60c ■ JUNE 1971

Radio-Electronics

MEN ... ELECTRONICS

BURGLAR ALARM DESIGN—24 CIRCUITS

High-Selectivity Preamp For FM

...eshooting CBs

...ONIC DRIVE CIRCUITS

...w-Rumble ...bles

How Dolby Reduces Noise

NEW FEATURE!

Potpourri of IC Applications

A GERNSBACK PUBLICATION

Have you tried our canned tuner?

It's not only great for color television sets, it's also great for guided missiles.

As a matter of fact, Krylon® Tuner Cleaner is made with the same solvent used in the missile industry. Plus a special lubricating oil.

Just one little spray leaves a thin, non-drying film of lubricant that conditions contact surfaces and protects them from corrosion.

And that same little spray keeps surfaces self cleaning and water repellent without ever harming any plastic surface.

Krylon Tuner Cleaner also comes with a plastic tube for controlled spraying in hard-to-reach areas.

Try it just once. You're sure to develop a taste for it.

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Send for free price list of the full line of Krylon Aerosol Products. Krylon Dept. 1202A, Borden Inc, 350 Madison Avenue, New York, New York, 10017

Circle 1 on reader service card

NEW & TIMELY

Volume 42 Number 6 RADIO-ELECTRONICS . . . FOR MEN WITH IDEAS IN ELECTRONICS June 1971

ALARM SYSTEM LINKED TO CATV

NEW YORK, N.Y.—An alarm system whose only prerequisite is that the homeowner be a subscriber to cable TV has been developed by Holmes Protection Inc. Frank Fritz, senior vice president of Holmes says the system "provides monitoring service to customers while making cable television a two-way system".

The device is plugged into the CATV apparatus and signals a central office when a home is broken into. Expected to cost between $200 and $250, the alarm system can also be used to monitor refrigeration and heating systems, for gas leak protection; as a lawn sprinkler timer and water detection device; an automatic garage door opener for light switch control; and as a medical emergency alerter.

Mr. Fritz sees the 2500 cable TV companies of the United States as potential distributors of the alarm system, which is not yet on the market. The consumer field is large, with current CATV subscribers at 5 million, and more than 28 million expected subscribers by the end of the decade. ★

Detection Units Deter Shoplifting

AKRON, OHIO—A theft detection device developed and manufactured by Sensormatic Electronics Corporation is an electronic approach to the widespread problem of shoplifting and pilferage.

The system uses a controlled electronic field and a sensitized substance or marker on the protected articles. The sensor units, about one foot square by three feet high, are located at exits or other locations, such as escalators and elevators. If proper checkout procedure is followed and merchandise is paid for, there is no reaction from the sensor. But if articles are improperly removed from the store, the sensitized material on them activates the detection system and triggers an alarm or signal.

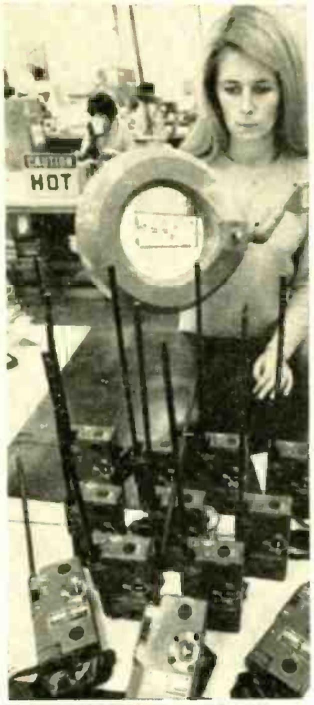
A variety of signals may be used, including a bell, a buzzer, a flash of light, and a stop sign. The detector may be programmed to take a picture of the offender, or flash

an alarm to security officers or the police department.

A feature of the system is the many different ways of planting markers or sensitized material on the articles and removing them, thereby impeding thefts by habitual shoplifters as well as stopping the novice thief. ★

Electronic Music On Elevators

NEW YORK, N.Y.—Morton Subotnick's compositions spill from six speakers in each elevator at 77 Water Street in Manhattan's financial district. The ultra-modern electronic music harmonizes with the space-age look of the building. In this aura of beeps and blips the rider feels as though he were going off to an interplanetary station. ★



TWO-CHANNEL RESCUE radios designed to speed recovery of downed airmen are made by GTE Sylvania, a subsidiary of General Telephone & Electronics Corporation. An employee (shown in picture) inspects a solid-state thick-film hybrid microcircuit which enables the radios to send a homing signal more than 50 miles, transmit and receive voice communication on two channels, or send Morse code.

NEW FORMAT FOR WWV

WASHINGTON, D.C.—The National Bureau of Standards' standard time and frequency radio stations WWV and WWVH will revise the formats of their broadcasts, starting July 1, 1971.

The new formats will include voice announcements of the time every minute instead of every five minutes, use of male and female voices to help distinguish between WWV and WWVH, and eliminate all Morse code signals from the transmissions. Only the content of the broadcasts will change; frequencies will remain the same.

The minute slots will be divided into a 45-second segment and two 7.5-second segments. On alternate minutes the 45-second segment will contain either a standard tone (tentatively 600 Hz) or an announcement. The announcement slots will be available to Government agencies. ★

HUGO GERNSBACK AWARD WINNER ANNOUNCED

LOS ANGELES, CALIF.—National Technical Schools announced that it has selected Stewart O. Hoffman to receive one of the eight Hugo Gernsback Scholarship Awards of $125.00 for 1971. Mr. Hoff-

man, a twenty-three year old Californian, plans to enter the video phase upon completion of his electronics study. He works in carrier systems and special services as a "transmission man". He is currently pursuing an FCC license in a program given by his employer, Pacific Telephone.

Stewart is a "shutterbug". When not working, doing his homework, or tinkering with cars, he enjoys photographing scenic Southern California. ★

EIA WORKSHOP

WASHINGTON, D.C.—Fifteen thousand men will be introduced to careers in electronic servicing this fall through efforts of the EIA Consumer Electronics Group Service Committee.

Fourteen colleges and universities are presenting 2-week EIA sponsored workshops this summer for instructors who wish to include consumer product servicing in their school.

(continued on page 6)

Radio-Electronics

FOR MEN WITH IDEAS IN ELECTRONICS

June 1971 • Over 60 Years of Electronics Publishing

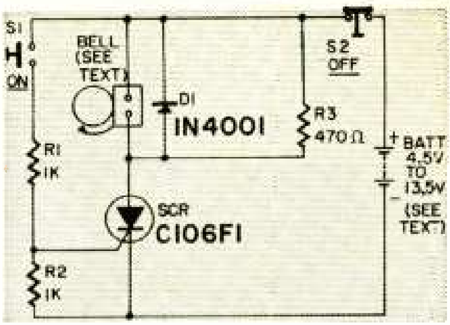
SPECIAL FEATURES

TELEVISION

GENERAL ELECTRONICS

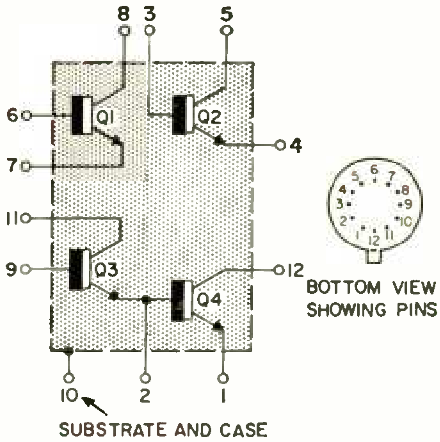
HI-FI—AUDIO—STEREO

DEPARTMENTS



Printed-circuit breadboard makes it a cinch to try these 24 burglar alarm circuits. We present the first eight in this issue. Get started today.

. . . see page 23



ICs are great. To find out what's inside those tiny "black boxes" and see what you can do with them don't miss this great feature.

. . . see page 58

This is Dolby. A simplified explanation tells how his noise reduction system works in tape recording and FM broadcasting.

. . . turn to page 38

RADIO-ELECTRONICS, June 1971. Vol. 42, No. 6
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LOOKING AHEAD

Volume 42 Number 6 RADIO-ELECTRONICS . . . FOR MEN WITH IDEAS IN ELECTRONICS June 1971

by DAVID LACHENBRUCH
CONTRIBUTING EDITOR

TV goes modular

This year, 1971, will go down in history as the year television went modular. The majority of American manufacturers, in their 1972 color models, have now entered the field Setchell-Carlson pioneered many years ago and Motorola popularized when it introduced the first Quasars in 1967. In addition to Motorola, the modular-design roster now includes Magnavox, Heathkit, RCA, Zenith, Warwick (which makes most Sears Roebuck sets) and Wells-Gardner (the private-label manufacturer which makes big-screen sets for W. T. Grant, Western Auto and many others). In the audio field, Dynaco, Electro-Voice, Fisher, Heathkit and Scott are using modular design.

The approaches to modules differ widely, but all have one thing in common: the equipment may be repaired by replacing ailing modules, and either repairing the modules or discarding them. RCA, in introducing its ceramic-encapsulated thick-film modules, obviously is moving in the direction of the throwaway circuit. Zenith, with its discrete Dura-Modules, aims at easily repairable circuits. Motorola's Quasar modules are designed for repair in the field or by the factory. The entire modular approach makes it far easier for the factory to change models by changing or rearranging modules, or to make changes in the midst of production runs by updating individual modules. Some modular designs—for example, Zenith's and RCA's—lend themselves to automated or computer-controlled production.

At the real root of the "modular revolution," however, is the problem of service. With the disappearance of the vacuum tube, the tube jockey is unemployed, or should be. In color television, the service profession requires top-notch technicians who keep fully abreast of the state of the art—a species already in short supply. Although few manufacturers will admit it, the modular revolution envisions the development of "module jockeys"—or, to put it more gently, "technicians' aides," who might be competent to make tests and measurements prescribed in the service manual, remove and replace the offending module, and return it to the shop or factory for repair.

The module is a mixed blessing for the service technician. To be fully equipped, of course, he must carry module caddies for every set he's called upon to service. For all of its sets introduced since 1970, Motorola has a total of about 20 different modules. RCA has about 15. Zenith has seven. And so on. More will be coming as new modular models are introduced and more sections of the chassis are modularized (although one module type may be used in many different models). The problem facing the technician, of course, is how many different types of modules he's going to have to stock, and at what cost in money and space. As for module standardization—forget it; it's just not in the cards.

How much?

If you've wondered whether television prices are going up or down, the answer is—both. The average American-brand portable color set sold in 1970 was about three dollars cheaper (in factory price) than its 1969 counterpart—\$268 vs \$271. On the other hand, the average color console rose \$13 to \$399 from \$386. Averaging all color sales, however, the price came out to \$336.62 in 1970, compared with \$341.30 in 1969, principally because a greater percentage of sales was in the portable category. The average black-and-white set reached an all-time low of \$87.69 at the factory in 1970, down from \$88.70 in 1969. Portable and table phonographs fell to \$40.19 from \$47.45 and console phonographs declined to \$206.22 from \$213.11. *What* inflation?

Facsimile via FM

Relatively low-cost facsimile systems, which operate over standard telephone lines, have become increasingly popular with businesses for transmission of documents, blueprints, signatures and other material. It's estimated that perhaps 60,000 such instruments are now in use, manufactured by Xerox, Magnavox, Data Sciences, Stewart-Warner and others. For point-to-point communications, the telephone system works fine. But how about a bank that wants to transmit the same document to 50 branches, or a supermarket chain, which is sending proofs of today's newspaper ads to 75 stores? This means 50 to 75 individual phone calls, repeating the transmission to each one.

A new system, proposed by Broadcast Facsimile Network, Inc., would use the subcarriers of FM stations for transmitting business facsimile information. The stations would merely offer their subcarriers for private multiplex use. The bank could use the same facsimile equipment designed for telephone circuits, as could the supermarket, reaching all receiving stations at the same time. Security of the circuits would be preserved by special printed-board decoders, which respond to a specific signal, inserted in the receivers. An additional use of the Network's facilities could be made by special information services and newsletters, which would sell or lease decoders to their subscribers. Just plug the decoder into the fax receiver and you'll get your investment newsletter or business-service information, or whatever. For private business newsletters, the subscriber would receive a decoder upon payment of his subscription fee.

An FM station transmitting in stereo could still accommodate one 5-KHz fax transmission. If the station were mono-only, it could carry four or five business-fax transmissions simultaneously. The FCC recently authorized tests of this system, but no commercial operations may be conducted without a special ruling. If such a ruling were forthcoming, it could herald the day of special facsimile subscriptions to newspapers and magazines aimed at the regular public—in addition to business services—via your friendly neighborhood FM station.

Dolby improves FM

The Dolby noise-reduction system, employed in some high-quality cassette recorders, has surprising results when used in conjunction with FM. Experiments in Chicago and London have indicated that the reduction in noise levels can provide an improvement in signal which would be expected from a tenfold increase in transmitter power, and can effectively triple an FM station's useful coverage area. The same Dolby "B" system used in cassette recorders is employed—an encoder at the transmitter and a decoder at

(continued on page 14)

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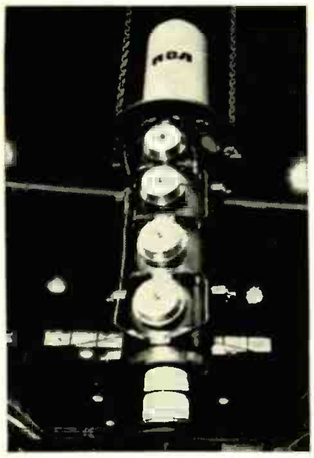
For complete, details, instructors should contact EIA Consumer Electronics group, 200 Eye Street, N. W. Washington D.C. 20006. ★



BOOSTER FOR UHF-TV. Three power tubes for uhf-TV transmitters, like one shown above, are made by RCA Electronic Components. Technically called four-cavity klystrons, the 30,000-watt electron tubes can generate powerful, high-quality video and audio signals at uhf-TV transmitters for broadcast into viewer homes, and may aid the expected growth in uhf television.

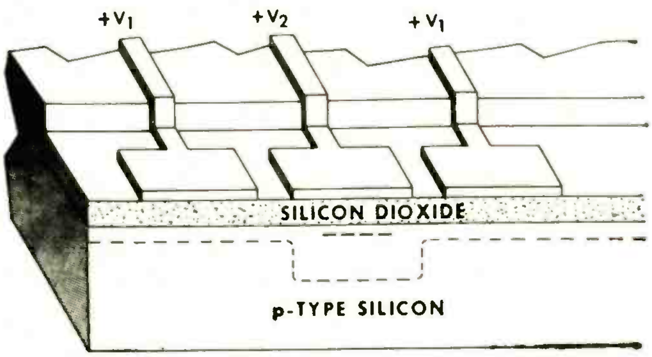
ELECTRONIC DRIVES IN STEREO TURNTABLES
It's a "better way" to keep turntables moving at a constant and correct speed. Three different units are described and their circuitry analyzed. The article starts on page 61.

Charge-Coupled Imaging Device

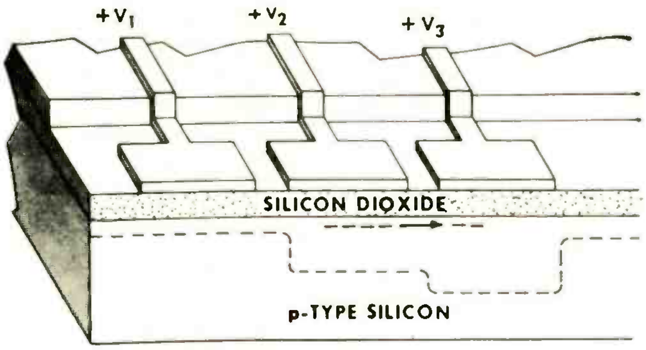
MURRAY HILL, N.J.—Charge coupling is used in a new solid-state device for electronically "reading" graphic material. This unit which has been developed at Bell Laboratories, can be used to scan print or photos line-by-line and convert variations in light intensity into an electrical signal. Transmitted to a remote location, this signal can reproduce an image of the original with high resolution.

The charge-coupling principle makes possible simple devices that perform electronic functions usually requiring complex integrated circuitry. Fewer critical processing steps are required for fabrication than with many IC's.

CHARGE COUPLED DEVICE
STORAGE



CHARGE COUPLED DEVICE
TRANSFER



In a charge-coupled imaging device, incident light causes free electrons to be generated within the silicon, more where the light is brighter and fewer where it is less bright. An array of electrons collect at the electrode with the highest positive potential in the area where they

(continued on page 12)

Radio-Electronics

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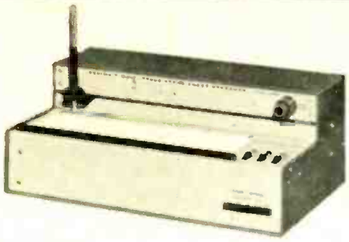
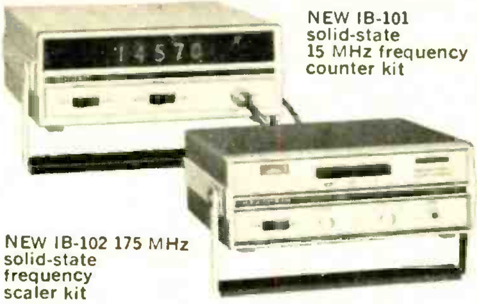


NEW IR-18M solid-state 12-speed chart recorder kit

NEW GR-371MX 25″ square-corner solid-state color TV kit

NEW GD-29 microwave oven kit



NEW IB-101 solid-state 15 MHz frequency counter kit

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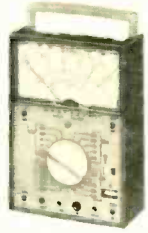
NEW IO-102 solid-state 5″ scope kit



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NEW! **GR-371MX 25″ solid-state ultra-rectangular color TV.** Check out the competition for standard features like these: 25″ square corner Matrix picture tube for the biggest, brightest, sharpest color picture ever...high resolution circuitry plus adjustable video peaking ...Automatic Fine Tuning...pushbutton channel advance..."Instant-On"...Automatic Chroma Control...factory assembled 3-stage solid-state IF and VHF & UHF tuners for superior reception, even under marginal conditions...adjustable noise limiting & gated AGC...adjustable tone control...hi-fi sound output to internal speaker or your hi-fi system. Plus your choice of installation in one of the three beautiful Heath cabinets or custom wall mounting capability. And the exclusive Heath self-service features let you do all normal adjustment & servicing, saving hundreds of dollars in service costs. If you want the finest, this is it...order your 371MX now. **Kit GR-371MX**, 125 lbs. **579.95***

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NEW! **IB-102 Scaler and IB-101 Frequency Counter** combination give you frequency measurement capability to 175 MHz at low, low cost. IB-101 counts from 1 Hz to over 15 MHz. Hz/kHz ranges & over-range indicator let you make an 8-digit measurement down to the last Hz in seconds. 5-digit cold-cathode readout...extremely low input triggering...all solid-state with 26 ICs, 8 transistors. NEW IB-102 Frequency Scaler can be used with virtually any counter on the market to extend your measurement capability well into the VHF range...at a price far below the cost of a 175 MHz counter. 10:1 and 100:1 scaling ratios give resolution down to 10 Hz...1:1 ratio provides straight-thru counting for frequencies in range of counter. Exclusive Heath input circuit triggers at very low levels – at 100 MHz less than 30 mV is needed. A handy Test switch gives a quick, accurate check of proper operation. All solid-state; fully regulated supplies; convenient carrying handle/tilt stand. Extend your frequency measurement capability now with these two new kits. **Kit IB-101**, 7 lbs. **199.95***
Kit IB-102, 7 lbs. **99.95***

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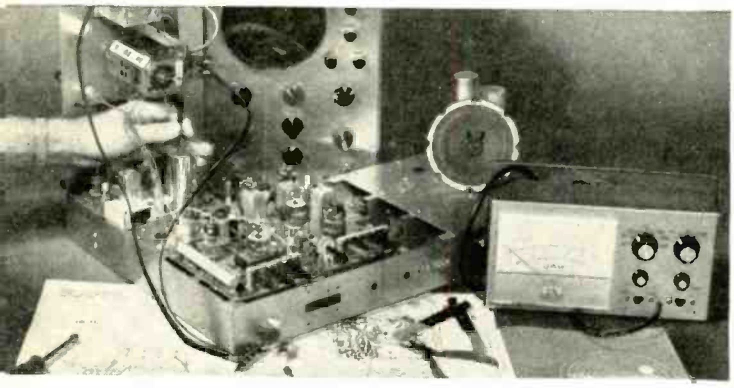

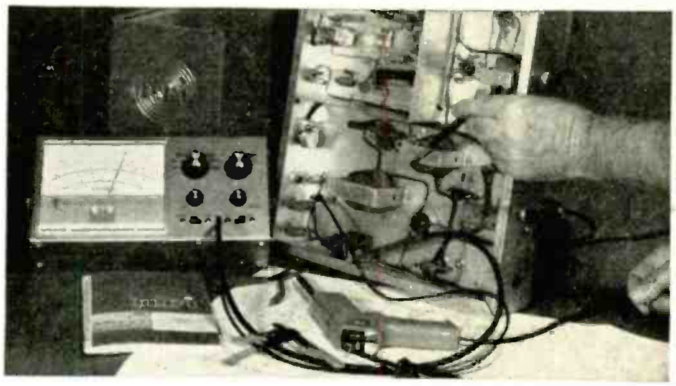

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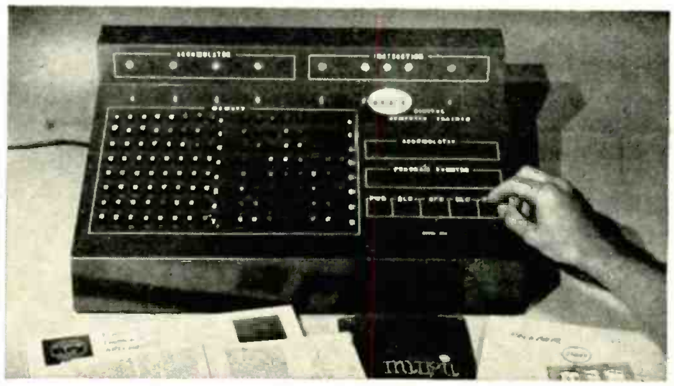

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OVER 50 YEARS OF LEADERSHIP IN ELECTRONICS TRAINING

(continued from page 6)

are generated. These charged packets are transferred along the surface of the silicon by applying a more positive voltage to the electrode next to the one holding the charge. The varying packets of charges collected at the end of the device are read out as an electrical current whose analog variations represent variations in light intensity on the document being transmitted.

This is a practical application of the charge coupling technique which was announced by Bell Labs last year. Ultimately it could be used to transmit images of print, drawings or photographs over the telephone network. ★

ASTRO-MIKE KIT from Bell & Howell combines a portable cassette player/recorder with a long distance microphone with parabolic reflector (held in model's right hand) which is pointed at the subject to be recorded. Sounds from the sports field can be picked up from the stands, while indoor events can be recorded at a distance from the subject.

PHILO T. FARNSWORTH DIES

Philo T. Farnsworth, one of the fathers of electronic television, died March 11 in Salt Lake City, Utah. He was 64.

At the age of six he decided he would be an inventor and he first fulfilled that aim when, as a 15-year-old high-school boy he described a complete system for sending pictures through the air. Six years later his first patent covering the complete electronic television system was filed.

Dr. Farnsworth was awarded the basic patents on electronic television, and is the inventor of the basic principles of the camera tubes now known as Image Orthicon and Image Dissector, both widely used today. He made the first public demonstration in the world of electronic TV at the Franklin Institute, Philadelphia, for 10 days during the summer of 1935.

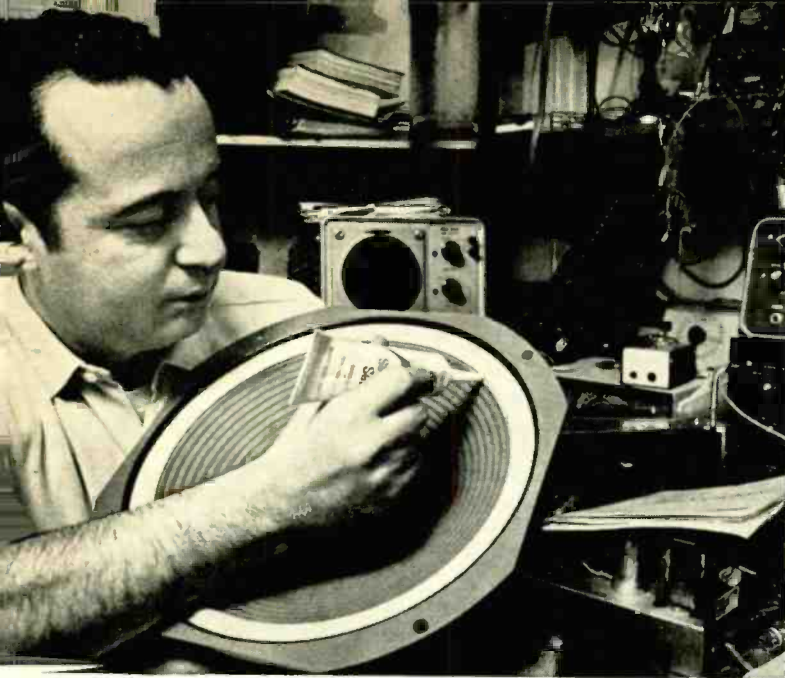
The firm he founded,

Farnsworth Radio & TV Corporation, later became part of the International Telephone and Telegraph System. He was president and technical director of this corporation until his retirement in 1967. ★

TIRE SAFETY SYSTEM

LOS ANGELES, CALIF.—Mr. Bernard Ivenbaum, an electronics engineer, is the inventor of a new safety system for autos, trucks, buses, planes, or other vehicles that travel on pneumatic tires. PinRay Enterprises is marketing the "Electronic Tire Pressure Sensing System", which works with sub-miniature transmitters which are attached to the valve stem of each tire. The unit is placed directly over the valve stem, screwing on like a valve cap, and can be easily added to any tire.

(continued on page 14)



Steckler

-Electronics

Wayne C. Leckey (Top)
Home and Shop Editor
Popular Mechanics

Jim Hall
Designer of the
Chaparral 2J, world's
most advanced racing car

Match wits with the experts and win a $1000 shopping spree.

Three top pros challenge you to come up with an imaginative use for General Electric Silicone Seal or Silicone Lubricant. Something they may not have thought of.

Using the seal, electronics expert Larry Steckler repaired a speaker cone, and sealed an antenna lead-in feedthrough and outdoor antenna terminals. With the lube, he sprayed telescoping auto and TV antennas, a record changer mechanism and slide, and an antenna rotator.

With the sealant, home-and-shop expert Wayne C. Leckey dabbed rubber "feet" onto a trinket chest, sealed a rain gutter and caulked a bathtub. With the lube, he sprayed a fishing reel, some stuck drawers and all of his tools.

On his Chaparral 2J, Jim Hall used Silicone Seal to make formed-in-place gaskets, to seal all electrical connections, and as an adhesive to hold components to the body. Then he spray-lubed the throttle linkage, suspension ball joints, wheel lugs and battery terminals.

Now here's what you can do: send in another use for either product, different from those mentioned above, and enter our sweepstakes. (To win, all you *must* do is fill in your name and address and the name and address of the store where you saw GE Silicone Seal and GE Silicone Lubricant on display.)

Grand Prize: $1000 worth of anything from your favorite store carrying GE Silicone Seal and GE Silicone Lubricant. Next 100 prizes: $25 worth each. Next 1000 prizes: one-year subscriptions (or renewals) to the magazines from which you clip your official entry blank.

GE Silicone Seal: The most reliable adhesive/sealant/insulator/moisture-proofer/instant rubber. Guaranteed for 10 years. Ignores temperatures from −60°F. to 500°F. Won't harden, soften, crack or shrink. Ever. Dab it on, overnight it becomes a strong, flexible, permanent rubber. In white, black, clear and metallic. In 3-oz. tubes and 12-oz. cartridges.

GE Silicone Lubricant: The slipperiest stuff in a can. Longest wearing, strongest moisture resister, best corrosion fighter. Age, water and temperature (−70°F to 400°F) can't hurt it. *First lube of its kind that can be painted over.* Really works on just about everything, even aluminum. (Not recommended for TV tuners.) In 6-oz. aerosol cans.

GENERAL ELECTRIC

OFFICIAL RULES—NO PURCHASE REQUIRED

(1) On Official Entry Blank or plain piece of 3"x5" paper, print your name, address, zip code and the name and address of your favorite store carrying GE Silicone Seal and GE Silicone Lubricant. Include suggestions for new or different uses for either product, and name of magazine in which you saw this ad.
(2) Enter often, but mail entries separately to: MATCH WITS, P.O. Box 250, Murray Hill Station, New York, N.Y. 10016. Entries must be postmarked by July 5, 1971 and received by July 12, 1971.
(3) Winners selected in random drawings by an independent judging organization. Decisions final. *All* prizes awarded. Only one to a family.
(4) BONUS PRIZE: If you win the Grand Prize and your entry includes a new or different use, you receive a Bonus Prize of $100.
(5) Any resident of the U.S. is eligible except employees and their families of General Electric Company Silicone Products Dept. and its agencies. Void where prohibited. Subject to all federal, state and local laws and regulations.

OFFICIAL ENTRY BLANK

MATCH WITS
P.O. Box 250, Murray Hill Station
New York, N.Y. 10016

Here's what I did with (check one) ☐ GE Silicone Seal or ☐ GE Silicone Lubricant: ____________

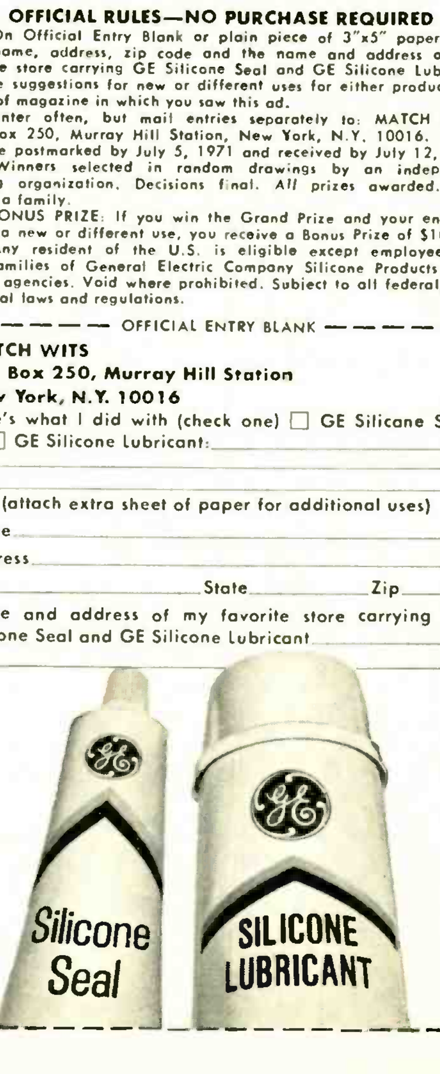
(attach extra sheet of paper for additional uses)

Name ____________

Address ____________

City ____________ State ____________ Zip ____________

Name and address of my favorite store carrying GE Silicone Seal and GE Silicone Lubricant ____________



Radio-Electronics

New & Timely

(continued from page 12)

If tire air pressure drops below or rises above a pre-

set pressure, a signal is transmitted to a special receiver, mounted under the driver's dashboard. He is alerted that a problem exists with one of his tires.

Each transmitter weighs around two ounces and is less than two inches long. The transmitters are made of materials impervious to any weather and temperature conditions that a tire might encounter, in any climate. The device is designed to withstand vibrations and bumps of the roughest type, on or off the road, without affecting the operation of the unit. ★

THIS LEVEL SENSOR tattles "tilt" at the tide in a teacup or, from the bottom of a gold mine, measures the movement of a mountain. The inventor, Siegfried Hansen of Hughes Research Labs, says it's capable of measuring tilt angles to about one part in one billion, equivalent to 1" in about 16,000 miles. R-E

LOOKING AHEAD

(continued from page 4)

the receiving end (for complete details see article on page 38 of this issue).

Dolby Laboratories claims that the Dolbyized signal will not sound unpleasant, even coming from receivers not equipped with Dolby decoders. The principal characteristic is an increase of brilliance in the highs, hardly noticeable on inexpensive sets and easily compensated for on better sets by turning down the treble. Of course, the noise reduction would be realized only for sets with Dolby decoders. The decoder would add about $10 to manufacturing costs at the outset, and costs presumably would come down with mass production. The effects of the use of the Dolby system are particularly noticeable with FM stereo, since the multiplex signal is normally subject to a much higher background noise level than are monophonic broadcasts. There has, as yet, been no ruling whether Dolby broadcasting would require special permission of the FCC.

The Dolby "B" system is a simplified version of the professional Dolby system, used by most record companies to reduce noise levels during the recording process. **R-E**

THIS MONTH IN HIGH FIDELITY

There are four important hi-fi articles in this issue. On page 33 you'll find full details on building an FM preamp.

Starting on page 38 is a complete article on the Dolby system. If the short piece in *Looking Ahead* (above) leads you into wanting to learn more, you'll find the answers here.

Stereo turntables are changing too. One of the newest differences is a move to electronic drives. Senior Technical Editor Bob Scott gives you the lowdown on page 61.

And on page 51 Mannie Horowitz continues his series.

Circle 7 on reader service card →

HOLD IT!

Ungar's New Feather-Light Solid-State Solder Gun

Hold it and you'll know why more pros have chosen Ungar's new #6760. Professional servicing or kit assembly . . . it's the most advanced gun available for soldering today's sophisticated circuitry. First, it's less than five ounces light — for pinpoint accuracy without hand fatigue . . . advanced circuitry replaces the usual heavy transformer.

Next, it's safer because the gun is grounded. No stray currents or static electricity to damage sensitive I.C.s or densely packed components — (it's safer for you, too) — the isolated-grounded tip, with a three wire NEMA plug and cord.

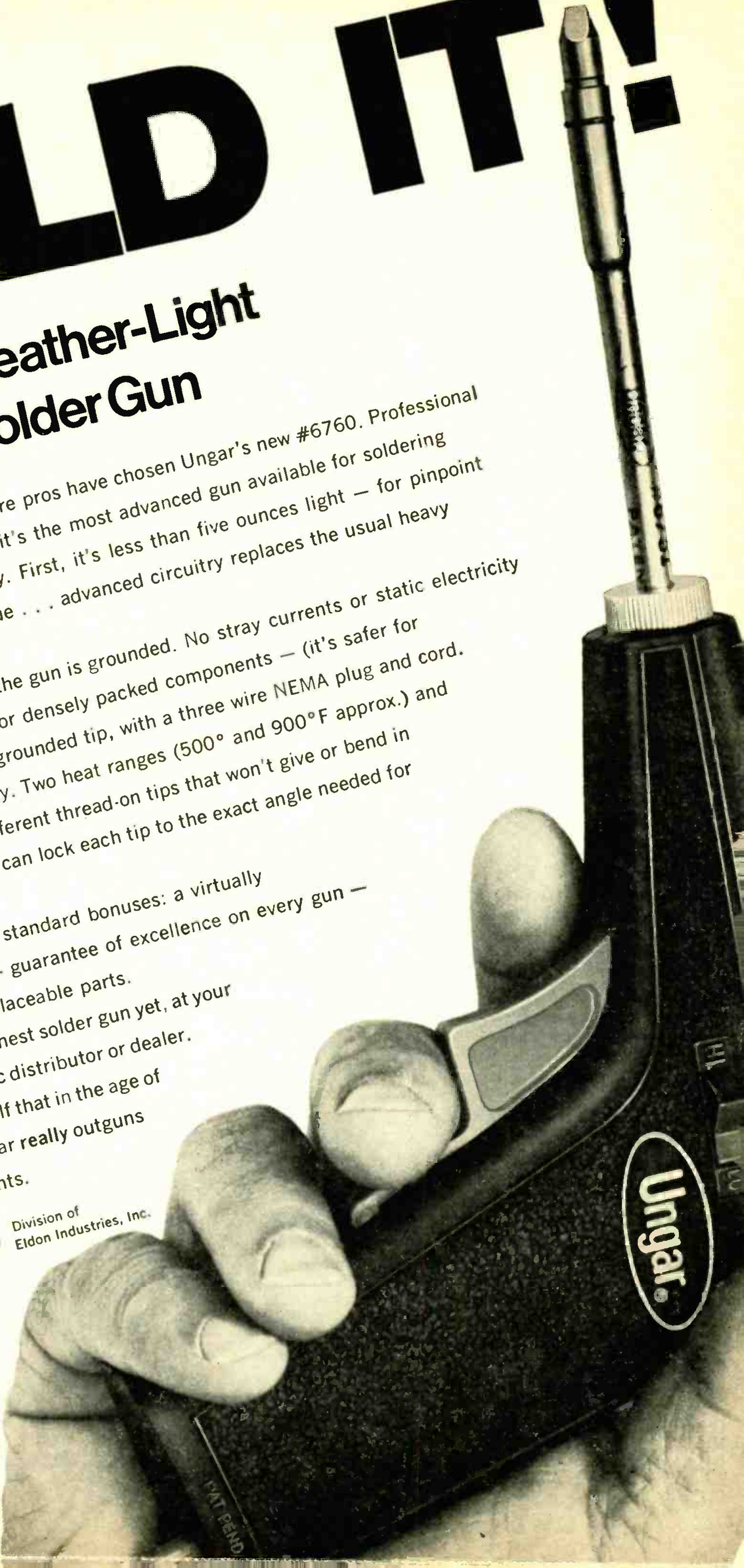
You also get versatility. Two heat ranges (500° and 900°F approx.) and your choice of three different thread-on tips that won't give or bend in constant use. And you can lock each tip to the exact angle needed for your job.

You get exclusive standard bonuses: a virtually shatterproof case — guarantee of excellence on every gun — and separately replaceable parts.

Reach for the finest solder gun yet, at your nearest electronic distributor or dealer.

Prove for yourself that in the age of solid-state Ungar **really** outguns the heavyweights.

Ungar® Division of Eldon Industries, Inc.



EQUIPMENT REPORT

Sencore FE 20 "Hi-Lo" Field-Effect Meter

For manufacturer's literature, circle No. 16 on Reader Service Card

FOR SOME TIME, SENCORE HAS BEEN building field-effect multimeters (FETVM's) and very good ones. The latest one is their FE-20 "Hi-Lo Field Effect Meter." This instrument has 9 dc voltage ranges, 9 ac voltage ranges, 3 high-voltage ranges (3, 10, 30 kV), 9 dc current ranges, and 7 resistance ranges. That's 37, and there are more.

The term Hi-Lo fits all of them. DC voltage can be read from 0.1 volt (full-scale!) to 30,000 volts; ac voltages from .01 volt to 1,000 volts, and dc currents from 100 μA to 1.0 ampere. The ac voltage ranges can be read rms or peak-to-peak. This would add 9 more!

The real reason for the Hi-Lo name, though, is the ohmmeter circuit, which is also "dual." The first is a standard ohmmeter circuit, marked HI-PWR OHMS. Seven ranges are used. R x1 up to R x1 Megohm; with a center-scale reading of 12 ohms on the lowest one. This uses a 1.5-volt battery. The other one is a specialized very-low-power ohmmeter circuit. It uses the same scales as the first, but it applies only 0.08 volt to the circuit being checked!

This was developed so the technician can make accurate resistance readings in transistor circuits. The low voltage will not (normally) make even a germanium transistor go into conduction. In fact, they send along a little demonstration-board, with a germanium transistor and three resistors on it. You can read the actual value of a 10,000-ohm resistor connected between the base and emitter of the transistor.

A note adds that in a very few cases, even this low voltage will make some germanium transistors conduct. For dealing with these, a 120,000-ohm isolation resistor is built into the probe, with a slide switch to short it out when not needed. By adding this resistor, and re-zeroing the meter, the actual applied voltage on the circuitry is reduced to 0.008 volts!

The isolation resistor can also be used for dc or ac voltage readings, if you need it, to isolate the cable capacitance from tuned circuits, etc. The probe cable is shielded, by the way, to get rid of stray pickup when the instrument is used on the very low voltage ranges. The input resistance of the FE-20 is so high, 15 megohms on dc and 12 megohms on ac, that the extra series resistance of the 120,000-ohm resistor makes it read only 0.6% low.

A slip-on high-voltage probe comes with the FE-20, clipped inside the lid of the heavy steel case. This raises the input impedance to 1500 megohms, and can be used on any range, multiplying the reading by 100. The most frequent use, of course, will be on the 3, 10 and 30 kV scales; for reading HV and focus voltages in color sets, etc. However, if you should ever need a 0 to 10-volt range at 1500 megohms impedance, just set the switch to the 0.1-volt scale, slip on the HV probe, and you've got it.

The 200-μA meter movement is diode-protected against overload, though the circuitry isolates the meter itself from applied voltage in the VOLTS positions. Six C-cell batteries power the amplifier circuits, and another one runs the ohmmeter ranges. A rocker switch at the bottom of the panel will be automatically turned off when the lid is closed. Battery-test slide switches are just below the meter, one for each battery, so that you can be sure that they're up to par.

The test leads are permanently attached to the meter and stow in a compartment just below the meter.

In case you pull one of the old Standard Stupids, and try to read voltages with the switch set on OHMS, or try to read a 750-mA current with it on the 0-1 mA scale, they thought of that, too! A fast-blow 0.6-ampere fuse is handily placed on the bottom edge of the case. This lets go if such things happen. So instead of replacing the meter, or the ohms multiplier resistors, you just reach inside the case, take out the spare fuse thoughtfully provided for such emergencies, install it, and go on, setting the switch to the right position this time!

A comprehensive instruction book, schematic diagram, servicing instructions, and a troubleshooting chart are provided. They even include a simple circuit for building your own ac/dc voltage calibrator. It uses a filament transformer, transistor and a couple of little mercury batteries.

The FE-20 is a handy instrument to use. We gave it the works on quite a few different kinds of equipment, including an orphan transistor guitar amplifier, and it came out very nicely. The meter movement is well-damped by the circuit design. Instead of vibrating all over the place, it swings up in a slow, dignified manner, and stops, as if to say "There! That's it!" Holds its zero quite well, too, which is handy. There are only two knobs to adjust, the FUNCTION and RANGE switches, with the two ZERO knobs, of course. The FE-20 can be set up for zero-center voltage readings on dc, which is often very useful for such things as adjusting afpc, afc, acc, aft, and discriminator circuits. In fact, by using the HV probe, you could even get a zero-center ±15,000 volt range, if you had to have it! **R-E**

Correspondence

DESIGN FOR STEREO

I have some comments on Part I of the series "Designing Solid-State Stereo Amplifiers" by Mannie Horowitz, which began in your December 1970 issue.

Mr. Horowitz states "the actual direction in which electrons flow is from the negative terminal of a battery through the load and back to the positive terminal." Now, if this is so, and I hold that it is, what is the significance of the preceding statement that this was "taken for granted" in the heyday of vacuum tubes," and "it is significant only because electrons flow from the heated cathode in the electron tube to the cooler plate?" What would happen if the plate is heated to a temperature equal to or above that of the cathode?

From the next assertion we learn that in semiconductor circuits "current flows from the positive terminal of the power supply through the load and back to the negative terminal" and "this direction is just the reverse of the electron flow" and the (diode) "arrows indicate the direction of the current, not electron, flow."

From this I must of necessity understand that in semiconductor circuits, *currents* rather than (or in addition to?) *electrons* flow. There is further a superfluity of information such as that "copper wire . . . is a common example of a conductor" and "insulators are just as important . . . as are conductors"—*in audio work*, you must note!

GORDON MARTIN
Nanaimo, B.C., Canada

MR. HOROWITZ REPLIES

You object to my saying that the actual direction in which electrons flow is from negative to positive, and then going on to state that it was taken for granted that this was the current flow through vacuum tubes. Actually, my statements were accurate. *Electrons*, as you agree, flow from the negative to the positive, but *current* takes the opposite direction. It *was* taken for granted by many technicians that these were identical in po-

(continued on page 22)

The Way to Get Ahead in Electronics is To Get More Knowledge Into Your Head And a Grantham Degree Into Your Pocket!

The above headline makes a point that affects more than your head and pocket. It can affect your *pocketbook* too. Getting ahead in the pocketbook is of great interest to most of us, and the Grantham ASEE Degree program not only helps you get *ahead* in the pocketbook but also puts a better one on your shoulders. As an electronics technician, you can really get ahead by getting more eduction, and if you don't need a degree in your pocket why not hang it on the wall!

Maybe we don't write the best ads, but we really know how to teach electronics and related subjects by correspondence. We have been doing it for twenty years. AND we are the only home-study school in the United States ever accredited to award a *degree* in engineering. True, it's an associate rather than a baccalaureate degree, but that's because we teach only engineering and engineering-related subjects and do not include the humanities in our curriculum. Grantham awards the degree of *Associate in Science in Electronics Engineering*—a degree in college-level engineering rather than the usual junior-college kind of associate degree.

Advance beyond the technician level. Become an engineer. If you are a high school graduate and have a good aptitude for electronics and mathematics, you can earn the Degree of Associate in Science in Electronics Engineering mainly by

STUDYING AT HOME

Investigate *now* the Grantham college-level program in electronics engineering, offered (by correspondence) to working technicians while they remain on their jobs. Grantham lessons place heavy stress on fundamental concepts of logic and mathematics (taught so you can understand them), and build from there in a systematic manner, covering physics, circuits, and systems. The lessons are easy to understand because they are carefully written, with step-by-step explanations and consistent review and regrouping of ideas.

Now is the time, not only to protect yourself from unemployment, but also *to prepare yourself for the greater demand in engineering* which is sure to come. You can't become an engineer in a few short weeks; it takes many months. You can be upgrading yourself in your present job while the economy is "slow", and then *be ready to move into engineering* when the national economy gets going again. Yes, now is the time to prepare, so that *you* will be ready to take advantage of opportunity when it presents itself.

STEP UP!

MOVE AHEAD

The Way to Get Ahead in Electronics is To Get More Knowledge Into Your Head And a Grantham Degree Into Your Pocket!

When the Degree of Associate in Science in Electronics Engineering is conferred upon you, it will be because you've *earned* it. You'll have a knowledge and understanding of electronics that won't fail you. You'll know *what* you're doing, and *why* you're doing it. And what's more — your associates will know that you know what you're doing. You'll be proud to say that you're a GRANTHAM man. The pride that the School takes in its graduates is reflected in this simple statement: GRANTHAM graduates are men who have learned to step up!

CORRESPONDENCE
(continued from page 17)

larity, but this was not true. By any textbook or definition, current flow is *opposite* to that of electron flow, and to say otherwise is wrong by all standards. Many of the engineering texts on vacuum tubes did show the actual direction of current flow rather than electron flow.

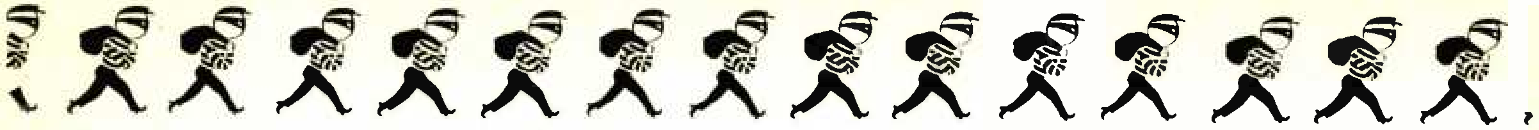
In the paragraph concerning direction of current flow, I mentioned that it is *opposite* in direction to electron flow. I indicated that it is a convention of direction, and does not negate the presence of electron flow. As for the significance of the item that flows, I would just like to quote a passage on page 20 of "Transistor Electronics," by the two very respected experts, Dewitt and Rossoff: "We will presently learn that the hole is peculiarly endowed with the attributes of a positive mobile charge or carrier which, in its own way, may constitute the medium for current flow and thus plays a tremendously important role in semiconductor processes." If these two authors say *may constitute* the medium for current flow, and they show some doubt, how can you or I, or anyone else, be so certain that our current flow is electron flow and not hole flow?

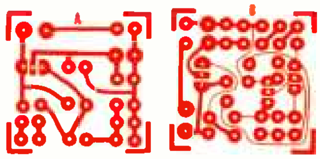
Regarding the good insulators of pure germanium and pure silicon, note the word "pure," and also note a statement in the article you missed—"especially at low temperatures." These are good, not excellent insulators at low temperatures. GE refers to them as semiconductors—and they are classified as such not so much because of their resistivity, but because of their negative temperature coefficient. However, I used these as examples in the article, as insulators, only to stress that impurities must be added to make them useful semiconductors for use in the various devices. To go one step further—where is the exact separation in resistance, and at what temperature, between an insulator and conductor? I must agree, however, that these should be classified as semiconductors, but I did *not* do so in order to emphasize the importance of the impurities.

I must say, too, that you are in error in your final statements: current is *not* a flow of electrons from the negative to the positive, but a flow in the reverse direction. It is not true in any circuit that current and electron flow are in the same direction.

I hope you continue to read the series, and I appreciate any constructive criticism you have to make.

MANNIE HOROWITZ **R-E**





24 easy-to-build burglar alarms

Take your pick; you're bound to find the right system for you. Use 2 circuit boards to build any of these first eight alarms

by R. M. MARSTON

THIS ARTICLE WILL DESCRIBE TWO DOZEN versatile and easy-to-build electronic alarm projects you can make. All of these projects are designed around a sensitive low-cost silicon controlled rectifier (SCR), and automatically operate an alarm bell, buzzer, or siren.

The projects described include both simple and advanced burglar alarms, light-beam alarms, smoke alarms, automatic fire alarms, over-temperature alarms, frost alarms, under-temperature alarms, and alarm circuits that are operated by contact with water or steam.

All of these alrm circuits can be built on a group of printed circuit boards, breadboard style, with plug-in circuit components You'll find prices and sources of the necessary parts at the end of this section of the article.

Basic principles and projects

All the projects described in this two-part article are designed around a 50-volt, 2-amp, type C106F1 SCR, manufactured by G-E. Table I lists the basic parameters of this device. The upper drawings in the right-hand column show its outline and pin connections.

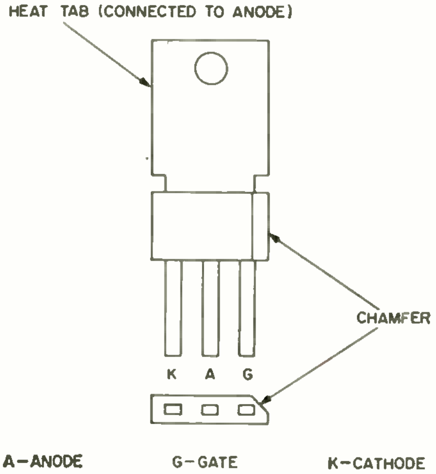
The SCR symbol is shown in the drawing at lower right. This symbol resembles a normal rectifier, but has an additional terminal (G) known as the gate. The SCR can be made to act like either a normal silicon rectifier or as an open-circuit switch, depending on how its gate is used; hence the name silicon controlled rectifier. The important characteristics of the device, as far as this article is concerned are:

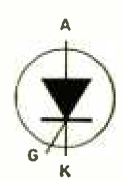
1. In dc circuits, the SCR is normally used in a basic configuration similar to that shown in Fig. 1. It is connected so the anode is positive with respect to the cathode, and the anode is connected to the positive supply via an external load (LM1). Normally, with no positive bias or signal applied to the gate, the SCR is off, or "blocked," and acts (between anode and cathode) like a reverse-connected silicon diode or open circuit switch: only a low leakage current, I_{FX}, (typically 0.1 μA in the C106F1) flows through the anode load.

2. When a positive bias is applied to the SCR gate (by closing S1), the SCR turns on, and then acts like a normal forward biased silicon rectifier; it conducts heavily in the forward direction, and a high current flows through the lamp. As in a normal rectifier, a saturation voltage, V_{SAT} (between 1 and 2 volts, depending on the magnitude of the forward current), develops between the anode and cathode of the device when it is conducting heavily in the forward direction.

3. Once the SCR is turned on and is conducting, the gate loses control, and the SCR self-latches and stays on even if the gate bias is removed. Thus, only a brief positive gate pulse is needed to turn the SCR on. This pulse needs a duration of only a few microseconds.

4. Once the SCR is locked on self-latching mode, it can only be turned off again by momentarily reducing its anode current to a near-zero value. In Fig. 1, therefore, the SCR can be reset to OFF by momentarily opening S2.





THIS IS THE SCR (right) used in all the alarm circuits in this article. Note carefully it's basing, and schematic symbol.

COMPLETE TABLE OF PARAMETERS for the C106F1 SCR is shown below.

PARAMETERS OF THE C106FI SCR @ 25°C.

	MIN	TVP	MAX
Peak Forward Blocking Voltage, V_{FXM}	50V		
Max Average Forward Current, I_{FM}	2 Amp.		
Gate Trigger Current, I_{GT}	—	30μA	200μA
Gate Trigger Voltage, V_{GT}	—	0.5V	0.8V
Holding Current, I_{HX}	0.3mA	1mA	3mA
Saturation Voltage, V_{SAT} @ 2A	—	—	1.8V
Saturation Voltage, V_{SAT} @ 0.5A	—	—	1.3V
Forward Leakage Current, I_{FX}	—	0.1μA	10μA

5. Since the SCR turns off automatically when its anode current falls to near-zero, there is a minimum anode current at which the device can be reliably operated in the self-latching mode. This minimum current, which is typically about 1 mA in the C106F1, is called the holding current. Its practical effect is to place a limit on the maximum value of anode load resistance that can be reliably used with the SCR if it is to be used in the self-latching mode.

6. The SCR delivers high power gain between the gate and the external anode load. Typically, the C106F1 turns on with a gate current (I_{GT}) of 30 μA and a gate voltage (V_{GT}) of 0.5 V. (i.e., it needs a turn-on gate power of only 15 μW.) The C106F1 can switch anode currents of 2 amps through a load taken from a 50 volt supply; roughly 2 volts are lost in saturation across the SCR, so the SCR can switch 96 watts into the load in this case.

The overall power gain, between gate and load, is thus 6,400,000 times. Note in this example that, when 96 watts switched into the external anode load, only 4 watts is lost across the SCR. The C106F1 has a small heat tab, so the device can be kept cool while dissipating this 4 watts of power by connecting it to a small heat sink.

Now, with all of these points in mind, you can see that, because of the resistive nature of its anode load, the simple lamp-driving circuit of Fig. 1 is inherently self-latching. Once the lamp has been turned on by operating S1, it stays on until the SCR's anode current is momentarily reduced to zero by opening S2.

Consider now how the circuit will act if the lamp is replaced by an electric bell, as in Fig. 2. A normal electric bell is a self-interupting device. When it is connected across a power supply, a current flows through a solenoid via a pair of contacts. This current induces a magnetic field in the solenoid, and causes a striker to fly outward. As the striker flies outward, it causes the contacts to open. The current then falls to zero, the magnetic field collapses, and the striker falls back again. Once the striker falls back, the contacts close again, and the action repeats.

Consequently, when a self-interrupting device of this type is connected as in Fig. 2, the SCR will not self-latch normally, and the bell will operate only when S1 is closed. The same non-latching operation is obtained if the bell is replaced by some other self-interupting type of alarm, such as a buzzer or siren.

The alarm circuit can be made to self-latch, if required, by wiring a 470-ohm resistor in parallel with the bell, as in Fig. 3. Here the anode current of the SCR does not drop to zero when the bell self-interupts, but falls to a value dictated by R3 and the battery voltage. If this current exceeds the SCR's holding current, the SCR automatically stays in the self-latching mode. The circuit can be unlatched by operating S2, to reduce the anode current to zero when the bell enters a self-interupting stage.

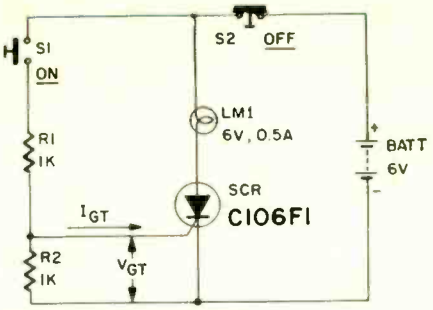
The two simple circuits of Fig. 2 and Fig. 3 form the basis of all the alarm projects described in this two-part article. In these projects, the alarm can be any low voltage (3 V to 12 V) self-interupting bell, buzzer, or siren that draws an operating current of less than 2 amps. The battery or power supply should deliver a voltage roughly 1.5 volts higher than the normal operating voltage of the alarm device.

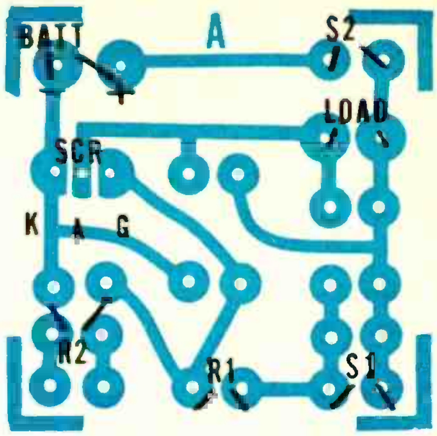
Diode D1 suppresses any back emf from the alarm, which might otherwise damage the SCR or associated circuitry. Resistor R2 stabilizes the gate characteristics of the SCR, and enables it to operate reliably at temperatures up to 110°C. R1 limits the gate current to a safe value.

When building the projects described in the following pages, check to be sure that the SCR does not get too hot when the alarm is driven on. If it does, connect the SCR heat tab to a heat sink with an area of a couple of square inches.

As far as power supplies for these

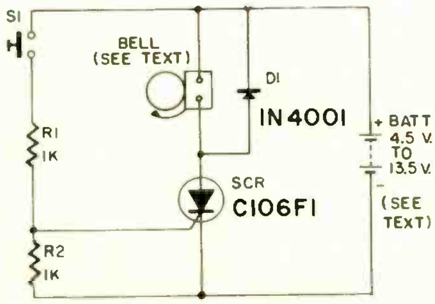
1.

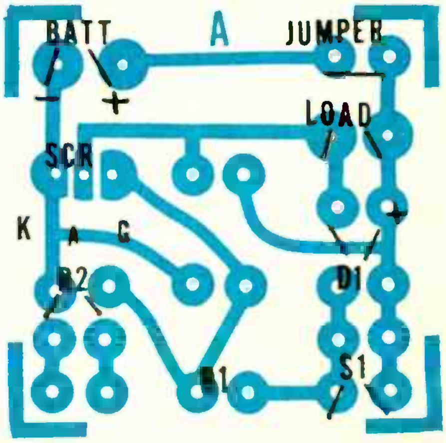




R1, R2—1000 ohms, ½ watt
S1—spst normally open
S2—spst normally closed
LM1—6V 0.5A lamp
SCR—C106F1
BATT—6V
Circuit Board "A"

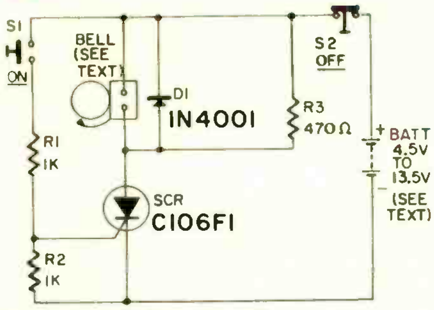
2.

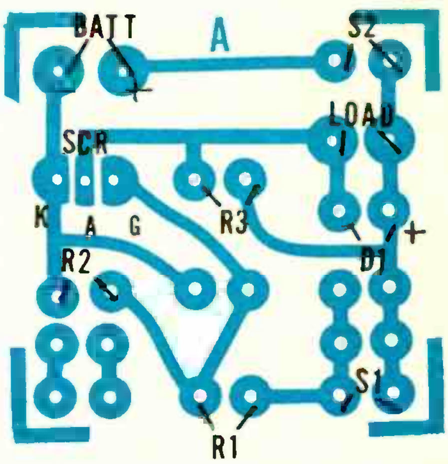




R1, R2—1000 ohms, ½ watt
D1—1N4001
SCR—C106F1
S1—spst normally open
BATT—4.5 to 13.5 V
Bell (see text)
Circuit Board "A"

3.





R1, R2—1000 ohms, ½ watt
R3—470 ohms, ½ watt
D1—1N4001
SCR—C106F1
S1—spst normally open
S2—spst normally closed
BATT—4.5 to 13.5 V
Bell (see text)
Circuit Board "A"

projects are concerned, most of the circuits have been designed to operate from batteries, but will operate equally well from ac power supplies, so long as these supplies have a reasonably well smoothed output. If ac powered supplies are used, however, you must insure that the alarm systems will not be turned off if the power lines fail or are deliberately cut.

This can be done by connecting a normally-on relay in the power supply, so it will automatically turn off and connect the alarm circuit to an emergency battery supply if ac power fails.

If such a power supply is used, you may have to connect a large smoothing capacitor across the alarm circuitry, to make sure the alarm is not triggered by switching transients that may occur as the relay changes over.

Contact-operated alarms

The simplest type of alarm circuit that can be built around the C106F1 is the remote-operated alarm shown in Fig. 4. The circuit is a non-latching type, and operates when any of the input switches (S1 to S_n) are closed. Dozens of these switches can be wired in parallel, and each will cause the alarm to operate. These switches pass currents of only a few milliamps, so they can be placed hundreds of feet away from the SCR and alarm, without risk of trouble from high cable resistance.

The circuit can be converted to a simple self-latching burglar alarm or a multi-input fire alarm by wiring a latching resistor across the alarm and adding a reset button, as in Fig. 5.

These two circuits have many applications in the home and industry. They pass typical standby currents of only 0.1 μA when the alarm is off; so they draw negligible batteries current. If snap-action or reed switches are used, the circuits can be made to operate whenever a door or window is opened, or when an object travels beyond a pre-set limit. If pressure-sensitive switches are used, the alarm can be made to operate whenever a person stands on a mat or a vehicle passes over a pressure-pad.

The circuit of Fig. 5 is useful as a burglar alarm, but unfortunately is not completely "burglar proof;" each switch circuit can be disabled by simply cutting the cable linking the switch to R1 or to the positive supply line.

A more reliable burglar alarm circuit is shown in Fig. 6. This circuit operates and self-latches if any of the switch contacts open, or if their connecting leads are cut.

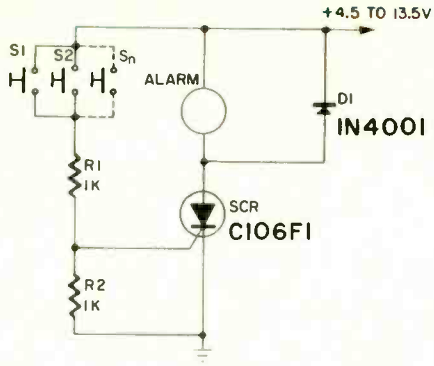
C1 is a noise-suppressing capacitor. It insures that the alarm will not be inadvertently operated by the action of switch contacts momentarily bouncing or sliding apart because of vibration or shock. The alarm will operate only if the contacts are held open for 1 msec or so.

The alarm system of Fig. 6 draws a standby current of about 380 μA when used with a 4.5-volt supply. Standby current can be reduced, if required, by modifying the circuit as shown in Fig. 7 or 8. In Fig. 7, transistor Q1 is used as a simple common-emitter amplifier. Its collector current feeds into the SCR gate via R2. Normally, in the standby condition, Q1 is held cut off by the switches wired between its base and emitter; negligible current flows into the SCR gate; and the alarm is off.

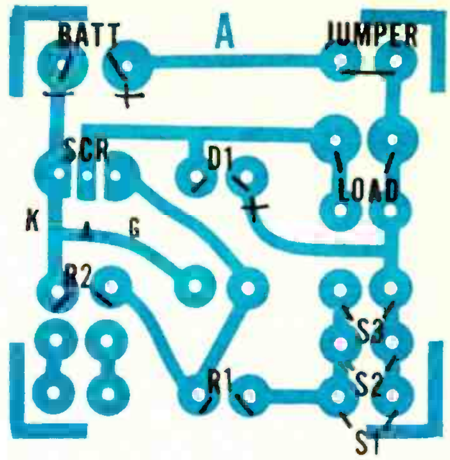
A small standby current (45 μA when a 4.5-volt supply is used) flows through R1 under this condition. When any of the switch contacts open, base current flows into Q1 via R1, and Q1 turns on. Its collector current flows into the gate of the SCR, and the alarm circuit turns on and self-latches.

The circuit of Fig. 8 is similar to that of Fig. 7, except that the common-emitter amplifier is made up of a Super-Alpha-connected pair of transistors, and the circuit draws a typical standby current of only 1 μA from a 4.5-volt supply. In both of these circuits, C1 acts as

4.

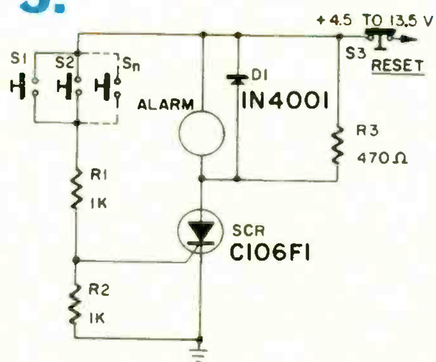


R1, R2—1000 ohms, ½ watt
D1—1N4001
SCR—C106F1
S1, S2, S_n—spst normally open

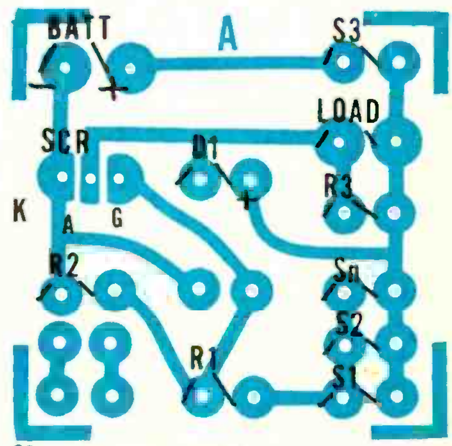


Alarm
Circuit Board "A"

5.

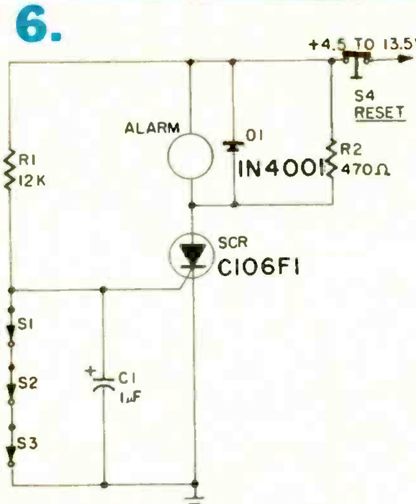


R1, R2—1000 ohms, ½ watt
R3—470 ohms, ½ watt
D1—1N4001
SCR—C106F1
S1, S2, S_n—spst normally open

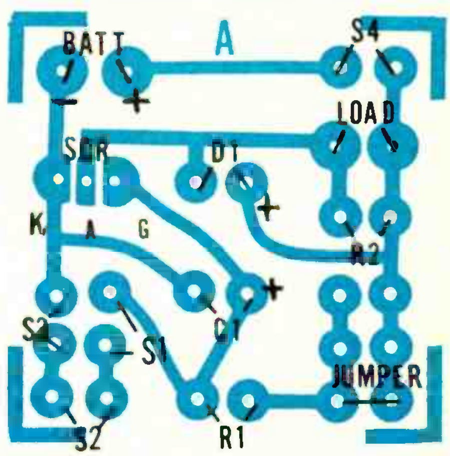


S3—spst normally closed
Alarm

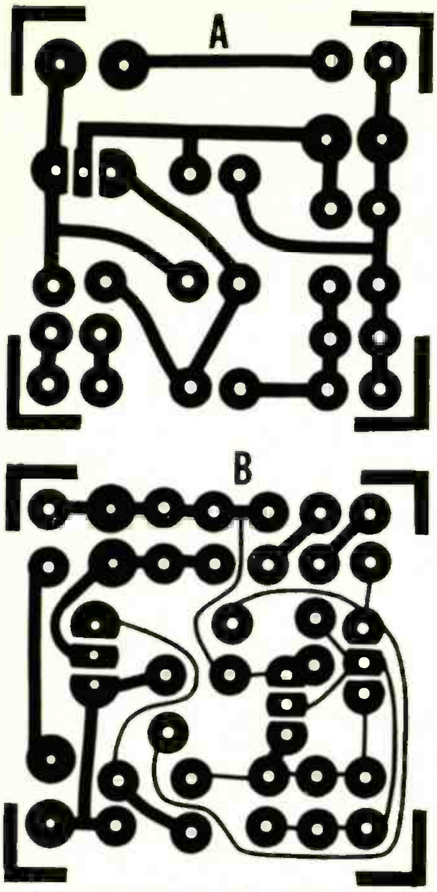
6.



R1—12,000 ohms, ½ watt
R2—470 ohms, ½ watt
C1—1 μF, 25 V



D1—1N4001
SCR—C106F1
S1, S2, S3—spst normally closed
S4—spst normally closed
Alarm
Circuit Board "A"



CIRCUIT BOARDS "A" AND "B" are shown here actual size. With these two boards, following the diagrams with each alarm circuit, you can build all of the eight alarms shown here.

a noise-suppressing capacitor across the switch contacts.

The "break-to-operate" burglar alarm systems of Figs. 6, 7, and 8 are considerably more useful than that of the simple 'make-to-operate' system of Fig. 5, but are still not fully tamper proof. They can be disabled by wiring a jumper or shorting lead across the normally-closed switch leads.

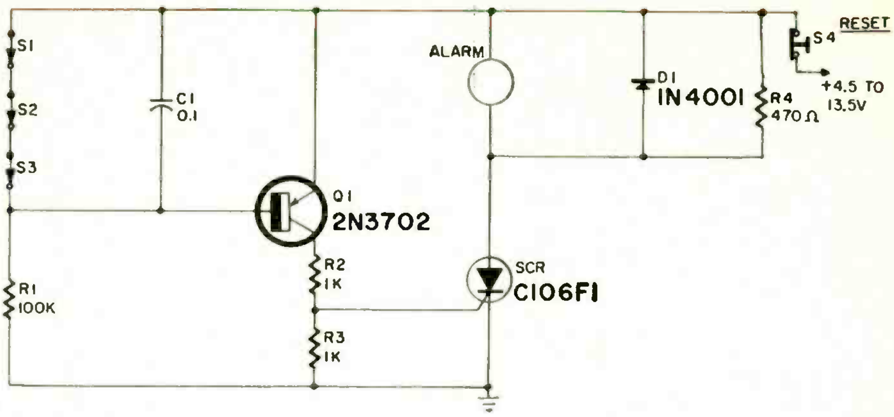
This can be overcome by combining both "break-to-operate" and "make-to-operate" switching in a single alarm system, as in the "tamper-proof" alarm of Fig. 9; you'll see this one next month.

A burglar is unlikely to know which alarm leads are the "break" or "make" types, and if he cuts or shorts the wrong ones the alarm will sound. His problems can be made particularly difficult by running "make" and "break" lines next to one another in a twin-lead shielded cable.

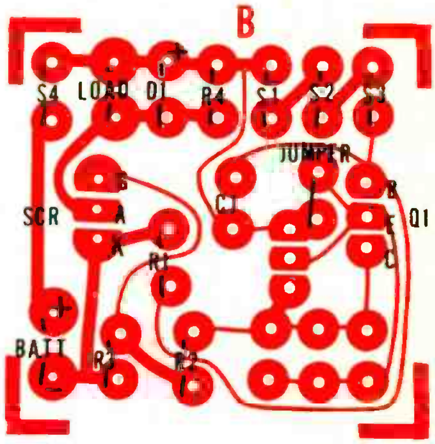
A tamper-proof alarm was developed by combining the circuit of Fig. 5 with that of Fig. 8, to form a high-performance arrangement that draws a standby current of only 1 μA. Equally tamper-proof circuits can be developed by combining Fig. 5 with the circuits of Figs. 6 or 7. **R-E**

The following alarm parts are available from Photolume Inc., 118 E 28 St., N.Y., N.Y.
Kit RE671-PC consisting of 1-panel of 4 alarm circuit boards; 1-panel of 3 component-mounting strips; 100 plug-in connectors . . . $6.25. postpaid.
Kit RE671-T consisting of 1 SCR; 1 diode; 3 transistors (2 npn, 1 pnp) and 1 photocell . . . $3.75 postpaid.

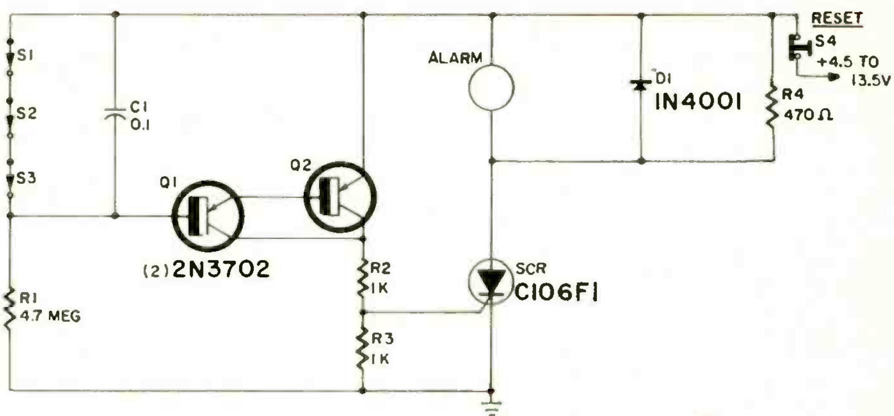
7.



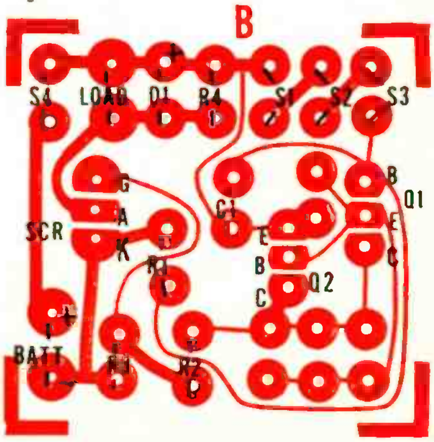
R1—100,000 ohms, ½ watt
R2, R3—1000 ohms, ½ watt
C1—0.1 μF, 25 V
D1—1N4001
Q1—2N3702
SCR—C106F1
S1, S2, S3—spst normally closed
S4—spst normally closed
Alarm
Circuit Board "B"



8.



R1—4.7 megohms, ½ watt
R2, R3—1000 ohms, ½ watt
R4—470 ohms, ½ watt
C1—0.1 μF, 25 V
D1—1N4001
Q1, Q2—2N3702
SCR—C106F1
S1, S2, S3—spst normally open
S4—spst normally open
Circuit Board "B"



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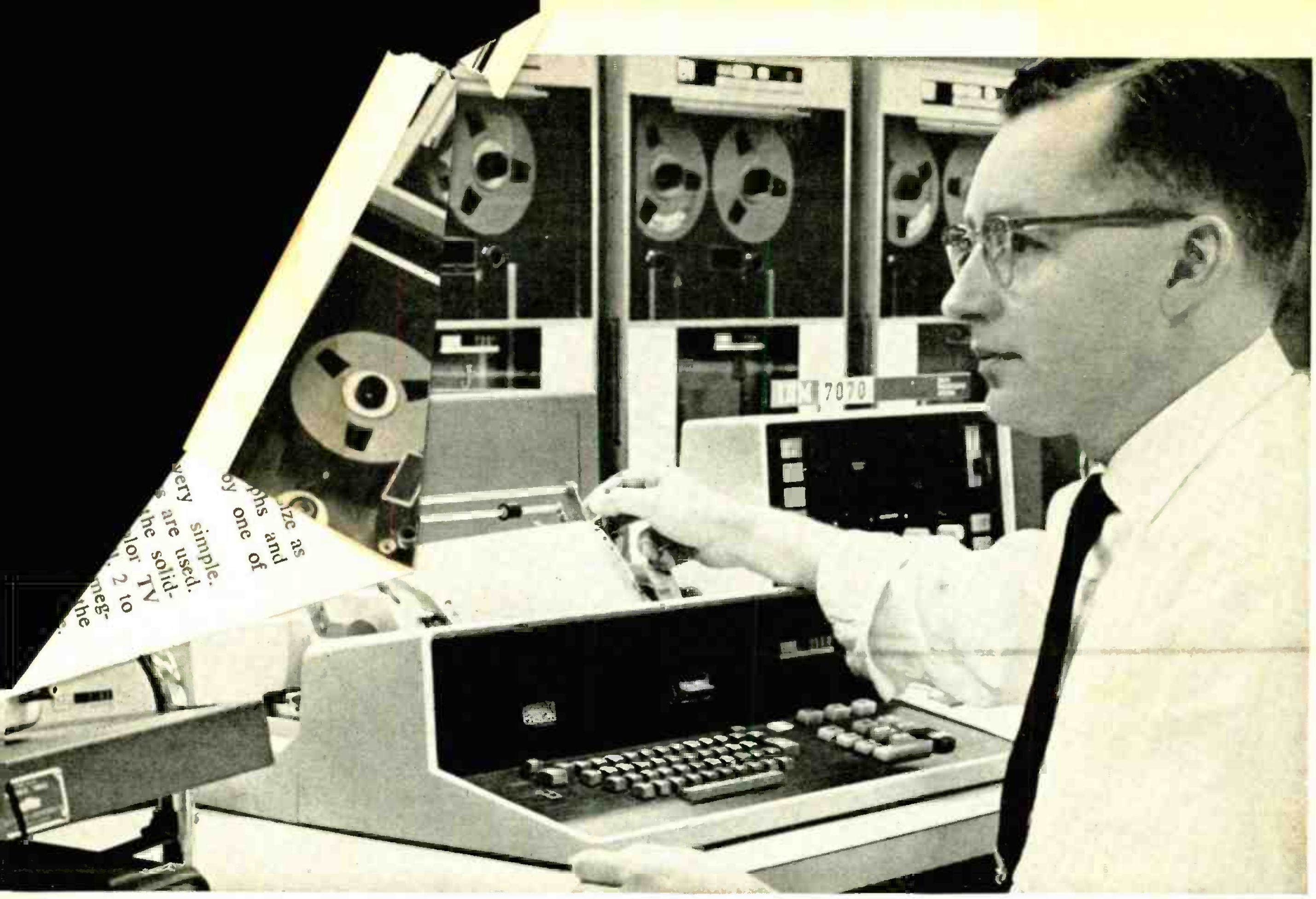

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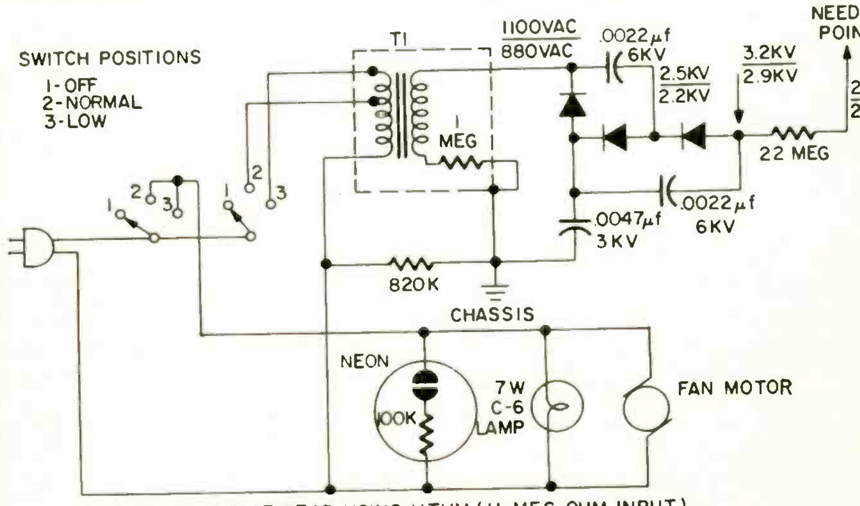
HOME AP ELECTRO

by **JACK DARR**
SERVICE EDITOR

THE AIR IONIZER

A WHILE AGO, WHILE WORKING WITH AIR-conditioning in all its aspects beside cooling, they discovered that the ion content of the air was important. This was especially true in cases of hay-fever, and other respiratory ailments, certain allergies, and so on. Indoor air in particular, was found to have a shortage of negative ions. Normal outdoor air was well-balanced in that respect. Restoring the ion-balance of indoor air gave relief to the sufferers.



NOTE: DC VOLTAGE READ USING VTVM (11 MEG OHM INPUT). INPUT RES. OF METER WILL AFFECT VOLTAGE READING

The Philco Co. developed a device which would feed negative ions into the air of a room. Beside this, the air was forced through a filter and treated with a germicidal agent. This removed dust, pollen, etc., which also helped. The basic principle of this is very familiar to electronics technicians; we see it all the time!

The complete circuit is in Fig. 1 (above). You'll recognize it right away! About 1,000 volts ac is provided by a small power transformer. This is fed to a standard voltage-tripler rectifier, which develops about 3 kV. This voltage, negative in polarity, is connected to a long, thin metal needle, mounted in a plastic insulator. The insulator is positioned in the center of a plastic duct, called the stack, with the air forced up through this by the fan (after being filtered).

As the air passes the sharp point of the needle, negative ions are discharged into it and the air-stream carries them throughout the room. This is very familiar to us. We've often seen corona discharges from highly-charger sharp points in HV circuits! Same thing.

The only moving part in this unit is a small electric motor driving a squirrel-cage blower. It is ab the motors used in could probably be rep these, if necessary.

The electronics are Three solid-state HV rectifie These are the same type as state focus rectifiers used in c sets. The filter capacitors are sma 3 kV rated ceramic disc types. A 22 ohm resistor is connected between tripler output and the discharge need Since this is strictly a voltage device, there is negligible current flowing. The high-value resistor prevents the chance of serious shock if the needle tip is accidentally touched.

Testing

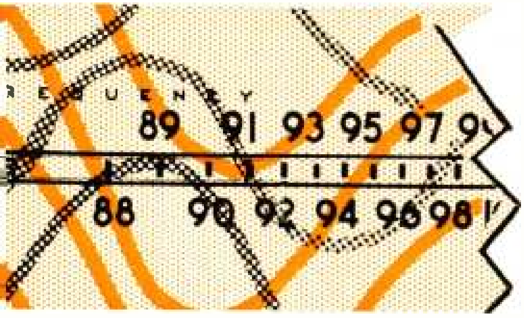
Checking these units can be very easy. Any HV probe, used with a very high impedance TVM or VTVM will read the 3-kV voltage on the needle. Philco also shows a home-made tester for this unit (see Fig. 2 on page 74). The lamp is an NE-2 and the capacitor anything from .05 to a .1µF. The bigger the capacitor, the slower the rate of flashing. A 2-inch metal plate is connected to one side of the lamp-capacitor circuit, and a ground lead, with clip, to the other. Fasten the clip to the chassis, and hold the metal plate over (but not touching) the tip of the needle. If the neon lamp flashes continuously, the thing is working. I don't think the plate has to be round; it would be easier to make if it were square, etc.

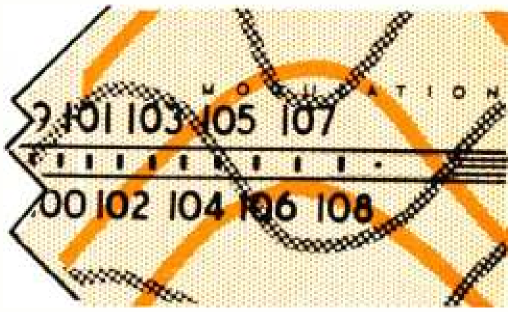
If you find there is no HV, the rectifiers can be checked by substitution. The dc HV can be traced through the

(continued on page 74)

Etched-inductors on a printed-circuit board make this FM preamp the device you need to add more stations to your FM listening pleasure

Break Through Radio Pollution: use etched coils in FM preamp





by ROBERT B. COOPER, JR.*

APPROXIMATELY A DECADE AGO E. Newton Minow, then Chairman of the FCC, described the television broadcast service as a "vast wasteland." Today, ten years later, Mr. Minow's description may be coming true.

Chairman Minow was refering to television's bland programming. We are not. Perhaps you haven't noticed, but the once so vast spectrum between 30 and 300 MHz, our spectrum workhouse that houses nearly all television, FM and two-way radio services, has become polluted. We are discovering that the old physics adage "for every action there will be a reaction" has a place in spectrum management. We have discovered, hopefully not so late as to be uncorrectable, that there are just so many transmitters which can be placed into operation within a limited geographic area and within a limited spectrum range, before chaos results.

The Federal Communications Commission recently funded a $400,000 spectrum study program, to try to determine just how severe our "ether pollution" has become, and what steps, if any, can be taken to remedy the problem. The same FCC has reported a ten-fold increase in "receiver interference reports" in just two years primarily due to intra-service complaints (one taxi cab company interfering with the radio service of another taxi cab company; one FM radio station interfering with the reception of another FM radio station, and so on). Apparently, in many, if not all metropolitan areas in the United States, "saturation" of the ether has already occurred and now the chickens are coming home to roost!

During the past decade vhf receiving and transmitting equipment has become increasingly solid state, increasingly reliable, and increasingly smaller. But the basic parameters of receiver design have changed very little since the late 1940's.

The basic receiver still consists of antenna input circuit, tuned (or broadband) rf amplifier stage, a mixer stage driven by the rf stage output and local oscillator output (to produce an intermediate frequency), one or more stages of i.f. amplifier for both circuit gain and selectivity, the demodulator stage to convert the rf/i.f. energy to either sound or sound and picture, and the display system. All receivers are designed along these lines, with few exceptions.

Most receiver designers once believed that the sole purpose of the rf amplifier stage was to build the antenna output signal level(s) up to sufficient voltage to drive the mixer stage and produce suitable signal-plus-noise to noise ratios to cause the end-of-line display system to function. That was before the airwaves became so jammed so as to produce so many signals at the receiver rf stage that the rf stage itself became overloaded. Because a typical rf stage consists of one or two solid-state (transistor) devices, it has a rated maximum total output level which is the sum of all signals passed through the rf stage(s). In a typical FM receiver, tuned to 100.1 MHz, the rf stage is amplifying the 100.1-MHz signal, as well as signals 5, 10 or even 20 megahertz away from 101.1. All of these signals, when added together, equal the total amplified voltage passed by the stage. And if these voltages add up to a greater output than the rf stage transistor is capable of handling, receiver front-end overload occurs: the rf stage becomes saturated.

Looking further into the operation of a typical FM receiver: if our receiver is tuned to 100.1 MHz, the local oscillator is typically functioning at 110.8 MHz to produce a difference frequency (110.8 minus 100.1) of 10.7 MHz, our receiver i.f. Now all this receiver needs, for signals to appear at the output, is for a signal to get through the mixer at 10.7 MHz. So while the receiver is tuned to 100.1 and the local oscillator is on 110.8 (thereby producing 10.7 MHz i.f.), a 121.5 MHz signal (from the much used aircraft band) bulldozing its way through the receiver's rf stage and to the mixer will also mix with the 110.8 MHz local oscillator, and also produce an i.f. signal on 10.7 MHz. This is, incidentically, a very frequent problem in regions near airports.

In a nutshell, i.f. stages are well known for their selectivity and gain. Most i.f. stages operate at a relatively low frequency where high circuit Q's and good gain can be developed relatively inexpensively and reliably.

By the same token, rf stages are not noted for their selectivity, and are typically rated for their gain and noise figure (ie. ability to deliver good reception from weak signals). And

*Mr. Cooper is President of CADCO, Oklahoma City, Oklahoma, a research and development firm specializing in receiver front-end design problems and CATV receiving equipment.

most, if not all, of the ether pollution we are faced with today could be solved if stable high Q (selective) rf stages are developed.

This article deals with early inroads made into this problem, and includes a home construction project for the enthusiast who wants either a top notch FM band (88–108 MHz) preamp/*filter* to improve his FM receiving system, or merely wants to be working on the workbench on a state of the art concept.

Early research at CADCO has dealt with problems found in CATV systems across the country. Many CATV systems bring in distant (75–200 miles) television signals. And more often than not, the distant signal is on a channel adjacent to a strong nearby or local station (such as having a local channel 3 and wanting to carry on the CATV system distant channels 2 and 4). Obviously in a situation like this, channels 2 and 4 have to be amplified. But the amplification equipment must be sufficiently selective to amplify say just channel 2, and not channel 3, or the already wide ratio in signal levels (channel 3 being strong and channel 2 being weak) will only get worse. Unfortunately, so-called "single channel" preamplifiers are usually quite broad–several channels wide–but peaked on a single channel. A 20-dB gain channel-2 unit, for example, typically also has 10–15 dB gain on channel 3.

The answer in CATV (and other off-the-air television receiving systems) has proven to be the Interdigital Pre-Amplifier[1]; a device that combines the best features of a rock stable highly selective bandpass filter, and a high-gain, low-noise, overload-resistant JFET preamp in a single integrated package. As the spectrum-analyzer display screen shows in Fig. 1, the desired channel passing through this unit is amplified, while the two adjacent channel signals are severely attenuated. In effect, an equalizing of distant TV signal level and local TV signal levels (on adjacent channels) occurs through the unit as the distant signal gets a 20-dB shot of amplification while the local channels on either side are attenuated by 25 to 50 dB.

In both the initial passive filter section, and the succeeding stages of amplified filter, all inductances are etched onto the circuit board. There is more here to design than perhaps meets the eye. True, etched inductances have not been utilized extensively outside of the microwave region (MIC—microwave integrated circuits), and aside from a few trial balloons, have found virtually no application at vhf. And equally true that with an etched inductor you have one, 100 or one million exact copies of the original board-master. And also true that with etched inductances you also have stability factors which are difficult to attain with conventional air-wound, form-wound or core-wound inductances.

But the real reason the etched inductances are found here is that in the marriage process, of combining a passive bandpass filter with an amplified filter device, *without* etched inductances you create a nightmare of adjustments and sub-adjustments, tweeking and re-tweeking so that eventually the poor alignment technician gives up in disgust. In short, for this type of marriage to survive, the inductances must assume a horizontal position and that spells etched inductances!

With etched inductors, this circuit, as precise as it is, is as stable as a 1-kHz audio amplifier and twice as easy to align.

If etched inductors are so good, why don't we find more application of them? The truth is that until recently, it was assumed that etched inductances were always going to be too large, physically, to make them attractive. Remember that in a consumer product, such as a TV or FM receiver, micro-miniaturization has become the rule. It wouldn't do to compress a complete FM receiver down to a 3 by 6 inch PC board, and then require another board of equal size for the inductances!

More recently, we have found that etched inductors *can be* compressed. Just how small they can and will go no one is certain yet, but many are betting on something approximating about twice the size of a TO-18 can in 18 months or two years which will self-resonate at 100 MHz and include both a bandpass filter and one or two stages of JFET amplification; just apply operating voltage and plug it in.

In the meantime, applications where size is not as important as performance are enjoying an etched-inductance boom. Nothing major mind you, but a substantial turn around from a year ago when etched inductance conversations immediately identified you as a microwave man.

In addition to CATV applications, etched inductances are finding their way into amateur radio vhf equipment[2]. This summer, SGI TV Products, Oklahoma City, Okla.* will offer the first etched-inductance device for home consumption; the All American Sports Amplifier. It is a wired and tested unit designed to bring black-out professional sports events into your living room. Thus, when a sports event is blacked out on local channels; this device makes possible 75–125-mile TV reception in major metropolitan areas, on channels immediately adjacent to locally strong signals. These units will be distributed nationally in each of the 23 professional football markets at approximately $80.00 each, starting late in July.

*SGI TV Products, P.O. Box 94970, Oklahoma City, Okla. 73109.

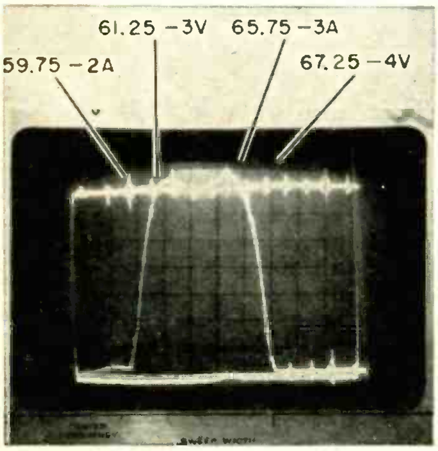


FIG. 1—RESPONSE of channel-3 preamp. Note sharp roll-off of channel-2 sound and channel-4 video carriers.

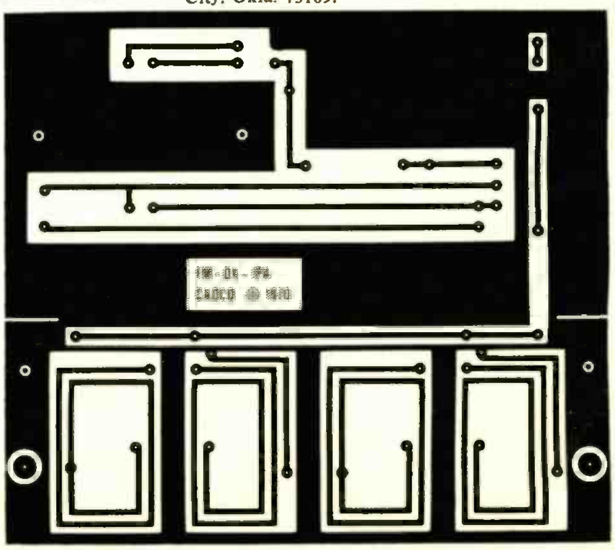


FIG. 2—PRINTED-CIRCUIT pattern for the etched-inductor FM preamp. This pattern is presented exactly one half actual size.

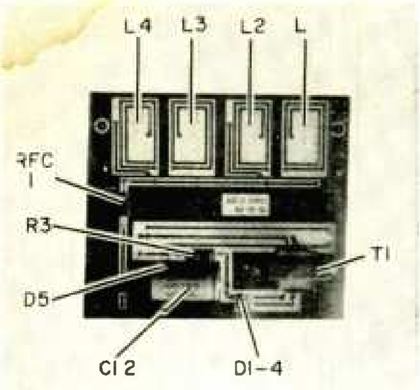


FIG. 5—POWER SUPPLY parts in position on the main circuit board.

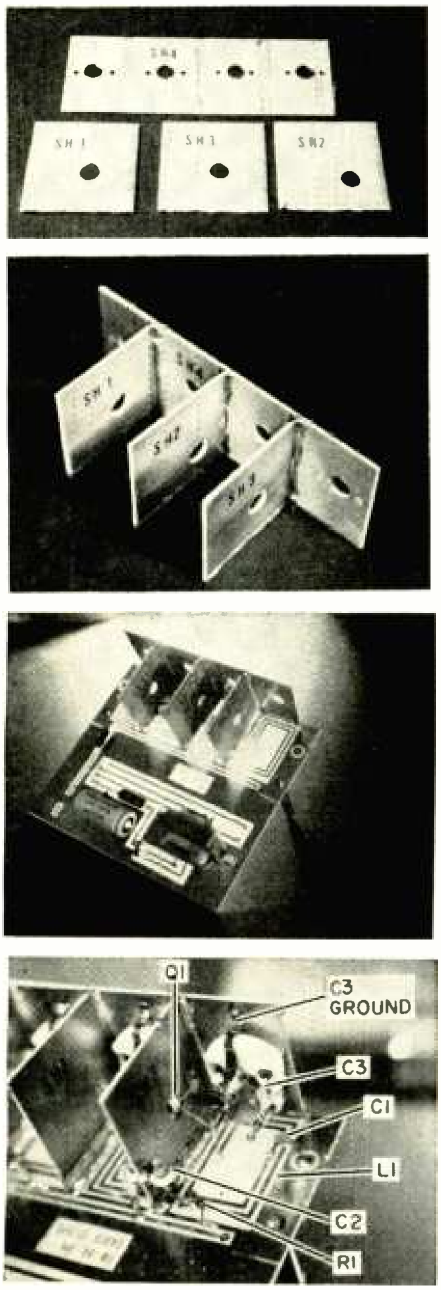


FIG. 6—ASSEMBLING the FM circuitry. (Top to bottom). (a)—SHIELDS are cut, drilled and then tinned along mating edges, (b) SOLDERED TOGETHER and then (c) MOUNTED on the etched board. (d) LAYOUT OF PARTS in the antenna input circuit. A lead from J1 goes to the pad for the right-hand lead of C1.

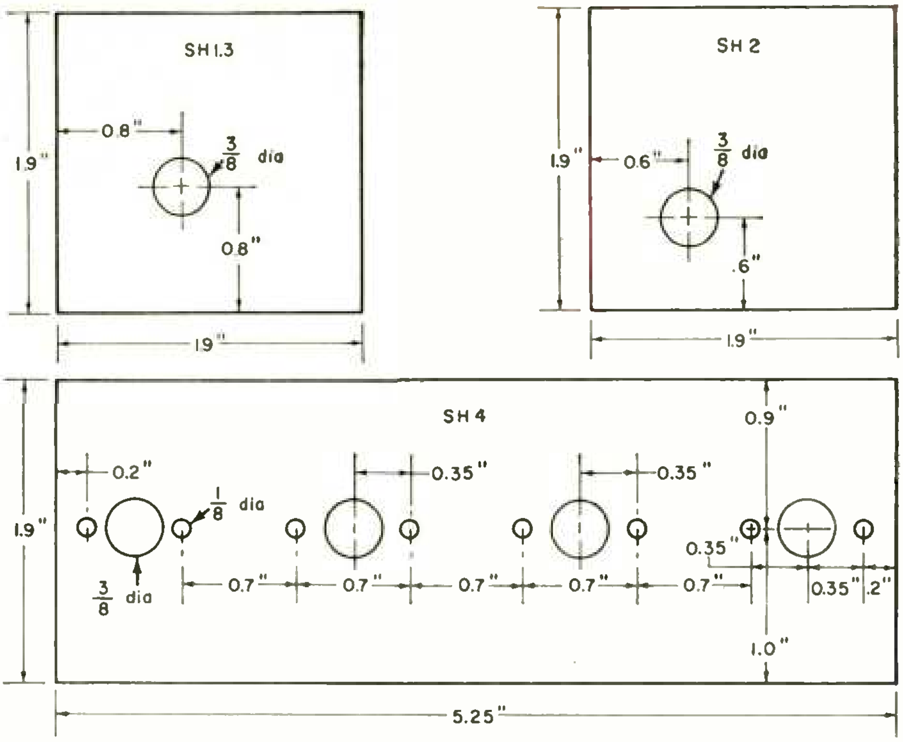
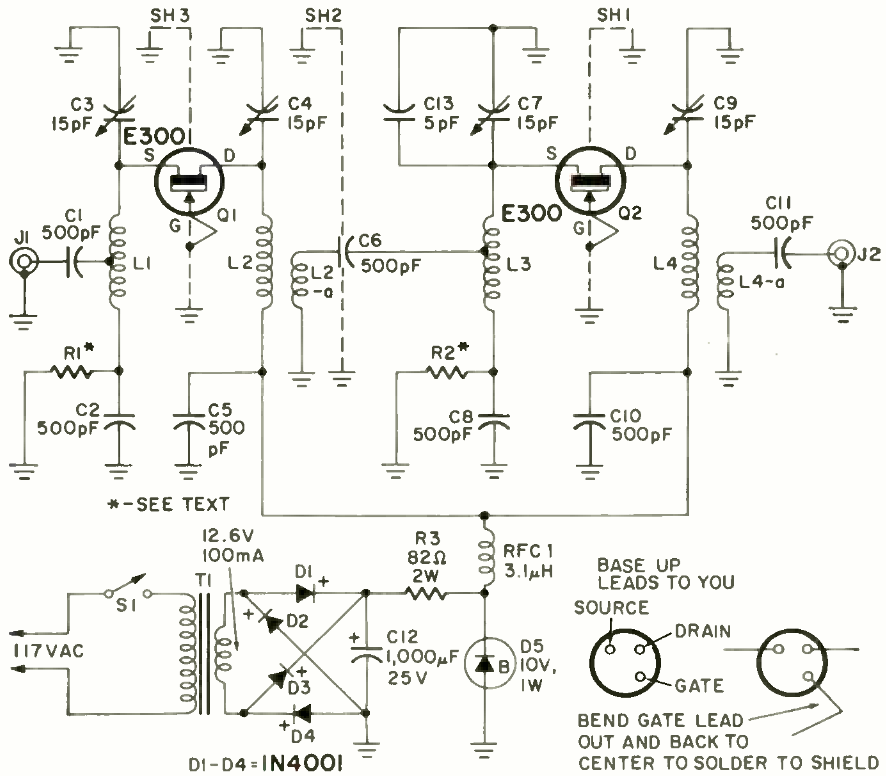


FIG. 3—COMPLETE SCHEMATIC of the preamp is shown below. Two FETS make the circuit work. Above is a detailed drawing of the shields.



Capacitors
C1, C6, C11—500 pF disc ceramic
C2, 5, 8, 10—500 pF stud mounting uhf by-pass (Sprague BH-105 series, Centralab type MFT or equal)
C3, 4, 7, 9—15 pF (maximum) variable (Philmore model 1952)
C12—1,000 mF 25 volt dc electrolytic
C13—5.0 pF disc ceramic

Resistors
R1, R2—1/4 watt between 91 and 560 ohms typically—see text
R3—82 ohm, 2 watt

Semiconductors
Q1, Q2—Siliconix E300

Miscellaneous
RFC1—3.1 μH rf choke (Ohmite Z144 adequate substitution)
D1, 2, 3, 4—50 V, 1A, power supply diodes (1N4001)
J1, J2—"f" series female chassis mounting coaxial connector (Amphenol 461-6005 or equal)
D5—10-volt, 1-watt zener
S1—Spst toggle switch
T1—12.6 volt 100mA secondary, 117 Vac primary power transformer (Westcom TF-121, or Stancor P8390)
117 Vac line cord, 440 hardware

Circuit Board
Inductances L1, 2, 3, 4 are etched onto the master circuit board as shown in Fig. 5. The complete circuit board alone is available from PAIA ELECTRONICS, P.O. Box 14359, Oklahoma City, Oklahoma 73114; price $8.00. Specify item 2712PC. The same source will supply a complete kit of all parts including the circuit board, but less the case and knobs, for $27.50 plus postage for 3 pounds. Specify item 2712K.

Before the etched-inductor technique brings the inductor down so small that it is no longer fair game for the home constructor, FM fans may find the Interdigital Pre-Amplifier for FM (88–108 MHz) an interesting project.

Such a unit is shown at the beginning of this article. A layout of the complete circuit board, including four etched inductors is in Fig. 2, and Fig. 3 is the schematic plus shield layout.

This is a two-stage pre-amp with active filter elements. In other words, a pre-amplifier with sufficiently high Q that the 3 dB gain-bandwidth product occupies slightly over a megahertz, resulting in much improved selectivity for virtually any FM tuner or receiver in use today.

The preamplifier is designed around the Siliconix E300; a plastic-cased JFET of the 2N5397 family and with most unusual noise-figure and signal handling capabilities at 100 MHz. Operating in the grounded gate (non-neutralized) configuration, the E300 is factory rated at 1.3 dB noise figure, with a signal handling dynamic range of 100 dB.

The E-300 was designed especially for grounded-gate operation. And this makes circuit design using the device simply a matter of putting tuned input and tuned output circuits around the transistor, applying proper voltage, and tuning for max! The *only* adjustment per stage is to match the source-to-ground resistor so that the E-300 draws between 4.8 and 5.2 mA (at 10 volts dc).

Looking first at the operational characteristics of the preamplifier, Fig. 4-a shows a spectrum sweep display centered at 100 MHz. The markers on the horizontal line are 1 MHz apart. The center is 100 MHz, and this represents 18 dB gain at frequency. Note that the 3-dB-down points fall at 99.0 and 101.0 MHz. In Fig. 4-b the display has been increased so that now we are looking at the 10-dB down points; 97.8 and 102.6 MHz. Figure 4-c shows the 18-dB down points (the preamplifier has 18 dB gain, so signals within the 18-dB-down points fall at some point between 0 dB and 18 dB gain); 96.2 and 104.7 MHz. You might go back and compare this with the flat-topped curve in Fig. 1, the single-channel TV unit for some idea of the flexibility of the etched inductor passive and active filter combinations.

Construction

Construction of the etched-inductor FM preamplifier is truly straightforward. The usual tricky adjustments for neutralizing, noise figure vs maximum gain and tweeking of the coils are eliminated. The E-300 grounded-gate operation eliminates neutralizing and noise figure/gain adjustments while the etched inductors eliminate tweeking of inductors.

In the schematic (Fig. 3) antenna energy from a 75-ohm antenna downlead or 300-to-75 ohm matching transformer is coupled into Q1 source through C1, a 500-pF disc ceramic capacitor. L1 and C3 comprises the tuned input circuit. L1 is of course an etched inductor (see Fig. 2). C3 is a Philmore type 1952 15-pF variable capacitor. The same network is repeated in the combinations L2, C4; L3, C7 and L4, C9.

The cold end of each inductor is bypassed to ground with a stud mounted uhf bypass capacitor, such as the Sprague BH-105 series or Centralab type MFT. (Note: Do not attempt to use disc ceramics for bypassing in this device.) L1 and L3 are also coupled to ground with ¼-watt resistors (R1, R2), each chosen so that their resistance draws between 4.8 and 5.2 mA current for the respective E300's. (Note: The circuit board is laid out so that the 10 volt dc positive supply voltage from the power supply may be broken at RFC1, and a 0–25-mA meter placed in series with the dc line at this point to monitor E300 current while R1 and R2 are properly balanced.) Typical values for R1 and R2 fall between 91 and 560 ohms.

Coils L2 and L4, in addition to bypassing to ground through the stud mounted 500-pF capacitors are also coupled to the positive voltage line shown in Fig. 3 and in the construction photos. L2 and L4 are "jumped" to the positive supply line with ⅜-inch lengths of number 22 or 24 wire, bent into an inverted "U" to span the ground line between.

Interstage shields (SH1–SH3) shown in the construction photos are constructed from double-sided G-10 copper-clad epoxy-glass board (see Fig. 3). SH1 and SH3 separate the respective input and output sections of Q1 and Q2, and also serve as a convenient ground attachment point for the E300 gate leads. Note that the E300's mount inside of ⅜-inch holes drilled in SH1 and SH3.

Interstage shield SH2 separates the first stage output from the second stage input and it has a ⅜-inch hole drilled to pass C6, the interstage 500-pF coupling capacitor (see Fig. 3).

Mounting shield SH4 serves merely as an anchor on which C3, 4, 7 and 9 are suspended and grounded.

The power supply is so straightforward that there is no need to elaborate on its components or their functions. A well regulated and heavily filtered 10 volts dc is supplied and total two-stage current drain is 10 mA.

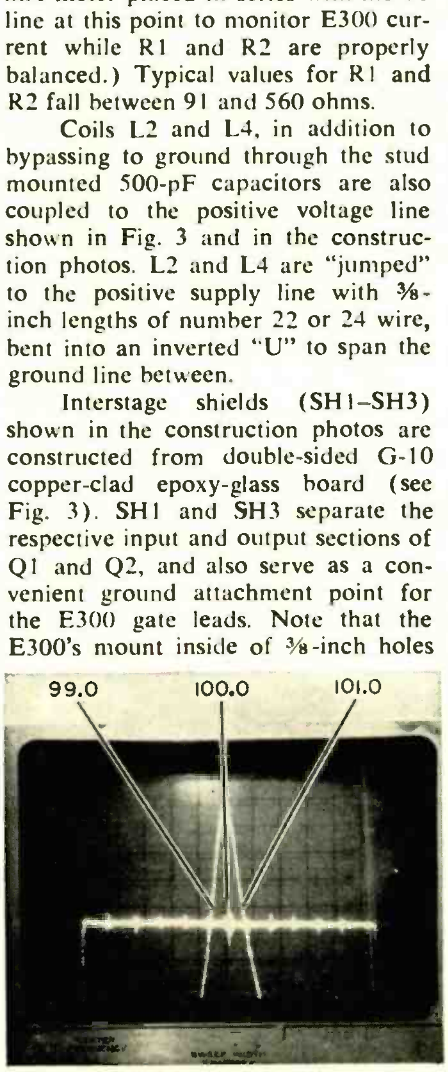
The board master may be duplicated directly from Fig. 2, or the board may be purchased singly or as part of a complete parts kit (see parts list).

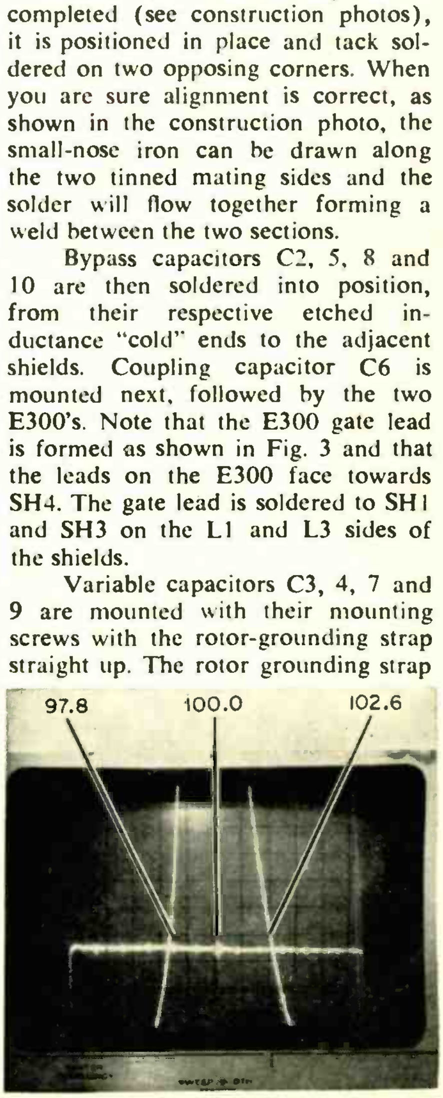
The shield sections should be cut and drilled as in Fig. 3 and construction photos. Soldering G-10 board together, as shields, is no trick if you tin mating sides first and use a 35–50-watt iron (Note: Do not use anything over a 50-watt iron on these boards as the etched inductors may lift from the board proper with too much or prolonged heating.)

When the shield composite is completed (see construction photos), it is positioned in place and tack soldered on two opposing corners. When you are sure alignment is correct, as shown in the construction photo, the small-nose iron can be drawn along the two tinned mating sides and the solder will flow together forming a weld between the two sections.

Bypass capacitors C2, 5, 8 and 10 are then soldered into position, from their respective etched inductance "cold" ends to the adjacent shields. Coupling capacitor C6 is mounted next, followed by the two E300's. Note that the E300 gate lead is formed as shown in Fig. 3 and that the leads on the E300 face towards SH4. The gate lead is soldered to SH1 and SH3 on the L1 and L3 sides of the shields.

Variable capacitors C3, 4, 7 and 9 are mounted with their mounting screws with the rotor-grounding strap straight up. The rotor grounding strap





is bent back to SH4 as shown in the construction photos and soldered into position, since the capacitor itself is not automatically grounded when mounted.

The source and drain leads of the E300's, if mounted according to instructions and as shown in the construction photos, will connect to the variable-capacitor studs nearest the shields. Before they are attached to the capacitor studs, run a length of number 22 or 24 solid wire from the *inside* connection point of the etched inductor straight up to the stud of the variable capacitor where the E300 lead will attach. Also, run a 5.0-pF disc ceramic (C13) from that same stud on C7 straight to the shield next to it; effectively placing 5 pF in parallel with the 15-pF variable on C7 *only*.

When attaching the E300 leads to the studs, exercise the usual care that you would with any transistor device by placing a heat sink between the JFET proper and the soldering iron tip on the lead. The JFET is quite difficult to damage (unlike the MOSFET) but sustained heat is not advised for any transistor.

Coupling capacitors C1 and C11 may now be attached, and the E300's resistance-matched (R1,R2) as previously outlined.

It is difficult to see, but in our black plastic housing we use "F" series chassis-mounting connectors. A short length of number 22 or 24 wire is run from the center pins on the connectors to the pads where C1 and C11 terminate. And, a piece of braid, removed from a piece of RG-59/U coaxial cable has been tinned, and it provides ground connection between the connector shell and the circuit board proper, just adjacent to the C1 and C11 pads. Unless the body of the connector is grounded in this way to the circuit board proper, you will have no end of problems in making the unit operate properly.

If 300-ohm antenna lead-in and connection to your FM receiver is utilized, use a pair of 75- to 300-ohm matching transformers before and after the preamplifier so it "sees" 75 ohms at both the input and output circuits.

The preamplifier is tuneable over the complete FM band, and for a little ways on either side. With the capacitors fully meshed, the unit tunes down to about 85 MHz, and with the capacitors fully open the unit tunes up to approximately 115 MHz. Alignment is not required.

There is only one no-no associated with the unit. The etched inductances are flush to the bottom of the (plastic) case so the preamp should not be placed directly on top of a metal cabinet. Nor in a metal chassis. If metal surfaces are going to be used, be certain the etched inductor surfaces are 1 inch above these surfaces (i.e. use standoff spacers when mounting in a metal case) so as to not detune the etched circuits.

The front of the unit is easily calibrated with rub-on numbers and while electrical tuning is quite sharp, mechanical bandspread is bunched fairly closely together as the photo shows. In tuning, adjust C4 and C9 (marked 2 and 4 in the front unit photo) first for maximum signal, then C3 and C7 (marked 1 and 3).

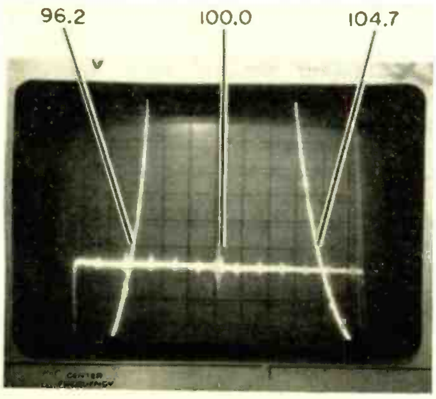


FIG. 4—OPERATING PREAMP SPECS (left to right) a—spectrum sweep display centered at 100 MHz. 3-dB down points are shown. b—sweep display showing 10-dB down points. c—18-dB down points.

Construction hints

If the complete etched-inductor/circuit board is utilized as shown and described here, the power supply components should be mounted first, and the power supply checked out as shown in Fig. 5. At the top of the board, etched inductors L1,2,3 and 4 appear from right to left. Note use of etched link coupling for inductors L2 and L4 output coupling.

Shields SH1, 2, 3 and shield mount SH4 are shown drilled and tinned prior to assembly (see Figs. 3 and 6-a).

The shield sections are pre-assembled into a complete unit (Fig. 6-b) for soldering onto the etched inductor/circuit board proper. Soldered into place, (Fig. 6-c) the shield subassembly provides a mounting plate for capacitors C3,4,7 and 9 mounting plates for transistors Q1 and Q2; and ground connection points for bypass capacitors C2, 5, 8 and 10.

Figure 6-d shows how E300 Q2 is soldered to the L1-side of SH3. The source lead of Q1 and the short length of number 22–24 wire coming up from the inside tie point of L1 connect to the inner-most lug on C3. Also note that bypass capacitor C2 is mounted between the shield of SH3 (which is at ground potential) and the outside (cold) end of L1. R1 is in place from the base of C2 to the ground strip between L1 and the positive dc supply line. Note that variable capacitor C3 has it's ground lug bent back and soldered to SH4.

The completed circuit board may be mounted in a plastic equipment box, as shown. SH4 provides a "template" for front panel holes for capacitors C3, 4, 7 and 9 while coaxial connectors J1 and J2 mount directly opposite the pads that C1 and C11 attach to, and one inch above the board proper.

Conclusion

Etched inductances, in one or several forms, are about to become a way of life for every user/servicer of vhf and possibly uhf equipment. The FM preamplifier described here, with a 1.3 dB noise figure, 18 dB gain and good selectivity, will give everyone associated with the vhf-uhf industry an opportunity to find out what makes them tick, while providing a real state-of-the-art FM receiving system as a bonus! **R-E**

Footnotes

[1] *Interdigital Pre-Amplifier*—copyright 1970 by CADCO. Interdigital Pre-Amplifiers are the subject of patent applications pending by the author. Utilization of circuits described here for personal (non-commercial) applications is permitted by the author: commercial applications are reserved and are subject of numerous licensing arrangements arranged by CADCO. Readers wishing a more detailed discussion of the Interdigital Pre-Amplifier technique are referenced to HAM RADIO Magazine, August, 1970 for a complete treatment by the author.

[2] Amateur radio applications of Interdigital Pre-Amplifiers, with etched inductances, is described by the author in the February 1971 issue of HAM RADIO Magazine; page 6.

An Irish technician named Finnigan,
got a set that cut out and then innigan;
this went on for a week,
so he went to the creek,
tossed it in and said "You'll not come
innigan!" *Jack Darr*

all about DOLBY

For lower noise on tape playback and FM stereo broadcasts, Dolby may be the answer

by STEVE LECKERTS

Ray M. Dolby, holding one version of his stereo noise reduction system. In addition to uses in tape recorders, applications in FM stereo broadcasting are being developed.

EVERY WAY WE HAVE TO STORE OR send messages, also stores or sends noise along with the message. There is no known way to eliminate noise completely from any message. However, the degree to which noise actually interferes with the messages is not the same for all media. For example, we can readily ignore the "noise" of small marks and defects in a newspaper while we read an article. On the other hand, even loud breathing by a neighbor at a concert is enough to destroy the mood or sensation that the composer and performers are trying to create.

Since all noise is caused by real physical disturbances, noise cannot ever be completely removed. However, the amount of noise heard by a listener depends upon certain conditions, some of which can be controlled to reduce noise.

In magnetic tape recording, for instance, the predominant noise heard is that produced by the tape itself. This tape noise (hiss), in turn, results from the nature of magnetic recording—magnetizing particles of a powder with which one side of the tape is coated. When the sound being recorded is a loud one, more particles are magnetized. When the sound is soft, fewer particles are magnetized. Because the number of particles varies slightly from one place on the tape to the next, the intensity of the recording cannot be made perfectly uniform. When the tape is played back, there is a slight fluctuation of loudness heard by listeners as a steady hiss superimposed on the recorded program. During quiet passages or intervals in the music this hiss can be quite noticeable and rather disturbing.

One way to reduce this tape noise is to record at the highest possible program level—to increase the power of the electrical signal before recording so we can magnetize more particles for a sound of given loudness. Then, when the tape is played back, the sound from the speakers will be louder. When the listener reduces the volume to restore the original level, he also reduces the noise of the tape, since the noise remains the same no matter how the recorded level is varied.

Obviously this technique has limits. At some level, when the program becomes quite loud, all the magnetic particles on the tape are magnetized. Now it is impossible to record a sound which is even slightly louder, for it still gives the same result—all of the particles are magnetized. In the best recording tape used in professional recording of classical orchestral music, this maximum level is often reached at a point at which the quietest sounds of solo instruments are barely audible above the noise. For this reason, the dynamics of recorded music must be sacrificed if the listener is to hear the music without exceeding normal tolerances of distortion and noise.

Much of the disturbing noise of a tape recording is in the higher frequencies. This has led to recording high frequencies at an increased level, and then attenuating them during playback. We call this equalization. The technique works because high-frequency portions of the program are normally at lower levels than other parts of the original program, so there is not as much danger of saturating the tape. However, this is only a statistical truth. It is usually, but not always applicable. Because of equalization, loud cymbal crashes or other passages that have loud high-frequency sounds may be distorted even on the best recordings, unless these instruments are positioned at a distance from the microphones during the performance.

The Dolby noise reduction system

The Dolby noise reduction system takes advantage of psychoacoustic phenomena in a way that enables a substantial reduction of noise without any other audible effect on the program. Intrinsic to the system is a reliable method of electronic control. Large numbers of noise reduction units can be built that are fully and exactly compatible with each other. Any recording or broadcast made with one Dolby-type unit can be played or received through any other Dolby-type unit.

There are two versions of the Dolby System. One, the "A" system, is designed for professional use, and suppresses noise, hum and other disturbances over the entire frequency range. The simpler "B" system has been specifically developed to reduce noise in broadcasts and recordings for home listening. The entire "B" system circuitry, completely assembled on a circuit board, can be made by a manufacturer for less than \$10. Built in as a part of a receiver, a Dolby "B" system might raise the list price by approximately \$50.

A lot of research has been aimed at investigating the psychoacoustic effect, known as masking, by which a louder sound conceals from the listener the presence of a different, softer sound. This effect plays an important part in the operation of the Dolby noise reduction system. Noise is only disturbing to the listener when the program level is low enough to permit the noise to come through and be heard. A trombone playing at high volume, for example, masks the sound of a tambourine being played softly at the same time, or the sound of noise caused by recording tape.

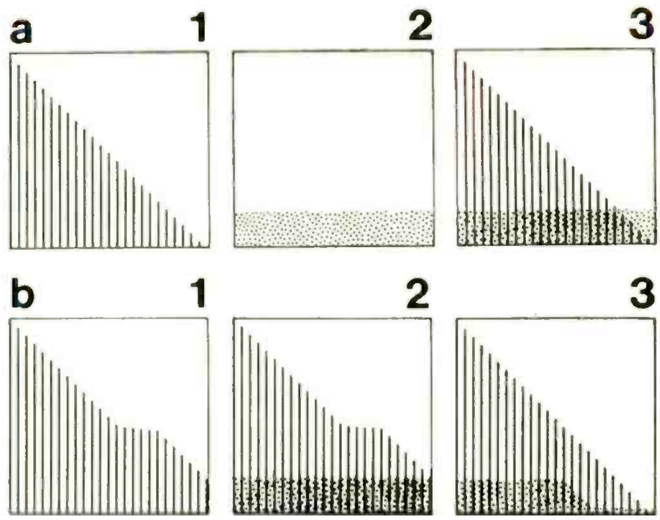
An important peculiarity of the masking effect is that it does not occur when the two sounds concerned are very different in pitch. Therefore, a trombone may mask the sound of a tombourine, but even a very loud note of a bass drum will not, because tambourine and bass drum are so different in pitch. The same effect occurs with the masking of noise during the playback of tape recordings or FM broadcasts, since much of the noise which is heard by the listener is high-pitched noise in the form of a steady hiss. The noise is, therefore, more easily masked by high-pitched sounds than bass notes.

As discussed earlier, increasing recording level and reducing playback level can be used to reduce noise. However, the effectiveness of this approach is limited, since at some point the recorded level simply can no longer be increased. In disc recording, too, a maximum level is reached, when the grooves run into each other. In FM broadcasting, the limit is the point at which overmodulation (i.e., excessive deviation) occurs.

The Dolby System integrates the ideas of masking and automatic level control. The system automatically increases the recording or broadcast level of *quiet musical passages which could not mask noise,* and then reduces the level of the same passages during reception or playback. In the process, the original sound is exactly restored, but noise which would otherwise be audible is greatly reduced. The encoding, during broadcast or recording, and the decoding, during playback, are done by circuits which are nearly identical and can, in fact, perform either function if appropriately wired or switched. Because the system can analyze the program so quickly as to make its operation inaudible, noise is suppressed without changing any other program characteristic which can be heard.

Since the encoding process has no effect at all upon loud parts of the program, it cannot cause excessive levels to be reached during recording or broadcast. Its effect upon the program sound is so subtle that listeners who do not have decoding devices often cannot even tell that the program they are hearing has been processed in some way. They may even believe that it has been improved over the original, especially if they listen with inexpensive equipment. When the encoded signal is heard through wide-range equipment without Dolby

HOW THE DOLBY SYSTEM WORKS



(a) These three pictures show how an ordinary recording or broadcast is made.

(1) Music is made of sounds of different loudness, shown here as vertical lines of different length. Before recording, the noise is usually so low that even the weakest sounds can be heard clearly.

(2) Any recording or broadcast medium introduces noise. Good high-fidelity tape recorders or FM tuners make much less noise than the tapes or broadcasts heard through them.

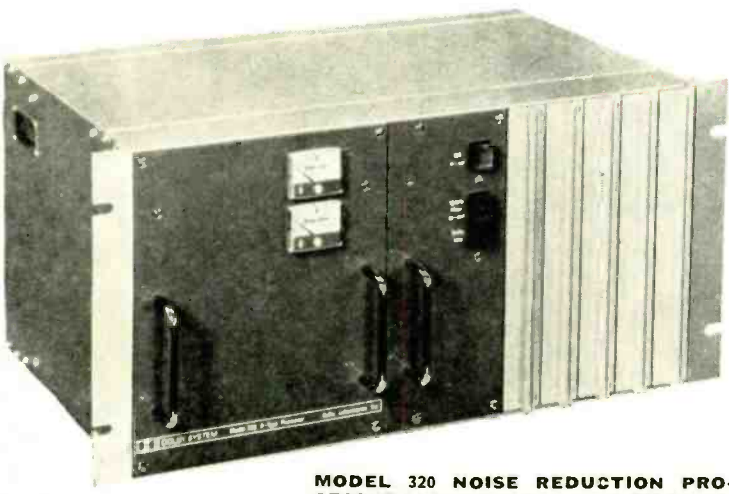
(3) When the music is finally heard, it is mixed with noise which hides or interferes with the quietest passages and fills the silence between the notes, when there should be no sound at all.

(b) These three pictures show how a Dolby system recording or broadcast is made.

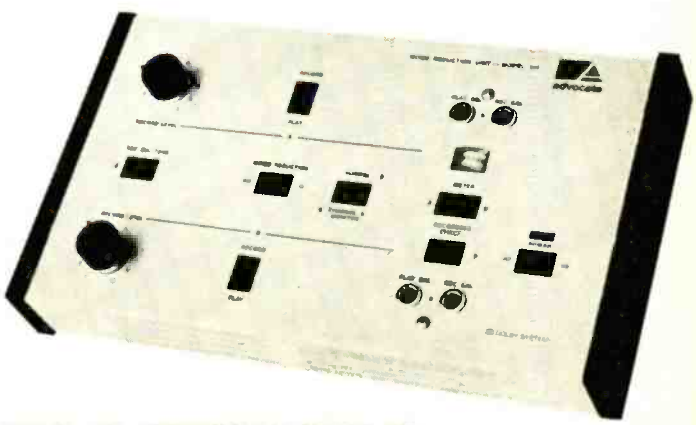
(1) Before recording, the music passes through a special Dolby circuit which analyzes the music and automatically increases volume during quiet musical passages.

(2) After recording, these passages stand out above the noise and are no longer hidden.

(3) Played on a high-fidelity recorder with built-in or added Dolby circuit, the volume during quiet musical passages is automatically reduced. This restores the original sound levels and at the same time reduces the noise added by the process of recording or broadcast. Noise remains during loud passages which are not affected by the Dolby System, but cannot be heard because the music hides it.

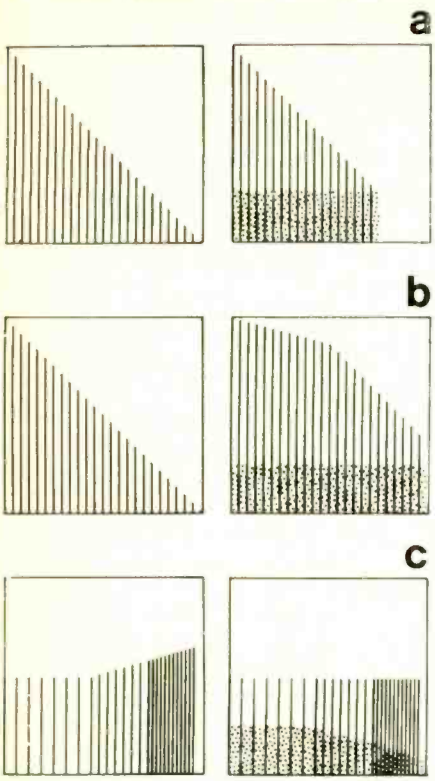


MODEL 320 NOISE REDUCTION PROCESSOR is intended for use at FM broadcast stations.



MODEL 101 SWITCHABLE NOISE REDUCTION UNIT is used for both recording and playback of tape.

OTHER WAYS TO REDUCE NOISE



(a) Level Detector. Circuits can be made which turn off the sound completely unless it is louder than an adjustable pre-set level. If the level is set to match the noise level, there will be complete silence whenever the program drops below this point. In a variation of this technique, only high-frequency sounds are affected.
(b) Limiter. To make an orchestral recording in which the quietest passages are louder than the tape noise the volume would have to be turned up quite high during recording. If this were done, the loudest sounds would cause severe distortion. The limiter automatically reduces the difference between loud sounds so that they can be recorded without excessive distortion. When played back, a recording made this way has soft passages which are well above the noise level.
(c) Equalization. The most common noise reduction method is one used on all disc and tape recordings and FM broadcasts. This technique is equalization, and it is based on the fact that most of the annoying noise heard by the listener consists of high frequencies. During recording, high frequencies are increased in volume by a simple filter circuit. Then, during playback, a filter which is designed to exactly complement the first *reduces* high frequencies. At the same time, high-frequency noise introduced by the recording medium (tape or disc) is reduced.

circuitry, it is noticeably brighter in overall sound. However, if the treble tone control is adjusted slightly, even this effect disappears. The system is therefore compatible, in the sense that its use does not require that listeners own playback equipment with Dolby circuitry unless they wish to gain the advantages of noise reduction which the system provides.

There has been no noise reduction technique in the past which has been considered acceptable by any significant number of recording engineers or artists. The Dolby System, however, is now used by more than 300 recording and film companies. Its application is mandatory in classical recordings at many record companies.

Problems of FM broadcasting

From the standpoint of the high-fidelity listener or broadcaster, FM presents several serious problems. The problems arise largely because the potential of FM broadcasting as a medium of the highest technical quality, potentially superior to any form of recording available to the home listener, has been eroded by a series of technical changes. As a result, the exceptional channel by which FM gains its special identity has not been fully preserved.

Much has been said and written of the equalization used in FM broadcasting, particularly of the restricted level of high frequencies imposed by the standard. The transmission of high quality recordings or live broadcasts is often made impossible without artificial limiting of program levels.

The system of stereo multiplex broadcasting in general use has degraded reception considerably. Even the theoretical *minimum* increase in noise produced by stereo broadcasting is nearly 24-dB per channel, and this figure is attained by only the very best circuits.

SCA background music services which are economically necessary for the survival of many FM stations, impose technical requirements on tuners for home use which are rarely met. Even tuners of very high quality (and cost) often emit high-frequency "chatter" when both SCA and stereo multiplex broadcasts are transmitted.

Experiments show that the Dolby "B" system has pronounced effects upon broadcast reception because of the system's highly effective noise reduction.

When the "B" system is used during broadcast, and listeners equipped with decoders, the result is approximately 10 dB of noise reduction. Ten dB is the difference in level when power is changed by a factor of ten.

TWO DOLBY SYSTEMS

"A" System

This professional system divides the audio spectrum into four bands —below 80 Hz, 80 to 3000 Hz, 3000 Hz to 9000 Hz, and 9000 Hz and up. Each band is treated separately. Signals above a certain level feed right through unaltered. Signals below that level are "expanded" 10 dB or 15 dB, according to their frequency.

"B" System

This system operates on one frequency band—600 Hz and up. It reduces noise about 3 dB at 600 Hz, 6 dB at 1200 Hz, and 10 dB at 4000 Hz and higher.

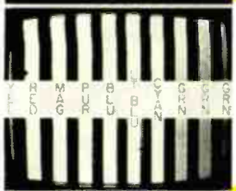
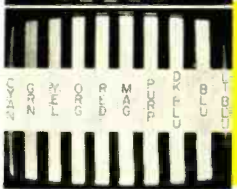
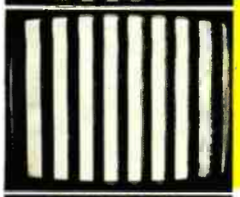
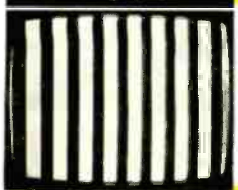
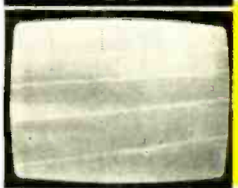
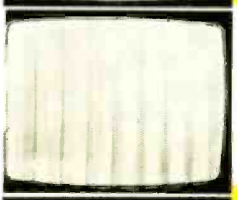
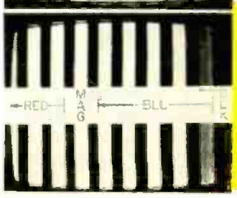
The improvement can be interpreted in various ways. It is, for example, the same additional quieting which listeners in various locations would obtain if the power of a 50,000-watt ERP (Effective Radiated Power) station were increased to 500,000 watts. On the other hand, it is the increase in quieting which would result if the sensitive figure of all tuners, usually given in microvolts, were divided by slightly more than 3. Thus, a tuner with about 10-μV sensitivity for 20 dB quieting would now achieve that degree of quieting at about 3-μV. The result is extending coverage to an area much larger than that which the station could reach formerly.

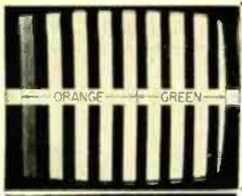
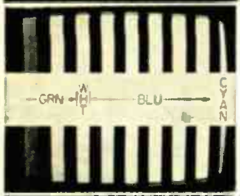
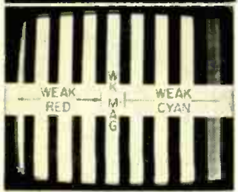
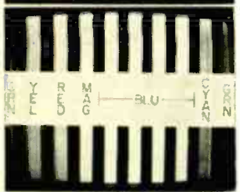
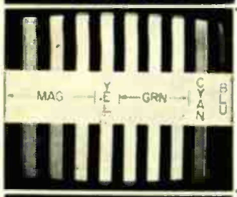
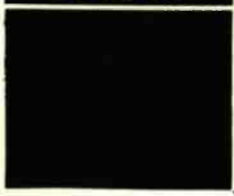
It is in the indirect effects it may have that the Dolby system offers significant benefits to broadcasters and listeners. Obviously the availability of "A"-type tape recordings brings a new standard of quality in musical source material to stations even without any other change in technique. Several FM stations have already broadcast such "A"-type tape recordings. In the fall of this year, Dolby Laboratories and Decca (U.K.) will make available to FM stations a series of "A"-type master tape recordings made during the past few years by Decca. These performers have never before been available to broadcasters in "A"-tape form. If these stereo programs are broadcast and received using the "B-system, listeners will be able to obtain quality impossible to achieve today.

The characteristic proposed by Dolby Laboratories for FM broadcast noise reduction is the same as that of the "B"-system now used in tape recorders and pre-recorded tapes. The Model 320 noise reduction unit, now used to encode such tapes, could also be used for the FM broadcasts by radio stations, and the products that use the "B" system, that are available to consumers can be used to receive the broadcasts in decoded form. All in all, it looks like better FM music reproduction is on its way. **R-E**

Integrated-circuit color demodulator system

Kwik-Fix™ picture and waveform charts

SCREEN SYMPTOMS AS GUIDES		WHERE TO CHECK FIRST		
SYMPTOM PIC	DESCRIPTION	VOLTAGE	WAVEFORM	PART
	Normal keyed-rainbow color bar pattern			
	Hue not tracking; too many bars of one color, not enough of others	no help	not much help	IC faulty
	Hues wrong; bars shifted about 120° to right	no help	WF4 WF5 WF6	C3 open
	Red missing	IC-pin-11	WF5	R4 low
	No color; only black-and-white bars	IC-pin-3	WF2	R1 faulty C1 faulty T1 open C2 shorted
	Weak colors; bars well defined	no help	not much help	R1 high
	Screen all one color; out of focus; retrace lines visible	no help	WF4, WF6 WF4, WF5 WF5, WF6	(red) R5 open (grn) R7 open (blu) R3 high
	Screen all one color; bars visible but poorly defined	IC-pin-11 IC-pin-9 IC-pin-13		(red) R4, R5 (grn) R6 (blu) R2, R3
	Green missing	IC-pin-9	WF6	R6 low

	Blue missing	IC-pin-13	not much help	R2 low
	Red missing	IC-pin-6	WF3 WF5	C4 leaky, shorted
	Blue almost gone; red and green weak	IC-pin-7	WF3 WF4	C5 leaky, shorted
	Red weak; too much blue and green	no help	not much help	R5 low
	Phase shifted 180°; red weak	no help	WF3	C5 open
	Screen black; no raster	IC-pin-8	WF4 WF5 WF6	IC faulty L1 open C6 shorted C7 shorted

NOTES:

The test signal comes from a keyed-rainbow color bar generator fed into the antenna terminals of the receiver. Rf signal must be strong, and color saturation set for 100% or more.

Use this guide to help you find which key voltage or waveform to check first.

Study the screen, noting positions of bars and whether they are weak. Try the HUE *and* COLOR *controls.*

Most helpful clues to the fault are found at the key test points indicated in Voltages or Waveforms column.

Make the voltage or waveform checks indicated for symptoms you see on the screen.

Use the Voltage Guide or Waveform Guide to analyze results. For a quick check, test or substitute the parts listed as the most likely cause of the symptoms.

THE STAGES

The schematic makes this look like one stage, and from the standpoint of having only one active component (the IC), it is. Nevertheless, inside the IC are several stages.

There are two demodulators, B-Y and R-Y. They're about what you might expect in any solid-state demodulator—except of course they're infinitely smaller. There's also a G-Y matrix stage; it takes demodulated R-Y and B-Y and compiles a G-Y signal from them.

Then, three multi-transistor amplifiers boost the three color-difference signals. These are the B-Y, R-Y preamp and G-Y preamps.

Components in a regulator stage inside the IC drop the 23-volt dc input to a little less than 15 volts dc and hold it carefully constant to power the three preamp stages.

SIGNAL OPERATION

Three signals are fed to this demodulator system. One is chroma sidebands from the chroma section of the color receiver. Resistor R1 is the input load. Capacitor C1 and transformer T1 couple the chroma sidebands to the balanced input of the IC, at pins 3 and 4. Capacitor C2 grounds the center tap of T1's secondary for signal. C3 tunes the secondary.

Two CW signals are supplied. On an ordinary service scope, they appear alike. Actually, they're at different phases.

Both originate from a 3.58-MHz CW oscillator or subcarrier regenerator. The source signal is held precisely in phase with the color-sync burst from the TV station (or color-bar generator). The R-Y injection signal is phase-shifted almost 60° and then coupled by C4 to pin 6 of the IC. The B-Y injection is shifted about 105° further, and coupled by C5 to pin 7 of the IC.

The IC recovers B-Y, R-Y and G-Y color-difference signals and preamplifies them. They don't have video or Y component with them. The B-Y terminates at pin 13 of the IC, R-Y at pin 11 and G-Y at pin 9. Output loads are R2, R4 and R6, respectively.

Decoupling and bypassing for the dc input supply are the jobs of choke L1 and capacitors C6 and C7.

(*copy continues on page 46*)

DC VOLTAGES AS GUIDES

Voltage change	to zero	very low	low	slightly low	slightly high	high
IC-pin-3 Normal 3.5V	C2 shorted		C2 leaky			
IC-pin-4 Normal 3.5V	C2 shorted		C2 leaky			
IC-pin-6 Normal 6V						C4 shorted
IC-pin-7 Normal 6V						C5 shorted
IC-pin-8 Normal 23V	L1 open C6 shorted C7 shorted					
IC-pin-9 Normal 14V			R6 low		C2 shorted R6 high	R6 open, high
IC-pin-11 Normal 14V			R4 low		C2 shorted R4 high	R4 open
IC-pin-13 Normal 14V			R2 low		C2 shorted R2 high	R2 open

NOTES:

Use this guide and the Waveform Guide to help you pinpoint the faulty part.

Measure each of the eight key voltages with a vtvm.

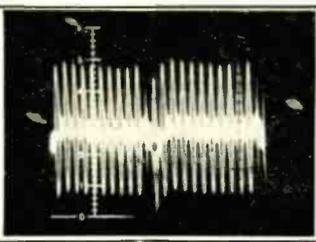
For each, move across to the column that describes whatever change you find.

Notice which parts might cause that change.

Finally, notice which parts are repeated in the combination of changes you found.

Test those parts individually for the fault described, or try a substitution.

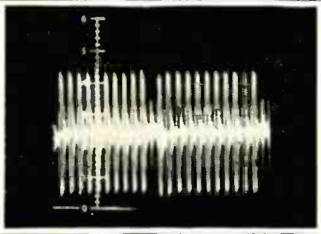
WAVEFORMS AS GUIDES



WF1 Normal 0.5 V p-p

Input waveform is color sidebands signal from bandpass amplifier. In some chassis, signal may come more or less directly from Color control. Scope display in photo is locked right at end of horizontal blanking (external sync lead draped across yoke). First bar visible is yellow bar from keyed rainbow generator. In blanking at center, suppressed bar is slightly visible; first bar following that is treated by receiver as 3.58-MHz color sync.

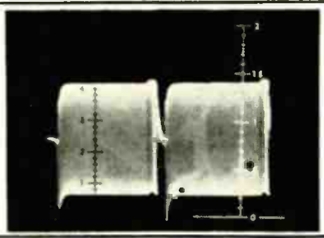
V p-p low	V p-p high	V p-p zero	Changed Shapes			
R1 low		C1 open				



WF2 Normal 4.5 V p-p

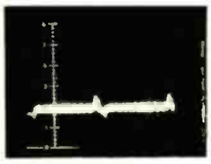
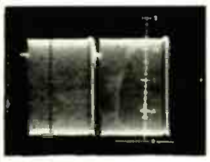
Chroma (color) sidebands signal, coupled into demodulator system by capacitor C1 and transformer T1. (Capacitor C2 holds center of T1 secondary at rf ground.) Sequence of bars in this waveform is same as in WF1, the input waveform. Bars are amplitude-leveled by transformer action. Waveform is the same at either end of transformer T1 secondary winding.

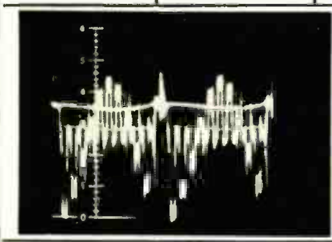
V p-p low		V p-p zero				
R1 high R1 low		R1 open R1 low C1 open C1 shorted T1 open				



WF3 Normal 1.5 V p-p

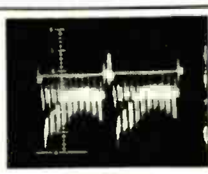
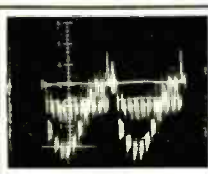
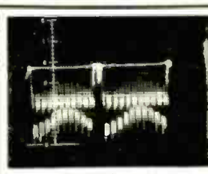
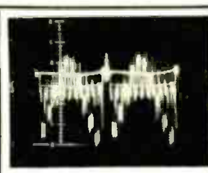
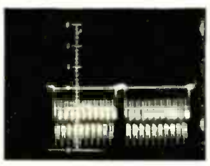
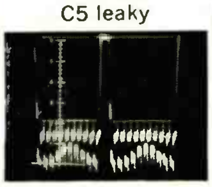
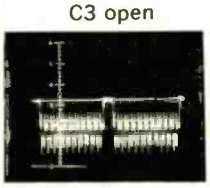
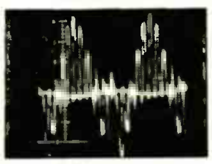
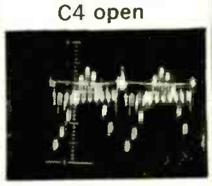
This is 3.58-MHz subcarrier signal. Originates in 3.58-MHz color oscillator or (in some Zenith chassis) in subcarrier-regenerator IC. The 3.58-MHz subcarrier is split into two signals and phase-shifted before being applied to the color demodulator system. Phases are about 105° apart. The two signals are shown as one because they look alike on a scope. Blanking accounts for the blacked-out portion during horizontal sync period.

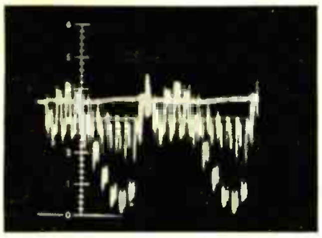
			 0.1 V p-p (pin 6) C4 open (pin 7) C5 open	 2.0 V p-p (pin 6) C4 shorted (pin 7) C5 shorted		



WF4 Normal 4.5 V p-p

Output waveform coming from pin 13 of the IC, output terminal of the B-Y preamp stage. This is the blue signal for the color CRT. Counting the positive-going bars, correct phase at this point makes the sixth bar the highest one. Bars at or below "zero average" line produce no output in blue gun of the CRT. Some of the first bar is lost in blanking space.

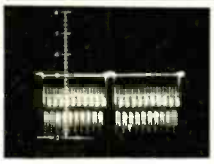
		V p-p zero R3 open L1 open	 5.0 V p-p C5 leaky	 5.0 V p-p C3 open	 3.0 V p-p C2 shorted	 4.5 V p-p C4 open
 3.0 V p-p R1 open C1 open C1 shorted T1 open		 4.0 V p-p C5 open	 6.0 V p-p R2 high	 3.0 V p-p R2 open	 7 V p-p R4 open R6 open	 4 V p-p R5 open R7 open



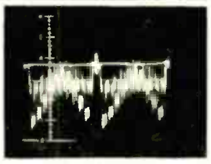
WF5 Normal 4.0 V p-p

Output waveform coming from pin 11 of the IC, output terminal of the B-Y preamp stage. This is the red signal for the color CRT. Counting the positive-going bars, correct phase at this point makes the third bar the highest one. Bars at or below the "zero average" line produce no output in the red gun of the CRT.

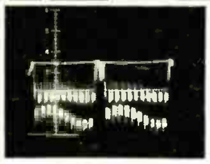
V p-p zero
R5 open
L1 open



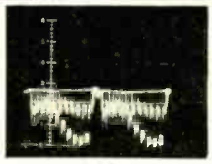
3.0 V p-p
R1 open
C1 open
C1 shorted
T1 open



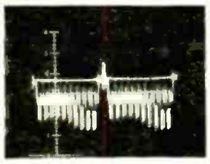
4.0 V p-p
C3 open



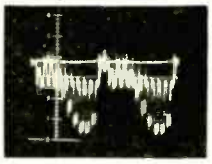
3.0 V p-p
C2 shorted



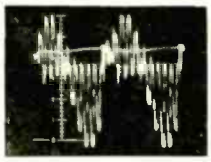
3.0 V p-p
C4 open



3.0 V p-p
C4 leaky

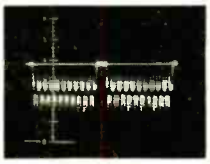


4.0 V p-p
C5 open

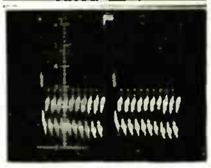


6.0 V p-p
R2 open, high

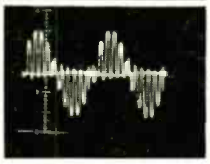
6.0 V p-p
R4 high



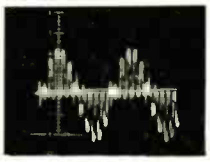
3.0 V p-p
R4 open



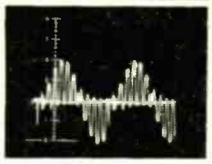
3.5 V p-p
R4 low



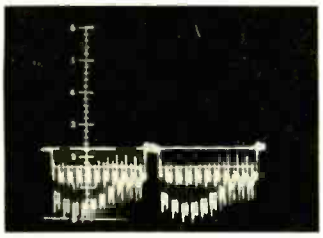
4 V p-p
R3 open, high



4.5 V p-p
R6 open



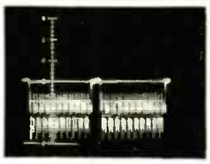
4 V p-p
R7 open



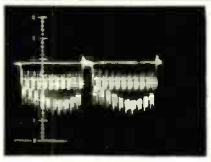
WF6 Normal 2.0 V p-p

Output waveform coming from pin 9 of the IC, output terminal of the G-Y preamp stage. This is the green signal for the color CRT. It always is somewhat less in amplitude than the other two color-difference signals. Counting the positive-going bars, correct phase at this point makes the ninth bar the highest one. Bars below the indistinct "zero average" here produce no output in the green gun of the CRT.

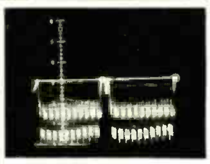
V p-p zero
R7 open
L1 open



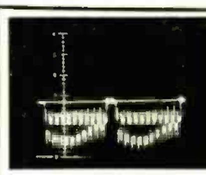
3.0 V p-p
R1 open
C1 open
C1 shorted
T1 open



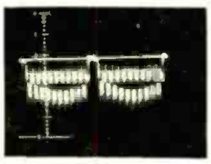
2.5 V p-p
C3 open



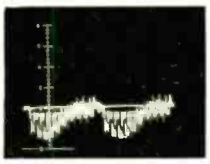
3.0 V p-p
C2 shorted



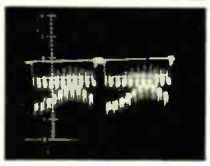
2.5 V p-p
C4 open



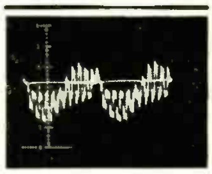
2.5 V p-p
C4 leaky



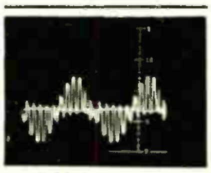
3.0 V p-p
C5 open



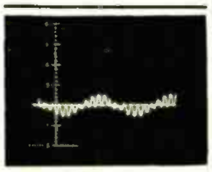
2.0 V p-p
R2 open, high



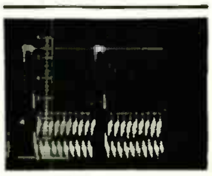
3.0 V p-p
R4 open, high



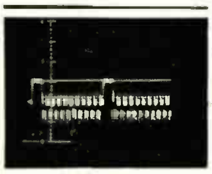
1 V p-p
R3 open, high



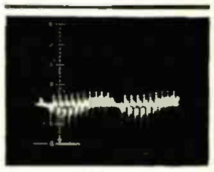
1 V p-p
R5 open



6 V p-p
R6 high



2 V p-p
R6 open



2 V p-p
R6 low

(turn page for waveform notes)

NOTES:

Use this guide and the Voltages Guide to help you pin down fault possibilities.

Use the direct probe of your scope. Set the scope sweep for 7875 kHz, to show two lines of each signal. External sync works best, with lead draped near horizontal output stage.

Check the six waveforms at the eight key test points.

Note amplitude. If it's low or high, check the parts listed under those columns.

Note waveshape. If there's a change that matches one shown, check the parts indicated.

DC DISTRIBUTION

Dc to operate the IC comes from a 23-volt supply. It is brought through L1 to pin 8 of the IC. The dc voltage levels at pins 3, 4, 6 and 7 depend on the dc distribution system inside the integrated circuit.

The voltages at pins 9, 11, and 13 depend mainly on what's happening inside the IC, too. However, they do have dc connections (through R3, R5, and R7) to the color-difference amplifiers. Output load resistors R2, R4, and R6 are dc ground returns for the transistor stages inside the IC. These resistances also "load" the internal dc distribution paths. When one of them is open, the voltage at that IC terminal goes up almost to 23 volts.

SIGNAL AND CONTROL INFLUENCES

There are no variable controls in this demodulator system. But controls in other sections of the chassis may affect operating conditions here. The CHROMA and COLOR KILLER controls have the most effect. If the color level is turned down, the chroma content of waveforms WF1, WF2, WF4, WF5 and WF6 is reduced. An improperly set color killer could cut chroma off completely, and color outputs of the demodulator system would be virtually nil.

Strength of the station signal has little bearing on this section. If it's too weak, the color killer blocks any color information, so there's no color output from the demodulators. Variations in signal strength are smoothed out by automatic color control (acc) in the chroma section.

For testing, however, don't use a station signal. A keyed rainbow is much more meaningful. Its rf strength can be varied—if not by a control on the generator, then by loose coupling of the rf cable. A knob on most generators allows color saturation level to be varied.

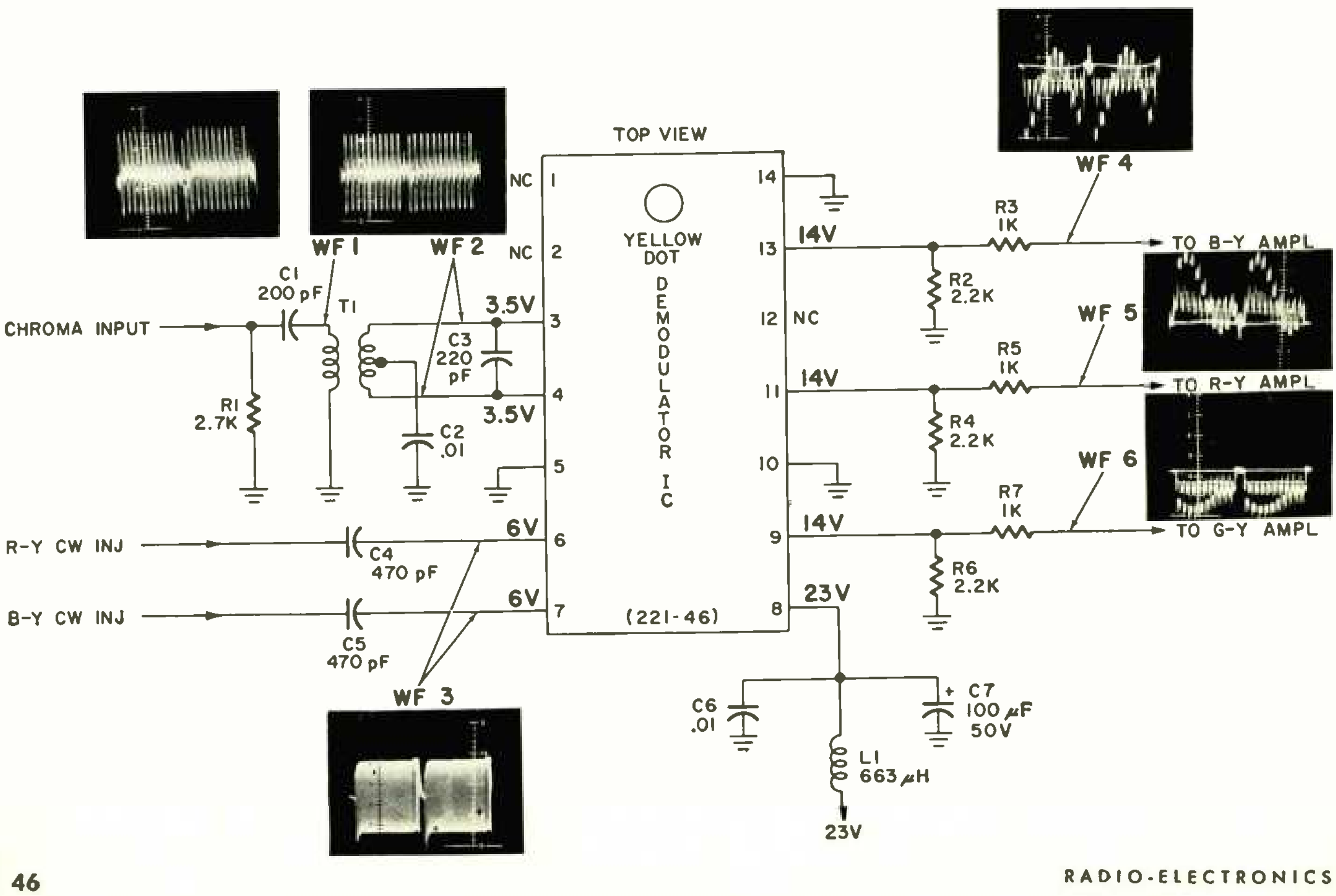
QUICK TROUBLESHOOTING

Your scope tells you more than dc voltages do, as you can see from the charts.

First verify that the three input signals are present. You can't handily check the phase of the two 3.58-MHz cw signals. But don't worry about them unless hue phase won't track and a new ICC doesn't help. Of course, you made all color-sync adjustments before you started testing the demodulator system.

The waveforms put out by the three color preamps inside the IC contain a wealth of clues. Notice especially which bar (first, second, third, or whatever) is highest *positive* in any waveform. That's the bar on the screen that's getting most output from that particular color-difference preamp. If overall levels and bar positions seem okay in all three, suspect the color-video output amplifiers (transistors or tubes) that follow.

The operation of this 14-pin flat-pack IC demodulator is the same as that of 9-pin TO-package IC demodulators. Just study the different pin numbering, and you can use this *Kwik-Fix* to help you troubleshoot them. R-E



Three charts you will want to keep show how to make CB repairs fast and easy. Add CB work to your shop's price sheet and start earning extra dollars today.

Troubleshooting CB transceivers

by **ANDREW J. MUELLER, CET**

TODAY THERE ARE ABOUT 1,250,000 CB LICENSEES IN THE United States. If we assume that each licensee owns at least two transistor CB radios, this is quite a few rigs. At one time or another every one of them will need some servicing. If you have the basic knowledge of transistors, following schematics and simple test procedures, you can do CB repairs in addition to your other service work.

The key to servicing these units is simplicity. I have developed a series of servicing charts to guide you to the trouble. With a few basic tools and a minimum of test gear you can get your ailing set back into operation in no time.

The first step is to check the tools you will need. You should have a small "dikes" (4"), a good needle-nose pliers, assorted screwdriver and pliers, and a soldering aid. You should also have a 20- to 40-watt soldering iron.

You should have a good vom, vtvm or tvm. The vom should be at least a 20,000 ohms/volt type. The 1000 ohms/volt type is not sensitive enough and can load the circuit under test. This will produce faulty readings and lead you in the wrong direction.

A necessary accessory for the meter is an rf probe. It is required when making checks in the oscillator stages of the receiver and in most of the transmitter stages. Fig. 1 shows two rf probes that you can build.

Another useful item is an rf-i.f.-af injector probe. These are available on the market from various manufacturers. If you want to build one of these probes for yourself, a simple circuit is in Fig. 2.

Last, but not least, is a transistor-diode checker. Most experts do not use the checker until the last step. I feel that we are justified in using it early in our diagnosis. Once the defective stage has been located, I recommend that the first thing to do is to check the transistor. This is done by measuring the voltages on the elements of the transistor. Any obvious defects such as a complete lack of a certain voltage should be investigated and corrected *before* removing the transistor. If the voltages are somewhat near what they should be, you can then remove the transistor and check it. About 7 out of 10 times you will find a bad transistor which is the cause of the problem. The remaining 3 times you will find defective associated components and/or a defective solder connection.

When checking a transistor, there are 2 important tests to be concerned with. Will it amplify a signal, or is it leaky, shorted or open? These properties can be determined by the above testers. If the transistor is ok, it will show a current gain, or Beta, from 5 to 300. This will vary from one transistor type to another. If you get no reading, it is probably defective. Any signal transistor with more than 300-μA leakage should be replaced. Typically speaking, a

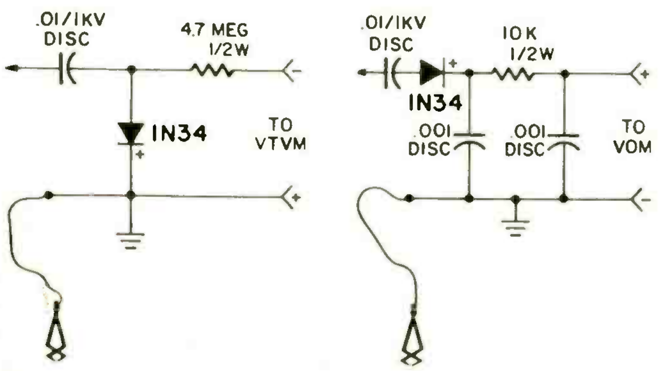


FIG. 1—TWO SIMPLE RF PROBES you can build to use with your vom, vtvm or tvom. Use it to check receiver oscillator stages and just about every part of the transmitter.

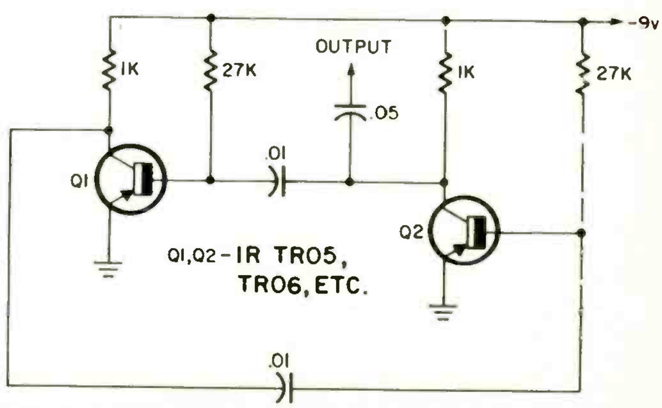
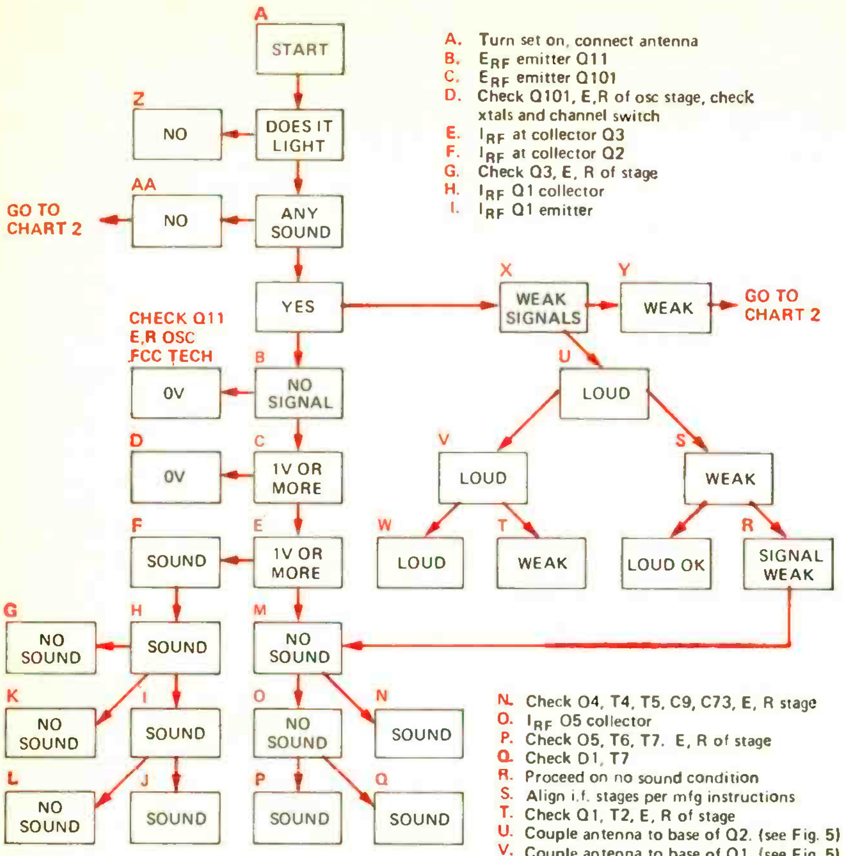


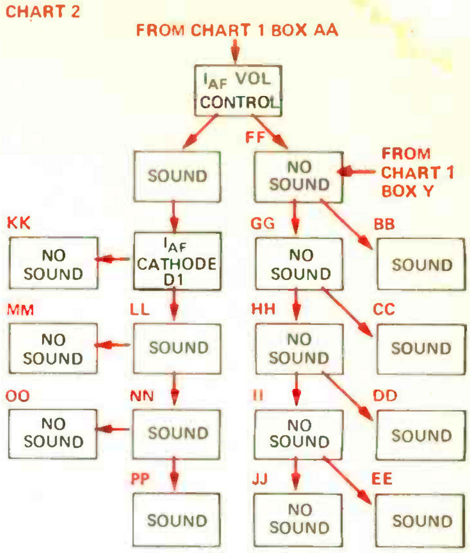
FIG. 2—TWO-TRANSISTOR SIGNAL INJECTOR is easy to build and extremely handy when troubleshooting CB gear.

CHART 1



A. Turn set on, connect antenna
B. E_{RF} emitter Q11
C. E_{RF} emitter Q101
D. Check Q101, E,R of osc stage, check xtals and channel switch
E. I_{RF} at collector Q3
F. I_{RF} at collector Q2
G. Check Q3, E, R of stage
H. I_{RF} Q1 collector
I. I_{RF} Q1 emitter
J. R of T1, wiring of antenna in set, TR relay
K. Check Q2, T2, E, R stage
L. Check Q1, E, R stage, check C2, R2.
M. I_{RF} Q4 collector
N. Check Q4, T4, T5, C9, C73, E, R stage
O. I_{RF} Q5 collector
P. Check Q5, T6, T7. E, R of stage
Q. Check D1, T7
R. Proceed on no sound condition
S. Align i.f. stages per mfg instructions
T. Check Q1, T2, E, R of stage
U. Couple antenna to base of Q2. (see Fig. 5)
V. Couple antenna to base of Q1. (see Fig. 5)
W. Check T1, C56, R61, TR relay
X. I_{AF} at volume control
Y. Proceed and assume no sound condition
Z. Check fuses, power cord, switch and wiring.
AA. Check spkr, mike, TR relay, audio output xfmr

CHART 2



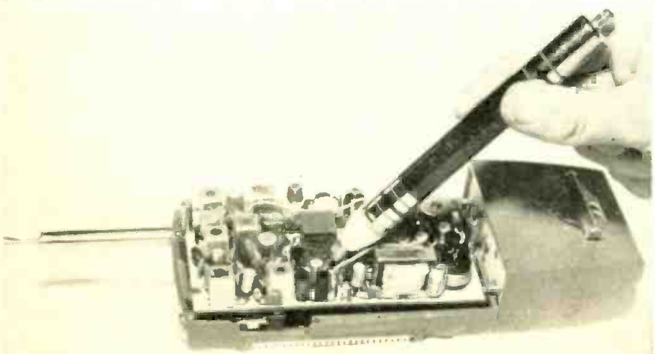
BB. Check Q6, C19, R21, R20, squelch control and associated components
CC. Check Q7, R23, R24, C25, R39, C29
DD. Check T8, C79, R26, R27, C22
EE. Check Q8, C24, C22, R27, R28, R26, T8
FF. I_{AF} Q6 emitter
GG. I_{AF} Q7 collector
HH. I_{AF} Q8 base
II. I_{AF} Q8 collector
JJ. Check output transformer T9, TR relay wiring, spkr.
KK. Check D1, D2, C16, C15, R17
LL. I_{RF} Q5 collector
MM. Check Q5, T7, E, R of stage
NN. I_{RF} Q5 base
OO. Check Q5, T6, C12, E, R of stage

TROUBLESHOOTING CHARTS 1 AND 2 (above) lead you through the receiver. CHART 3 (below) takes care of the transmitter section. All part references in these charts refer to the typical schematic on the facing page.

silicon type will show less than 50-μA leakage while a germanium will show about 100-μA. If any one checks shorted or if any elements are open, it is bad and must be replaced.

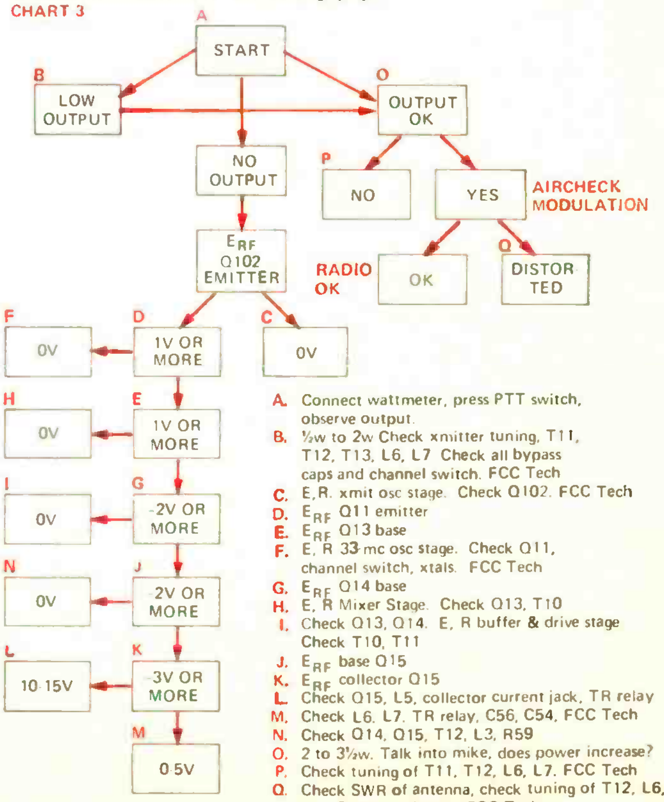
When replacing transistors, you must be careful in using substitutes. In certain stages, such as the transmitter and receiver rf amplifier, mixer and oscillators, only the original type supplied will work properly. These special types may be obtained from the manufacturer or the local service center. You would be surprised how many sets I have repaired in which the wrong transistor replacement was used. In other less critical circuits, such as the audio stages, i.f. amplifiers and voltage regulators, the so-called universal replacements will work very well. These are available for RCA, Motorola, IR, GE and others.

Now let's get down to troubleshooting. The programmed servicing charts are based on the schematic on page 49. They are intended to guide you to the defective

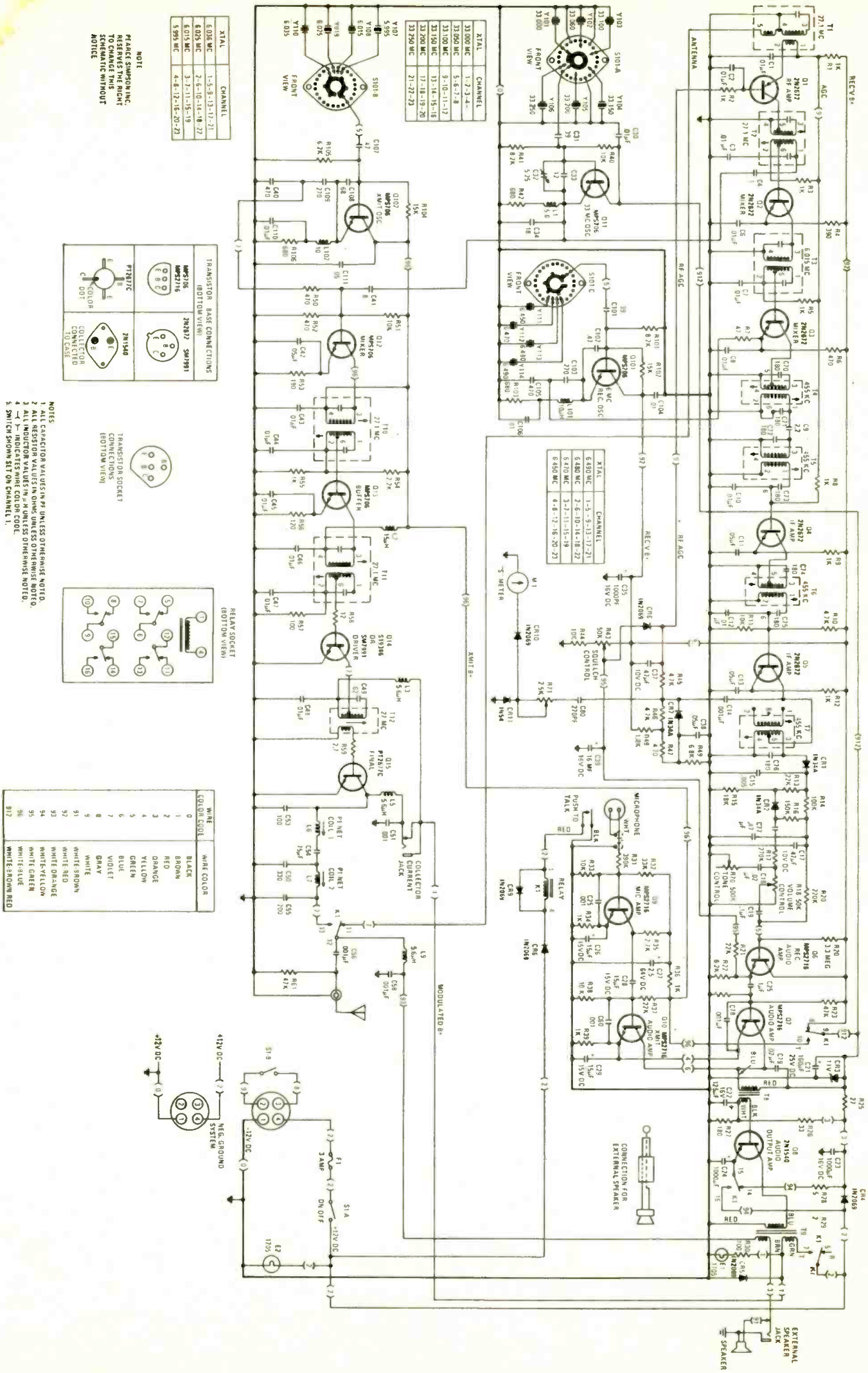


TYPICAL SIGNAL INJECTOR used to troubleshoot CB transceiver. It's like having a portable signal-generator in your hand.

CHART 3



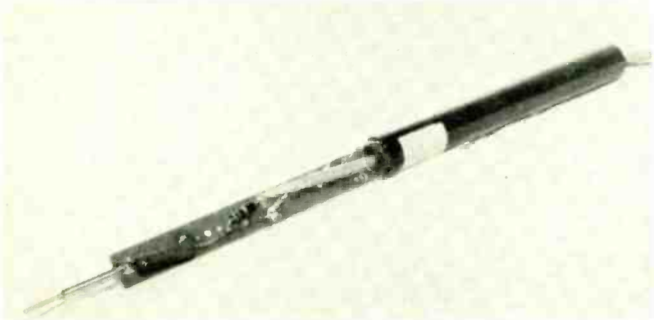
A. Connect wattmeter, press PTT switch, observe output.
B. ½w to 2w Check xmitter tuning, T11, T12, T13, L6, L7 Check all bypass caps and channel switch. FCC Tech
C. E,R. xmit osc stage. Check Q102. FCC Tech
D. E_{RF} Q11 emitter
E. E_{RF} Q13 base
F. E, R 33 mc osc stage. Check Q11, channel switch, xtals. FCC Tech
G. E_{RF} Q14 base
H. E, R Mixer Stage. Check Q13, T10
I. Check Q13, Q14. E, R buffer & drive stage Check T10, T11
J. E_{RF} base Q15
K. E_{RF} collector Q15
L. Check Q15, L5, collector current jack, TR relay
M. Check L6, L7, TR relay, C56, C54, FCC Tech
N. Check Q14, Q15, T12, L3, R59
O. 2 to 3½w. Talk into mike, does power increase?
P. Check tuning of T11, T12, L6, L7. FCC Tech
Q. Check SWR of antenna, check tuning of T12, L6, L7. Check 5w input. FCC Tech


NOTE
PEARCE SIMPSON INC. RESERVES THE RIGHT TO CHANGE THIS SCHEMATIC WITHOUT NOTICE
TRANSISTOR BASE CONNECTIONS (BOTTOM VIEW)
TRANSISTOR SOCKET CONNECTIONS (BOTTOM VIEW)
RELAY SOCKET (BOTTOM VIEW)
ANTENNA
"S" METER
SQUELCH CONTROL
MICROPHONE
PUSH TO TALK
VOLUME CONTROL
TONE CONTROL
XMIT B+
RECV B+
MODULATED B+
NEG. GROUND SYSTEM
CONNECTION FOR EXTERNAL SPEAKER
EXTERNAL SPEAKER JACK
SPEAKER

stage. It is then a simpler matter of checking several complements to find the defective one. Your set may not be quite like the one shown so you can skip certain tests that do not apply to stages that are not in your set. I have used abbreviations to indicate what test to make. They are:

IAF—Inject audio signal
RF—Inject rf signal
ERF—Measure rf voltage with rf probe
E—Measure dc voltage
R—Measure resistance

The best way to illustrate the use of the charts is to cover several case histories. The first case is a Johnson Messenger Model 242-102 portable unit. It transmits but

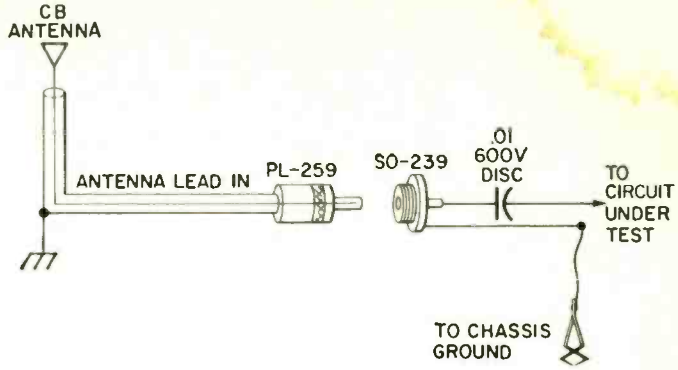


BUILD AN RF PROBE like the ones shown in Fig. 1 and you will end up with a unit that looks like this one.

does not receive. Referring to Chart 1, the first step is to turn the unit on. We hear a click and a rushing noise so we can assume that the audio stages and the speaker are ok. The next step is to take the rf probe and measure the rf voltage at the collector of Q3, the receiver local oscillator. This results in a reading of 0 volts so the defect lies in this area. Next we should measure the voltages on the elements of the oscillator. On the emitter we read −0.3V, the base −0.5V, and the collector, 0V.

Apparently, the trouble lies in the collector circuit. A voltage check at rf amplifier end of the oscillator transformer reveals 0 volts so the transformer is not open. Next we measure at the junction of R32, R6 and we read −10 volts. Since there are 10 volts on one side of R32 and zero on the other, the only two parts that could be defective are R32 and bypass capacitor C10. A check of C10 with an ohmmeter reveals that it is shorted. R32 was also checked and found to have changed value to 10,000 ohms. Replacing both parts restored the unit to normal operation.

In our second case we have an Amphenol Model 725 that does not transmit. Referring to Chart 2 under NO-OUTPUT, the first checkpoint is the oscillator stage. Placing the rf probe on the collector of the oscillator reveals 5V rf which is ok. Then we move to the base of the driver. This reveals 3V rf——ok. Moving on the base of the output



EASILY-MADE ADAPTER lets you insert an rf station signal into the transceiver being tested.

transistor reveals 6V rf——ok. On the emitter we read 25V rf——ok. The only thing left that could be causing trouble is the TR relay or the output tank circuit. We substitute the relay but the trouble remains. Next, we take an ohmmeter check across the coils in the tank circuit. It should measure zero ohms but it reads infinity. Closer inspection of the tank circuit reveals that there is a broken solder connection at the end of one coil. Resoldering the PC board restores the transmitter to normal operation.

CHECK TRANSISTORS CAREFULLY for both Beta gain and leakage. Several semiconductor testers are available and you should have one.

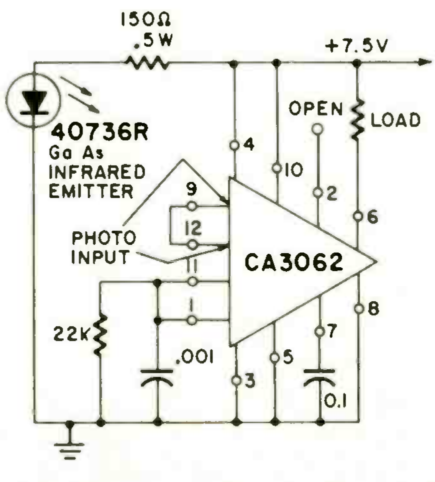
One last thing to touch upon is that if you replace parts in the transmitter section of your radio, the work *MUST* be checked out by an FCC licensed radiotelephone technician. This is required by the FCC rules and regulations and it will assure you that the radio is in A-1 condition. **R-E**

PHOTOELECTRIC IC

The CA3062 is an integrated circuit consisting of a photosensitive section, an amplifier and a pair of high-current output transistors on a single monolithic chip. It is used for such photoelectric applications as counters, sorters, level controls, intrusion alarms, position sensors and isolators.

The photosensitive section consists of two Darlington pairs (working into a common emitter load resistor) for high sensitivity. The power amplifier is a differential circuit that provides complementing outputs in response to light input—normally on and normally off.

Although the CA3062 can be used in linear-output applications, its design purpose is for switching service. Its 100-mA output current capacity can be used to drive a relay or thyristor directly. Power supply range is 5 to 15 volts dc.



The IC housing is a modified 12-lead TO-5 package with the top open to expose the photosensative surfaces. If invisible light is needed for excitation, the IC response curve is compatible with the output of the type 40736R GaAs infrared emitter diode. The diagram shows a circuit for using the CA3062 in on-off applications. If the device drives an inductive load such as a relay, a diode should be connected across the load. **R-E**

Design for STEREO

by MANNIE HOROWITZ*

how to design your own solid-state audio amplifier

JFETS in audio amplifiers are semiconductor components you should expect to find. Discover how they may be used

LAST TIME WE TOOK A DETAILED LOOK INTO bias circuits for bipolar transistors. This section will examine, in detail, various FET circuit arrangements that are used in modern audio amplifiers.

Bipolar amplifiers can conveniently be divided into two groups—the small-signal voltage-gain types and the large-signal groups designed to deliver high power. As yet, there are no power FET's for use in entertainment equipment. We will treat FET amplifiers as a cross between small-signal and power devices, but will parallel the previous discussion on small-signal bipolar amplifiers.

Three basic circuit arrangements are frequently used—the common-source, common-drain (source follower) and common-gate. They are similar to their bipolar counterparts. The most useful one, the common-source, will be the center of most discussions here, while the characteristics of the remaining two circuits will be noted.

Circuit characteristics

As is the case with bipolar devices, different equivalent circuits are possible for the JFET. An approximate equivalent of the transistor itself is shown in Fig. 1. It will suffice for the common-

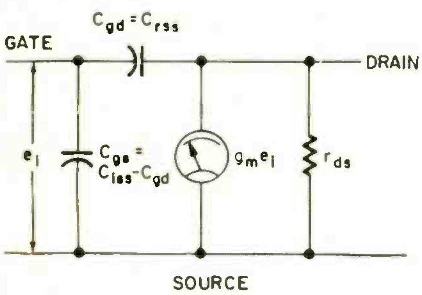


FIG. 1—EQUIVALENT CIRCUIT OF JFET operating in the common-source mode.

drain mode of operation when audio frequency designs are considered.

At first glance, there is one obvious difference between this circuit and that drawn for bipolar devices in a previous article. Capactitors are integral components in the equivalent circuit of FET's. Reactive components are negligible when compared to the resistive elements in the small-signal bipolar equivalents, and are thus omitted from these circuits. High impedance is an important inherent characteristic of the FET, so the shunt and series capacitors gain new significance at audio frequencies.

Significant capacitances (C_{gs} and C_{gd}) exist between the gate and source and gate and drain, respectively. Input voltage e_i, sees capacitance rather than resistance. We therefore talk about the input impedance, Z_{in}, of a device rather than of the input resistance. These capacitances limit the high-frequency response of an amplifier stage. It is fortunate that the capacitors are small, being but a few picofarads in size.

Two capacitances other than C_{gs} and C_{gd} are frequently stated in the specifications. These are C_{iss}, the input capacitance when the drain is bypassed to the source, and C_{rss}, the gate-to-drain capacitance with the gate bypassed to the source. While C_{rss} is equal to C_{gd}, C_{iss} is the sum of C_{gs} and C_{gd}. The latter is obvious, for by the definition of C_{iss}, C_{gs} is shunted by C_{gd} when the drain is connected to the source.

For JFET's, the output capacitance between the drain and source is negligible and is not shown in the equivalent circuit. In this article, we will consider all capacitance in the equivalent circuit as negligible. This is not a wild approximation when designing circuits that apply to all but the top frequencies in the audio spectrum. It is nevertheless important to realize that the frequency limitation does exist and to keep in mind the capacitance relationships just discussed.

The channel drain-to-source resistance, r_{ds}, and the current source, $g_m e_i$, are significant and important factors in determining the characteristics of the device in a circuit at any frequency. These factors, when added to components in the surrounding circuit, are used in various equations to describe the performance of a particular circuit arrangement.

Input impedance, Z_{IN}, and output impedance, Z_{OUT}, are two important characteristics of the circuits. The only other characteristic of importance necessary to describe an audio JFET circuit is voltage gain, A_v. Unlike the bipolar device, current and power gains are insignificant factors. The effects of the capacitors in the equivalent circuits will be discussed in the future when frequency limitations of bipolar transistors and JFET's will be detailed.

The various circuit arrangements and the significant approximate equations describing the circuits, are shown in Fig. 2. The input and output impedances are seen by looking into the transistor from the V_{IN} source and the V_{OUT} terminals, respectively. Various symbols in the equations require elaboration. Several modifications must also be included to account for circuit components not shown in the drawings.

Start with R_D. In the equations, it is the load resistor in the drain circuit. Should the transistor manufacturer specify a drain-to-source resistance, r_{ds}, that is comparable in size to R_D, then R_D in Fig. 2 is no longer the resistance to be

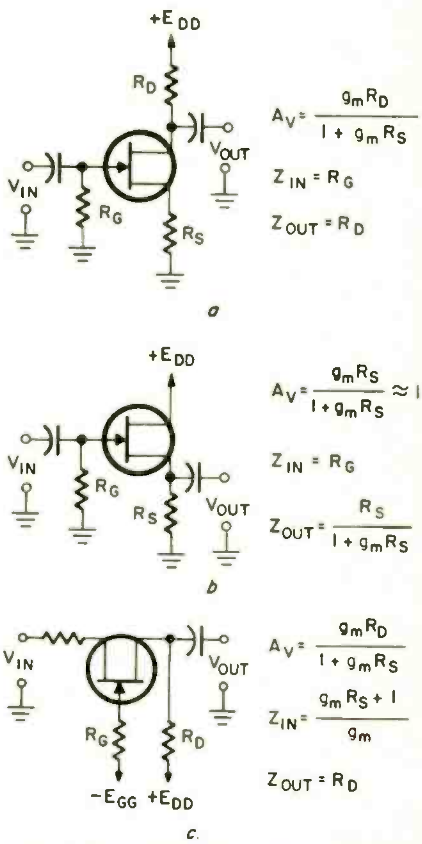


FIG. 2—FET CIRCUIT arrangements (a)—common-source, (b)—common-drain and (c)—common-gate; with formulas used to calculate characteristics of each.

used in the equation. Instead, substitute an R_L for R_D, where R_L is a resistor equal to the parallel combination of R_D and r_{ds} [$R_L = R_D \times r_{ds}/(R_D + r_{ds})$].

Take this one step further. If the load at the output terminals is about equal to R_D, it must also be considered as paralleling R_D and r_{ds} to form R_L. R_D

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is stated in the equation rather than R_L because in audio designs, r_d, and other paralleling loads are usually (not always) negligible when compared with R_D.

Now let us turn our attention to R_S and R_G. Any resistor of comparable size shunting either of these will automatically make the results found from the equations inaccurate. Shunting components must be added in parallel with these resistors before numbers are plugged into any of the equations. This calculation must be made irregardless of the paralleling components, be it a shunting resistor, capacitor or inductor. In the latter two cases, the shunting impedance due to an inductance is 6.28fL and the impedance due to a capacitor is 1/6.28fC, where f is the frequency in Hertz, L is the inductance in henrys and C is the capacity in farads.

The final symbol of interest in the equations is g_m. This is the actual transconductance of the FET at a specific quiescent drain current, I_D. It is related to g_{mo}, the transconductance when the drain current is equal to I_{DSS}, by the equation

$$g_m = g_{fs} = y_{fs}^* = g_{mo}\left(\frac{I_D}{I_{DSS}}\right)^{1/2} \quad \text{Eq. 1}$$

I_{DSS} is the drain current when the gate-to-source voltage, V_{GS}, is equal to zero. As a rule of thumb, g_{mo} is approximately equal to $1/r_{dso}$, where r_{dso} is the drain-to-source resistance of the $V_{GS} = 0$ curve in the ohmic region. Both g_{mo} and I_{DSS} can be found on specification sheets.

A range of g_{mo} is usually stated in the specifications for a device, as it is for the pinch-off voltage and I_{DSS}. (See Fig. 3

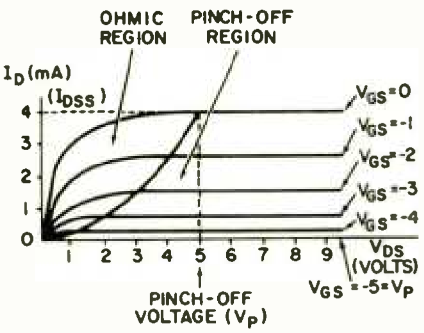

FIG. 3—TYPICAL DRAIN characteristics curve. I_{DSS} is 4 mA, V_P is −5 V and g_{mo} 1.6 X 10^{-3} mhos (1600 µmhos).

for a plot describing V_P and I_{DSS}.) Should one or the other of these factors be missing in the data, it can be found from:

$$(g_{mo})\ |V_p| = 2\ I_{DSS} \quad \text{Eq. 2}$$

$|V_p|$ is the pinch-off voltage with the polarity disregarded.

A procedural example

It is simple for me to follow the standard procedures when presenting an example in the design of an amplifier stage. All the designs would then follow carefully chosen steps and all calculations would produce whole numbers. Unfortunately, little can be learned from this. No design is as straightforward as it appears on the printed page. In the example to follow, I present a design method used by many engineers. Solutions are tried and discarded for different reasons, even after many calculations. In the problem, it is first attempted to use a less expensive FET. Finally, a slightly more expensive device was found necessary to satisfy all aspects of the problem. In the final circuit, much of the original work is discarded in favor of a better and cheaper design.

This is a procedure concluding with a design. It is detailed here to present facts as well as to show the reader the mental gyrations he must pursue to derive the compromise between the best and the most economical of circuits. Variations of parameters with temperature are disregarded as they were discussed thoroughly in a previous article.

A procedure detailed in a previous issue concerned the design of an amplifier stage using a bipolar transistor. The basic design included a voltage signal source with a maximum 20 mV peak output feeding a voltage amplifier stage with a gain of 3. The voltage across the load resistor of this stage to be designed, must be capable of varying a minimum of ±20 mV × 3 = ±60 mV, peak. The stage is to present a 47,000-ohm load to the source and its output is to look into 47,000 ohms. Let us redesign this stage, but this time use an n-channel JFET.

In choosing a circuit, the common-drain arrangement must be excluded because the voltage gain is somewhat less than one. The common-gate circuit cannot be used because its input impedance is about R_S, and R_S is normally much less than the required 47,000 ohms. By the process of elimination, only the common-source circuit remains.

The drain resistor is chosen here on the same basis as the collector resistor was chosen for the bipolar device. The effect of any load on the circuit must be negligible. Drain resistor R_D should be less than 1/10 the size of the load it must feed, or 1/10 of 47,000 ohms. Let R_D = 4700 ohms. The current swing across this resistor is at least ±60 mV/4700 ohms or approximately ±13 microamperes. This is indeed a very small current.

Let us try an initial paper design by choosing an inexpensive 2N4302 to do the job. Due to transistor tolerances within this type, I_{DSS} can have any value between 0.5 mA and 5 mA, and still pass as a standard 2N4302. From the curves supplied by the manufacturer, it is estimated that the pinch-off voltage is 0.8 volts when I_{DSS} is 0.5 mA and 3.3 volts when I_{DSS} = 5 mA. Using Equation 2, the respective g_{mo} values are 1.25 × 10^{-3} mhos and 3 × 10^{-3} mhos.

Now determine if this transistor can do the job. Draw approximate transfer characteristic curves for this transistor as shown in Fig. 4. This is executed by connecting the maximum I_{DSS} point to the respective maximum V_{GS} point with a straight line, and then repeat this procedure for the minimum values of these characteristics.

The quiescent drain current and drain to source voltage are the next items to be considered. It is obvious

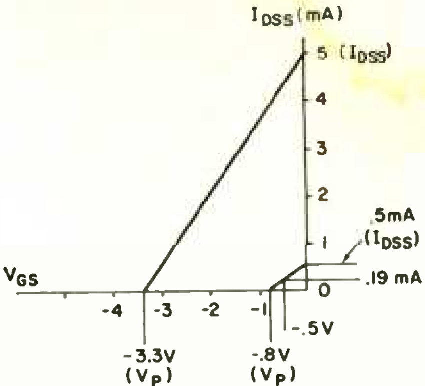

FIG. 4—TRANSFER CHARACTERISTIC curves for 2N4302 field-effect transistor.

from the drain characteristic curve in Fig. 3 that V_{DS} should not be allowed to drop below 1.5 times the pinch-off voltage if we are to operate within the linear pinch-off region of the curves. The minimum idling gate-to-source voltage, V_{GS}, should be about ⅔ of pinch-off voltage at a minimum so that the drain current changes with V_{GS} will be relatively linear.

The idling current is most critical on the lower curve in Fig. 4, for the current swing is limited to but 0.5 mA. The minimum idling V_{GS}, limited to ⅔ V_P can be set at 0.5 volts. The idling current will be 0.19 mA. It can easily swing the required ±13 µA around this value without forcing the FET into pinch-off.

The transconductance at a 0.19 mA drain current, from Equation 1, is $g_m = g_{mo}\ (I_D/I_{DSS})^{1/2} = 1.25 \times 10^{-3}\ (.19/.5)^{1/2} = .76 \times 10^{-3}$ mhos. Assuming $R_S = 0$ and R_D = 4700 ohms and using the common source equation in Fig. 2, the maximum possible gain is $g_mR_D = (.76 \times 10^{-3})\ (4.7 \times 10^3) = 3.6$.

At first glance, the gain of 3.6 is satisfactory. Consider that the source resistor, R_S, is shorted to obtain this gain. The source resistor is important for distortion reducing feedback voltage is normally developed across it. If, for example, the gain were to be 6 rather than 3.6, half the gain may be lost by developing feedback voltage across the source resistor. At the same time this feedback will provide a reduction in distortion by a factor of two. Although the gain using a 2N4302 borders on the satisfactory, we should do better.

Choose a somewhat higher gain and higher priced transistor, the 2N4303. It has a minimum g_m of 2000. Do the rough estimations to determine if this device will work.

The curves for the 2N4303 reveal the following characteristics. I_{DSS} can assume values anywhere between 4 and 10 mA. The respective pinch-off voltages are 2.9 and 5. Using Equation 2, it can be shown that g_{mo} is 2.75 × 10^{-3} mhos for a device whose I_{DSS} is 4 mA and 4 × 10^{-3} for the 2N4303 whose I_{DSS} is 10 mA. Draw transfer charactertistic curves for this transistor, as in Fig. 5.

The minimum quiescent V_{GS} is chosen on the lower curve at ⅔ of V_P, or at about 2 volts. The idling current for the 2N4303 with this extreme characteristic is 1.25 mA. The g_m at this idling

*g_m and g_{fs} are identical. At low frequencies, these are equal to y_{fs}, the common-source transadmittance. Since y_{fs} includes the capacitor in the equivalent circuit, it is much larger than g_{fs} at high frequencies, where g_{fs} is more significant. These symbols may be shown on data sheets.

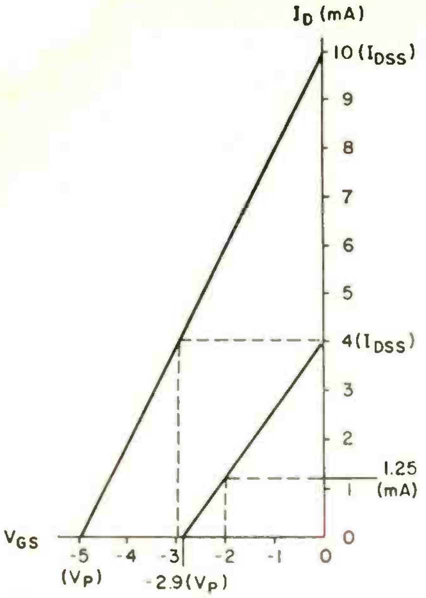

FIG. 5—APPROXIMATE TRANSFER curves for the 2N4303 transistor.

current is $(2.75 \times 10^{-3})\ (1.25/2.9)^{1/2} = 1.8 \times 10^{-3}$ mhos. The maximum possible gain, g_mR_D, is $(1.8 \times 10^{-3})\ (4.7 \times 10^3) = 8.5$. This gain is more satisfactory than was possible with the 2N4302.

As for a transistor with characteristics approximated by the upper transfer curve, the idling gate-to-source voltage (about ⅔ of V_P) is 3 volts while the quiescent drain current is 4 mA. The g_m at this current is $(4 \times 10^{-3})\ (4/10)^{1/2} = 2.5 \times 10^{-3}$ mhos. The maximum possible gain for this particular device is therefore $(2.5 \times 10^{-3})\ (4.7 \times 10^3) = 11.8$. The gain using a 2N4303 with an I_{DSS} of 10 mA is as satisfactory as the gain of the 2N4303 with the I_{DSS} at the lower extreme.

Being convinced that we have a good chance to complete the design using a 2N4303, draw fairly exact transfer characteristic curves for this device. We do this using the equation derived in a previous article, $I_D = I_{DSS}\ (1 - |V_{GS}|/|V_P|)^2$, where I_D is the drain current that will flow when $|V_{GS}|$, the absolute value of the gate-to-source voltage, is applied between these elements. Substituting numbers into the equation yields the curves in Fig. 6. One curve is for a device whose I_{DSS} is at its maximum of 10 mA and the other for a 2N4303 with an I_{DSS} at 4 mA. We will assume operation is at 25°C. See

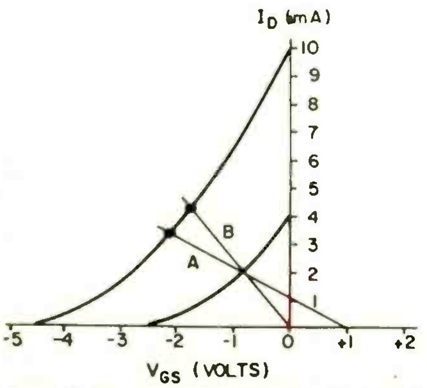

FIG. 6—TRANSFER CURVES for 2N4303 at 25°C. Upper and lower curve are for I_{DSS} values of 10 and 4 mA, respectively. Reciprocal of line A is value of R_S in Fig. 7-a and line B is for Fig. 8.

Table 1. Determination of transfer characteristic curves from equation $I_D = I_{DSS}\ (1 - |V_{GS}|/|V_P|)^2$ for 2N4303 transistor. The equation is used to derive the curves for the extreme conditions when $I_{DSS} = 4$ mA, $|V_P| = 2.9$ volts and when $I_{DSS} = 10$ mA and $|V_P| = 5$ volts.

V_{GS} volts	$I_{DSS}\ (1 - \lvert V_{GS}\rvert / \lvert V_P\rvert)^2$	I_D mA
For $I_{DSS} = 4$ mA, $V_P = 2.9$ volts		
0	$4\ (1 - 0/2.9)^2$	4
1	$4\ (1 - 1/2.9)^2$	1.71
2	$4\ (1 - 2/2.9)^2$	0.38
2.9	$4\ (1 - 2.9/2.9)^2$	0
For $I_{DSS} = 10$ mA, $V_P = 5$ volts		
0	$10\ (1 - 0/5)^2$	10
1	$10\ (1 - 1/5)^2$	6.4
2	$10\ (1 - 2/5)^2$	3.6
3	$10\ (1 - 3/5)^2$	1.6
4	$10\ (1 - 4/5)^2$	0.4
5	$10\ (1 - 5/5)^2$	0

Table 1 for the various points to be plotted, as determined from the equation.

On the lower curve, when $V_{GS} = 2$ volts, $I_D = 0.38$ mA. The actual g_m at this current is $(2.75 \times 10^{-3})\ (.38/4)^{1/2} = 0.84 \times 10^{-3}$ mhos and the maximum gain is $(.84 \times 10^{-3})\ (4.7 \times 10^3) = 3.95$.

This gain is too close to the required 3. We should actually have a minimum gain of about 6 without feedback so that we can apply 6 dB of feedback to cut gain and distortion in half. To establish a minimum gain of 6, use the following procedure. Substituting numbers into the gain equation, $A_v = g_mR_D = 6 = g_m\ (4.7 \times 10^{-3})$, we find that g_m must be at least 1.28×10^{-3}.

The minimum drain current for this g_m can be derived using Equation 1 where $g_m = g_{mo}\ (I_D/I_{DSS})^{1/2}$. $1.28 \times 10^{-3} = (2.75 \times 10^{-3})\ (I_D/10)^{1/2}$. Solving for I_D, we find it must be at least 2.1 mA. Use $I_D = 2$ mA and $V_{GS} = -0.82$ volts as the bias point on the lower curve.

As for the upper curve, when $V_{GS} = 3$ volts, $I_D = 1.6$ mA. This is less than the quiescent current chosen for the lower curve. Proceed up the $I_{DSS} = 10$ mA curve and select a point where the idling current will be higher than that chosen for the lower curve. Let us use, for example, $I_D = 3.4$ mA and $V_{GS} = -2.1$ volts. The g_m at this drain current is $(4 \times 10^{-3})\ (3.4/10)^{1/2} = 2.33 \times 10^{-3}$ mhos so that the maximum gain for a transistor whose characteristics are along the maximum I_{DSS} curve is $(2.33 \times 10^{-3})\ (4.7 \times 10^3) = 11$.

Connect the point determined on the upper curve to the one on the lower curve with line A. The reciprocal of the slope of this line, (2.1 volts − 0.82 volts)/(3.4 mA − 2 mA) = 910 ohms. This is R_S in the transistor circuit. Extend line A to the horizontal axis at +1 volt. This positive voltage must be placed between the gate and ground. (See the article on FET bias). The circuit will initially take the shape shown in Fig. 7-a. We must now proceed to determine the remaining components in the circuit.

The minimum drain supply voltage, E_{DD}, is the sum of the maximum voltage across R_D and R_S added to the minimum voltage that can be placed between

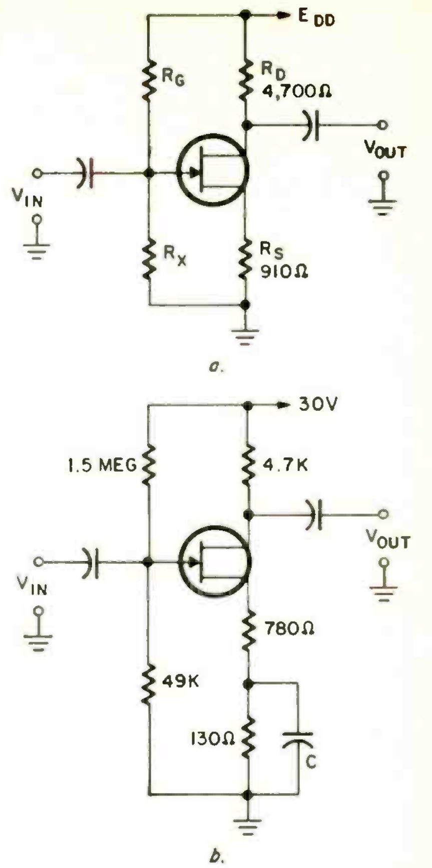

FIG. 7—POSITIVE GATE VOLTAGE bucks negative voltage across R_S. Negative feedback across R_S (in a) reduces gain below desired level. Spliting R_S (in b) and adding capacitor C eliminates feedback across the 130-ohm resistor.

the source and drain of the FET. To be certain that the FET is operating in the pinch-off region, the minimum voltage across the transistor should be $1.5V_P$ (max) = 1.5 × 6 = 9 volts. (The maximum pinch-off voltage is specified by the manufacturer of the 2N4303 as 6 volts.) The maximum voltage across R_L and R_S is $I_D(\max)\ (R_L + R_S) = (3.4 \times 10^{-3})\ (4700 + 910) = 19.1$ volts. E_{DD} must be at least 19.1 + 9 = 28.1 volts. Use a 30-volt supply.

Knowing that $E_{DD} = 30$ volts and that 1 volt must be across R_X, we can now write two simultaneous equations to determine R_X and R_G.

The circuit must present a 47,000-ohm resistance to the signal source. As far as the input is concerned, R_X is in parallel with R_G. One equation is therefor $47{,}000 = R_GR_X/(R_G + R_X)$.

One volt is to be across R_X. R_G and R_X form a voltage divider and E_{DD} (30 volts) is across the two resistors. The second equation is $1 = 30\ [R_X/(R_G + R_X)]$. The approximate solution to the two equations yields $R_X = 49{,}000$ ohms and $R_G = 1.5$ megohms.

The 910-ohm resistor in the source reduces the gain due to feedback. From the $I_{DSS} = 4$ mA curve, where $g_m = 1.28 \times 10^{-3}$ mhos, the overall gain of the circuit using the equation in Fig. 2 is $A_v = (1.28 \times 10^{-3})\ (4.7 \times 10^3)/[1 + (1.28 \times 10^{-3})\ (910)] = 2.77$. This is somewhat less than the required 3.

(continued on page 75)

10 Reasons why RCA Home Training is

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Potpourri of IC Applications

New feature goes inside the IC. Examines the circuits in that little black box and shows some new ways of using them

by WALTER G. JUNG

THE ARTICLE AND CIRCUITS WHICH FOLLOW are a departure from conventional circuit or construction articles. Over the years **Radio-Electronics** has published several IC articles, covering a variety of devices and applications. But while these projects do have great appeal to those interested in the particular speciality, you cannot satisfy all tastes simultaneously while still providing in-depth coverage of a particular area. To bridge the gap the following alternative has been developed. We hope that in a sense it will allow some (hopefully most) readers to have their cake and eat it too.

What it amounts to is suggested in part by the title. But it is not just a collection of circuit applications for a particular IC type. It is also a potpourri of IC types as well as applications. So the reader can put his new found knowledge to work on his own pet project. The IC types used are standard types, readily available at palatable prices. We hope this approach will come a step closer towards providing something meaningful for more readers. As always your comments are welcome.

The IC lineup

Before we get into actual circuit discussion, it might be appropriate to discuss typical types of IC's we'll be using.

The CA3018

Leading off is an IC which is a sort of hybrid between discrete transistors and their monolithic cousins. This device, the CA3018, is a 4 transistor array with the matched parameters typical of monolithic IC's (see Fig. 1). This IC provides the flexibility of discrete transistors as all the internal transistor terminals are brought out to our outside world, yet the 4 transistors within are extremely well matched electrically. This is the really big difference in IC transistors, the matched characteristics. When we get into the circuits portion later we'll see how to put these matched properties to work for us. In the meantime remember the CA3018 provides 4 general-purpose matched monolithic transistors which can be interconnected in a variety of ways.

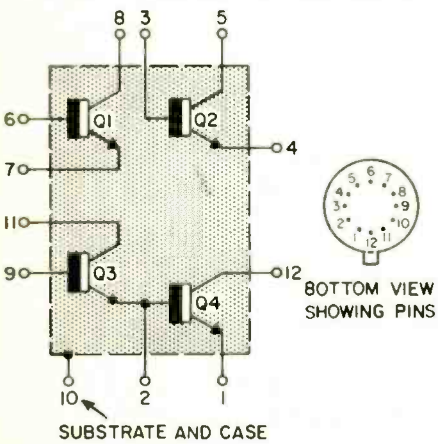


FIG. 1

The 709

The second device we'll be talking about is the operational amplifier, and the prototype of all op-amps is the 709. Just about every chipmaker and his brother makes this IC, and it can be found weakly disguised under many similar sounding "709" type numbers. The circuit symbol for the 709 is shown in Fig. 2. Also shown here are the two input connections, the single output, the power supply connections and components necessary to stabilize the unit in most circuit applications. While we won't be able to go in depth into op-amp theory, we'll cover enough here to be able to apply the device to basic applications. The really energetic reader, should he care to, can refer to previous **Radio-Electronics** op-amp coverage.

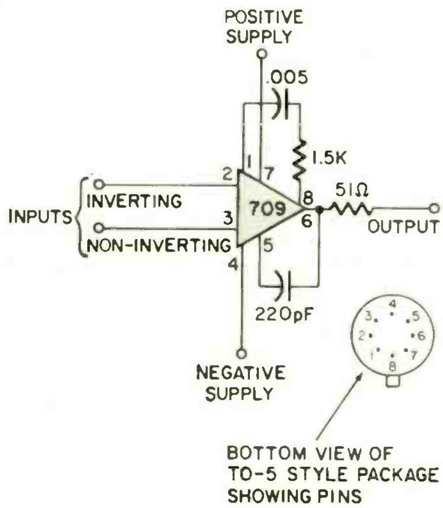


FIG. 2

Basically a 709 (or any op-amp for that matter) is a high-gain differential-input amplifier with a single-ended output. This means it will amplify the difference between two input terminals and ignore their potential with respect to the circuit common. The device has a very high open-loop gain, usually over 10,000 and in some instances as much as 100,000 or 1,000,000. The commercial-industrial version of the 709's we'll be discussing has a minimum gain of 15,000. This very high gain can be used to advantage in the negative-feedback configuration of Fig. 3. This basic connection for the 709 illustrates several fundamental op-amp principles. We'll go over these quickly now so as to have a good grasp for the circuits to be covered later.

In this circuit, the input signal is applied to the amplifier through input resistor R_{in}. If we ignore resistor R_f for a moment, let's see what happens to the signal. Since the 709 is a differential-input amplifier, it will amply this input signal since it is applied between the − and + inputs (+ side of input is grounded). The 709 will invert the phase of this signal and the amplified output will be 180° out of phase with the input. You would expect anything but the smallest millivolt level signal to overdrive this circuit, and it does in fact since the 709 will amplify it by a factor of 45,000 average gain. Right off hand, this doesn't appear to be too useful, but let's see what happens when some negative feedback is applied.

Since the output voltage is out of phase with the input, connecting R_f from the output to the input should provide negative feedback. To visualize what happens, let's examine the amplifier for a moment. Before we applied the feedback, we had a big output signal, 180° out from our input. Now if we connect this signal back to the amplifier input through R_f, what must happen? Obviously, current must flow in R_{in} and R_f as their two opposite ends have different potentials, 180° out of phase. If this is true, then somewhere along their lengths there will be a zero voltage point. Now even if I didn't already know I'd begin to suspect the amplifier, as it's the only thing there that could be causing this phenomenon. After all the resistors can't amplify can they?

Well, if you suspected the input of the amplifier might be a zero voltage point you're right. But let's qualify this statement. How can the input of an amplifier be at zero potential and the amplifier have an output? It can't! But this is where the very high gain comes in. We know that if the amplifier is to have an output it *must* have an input. But if the amplifier has a very high gain, as we have previously stated, the input need only be very small. A 10-volt output would only require a 1-mV input signal if the amplifier had a gain of 10,000. Now it is beginning to make some sense. Compared to 10 volts, 1 mV *is* almost a zero potential. So the input terminal of the amplifier is for all practical purposes a "zero potential" point.

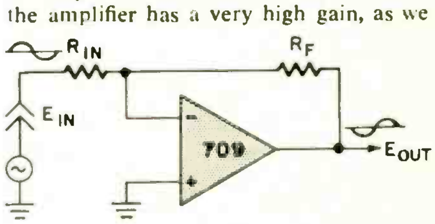


FIG.3

There is still one point to be covered—gain. We have stated that the input voltage and output voltage sum together to zero volts at the amplifier input. But what about the gain of the circuit? Suppose we want a gain of 10 for instance, what governs the selection of R_{in} and R_f?

It turns out this boils down very logically also. If R_{in} and R_f are to sum the input and output voltages to zero, then the currents flowing in each resistor must be equal and opposite. So, to make the voltage at the end of R_f (the output voltage) larger, increase R_f since the current must remain the same as that in R_{in}. It's as simple as Ohm's law. The input current will be $I_{in} = \frac{E_{in}}{R_{in}}$. Since the output current (I_f) is the sme value but opposite sign, then $E_o = I_{in} \times R_f$ or $R_f \times \frac{E_{in}}{R_{in}}$. And this is the gain of the circuit $\frac{E_o}{E_{in}} = \frac{R_f}{R_{in}}$.

Just crank in various values of R_f and R_{in} and the amplifier will go to work and generate an output which will satisfy these conditions. This is the basic principle of this configuration. The amplifier's negative input is a summing junction for the input current (I_{in}) and the feedback current (I_f). This junction is considered a zero voltage point or "virtual ground" and the minute voltage which does appear at this point is the error voltage which drives the amplifier.

There are a few general characteristics we should remember about this configuration.

1. Input impedance is equal to input resistor R_{in} since the summing junction is effectively at ground potential.

2. The gain is equal to the ratio of R_f to R_{in}. Variation of either can change the gain. By the same token, if either the R_f or R_{in} path is made frequency selective (such as a RC network) special response shapes can be tailored. It is important to remember that the gain and response of the circuit will be dependent on the feedback components rather than the amplifier itself.

There are a few other general points to remember about op-amps. Circuits using them are generally dc coupled, which means dual power supplies. If you're one used to single supply ac coupled designs, don't let this slow you down. We'll show you how to make an economical yet high performance dual supply using some more IC's.

The 723

Next in our IC lineup comes the 723, a popular power supply regulator. The 723 is a complete power supply system built into an IC chip. Refer to Fig. 4 to see what we mean. In this functional block diagram we'll show a typical example of how the 723 is used as a series regulator.

The 723 contains 4 basic components used in the control of a regulated voltage. First is a *Zener diode reference* that develops a stable 7-volt dc potential which is used as a reference for an error amplifier. This reference voltage appears on pin 4. The *error amplifier* is a high-gain differential amplifier. This amplifier has two inputs, inverting and non-inverting; similar to the 709 we've just been discussing. The

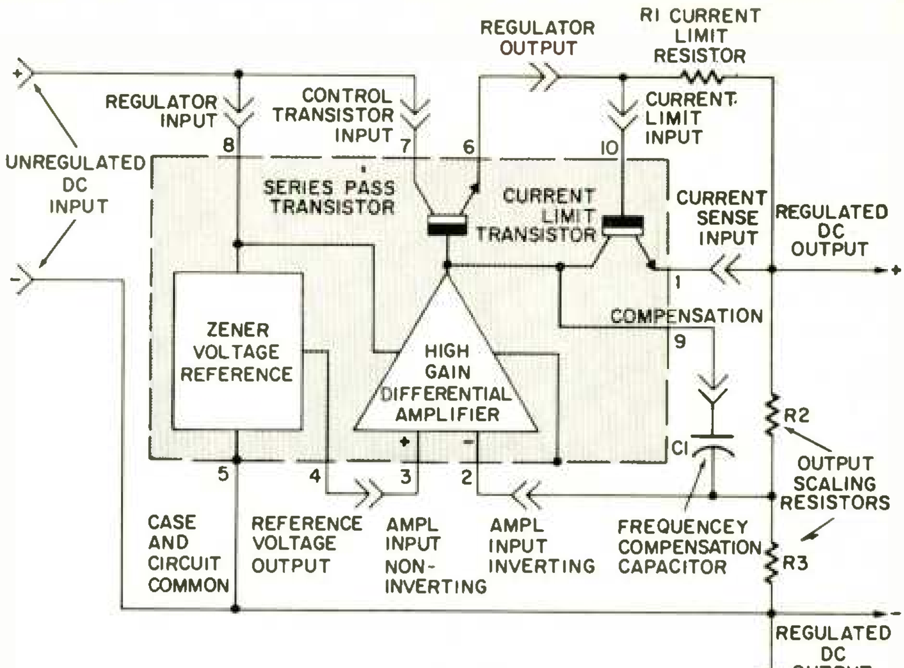


FIG. 4

series pass transistor is connected in series with the unregulated input, and acts as a variable resistance controlled by the error amplifier to regulate the output to the desired potential. The *current limit transistor* samples the output current to detect overloads.

So now let's run through the hookup as shown to see how regulation is actually accomplished in this circuit. The reference voltage is applied to one side (+ input, pin 3) of the differential amplifier. This stable potential serves as a comparison voltage for the output sample provided by R2 and R3. If the output voltage is attempting to drop because of increased loading, the tap on R2-R3 will feed back this change to the amplifier (− input, pin 2). Nominally this tap will be 7 volts dc, or equal to the reference input. But an output change will cause an error voltage to be generated at R2-R3. Since the reference input is stable and independent of the output, this error voltage appears as a *differential* signal to the error amp and is amplified, and drives the series pass transistor in the proper direction to correct the error.

R2 and R3 are called output scaling resistors because they multiply the reference voltage applied to pin 3. It can best be visualized by looking at R2 and R3 as a voltage divider which always has the same output voltage, 7 volts (this is true because of the differential input amplifier). Since the divider output across R3 is always equal to the reference voltage, the output can be changed simply by varying the $\frac{R2 + R3}{R3}$ ratio.

The current limit action is independent of the voltage regulator and is determined entirely by the value of R1 and V_{be} of the current limit transistor. Since the output voltage is sampled *after* this current limiter, its series resistance does not adversely affect the voltage regulation.

The remaining factor we haven't discussed is the compensation terminal, pin 9. This point is brought out to control the frequency response of the error amplifier (similar to the corresponding components on the 709). The correct response is set by a small feedback capacitor to the amplifier's inverting input.

Essentially, that is how the 723 regulates a voltage. One might ask "what's so different about it, don't most all regulators operate pretty much that way?" Well that's true, most do. But this one does it all within a TO-5 can, up to 150 mA worth and at up to 37 volts output. And with performance hard to match—better than 0.1% line and load regulation and excellent temperature stability. Later on in the circuits section we'll put together a number of cuircuits using this IC; enough power supplies to power any circuit in this series and many more for time to come.

The LM371

Another IC we'll be talking about is the LM371, an integrated circuit differential amplifier. In Fig. 5, we see that the LM371 has a matched pair of transistors with their emitters tied together and connected to the collector of a third transistor. This transistor provides the emitter current for the Q1-Q2 pair. It is commonly referred to as a "constant-current" transistor because its collector current remains constant under changing conditions on base bias to Q1-Q2. With the *total* emitter current of the Q1-Q2 pair determined by Q3, the relative proportions (or balance if you prefer) of this current will be determined by the difference in the base voltages of Q1 and Q2. If Q1's base voltage is higher, it will conduct a larger percentage of current than Q2. On the other hand if Q2 were to become more positive, it would then conduct the larger proportion. If both base voltages are equal, Q1 and Q2 will share the current from Q3 equally and their collector currents will be balanced.

An interesting property of this cur-

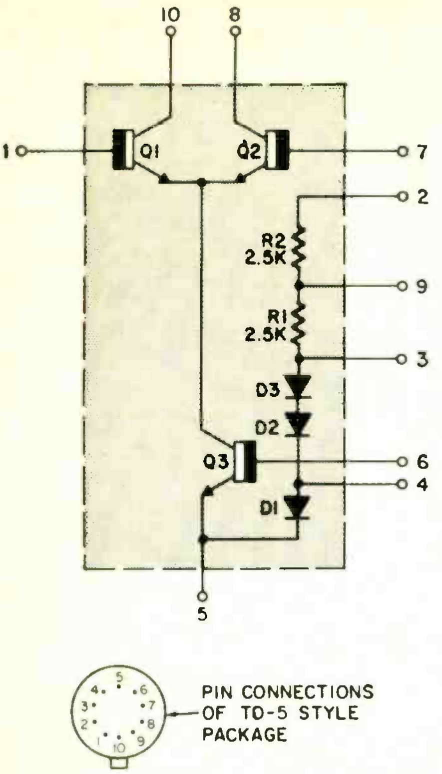


FIG. 5

rent shifting between the Q1-Q2 pair is the relatively small voltage required to transfer the current from one side to the other—its only about 100 millivolts! If an input signal goes beyond this no further change in collector current will occur as it is limited to the total amount being supplied by Q3.

So you can transfer the signal back and forth between the differential pair with a relatively small input level, but the maximum output current of either one of the pair is limited to that of the emitter transistor, Q3. However at low signal levels where each transistor is conducting 50% of the static current, linear amplification of the differential input signal occurs.

We see how it amplifies differential (base to base) signals. But what about signals to ground? Suppose we put the same signal on both bases and tried to amplify it. Since both bases receive the same signal there is no differential signal and the balance remains the same. What about the total current, does it change? This is where Q3 comes in. Q3 is immune to any voltage changes on the bases of Q1 and Q2, as we stated before. So if it is, the total current in Q1 and Q2 cannot change and they will not amplify. This is what is called *common-mode rejection*, as it rejects a signal which is common to both transistors of the differential pair. So there is little amplification of common mode signals.

The biasing of the Q1-Q2 pair is provided, as we said, by Q3. Q3 is biased by jumpering pin 4 to 6, connecting the base of Q3 in parallel with D1. Now D1 is really a diode connected transistor identical to Q3 (remember how we said monolithic transistors are naturally matched). So this means that they will drop the same amount of voltage for the same current. If we connect R2 or R1 to a positive voltage and ground pin 5, a current will flow through D1-D3 and R1-R2. Since D1 is in parallel with Q3, Q3 will conduct the *same* current as that in D1 since they're identical. And so this same current will flow in Q1-Q2 and thus their external loads. By connecting a tap on the bias string (either R1 or R1 + R2) we can bias the Q1-Q2 pair at a predictable current level, the same as the bias string.

What about the base bias of Q1 and Q2 you say? Another tap is available for them, pin 3. Connecting the bases of Q1 and Q2 through equal resistors to this point will ensure a 50-50 balance between Q1-Q2. Fig. 6 is a complete picture of the LM371, all biased up as a push-pull amplifier.

Later on when we get into the circuits section we'll see how to really use this IC to advantage.

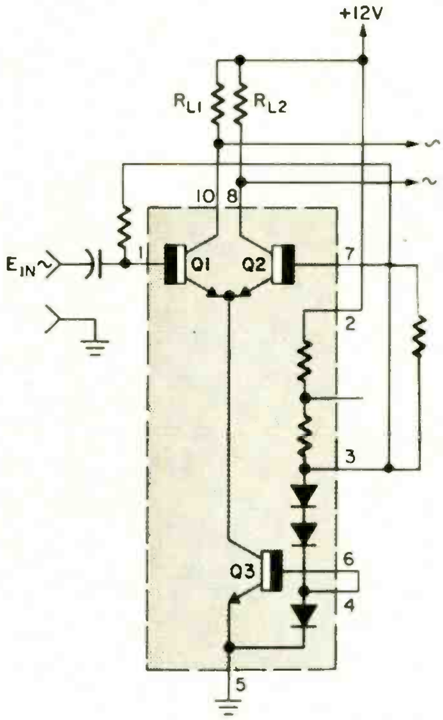


FIG.6

Logic devices

We'll also cross over into the digital world and talk about a few applications of some popular logic elements. We'll talk about the Utilogic series of OR and NOR gates and some interesting applications. This particular family is attractive because it is representative of today's technology, is highly versatile, and priced right.

Rather than go into the complex innards of these elements we'll talk about their use in terms of function.

The OR and NOR gates are shown in Fig. 7. These gates are logically very similar but the NOR gate has an inverting function also. Logically speaking an OR gate is a device or circuit which will give a logic "one" or "high" output when either of its inputs is high, such as A or B. So a one on either input gives a "one" out. A NOR gate is similar in input logic, but gives a "zero" output of either A or B is high, thus the term NOR or NOT-OR. Now all of this thinking is based on the premise of a "one" signal being true. In other words these circuits give an output based on the combination of high inputs. If either A or B input of an OR gate is high, the output is high, or true.

But by inverting our thinking, the same device can be used for the AND and NAND functions. Think about the OR gate for a moment. We said the output would be high if either A or B were high. What are the requirements for a *low* output? Both A *and* B must be low to give a low output. So this same device can serve as an AND gate for negative or inverted logic. It is however, convention to think always in terms of the one state as true.

We also see in Fig. 7 that each package contains four of these two-input NOR or OR gates. All of the gates within a single package use a common supply

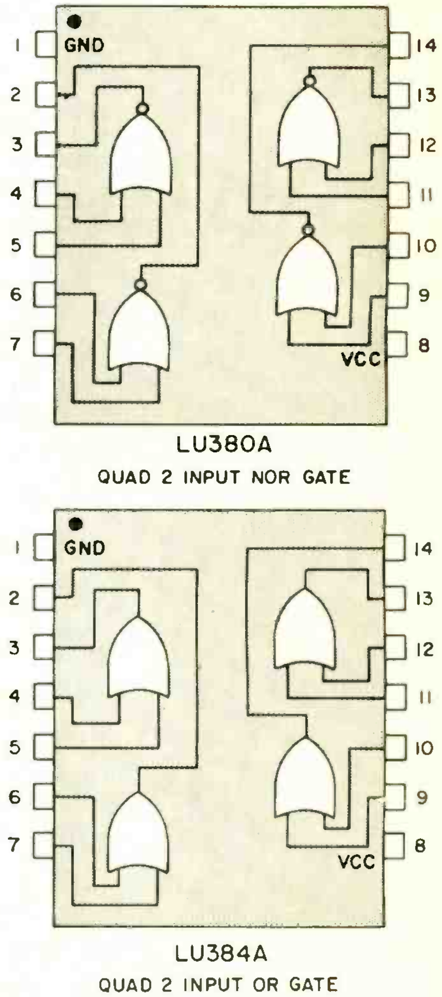


FIG.7

line (pin 8) and a common ground line (pin 1). So in using the gadgets you just hook up the power supply to the chip and then apply the signals to get the logic combination desired. The output signals of course, are always 0 to +5 volt levels.

In our circuits discussion we'll show how these gates can be used to make oscillators, Schmitt triggers, pulse generators, and other useful waveforms. These things can be quite handy when combined with other IC's and some discrete parts. R-E

Rumble has long been a problem in hi-fi turntables. Here are three unique solutions using electronics for precise record speed.

those new turntables

Sony TTS-3000

Norelco 202

Thorens TD-125

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

THROUGH THE YEARS WE HAVE WATCHED THE WAX AND wane of hi-fi circuit innovations and have tried to keep you up to date on the newest developments. Well, quadrasonic or 4-channel stereo is the most-talked-about development today but we'll let others fill you in on day-to-day developments in this field and we'll wait until we can give you actual circuits and a rundown on how they work. In the meantime, let's take a look at electronic turntables—a development that appears to have great promise in the hi-fi field.

Rumble from phono turntables becomes increasingly evident as the low-frequency response of speakers and cartridges is improved. Rumble is the result of mechanical vibrations in the motor, idlers, pulleys and other rotating components in the turntable system. The vibrations are picked up by the cartridge and amplified as an annoying and unwanted sound.

Rumble intensity depends on the weight (mass) of the rotating parts and their velocity. If precision bearings are used throughout the system, then rumble intensity equals *half* the mass of the rotating components multiplied by the square of the velocity. Thus, rumble can be reduced by reducing the number of rotating parts and by reducing their weight and velocity.

Around 10 years ago, Weathers developed a turntable with exceptionally low (at that time) rumble by using a very light rim-drive turntable platter driven by *two* tiny motors resembling those used in ordinary electric clocks. Weathers cut rumble intensity by sheer weight reduction.

Most turntables (and record changers) are driven by motors rotating at speeds ranging from several hundred to several thousand rpm. Turntable platter speed is reduced to 16⅔, 33⅓, 45 or 78 rpm by belt drives, step pulleys, gears, etc. In an effort to reduce motor speed; and thus the velocity and number of speed-reducing components, several firms have developed electronic turntables employing lightweight motors that operate at comparatively low speeds.

Thorens TD-125

Sold in the United States by Elpa Marketing, the TD-125 uses a 16-pole synchronous motor driven by a variable-frequency synchronous Wien bridge oscillator whose frequency is, in turn, locked to the motor speed. A 3-position speed-change switch sets the oscillator frequency to approximately 20, 40 and 50 Hz for motor speeds of approximately 150, 300 and 375 rpm for 16⅔, 33⅓ and 45-rpm records, respectively. Record speed can be precisely set by adjusting a knurled thumbwheel (PITCH control) so the appropriate stroboscopic pattern is stationary. The PITCH control can be seen just below the window through which the stroboscope pattern may be seen in the TD-125 photo.

The diagram of the TD-125 is shown in Fig. 1. Transistors Q1 and Q2 form the push-pull Wien bridge oscillator. The output is taken from the collector of Q1, amplified by Q3 and then fed to the OTL output stage (Q6-Q7) via drivers Q4 and Q5. Motor winding L1 and feedback for the bridge are fed from the junction of the collectors of output transistors Q6 and Q7. Motor excitation winding L2 is returned to ground through one of three R-C networks to provide maximum torque at the operating speed.

The TD-125 comes with an interchangable pickup-arm mounting board so arms can be changed at will. The mounting board is bolted firmly to the heavy cast aluminum chassis that supports the turntable. This chassis is shock-mounted by springs to a second chassis (Fig. 2) that supports the motor and the controls. Thus, the turntable and pickup arm are isolated from motor vibrations and external shock. The suspended chassis with turntable platter and pickup arm weighs more than 16 pounds. The inertia of this mass further minimizes the pickup of vibrations caused by external shock or acoustic feedback.

Sony's TTS-3000

This turntable uses a dc motor whose speed is controlled by the voltage applied to it. The motor drives the turntable through a belt system. Also on the motor shaft is a toothed wheel made of soft iron. A magnetic pickup generates an ac pilot signal voltage whose frequency depends on motor speed.

This ac voltage is amplified, clipped and then fed through a bandpass filter to an amplifier and full-wave rectifier. The filters have a rolloff of 70-dB per octave and are set to 500 Hz and 675 Hz, for 33⅓ and 45 rpm, respectively, are centered on the linear portion of the rolloff slope (Fig. 3).

The rectifier output—a dc voltage determined by motor speed—controls the dc amplifier driving the motor. The dc amplifier is blocked in the absence of the pilot signal from the magnetic pickup. Thus, a starting circuit is used to unblock the dc amplifier when the turntable is first turned on.

The schematic of the TTS-3000 is shown in Fig. 4. The magnetic pickup carries the base current of Q1. The ac pilot signal, generated in the pickup by the toothed wheel, is fed to the base of Q1 through C1. This pilot signal is amplified and then clipped to 1.4 volt p-p by a double diode (D1). The clipped signal is fed to one of a pair of series-connected "L" and Twin-T filter networks; one tuned to 675 Hz for 45 rpm and the other to 500 Hz for 33⅓ rpm. The filters are tuned to precise frequencies by R2 and R3.

The filter output is fed to emitter-follower Q2. This provides a high input impedance to minimize loading on the filters. The SPEED control, R3, controls the signal amplitude and thus the motor speed. This ac signal is amplified by Q3 and transformer coupled to full-wave detector D2-D3. The detector output is a positive voltage that turns on and controls the conduction of dc amplifier Q5-Q7. Collector current for Q7 flows from the 12.3-volt positive line through the motor winding and diode D6 in series. The diode protects Q7 against voltage spikes that develop as the motor is turned off.

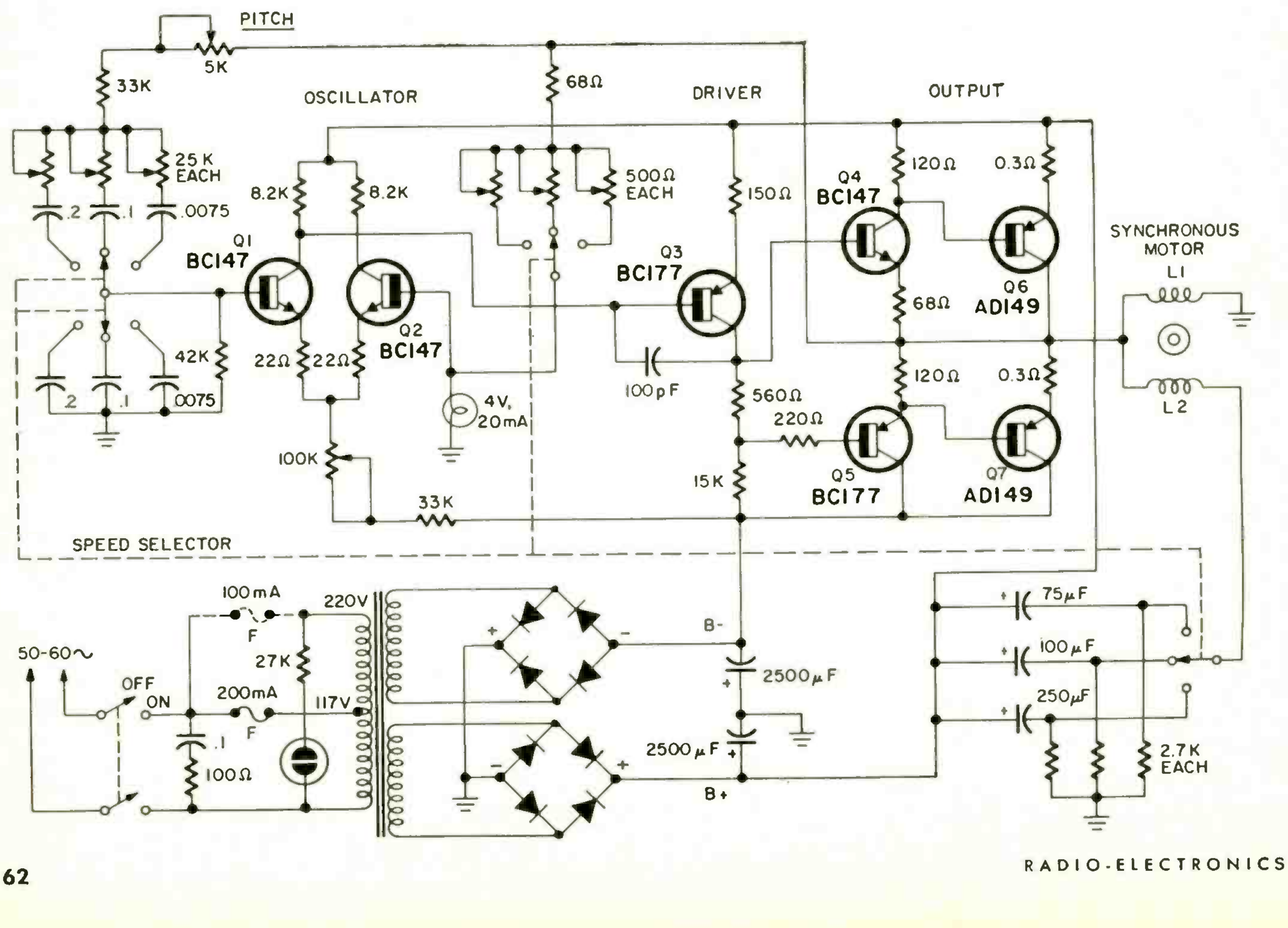
Motor-starting circuit

We have seen that Q5 and Q7 are turned on by the rectified pilot signal. Thus, when the motor switch is first closed, Q5 and Q7 are turned off and current cannot flow to the motor. Similarly, transistor Q4 in the motor-starting circuit is turned off.

When the motor switch is closed, a positive dc voltage is applied through network R4, R5, D4 and R6 to turn on Q5 and Q7; starting the motor. The pilot signal, now present at the output of clipper D1, goes through R7 and C2 to diode D5 to develop a positive voltage on Q4's base. This positive voltage drives Q4 to saturation and pulls the junction of R4 and R5 to ground.

At the same time, a positive voltage appears at the detector output. D4 is then back-biased; disconnecting the starting circuit and maintaining Q5-Q7 in conduction.

The power supply (not shown), a full-wave bridge developing 12.3 volts dc, feeds Q7's collector through the motor winding. The other transistors are fed a regulated 6.1 volt through series regulator Q6. A neon lamp illuminates a strobe disc around the turntable perimeter so the SPEED control can be set for precise speed.



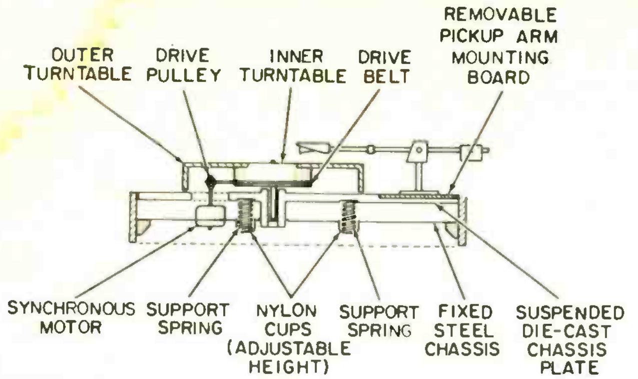


FIG. 2—SHOCK-MOUNTING system in the Thorens TD-125 turntable. Pickup-arm mounting board is interchangeable.

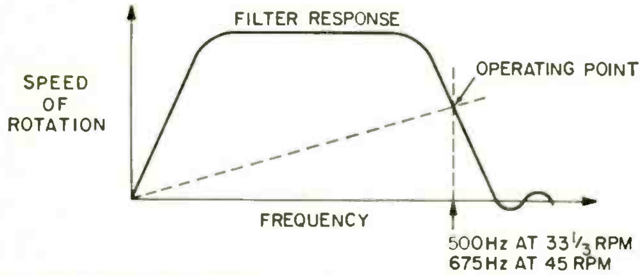


FIG. 3—RESPONSE CURVE of the L and Twin-T filters in series in the electronic control of Sony's TTS-3000 turntable.

Norelco 202 electronic turntable

This 3-speed (33⅓, 45 and 75 rpm) unit uses a dc motor with solid-state circuitry for minimum rumble, precise speed control and automatic shut-off. Since the speed of a dc motor varies with the voltage applied to it, two types of voltage regulation are employed. The schematic of the 202 is shown in Fig. 5.

The circuit operates from a −9-volt source using a shunt-type regulator. Additional circuitry holds motor speed constant regardless of variations in load or power supply. In a dc motor without voltage regulation, when the supply voltage changes, the voltage across the motor V_m changes by ΔV_m and motor speed changes by a factor n which equals $V_m - IR/C$: where I is load current, R is motor resistance and C is a motor constant.

Circuitry consisting of Q1 and Q2 compensate for ΔV_m. When the motor voltage varies by ΔV_m, there is a corresponding change in the voltage drop across Q1's emitter resistor. (Diodes D1 and D2 are forward-biased so the voltage drop across them is constant.) Q1's base voltage varies with respect to −9 volts by a factor (considering 33⅓ rpm).

$$\frac{R2 + R3 + R4_a + R5}{R2 + R3 + R4_a + R4_b + R5} \times \Delta V_m.$$

As the result of variation in Q1's base voltage, Q2's conduction changes so the change in emitter-collector voltage is exactly ΔV_m and is in a direction that holds motor speed constant.

Increased loading on the motor tends to decrease motor speed by factor n. Consequently, the motor terminal voltage must be increased by ΔV_m to keep the speed constant. As the load increases, the motor draws more current and there is an increase in the voltage drop across the resistor network between the positive motor terminal and Q2's collector. Q2's base current increases and its collector-emitter voltage decreases by ΔV_m volts to keep motor speed constant.

Automatic shut-off

The start-stop and automatic shut-off are controlled by Q3 and by bistable multivibrator Q4-Q5. When power is first applied to the circuit Q3 and Q5 are cut off and Q4 is conducting. The motor is off because its path to ground is through the collector-emitter circuit of Q5. This transistor is cut off and acts as an open switch.

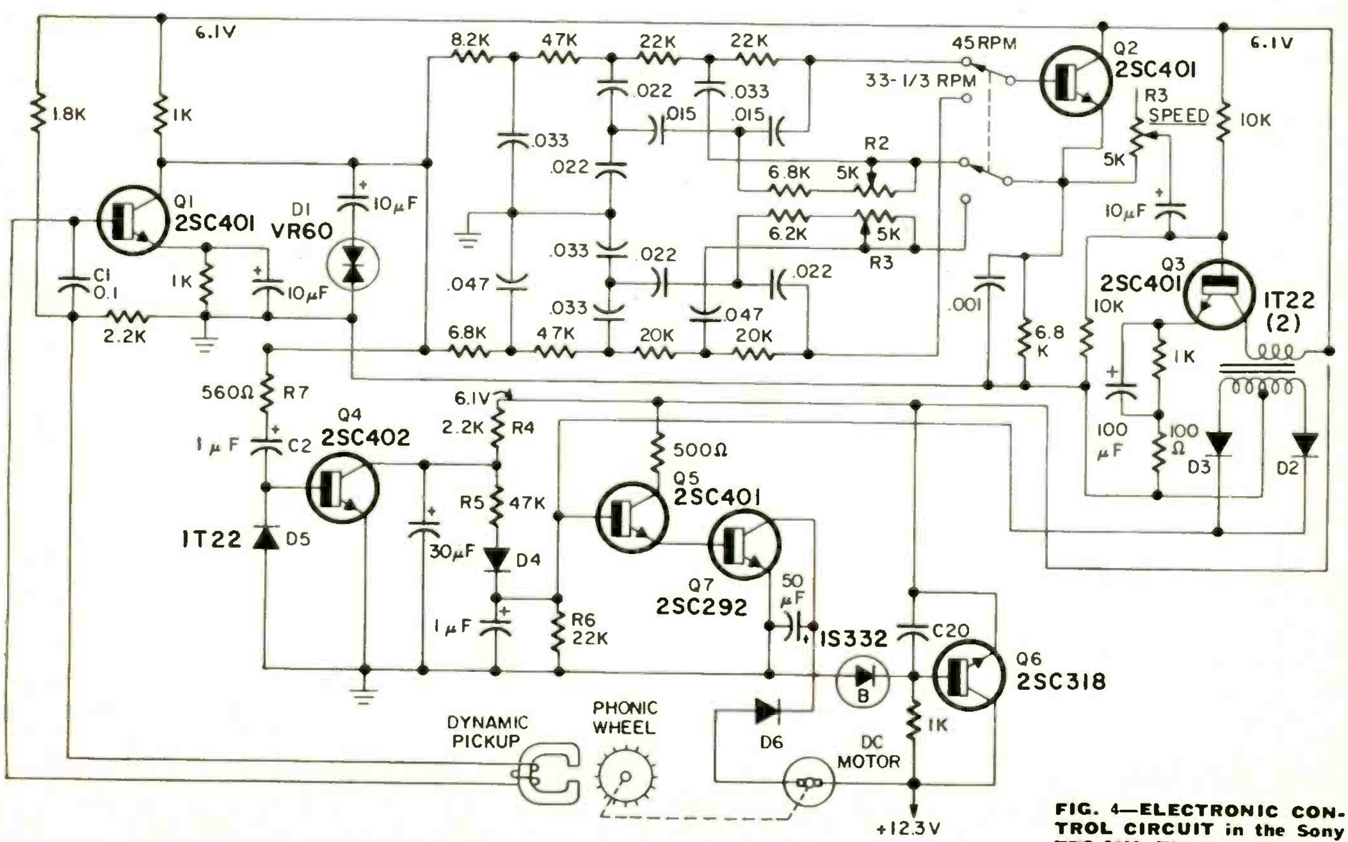


FIG. 1 (left)—WIEN-BRIDGE OSCILLATOR controls record speed in the Thorens TD-125 electronic turntable.

FIG. 4—ELECTRONIC CONTROL CIRCUIT in the Sony TTS-3000. The dc motor generates its own pilot control signal.

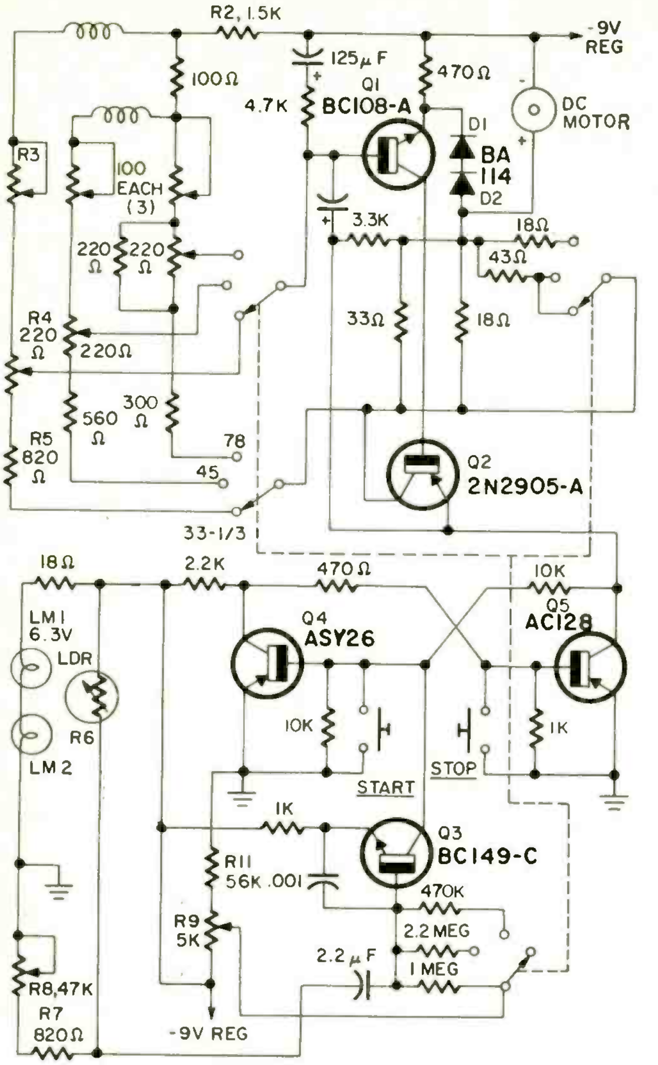


FIG. 5—NORELCO MODEL 202 CONTROLS. R4-a and R4-b in text are resistances above and below the arm of R4.

Pressing the START button grounds Q4's base so the multivibrator switches and Q5 conducts to complete the motor circuit. Pressing the STOP button grounds Q5's base. This causes the multivibrator to change state; cutting off current to the motor and keeping it off until the START button is pressed again.

The automatic shut-off is activated by a photoelectric circuit consisting of lamp LM2 and light-dependent resistor (LDR) R6. Attached to the bottom of the pickup-arm shaft or spindle is a film mask with a "V" shaped slot that passes between LM2 and LDR when the stylus moves in to about 65 mm from the turntable center. The mask decreases the light striking the LDR, causing its resistance to rise and increases the voltage drop across it. Note that C1 is connected between two voltage dividers: one R6-R7-R8 and the other R9-R10-R11 (in the 33⅓-rpm position).

The amount of light on the LDR decreases with each revolution of the record, resulting in a voltage drop of ΔE volts per revolution. The time-constant of the R-C circuit is set so the charge on C2 drains off faster than it increases and, thus, has no affect on circuit operation.

However, when the stylus reaches the run-out grooves at the end of the record—run-out grooves have a much greater pitch than music grooves—the voltage drop across the LDR is now much higher than ΔE volts per revolution. The voltage across C1 is now rising faster than it can leak off so it soon reaches the point where it turns on Q3. This triggers the multivibrator; turning on Q4 and turning off Q5 to stop the motor. R-E

Mounting IC Flat-Packs

by CHARLES D. GEILKER

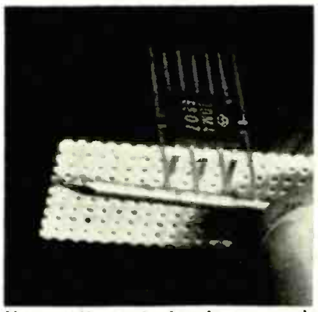
Flat-packs are currently the biggest bargain for IC experimenters—but making fourteen connections to a ¼-inch square can have its problems. The ideal mounting method would not greatly increase the size, would not require special tools, and would cost only a small fraction of the price of the IC.

Test sockets are available, but the least expensive ones cost more than $2, which seems excessive when the flat-packs cost only 75¢.

The appearance of Veroboard for ICs and (Vero Type 50255) and Micro-Vectorboard (Vector Electronics Type 126M76/032), a perfboard with diameter holes 0.025-inch, spaced on 0.050-inch centers, has made flat-pack mounting simple.

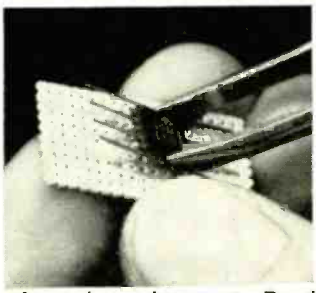
1. Using regular scissors, cut a 0.50 by 0.95-inch rectangle of perf board. This can best be done by cutting along a line drawn through the 10th and 19th rows of holes.

2. Using the edge of the board as a guide for thickness and spacing, bend down



three alternate leads on each side. A nail or small screwdriver blade is helpful here.

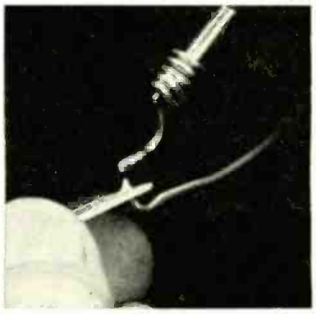
3. Insert the bent leads into the 6th row of holes from each end, using a pair



of manicure tweezers. Bend the six inserted leads flat against the reverse side of the board.

4. Cut fourteen 3-inch-long pieces of Belden 8014 indoor antenna wire. This may be done speedily by inserting the wire through the center of the metal spool (500-foot size), snipping, inserting more wire, snipping, etc. Strip both ends of each piece of wire: one end 1/16 inch, the other ¼ inch. Do not twist or tin.

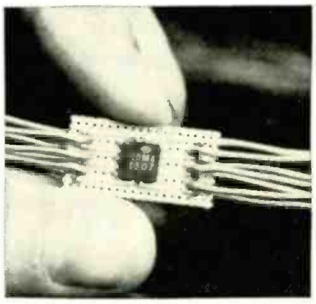
5. Wrap the tip of the soldering iron with bare No. 18 copper wire and form into a curved extension. Heat up the iron and tin the extension thoroughly. Even a ⅛



inch tip used directly is both too large (wider than two flat-pack leads) and too hot (the end of the extension should just comfortably melt the solder without "flashing" the flux to instant smoke).

6. Solder a wire to each flat-pack lead, passing the 1/16 stripped end through the perf-board hole from the opposite side, beginning with lead #1 and continuing, in order, to lead #14. The extension tip of the soldering iron should be brought in parallel to the lead and at an upward angle.

7. After all leads are soldered, with six entering from the top and eight entering from the bottom, bend the leads from both sides outward.



The finished product is a 923-923 dual J-K flip-flop, ready to use in an experimental circuit. A single piece of micro perf-board will mount more than fifty flat-packs, for about 6¢ each, and with a little practice the mounting procedure can be done in ten minutes.

Mounted in this way, the IC assembly is smaller than the commercial socket, and the experimenter has a durable, component. R-E

NEW PRODUCTS

More information on new products is available from the manufacturers of items identified by a Reader Service number. Use the Reader Service Card on page 89 and circle the numbers of the new products on which you would like further information. Detach and mail the postage-paid card.

SIREN ALARM SYSTEM *Archer,* comes complete with police-type siren. Any attempt to open hood, trunk or doors of vehicle sets off the alarm. Do-it-yourself installation can be accomplished without use of special tools. System includes siren, six alarm switches, lock,

two keys, warning decal, all necessary wire and hardware, and installation instructions. For 12-Vdc negative ground vehicles. $21.95.—**Allied Radio Shack,** 2725 W. 7th St., Fort Worth, Texas 76107.

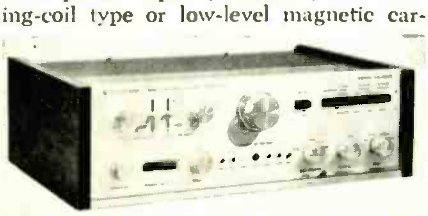
Circle 31 on reader service card

ISOLATION & BOOSTER FOR COLOR TUBES, *Perma-Power models C-503 and C-315.* Units correct for cathode-to-heater shorts by isolating the short. A slide switch supplies voltage boost when needed later in life of tube to com-

pensate for fading resulting from lowered electron emission. *Model C-503* is for 70° shell base (round) picture tubes and *Model C-513* for 90° small button base (rectangular) color picture tubes. $7.75 each.—**Chamberlain Mfg. Corp.,** 845 Larch Ave., Elmhurst, Ill. 60126.

Circle 32 on reader service card

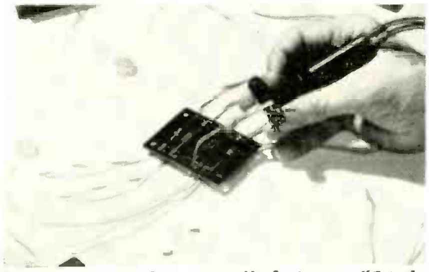
STEREO AMPLIFIER, *KA-7002,* features direct coupling and complementary—symmetry driver stage; low-level phono input (0.06 mV) for moving-coil type or low-level magnetic car-



tridges. Power output (IHF) of 196 watts at 4 ohms; 170 watts at 8 ohms. Continuous power output (rms) is 100 watts, 50 watts per channel with both channels operating simultaneously with 8-ohm load at any frequency from 20 Hz to 20,000 Hz. IM distortion less than 0.3% at rated output or any lower level; less than 0.1% at —3 dB rated output. $299.95.—**Kenwood Electronics, Inc.,** 15777 S. Broadway, Gardena, Calif. 90248.

Circle 33 on reader service card

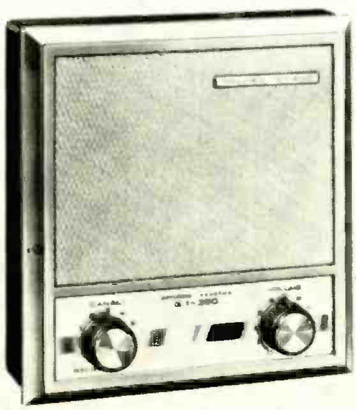
MINIATURE WELDING TORCH, *"Little Torch,"* operates on oxygen and fuel gas (acetylene, hydrogen, LP-gas or natural gas), produces up to 6000° F. flames so small as to go through the eye of a needle. Equipped with 5 different size tips, each with sapphire jewelled ori-



fice; tips can be swivelled 360°. *"Little Torch"* welds metal smaller than .002" wire up to 16 gauge steel. Used for heat bonding, welding and soldering, on glass, ceramics, and most special experimental metals with high melting points.—**Instrument Div., Tescom Corp.,** 2633 S.E. 4th St., Minneapolis, Minn. 55414.

Circle 34 on reader service card

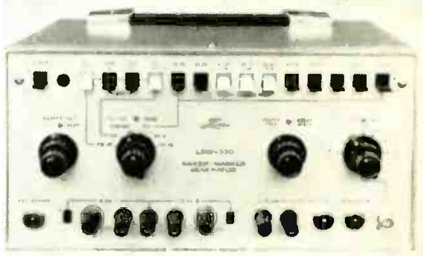
MUSIC/PAGING BAFFLES with ceramic-magnet speakers. *Model 10/360T* (shown) has a 5-channel selector, 6 position stepped volume control, 70-volt line transformer, and screw type terminal



strip for direct connection to line. Suited for hotels, hospitals, schools. *Model 10/370* can be mounted recessed in walls, panels, cabinets, and used as an extension speaker for music and paging systems. *Model 10/3681* is a remote-control panel designed to provide control of speakers that are hard to reach.—**American Geloso Electronics, Inc.,** 251 Park Ave. So., New York, N.Y. 10003.

Circle 35 on reader service card

SWEEP MARKER/GENERATOR, *model LSW-330,* a solid-state, post-injection sweep marker/generator for color TV alignment, testing and servicing. Instrument provides all sweep/marker signals for circuit alignment of chroma, sound and video i.f.'s, as well as two rf channels, switch selectable and features



a 10.7-MHz sweep for FM-i.f. Offers automatic amplitude control; crystal controlled markers; 0 to 90° marker tilt; triangular waveform voltage facilitates sweep linearity; 1-kHz modulation. $399.50—**Leader Instruments Corp.,** 37-27-27th St., L.I.C., N.Y. 11101.

Circle 36 on reader service card

SOLID-STATE VOM, *model 179.* This FET vom has wideband ac response (to 3 MHz), 55 ranges including ac current. 10-megohm input impedance, internally regulated voltage, 80-μA movement, mirror scale. Ranges include eight each in +dc volts and —dc volts (0.3V to 1000V); dc current (.03mA to 300 mA); ac rms volts (.3V to 1000V); ac peak-to-peak volts (.3V to 1000V); ac rms current (.03mA to 300mA); and seven ohms ranges (0 to 500 megohms). 2% accuracy on dc volts and dc current. 3% on ac volts and current. Comes with batteries, instruction manual and shielded test cord set. $74.95.—**Dynascan Corp.,** 1801 W. Belle Plaine Ave., Chicago, Ill. 60613.

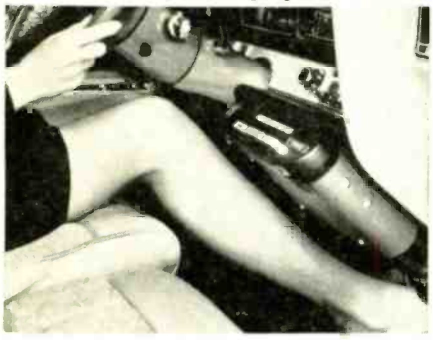
Circle 37 on reader service card

AMATEUR BAND MOBILE RIG, *model A,* solid-state 2-meter ham rig, 4 channels, 2 pairs of crystals. The 6-watt

Model A features aluminum vinyl-clad enclosure with molded front panel, front mounted speaker, mounting cradle, and press-to-talk microphone with coil cord. Separate plug-in transmitter and receiver boards, with IC's, and diode frequency switching. Frequency range from 144-148 MHz with 0.6 μV sensitivity or less for 20-dB quieting. $249.00.—**Simpson Electronics, Inc.**, 2295 N.W. 14th St., Miami, Fla. 33125.

Circle 38 on reader service card

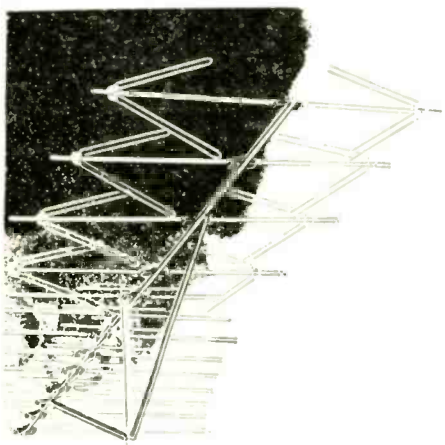
AUTO CASSETTE PLAYER, *model AC-7*. Hi-fi unit with continuous playback in both directions. Transport uses two fly wheels, a servo controlled drive motor, and monolithic IC's. Automatic loading design allows cassette to drop onto the drive mechanism instead of drive mechanism moving up the the cas-



sette. Uses 12-volt dc, provides wow and flutter of less than 0.3%. Frequency response curve is 40 Hz to 8,000 Hz, and produces output power of 6 watts rms. $129.50.—**TEAC Corp. of America**, 2000 Colorado Ave., Santa Monica, Calif. 90404.

Circle 39 on reader service card

TV/FM ANTENNAS, *Color Crossfire Series*, 13 models, covering near suburban to deepest fringe applications. Antennas use solid aluminum ribbed harness, 1" tubular boom braces and preassembled hardware. Rear elements



are 7/16" in diameter. Hardware pre-assembled to the boom. All the elements protected against acid, salt and air pollution by golden EPC coating.—**Channel Master**, Ellenville, N. Y. 12428.

Circle 40 on reader service card

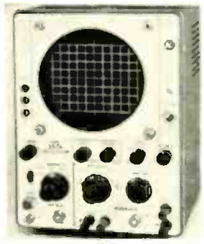
STANDARD TIME RECEIVER, *model STR-1*, receives continuous NBS standard-frequency and time broadcasts from WWV or Canadian standard-time broadcasts from CHU. Three channels, dual-gate MOSFET's, 12-volt dc operation for mobile, marine, or portable appli-

Circle 62 on reader service card

cations, UL approved power pack for ac operation. Sensitivity 0.25 μV for 10 dB signal-plus-noise to noise ratio; i.f., 455

kHz. $74.95 for kit.—**Caringella Electronics, Inc.**, P.O. Box 327, Upland, Calif. 91786.

Circle 41 on reader service card



OSCILLOSCOPE, *model 557A*, for general purpose field or bench use. Vertical amp is ac/dc; sensitivity of 20 mV/cm over dc to a 5 MHz bandwidth; sweep frequency range from 10 Hz to 100 kHz in 4 ranges, continuously variable in the respective ranges, line sweep; 4 step decade input attenuator; 5" flat-faced CRT; solid state circuitry; 3 calibration voltages. $249.00.—**Kikusui Electronics Corp., c/o Marubeni-Iida (America) Inc.**, 200 Park Ave., New York, N.Y. 10017.

Circle 42 on reader service card

Circle 63 on reader service card

AM/FM STEREO RECEIVER, *model 1000X*, offers 100 watts of IHF music power, combined with a 2.0-μV sensitivity (IHF) FM stereo tuner that uses a FET in the front end. Wide-dial linear-scale tuning, FM muting, precise signal-

strength meter, two tape monitor circuits, mode switch, independent bass and treble boost-and-cut tone controls, high-frequency filter and loudness control. Walnut cabinet. $269.95.—**Sansui Electronics Corp.**, 32-17 61st St., Woodside, N.Y. 11377.

Circle 43 on reader service card

AUTOMATIC TURNTABLES, *models 502, 402, 302*. Three-speed units' operating functions controlled by single lever; variable anti-skating compensation; cue control, viscous damped. Pitch control allows user to vary speed of record ±3%. Modes of operation include auto-

matic repeat, automatic-single play, semi-automatic single play, full manual single play, and automatic multiple play. *Model 502* is $149.95; *model 402* is $129.95; *model 302* is $99.95.—**Fisher Radio**, 21-21 44th Dr., L.I.C., N.Y.

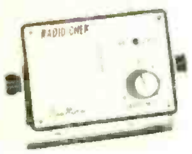
Circle 44 on reader service card

AUTOMATIC TRANSISTOR ANALYZER, *model 900*, has 8" linear mirrored meter. Solid-state instrument measures beta directly and indirectly and leakage

to the nearest nanoamp, automatically differentiates between pnp and npn, indicates silicon or germanium, tests to go-no go parameters of transistors and diodes.

Operates on 115-230 volts, weighs 6¾ lbs. $287.00 (*model 103* probe $15.00).—**Vanguard Electronic Tools Inc.**, P.O. Box 667, Newton, Kan. 67114.

Circle 45 on reader service card



MARINE RADIO CHECKER, *Radio-Chek*, provides visual indication of transmitted output power and voice modulation intensity for 2–3 MHz AM marine band. Requires no external power nor connection to the boat's marine radio equipment. $28.50.—**Sea Mate Inc., Subs. Data Research Corp.**, 2601 E. Oakland Park Blvd., Ft. Lauderdale, Fla. 33306.

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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 on page 89 and circle the numbers of the items you want. Then detach and mail the card. No postage required!

CAR STEREO/RADIO ACCESSORIES. *No. FR-132.* Brochure includes cartridge radio tuners. burglar alarms. under-dash equipment alarm, lock mounts, locks. power supplies, transverters for using small battery/transistor equipment in a car. loudspeakers.—**GC Electronics**, 400 S. Wyman St., Rockford. Ill. 61101.

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INSTRUMENT AMPLIFIER SPEAKER BROCHURE, illustrating eight amplifier speakers in wide choice of power ratings and frequency responses for musical instruments such as the guitar and electronic organ. Includes descriptive data. price and ordering information.—**CTS of Paducah, Inc.**. 1565 N. 8th St.. Paducah. Ky. 42001.

Circle 48 on reader service card

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

REPLACEMENT COMPONENTS. *1971, Catalog #100*, for radio and television. 64 pages of resistors. fusing devices. circuit breakers. convergence controls. service accessories. electronic chemicals. audio cables, adapters for hi-fi and cassette type recorders. battery holders and prototype kit components. Available free to qualified distributors. servicemen and experimenters.—**Workman Electronic Products. Inc.**, Box 3828, Sarasota. Fla. 33578.

LASERS CATALOG shows helium-neon gas lasers for industrial. research. and educational applications. Seven laser models ranging in price from $99.50 to $275.00 are described and illustrated. along with laser education kits designed for optics experiments in schools: the laser communicator and holograph systems: details on power supplies: optics benches; photometer: and laser accessories.—**Metrologic Instruments. Inc.**, 143 Harding Ave.. Bellmawr. N.J. 08030.

MEDIUM POWER RECTIFIER CATALOG, *No. 54-100* Comprehensive semiconductor catalog cross-references more than 400 medium power rectifiers by performance rating and by JEDEC and industrial-type number, and covers the full line of 3- to 70-ampere. stud-mount rectifiers. Representative power-derating and efficiency curves are included. Dimensioned drawings and exploded views of devices assist mounting and show key features.—**Mr. J. DeFazio. Mktg. Svcs. Mgr.. Semiconductor Div., Westinghouse Electric Corp.**, Youngwood, Pa. 15697.

R-E

Service Clinic

By JACK DARR SERVICE EDITOR

VERTICAL OUTPUT CIRCUITS

If we hooked up the bare-bones multivibrator, we showed last month, and "let it run," we wouldn't get too good a vertical sweep. Multivibrators usually produce something like a rectangular waveform. What we need is a specially shaped sawtooth, with a negative going spike, to get good linear sweep. Fig. 2 (right) a typical waveform. This is the "trapezoidal"

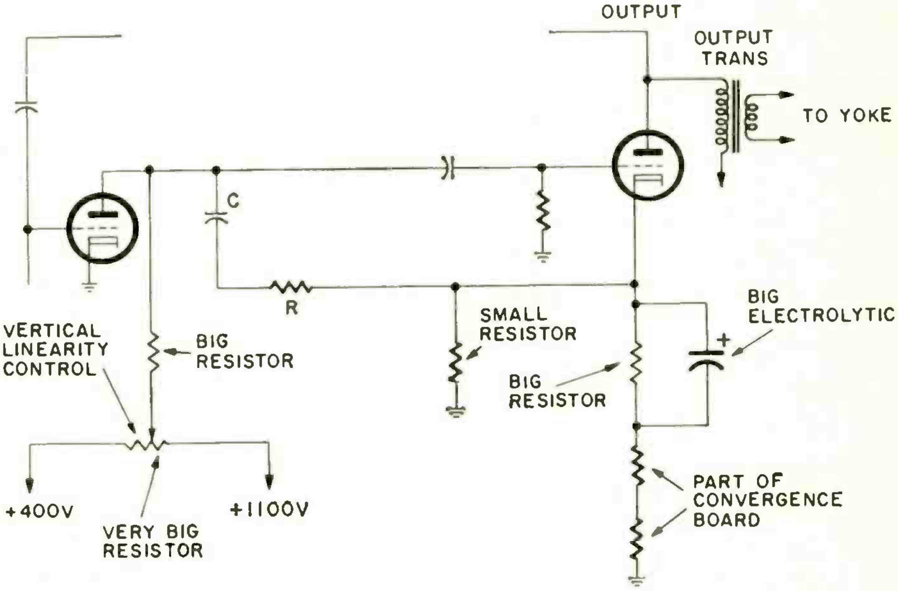


Fig. 3

waveform you hear about.

It actually has two parts; a linear "sawtooth" and a sharp negative-going "spike." How do we get this thing? By connecting a little R-C network from the plate of the input tube to

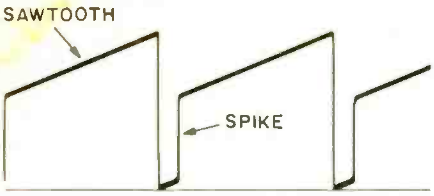


Fig. 2

ground (Fig. 3 at left). Each part does its own thing. The capacitor charges to produce the saw, and the resistor affects the spike. We need this negative going spike to turn off the output tube, quickly and completely, during vertical-retrace. (We also turn off the picture tube with the same spike, if you were wondering.) This is a "saw-forming network."

This is very important, and the parts are critical. The saw part of the trapezoid must be linear. However, the charging curve of a capacitor is anything but linear. It's exponential, as in Fig. 4 (below). So, what do we do? We use only a *small part* of the whole curve, right at the start,

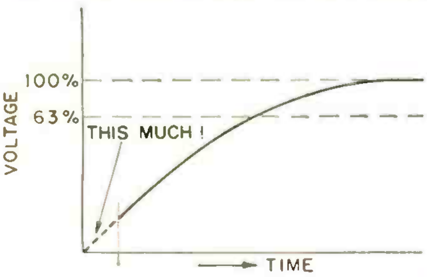


Fig. 4

where it *is* linear! If we let the capacitor rise to full charge, or rather to 63% of full charge, we'd have "one full time constant" (and a heck of a looking curve).

The time needed for a capacitor to charge up to 63% of the applied voltage, through the resistance in the circuit, is one time-constant. This is figured by multiplying the resistance, in megohms, by the capacitance in microfarads, and you come out with the time in seconds. T=RC. To make sure that this thing uses only the *linear* part of the curve, we make sure that the time constant is quite a good deal *longer* than the operating frequency of the circuit, 1/60 second. In the actual set from which this circuit was taken, the capacitor is a .039 μF, and the series resistance, all together, is about 4 megohms, at least.

In operation, this capacitor starts to charge when the input tube is cut off (by the feedback pulse coming from the output tube through the network). Its plate voltage starts to rise to the full supply voltage. Before it can get there, or get off the linear part of the curve, the input tube is turned on, by the sync, it conducts heavily, and its plate voltage drops practically to zero: the saw-former capacitor discharges. This forms a negative-going spike. (Not a negative spike; a *negative-going* spike.)

Now, let's add some controls, as in Fig. 3. One side of the capacitor discharges to ground, through small resistance R, then to the cathode resistor of the output stage. The *complete* path for this is through the little resistors to ground, to the dc power supply, then back up to the plate-side of the capacitor through some very big resistors. (That's where the long time constant comes from.)

Now we come to the first of the "areas of confusion" about this circuit. Notice the high-resistance control, connected between +400 and +1100 volts, and marked VERTICAL LINEARITY. This happens to be in a color set, but they all work the same. Actually, this control regulates the charging-time of the capacitor, because it is in series *with the voltage supply*. It is also in the plate circuit of the input tube.

So you'll sometimes find this one marked VERTICAL HEIGHT or SIZE! Same control, same reaction; but different names! Next month, in the third installment, you'll see another control with the same reaction, and a couple of names! If you know *what* each one does, and why it is put in there in the first place, it'll be easy!

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.

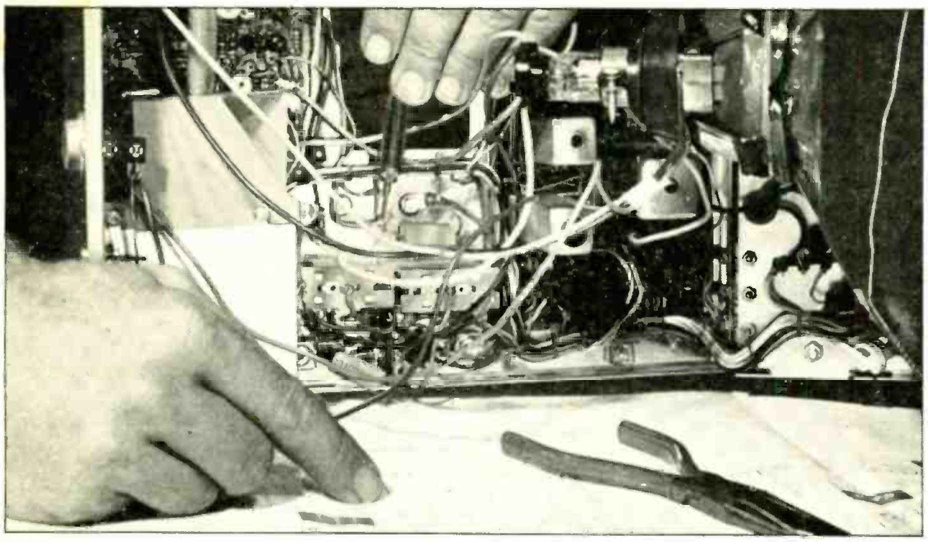
If you're really stuck, write us. We'll do our best to help you. Don't forget to enclose a stamped, self-addressed envelope. Write: Service Editor, Radio-Electronics, 200 Park Ave. South, New York 10003.

HORIZONTAL OSCILLATOR TOO HIGH

All I can get out of this Zenith 14M29 chassis is a high-pitched whine. Flyback and oscillator coil have been replaced. The horizontal oscillator is running, but at a very high frequency. What's going on here?—H. B., Riverdale, Ill.

This set uses an electron-coupled horizontal oscillator, very much like the circuit used in many radios! Notice that the horizontal oscillator coil is tapped, and that the two halves are

There is no substitute for training on real electronic equipment.



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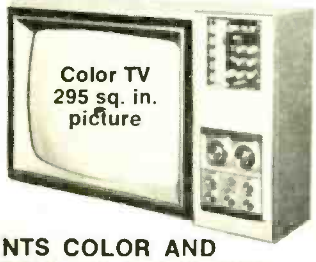

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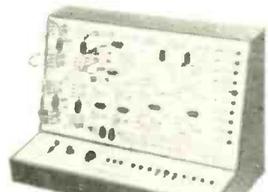

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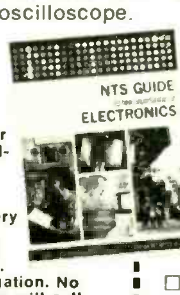

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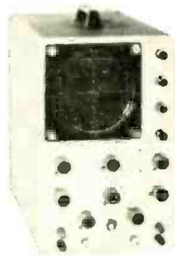

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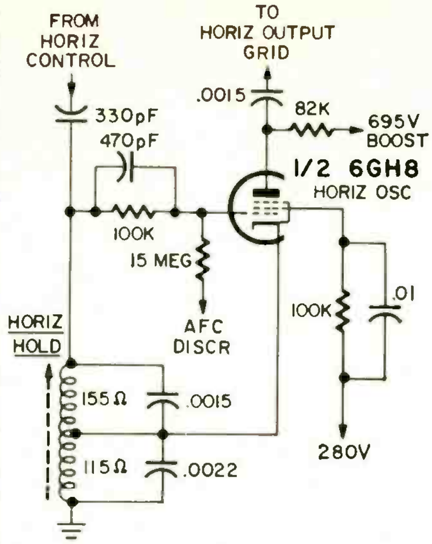
not equal. Also, the two capacitors connected across the coil are not of the same value.

Reversing the coil connections, or the capacitors would change the



frequency of the horizontal oscillator. Check this. At a guess, since the oscillator is running too fast, I'd say that you have the low-inductance (higher-frequency) section of the coil "on top"; in the grid circuit. The diagram shows the correct connections.

CONVERGENCE TROUBLES—DIODES?

I've got a convergence problem that won't quit! All waveforms on the convergence board look ok as nearly as I can tell. But the lines bow on me, and I can't straighten them out. What's going on?—G. S., Peoria, Illinois.

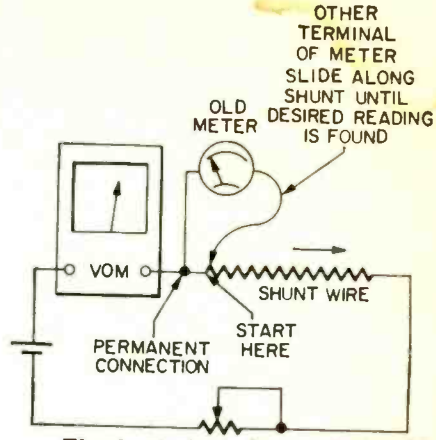
If your waveforms look ok at the input to the convergence board and you still have a very severe bowing of the lines (especially horizontal lines), check the clamping diode assembly on the convergence board. If one of these diodes is leaky or shorted, this will cause a very severe bowing of the line of that color.

The purpose of the these diodes is to "clamp" the dynamic convergence sweep *at the center* of the screen, giving it more effect on the beams at each end of sweep. So if the diode is bad, the entire line will bow, and won't respond to the controls. Quick-check: just short each diode with a screwdriver. This should *cause* bowing. No effect, this is shorted!

THERE'S A BETTER WAY

A while back you suggested a way to make shunts for old meters. If your shunt-wire should come loose during the tests, the current could damage the meter. We use a safer method here.

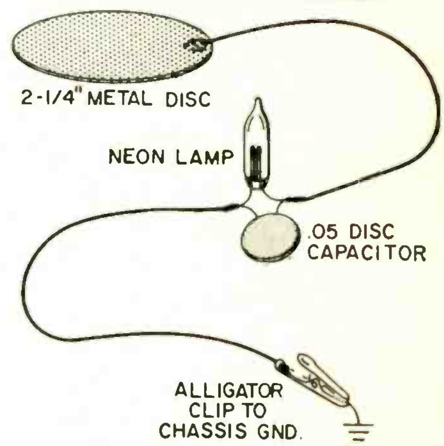
The circuit is set up just as yours is, but the shunt wire is permanently connected at all times. One of the meter terminals is connected to one end of the shunt-wire. The other meter terminal is simply slid along the shunt, starting at the "short" end, until the desired current reading is found.



The shunt wire is then marked at this point, the power turned off, and the shunt-wire cut, wound up and fastened tightly across the meter terminals.—F. S., Chicago, Ill.

Comment from Clinic Conductor: Right! There's always someone around to work out a better way. Thanks! **R-E**

HOME APPLIANCE ELECTRONICS
(continued from page 32)



tripler circuit to find out where it stops multiplying. Most troubles will be bad recifiers or shorted or leaky capacitors. Incidentally, the voltage-multiplier circuit will be found in quite a few late-model color TV sets! If rectifiers are bad, it should be possible to replace them with a stock color-TV tripler.

All parts should be easy to replace with stock TV parts. The exception would be the power transformer. It might be replaced by a small oscilloscope power transformer. Check transformer catalogues. The physical size would be the worst problem.

Here again is an application of the same old electronic principles and apparatus, just like those we've been working with for so many years. In future columns we'll see a lot more. Used for different purposes, but just the same, the old basic-circuits that we've been fixing for a long time. If we know how they work, we can handle 'em. **R-E**

DESIGN FOR STEREO
(continued from page 53)

To get the gain of 3, the maximum R_s as determined from the same gain equation, is $3 = (1.28 \times 10^{-3})(4.7 \times 10^{3})/(1 + 1.28 \times 10^{-3} R_s)$, is 780 ohms. Since 780 ohms is less than the 910 ohms calculated from the curves, the 910-ohm resistor can be split into two parts, 780 ohms and 130 ohms. The 130 ohms is to be by-passed with a large capacitor (Fig. 7-b) so that it will not affect the gain but will still be in the circuit to help set the quiescent bias voltage. Feedback voltage affecting gain and distortion will be developed only across the 780 ohms. The capacitor across the 130-ohm resistor should be large enough to short the 130 ohms at the lowest audio frequency to be amplified.

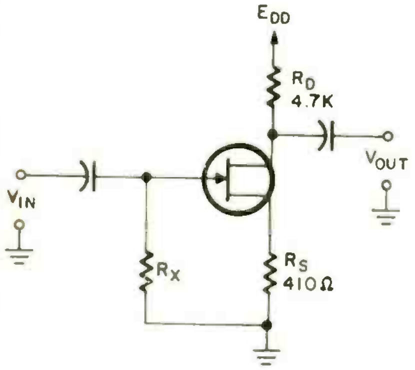


FIG. 8—SIMPLIFIED CIRCUIT saves cost of two resistors and a capacitor.

The circuit should work. An alternate method can be used to eliminate resistor R_G. This is desirable as any ripple in the power supply is fed through this resistor to the gate and amplified by the JFET stage. Use line B (Fig. 6) extended from the point on the lower I_{DSS} curve to a zero V_{GS} point on the axis, so that no positive voltage will be required across R_X. The reciprocal of the slope of curve B is $R_s = (.82 - 0)$ volts$/(2 - 0)$ mA $= 410$ ohms. As this is less than the maximum $R_s = 780$ ohms calculated above, the gain will be more than satisfactory, although the feedback and distortion reduction will not be as pronounced. The simplified circuit in Fig. 8 can now be used, omitting C, the 1.5 megohm resistor and one of the source resistors.

The input resistor, R_X, is the 47,000 ohms the source must see. The maximum idling current is 4.25 mA, determined by extending line B to the upper curve in Fig. 6. The minimum drain-voltage supply (E_{DD}) is $I_D(\max)(R_D + R_s) + 1.5\,V_P(\max) = (4.25 \times 10^{-3})(5110) + 1.5(6) = 30.8$. A 30-volt supply will suffice; the JFET will just work a bit closer to the rounded pinch-off voltage portion of the characteristic curve in Fig. 3.

Which design is more desirable? Try both and decide for yourself. Some adjustment to both circuits may be necessary in the laboratory.

In the above discussion, as well as in the description of the amplifier stage designed using bipolar transistors, the noise factor was omitted. **R-E**

TECHNOTES

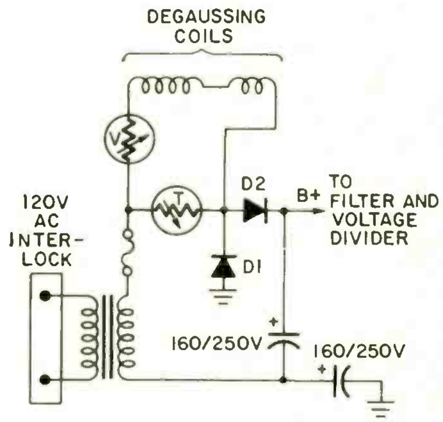
DuMONT 120926, -928, -957, -958 & EMERSON 120924, 120974 TV CHASSIS

Symptom: On color programs, with the color control turned down, it has been observed that the TINT control will sometimes act like a COLOR FIDELITY control. Rotation of the TINT control will change the background color from blue to sepia. Remedy: Capacitor C126 is connected from one end of the BRIGHTNESS control to the ground lug of the TINT control. Remove the ground lead of C126 from the TINT control and ground directly to the control mounting panel.—*DuMont-Emerson Field Service Bulletin*

STOP 'TOP-HATS' FROM BLOWING THEIR TOPS.

Many Zenith 25NC37 color chassis, as well as other brands of color TV sets, have been blowing silicon rectifiers. This malfunction occurs on late-model color sets that incorporate automatic degaussing.

This is what happens: The rubber cup on high-voltage anode lead deteriorates or moisture collects under it and a HV arc occurs. On many of the Zenith 25NC37 chassis the degaussing coils are located very close to HV anode connection of the CRT. When a HV arc occurs, this then sends a tremendous spike surge voltage through the degaussing coils



and hence onto the silicon rectifiers D1 and D2 (note power supply schematic) and of course, blows out one or more silicon diodes.

To eliminate the recurrence of top hat failure; reposition the automatic degaussing coils as far from the HV anode cap as possible and replace the HV anode cup with the new small size rubber cup. Clean the area very thoroughly around the CRT HV anode connection. Be sure the HV shunt regulation system is working properly. Now check and adjust the HV at the CRT anode according to the manufactures specifications. This should eliminate "blown top hat" call backs. However, spike voltages on the incoming power line to the receiver may cause the same type of rectifier failures.—*R. L. Goodman*

G-E KD COLOR CHASSIS

Complaints of insufficient width may develop after a year or so of use. In most cases, these complaints are not due to the usual tube or components failures.

The problem is due to low heater voltage on the 6CG3 damper tube. (In some cases, it measures only 5 volts.) This low heater voltage is due to a poor contact on the riveted ground on terminal board 2 which carries the heater ground return from pin 12 of the damper.

Adding a length of bus wire from the ground lug of the terminal board to the nearest solder "lance" on the chassis will cure the problem. Be sure that you get a good soldered joint.—*G-E Service Talk* **R-E**

Photo courtesy RCA Princeton Labs

Basic laser experiments

by U.S. BUREAU OF RADIOLOGICAL HEALTH

The following experiments demonstrate properties of light and other electromagnetic radiation using the laser. The experimenter is expected to be familiar with the classical elementary theory of light; therefore, explanations are kept to a minimum. The experiments produce effective demonstrations with minimum equipment and maximum safety.

Equipment necessary for these demonstrations:

1. Laser
2. Display tank
3. Support for display tank
4. Milk
5. Aerosol room deodorizer or smoke source
6. Liquid detergent
7. Ink
8. Boiled or distilled water
9. Detector (CdS light meter with red filter)* see note below
10. Mirror
11. Pivot mount for mirror
12. Protractor
13. Ruler
14. Thick slab of glass
15. Prism (45° – 45° – 90°)
16. Polarizing filters (3)
17. Small test tubes
18. Quarter wave plates (2) doubly refracting, red
19. $AgNO_3$
20. Single-slit diffraction aperture
21. Double-slit diffraction aperture
22. Circular diffraction aperture
23. Divergent lens
24. Hologram
25. White paper
26. Transmission grating
27. Razor blades

Light detection and intensity measurements can be made with a photographic light meter, preferably one that uses a CdS (cadmium sulfide) detector. The light levels from a 2.5-mW laser will not overdrive the meter and used meters can be purchased in camera stores. The meter's response to light is not linear, however, and response must be calibrated against a more accurate standard.

EXPERIMENT 1—SCATTERING OF LIGHT

Explanation:

When light passes through the atmosphere, it is scattered by the large number of gas molecules and particles that make up the atmosphere. Objects are visible only because of the light they scatter toward the viewers' eyes. For this reason (i.e., the lack of light scattered toward them) astronauts are largely in the dark when they travel in orbit beyond the earth's atmosphere. For this same reason, an observer may not see a laser beam headed across his path. On the other hand, if smoke is blown into the path of a laser beam, it immediately becomes visible.

This mechanism of optical scattering varies with the size of the scattering particles. Particles such as smoke may be considered "large" if their radii approach the wavelength of the incident light. The scattering from such particles is referred to as large-particle (i.e., Mie) scattering. In this type of scattering the particles may be considered as opaque spheres which scatter according to the principles of the diffraction theory. It is this type of scattering that can pose a potential hazard when high-powered lasers are used in the atmosphere.

Particles whose radii are much smaller than the wavelength of the incident light (radius $< .05\ \lambda$), scatter by a different mechanism called Rayleigh scattering. In this type of scattering, each microscopic particle acts as an electric dipole, reradiating the incident wave by electrically coupling into resonance with the electric field of the incident light. This type of scattering can be seen by observing different regions of the daylight sky through a polarizing filter.

Materials:

Laser	Boiled or distilled water
Display tank	Milk
Smoke source or aerosol can	

Experimental procedure:

Large particle or diffraction scattering

Direct the laser beam so it passes through the clean display tank filled with boiled or distilled water. The path of the beam will probably not be visible in the water. Add a small amount of homogenized milk to make the water turbid. The path will then become visible. Instead of milk, a concentrated solution of colloidal silica solution can be added to the water to make a permanent display solution. Large particle scattering can also be demonstrated by blowing smoke or the spray from an aerosol can into the path of the laser beam.

EXPERIMENT 2—ABSORPTION OF LIGHT

Explanation:

In passing through a material, laser light, like all electromagnetic radiation, undergoes absorption which can be expressed by the exponential relationship $I = I_o e^{-\mu x}$, where μ is a function of the absorbing material and the wavelength of the light, and x is the thickness of the absorbing material. If a green piece of cellophane is placed in the path of a helium-neon laser beam (i.e. red light), there is a substantial reduction in the beam intensity. If, on the other hand, a red piece of cellopane is used with the same beam, relatively little absorption occurs. This principle of selective absorption of light from laser beams with given wavelengths is used in some of the commercially available protective goggles sold for use with lasers. This experiment demonstrates both quantitatively and qualitatively how the absorption of light depends upon the thickness of the absorber.

Materials:

Laser	Detector for measuring light intensity
Display tank	Ink
Liquid detergent	

Experimental procedure:

Prepare a display solution by adding a few drops of a liquid detergent to water and stir until it is uniformly mixed. Fill the display tank with this solution and project the laser beam into the tank so that the path of the beam is clearly visible. Now add a drop or two of blue or black ink to the solution and stir until the solution is uniform. Notice how this causes beam intensity to decrease rapidly as it penetrates further into the solution. Continue to stir in ink a drop at a time until the beam vanishes (i.e. is completely absorbed) before it reaches the opposite end of the tank.

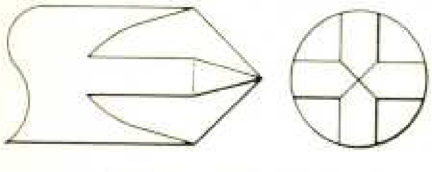
To make a quantitative measurement of the exponential absorption of light in a material, direct the laser beam onto a detector which measures light intensity or beam power. Record this value. Using various pieces of absorbing materials such as a semi-opaque plastic, insert one thickness at a time, gradually increasing the thickness of the material through which the laser beam passes. Record the light intensity for each value of the total thickness of the material and plot the data on semi-log paper. What is the shape of the line obtained? Why?

R-E

TRY THIS ONE

NEW LIFE FOR OLD PHILLIPS SCREWDRIVERS

When a Phillips head screwdriver has worn so it is no longer usable,



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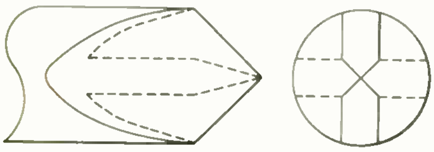


DOTTED LINES SHOW AREA GROUND OFF, LEAVING A FLAT SIDED SCREWDRIVER.

grind off opposite flutes. Then the remaining two can be shaped to a perfect angle again. Just as good as new for light work.—*Miller Service*

ERASER CLEANS CIRCUIT BOARDS

Before attempting to solder a printed-circuit board on which the foil has separated, carefully clean the copper foil with a pencil-type typewriter eraser.

These erasers contain abrasive that is ideal for removing dirt and oxidation so joints are easier and more quickly tinned and soldered without subjecting them to excessive heat.—*S. Clark*

PUT A DIODE TO WORK

An ordinary rectifier diode is handy when you have to phase pairs of wires in long remote runs as in some intercom and speaker installations. Phasing can be quite a chore if the wire pairs are not color-coded or are twisted together.

A quick way for one person, working alone, to identify wires and phasing is to connect a diode across

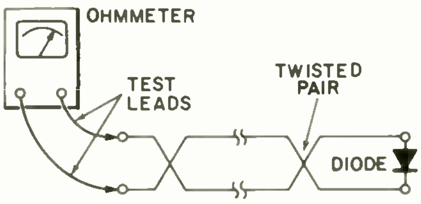


FIG. 1

one end of a pair and then check the other end with an ohmmeter as in Fig. 1. Set the meter to the X1 or X10 range and touch the test leads to the ends of the wire pair. Reverse the test leads if the meter does not deflect. When the meter deflects, the wire connected to the plus test lead is the same one that is connected to the anode of the diode at the other end.

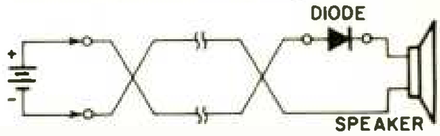


FIG. 2

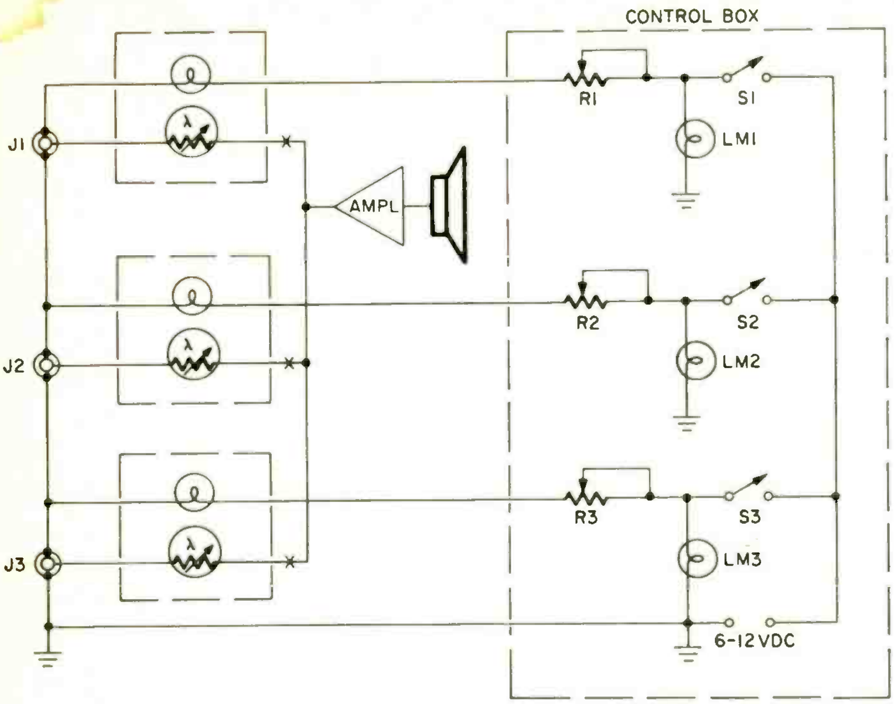
If speakers are connected at one end of the pairs and are within hearing range of the sending end, then an ohmmeter is not needed. Simply connect a diode as shown in Fig. 2 and momentarily connect a low-voltage battery across the open end. Connect the battery one way or the other until a thump is heard from the speaker. The wire connected to the plus side of the battery is the same one that connects to the anode of the diode at the speaker end.

Any rectifier-type diode will work for this purpose. Miniature clips can be connected to the diode leads to facilitate making connections.—*Herbert E. Pasch* **R-E**

NOTEWORTHY CIRCUIT

REMOTE CONTROL FOR AUDIO

This novel photoelectric control circuit for switching and setting the level of audio amplifier inputs from a remote point was described in *RADIO*, a Russian amateur magazine. A photoresistive photocell—also called an LDR or light-dependent resistor—is inserted between each input and the common input to the audio amplifier.



The LDR's resistance is very high in darkness and decreases sharply as light intensity increases. The resistance of the LDR and the input resistance of the amplifier form a voltage divider that controlls the signal fed to the amplifier input.

Each LDR is housed in a light-tight enclosure along with a miniature pilot lamp which, when turned on, decreases the LDR resistance and allows the signal at the input jack to reach the amplifier. Switches S1, S2 and S3 turn on the lamps illuminating the LDRs in series with J1–J3. Potentiometers R1-R3 are used to set lamp brilliance and thus control the amount of signal fed to the amplifier. Lamps LM1–LM3 are indicators to show at a glance just which input circuits are being used.

The LDR's used should have a dark-resistance many times higher than the amplifier's input resistance. Their resistance, when illuminated by the lamp, should be considerably lower than the amplifier's input resistance for minimum insertion loss. If the circuit is to be used as a mixer, then it may be advisable to insert isolating resistors of several thousand ohms in series with each LDR at point "X". **R-E**

NEW BOOKS

MODERN CONTROL THEORY AND COMPUTING edited by Donald Bell and A. W. J. Griffin. McGraw-Hill Book Co., 330 W. 42nd St., New York, N.Y. 10036. 6 x 9¼ in. 221 pages. Hardcover, $16.50.

This book presents at an engineering level the basic principles of modern control theory. It encourages the use of analytical design techniques in seemingly complicated industrial problems. Special features of the book include new information on hybrid computation, and extensive data in the field of adaptive control systems.

SERVICING TRANSISTOR EQUIPMENT, by Gordon J. King. Hart Publishing Co., 510 Sixth Ave., New York, N.Y. 9¼ x 6½ in., 151 pp. Hardcover, $7.95

Guide to servicing transistor radio, TV, tape and hi-fi equipment. Emphasis is on speedy diagnosis of what ails the machine. Some chapters concentrate on fault diagnosis, with summary chart of faults in audio, and video amplifiers, various circuits and oscillators.

MOST OFTEN NEEDED 1971 COLOR TV SERVICING INFORMATION, compiled by M. N. Beitman. Supreme Publications, 1760 Balsam Rd. Highland Park, Ill. 192 pages, 8½ x 11 in. Softcover, $4.00.

This new volume presents needed repair information on many popular color sets of all makes. Includes double and triple page schematics, printed circuit board views, alignment facts, and other factory supplied material to aid in completing needed repairs.

THE VERSATILE OP AMP, by Michael Kahn. Holt, Rinehart and Winston, Inc. 383 Madison Ave. N.Y. N.Y. 10017. 227 pages, 6¼ x 9¼ in. Hardcover, $10.00.

This text covers the fundamentals and significant applications of the operational amplifier. Detailed explanations and numerous worked-out examples explain this device in great detail. The book first discusses the fundamentals of amplification. It then departs from traditional presentations by treating the amplifier on a black box or module basis. The basic concepts pertinent to amplifiers: gain, distortion, feedback, matching, offset and drift, frequency response are all covered, but here they are applied specifically to an amplifier which is manufactured in a single package.

ELECTRONIC CIRCUIT DESIGN HANDBOOK, third edition, by the editors of EEE magazine. Tab Books, Blue Ridge Summit, Pa. 17214. 8½ x 11¼ in. 383 pages, hard cover. $17.95.

The expanded third edition contains more than 600 proven and tested circuits for all types of functions selected on the basis of their originality and practical application. This is 100 more circuits than the previous edition. 750 schematic diagrams and illustrations are used to supplement the text. Contents include control circuits, protection circuits, pulse circuits, alarm circuits, sensing circuits, and logic circuits.

RADIOTELEGRAPH OPERATOR'S LICENSE Q AND A MANUAL by Milton Kaufman. Hayden Book Co. 116 W. 14th St. N.Y. N.Y. 10011. 400 pages, 5⅜ x 8¼ in. Hardcover, $11.95.

This book provides all the necessary study material for successful completion of the FCC examinations for all 3 classes of FCC radiotelegraphs operator's license, as well as for endorsements for ship radar and aircraft radiotelegraph. Each section of the book contains a series of pertinent questions and concise answers. Most of the answers are followed by more detailed explanations in discussion sections. Additional data on FCC rules, regulations and radio laws are included in the Appendices.

R-E

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JULY 1971

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- **Using The Tone-Burst Generator**

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- **More Burglar Alarms**

  In this second article, another, more-advanced group of alarm circuits is presented. Breadboard and printed-circuit construction details are included.

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Home Appliance Electronics

Kwik-Fix Troubleshooting Charts

Designing Solid-State Amplifiers

Jack Darr's Service Clinic

Using an impedance tester

Sennheiser ZP2 can be a valuable aid to the service technician

by HORST A. ANKERMANN*

NEXT TO SCOPE, VTVM AND SIGNAL GENERATOR, an impedance tester could well prove to be the most important and helpful piece of test gear in the lab and shop that handles audio equipment. Yet it is not widely known, that impedances of microphones, speakers, filters, transformers, amplifier inputs etc. can be measured as easily as the resistance of a component with an ohmmeter. Maybe technicians remember faintly the complicated impedance bridges.

The behavior of complex networks in ac circuits with variable frequency is a rather abstract topic enjoyed by the theoretically minded only. Fortunately, the knowledge of the impedance magnitude, following the relation $|Z| = \sqrt{R^2 + X^2}$ is for most practical purposes not only enough, but also more usable than the determination of the reactive and real parts.

For impedance measurements an equal deflection methode is often used, as shown in Fig. 1. Using standard test

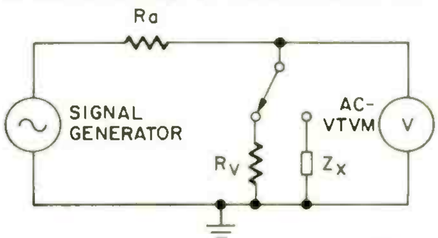

Fig. 1

instruments, a high degree of accuracy can be obtained, depending only on the calibration of variable resistor R_v.

A signal generator is connected in series with high value resistor R_a ($> 100\ Z_x$) to obtain a constant current source. The ac-voltmeter with an input impedance $> 10Z_x$ and the current source are alternately switched to measure the voltage drop across resistor R_v and unknown impedance Z_x. Resistor R_v is varied until the meter shows an equal deflection in both switch positions. The absolute indication is unimportant, it should be high enough above any hum interference, and low enough not to overload the test object. When the two voltages are made equal, the impedance magnitude Z is equal to the value of R_v. The impedance characteristic versus the frequency can easily be determined by repeating the measurement at various frequency settings of the generator, also any resonancies can readily be observed.

In a variation of the described procedure, a constant voltage source may be used and the current in the test object and a reference resistor are compared.

On another scale of this meter, the battery voltage can be monitored. The loading of the object or circuit under test is never more than 90μVA, preventing any damage to sensitive components. Besides its primary purpose, the ZP2 can be used as a signal source. The ac-voltage is available between the left jack and ground. The output voltage is dependent upon the position of the range switch and can be set to either 3 mV, 30 mV, 300 mV or 3 V.

To speed up the operation and facilitate measurements, the generator is not continuously variable, but offers three fixed frequencies of 250, 1000 and 4000 Hz. Also, the reference resistors are fixed, and the meter scale is calibrated to directly read the impedance in ohms.

Six ranges and a times 3 multiplier switch afford quick determination of impedances from 1 ohm to 1 megohm.

In the ZP2, an RC-generator is used to supply the test voltage. A voltage-regulator lamp in a bridge circuit provides a constant output. The possibility of switching among three different test frequencies facilitates indentification of the reactive component, enabling differentiation between C and L, since X_C and X_L change in opposite directions with changes in frequency. The object to be tested is connected between two transformers and the test voltage is applied to one of them. The other transformer, which has a low impedance, is connected in series with the object being measured. The voltage induced in the second transformer is dependent upon the current through the object, since the applied voltage is kept constant.

To furnish the different voltages re-

*Sennheiser Electronic Co.

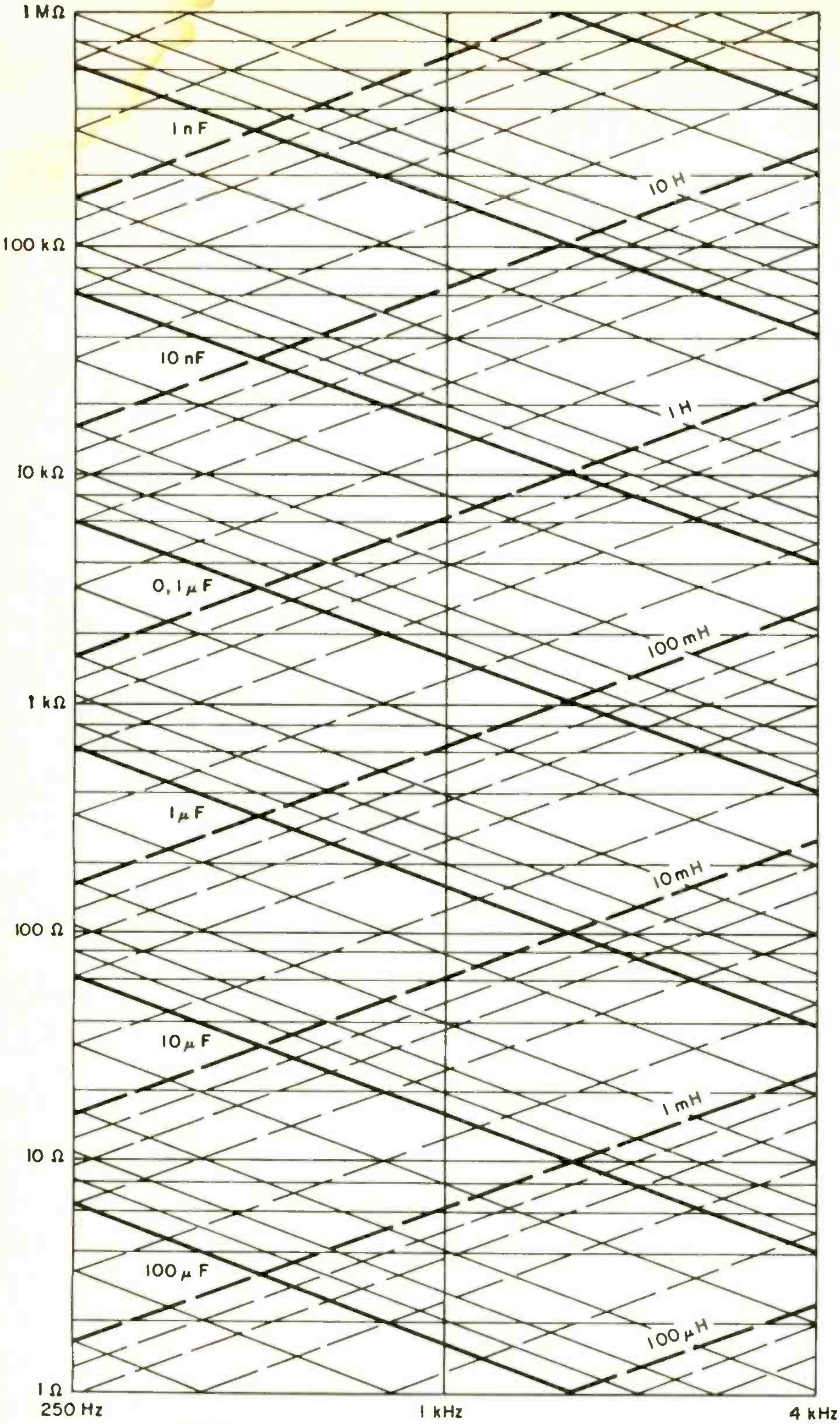

Fig. 2

quired for measurements within the various ranges, the transformers are equipped with taps. Depending on the range being used, different taps are connected to the output jacks via the switch. The second transformer is coupled to the input of a four-stage amplifier, where the voltage from the object under test is amplified sufficiently to drive the meter movement. Due to the principle of measurement, the meter scale is nonlinear, but because of several ranges of measurement, high accuracy is assured. The overall range of measurement is divided into twelve segments.

Of the many possible uses, here are some of the more frequent applications.

1. For matching purposes: loudspeakers, dynamic microphones, headphones, tapeheads, phone cartridges and amplifier inputs can be connected directly to Impedance Tester ZP2, and the impedance value is shown on the meter scale in ohms. (Amplifiers must be connected to their power source and switched on since they often display a different input impedance when turned off.)

2. Capacitance of unknown or sus-

(continued on page 85)

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IMPEDANCE TESTER
(continued from page 83)

picious capacitors can be varified by measuring their impedance and either referring to the chart in Fig. 2 or by solving the equation:

$$C = \frac{1}{2\pi f Z}$$

For measuring at a frequency of 4000 Hz., this equation can be written in an easy to use form:

$$C\,[\mu F] = \frac{40}{Z\,[\Omega]}$$

Since the ZP2 can determine impedances from 1 ohm to 1 megohm, capacitances from 40 pF to 40 μF are measureable, and by using the 250-Hz frequency, the capability extends to 640 μF. For the small capacitances, the test leads must be made very short to reduce their influence on the result.

3. Inductances are found as readily by using the formula: $L = \frac{Z}{2\pi f}$ provided, that the inductor has a Q of at least 10. The lowest measuring frequency is preferred to avoid erroneous results due to possible self resonance effects in inductors with large L-values. Also, the inductance of coils with iron cores depends on the measuring frequency and voltage so that they should be tested under actual circuit conditions. Otherwise, inductances from 40 μH to 400 H are covered by the ranges of the ZP2.

4. The ZP2 Impedance Tester is of great help if the main criteria of audio transformers, i.e. turn ratio and matching impedances are to be measured. With the frequency selector set to 250 Hz, the tester is connected to one of the transformer windings; for instance the primary and the other winding is left unterminated. The open circuit impedance Z_o is noted, then the secondary winding is shorted and the impedance as measured at the primary goes down to Z_s.

The proper source impedance for the −3dB point at 25 Hz is then:

$$R_{source} = \frac{Z_o}{10} - Zs$$

This is valid for a transformer with unloaded secondary. If matching of the secondary is intended, the source impedance may be twice the above value.

A resistor connected to the secondary is transformed into the primary circuit with the square of to turn ratio $\frac{W1}{W2}$.

For measuring the turns ratio of an unknown transformer, the secondary is loaded with a resistor R, until impedance Z_p, measured at the primary, goes down to approximately 50% of the unloaded condtion. The turns ratio is calculated:

$$\frac{W1}{W2} = \sqrt{\frac{Z_p}{R}}$$

These few examples show that the application of an impedance tester is simple and straightforward. Its usefulness in all kinds of audio technical work is obvious, and impedance testers will increasingly show up as standard equipment in laboratories and workshops. **R-E**

ADVERTISING INDEX

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R-E ON FILM

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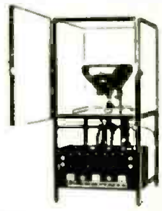

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