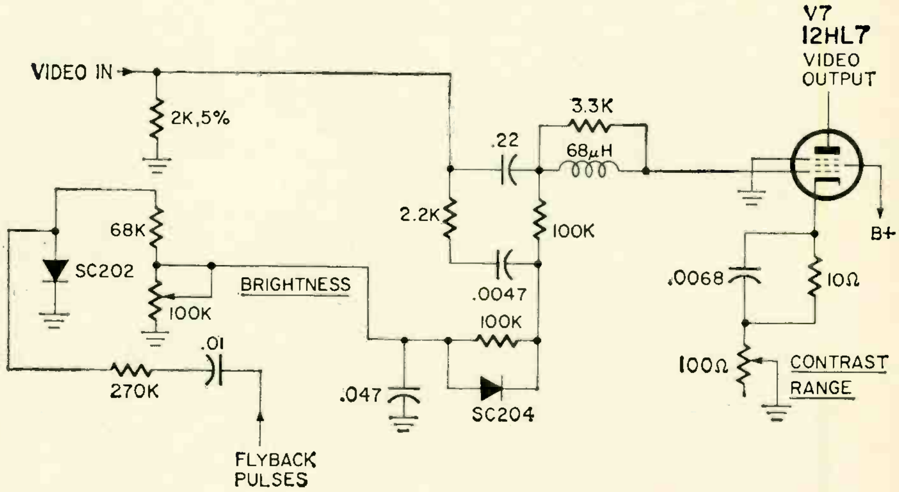


Fig. 8—Sylvania uses diodes for dc restoration and automatic brightness control in some sets.

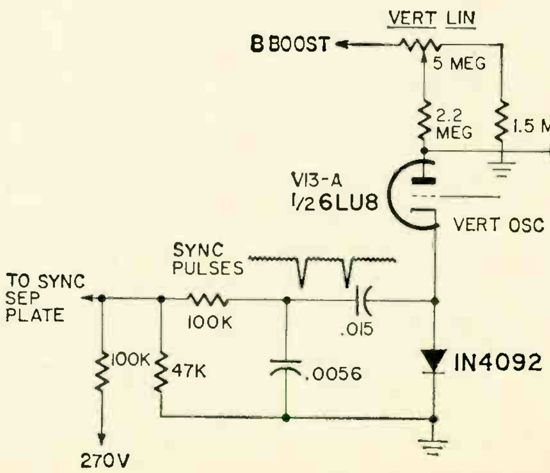


Fig. 9—Diode in cathode circuit insures that the vertical oscillator is triggered only by the negative-going part of the sync pulse.

How it works—

VARIABLE-VOLTAGE TUNING

A new kind of tuning "capacitor" for the new sets

by **ROBERT F. SCOTT**
SENIOR TECHNICAL EDITOR

DURING THE EVOLUTION OF RADIO communications, the galena crystal and spark gap gave way to vacuum tubes and now the vacuum tube is rapidly being replaced by semiconductors. The variable tuning capacitor —which, except for permeability tuning in auto radios, seemed to be forever with us—is now bowing out in favor of a solid-state equivalent. These semiconductors that are replacing the tuning capacitor are generally known as voltage variable capacitance (VVC) diodes, varactors, voltage variable diodes or capacitance diodes and by such trade names as Varicaps, Epicaps, Minicaps, Voltacaps, Capistors and Varactrons.

The VVC is a special type of silicon diode that acts like a capacitor when its pn junction is back-biased. The effective capacitance of a diode varies as the formula $1\sqrt{V}$ as the voltage across its terminals is varied. The capacitance versus bias voltage curve for a typical VVC diode is shown in Fig. 1.

There doesn't seem to be a standard symbol for the VVC. Some of the more common ones are shown in Fig. 2.

The earlier VVC's had a low maximum capacitance and a maximum capacitance ratio of around 5.5:1 which limited their use to modulation and afc circuits. Recently, high-Q VVC's have been developed with capacitance ratios greater than 26:1 for a voltage range of 0 to 10 volts. This makes it possible to use them as replacements for the conventional mechanical variable capacitor tuning over as much as a 3 to 1 frequency range of any band on a receiver or signal generator. The VVC offers many advantages over its conventional mechanical equivalent. Among them are:

- Small size—they average around 0.1 inch in diameter and 0.3 inch long.
- No need for mechanical coupling to dial or drive mechanism.
- High-speed tuning.
- Greater electrical stability because of immunity to shock and vibration.
- No moving parts to wear out or come loose.
- Temperature coefficients are known and easily compensated.
- Tuning controls (a potentiometer or pushbutton switch to adjust the dc bias) can be remote from the tuner.

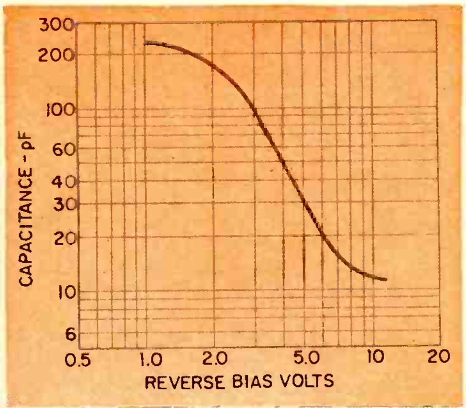


Fig. 1—Capacitance vs reverse voltage curve for VVC. Nominal capacitance is the value obtained with 4 volts of reverse bias.

VVC front-end for AM radio

VVC diodes have been used for tuning and bandswitching in some European TV sets and in some Japanese and European AM/FM radios since around 1964. The front-end (converter) of a pushbutton AM tuner is shown in Fig. 3. It was described in an application note for the BA 163 made by ITT.

The BA 163 is a silicon epitaxial diode with a capacitance ratio of greater than 26:1 over a voltage range of 0 to 10 volts. Its Q ranges from 200 (minimum) to 500 (typical) from 150 to 500 kHz at 1 volt and from 300 to 1500 kHz at 10 volts.

In the diagram, one BA 163 is connected in series with a .047-μF capacitor across the high-impedance winding of a ferrite-type antenna coil. The series capacitor blocks the dc control voltage and prevents it from shorting to ground. Its value is high enough so it does not affect the capacitance range of the VVC. C1-L1 form a trap to reject signals in the set's i.f. range.

The oscillator circuit works in the common-base mode with feedback from collector to emitter. The oscillator voltage in the collector circuit is limited (by design) to 1 volt p-p to limit distortion.

Antenna-tuning diode D1 is fed from the 10-volt bias line through an adjustable voltage divider consisting of R3 and R4, and the oscillator diode is fed from a fixed voltage divider consisting of R1, R2 and R4. R3 is adjusted for proper tracking between the oscillator and antenna circuits.

The bias voltage for the tuning diodes is applied through interlocking pushbutton switches S1–S6. When S1 is closed, R5 is used for continuous tuning. Switches S2–S6 and pots R6–R10 are for preset pushbutton tuning. Potentiometer R11 sets the maximum bias voltage developed across the control pots.

The BA 163 is supplied in matched sets of 2, 3, 4 or as is required. For any two, the maximum ratio of voltages at 30 pF is 1:1. The basic tracking circuit for any two diodes is shown in Fig. 4. Potentiometers R1 and R2 are set so the capacitance of D1 and D2 is 30 pF. The capacitance ranges that can be obtained by varying voltage V_{ab} (with R1) are 120–260 pF, 30–120 pF and 10–30 pF. When the ratio of the voltages across D1 and D2 is constant, the capacitance differential is less than 5% from 120 to 260 pF, less than 2% in the 30–120-pF range and less than 1 pF between 10 and 30 pF.

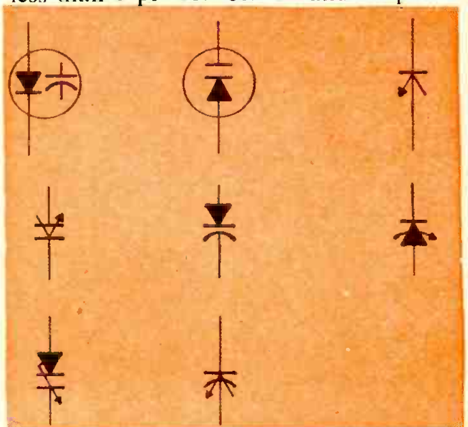
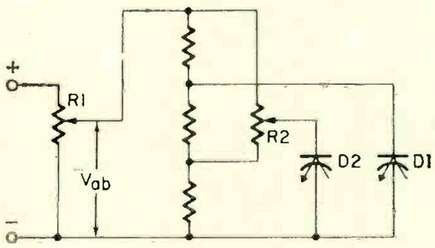


Fig. 2—There is no common VVC symbol. Here are the most common ones in use. R-E uses the one shown at right in bottom row.

VVC all-channel TV tuner

With the coming of varactor-tuned TV tuners, the channel selector can be mounted on any convenient part of the cabinet—or even in a remote location—instead of being mounted directly on the tuner shaft as in capacitor-tuned conventional models. Standard Kollsman Industries has announced a new solid-state all-channel TV tuner whose circuit will probably resemble Fig. 5, which is a basic diagram prepared from US patent No. 3,354,397, issued to Karl H. Wittig and assigned to SKI.

In this circuit, VVC's are used for channel selection and for switching between vhf and uhf TV bands. On the vhf channels, antenna coil L1 is tuned by varactor D2. The collector tank circuit of the rf amplifier is composed of L4 tuned by varactor D4.



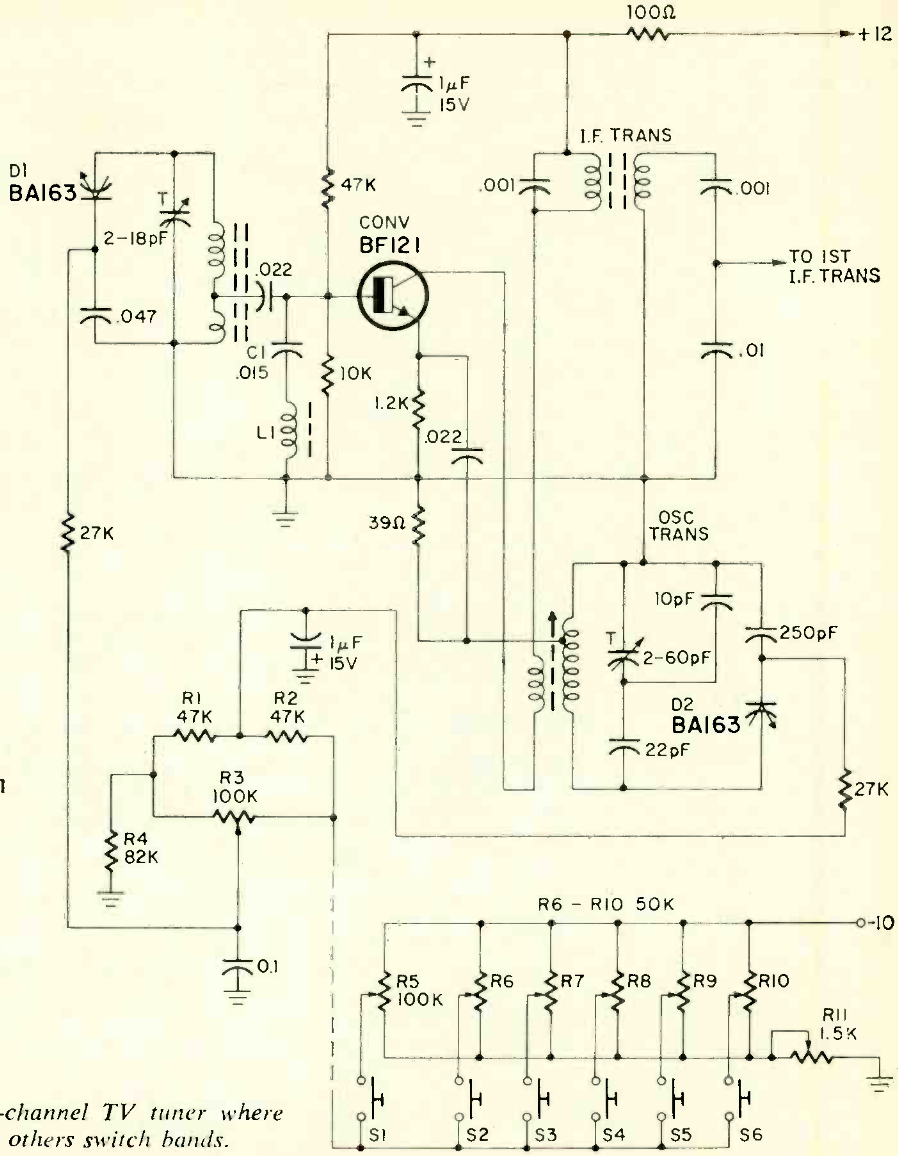
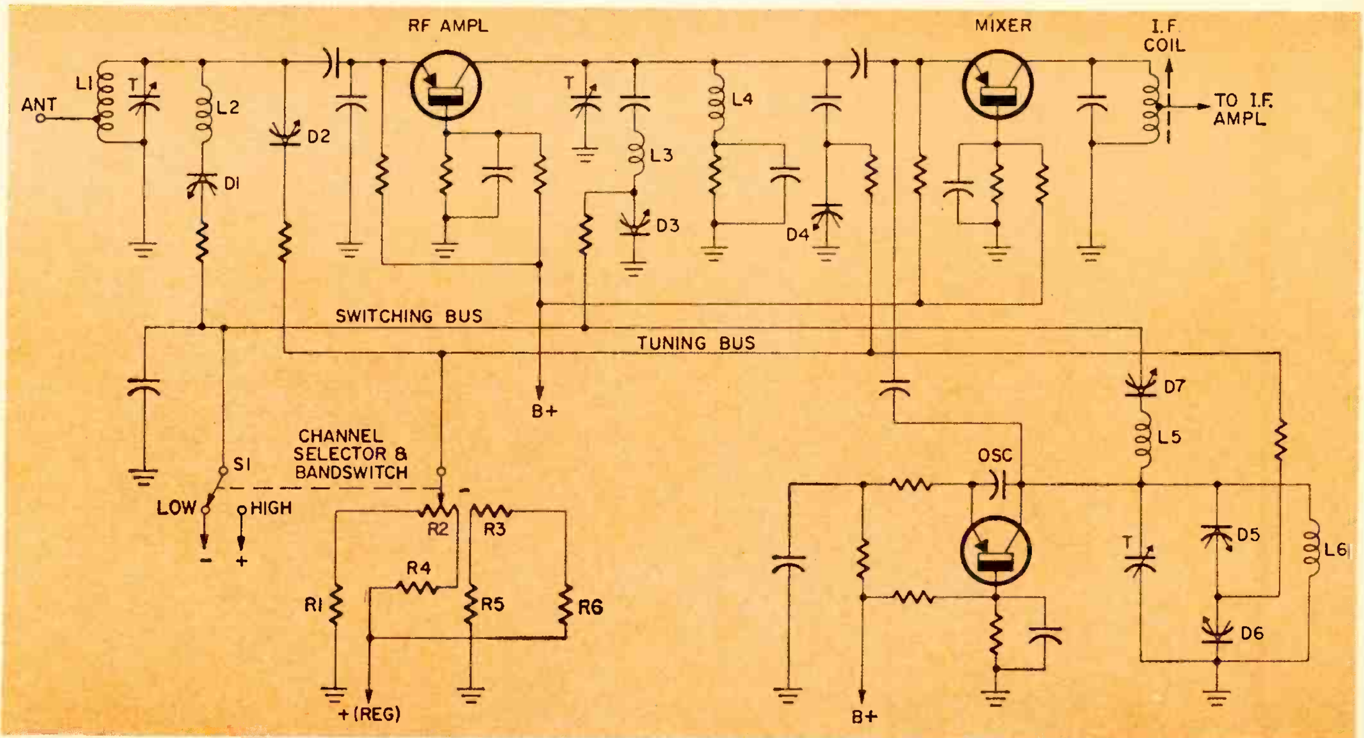


Fig. 3—(right)—Front-end of AM tuner designed by ITT to illustrate the use of the BA163 capacitance diode.

Fig. 4—(above)—Basic circuit for adjusting tracking to two VVC diodes.

Fig. 5—(below)—Basic circuit of all-channel TV tuner where D2, D4, D5 and D6 tune stations. The others switch bands.



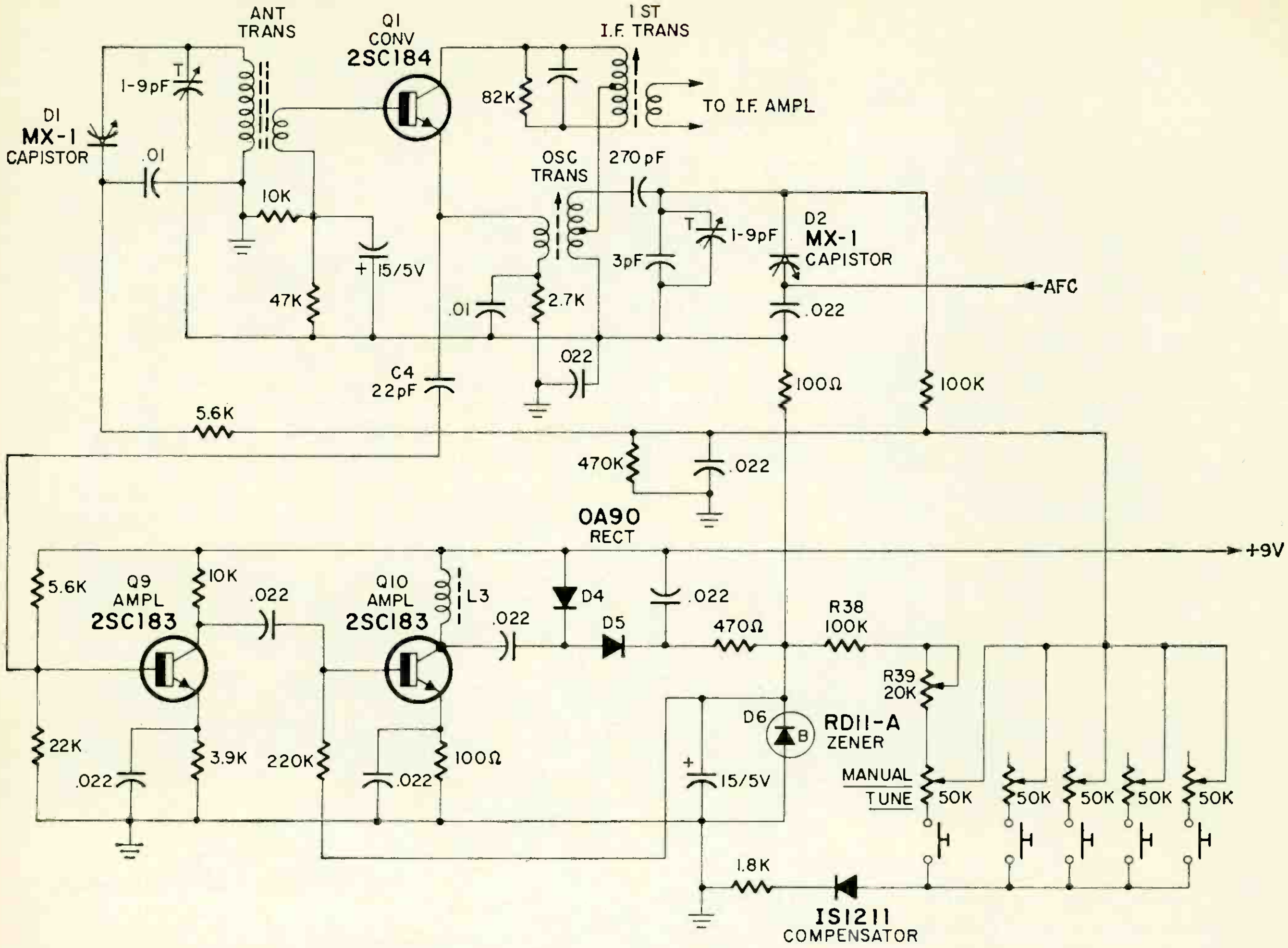


Fig. 6—Front-end and voltage-regulator circuit in the Panasonic R-1500 battery-powered transistor portable radio. The oscillator voltage is tapped off, amplified, rectified and then added to supply voltage to compensate for low batteries.

Oscillator coil L6 is shunted by varactors D5 and D6 connected back-to-back and tied to the tuning bus. (In the oscillator circuit, the rf voltage across the tank coil is high compared to the tuning voltage applied to the varactors. If a single diode were used as in the antenna and mixer tuned circuits, this high rf voltage would lead to frequency instability and high harmonic output. With two varactors back-to-back, the dc tuning bias varies the capacitance of both by the same amount and in the same direction—as with a split-stator capacitor—while the rf voltage causes equal and opposite capacitance changes.)

The channel selector consists of a special two-section potentiometer (R2–R3) ganged to bandswitch S1. As the arm of the channel selector is moved to the right (toward the junction of R2 and R4) the voltage applied to D2, D4, D5 and D6 goes more positive. This decreases their effective capacitance and tunes the antenna, mixer and oscillator circuits to successively higher channels in the vhf band.

Coils L2, L3 and L5 are isolated from the circuit during vhf operation by the very low effective capacitance of D1, D3 and D7 which is produced by the negative bias on the switching bus.

As the arm of the channel selector passes the mid-point of its travel, it moves to the junction of R3 and R5 and S1 switches to the high position. D1, D3 and D7 are now forward-biased so they act as short circuits or closed switches which connect L2, L3 and L5 in parallel with the vhf coils. This reduces the effective inductance in the antenna, mixer and oscillator circuits so the uhf channels can be covered.

Battery portables too

When VVC tuning was applied to the Panasonic R-1500 battery-powered transistor portable, special circuits were added to insure that a stable 10 volts was available for the Capistors (D1 and D2) in the antenna and mixer circuits so as to compensate for the normal decrease in battery voltage with time and use. The front end and compensating circuits in the R-1500 are in Fig. 6. The set has five pushbuttons: one to select manual tuning and four for preset stations.

When the set is first turned on, battery current from the 9-volt line flows through D4 and D5 and turns on converter Q1. As Q1 starts oscillating, a part of the oscillator voltage is tapped off the emitter circuit and fed through C4 to the base of Q9. Transistors Q9 and Q10 amplify the oscillator signal and develop a fairly high rf voltage across rf choke L3.

This voltage is rectified by D4 and D5 and added to the converter supply voltage and stabilized by Zener diode D6. This stabilized voltage is also fed through R38 and R39 to the manual tuning or preset pots as bias for the Capistors in the antenna and mixer circuits.

The afc circuit (not shown) consists of a separate i.f. amplifier stage —fed from the output of the second i.f. amplifier—feeding a discriminator that develops a correction voltage. This voltage is applied to the anode of the oscillator Capistor (D2) to aid or oppose the tuning bias and tune the station in right on the nose. **R-E**

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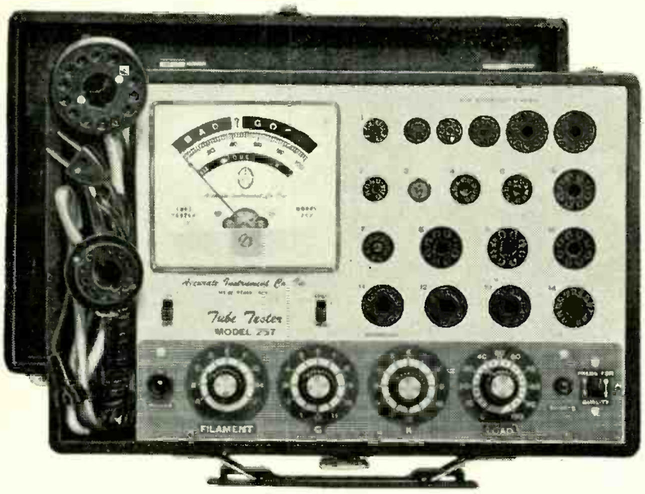

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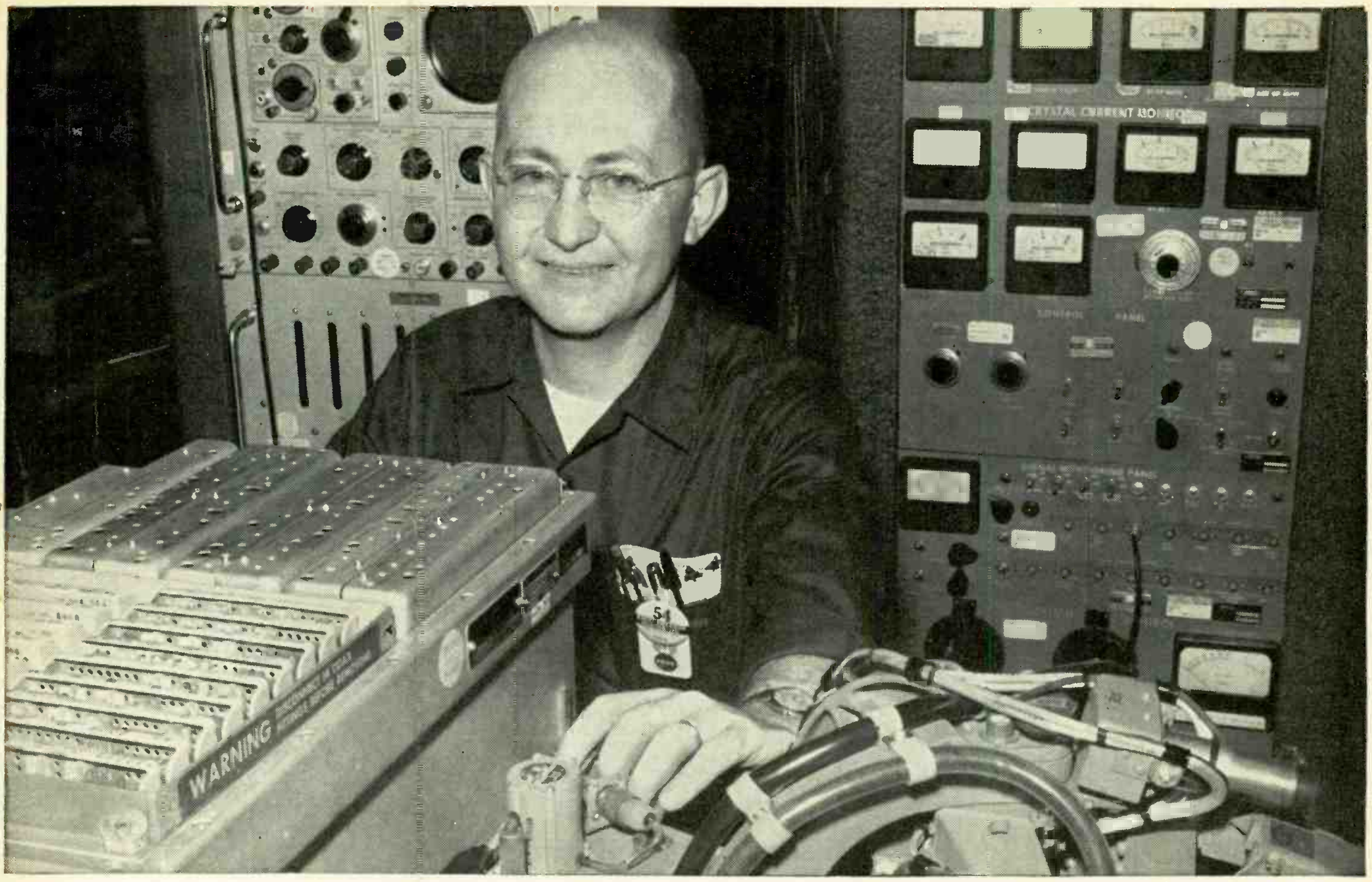

replacing components. You need to really know the fundamentals.

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NEW BOOKS

KNOW YOUR TUBE AND TRANSISTOR TESTERS, by Robert G. Middleton. *Howard W. Sams & Co., Inc., 4300 W. 62 St., Indianapolis, Ind. 46206. 5⅜ x 8½ in., 144 pages, soft cover, $3.50.*

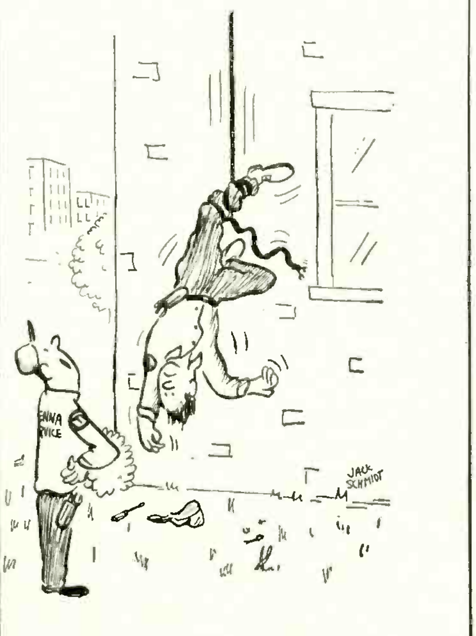
Covers principles of tube and transistor testers and circuits used in them. Typical service and lab-type testers are analyzed. Furnishes background necessary for troubleshooting and repairing various testers.

ELECTRONIC DIGITAL TECHNIQUES by Paul M. Kinter. *McGraw-Hill Book Co., 330 W. 42 St., N.Y., N.Y. 10036. 9¼" x 6¼". 315 pp, hard cover, $11.95.*

A down-to-earth approach to digital systems geared to the needs of the practicing engineer. Non mathematical guide is concerned only with actual design problems and the techniques for their solutions.

ELECTRONIC CIRCUITS, by Samuel Seely. *Holt, Rinehart & Winston, Inc., 383 Madison Ave., New York, N. Y. 10017. 6¼" x 9¼", 752 pp. Cloth, $13.95*

This text introduces the theoretical and practical aspects of semiconductor and tube circuits. It explains how an FET is often used without basic changes in a normal tube circuit configuration. Circuit discussion includes small signal untuned amplifiers, analog computing circuits, sinusoidal oscillators, sawtooth generators, integrated circuits and power supplies.



THE BOSS'LL BE FURIOUS. YOU BENT THE ANTENNA.

TRANSISTOR TROUBLESHOOTING PRECAUTIONS

Be careful when working with transistors. They can be destroyed almost instantly.

Do not work on transistor equipment with power connected. The only time you should have power on is when the equipment is operating or when you are making measurements.

Do not probe energized circuitry. A momentary short from base to collector will almost always destroy a transistor. In direct-coupled stages other transistors may be destroyed as well. Guard against dropped tools, too. In the time it takes a screwdriver to glance off a pair of terminals a transistor may be destroyed.

Clean all foreign materials off the insulators when replacing power transistors. Such particles can pierce the mica insulator or prevent adequate heat transfer to the heat sink.

Apply silicone grease on both sides of the mica insulator used with power transistors.

When soldering transistors, use a heat sink whenever possible and keep heat application time short.

Use only test equipment which is well isolated from the line when making measurements on a chassis which is connected to a power source (even though the switch is turned off). Check all test equipment and use an isolation transformer on the chassis under test if necessary.

Do not use just any ohmmeter to check resistance in transistor chassis. The voltage at the leads of some ohmmeters may exceed the current or voltage limitations of the transistors. Usually, the lower resistance scales on 20,000 ohm/volt meters are safe for short and open tests.

Do not arc high voltage haphazardly. Arcing can cause small-signal transistor failure.

Do not shunt capacitors without fully understanding the circuits. Shunting can cause transistor failure.

Do not operate the TV with the yoke disconnected.

Do not operate the set with the speaker disconnected.

Many transistor stages are direct-coupled. A malfunction in one stage can cause improper readings elsewhere. **R-E**

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Short-Wave Tuning Aid

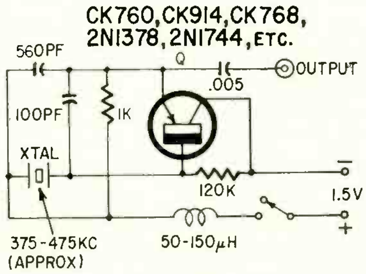
SOME OLDER RECEIVERS ARE HARD TO tune to an exact frequency. You log a foreign station one night, but cannot find it the next night because the dial is critical to manage, and because the frequency drifts.

This crystal oscillator uses a crystal in the i.f. range, about 400 or 450 kc. (Make sure its at least 10–15 kc away from the set's i.f.) The wide span between harmonics produces less confusion and maintains a stronger signal, than a 10-kc oscillator.

As an application example, consider the SX-71 (popular about 12 years ago.) Its bandspread is calibrated for the ham bands, and it also carries a 0–100 logging scale. The main dial is correctly calibrated in mc *only* when the bandspread dial is at 100. The bandspread calibrations are correct *only* when the main dial is on the desired band marking.

Assume you place a 474-kc crystal in the calibrator circuit. You wish to tune the receiver to the 7-mc ham band. The closest harmonic of 474 kc is 7.1 mc (the 15th harmonic). So you set the bandspread to 7.1 and tune near the 40-meter marker on the main dial till you hear the oscillator signal. The bandspread dial is now correctly calibrated for the band.

The oscillator helps you tune shortwave broadcasts and other signals, too. Say you wish to scan the 6-mc region. The closest harmonics of 474 kc are the 12th (5.7 mc) and the 13th (6.2 mc). Set bandspread to 100 and tune the main dial for 6.2 *approximately*, till you pick up the oscillator. Unless your dial is badly in error, it will point to near 6.2 mc. Now search for stations with the bandspread, logging as you find them.



The diagram shows some of the transistor types found suitable for the circuit. Low-frequency types are not suitable. Sluggish transistors may require a 3-volt battery. Total current drain is less than 0.5 ma. The output terminal connects to or near the antenna post of the receiver.—*I. Queen* **R-E**

COMING NEXT MONTH

You'll find two special roundup features in our exciting May issue. If you're a CB'er or operate a boat, don't miss:

- **CB Radio Roundup**—What's happened to 1969 transceivers? Frequency synthesis, mechanical filters, FET's and IC's are just part of the story.

- **Electronics Afloat**—Sophisticated electronics is no longer limited to yachts. Here's a look at new devices that bring safety and convenience to boating.

PLUS THESE FEATURES

- **IC Stereo Preamp**—Start on part two of R-E's "last word" stereo system. This month we describe our 125-watt per channel amplifier. Feed signals to it with this professional preamp.

- **Build a 50-Watt Booster Ampl**—Turn a low-wattage guitar amplifier into a setup that'll shake the walls.

May Radio-Electronics

The cartridge looms large for a simple reason:

It is the point of contact between the entire hi-fi system and the recording. What happens at the tip of its tiny stylus determines what will happen in all those big and impressive components that are so obvious to the eye and, in the aggregate, so apparent to the pocketbook. Worldwide, experts and critics have hailed the discovery of Trackability as *the* definitive measurement of cartridge performance. When evaluated against this measurement, the superb **Shure V-15 Type II Super Track** stands alone. Shure Brothers, Inc., 222 Hartrey Ave., Evanston, Illinois 60204

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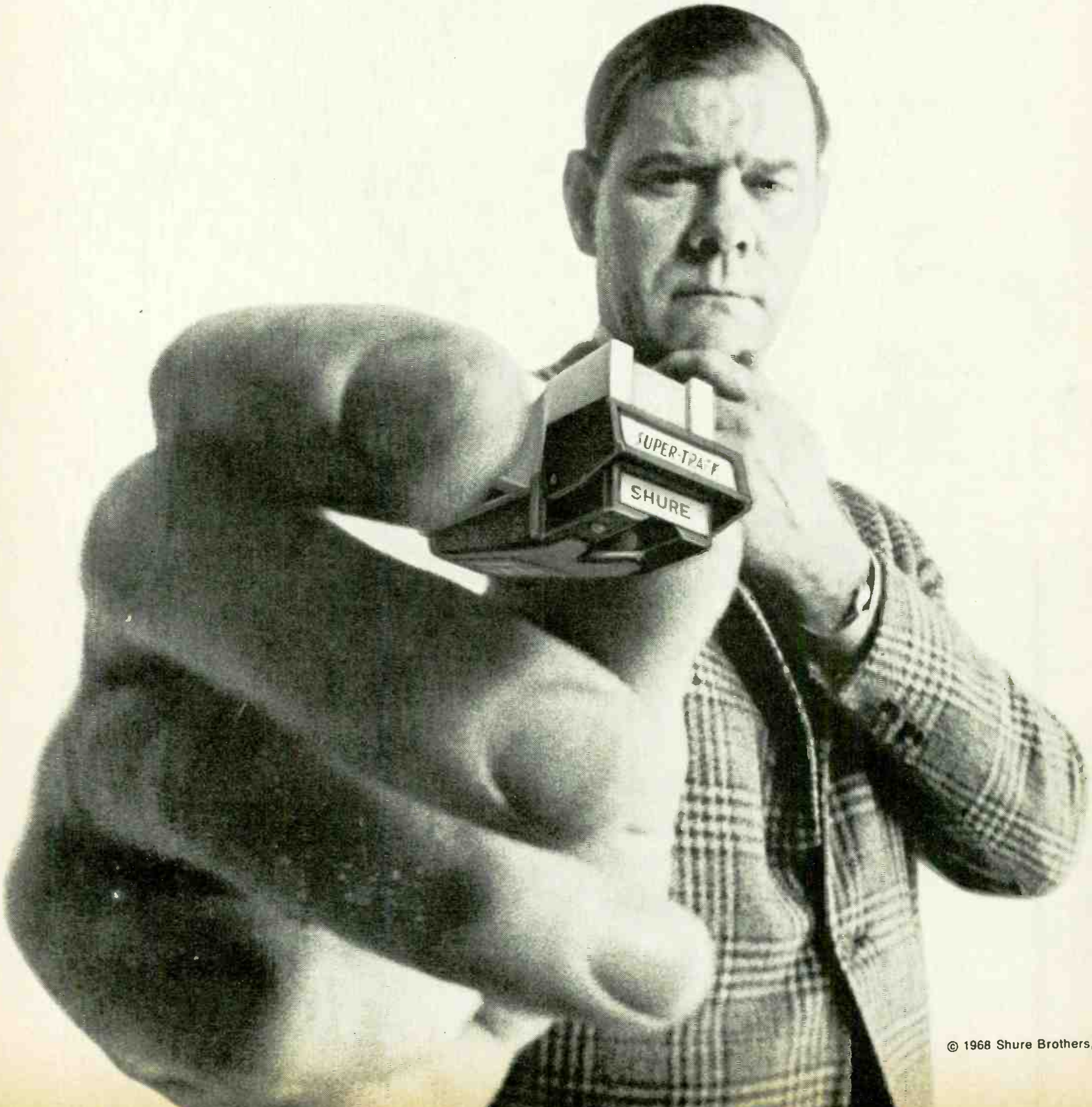
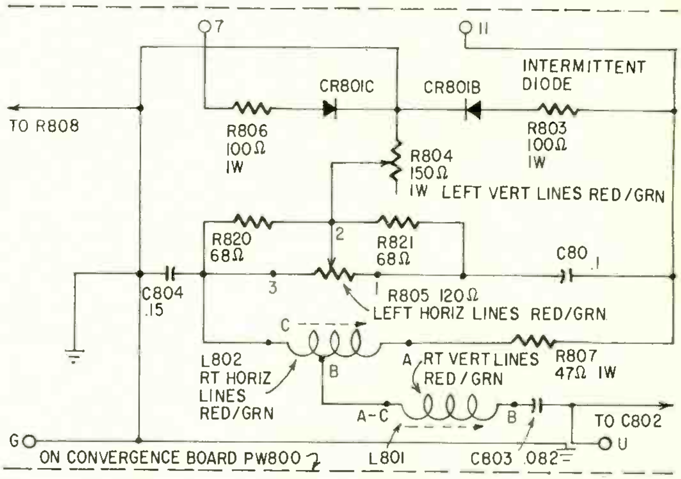


Trouble: Poor Color

The set was brought in with a complaint of poor color. A check showed that the red field began to move diagonally toward the upper right corner of the screen as the set warmed up. The effect was more pronounced on the right side.

Troubleshooting, we let the set cool down and then played hot air from a hair dryer over the convergence board around diode block CR801 (see diagram). This caused the red field to misconverge a lot sooner. The diode



end of resistor R803 was jumpered to ground and the red field moved back in the direction of normal convergence. This showed that diode CR801B was intermittent—opening up when the diode block became sufficiently warm. The whole diode assembly must be replaced.—*G. C. Heddle* **R-E**

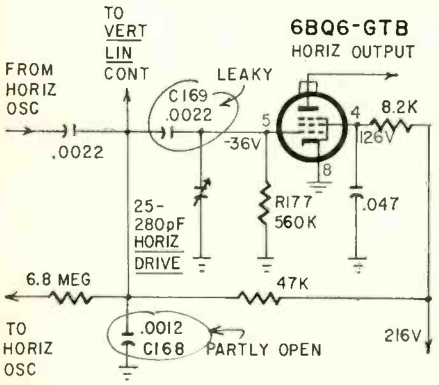
TECHNOTES

SMALL SMALL-SCREEN PICTURE

An RCA 8PT7030 8-inch portable came into the shop with a 3-inch-square picture. Both vertical and horizontal sides were squeezed together.

All tubes were checked in the horizontal and vertical section. Replacement helped some but there was still a 1½-inch black edge around the picture.

The low-voltage power supply voltages compared favorably with those on the schematic. We checked the voltages in vertical and horizontal circuits and noticed that the vertical sweep supply voltage came from the



B+ boost supply. The B+ boost voltage was only 350, which was quite low.

Using a high-voltage probe, the picture-tube anode voltage was measured at 3,500. It should be 5,800 volts. The horizontal drive voltage was a −20 volts and should have been −36. Further checking, after replacing the 6C67 and 6BQ6 horizontal tubes, showed capacitor C169 was leaking. This capacitor was replaced and picture width was improved but was not perfect. The .0012-μf capacitor, C168, was found to be partly open. Replacing it gave us a picture that filled the screen.—*Homer L. Davidson*

OLYMPIC CTC-400 SERVICE HINTS

Symptom: High-pitched sound that appears to come from the flyback transformer.

Cure: The sound is at 7,875 Hz, which is half the horizontal sweep frequency. In some sets, the door of the high-voltage cage is resonant at this frequency. This can be corrected by placing a piece of tape around the edge of the door and tightening the screws around the cage area.

Symptom: Critical vertical hold, accompanied by some high-voltage arcing in the picture.

Cure: Make sure that the CRT's Aquadag coating makes contact with the grounding wire finger from the CRT harness. There should be two spring contactors.

Symptom: A 60-Hz sync buzz is audible when the volume is lowered.

Cure: Ground the low side of the volume control to the control mounting bracket.

Symptom: Beat patterns on the screen when viewing channel 3 with an indoor dipole antenna.

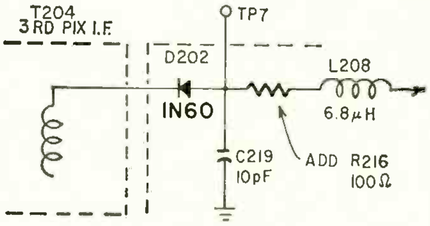
Cure: Add a 100-ohm, ½-watt resistor (R216) between the anode of D202 and the end of L208 as shown

(Continued on page 72)

Circle No. 33 on reader service card

TECHNOTES
(continued from page 71)

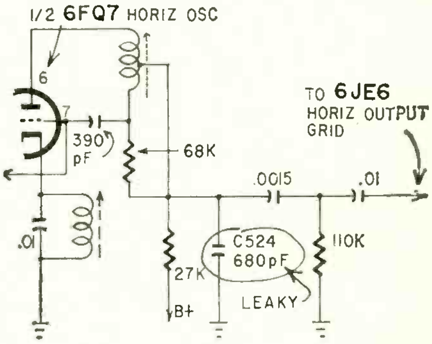
in the diagram. (Note well that capacitor C219 connects to the anode of D202 and *not* to the right-hand end



of R216 as in the schematic supplied with late versions of CTC-400.)—*Olympic Service Bulletin*

CTC17X HIGH-VOLTAGE TROUBLE

This color chassis had no raster and no high voltage. After a few minutes the 6JE6 horizontal output tube got red-hot and then the circuit breaker cut out. The horizontal output, damper and horizontal oscillator tubes were replaced but still the circuit breaker wouldn't hold.



The chassis was pulled and a voltage check on the grid of the 6JE6 showed only −10 volts. To check the drive voltage, we removed the plate cap of the 6JE6 and watched for the grid voltage to shoot up. But it climbed only a few volts. The trouble had to be in the horizontal oscillator circuit.

There was only +47 volts on the plate (pin 6) of the horizontal oscillator. The reading should have been +268 volts. A leakage check showed that C524, a 680-pF capacitor, had a 31,000-ohm leakage. The capacitor was replaced and high voltage and raster were restored once again.—*David Mark* **R-E**

COLOR TV SELLS

Color TV sales rose to an all-time high in 1968. Almost 25% of all TV sets sold were color sets. **R-E**

Service Clinic

By JACK DARR
SERVICE EDITOR

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.

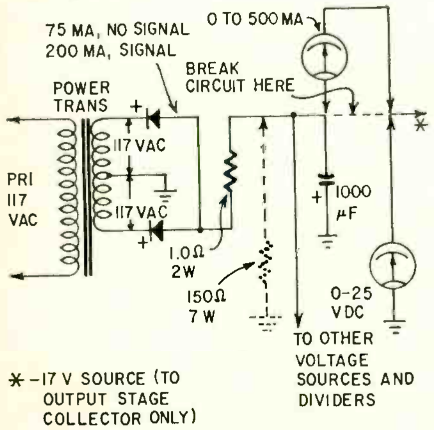
If you're really stuck, write us. We'll do our best to help you. Don't forget to enclose a stamped, self-addressed envelope. Write: Service Editor, Radio-Electronics, 200 Park Ave. South, New York 10003.

Slow-burn transistors

I have an Airline GHJ 2346A stereo amplifier with an odd problem. After running for about 30 minutes, the output transistors begin to heat up. They get very hot—then, if you don't turn the set off, out they go. At the same time, the 1-ohm 2-watt resistor in the power supply gets very hot.

I see a 150-ohm, 7-watt resistor connected from the −17-volt tap to ground; I've seen this on several other sets of the same model. It's not on the schematic, though. What is it for?—H.G., Fredericksburg, Va.

Well, "what" is easy in this case. Your output transistors are undergoing a "thermal runaway." The junction(s) are carrying too much current and getting too hot. This makes them increase their current drain and get even hotter, until finally the junction is destroyed. This is a reasonably common trouble.



The major cause is incorrect bias or insufficient heat-sinking (or both). You will have to run "elimination" tests to find out what's going on.

The power supply for the output circuit is shown. Break the circuit and insert an 0–500 dc milliammeter, at the load end of the 1-ohm resistor. The normal current here is 75 mA, no signal, and about 200 mA with signal. Turn the set on, and check for these values. It would also be a good idea to monitor the voltage output at the same point, although the current will tell you when there is danger. Watch out for an increase in the supply voltage.

If the current starts to go higher than the rated maximum of 200 mA, cut the amplifier off. Here are a couple of things you might try: add more area to the heat sinks on these transistors, and check the heat sinks to be sure that there is silicone grease between them and the transistor cases for best heat transfer.

You might get better results with one of the small ventilating fans, set to blow directly on the heat sinks. Actually, this sounds very much like "not enough heat sink area."

The 150-ohm shunt resistor across the −17-volt point must be a modification, added to help stabilize this voltage. It isn't shown in the Sams diagram either.

(continued from page 73)

FM TVI on ch. 6.

I live close to an FM station. This didn't bother me in the past, but in the last 3 months they've been chewing up both sound and picture on Ch. 6! I called the station and they said they couldn't do anything about it. Should I contact the FCC? Is there a trap which will eliminate this kind of interference? C. V., Penna.

Before going to the FCC, it would be a good idea to check with several of your neighbors, and see if their sets are acting the same way. If so, and if this interference has been seen only in the last 3 months, then there *is* a chance that the FM station is getting 'out-of-band' or radiating some kind of harmonics. Find out if the station has increased power, etc., or made any change in its transmitter at about that time.

In a lot of cases, 'TVI' is not actually caused by a nearby transmitter, but by intermodulation effects in the front end of the TV receiver itself! The strong RF signals that are unavoidably picked up on your antenna may mix with the TV signals, and create 'beats' that in turn make interference. This, of course, can happen even if the FM station or amateur transmitter is operating within the FCC tolerances. In this case, the only thing to do is cut down on the amplitude of this interfering signal.

Try RCA's favorite trap-circuit. This is simply a 4.5 inch length of 300-ohm twin-lead, with one end shorted, and a 2–15 pf ceramic trimmer capacitor tied across the other end. Tape this tightly to your leadin cable, preferably as near to the TV tuner as possible. Now, tune to Ch. 6, and adjust the trimmer capacitor for minimum interference. Many TV sets, such as RCA, have 'FM trap circuits' built into the balun coil assembly on the tuner. You might make up an FM trap and hook it into the antenna lead; any good service technician can fix up one of them from stock parts and tune it up.

If all else fails, and you find that all other sets in the area are getting the same interference, then write to the FCC, Washington, D. C., Field Engineering and Monitoring Division, and they'll investigate as soon as they can.

P-P Voltage off on VTVM.

I get odd readings on my vtvm when I try to read peak-to-peak voltages in the agc keyer circuit. Reads different voltages at the same point when I change meter ranges. Seems to read right on 60-Hz voltages, though.—A. A., Cumberland, Md.

Many ac voltmeters won't read exactly right on very narrow pulse voltages, which this is, in the ac keyer circuit. You're trying to read about a 4-5-usec pulse! If the meter input time-constant isn't correct, the capacitor won't have time to charge up on such short pulses, and the meter will read low. (All p-p meters like this read the voltage developed by charging a capacitor.)

Many meters are calibrated for 60-Hz cycle sine-wave ac, and will read correctly with that frequency and waveform; however, when we get away from a pure sine wave, we can get into troubles. A scope is still best for this.

Testing low-voltage electrolytics

I wish I had a good reliable test for low-voltage electrolytic capacitors in transistorized equipment.—L. S., Sandy, Utah

So do I. In the meantime, try this one. The best test for any part is "Does it work?". That is, does it do what it's supposed to.

There are two main uses for electrolytics in this kind of stuff—coupling and bypassing (or filtering). To check each, see if the capacitor is doing what it should. For couplers, feed a test signal into the circuit, then check its level at the input and output of the capacitor. Should be the same. If not, it's bad.

For bypasses, use the same test. For instance, in a typical af transistor circuit, I found the same signal *level* on the emitter and the collector. Obviously, the big emitter bypass should have killed all *signal* on the emitter. When I saw that high signal level there, I knew that the emitter bypass was *open*.

Filters, too: if you find more than about 1 volt of *anything* (signals, ripple, hash, etc.) on one of the supply lines where a big electrolytic capacitor should filter it out, look out. That capacitor is either open or very low in capacitance.

FM station covers whole band

I've got a strong FM station near the house; it covers the whole band! Is it blocking out the other stations by capture effect, or what? If I turn the set off, and then on again, I can hear other stations before they're drowned out. How can I eliminate this?—R. S. W., San Francisco, Calif.

This effect isn't confined to FM; you can get it by being too near a high-powered AM station. There's only one answer: reduce the signal strength of the offending station.

Try this trap circuit: Cut a piece of 300-ohm twin-lead about 4½ inches long, short one end, and connect a 3–15 pF ceramic trimmer capacitor across the other. (This is RCA's famous "TVI trap.") Tape this tightly to your lead-in as near to the tuner as possible. Tune the trimmer for minimum signal from the local station.

Sweep generator output low?

My sweep generator works very well on i.f. alignment, but I can't get enough scope pattern height on tuner alignment, especially on the high channels. What can I do about this?—E. N., Winnipeg, Man.

This is pretty much "normal." Most sweep generators use fundamentals on i.f.'s and even the low TV channels, but go to harmonics for the very high bands. When you double the frequency of an rf signal, you also *halve* the amplitude! Since we have a good-sized loss in our pickup probes, too, this often leaves us with not a heck of a lot of "curve" on alignment.

You might do two things: One, go on through the first i.f. stage and hook the scope to the second i.f. grid. Shunt the tuned circuit in the first i.f. plate with about a 10,000-ohm resistor, to flatten it and keep it from affecting the curve. Makes the first stage act as a "preamp" for the scope.

The other thing you might do—add a wide-band rf amplifier between the sweep generator and tuner input. A good all-band TV antenna booster might work very well for this, since many of these have overall gains of up to 20–25 dB. Some boosters have 75-ohm coax input and output, or 75 in and 300 out. **R-E**

SOLUTION TO R-E PUZZLER

(*page 40*)

1. printed
2. scrambler
3. adapter
4. audion
5. moire
6. roentgen
7. ripples
8. electrodes
9. Cesium
10. Actuator
11. Inverter
12. Brown
13. Anodizing
14. Alnico
15. Circuit
16. Arcs
17. Atmospherics

A perfect score is 102. Subtract 6 points for each part you may not have answered correctly and find your rating below.

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66–72 Norm.
78–84 Super.
90–96 Ultra.
102 PERFECT!

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More information on new products is available from the manufacturers of items identified by a Reader Service number. Use the Reader Service Card at the left and circle the numbers of the new products on which you would like further information. Detach and mail the postage-paid card.

COMBO BASS AMPLIFIER, *Model TA-38,* solid-state, delivers 120 watts of EIA music power with a peak power rating of 240 watts. Two 12" speakers designed to reproduce complete frequency range of bass guitars, organs and other bass

instruments at high sound levels with low distortion. Unit has two bass inputs, volume, bass and treble controls and Depth and Presence switches on the front panel. $225. Black vinyl cover, *TAA-38,* available at $11.95.—**Heath Co.**

Circle 46 on reader service card

STEREO HEADPHONE, *SE-20.* Matching impedance: 4-16 ohms, earpiece element impedance: 8 ohms. Maximum

input: 0.5 watt per earpiece. Frequency response: 20-18,000 Hz. Rigid molded vinyl earcups are slightly larger than average to ensure optimum isolation of sound. Acoustically absorbent, soft "kid" ear cushions supply maximum listening comfort. $19.95 including case, 8-ft cord and a 3-conductor plug.—**Pioneer Electronics USA Corp.**

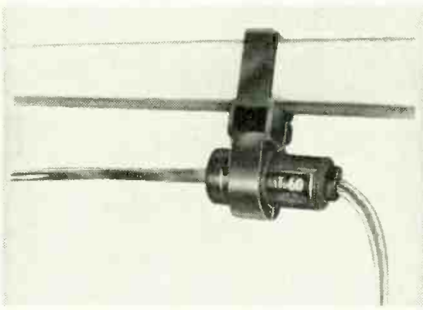
Circle 47 on reader service card

DIGITAL SET-POINT CONTROLLER, *Model 1050,* operates from either 115 V or 220 V power source, 47 to 400 Hz, with *Digital Measuring System, DMS 3200P,* or other devices having 10-line decimal outputs; determines operation of any peripheral function at preset measurement values. As a 3-digit controller, it has 1 MHz response. As a 6-digit con-

troller (2 units in tandem), 100 kHz response. Indicator lamps on front panel show measurements falling within or outside "accept" band. Upper and lower set-points provide absolute values at which external control circuitry is activated. $230.—**The Hickok Electrical Instrument Co.**

Circle 48 on reader service card

MATCHING TRANSFORMER, *Model MT60,* indoor, 82 channels. Matches 75-ohm coaxial cable to 300-ohm TV and FM inputs. Passes all uhf and vhf TV



channels plus all FM stations. $2.95. Outdoor version: *Model MT61,* completely weatherproof. $3.50.—**JFD Electronics Co.**

Circle 49 on reader service card

AUTO TURNTABLE, *Model 929,* allows fully automatic, semi-automatic or manual operation of stereo and monophonic records. Four speeds; 16⅔, 33⅓, 45 and 78 rpm. Pickup arm may be lifted off a record in play and then lowered into the same groove. Resiliently mounted 4-pole motor reduces wow to

less than 0.12% rms and flutter to less than 0.05% rms at 33⅓ rpm. $69.96 with 3 choices of stereo cartridge. Wood base and dust cover optional.—**Allied Radio Corp.**

Circle 50 on reader service card

DYNAMIC MICROPHONE, *No. 38-175,* unidirectional, is equipped with wire mesh windscreen to eliminate noise caused by wind and static pressure. Fre-

quency response, 100 Hz-12,000 Hz; dual impedance, 600-50K ohms; sensitivity, —73dB to 54 dB. Comes with 20' cable and standard phone plug and swivel mike stand connector. $13.95.—**AMD Electronics**

Circle 51 on reader service card

2-WAY STEREO HEADSET, *SE-50,* has 3" cone-type transducer for bass and mid-range, and a miniature type

with Mylar diaphragm for treble. Stated frequency response: 20 Hz to 20 kHz. Audio power input: 0.5 watt max. each channel. 12′ coil cord and a 3-conductor stereo plug. $49.95.—**Pioneer Electronics USA Corp.**

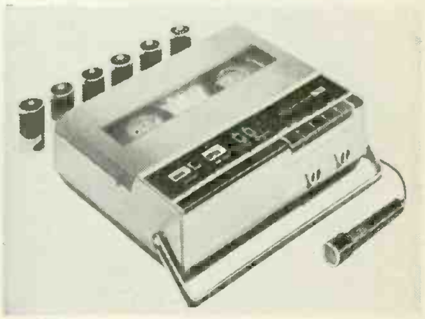
Circle 52 on reader service card

BACKGROUND MUSIC DECODER, *Model SCA-1,* picks up "hidden" musical programs from many FM stations, 400 in USA. Works with any FM tuner or receiver, and provides commercial- and

talk-free background music. All solid-state circuitry including 2 IC's, 3 FET's and 3 transistors plus "mute" control for total silence during pauses between musical selections. $64.50 wired, $49.95 kit. —**S.C.A. Services Co.**

Circle 53 on reader service card

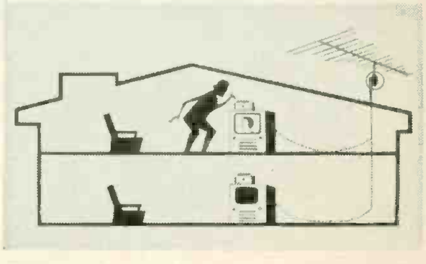
PORTABLE TAPE RECORDER, *Model 1055,* solid-state, operates on ac or batteries. Records and plays 2-track mono at 3¾ and 1⅞ ips. Speaker monitoring permits operator to listen to material be-



ing recorded. Inputs for mike and auxiliary; outputs for extension speaker and headphones. On/off mike, 6 D-batteries, ac cord, patch cord, 5″ reel of tape and 5″ takeup reel. $69.95.—**Allied Radio Corp.**

Circle 54 on reader service card

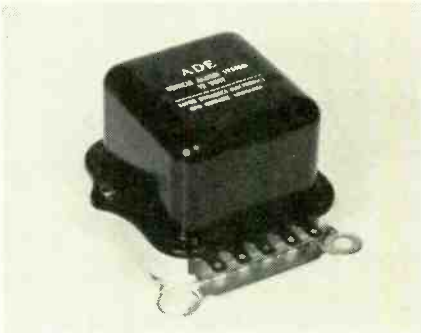
ANTENNA-ROTOR SYSTEM. *Model T-45 Tenna-Rotor* can be operated by up to 5 controls located in different areas.



Shows antenna direction on all controls. 5-wire circuit unaffected by motor current, cable length or line-voltage variations. Weatherproof unit turns the largest color antennas. Finger-pressure control bar directs rotation through 360° at 1 rpm.—**Alliance Mfg. Co.**

Circle 55 on reader service card

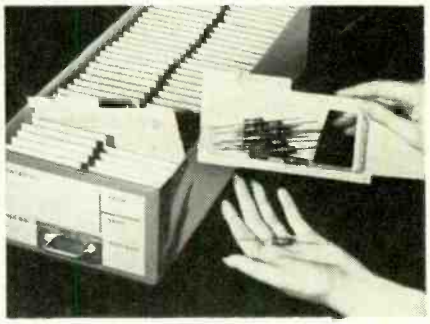
VEHICLE ALARM SYSTEM senses electrical current flow from battery. Pulsates the horn and headlights of car as a warning signal if car is tampered with.



Shuts off and resets after 3–5 minutes. Five connections to hook up unit. Complete with lock switch, wire, terminals, miscellaneous hardware and instructions. $28.50.—**Astro-Dynamics Electronics**

Circle 56 on reader service card

FILL N'FILE SYSTEM is a reusable see-through/plastic dome secured to a heavy-duty index card with a sliding card insert. Pull out sliding card insert



until opening matches opening in the file card and a part can be placed into the unit. Part is inventoried with the file card. Wide range of sizes.—**Apsco Packaging Co.**

Circle 57 on reader service card

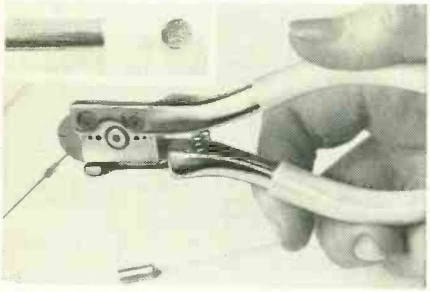
CB 2-WAY RADIO has built-in police and fire monitor receiver. *Telsat 150*, provides mobile two-way communications on 23 crystal-controlled CB channels as well as receiving vhf FM 150–174-MHz) police and fire frequencies. Includes power supply for 12 Vdc, negative or positive ground. Operates on 117

9 1

Vac with optional power supply. Sensitivity 0.7 μV on CB, less than 1 μV on vhf FM. Input power: 5 watts; modulation: 100%. $199.95.—Lafayette Radio Electronics Corp.

Circle 58 on reader service card

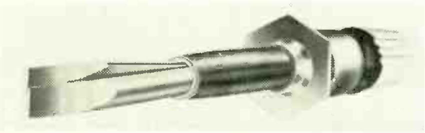
WIRE/RIBBON CUTTER, *Square-Kut*, cuts absolutely flat on wire or tubing up to 0.0734" (13 gage) diam or on metal



ribbon up to 0.025" thick and 0.125" wide. Shearing action eliminates distortion or burring.—Henes Mfg. Co.

Circle 59 on reader service card

SCREW-HOLDING SCREWDRIVER has vinyl tubing cover for protection for



electrical work. Useful for any type of electronics work where protection from shock is essential. Dielectric strength at room temperatures is 20,000 volts.—Kedman Co.

Circle 60 on reader service card

STYLUS CLEANER consists of a lint-free treated pad. May be used on either

radial or elliptical styli. $1.25 each, with instructions.—Elpa Marketing Industries Inc.

Circle 61 on reader service card

VHF/FM MONITOR RECEIVER, *Reporter*, operates on up to 6 crystal-controlled channels in 30–50-MHz or 152–174-MHz band. Dual-conversion solid-state superhet circuit with silicon mesa transistors in the rf, i.f. stages and oscillator circuit. For mobile applications, 12-volt electrical power source required.

At fixed locations, 110–115-volt ac power line.—Unimetrics Inc.

Circle 62 on reader service card

AEROSOLS FOR ELECTRONICS, *No. 2000*, protects against rust and corrosion of critical circuit components. Waterproof

spray dries quickly, forms flexible film that seals treated area. Comes with spray nozzle attachment.—Sprayon Products Inc.

Circle 63 on reader service card

E

NEW LITERATURE

All booklets, catalogs, charts, data sheets and other literature listed here with a Reader's Service number are free for the asking. Turn to the Reader Service Card facing page 78 and circle the numbers of the items you want. Then detach and mail the card. No postage required!

HAND TOOLS. *Plier No. 4916* designed for easy in-circuit installation and removal of 10- and 14-lead IC flat-pack units. *Tran-Semi,* a multipurpose tool for handling transistor and semiconductor devices and flush-cutting leads of any currently available device from circuit. 96 pages.—**Techni-Tool Inc.**

Circle 76 on reader service card

PRINTED-CIRCUIT CONNECTION problems and suggestions, together with many engineering diagrams of simplified printed-circuit assemblies. Information and application ideas for single- and multiple-bead pin-type connections, more economic assembly costs and faster production are in *Catalog M400,* 20 pages.—**Molex Products Co.**

Circle 77 on reader service card

SLIDE SWITCHES including the new *Phase II* "double wipe" are described in 4-page *Bulletin No. 178.* Also included is a newly designed slider with either 3- or 6-A ac ratings. Engineering drawings show mounting configurations and contact arrangements available with the new series.—**Switchcraft Inc.**

Circle 78 on reader service card

SPRINGRIP FASTENERS, various types and sizes, data on other shaft-retention fasteners, special C-ring washers, push-on and Plasti-rings are illustrated in a 8-page brochure, *Form AF-9.* Information on standard in-stock Springrips of internal tooth design plus the manufacturer's other retaining fasteners is provided.—**Fastex Div. Illinois Tool Works Inc.**

Circle 79 on reader service card

TOOLS FOR ELECTRONICS assembly and precision mechanics plus numerous items on tool kits, test and vacuum ultrasonic cleaner, lighting and optical devices are described with charts and photos in 66-page *Catalog No. 386.* Sections of useful tips along with specs and data on various tools are informative and helpful. Prices listed.—**Jensen Tools & Alloys**

Circle 80 on reader service card

DIGITAL SYSTEM PLUG-INS in the "DP" series for digital measuring system *DMS 3200* are capable of measuring nearly all basic electrical parameters and providing a full digital display of measurements. The entire line is detailed with specifications and photos in *Form 185-59.* Accessories for these models are also described.—**Hickok Electrical Instrument Co.**

Circle 81 on reader service card

1969 CATALOG, 32 pages, outlines with photographs and prices a large variety of design slide rules, data selectors and templates-kits etc. Easy guidance for designers, draftsmen and engineers. —**TAD Products Corp.**

Circle 82 on reader service card

ACCESSORIES, EQUIPMENT, HAND TOOLS for vacuum systems, optical inspection, soldering and welding, Ednalite systems, Wassco and microminiature and other electronic assembling aids are illustrated with charts and diagrams in *Catalog No. 15,* 82 pages. Specs and price list included.—**Techni-Tool Inc.**

Circle 83 on reader service card

DIGITAL PANEL METERS. *Model 7020,* 3-digit, single-range, single-polarity, 3 readings/sec. *Model 7030,* 3-digit. *Model 7040,* 4-digit. The last two have the same characteristics—overrange, dual polarity, 6 readings/sec. Full specs and description on these units plus two panel remote readouts for these models are contained in a sheet titled "Panel Mount Digital Meters".—**Fairchild Instrumentation**

Circle 84 on reader service card

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

1969 IC SHORT-FORM CATALOG, 24 pages, includes reference data for op amps. voltage regulators, communication circuits, TTL 54/74 series, TTL MSI types, MOS memories, analog switches and logic elements.—**National Semiconductor Corp.** 2975 San Ysidro Way, Santa Clara, Calif. 95051.

ZENER DIODE HANDBOOK, 74 pages, illustrated with schematics, graphs and tables. Covers semiconductor theory and reverse-breakdown phenomena plus specific information on dynamic resistance, temperature-compensated Zeners, thermal consideration, ac and dc applications, audio and rf applications and circuit protection. Computer and instrumentation applications included. **$3 each.—Write to International Rectifier Corp.,** 233 Kansas St., El Segundo, Calif. 90245

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Call your RCA distributor. He'll set you up with a supply of the fastest moving ones today.

Parts and Accessories, Deptford, N.J.

125 WATT STEREO AMPLIFIER
(*continued from page 44*)

than 0.1 volt when set up in this fashion.

If power supply voltages are correct and the dc output voltage is nearly zero, apply a small audio signal to the input. Monitor the output signal with a scope or ac voltmeter while advancing the level control slowly. With no other output load, the output voltage should reach about 33 volts rms. If severe clipping on half of the signal swing is noticed, do not proceed further until the difficulty is corrected. Crossover distortion will be noticed, but this is a normal condition at this time.

Turn the amplifier off and insert a milliameter set to its 100-mA range in series with the collector lead of Q6. Turn the input level controls all the way down and apply power to the amplifier. Slowly increase the potentiometer substituted for R11 until the meter reads 20mA. Turn the amplifier off, measure the pot resistance and insert the nearest 5% value to this resistance as R11. This resistor might need changing if transistor Q5, Q6, Q8, or Q9 are changed in the amplifier.

Repeat this procedure for the other channel. It is not necessary to set the current to exactly 20mA. After reconnecting the Q6 collector lead to the PC board, you are ready to test the amplifier with a load. Connect your resistive load (4 ohms) across the output terminals, apply power and monitor output voltage as the input level is increased. At only a few watts, severe clipping will be noticed since the power supply cannot deliver rated output with the lamp resistance in series with the line input.

If the amplifier operates correctly thus far, it is unlikely that higher power operation will disclose any problems. However, you may wish to test with higher wattage lamps in series with the ac input.

After all tests are completed, a perforated protective cover may be fabricated if needed. In the final installation, be sure the bottom of the chassis is at least ½-inch off the mounting surface. Allow at least ¾-inch clearance above the heat sinks for heat dissipation.

If you plan to drive 25 volt line transformers install D8 and D9. The output network shown on the schematic should be added when electrostatic speakers are used with this stereo power amplifier. **R-E**

COMING NEXT MONTH

If you think this amplifier is a honey, just wait until you see the preamp the author has dreamed up. Watch May.

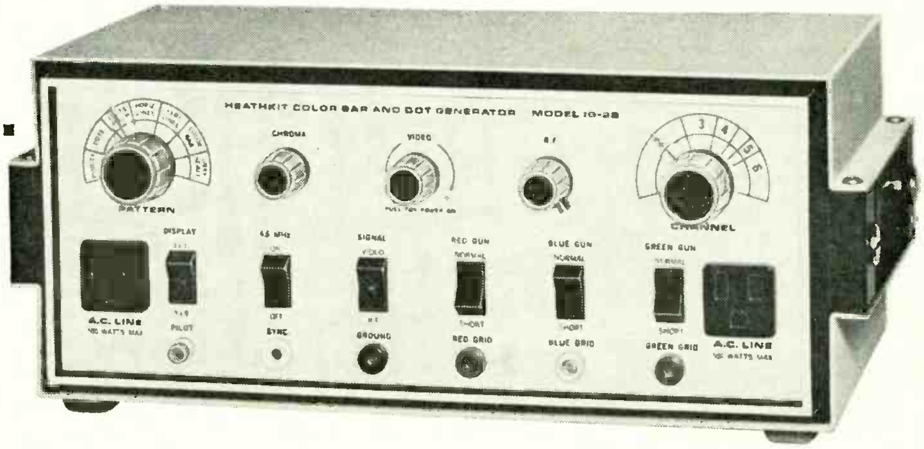
85

For Top Performance And Value In Electronics —

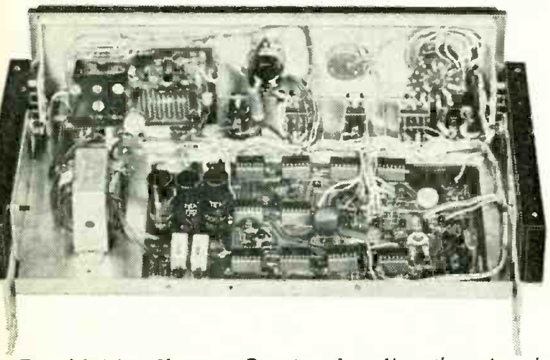
Introducing The NEW Heathkit® IG-28

Color Bar — Dot Generator...

Advanced IC Design Gives 12 Patterns Plus Clear Raster Display & Eliminates Divider Chain Instability Forever!

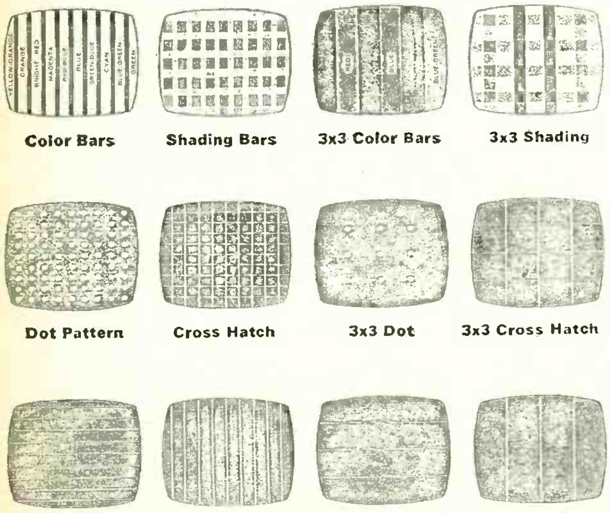


Stable Integrated Circuitry And Well-Engineered Layout



Circuit Board-Wiring Harness Construction. Note the extremely clean, open layout — another advantage of integrated circuitry. The Video board is upper left, the Divider board mounts on the chassis.

Fast Switch Selection Of Either Standard 9 x 9 Display OR Exclusive Heath "3 x 3" Display



Color Bars · Shading Bars · 3x3 Color Bars · 3x3 Shading

Dot Pattern · Cross Hatch · 3x3 Dot · 3x3 Cross Hatch

Horizontal Bars · Vertical Bars · 3x3 Horizontal · 3x3 Vertical

The Most Advanced Instrument In Color TV Service

• All solid-state construction using Integrated Circuitry • No divider chain adjustments • Stable pattern display — no flicker, bounce or jitter • Produces 12 patterns plus clear raster • Instant switch selection of all functions • Exclusive 3x3 display plus standard 9x9 display of all patterns • Horizontal lines only one raster thick for added accuracy • Variable front panel tuning for channels 2 through 6 • Variable front panel positive and negative video output • Front panel negative going sync output • Two handy AC outlets on front panel • Built-in gun shorting circuit with lead piercing connectors • Front panel switchable crystal controlled sound carrier • Copper-banded transformer to reduce stray fields • Safe three-wire line cord • Fast, easy construction with two circuit boards and two wiring harnesses

The new Heathkit IG-28 is the ultimate signal source for all Color and B&W TV servicing. No other instrument at any price will give you as much stable, versatile TV servicing capability. Here are the details:

All Solid-State Circuitry produces dots, cross-hatch, vertical and horizontal lines, color bars and shading bars in the familiar 9x9 display . . . plus the exclusive Heath 3x3 display of all these patterns so necessary for static convergence, linearity and color demodulator phase adjustments . . . plus a clear raster that lets you adjust purity without upsetting AGC adjustments. Fifteen J-K Flip-Flops and associated gates count down from a crystal controlled oscillator, eliminating divider chain instability and adjustments.

Time-Saving Versatility. While many generators only give you one or two channel capability, the new IG-28 has variable front panel tuning for channels 2 through 6. The RF tank coil is actually etched into the circuit board for extra stability. Plus and minus going video signals are available at the turn of a front panel control. And for sync, in-circuit video or chroma problems, there's a front panel sync output. Convenient AC outlets are provided for degaussing coil, test instruments, TV set etc. Built-in gun shorting circuits and grid jacks are also included. Add any service type scope (with horizontal input) to the IG-28 and you have vectorscope display capability too. Other features include a crystal controlled sound carrier oscillator, a well regulated full wave power supply with dual primary copper-banded transformer, safe three-wire line cord, and rugged, compact Heath instrument styling. Two circuit boards and two wiring harnesses provide easy construction in about ten hours. Start enjoying the versatility you couldn't get before . . . put the remarkable new Heathkit IG-28 on your service bench now.

Kit IG-28, 8 lbs. **$79.95***

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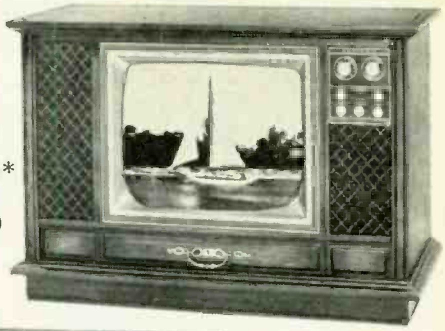
NEW Deluxe "681" Color TV With Automatic Fine Tuning



kit GR-681
$499.95*
(less cabinet)

The new Heathkit GR-681 is the most advanced color TV on the market. A strong claim, but easy to prove. Compare the "681" against every other TV — there isn't one available for any price that has all these features. Automatic Fine Tuning on all 83 channels . . . just push a button and the factory assembled solid-state circuit takes over to automatically tune the best color picture in the industry. Push another front-panel button and the VHF channel selector rotates until you reach the desired station, automatically. Built-in cable-type remote control that allows you to turn the "681" on and off and change VHF channels without moving from your chair. Or add the optional GRA-681-6 Wireless Remote Control described below. A bridge-type low voltage power supply for superior regulation; high & low AC taps are provided to insure that the picture transmitted exactly fits the "681" screen. Automatic degaussing, 2-speed transistor UHF tuner, hi-fi sound output, two VHF antenna inputs . . . plus the built-in self-servicing aids that are standard on all Heathkit color TV's but can't be bought on any other set for any price . . . plus all the features of the famous "295" below. Compare the "681" against the others . . . and be convinced.

GRA-295-4, Mediterranean cabinet shown **$119.50***
Other cabinets from $62.95*

Deluxe "295" Color TV . . . Model GR-295

kit GR-295
now only
$449.95*
(less cabinet)

Big, Bold, Beautiful . . . and packed with features. Top quality American brand color tube with 295 sq. in. viewing area . . . new improved phosphors and low voltage supply with boosted B + for brighter, livelier color . . . automatic degaussing . . . exclusive Heath Magna-Shield . . . Automatic Color Control & Automatic Gain Control for color purity, and flutter-free pictures under all conditions . . . preassembled IF strip with 3 stages instead of the usual two . . . deluxe VHF tuner with "memory" fine tuning . . . three-way installation — wall, custom or any of the beautiful Heath factory assembled cabinets. Add to that the unique Heathkit self-servicing features like the built-in dot generator and full color photos in the comprehensive manual that let you set-up, converge and maintain the best color picture at all times, and can save you up to $200 over the life of your set in service calls. For the best color picture around, order your "295" now.

GRA-295-1, Walnut cabinet shown **$62.95***
Other cabinets from $99.95*

Deluxe "227" Color TV . . . Model GR-227

kit GR-227
now only
$399.95*
(less cabinet)

Has same high performance features and built-in servicing facilities as the GR-295, except for 227 sq. inch viewing area. The vertical swing-out chassis makes for fast, easy servicing and installation. The dynamic convergence control board can be placed so that it is easily accessible anytime you wish to "touch-up" the picture.

GRA-227-1, Walnut cabinet shown **$59.95***
Mediterranean style also available at $99.50*

Deluxe "180" Color TV . . . Model GR-180

kit GR-180
now only
$349.95*
(less cabinet)

Same high performance features and exclusive self-servicing facilities as the GR-295 except for 180 sq. inch viewing area. Feature for feature the Heathkit "180" is your best buy in deluxe color TV viewing . . . tubes alone list for over $245. For extra savings, extra beauty and convenience, add the table model cabinet and mobile cart.

GRS-180-5, table model cabinet and cart **$39.95***
Other cabinets from $24.95*

Now, Wireless Remote Control For Heathkit Color TV's

New Wireless TV Remote Control
For GR-295, GR-227 & GR-180
$69.95*

New Wireless TV Remote Control
For GR-681
$59.95*

Control your Heathkit Color TV from your easy chair, turn it on and off, change VHF channels, volume, color and tint, all by sonic remote control. No cables cluttering the room . . . the handheld transmitter is all electronic, powered by a small 9 v. battery, housed in a small, smartly styled beige plastic case. The receiver contains an integrated circuit and a meter for adjustment ease. Installation is easy even in older Heathkit color TV's thanks to circuit board wiring harness construction. For greater TV enjoyment, order yours now.

kit GRA-681-6, 7 lbs., for Heathkit GR-681 Color TV's **$59.95***
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NEW TUBES AND SEMICONDUCTORS

NEW 5-WATT IC AMPLIFIER

General Electric's PA246 is a monolithic power amplifier delivering 5 watts (rms) of continuous power into a 16-ohm load. It is housed in an especially designed package with 8 leads and two heat-sink tabs as shown in the photo and drawings. Its applications include monaural and stereo phonographs and receivers, movie projectors, op amp boosters, relay drivers and servo amplifiers. The leads are staggered to simplify PC board design. The copper heat-sink tabs can be readily soldered to an external heat sink.

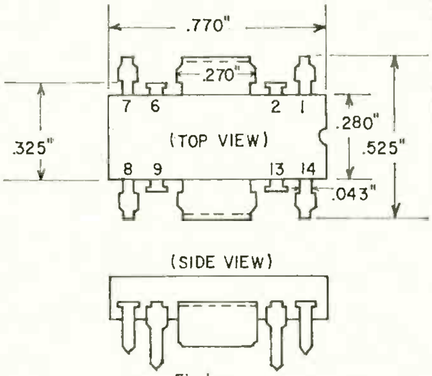


Fig. 1

The amplifier operates from a wide range of power supply voltages up to 37. Frequency response extends from 30 Hz to 100 kHz. Noise output is typically 70 dB below 5 watts. At 5 watts output, input sensitivity is 180

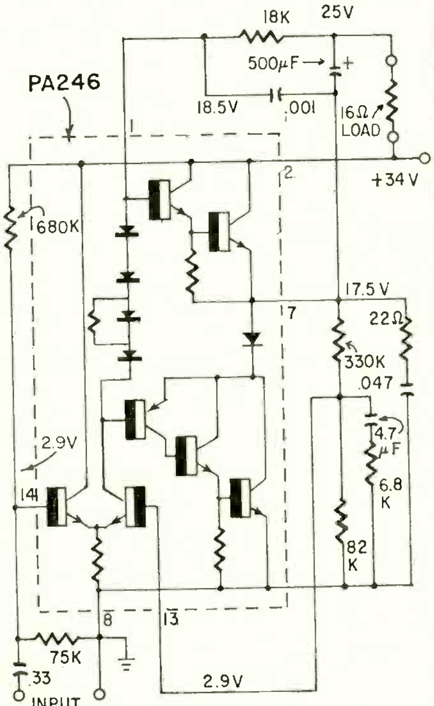
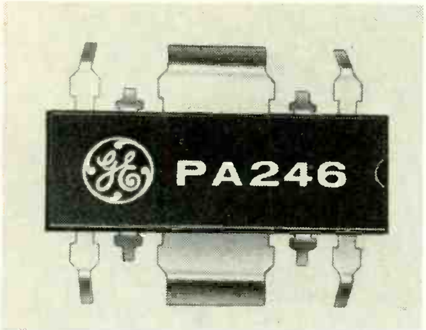


Fig. 2

mW and total harmonic distortion is below 1% at 1 kHz. IM distortion (60 Hz and 6 kHz, mixed 4:1) averages around 2.4% between 0.05 and 5 watts output.



Dimensions of the PA246 are shown in Fig. 1. The IC and its test circuit are in Fig. 2.

This IC is available for $3.84 is lots of 1 to 99. Additional information can be obtained from A&SP Distribution Services, General Electric Co., Building 705, Corporations Park, Scotia, N.Y. 12305.

IC FM STEREO DEMODULATOR

The Motorola MC1304 monolithic FM multiplex stereo demodulator not only separates the right and left audio channels of a stereo broadcast signal but also includes:

- A driver circuit for selectively turning on a panel-mounted indicator.
- An audio-muting circuit to eliminate interstation hiss by reducing the audio output by 55 dB during tuning.
- An automatic switching circuit for converting weak stereo signals (with poor signal-to-noise ratio) to monaural signals for distortion-free reception. External circuits can be added for adjustable switching threshold or to mute the receiver or monaural signals and permit only stereo stations to come in.

The MC1304 has a power dissipation of only 150 mW and can be used with 8-Vdc power supplies. Current drain is about 10 mA at 8.5 V and 40 mA at 10V—the latter is mostly for energizing the stereo lamp. A built-in hysteresis eliminates lamp flickering.

This IC is in the dual in-line ceramic or Motorola Unibloc case.

Stereo channel separation is typically 40 dB at 1.0 kHz, 30 dB at 100 Hz and 25 dB at 10 kHz. Rejection levels are 25 dB at 19 kHz, 20 dB at 38 kHz and 50 dB at 67 kHz. Total harmonic distortion is typically 0.5%. For more information, write to Technical Information Center, Motorola Semiconductor Products Inc., Box 20924, Phoenix, Ariz. 85036. **R-E**

Circle 116 on reader service card

Circle 117 on reader service card

Circle 118 on reader service card

EQUIPMENT

Sencore TF151
Transistor-FET Tester

THINGS HAVE ALREADY GOTTEN TO the point where a transistor tester is indispensable. With PC construction we need instruments that will perform reliable in-circuit and out-of-circuit tests.

Field-effect transistors (FET's) are showing up in more equipment every day. Regular bipolar transistor testers won't check FET's.

Sencore's latest instrument in this category, the TF151 "In Or Out-of-Circuit Transistor–FET Tester," will do exactly four times as many things as its predecessor, the TR139.

The selector switch now has 12 positions, in four groups. Six positions are for bipolar transistor beta and leakage—both low- and high-power types. Each of these functions has a $\times 1$ and $\times 10$ scale, plus the vital I_{cbo} leakage test. There is also a special range for checking drift-field rf transistors (used in solid-state TV tuners as the rf amplifier).

FET's are tested on two separate ranges. The first, with $\times 1$ and $\times 10$ scales reading directly in micromhos, are used for common single-gate transistors. I_{GSS} or gate leakage can be read directly on the meter in microamperes.

Dual-gate FET's are checked on the second FET range. Gate leakage (I_{G2SS}) is read by setting the selector to the lower leakage position. This is

COMING NEXT MONTH

Getting to Know the JFET. In May Tom Haskett gives you an introduction to the junction field-effect transistor. You'll learn how it works and how to use it.

REPORT

For manufacturer's literature, circle No. 122 on Reader Service Card.

exactly like checking a dual-triode on a tube tester.

Another important FET test is zero bias drain current. This is like I_{CBO} in bipolars—the current which flows even though the FET *should* be biased to cutoff. Since FET's are often found in balanced circuits, both G_m *and* I_{DSS} must be matched. If one FET of a pair has blown, you'll have to check the replacements for a correct match.

Maximum power dissipation of a replacement FET as it is used in the circuit should also be checked. (Just use Ohm's law, the value of the supply voltage, and the value of the FET load resistor. The voltage drop across the load resistor will give you the value of the current. Then, the remaining voltage is dropped across the FET's drain-source resistance. Multiplying this out will give you the power dissipation of the FET.

Along with the instruction book, a very complete transistor reference book is included with the instrument. Beside the EIA types, it lists all imports, giving full data on each.

Most FET's in use are the depletion-mode type. Enhancement-mode FET's are rare, but since we may run into them in the future, a provision is made for testing them. Depletion-mode FET's use zero bias; enhancement-mode FET's use a positive bias. Bias can be selected by the BIAS-NORMAL-POSITIVE slide switch at the bottom of the panel. Correct bias settings are given in the reference book.

Like the TR139, the TF151 can be used to check completely unknown transistors without damaging them. You'll generally be able to tell by the circuit location whether a transistor is a small-signal, rf, audio or power type. Even if the connections are reversed, the transistor won't be damaged.

In-circuit testing of both FET's and bipolars can save an enormous amount of time. Even if a transistor should check bad in the circuit, then check good after being removed, you've still found the trouble. There must be a bad part in that stage.

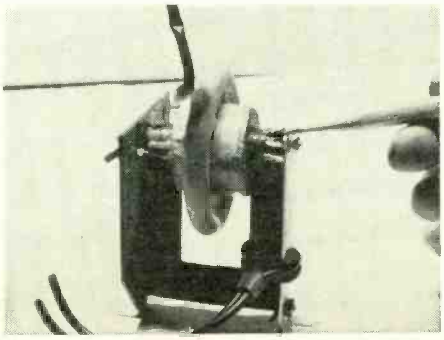
The TF151 is a very well-built instrument and meets the No. 1 prerequisite for all useful test instruments: "Will this thing make money for me by saving *time?*" In this case, I think the answer is: Yes. **R-E**

93

SCHOOL DIRECTORY

ELIMINATING HV-TRANSFORMER SQUEAL

Our TV receiver developed a squeal that was annoying, intermittent, and came from the high-voltage cage. By pushing with the handle of a toothbrush against the high-voltage winding, I could make the noise quit. The high-voltage winding was loose on the powder-iron core and set up a vibration at the horizontal scanning frequency. Several flat toothpicks pushed under the transformer winding beside the iron core made a quick repair. A coat of model airplane cement or glue was spread over the toothpick wedges, and the transformer has been quiet ever since.—*Homer L. Davidson*

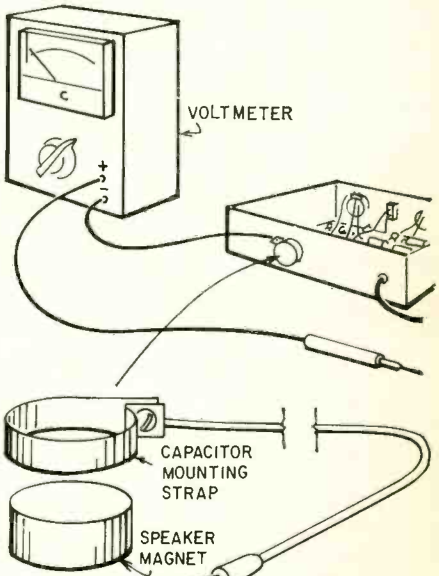


TRY THIS ONE

MAGNETIC GROUND LEAD

For a while, equipment ground leads were frequent casualties on my service bench. I'd either flip a heavy chassis over on them or yank the leads off while moving the set around.

I solved this problem by making up magnetic terminals for my scope and meter ground leads. I use a button magnet or the core from a small PM speaker clamped in a capacitor mounting strap. The ground lead is soldered to the strap as shown above. The magnet can't be damaged by a toppling chassis and the lead can't be damaged while moving the test gear or equipment being serviced.—*Peter Legon* **R-E**



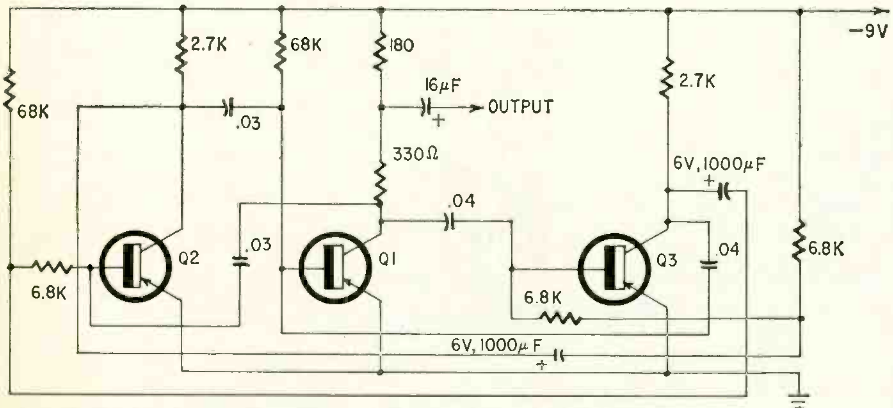
NOTEWORTHY CIRCUIT

WARBLE-TONE GENERATOR

Hardly any sound attracts attention as quickly as a strident warbling note. This is borne out by the warble-tone sirens that are replacing the more conventional type on fire, police and other emergency vehicles. A novel tone generator that should be a real attention-getter was described by A. B. Blackwell-Jones in *Wireless World* (London, England).

The circuit (see diagram) has transistors Q1, Q2 and Q3 each coupled to the other two to form a free-running multivibrator. With the values shown, Q1 and Q2 oscillate around 700 Hz, Q1 and Q3 work at around 500 Hz while Q2 and Q3 loaf along at about 1.5 Hz. A square-wave pattern at Q1's collector alternates between the two higher rates at about 1.5 times per second.

When Q2 is turned off, multivibrator Q1-Q3 oscillates at 500 Hz, and when Q3 is off, Q1-Q2 oscillates at 700 Hz. The output is taken off a tap on Q1's collector load.



NOTE: Q1, Q2, Q3 ARE GENERAL-PURPOSE AUDIO TRANSISTORS WITH β30-50

AUTO TURN AND BACKUP INDICATOR

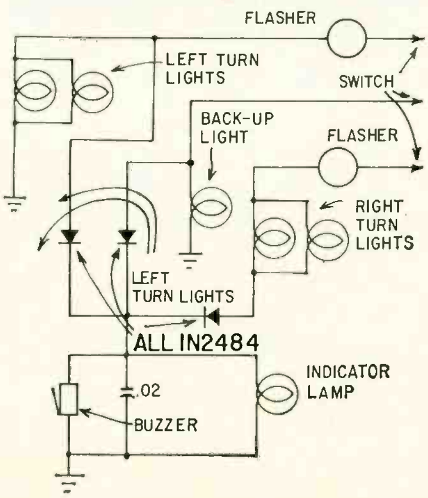
When manually-operated turn and backup lights are added to most older vehicles, the lights are not visible from the cab, and are frequently left on when they should not be, resulting in highway confusion, tickets, or accidents.

This trouble can be reduced or eliminated by connecting a buzzer or lamp across each indicator lamp, so that the driver is aware of which lights are on. This works quite well, but three buzzers, or three "idiot lights" are likely to clutter up an already crowded dashboard, as well as imposing a maintenance problem.

By using three diodes, connected as shown in the diagram, a single buzzer or lamp can be used to indicate anything amiss. As applied, intermittent buzzing indicates that one of the flashing turn indicators is on; whereas a steady tone indicates that the backup light is on.

If a buzzer is used, be sure that it is loud enough to be heard over motor noise. The 0.02-μF capacitor across the buzzer reduces radio interference.

This circuit is designed for a negative ground system. If the system has a positive ground, reverse the diodes. Rated voltage of the buzzer should be that of the car battery. If it draws more than ½ ampere, use larger diodes.—*Ronald L. Ives* **R-E**



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SERVICING VIDEO AMPLIFIERS

The video circuitry is basically a broad-band amplifier (from detected video signals up to 4.2 Mhz), and it is usually easy to determine if the two stages are functioning. Signal tracing with a scope is the best procedure although the CRT can be used as an indicator. Noise can be injected into the base of the first video amplifier by touching it with your finger or a metal tool and noting the effect on the screen. If both stages are functioning, noise or flashing will appear on the screen.

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- RCA UHF transistor type TV tuners, KRK-120 (long-shaft) cat. #UHF-20; KRK-120 (short-shaft), cat. #UHF-21, each $4.98.
- RCA VHF transistor type TV tuners, KRK-146, cat. #VHF-74, $9.99 each.
- Transistorized U.H.F. tuners used in 1965 to 1967 TV sets made by Admiral, RCA, Motorola, etc. Removable gearing may vary from one make to another. Need only 12 volts d.c. to function. No filament voltage needed. Easy replacement units. Cat. #UHF-567, $4.95.
- U.H.F. Tuner-original units as used in TV sets such as RCA, Admiral, etc. covering channels 14 through 82, as part #94D173-2. Complete with tube. Drive gearing is removable. Can be used in most sets. Cat. #UHF-3, $4.95.
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- Silicon rectifier, octal based replacement for 5U4, 5Y3, 5AS4, 5AW4, 5T4, 5V4, 5Z4. With diagram. Cat. #Rect-1, 99¢ each.
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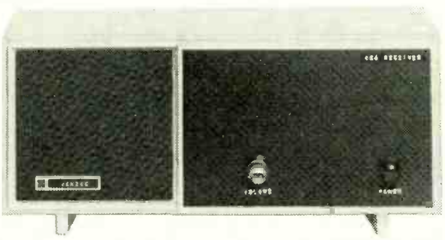

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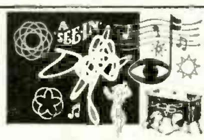

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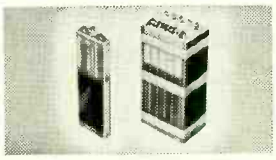

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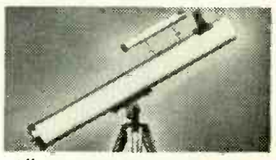

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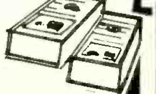

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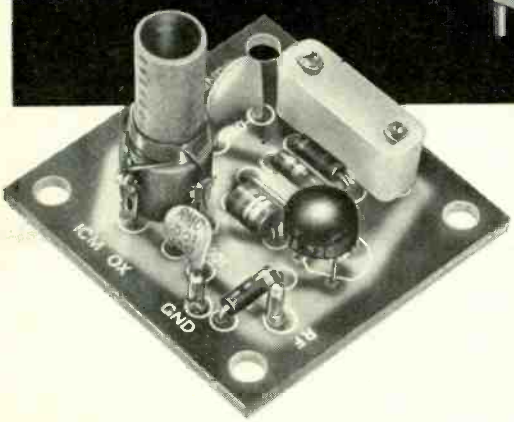

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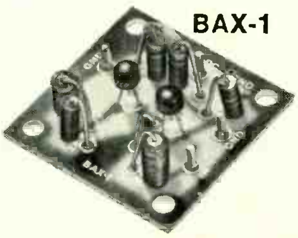

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