SEP 26

elementary Electronics

NOVEMBER-DECEMBER 75c

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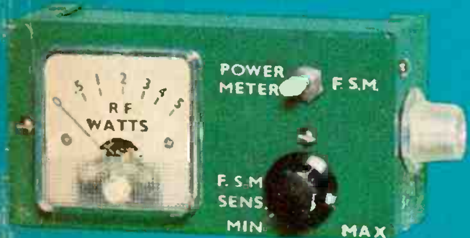

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NOVEMBER/DECEMBER 1967
VOL. 5 NO. 2

elementary Electronics

Dedicated to America's Electronics Experimenters

SPECIAL CONSTRUCTION FEATURE

THEORY

CONSTRUCTION

FEATURES

DEPARTMENTS

☆ Cover Highlights

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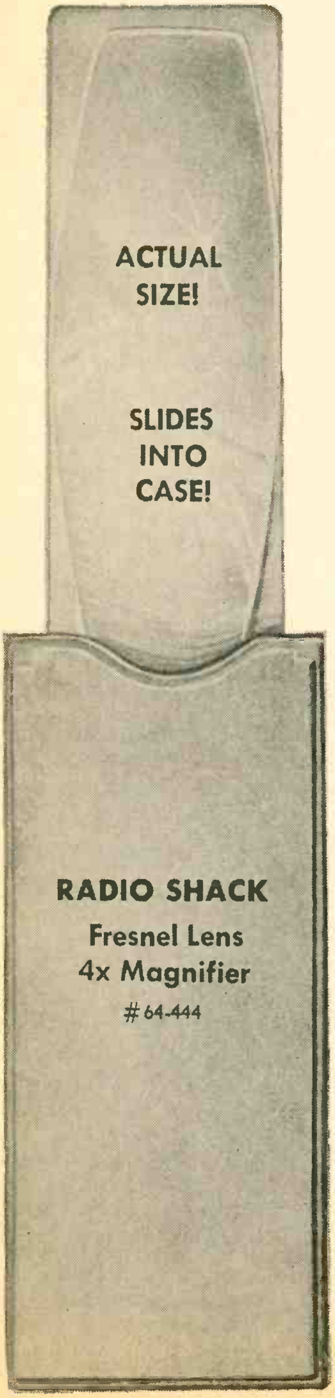

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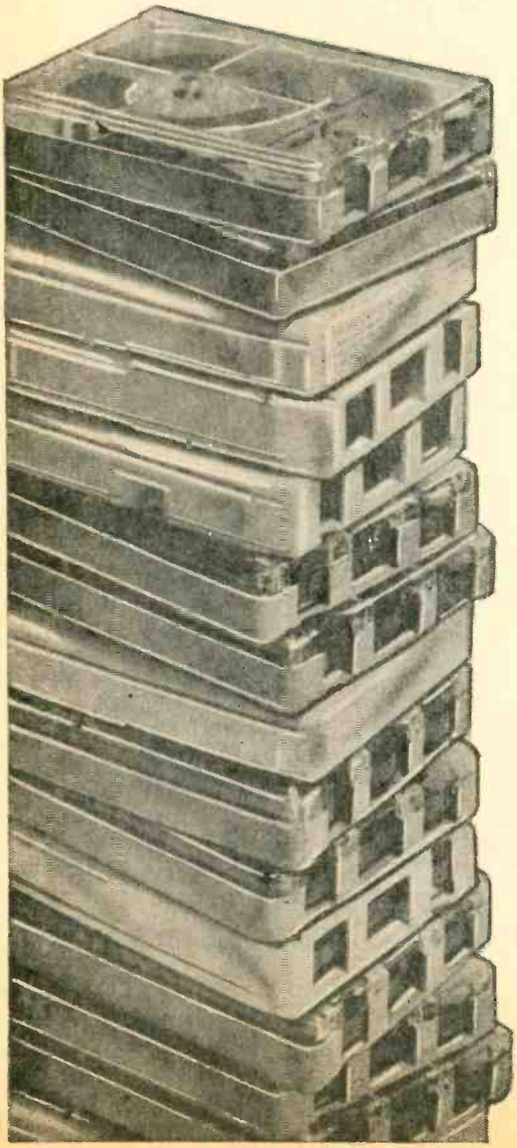

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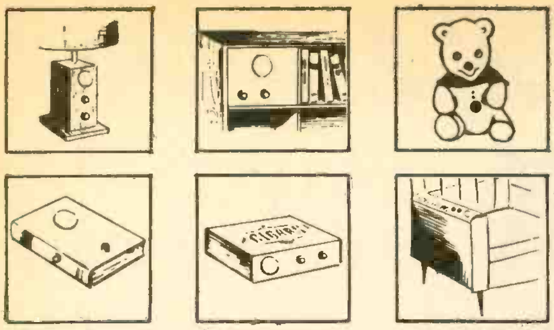

What's your project for our "Build In" radio?

Here's a wired transistor radio in 3 pieces. Dextrous do-it-yourselfers should have a field-day with this one.

You carpenters, metal-workers and gift designers will really appreciate Radio Shack's novel "Build In" — a 6-transistor superhet that's really *a kit that isn't a kit.* Confused? Part *one* is the radio, 100% wired, installed in a crystalline 2¼ x 1 x 3⅛" case with the tuning knob sticking out of one end, and 8 wires out of the other. Part *two* is a separate volume control with built-in switch, knob, and soldered leads. Part *three* is a 2¼" PM speaker installed in a plastic case, with soldered leads.

The three parts (plus a flat 9V battery, not included) can be installed in, on, or under anything, in just about any desired angle or position. And you don't have to be an engineer — Radio Shack's geniuses have provided a simple, idiot-proof lashup pictorial. Now all you need is the price *(just $6.98, Cat No. 12-1150)* and some Yankee ingenuity! Whether you hide "Build In" in a jug of corn likker, junior's wagon or Tillie's sewing box, the result is sure to please.

The basic radio itself looks like a little jewel, a real work of art — our photo doesn't do it justice. And the "kit that isn't a kit" is another of Radio Shacks's exciting exclusive products that can't be bought elsewhere. Get a "Build In" at your nearest Radio Shack store . . . and start your Christmas *project* early!

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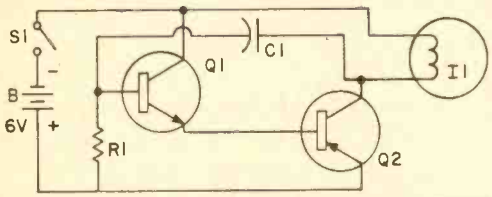

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This circuit is a real powerhouse — a relaxation oscillator capable of flashing a clearance lamp to full brilliance. The current drain is low since most of the current is drawn at the time of flash. Project takes no longer than one hour to wire.

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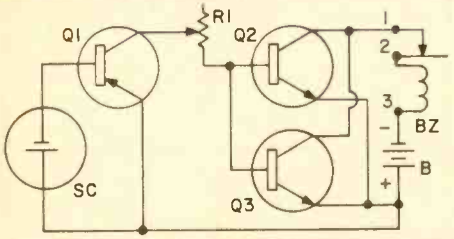
Excellent Burglar Alarm or Warning Buzzer! For an Interesting Experiment, Use Power Flasher Above to Work Buzzer.



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Here's an "electric eye" circuit that really works! By focusing a beam of light (flashlight or lens/bulb system) on the solar cell enough voltage is amplified to operate the buzzer. Adjust both the buzzer contacts and the sensitivity control (R1) for best sound.

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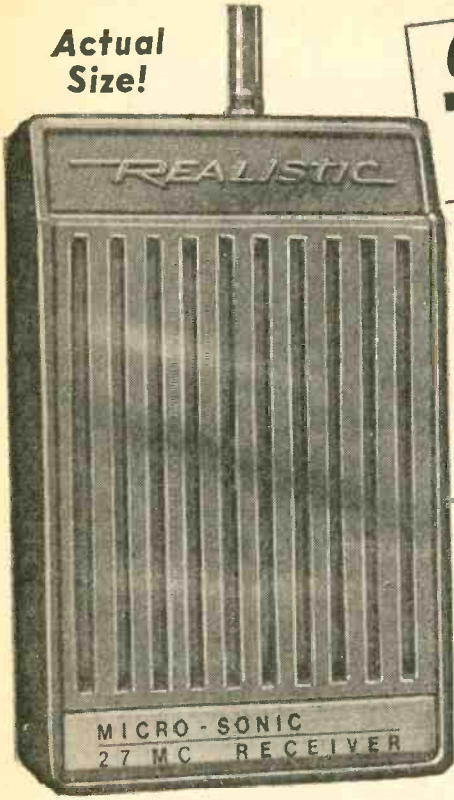
SLAVE "WALKIE" TO YOUR BASE, MOBILE, OR WALKIE TALKIES!

Actual Size!



ONLY 7.95

Crystal-controlled superhet receiver ONLY! Add as many ears to your network as you want. Fits in a shirt pocket — an excellent paging or guided tour device!

This unusual Radio Shack product, called the Realistic Microsonic 27MC Receiver, comes complete with a Ch. 11 CB crystal — and because it's a plug-in, it can be changed to any of the 23 channels. It's a teeny 3½ x 2½ x 1⅜". It includes an earphone with clip, and the phone's lead acts as the antenna. So if you want to hide it away as a pager, there's nothing showing. For DX we've included a 16" telescopic whip to be used only if necessary. Let your imagination run wild with this novel device!

21-109 Microsonic 27MC Receiver .... Only 7.95

NEW IDEA #2 — as a companion to the above, or a wireless CB microphone (!), there's also the Realistic Microsonic CB transmitter. Same size, color, everything. But transmit only, 100mw of course, with plug-in crystal for Ch. 11. Uses? For example: one of these plus x-number of receivers and you have a guided tour technique that'll never quit!

21-110 Microsonic CB Transmitter .... Only 7.95

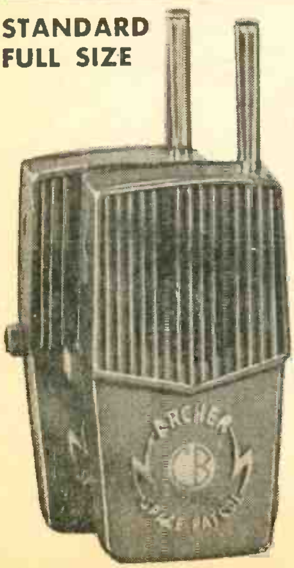
FREE ACCESSORIES:

- Receiver — earphone and whip antenna
- Transmitter — 35" telescopic antenna

Note: both units include crystals but require a 9V transistor battery to operate. 23-464, 29¢ each.

RADIO SHACK'S FABULOUS SPACE PATROL® TWOSOME

STANDARD FULL SIZE



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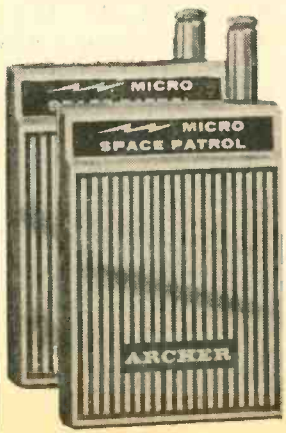

Double transformer talk-power in the world's smallest (3-5/6 x 2-7/16 x 1¼") case. Fits easily in your shirt pocket (and your budget). Handsomely styled hi-impact, custom-chromed case. Easy to operate with a hideaway "push-to-talk" button. 9-section telescoping antenna. With channel 14 crystal and battery.

14.95 PER PAIR

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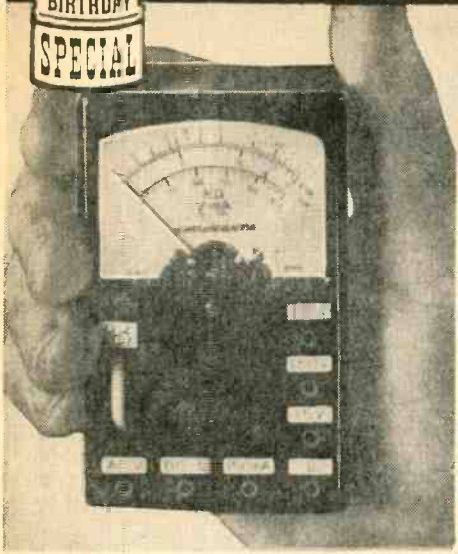
MICRONTA TEST EQUIPMENT AVAILABLE ONLY AT RADIO SHACK



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Pin jacks for 5 ranges. 2-color 1¾" meter scale. Reads AC or DC volts in 3 ranges: 0-5, 150, 1000V. DC Current: 0-150ma. Resistance: 0-100K ohms. Accuracy ±3% DC, ±4% AC. Bakelite case with test leads, instructions, batteries.

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22-011, Wt. 3 lbs. 11.95

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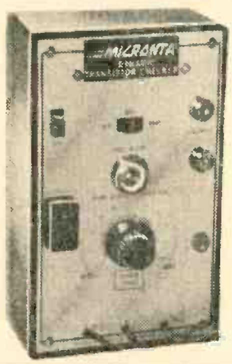

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- *Test Transistors "In" or "Out" of Circuit. Tests Low, Medium, High Power*

Visual indication of electrode open & short circuits, current gain, GO/NO-GO test 5ma-50ma, clip leads for in circuit tests. 6¼x3¾x2½".

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For auto radio AF amplifier circuits. Replaces: 2N176, 2N178, 2N179, 2N234, 2N235, 2N35B, 2N236, 2N242, etc.
276-406, Wt. 3 oz. 1.19

For high power AF circuits in auto radios. Replaces: 2N173, 2N174, 2N277, 2N278, 2N441, 2N442, 2N443, 2N1515, etc.
276-407, Wt. 3 oz. 2.29

NPN TYPES

For mixer/oscillator converter circuits. Replaces: 2N193, 2N194/A, 2N211, 2N212, 2N233, 2N234, 2N357, 2N358.
276-408, Wt. 3 oz. 1.09

For universal IF amplifier circuits. Replaces: 2N98, 2N99, 2N100, 2N145, 2N146, 2N147, 2N148, 2N149, etc.
276-409, Wt. 3 oz. 1.15

For 9 volt AF amplifier circuits. Replaces: 2N35, 2N169A, 2N213, 2N214, 2N228, 2N306, 2N312, 2N313, etc.
276-410, Wt. 3 oz. .... .99

For 12 Volt AF amplifier circuits. Replaces: 2N306A, 2N445A, 2N446A, 2N447A, 2N556, 2N557, 2N587, 2N649, etc.
276-411, Wt. 3 oz. .... .99

Silicon Field-Effect Transistors

1.98

- *High Impedance Input!*
- *Low Noise! High Gain!*
- *Characteristics Similar to Pentode Vacuum Tube!*

1000's of applications where pentode tubes are used in low level circuits: field strength meters, "gate dippers," receivers, flea power transmitters, etc. TO-5 case. Includes specifications.
276-664, Sh. wt. 2 oz. .... Net 1.98

IBM Component Boards

29¢

SAVE!

4 for 1.00

All quality American made parts; ideal for builder and hobbyist alike. Each board contains at least two transistors, plus loads of other components: resistors, capacitors, coils, diodes, modules, chokes, and heat sinks. Size: 2⅝ x 3⅞".
276-616, Sh. wt. ¼ lb. .... Net .29

Twin PAK "POP" SERIES

Popular PNP Types

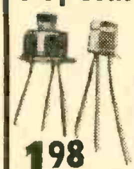
- 5-2N107 Types
- 5-CK722 Types

Radio Shack Exclusive! Great for experimenters, hams, hobbyists . . . all audio applications. Complete with transistor base diagrams.

1.98

276-031, Wt. 3 oz. 1.98

Popular NPN Types



- 5-2N35 Types
- 5-2N170 Types

Big savings on NPN type transistors! Especially suited for audio applications. Great for hams, hobbyists! Includes transistor base diagram.

1.98

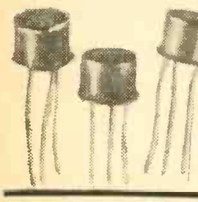
276-032, Wt. 3 oz. 1.98

Photo-Multiplier Power Transistor

1.98

Photo-sensitive cell, power transistor amplifier, electronic relay. Includes specs. and diagrams.
276-847, Wt. ¼ lb. .... Net 1.98

ARCHER Twin-Pak Transistor Kit



1.98 Kit of 25

- *10 NPN*
- *15 PNP*

BIGGEST BUY yet for the hobbyist or experimenter. Brand new . . . with full length leads. Ideal for RF applications, switching and general purpose audio types. Replace many popular numbers without circuit change.
276-1516, Ship. wt. 2 lbs. .... Net 1.98

750 MA Top Hat Rectifiers

25¢ PAK of 2

From 50-1000 PIV

276-1107	50 PIV	Pak of 2	.25
276-1108	100 PIV	Pak of 2	.39
276-1109	200 PIV	Pak of 2	.59
276-1110	400 PIV	Pak of 2	.89
276-1111	600 PIV	Pak of 2	1.39
276-1112	800 PIV	Pak of 2	1.79
276-1113	1000 PIV	Pak of 2	1.98

3 Amp Silicon-Controlled Rectifiers

1.95

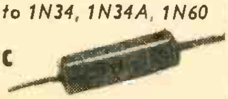
TO-66 Case! 200V

Designed to deliver loads up to 3 amps. Ideal for use in speed control operation, power converters.
276-1065 .... Net 1.95
276-1066, TO-66 mtg. hdwr. .... .30

10 GERMANIUM DIODES

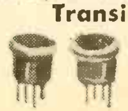
Similar to 1N34, 1N34A, 1N60

99¢



Equivalent in use to silicon diodes with lower forward voltage drop.
276-821, Ship. wt. ¼ lb. ...... Net .99

Transistor Sockets



99¢ Kit of 10

Takes PNP or NPN transistors with 3 contacts in line or triangle; complete with mounting plates. For every experimenter!
274-1510, Wt. 2 oz. .... Net .99

For Store Addresses, Order Form, See Page 20

ANY ARCHER-PAK ON THIS PAGE **$1** PER PAK

Celebrating Our 44TH Anniversary

RADIO SHACK 44TH BIRTHDAY SPECIAL

20 Power Resistors

Package consists of high-quality vitreous, cand-ohm and wire-wound types. Includes 5 to 25-watt power resistors; individual catalog net — $10!
271-1202, 2 lbs. ...... Net 1.00

35 Precision 1% Resistors

Large assortment of popular ½, 1 and 2-watt values; includes encapsulated, bobbin, carbon film, etc. Made by Aerovox, Shellcross, IRC, and other famous names.
271-1196, 1 lb. .... Net 1.00

50 Tubular Capacitors

An assortment of quality tubular capacitors, 100 mmf to .1 mf to 600 WVDC. Includes molded, paper and porcelain types. $10 if purchased individually from catalog!
272-1568, 1 lb. .... Net 1.00

4 Subminiature 455KC IF Transformers

Slug tuned, made for printed circuitry mtg., shielded. Size: ⅜ x ⅜ x ½".
273-515, ¼ lb. .... Net 1.00

8 Sets - RCA Plugs & Jacks

Quality items, ideal for use in phono amplifiers, tuners, recorders, etc. Take advantage of this Radio Shack Special low price!
274-1575, ½ lb. ...... Net 1.00

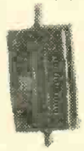
35 Miniature Resistors

World's smallest ¼-watt carbon type resistors! All have axial leads; built for transistor and subminiature circuitry: Assorted values, with resistor color code chart.
271-1566, ½ lb. ...... Net 1.00

40 Coils and Chokes

Shop assortment consisting of RF, OSC, IF, parasitic, peaking and many more types. Individually purchased, this would cost you $15!
273-1569, 1 lb. .... Net 1.00

45 Mica Capacitors



Famous name micas — Aerovox, Sangamo, C.D., etc. This assortment includes popular values 100 mmf to .01 mf, as well as silver type condensers. A $10 catalog net value!
272-1573, 1 lb. .... Net 1.00

8 Volume Controls

Most Popular Values

Contains 8 assorted values including long and short shaft types. A tremendous bargain for servicemen!
271-127, 1 lb. .... Net 1.00

Special! 50 Capacitors

Assortment of many types including disc, ceramic, mylar, temperature coefficient, molded, paper, oil, Vit-Q. You save $9 over industrial net catalog prices!
272-1199, 1 lb. .... Net 1.00

60 Half-Watt Resistors

Made by Allen Bradley and IRC. Many 5% and 10% tolerance. Color chart. All most popular values. An absolute "must" for hobbyists and kit-builders.
271-1612, 1 lb. .... Net 1.00

50 Ceramic Capacitors

Wide variety of popular values by Centralab and other famous-name makers. 10 mmf to .04 mf to KV. Assortment includes tubulars, discs, NPO's, temp. coefficient, etc.
272-1566, 1 lb. ..... Net 1.00

48 Terminal Strips

You get a wide variety of screw and solder lug type terminal strips with 1 to 6 lugs. Outstanding value at this low price! 101 uses for the builder and experimenter.
274-1555, 1 lb. .... Net 1.00

35 Disc Type Capacitors

A varied assortment of types, including NPO's, Hi-Q, N-750's, mylar and ceramic. 10 mmf to .01 mf to 6 KV. A $10 catalog net value!
272-1567, ¼ lb. ...... Net 1.00

150' of Hook-Up Wire

Assortment consists of 6 rolls of 25' each — solid and stranded wire. #18 through #22. Necessary for multitude of jobs and always useful!
278-025, ½ lb. .... Net 1.00

40 One-Watt Resistors

Here are resistors for hundreds of uses! Assortment has Allen Bradley and IRC carbons, with 5% values included. This pack is a regular $8.00 catalog net!
271-1576, 1 lb. .... Net 1.00

4 Transistor Transformers

Made by UTC and Remington Rand. Famous miniatures. Includes subouncer, mike, input types. Color coded leads.
273-1581, 1 lb. .... Net 1.00

$25 SURPRISE PACKAGE!

Loaded with Parts! **$1**

The biggest surprise package yet! Enough electronics components to make your eyes pop! Resistors, capacitors, condensers, diodes . . . your guess is as good as ours. The famous-make parts are worth *at least* $25.00!
270-1251, 1 lb., Net 1.00

50 Plugs and Sockets

Ideal bench assortment for servicemen, hams, etc. Subminiature and printed circuit types included! This assortment saves you $10 over individual catalog prices!
274-1562, 1 lb. .... Net 1.00

30 2-Watt Resistors

These quality 2-watt resistors are non-inductive, magnetic film, carbon types. Many with 5% values. Made by famous-name manufacturers.
271-1211, ½ lb. .... Net 1.00

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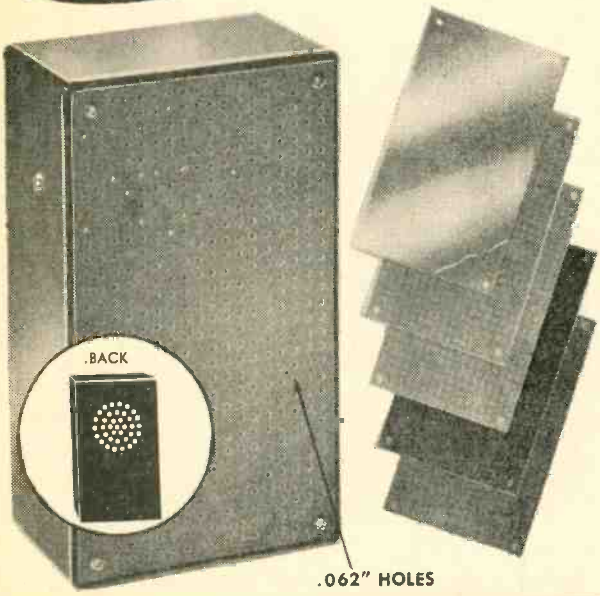
RADIO SHACK
44TH
BIRTHDAY
SPECIAL
Celebrating Our 44TH Anniversary
ANY ARCHER-PAK ON THIS PAGE
$1
PER PAK
4 Type 2N107 PNP Transistors
One of the most widely used transistors today for general audio use. Complete with base wiring diagram.
276-501, 1/2 lb. .... Net 1.00
6 Zener Rectifiers
Includes zener references! Ratings from 250MW-10 Watt. Stud, axial lead, upright types, assorted voltages; IN429, IN821, etc.
276-538, 1/2 lb..... Net 1.00
10 MAT High Frequency Transistors
Similar to 2N501 type PNP Freq. 30-180 MCS. Used in RF and switching circuits. Ideal for CB, Hams, and experimenters.
276-522, 1/2 lb. .. Net 1.00
4 100 Mc. NPN Planar Transistors
Similar to 2N1613, 2N-1893 and 2N2049. Made by Fairchild and Rheem. Rated at 700 MW. Vce 75; Hfe 40-120; 150 Ma; TO-18, TO-46 cases.
276-536, 1/2 lb. .... Net 1.00
8 Pre-Etched Boards
Assorted types of pre-punched boards ideal for transistor experiments, hobby work. Any path may be used.
276-1572 .... Net 1.00
5-10W PNP Power Transistor Pak
Ideal for the experimenter wanting higher wattage rating transistors. Types similar to 2N155.
276-527, 1 lb. .... Net 1.00
2 Silicon NPN 400 Mc. Planar Transistors
Excellent for VHF, switching and oscillator applications. Made by Sylvania. Similar to 2N-707-8. 360 MW; Vcb 15; Hfe 12-75; 10 Ma.
276-541, 1/2 lb. .... Net 1.00
5-6 Volt Zener Diodes
Rated at 1 watt. Gold plated. Long axial leads. Ideal for voltage regulated power supplies, transistor bias, etc.
276-518, 1/2 lb. .. Net 1.00
3 Coax Silicon Transistors
Similar to Hughes 2N1241-2N1243 type PNP. Used in audio and switching circuits. Vcb 35 Hfe 30 Ic 10. Rated 1 watt.
276-550, 1/2 lb. .. Net 1.00
Pak of 8 PNP Switching Transistors
PNP includes TO-5, TO-22, cases. Similar to 2N1305, 2N394, 2N404. Frequency: 4 MC, 150MV, Vcb 10; Hfe 70, 10 Ma.
276-539, Sh. Wt. 1/2 lb. .... Net 1.00
25-Pc. Surprise Pak
Includes both PNP and NPN's Silicon and Germanium types. Assorted cases TO-5, TO-18, and TO-46. Ideal assortment for the experimenter.
276-524, 1 lb. .... Net 1.00
3 Silicon 100MC 2W Transistors
PNP type TO-5 case. Similar to 2N1132, 2N2104 and 2N2303 types. Ideal for high frequency work. Vcb 60 Hfe 40-120.
276-523, 1/2 lb. .. Net 1.00
Pak of 8 NPN Switching Transistors
NPN Type; Similar to 2N333, 2N336-337, Specifications as above. With diagram.
276-540, Ship. Wt. 1/2 lb. .... Net 1.00
25 Germanium Diode Surprise Pak
Used in computer switching and general experimental use. Long axial leads. Ideal for experimenter and builder.
276-519, 1/4 lb. .. Net 1.00
3 RF Silicon Transistors
NPN type — similar to 2N790-2N792, 2N1150 and 2N170 types. Rated at 150 MW. Freq. 13 MC.Vcb 45. MA 22; TO-22 case.
276-528, 1/2 lb. .. Net 1.00
10 Popular PNP and NPN Transistors
Includes most popular types: CK-722, 2N35, 2N 107, 2N440, and 2N335. Invaluable to experimenters and hobbyists.
276-510, 1/2 lb. .... Net 1.00
20 Top Hat Rectifier Pak
Some up to T AMP. Flangeless types too! Assorted voltages and current. Long leads. Each Pak a real surprise!
276-520, 1 lb. .... Net 1.00
3 PNP High Power Transistors
Rating: 10-40 W. Similar to 2N155, 255, 2N1320, 2N1504. Top quality manufacturer. Includes cases TO-3, TO-10, TO-13.
276-529, 1/2 lb. .. Net 1.00
New! 6 NPN and PNP Micro-Transistors
Both silicons and planars with T and T-46 cases. Similar to T-706, 2N995, 2N834, 2N2357. Frequency: to 200 MC. Wiring diagram.
276-542, 1/2 lb. .... Net 1.00
25 250MW Silicon Zener Diodes
Glass miniature diodes in assorted voltages. Long axial leads. Excellent for transistor power supply regulation.
276-521, 1/2 lb. .. Net 1.00
New! 4-Micro Silicon Epoxy Rectifier
Rated at 1 amp a 400 PIV. Mfg. by GE. Long axial leads. Ideal for micro miniature circuitry where space is a factor.
276-549, 1/2 lb. .. Net 1.00
For Store Addresses, Order Form, See Page 20

RADIO SHACK 44TH BIRTHDAY SPECIAL

Ingenious New Radio Shack PERFBOX™ "Professionalizes" Project Building!

The bloody-knuckle brigade will appreciate Radio Shack's effort to eliminate chassis cutting and drilling, and make things prettier!

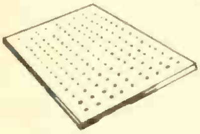


Somebody at "The Shack"—thank heaven!—must hate metal chassis and the generally sloppy look of breadboard projects. Now they've come up with a bakelite chassis box into which they've installed (4 screws) a 3½" x 6" perfboard top. But that's not all—the back of the box is pre-drilled for a 2¼" or other PM speaker, and there's a pre-drilled ¼" outlet hole on one side! This much-needed item is called the Radio Shack Experimenter's PERFBOX™. (*Cat. No. 270-097, price $1.69*) and should sell like film at Expo 67. As an added fillip, there's a companion deal they call Radio Shack Experimenter's 5-Piece Panel Set, consisting of 3 perfboards and 1 aluminum and 1 bakelite panel board, all 3¼"x6" predrilled to fit the PERFBOX™. The latter two boards are un-perfed (to coin a word), and the 5-piece set (*Cat. No. 270-100, price $1.69*) should answer just about any need for extending the usefulness of the PERFBOX short of filling it with champagne!

RECOMMENDED PARTS FOR USE IN PERFBOX PROJECTS

DESIGN, CONSTRUCT YOUR OWN CIRCUITS . . . using these time-saving phenolic boards, breadboard or permanent type. 3/32" holes punched on 0.265" centers. Can be sawed. Shipping weight 1 lb.

UNCLAD PERF-BOARD

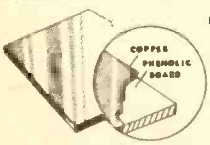


Punched

- *Accepts Miniature Components!*
- *Easy-In, Easy-Out Mounting!*
- *Ideal for Modular Construction!*

276-1582, 3.65x6.87x1/16" .... Net .59
276-1583, 6.87x9.8x1/16" .... Net 1.15

COPPER-CLAD SOLID BOARD

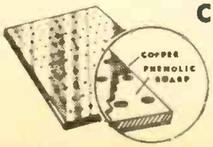


(Unpunched)

- *Make Your Own Printed Circuits!*
- *Quality-Manufactured Board*
- *Bonded with Copper!*

276-1586, 3.65 x 6.87 x 1/16" .... Net .79
276-1587, 6.87 x 9.8 x 1/16" .... Net 1.50

COPPER-CLAD PERF-BOARD

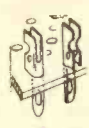


(Punched)

- *For Printed Circuit Design and Circuit Checkout!*
- *Easily Etched and Worked!*

276-1584, 3.65x6.87x1/16" .... Net. .89
276-1585, 6.87x9.8x1/16" .... Net 1.75

PUSH-IN TERMINAL KIT



1.49 Kit of 100

Use with prepunched perf boards. .062 diameter holes (1/16"). Serrated slots. Easy multiple connections.
270-1394, ¼ lb. Net 1.49

SPRING BANANA PLUGS

99¢ Set of 10

Ideal for 3/32" hole perforated boards. Overall length 1".
270-1543, 2 oz. .... Net 99¢

SOLDERLESS TERMINALS

99¢ Set of 15

Use with .093 diameter holes. Takes up to 7 leads without soldering. USA made. Spring action.
270-1395, 4 oz. .... Net 99¢

ALLIGATOR CLIP SET

99¢

10 brass plated 1⅜" long with insulated phenolic barrels. Strong spring: 5 red, 5 black.
270-1540, 2 oz. .... Net 99¢

For Store Addresses, Order Form, See Page 20

No One Beats Radio Shack on Reconditioned Phones!

Colored Desk Phones

• *Complete with Plug* • *Ready to Use*

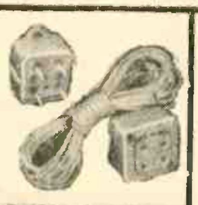
Just the ticket for private phone and intercom systems . . . and priced so low that everyone can own one . . . or two . . . or more! They're real time and step-savers you can install in any room, and so *attractive* they'll complement every interior decor. Complete with chrome dial, bell, induction coil and cable. Specify your second choice of color when ordering. Factory reconditioned, guaranteed.

279-375, Beige, Sh. wt. 10 lbs. .... Net 12.95
279-376, White, Sh. wt. 10 lbs. .... Net 12.95
279-377, Green, Sh. wt. 10 lbs. .... Net 12.95

12.95

★ Beige!
★ White!
★ Green!

30 Ft. Telephone Extension Cord



Move your phone from room to room! Highest-quality 4-conductor flexible cord plus standard telephone jack and plug. Ideal for intercom. Use 2 or more for extra length.
279-1261, Sh. wt. 1¼ lbs. .... Net 2.98

Telephone Plugs & Jacks

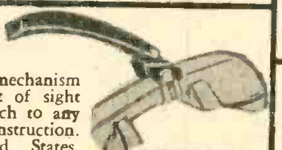
Ideal for making extensions, these plugs and jacks each weigh approximately ¼ pound.
279-366, plug .... Net 1.25
279-367, jack .... Net 1.40

Coiled Phone Cords

Stretches up to six feet. 3-conductor. Shipping weight: ¼ pound.
278-361 .... Net 1.19

Four conductor extends up to fifteen feet. Shipping weight: ½ pound.
278-1389 .... Net 5.95

Shoulder Rest



Frees both hands! Spring mechanism enables arm to be folded out of sight when not in use. Easy to attach to any phone. Long lasting metal construction. Manufactured in the United States. Weight: 1 pound.
279-606 .... Net 1.49

Telephone Wall Jack

For 2, 3, 4-wire systems. Fits standard wall conduit boxes. 1 lb.
279-1507 .... Net 1.99

Carbon Type Handset

For Mobile and Replacement Use!

Great for use with mobiles & intercoms, or as outdoor mike for camps and construction sites. Withstands extreme temperatures. High output mike can be used with low gain circuits. Adapt to your CB transceiver or radio. Includes earpiece and 3-conductor cord.
279-1351, Sh. wt. 1 lb. .... Net 2.99

Sound-Powered Elements

Kit of two! Talk without electricity—your voice powers these devices. Hook them up and talk up to 300 feet. Shipping weight: ½ pound.
279-1353 .... Net .99

100 Ft. 3-Conductor Telephone Wire

Multi-use 100′ 3-conductor wire for telephone work. Ideal for linking temporary phones for field uses.
278-370, Sh. wt. 2 lbs. .... Net 3.49

Handset Hanger

Hang up your phone without cutting off party on other end. Ideal for wall telephones. Anodized black aluminum.
279-1528, Sh. wt. ¼ lb. .... Net 1.25

Telephone Dials

Standard Western Electric unit. Can be used with automatic control circuits, & electronic combination lock circuits.
279-359, Sh. wt. 1¼ lbs. .... Net 2.99

Store Addresses, Order Form, See Page 20

POSITIVE FEEDBACK

JULIAN M. SIENKIEWICZ, EDITOR

Tear Down Big Ben! Though only eight years old, Randy Paulson of Kenosha, Wis., is a dedicated student. Getting test questions wrong isn't one of his favorite experiences. And when it happens, he does something about it. The folks at General Electric learned this recently when they received some advice from Randy. He suggested a modification to the next batch of clocks being made.

In a quiz on Roman numerals, Randy accurately reproduced the representation on the General Electric clock at home for the numeral four: *IIII*. His teacher marked his answer wrong. He protested, citing his source of information. This left him with but one alternative: get the clocks changed.

Randy wrote to GE and said, in part, "I'm studying Roman numerals in school. We have a General Electric clock and you know what? You made the number *4* like this *IIII*. This is wrong. You should make it like this *IV*. You see, my teacher marked my test paper wrong when I used your numeral *IIII*. I hope you will change it on your next batch of clocks."

Edwin C. Pease, manager of public relations for the Housewares Division that makes the GE clocks, answered Randy's letter. In his best PR prose, he pointed out that in the tradition of the clock industry, dating back centuries in European custom and continued in the early American period, the number four was represented by the symbol *IIII*. He suggested this might have been done initially to provide some design balance with the *VIII* which appears on the opposite side of the clock.

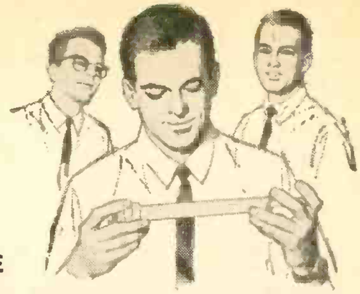
This Editor is in Randy's camp. (Like earlier Romans, my third grade teacher used *IIII* or *IV* for *4*.) Still, my eight-year-old son claims *IV* is correct; and he adds, "*V* is for *5*, Dad, in case the Romans didn't invent it when you were a little boy." Oh well, let's face it. Numbers ain't my racket.

What Gives? It doesn't matter what time of year it is—hot summer, crisp fall, balmy spring or blustery winter. There is always a horde of Elementary Electronics readers who would like to latch on to metal locators (or should they be called treasure locators!). The demand is so widespread and the mail so heavy that our regular mailman stutters whenever he spots a coin on a sidewalk. To spare our postal courier from this unseemly pastime, let me clue you in on an outfit in Texas. Relco is their name and they will mail you a catalog jammed with treasure locators you can buy in either wired or kit form. Just send a postcard to Relco Industries, Box 10563, Houston, Tex. 77018 and tell them the Editor of Elementary Electronics tipped you off. Maybe they'll sell enough treasure locators that they'll send one to your Editor, who is constantly sifting the sands of Coney Island.

Now How About That! It's official, folks! General Motors Truck and Coach Division is sticking with CB as original equipment. GMC Truck pioneered CB systems for truckers in the spring of 1964 when it introduced a vacuum-tube transceiver which was factory-installed original equipment. For 1968, GMC Truck has added a complete line of high-quality, moderately-priced CB equipment for mobile and base-station installations. And guess whose equipment the mammoth motor giant selected for the coveted label—*Lafayette Radio.* Yep, they're the same folks who supply experimenters with electronic parts, newlyweds with stereo components, SWLs with receivers, and *mucho* more of everything else including a very complete line of high-quality CB gear.

The factory and dealer installations offered in the GM-Lafayette package includes transceivers for trucks, three specialized antennas to snatch CB signals from the ether, and a base-station power pack to provide soup for the 12-VDC rigs from any AC outlet. The transceivers are solid-state mobile units costing slightly more than $100 each. Compact (they're smaller than a cigar box), the new units will enable truck drivers to make emergency calls when stranded, keep driver and dispatcher in two-way contact, and permit drivers to communicate with each other in various caravan-type applications. The transceiver comes with a built-in speaker and has a full 5 watts of transmitter input power. It is supplied complete with a crystal for one popular channel (the nation's monitored motor channel —9) and has five additional channels available for use with any of the 22 other CB frequencies. Smaller than a good many cigar boxes, it measures a mere 5 x 7 x 1½ in.

Hats off to General Motors for stepping up its original CB equipment program; and a *hip, hip* to Lafayette for packing top-quality CB rigs with *real* dollar value price tags. ■



Be the man who's always first to say: "I've got the answer right here."

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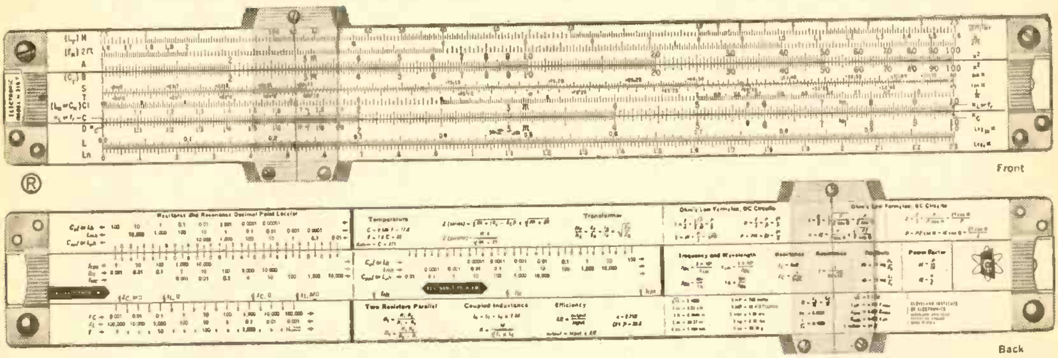

Front

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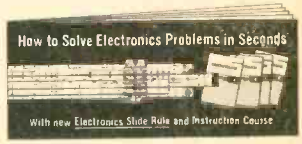

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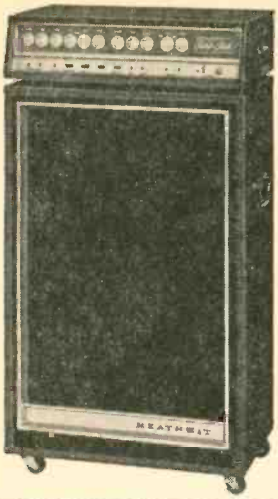

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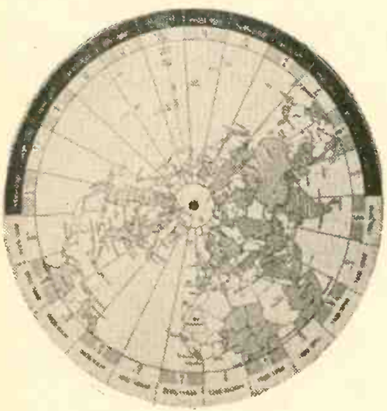

Weems & Plath Time Plotter

standard time anywhere. Made of heavy laminated plastic, there are charts for northern and southern hemispheres on opposite sides. Time zones are projected to the poles, with exceptions noted for ready reference.

Principal cities and political boundaries are clearly marked, and alternately shaded areas help the user follow the outlines of irregularly shaped time zones. Rotation of the center disc to match the user's local time gives an appropriate readout for all other time zones. The instrument is priced at $6.95 and can be obtained postpaid from Weems & Plath, Inc., 48 Maryland Ave., Annapolis, Md. 21401.

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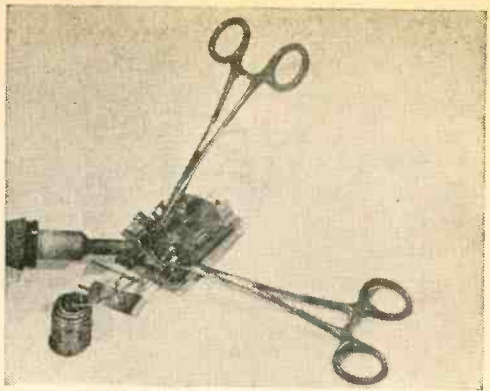

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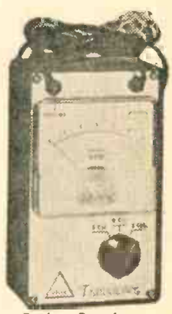
This "third hand" seizer/plier will give every assembler a surgeon's skill and precision in coping with tiny, miniaturized parts. The Allis-SEIZER is made of surgical stainless steel and features a medical locking device for clamping, permitting use of the instrument as a heat sink as well as holding microminiatures and fine wires securely for soldering. Several types are available: straight or curved nose with or without self-locking device, in various lengths. List prices (5½ in. size): $2.69 for the non-insulated version, $3.39 insulated, and $3.89 with Piperized nose cones for positive, non-marring grip. Descriptive bulletin can be handily had from Allis Industries, Inc., 143 W. 41st St., New York, N. Y. 10036.

Tune-Up Tach



Delta Products Tune-up Tachometer

Be your own auto mechanic with Delta's Model T-1000 tune-up tachometer, called the Transitester. Weighing only 1¼ lb., its range is 0 to 1200 RPM. The unit features a large, easy-to-read 3½ in. meter in a high-impact case. It uses two transistors; a Zener diode and timing capacitor in conjunction with a precision 100 μA d'Arsonval meter for RPM indication. In operation, the input signal from the point circuit charges the timing capacitor through a current limiting resistor to approximately 6 volts (maximum is limited by a Zener diode). When the points close, the driver transistor switches the output transistor to its *on* state, discharging the timing capacitor through the metering circuit. The unit discovers faulty plugs, enabling user to tune car for better gas mileage, fuel savings, smooth and quiet operation. Cost: $14.95 postpaid from Delta Products, Inc., Box 1147, Grand Junction, Colo. 81501.

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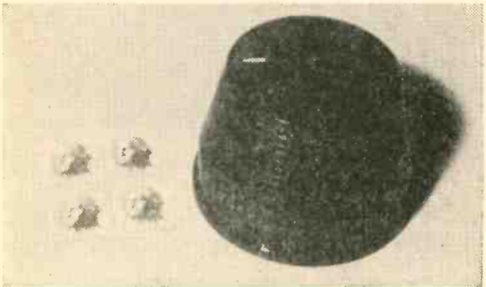
Push-Pull Red Light

Here's a long-life, flashing road-safety light that needs no batteries, being introduced to the market as Astroflare. The power source is a deferred action primary cell, and there are no toxic fumes or corrosive acids; the device is perfectly safe for any user. The Astroflare uses a Fresnel lens for optimum light diffraction, and utilizes



Crimpco Engineering Astroflare

a highly transparent, temperature-resistant polystyrene material. The brightness exceeds State Motor Vehicle Code requirements for passenger vehicles. The device is actuated by lifting a metal tab, which triggers the power source. It provides rapid warning flashes, and continues to operate for a period well in excess of an hour. The flasher units, which retail at $1.49 each, are available from Crimpco Engineering, Box 492, Canoga Park, Calif. 91305.

Mike Mix Master

American Geloso Microphone Mixer

The Geloso G 300-U solid-state, portable microphone mixer will accept low-, medium-, or high-impedance microphones with negligible change in performance (use of high-impedance mikes results in a 3-4 dB reduction in gain, nominal in view of the overall gain of 55 dB). The sound level of each microphone can be adjusted separately because each channel has its own preamp and volume control. Further, the G 300-U operates on either self-contained batteries or on AC, and automatically switches power sources if one should fail. Other features: input for a reverberation unit, a high level input, and an output master volume control. When more than four mikes are to be used, a group of G 300-Us can be connected in cascade using the cables supplied. Price: $89.95. Details of the new unit are available from American Geloso Electronics Inc., 251 Park Ave. S., New York, N.Y. 10010. ■

NEWSCAN

In the service shop, the Chek-a-Color unit provides a convenient, efficient bench tool for trouble shooting and testing color chassis. The unit, which also contains a deflection yoke, convergence assembly and blue lateral magnet assembly, is housed in a high-impact plastic case.

Color Serviceman's "VOM"

Sylvania has developed a portable color television test unit designed to save substantial time and effort in color TV repairs. Equipped with a 19-in., 90-degree rectangular bonded-shield color picture tube, deflection yoke, convergence assembly and blue lateral magnet assembly, the Sylvania *Chek-a-Color* unit allows service technicians to check quickly all 19- through 25-inch color TV receiver chassis without disturbing the neck components or picture tube. The unit isolates color TV problems thus enabling the serviceman to remove only the part of the set requiring attention. In addition to saving time and effort on service calls, *Chek-a-Color* provides conclusive support of the serviceman's recommendations for repair.

For example, if the test unit delivers a good picture when connected to the chassis of a malfunctioning set, it shows that the trouble lies within the picture tube or neck components. On the other hand, if the same problems appear on the Chek-a-Color screen, it shows that the problem is in the chassis/tuner group. This handy device will speed up home servicing with an attendant reduction in the service fee. How about three cheers?

Fumeless Ford

A prototype of an electric City or Shopping Car, the first to be designed and developed by any major motor manufacturer specifically for electric propulsion, was unveiled at Ford of Britain's Research and Engineering Center at Dunton, Essex. The experimental car, which is

The Ford Comuta (above) is an experimental electric car developed by Ford of Britain's Research Staff. Chassis and batteries of the experimental car are shown in the bottom photo.

called the Comuta, is only six feet, eight inches long, less than half the length of a Cortina (or a Mustang), and has been designed so that three can be parked in the normal parking meter space. It has a turning circle of 18 feet, no clutch, no gears and therefore offers *automatic driving.* *(Continued on page 32)*

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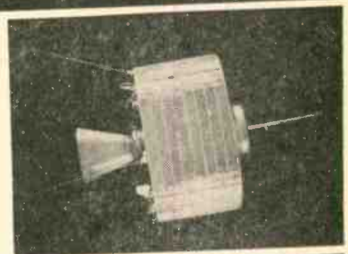

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The Comuta has been designed to carry two adults, and two children or the shopping. It is equipped with dimming headlamps, anti-burst door locks, and a sophisticated heating and cooling system. A battery charge indicator can be made available. The Comuta has independent suspension on all four wheels. The rear wheels are driven directly by two electric motors.

The Comuta and other electric cars are expected to be commercially feasible within the next ten years although their uses will be primarily as city-center delivery vans and suburban shopping cars. The internal combustion engine will continue to be the most practical form of power for long distance and motorway driving, but electric cars will have a part to play in meeting some future transportation needs.

The Comuta, a practical little experimental car, has a range of 40 miles at a steady speed of 25 mph and is powered by conventional batteries. With other, more expensive batteries, it can travel at more than 40 mph and greatly increased range. Improved battery technology will undoubtedly also increase the speed and range.

More for Experimenters

The Electronic Components Group of Slyvania Products Inc., has launched a sales program for a broad line of more than 30 popular components, integrated circuits, transistors, resistors, diodes, photoconductors, circuit breakers, pilot light assemblies, transistor sockets. These items are being offered pre-packaged on bubble pack cards. The program was developed to meet the increasing demand for stock electronic components required by experimenters and hobbyists. Products are displayed on a four-sided, double-duty display rack. Each of the four product classifications employs a separate color code for ease of selection. Three of the panels feature semiconductors, including seven of the most frequently used diodes, ten types of germanium and silicon transistors, and six different rectifiers including a versatile silicon controlled rectifier. The fourth panel offers photoconductors, circuit breakers, transistor sockets, pilot light assemblies, control relays and two basic integrated circuits.

Displays of this type are real boons to experimenters who have been pushed from pillar to post in electronics parts stores. After all, why should a salesman write up an NE-2 purchase when he can peddle a color TV? Now the experimenter can serve himself and save time. Just be sure you pay for the items you take. ■

ELEMENTARY ELECTRONICS ETYMOLOGY

By Webb Garrison

Toggle Switch

▲ Before the beginning of recorded history sailors recognized the importance of being able to hold a rope or chain in position. They solved the problem very early—by use of a short wooden or metal pin that could be slipped through a loop in the eye of a rope or a link in a chain.

Little changed during centuries of use, this device was still common when England entered the great age of exploration. Queen Elizabeth's sailors called the holding contrivance a *toggle*. Precisely why, no one knows. Perhaps the name emerged from a corrupt form of *tangle*, or from the then-current term *tuggle*, meaning "to catch."

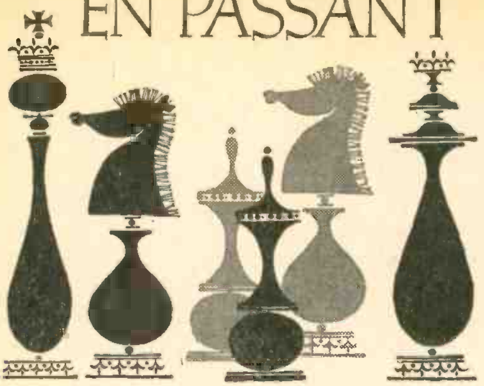
Impact upon speech was extensive. Artisans used the name of the sailor's toggle in many combinations. The togglechain was designed to hold timber firmly on a sled. The toggle-harpoon equipped with pivoted toggle in lieu of barbs was—hopefully—capable of locking itself into a whale. The toggle-lanyard and many other holding devices were in common use during Shakespeare's time.

Some toggles employed a special kind of joint—two pieces of metal hinged together endwise and capable of being tripped by slight pressure at the elbow of the joint.

After electrical devices had entered general use, someone had an inspiration. Why not replace slow and clumsy switches with a lever attached to a toggle-joint? This should make it possible to switch current on or off very rapidly as a result of movement through a relatively small degree of arc.

It worked so well that the name stuck and today's *toggle-switch* points to a function precisely opposite to the "holding fast" feature of the toggle that was familiar to 18th-century seamen. ■

EN PASSANT



BY JOHN W. COLLINS

In my previous column I showed how two World Champions, Dr. Max Euwe of Holland and Paul Morphy of the United States, actually lost games in ten and twelve moves, respectively. Continuing on the same theme, this time we witness two more immortals experiencing a similar fate.

Unlucky 13. Jose R. Capablanca, Cuba, champion 1921-1927, lost only 35 games (6%) in a lifetime of tournament and match play—a record never equaled by another Champion! Here he is forced to resign after thirteen moves. It was a Polish Opening, contested in a simultaneous exhibition given by Capablanca at Brooklyn, 1924, and his opponent was Alexander Kevitz, who is still a top player at the Manhattan Chess Club. Diagram at top of page.

1 P-QN4	P-Q4	6 N-B3	QN-Q2
2 B-N2	B-B4	7 N-K2?	N-N5!
3 P-K3	P-K3	8 P-B3	B-K2
4 P-KB4	N-KB3	9 P-KR3?	N-B4!
5 N-KB3?	BxNP		

Threatening 10 . . . N-Q6 mate.

10 N-N3 B-R5!
11 NxB . . . .

If 11 PxN? BxN# 12 K-K2, B-Q6 mate.

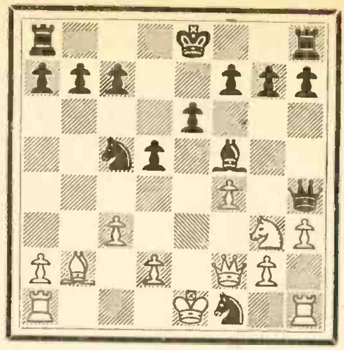
11 . . . . QxN
12 Q-B3 NxP
13 Q-B2 . . . .

If 13 QxN, N-K5 and Black regains his piece and remains two Pawns ahead.

13 . . . . NxB
Resigns

If 14 KxN, N-Q6 15 Q-K3, QxP# and Black has a winning material advantage. Or if 14 NxN or 14 RxN then 14 . . . N-Q6# wins the Queen.

Black



White

Unlucky 14. And, finally, we see Emanuel Lasker, Germany, champion 1894-1921, the great fighter and tactician who reigned longer than any other World Champion, being mated or losing his Queen in jigtime. Lasker defended with the Slav, his conqueror was H. Caro, and the game was played at Berlin, 1890.

1 N-KB3	P-Q4	4 Q-N3	Q-B1
2 P-Q4	B-B4	5 PxP	PxP
3 P-B4	P-QB3	6 N-B3	. . . .

Not 6 QxQP?? QxB mate.

6 . . . . P-K3
7 B-B4 P-QR3?

A weakening, non-developing move which loses.

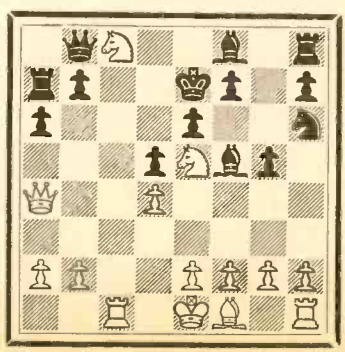
8 N-QR4	R-R2	11 Q-R4#	K-K2
9 N-N6	Q-Q1	12 R-B1	P-N4
10 BxN	QxB	13 N-K5	. . . .

Menacing 14 Q-Q7# K-B3 15 QxBP mate.

13 . . . . N-R3

On 13 . . . N-B3 14 N-B8# K-Q1 15 NxP mates. (Continued on page 38)

Black



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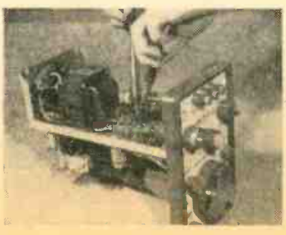


Construction of Multimeter.

Continued from page 34

14 N-B8# Resigns

For if 14 . . . K-Q1 15 Q-Q7 mate or if 14 . . . K-B3 15 N-Q7# wins the Queen.

From the Past. In my first column I promised to look at both chess of the past and the present. Recent "Game of the Month" has featured the contemporary (Fischer-Olafsson and Penrose-Botvinnik). But this month it will be the past—a game which has gone down in chess history as the "Immortal." It was a King's Gambit, played at London, 1851, L. A. Kieseritzky had Black, and Adolf Anderssen, Germany, unofficial World Champion 1851-1858 and 1862-1866, a genius for sacrificial combinations, timely and untimely, was the winner.

1	P-K4	P-K4	8	N-R4!	Q-N4
2	P-KB4	PxP	9	N-B5	P-QB3
3	B-B4	Q-R5#	10	P-KN4!	N-B3
4	K-B1	P-QN4	11	R-N1!	PxB
5	BxP	N-KB3	12	P-KR4	Q-N3
6	N-KB3	Q-R3	13	P-R5	Q-N4
7	P-Q3	N-R4	14	Q-B3	. . . .

Threatening to win the enmeshed Queen with 15 BxP.

14	. . . .	N-N1	17	N-Q5	QxP
15	BxP	Q-B3	18	B-Q6!!	. . . .
16	N-B3	B-B4			

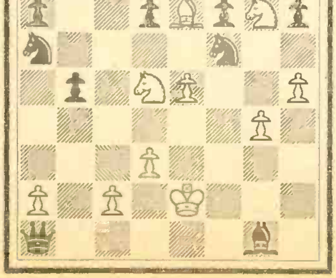
Already a Bishop behind, White offers two more Rooks for an uncanny mating attack!

18 . . . . BxR

If 18 . . . QxR# 19 K-K2, QxR 20 NxP# K-Q1 21 B-B7 mate!

19	P-K5!!	QxR#	22	Q-B6#!!	NxQ
20	K-K2	N-QR3	23	B-K7	mate!
21	NxP#	K-Q1			

Black



News and Views. Mrs. Gisela K. Gresser of New York won the U. S. Women's Championship for the eighth time—matching Grandmaster Robert J. Fischer's eight wins of the U. S. Men's Championship. She scored 8-2 to finish a point ahead of Miss Mona M. Karff and two points ahead of third place Mrs. M. Selensky.

Andrew Soltis, a nineteen year old student at City College and a former New York City Junior Champion, won the Marshall Club Championship with 7-1.

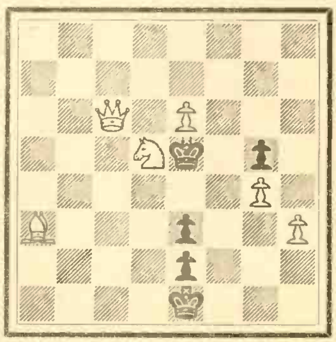
"Now, therefore, I, John A. Love, Governor of the State of Colorado, do hereby proclaim the week of April 9 through April 15, 1967, as CHESS WEEK in Colorado." Thus official notice was taken of the great increase in chess interest in several fields in one of our western states.

Chess and music suffered a loss when Louis J. Persinger of New York recently died at the age of 79. Mr. Persinger was an ardent player and once participated in the U. S. Championship. He was also a famous violinist, connected with the Juilliard School of Music, and had taught such virtuosos as Yehudi Menuhin.

Learn by Reading. "Bobby Fischer Teaches Chess" is one of the newest books for beginners. Co-authored by the youthful U. S. Champion, Robert J. Fischer, Stuart Margulies, Ph.D., a psychologist of Basic Systems, and Donn Mosenfelder, an innovator in education, it presents a new method of learning created by the education division of Xerox which has the student act on 275 chess situations. It is well produced, has 179 pages, is published by Basic Systems, Incorporated, an Education Subsidiary of Xerox Corporation, and costs about $6.95. ■

Problem 9
By Julius Buchwald
United States

Black



White

White to move and mate in two.
Solution in next issue

Solution to Problem 8: 1 P-Q5.

elementary Electronics NOV/DEC 1967

BY THE EDITORS OF ELEMENTARY ELECTRONICS

FM WIRELESS MIKE

Build our goof-proof project on a printed circuit board we supply absolutely free!

This is the ⌂ board you get!

You add 19 parts to build your very own FM Wireless Mike!

Here it is! The experimenters' project most requested by ELEMENTARY ELECTRONICS' readers—an FM Wireless Microphone. And to make it the most goof-proof project you ever built, the Editors are offering a specially designed printed circuit board free of charge to all subscribers and newsstand purchasers of this magazine. That's right, you read correctly: the printed circuit board is yours for the asking. Just fill out and mail the coupon on page 43—there are no postage or handling charges, nor any fine print obligations. (When we say *free*, we mean it!)

As an extra bonus, the Editors have arranged a guaranteed source of parts for the FM Wireless Microphone. If you have trouble getting the parts you need at your local dealer, then you'll appreciate this easy way to secure a *complete* parts package. Full details are on the coupon on page 43.

(Continued on next page.)

e/e WIRELESS MIKE

What It Is. The FM Wireless Microphone that you can assemble on our free printed circuit board has an effective range of 100 to 200 feet. The operating frequency falls at the low end of the FM band (around 88 MHz) and can be adjusted to any unused part of the dial.

The mike's sensitivity is very high, producing full, relatively undistorted modulation when the mike is held about six inches from the lips while speaking in a normal voice.

Typical uses of the FM Wireless Microphone include: remote paging, traveling mike for school plays, remote tie-in to public address systems, party snooping for a barrel of laughs, and wireless intercom service when two mikes are used.

Putting It Together. The FM Wireless Mike is assembled on the printed circuit board that can be yours free for returning the coupon included with this article. Since the printed circuit board is free, and since its layout has been specifically designed for trouble-free operation, we strongly suggest you don't try building a point-to-point wired model.

The following instructions are based on the *parts package* supplied by Sentry Mfg. Co., but you can purchase the very same components at your local or mail-order electronics-parts distributors. For this reason, there will be no discrepancies between those who use the Sentry *parts package* and those who purchase the required parts locally.

All parts needed for putting the FM Wireless Mike together are available in the component package shown at right. The printed circuit board is free, and with no charge for either postage or handling. Parts may also be obtained locally or from mail-order suppliers, if desired.

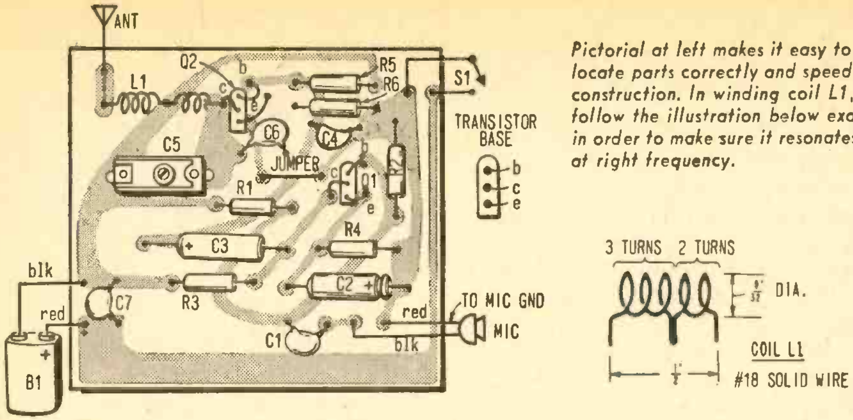
However, those who elect to buy parts locally must also drill the printed circuit board (the one supplied in the *parts package* comes predrilled).

The first step in building your FM Mike is to mount coil L1 on the printed circuit board. If you use the Sentry *parts package*, L1 is supplied pre-wound; simply stretch the coil so its total length (from start to finish of the turns—not to the end of the leads) is ½ in. If you wind your own coil, *tensilize* a 10-in. section of No. 18 solid-tinned wire by clamping one end in a vise and pulling on the other until the wire goes dead slack.

Winding The Coil. Next, using a 9/32-in. drill bit as the coil form, wind two turns and then bring out the wire from the form for a length of ½ in. This done, fold the wire back to the form and wind three more turns as shown in the drawing. Stretch the coil to a length of ½ in. and place it in the matching holes indicated on the printed circuit board. The 2-turn section of the coil is positioned towards the inside of the board, away from the left-hand edge.

After the coil is soldered to the board, place tuning capacitor C5 in its matching holes (it can be positioned either way). Make certain C5 doesn't touch L1, then fold over C5's mounting tabs on the bottom of the printed circuit board to ensure a rigid mount. Now, solder C5 in place.

Install all the resistors and the wire jumper as shown in the pictorial, then install the ceramic disc capacitors. Finally, mount the two electrolytic capacitors, C2 and C3, taking care that the polarity of each capacitor is correct—refer to both the schematic and pictorial diagrams.



Pictorial at left makes it easy to locate parts correctly and speeds construction. In winding coil L1, follow the illustration below exactly in order to make sure it resonates at right frequency.

Cut the length of the battery terminal wires to about 2 inches. Save the scrap ends of the red and black wire. Connect the red (positive) battery lead to the positive printed circuit board connection (this connection is indicated "+" directly on the board). Connect the black (negative) lead to the negative printed circuit board connection (indicated on the board as "—").

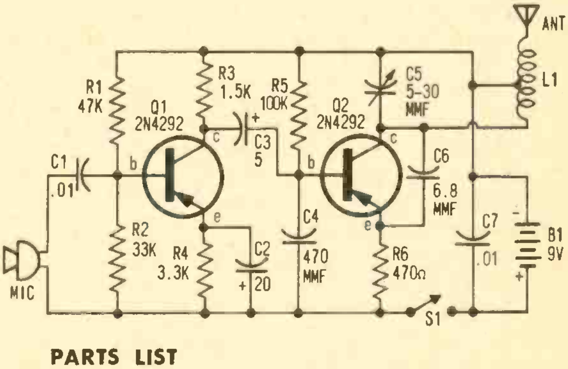
Take the remaining 2-in. section of black and red wires cut from the battery terminal and connect to the board's MIC terminals. As shown in the pictorial, the red wire must be closest to the right edge of the board.

Install two solid No.-18 wires, 1-in. long, at the switch (S1) printed circuit board connections at the upper right of the board—these wires will be cut to the correct length later.

Flat End Down. Finally, install the transistors, taking extra care not to use excess soldering heat. Mount Q1, the amplifier/modulator, first. Carefully note Q1's shape: one end is rounded; the other end is flat. Position the printed circuit board so that L1 is at the upper left, and orient Q1 so the flat end is down.

Now push Q1's upper lead (the one at the

Straightforward circuitry of Wireless Mike is shown at right. Audio amplifier Q1 output shifts frequency of oscillator Q2. Amount of shift depends on amplitude of audio.

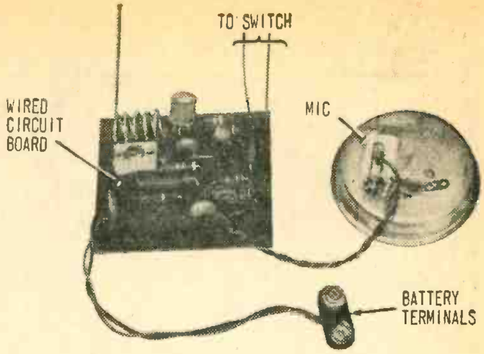


PARTS LIST

B1—9V battery (Burgess 2U6 or equiv.)
C1, C7—.01-uF ceramic disc capacitor
C2—20-uF, 3-WVDC miniature electrolytic capacitor
C3—5-uF, 12-WVDC miniature electrolytic capacitor
C4—470-pF disc capacitor
C5—5 - 30-pF miniature trimmer capacitor
C6—6.8-pF disc capacitor
L1—Antenna coil (see text)
MIC—Ceramic microphone element
Q1, Q2—2N4292 transistor
R1—47,000-ohm, ½-watt resistor
R2—33,000-ohm, ½-watt resistor
R3—1500-ohm, ½-watt resistor
R4—3300-ohm, ½-watt resistor
R5—100,000-ohm, ½-watt resistor
R6—470-ohm, ½-watt resistor
S1—Miniature pushbutton switch

Misc.—Nylon microphone screen, battery leads, soap dish, foam insulator, microphone protective cover, solder, etc.

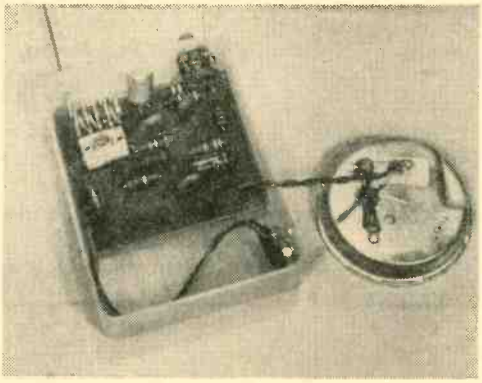
All the components listed above are supplied in the Sentry Parts Package—see coupon on page 43.



Completed circuit board with mike, antenna, and battery terminals attached. Unit is now ready for installation in soap-dish enclosure.

rounded end) into the hole indicated in the pictorial diagram as "b" (base). Bend Q1's center lead to the left and install it in the "c" (collector) hole. Bend Q1's bottom lead, the one nearest the flat end, to the right and install it in hole "e" (emitter). Push Q1 against the board as far as it will go—the leads will flare to the proper angle and the transistor will stop about ⅛-in. above the printed circuit board—and solder Q1 into place.

Solder as quickly as possible with an iron rated between 25 and 50 watts. Be sure leads do not touch each other. Now install Q2 in the same manner (see the pictorial diagram), with the flat end down.



Circuit board makes tidy fit in soap dish. Take care not to damage fragile mike diaphragm during construction. Wires to switch (top of photo), are now attached.

Temporarily set the completed printed circuit board aside and prepare the case. The case is a two-piece soap dish, approximately 2½ x 3½ x 1¼ in. Lay the phenolic microphone cover on top of the case's cover, mark the mike cover's hole, then drill the soap-dish cover. If the mike you use is supplied without a plastic cover, it will be necessary to drill about ten ¼-in. holes in the soap-dish cover within the confines of a 1¼-in. circle.

Mike Cover-up. Cut a section of nylon screen to the size of the mike cover and cement the screen and cover inside the soap-dish cover directly behind the drilled holes.

Slip the printed circuit board into the bottom of the soap dish and mark the antenna and power switch holes on the top edge. The antenna hole—1/16 in.—is directly next to the printed circuit board's ANT mounting hole. Switch S1 is placed directly adjacent to the two bare leads at the upper right of the printed circuit board: it uses a ¼-in. mounting hole.

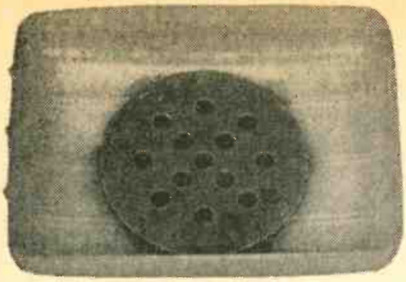
Solder a 5-in. length of No.-18 or 16 solid tinned wire to the printed circuit board's ANT terminal and slip the printed circuit board into the case. Press the board against

To prevent metal mike case from shorting PC board's components, square piece of plastic foam is placed over board. Battery is connected and tucked into space provided.

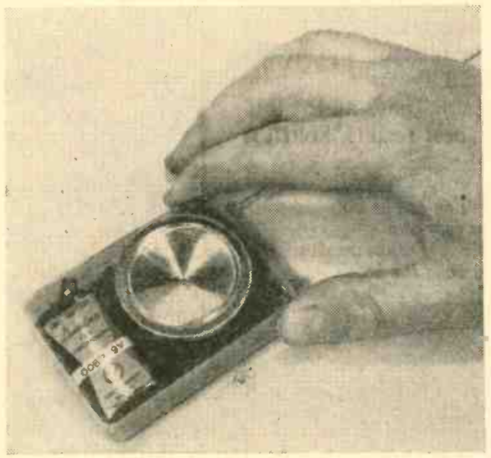
S1 (resistor R5 will touch S1), and solder the two bare printed circuit board wires to S1. Note that S1 may have three terminals; in this case, ignore the third terminal and solder to the two terminals that short together when the button on S1 is depressed.

Assuming you haven't rushed ahead and connected the mike, now is the time to do it. Note that one mike terminal is grounded to the case: connect this terminal to the red mike wire coming from the printed circuit board. Connect the remaining mike terminal to the black wire coming from the printed circuit board.

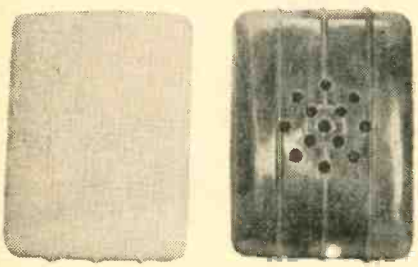
The battery should just fit between the printed circuit board and the bottom of the soap dish. Lay a 2-in.-square piece of plastic foam (insulation) on top of the printed circuit board and lay the mike on top of the foam. Install the cabinet cover, then glue a piece of aluminum foil over the entire bot-



Phenolic mike cover is placed in top of soap-dish and holes are marked with pencil or scribe.



Mike is placed on plastic foam when transmitter has been tuned. Final step in completing versatile Wireless Mike is to attach cover with rubber band or small sheet-metal screws.



Holes marked on cover are then drilled. A piece of screen is placed over mike cover, which is then attached to soap dish.

FREE PRINTED CIRCUIT BOARD OFFER

As a special offer to our readers, the Editors of ELEMENTARY ELECTRONICS have arranged for you to receive a Free FM Wireless Mike Printed Circuit Board from Sentry Manufacturing Company. All you do is fill out and mail the coupon on the next page so that it is postmarked on or before January 1, 1968. Sould you desire to purchase the parts for the FM Wireless Mike, place an X in the appropriate box and include a check or money order for $9.50 (price includes postage). Make checks payable to Sentry Mfg. Co. This free offer is invalid unless accompanied by the coupon on page 44.

The Editors
ELEMENTARY ELECTRONICS

tom of the soap dish case to prevent the effects of hand-capacitance from detuning the transmitter oscillator.

Tuning the Transmitter. Tune an FM radio to a clear spot at the bottom end of the FM band. Place the FM microphone within a few feet of the radio and, using an insulated (plastic) screwdriver, adjust tuning capacitor C5 until you pick up the mike's signal. Be sure to hold down pushbutton switch S1 while tuning up. That's all the tuning that's needed. For best results, hold the

This little lady is getting on the air in a big way with her very own FM Wireless Mike. Variety of uses makes unit handy to have around the house.

Wireless Mike at least six inches from the lips when speaking.

To hold the plastic case together use a rubber band or two ¼-in. long self-tapping screws. Start pilot holes and enlarge them until almost the size of the screw shank. Insert screws to hold case together. It may be necessary to carve away part of the cover to clear the pushbutton switch.

With the little rig ready to go you'll find many uses for it. Everything from remote babysitting to part of a wireless intercom or paging system are within its capabilities. In fact, about the only limitation to its uses is your imagination. ■

CUT HERE

FREE PRINTED CIRCUIT BOARD FM WIRELESS MIKE PROJECT

Sentry Manufacturing Co.
Box 12322, Oklahoma City, Okla. 73112

☐ Please send the Free Printed Circuit Board for the FM Wireless Mike as described in the November/December 1967 issue of ELEMENTARY ELECTRONICS.

☐ Please send the Sentry parts package and the free printed circuit board for the FM Wireless Mike. I am enclosing a check or money order for the sum of exactly $9.50, payable to Sentry Mfg. Co.

THIS OFFER IS NOT VALID UNLESS ACCOMPANIED BY THIS COUPON

Name ______________________

Address ______________________

City ______________ State ______________ Zip ________

Sorry, Free Offer expires January 1, 1968

AMAZING FOTONIC SENSOR

Step right up! You have to see this magic wand to believe it!

By Jorma Hyypia

■ What do you think of a device that can play a phono record without touching the grooves?, or measure distances to 10 millionths of an inch, or "watch" a speaker cone go through its gyrations to the tune of the 1812 Overture? A device that'll generate every imaginable waveform from rotating pieces of cardboard or make an ordinary funnel with a piece of plastic food wrap attached into a 0 to 40,000 Hz microphone.

These and many other fascinating audio-electronic experiments are possible with a new instrument called the Fotonic Sensor. Technically, the device is a non-contact optical proximity detector. In plainer English, it's a gadget for measuring extremely short distances, and distance changes, by means of a light beam. For example, the model KD-38 which is described in this article and shown in Fig. 1, can measure distances to within 10 millionths of an inch, and can measure displacement or motion at frequencies from DC to 40,000 Hz.

Static (non-fluctuating) readings can be made directly from a meter built into the sensor. Dynamic signals (vibrations) can be read by hooking the KD-38 output to an oscilloscope, or the vibrations can be made audible by feeding the amplified signals to a loudspeaker. These vibrational signals can be particularly useful to audio experimenters, as we shall see.

How It Works. Basically, the Fotonic Sensor consists of a special fiber-optics probe and an electronic circuit capable of translating light signals into electrical analog output signals. A number of different types of probes are available to meet a variety of different applications needs.

The standard probe provided with the KD-38 is 0.109 in. in diameter and contains 600 randomly distributed strands of glass fiber 3-feet long. The fibers are encased in a plastic-covered flexible steel monocoil jacket and terminate in a tubular metal probe tip about 3 inches long.

The end of the probe hidden inside the electronics box is branched. One branch consisting of 300 fibers leads to a 2.5V light bulb which sends light down the fibers to the

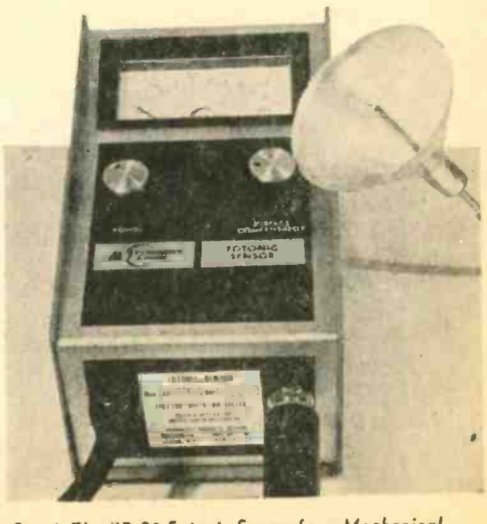


Fig. 1. The KD-38 Fotonic Sensor from Mechanical Technology, Inc. is shown here with its fiber-optic probe in a funnel as part of microphone experiment.

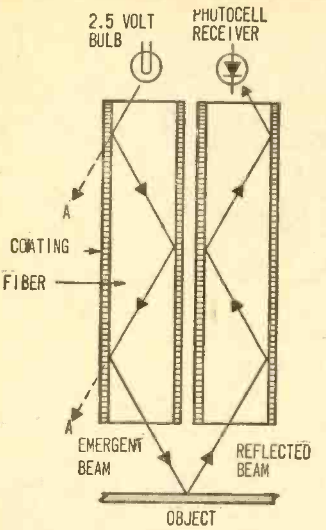


Fig. 2. Diagram of single pair of fibers shows how light is directed, reflected from object, received and detected.

tip of the probe. The light is bounced back to the probe by the object being studied; the other 300 fibers lead this reflected light back to a diode photocell which translates the light into an output signal that can be detected with a meter built into the sensor, or that can be fed into an oscilloscope or other electronic instrument.

Fig. 2 shows how the light travels down one fiber and back up an adjacent fiber. Actually, each emergent beam is in the form of a cone of light which is picked up by several adjacent receiving fibers. Each fiber has a special coating on the outside to prevent escape of light to its neighbors. This is important because otherwise "crosstalk" between the fibers would greatly impair the efficiency of the sensor.

If the tip of the probe is put into actual contact with an object, no light can emerge to be reflected back into the receiving fibers. The instrument would indicate zero response. But the slightest withdrawal of the probe from actual contact will permit light to enter the receiving fibers and the sensor meter will indicate the fact. As the probe is gradually withdrawn further away from the object, the amount of light received continues to increase until the overall cone of reflected light becomes larger than the diameter of the probe at which time the light reception begins to decrease again.

Fig. 3 shows the relationship of the percent output to the probe to object gap in mils (a mil is one one-thousandth in.). Note that the front side of the curve is very steep and that the maximum response is obtained when the probe is about 20 mils (0.02 in.) from the object being studied. Generally, the probe tip is placed about 4 mils from the object to make use of the most linear range of the sensor's response curve. However, there are many applications in which the

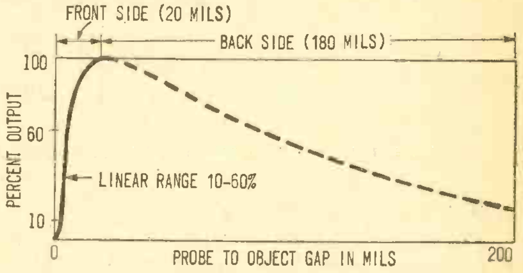


Fig. 3. Curve shows voltage output of sensor as a function of its distance from object. One-hundred percent output of the sensor equals one volt DC.

back side of the response curve (about 180 mils in length) is useful, and even the peak has specific industrial applications.

It is now obvious that the measured output of the sensor can be calibrated to indicate extremely small probe-to-object distances. If the object rather than the probe is moving back and forth, the distance changes will be immediately sensed and indicated; this is why the KD-38 can be used to observe very small magnitude vibrations, such as those of a speaker cone or a vibrating tuning fork.

The Fotonic Sensor is a very simple instrument to operate. It has only one control knob aside from the ON/OFF switch; this is called the "surface compensator" and is used to balance the instrument to work properly with objects having different degrees of reflectivity. A full scale reading on the panel meter will give 1.0 VDC at the output jack. The output impedance is approximately 4000 ohms.

Doing It Yourself. One possibility for the experimenter is to purchase a set or two of fiber optics from Edmund Scientific Co., Barrington, N. J. 08007—their No. 40,640 for example. Then, by building the relatively simple circuit shown in the schematic diagram elsewhere in this article and following the general principles of operation, a working unit could be built for considerably less than the current purchase price.

While operation of a homebrew version will probably not equal the professional job, it will allow the avid do-it-your-selfer to experiment with this brand new application of fiber optics.

The only area the experimenter should encounter any difficulty is in the exit area of the fiber optic, but some fiddling should render the system workable. One possibility would be to use two separate light guides coming together at the tip.

Phono Pickup. It is theoretically possible to play phonograph records without physical contact with the records, using the Fotonic Sensor in place of the usual stylus and cartridge. But to achieve this end satisfactorily would take some doing. Perhaps the toughest problem is to figure out a way to make the probe track the record grooves accurately. But if this could be done, it is obvious that there would never be any worry about sound deterioration due to stylus wear.

One half-way solution would be to mount the probe on the tone arm and use a stylus only for tracking purposes. It is also possible to point the probe at the stylus to pick up the vibrations, but there would appear to be little if any advantage in doing this.

We made a rough test, using the KD-38 loaned to us by the manufacturer. When the probe was held over a spinning platter, garbled sounds were heard. But it was pointless to try for better fidelity because the probe available had a diameter that was far too large for this purpose. The manufacturer of the sensor points out that a 30 mil diameter probe would be preferable to the 109 mil probe used in these experiments.

Funnel Mike. A funnel microphone can be made in a few minutes by stretching a piece of food wrap film (Handi-Wrap) over the mouth of a 2½ in. diameter funnel. This is best done by running a strip of "double stick" Scotch tape (adhesive on both sides of the tape) on the outside of the funnel, next to the rim. The plastic film is then laid over the funnel and folded over the rim so that it sticks to the tape.

Because the plastic film has very low reflectivity, a tiny reflecting tab (punched from white paper or aluminum foil) is attached to the center of the diaphragm with a bit of double stick tape. A reflecting spot could also be painted on, using the type of paint intended for coloring plastic models.

The sensor probe is inserted through a hole in a cork fitted into the neck of the funnel. The probe tip should be pushed in far enough to touch the diaphragm, and then backed up just far enough to give the maximum output signal on the sensor meter; in this way the probe will be positioned so as to use the front part of the instrument's response curve.

The test microphone shown in Fig. 1 easily activated a speaker when the sensor output was plugged into the microphone input jack of an auxiliary amplifier. This microphone clearly demonstrated that the sensor could easily translate diaphragm vibrations into audible sound. Obviously, one could experiment at length to determine the best funnel microphone design in terms of funnel size, diaphragm thickness, and diaphragm material (metal foils as well as plastic films can be used).

Speaker Testing. The Fotonic Sensor offers something new for Hi-Fi fans who have exhausted all the usual methods of testing and improving their sound systems. The loudspeaker is the one audio component that is generally accepted on faith, or is judged largely by ear. With the sensor, you can directly check the vibrational characteristics of your loudspeakers. You can feed in any and all test frequencies you like, going far beyond the human audible range

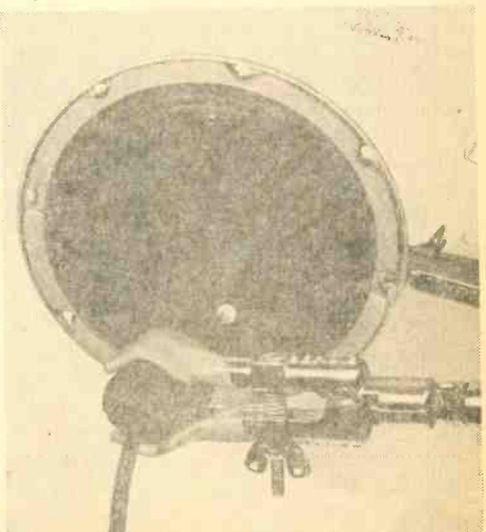


Fig. 4. A small circle of aluminum foil or white paper is glued to speaker cone to provide a reflective surface for light from the sensor probe which is held steady using a test tube clamp.

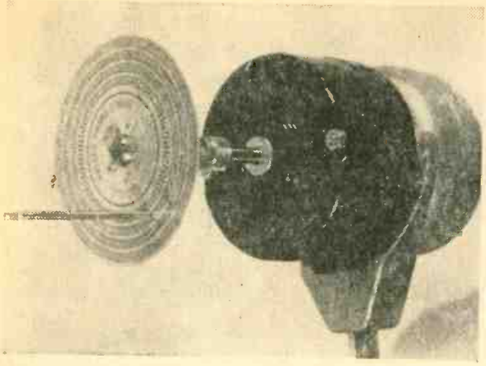


Fig. 5. When the sensor is directed at a spinning strobe disc of the type used to check turntable speeds, the amplified output is audio tone.

in case your big worry is whether your dog is enjoying top-notch Hi-Fi performance, or if you adhere to the belief that humans somehow respond to frequencies outside the normal audible range. The KD-38 is capable of measuring vibration frequencies from DC all the way to 40,000 Hz or more.

By placing the sensor probe close to the speaker cone, you can measure these vibrations and view them as waveforms on your oscilloscope. Unlike other direct testing methods, the light probe does not physically touch the speaker and therefore in no way affects the action of the cone. The black cone will not reflect enough light to activate the sensor properly, so a tiny tab of reflecting white paper or aluminum foil is attached to the cone as shown in Fig. 4.

Using information obtained with the sensor and oscilloscope, you can plot a frequency response curve for every speaker you have. You can also compare the waveform characteristics of the speaker vibrations with those of the amplifier output signal before it reaches the speaker.

An oscilloscope having calibrated gain settings and frequency response to 100 kilocycles per second at sensitivities of 5 mV/cm or higher should be used in order to realize the maximum capabilities of the Fotonic Sensor.

Strobe Siren. The so-called disc siren is a simple laboratory device used to study and demonstrate the relationship of sound pitch to frequency. In its simplest form, the disc siren consists of a cardboard or metal disc having a circle of holes punched into it. When an air jet is directed at the holes in the spinning disc, sound is produced. The pitch of the sound depends on the number of holes in the disc, and the disc's rotational speed.

The Fotonic Sensor can be used to make a novel optical siren that will produce any desired sound by the action of a beam of light on a spinning disc having rings of black bars rather than holes.

You can easily make your own disc by painting black bars on a cardboard disc. Or, for less than a dollar you can obtain a ready-made disc from your radio supply shop (Fig. 5). Phono strobe discs are used to check the speed of record turntables. The discs generally have four rings of evenly spaced black bars; these are designed to indicate 78, 45, 33⅓ and 16⅔ rpm turntable speeds.

The disc is mounted on the shaft of an electric motor, preferably a variable-speed job. The tip of the sensor probe is positioned perpendicularly over the disc, and very close to it so that it can scan the bar-bands. If the sensor output is plugged into an amplifier-loudspeaker unit, a steady tone will be heard as the disc spins. If the speed of the disc is changed, a siren-like wail is produced. At a given disc speed, four different tones can be produced by swinging the probe from one band to the next.

If you have a constant, but not variable speed motor, and want to produce sounds of specific frequencies, you can construct your own discs. Simple calculations will tell you how many bars, at the given disc speed, would be required to produce any desired frequency.

You can also hook the sensor directly to an oscilloscope to view the sinusoidal waveforms that are produced by the optical siren. Sinusoidal waveforms are produced if the black bars are narrower than the di-

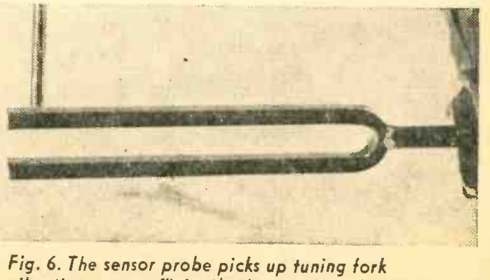


Fig. 6. The sensor probe picks up tuning fork vibrations more efficiently than a microphone. The signal can be amplified to drive a speaker or applied directly to oscilloscope input terminals.

ameter of the sensor probe. Under these conditions the probe always receives some reflected light. However, if the black bars are even slightly wider than the probe diameter, the oscilloscope will show square rather than sinusoidal waveforms.

Tuning Forks. Tuning forks would be far more useful for audio-electronic experimentation if the sounds were easier to amplify or if the vibrational waveforms could be fed directly to an oscilloscope without the use of an amplifier likely to add distortion. The Fotonic Sensor is ideal for this use because it eliminates the need of a microphone pickup and amplifier.

Fig. 6 shows how the sensor probe is pointed at the side of the tuning fork. It should be positioned very close to the fork in order to utilize the front of the sensor response curve.

Fig. 7 shows how the sensor output is (1) connected directly to the vertical inputs of an oscilloscope for waveform studies or (2) connected to an amplifier-speaker system for amplification of the audible sound. As indicated, an oscilloscope can also be added to pick up the amplified signal if the scope used seems too insensitive to properly show the sensor output signal.

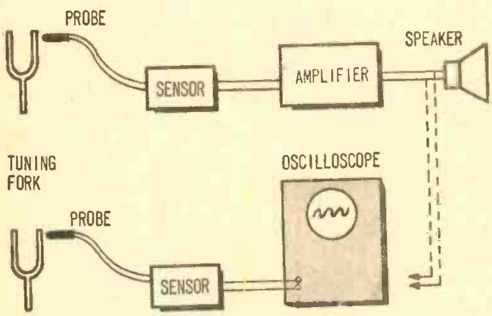


Fig. 7. If oscilloscope is not sensitive enough to display a waveform of sufficient magnitude, the signal can be amplified and picked off speaker line.

Use of the Fotonic Sensor in place of a microphone pickup is advantageous for several reasons. The tuning fork need not be mounted on a resonating box as must be done when a microphone is used. The sensor responds only to the tuning fork vibrations, hence picks up no background noises as a microphone does. This may seem puzzling until it is remembered that the Fotonic Sensor is actually measuring the changes in the probe-to-fork distance as the fork vibrates; this would occur even if the fork and probe were to be placed in a complete vacuum! A microphone will not work in a vacuum because it depends on air to carry the sound from the tuning fork (or any other sound source) to the microphone diaphragm. By the same token, any undesirable background sounds carried by air to the sensor probe do not interfere because these do not affect the light beam sensing system.

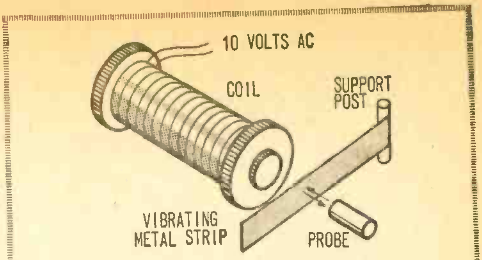


Fig. 8. A springy metal strip secured at one end and vibrated by AC coil generates a sinusoidal waveform.

Sets of tuning forks can be obtained at moderate cost from the Edmund Scientific Company, Barrington, N. J. 08007. If you want your fork to vibrate indefinitely without recourse to repeated tappings, try building a "magnetic valve" vibrator; this device is described in *Acoustics* by T. M. Yarwood (Macmillan, 1953).

Coil Vibrator. Sinusoidal waveforms can be generated by simply pointing the sensor probe at the side of flat strip of flexible metal vibrated by a small AC coil as shown in Fig. 8. The coil is easily made by wrapping enameled coil wire around a nail and then connecting the coil to an 8-10 VAC transformer. The springy steel strip is supported at one end and is positioned far enough from the coil core so that it will vibrate without touching the core.

Distorted sine waves will be produced by some sections of the vibrator, or if the probe is not held at the correct angle. A few tests will show the best positioning of the probe.

The sinusoidal waveform is generated in a somewhat different way than in the case of the strobe disc already discussed. In the latter case the probe-to-disc distance does not change; the light intensity changes are due to alternate reflection and absorption of the emergent beam of light. In the case of the vibrator, the sensor is actually measuring distance changes as was the case with the tuning fork.

Mechanical Analogs. A particularly intriguing area of experimentation, using the

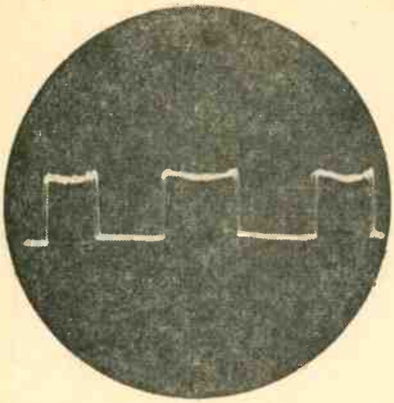


Fig. 9. Riples in square waves are from uneven cardboard target surface.

Fotonic Sensor, is the invention of what might be called "mechanical analogs" of electronic waveform generators. On the basis of admittedly limited exploratory tests made by the author, it appears fairly safe to predict that virtually any desired waveform could be generated by scanning simple moving objects with the sensor probe.

This discovery suggests two possible applications. It may be that the Fotonic Sensor, used with simple accessories that are easily constructed, might become a universal waveform generator. Secondly, the use of mechanical analogs might be useful in teaching and demonstrating the fundamentals of waveform theory and the use of the oscilloscope.

To understand the meaning of a particular waveform that appears on a scope screen, the student must visualize what is happening to invisible electric currents in an electrical circuit. This might be a great deal easier if the behavior of the scope were first demonstrated in terms of solid moving objects that can be seen. The experiments to be described will help make this idea clearer.

There are two possible approaches to mechanical analog experimentation; both are instructive and highly entertaining to analytically minded experimenters. The sensor output can be connected to the vertical input terminals of an oscilloscope and the probe can be pointed at all sorts of moving objects. Some sort of waveforms will be generated. The problem is to explain why the particular waveforms are produced in each case. The other, more challenging approach is to decide beforehand precisely what type waveform is to be produced, then invent the proper scan-object that will achieve this end.

Bear in mind that two general response characteristics of the sensor can be utilized: (1) light (and voltage) fluctuations can be created by changes in light reflectivity of the object (as in the strobe disc experiment) and (2) energy fluctuations can be created by distance changes (tuning fork, coil vibrator). There is a third possibility not yet mentioned. If the surface compensator knob of the sensor is turned way down so that the emergent light is as dim as possible, the probe can be energized by an external light source as in the case of ordinary photocell instruments.

Square Waves. Fig. 9 shows square waves photographed from an oscilloscope screen. These were created by the simple expedient of scanning a spinning, semi-circular white cardboard disc with the sensor probe. The sensor output was connected directly to the vertical input terminals of the scope.

Fig. 10 shows how the setup generates the waves. When the cardboard passes under the probe, light is reflected back into the probe to register the maximum voltage (shown as the lower line, as it appears on the scope screen). As the cardboard moves out of the line of sight of the probe, the beam is lost in space and zero voltage is registered by the scope. The transition from maximum to zero voltage is almost instantaneous; how vertical the rise and fall com-

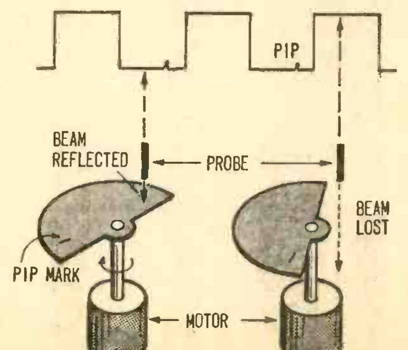


Fig. 10. Spinning disc segment generates square or rectangular waves.

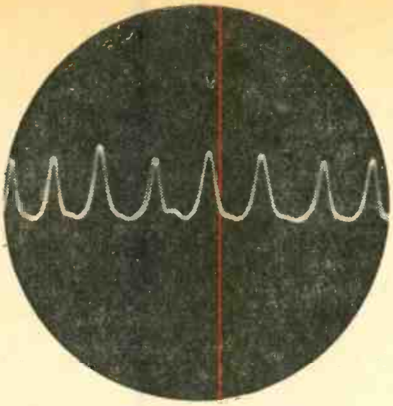


Fig. 11. Light reflection from spinning hex head bolt looks like this on scope.

ponents are depends on how fast the probe end passes over the cardboard edge—hence verticality improves as the speed of the disc rotation is increased.

To place a marker pip at any point along the maximum voltage plateau is almost ridiculously simple. All you need do is make a thin ink line on the cardboard as shown. The height of the pip is determined by the width of the ink line, and will reach the full wave height if the width equals or exceeds the probe diameter.

The square wave shown in the photograph could have been improved considerably by making the disc from smoother, more rigid material than cardboard, and by eliminating a slight wobble in the motor shaft.

Theoretically, a complete disc colored half white and half black would achieve the same end result. In practice this does not work out as well as the semi-circular disc because it is very difficult to make a completely light-absorbing black surface.

Rectangular Waves. Rectangular waveforms can be made just as easily by simply changing the shape of the disc segment. The maximum voltage line is shortened in relation to the zero voltage line if the disc is made less than 180 degrees; conversely, the maximum voltage line is lengthened if the disc angle is made greater than 180 degrees.

The waveform shown in Fig. 11 was also photographed from the oscilloscope screen. It resembles the half-wave sine waveform produced by a full-wave rectifier. How was it generated? By pointing the sensor probe at the hexagonal head of a spinning machine bolt!

The slight irregularities in the waves are due to the less than perfect symmetry of the bolt head. An accurately machined hexagon would have produced a series of perfect waves.

One important difference between the bolt-head waveform and that of the full wave rectifier is that the peaks of the waves represent different things. The peak of a rectifier wave represents maximum voltage. The peak of the bolt wave, however, represents the minimum voltage. The reason for this seeming anomaly will become clear through reference to Fig. 12, which is a graphic analysis of the way in which the bolt head creates the waveforms shown.

It is obvious that the probe end could not be placed within the 10 mil distance range from the bolt that would have enabled use of the front side of the sensor response curve (Fig. 3); the bolt would not have been able to spin without damaging the probe. Hence the probe was moved away far enough to permit use of the back side of the response curve. In this position the Fotonic Sensor's output voltage varies inversely as the square of the distance from probe to subject; this

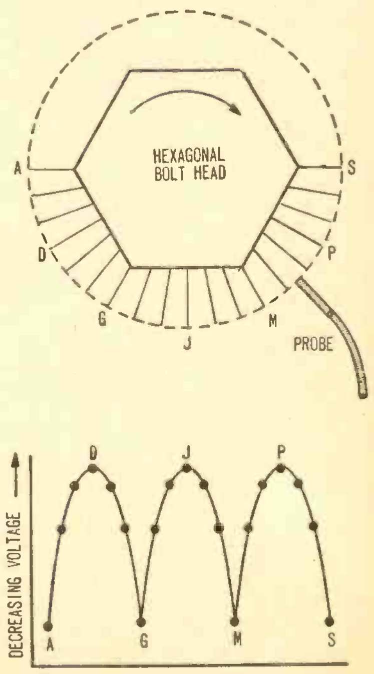


Fig. 12. Result of plotting curve generated by the bolt head is waveform like that of full-wave rectifier.

characteristic was made use of in the graphic analysis.

In Fig. 12, the various lines (marked A through S) represent the probe-to-bolt distances during a half revolution of the bolt. The lengths of these lines were measured and squared; the squared values were used to plot the sinusoidal curves shown. Points D, J, and P represent the longest probe-to-bolt distances; these are also the peaks of the curves. The peaks must therefore represent the minimum voltages because the Fotonic Sensor's voltage output characteristically drops as the probe-to-object distance increases.

The graphic analysis produces the same type of curve actually obtained, as shown in the photograph; a slight adjustment of the horizontal and vertical gains of the oscilloscope would have made this resemblance even more obvious. Strictly speaking, the probe does not measure the precise distances as indicated on the diagram because in most positions the probe is not perpendicular to the surface of the bolt head. In such cases the probe delivers average distance readings which, however, are adequate for the purpose at hand.

How could the wave peaks be made to represent maximum rather than minimum voltages as in the case of full-wave rectifier waveforms? Theoretically, this could be done if the probe could be made to scan the inside of a rotating hexagon; however, there probably is a more practical solution.

Undoubtedly, many other waveforms—the interesting saw-tooth variety, for example—could be generated as easily as the type discussed if the proper mechanical analog generators are worked out. In every case the frequency of the wave can be controlled simply by varying the rotational speed of the object scanned, and by changing the number of periodic components of the object—e.g., the number of faces on the bolt head.

Another possibility if you should want to build some electronic-fiber optics systems of your own, MTI (Mechanical Technology Inc., 968 Albany-Shacker Road, Gotham, New York 12110) can provide descriptions and prices of a variety of probes that the company sells as individual items. The schematic of the unit appears in Fig. 13.

The experiments described in this article are exploratory, and are intended to be purely suggestive of the many things the audio-electronics experimenter might do with this interesting instrument. There may be many other potential applications that remain to be discovered. One thing is certain: if you decide to play around with electronic fiber optics, you will definitely be in the front ranks of the audio avant garde. ■

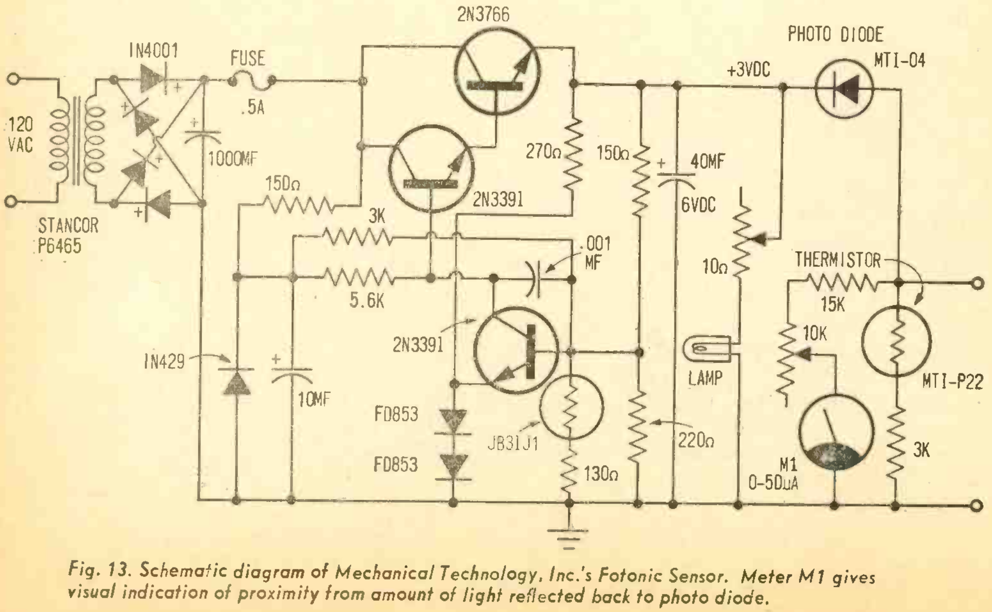


Fig. 13. Schematic diagram of Mechanical Technology, Inc.'s Fotonic Sensor. Meter M1 gives visual indication of proximity from amount of light reflected back to photo diode.

By Len Buckwalter, K1ODH/KBA4480

Pardon for the Color Killer

Here's the dope that'll give your TV a new lease on color.

The most avid color-TV viewer sometimes wishes his receiver didn't show color. Like when he's watching a black-and-white program. After all, good old Bogart looks better in gray and Count Dracula shouldn't be caught dead wearing a yellow cape and pink gloves. So color TV receivers are equipped with a circuit called a color killer. When it's working properly, the set won't murder the monochrome.

The color killer is first cousin to the squelch found in CB and other communications gear. Squelch automatically switches off audio when no signal is received, thus you don't hear annoying static and electrical interference in the speaker. Once an incoming carrier trips the squelch, the audio section comes alive and it's automatic: the squelch circuit can sense the presence of the carrier and take it from there.

That's similar to the operation of the color killer in TV. Only the static is false color spilling into a black-and-white picture.

The color-killer circuit doesn't have an easy time of it. Before it acts, it must decide whether you've tuned to a station transmitting in color. Also, it shouldn't disturb normal black-and-white reception. These are tall restrictions when you consider that in much of the receiver, color and black-and-white are as inseparable as a Mars bar and its wrapper around mid-July. Yet there is one electronic clue that instructs the color killer to paralyze color circuits at just the right time. That clue, as we'll see, is a received signal that's called the "burst."

The Human Killer. Early color receivers required the viewer to be the color killer. The viewer selected a channel and visually decided whether it transmitted in color. If not, he flipped a switch and disabled any circuits likely to feed false color to the screen (Fig. 1). Though that block diagram is greatly simplified, it illustrates the point. All frequencies which make up the video signal—black-and-white plus color—arrive at the upper left. Frequencies for black-and-white travel to the picture tube. (These frequencies span a range up to about 3 MHz and represent picture brightness and detail.)

You can see, too, that the video signal is split and also applied to the bandpass amplifier. Purpose of this stage is to snatch out color information contained in the complete video signal. It is actually a tube with tuned circuits which peak between about 3

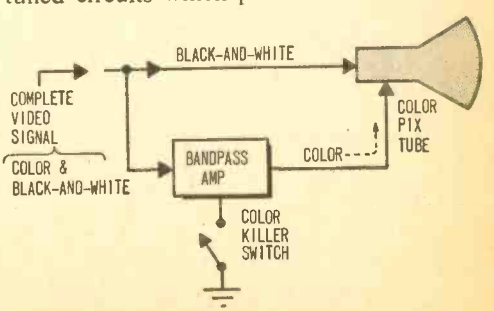


Fig. 1. Basic color killer turns color circuits on/off at appropriate time.

to 4 MHz, where color resides. After color information is trapped by the bandpass amp, it undergoes further processing until it reaches the picture tube to control the electron guns.

The bandpass amp can cause problems during black-and-white reception if permitted to remain alive. Noise, static or other interference could reach up into the color region of 3 to 4 MHz. These spurious signals are amplified by the bandpass stage and blotches of willy-nilly color appear on the screen. This stage should be completely disabled during monochrome reception.

As shown in Fig. 1, there's a switch for turning the bandpass on and off. Now the viewer may completely disable the stage to block the interference path. Some hash can still reach the screen over the black-and-white path but it's far less annoying when it appears as old-fashioned, black-and-white snow. If it sneaks through the bandpass, though, it fills the screen with heinous multicolored "confetti."

Murder, Inc. The trend in electronic equipment, however, is toward total automatic control. And since the set is already cluttered with many knobs, why not try to eliminate one? So the manually operated switch of the color killer has evolved into an all-electronic technique that's found in just about all modern color receivers. The switch is supplanted by a special sensing circuit that latches on to a portion of the color signal. It results in a go, no-go condition of the bandpass amplifier.

A Thirst for Burst. As mentioned earlier, color and black-and-white signals are closely tied together. What's more, they experience constant change as picture scenes and color vary. These wandering signals, therefore, cannot directly operate a color killer. There is one part of the color signal, though, that's an electronic Old Faithful. It's the "burst." This signal is transmitted in machine-gun fashion at the end of each picture line scanned across the screen. Not only does it repeat regularly, but is indifferent to program content. Since the burst is transmitted by the TV station only during a color program, it's a good reference for controlling the killer stage.

Before looking at the circuit, it should be said that the burst is not created solely for operating the color killer. Its main purpose is controlling a crystal oscillator located elsewhere in the receiver. This oscillator provides an accurate color sub-carrier signal needed during color detection. Nevertheless, we can steal a small sampling of burst signal and make it perform admirably well for operating the killer circuit.

Automatic Slaughter. The simplified block diagram in Fig. 2 reveals how the main part of the color receiver relates to the burst and color killer stages. The transmitted signal enters the antenna and travels to the video amp. Black-and-white proceeds to the picture tube even during a color program since it supplies the brightness, or "luminance," portion of the picture. The complete video signal also descends on the bandpass amp. Along with it rides the burst, shown as a series of cycles. (Each burst occurs at a frequency of 3.58 MHz. We're not concerned at this time with further details on the burst except to note that it always occurs when the program is in color.)

The burst is a fragile signal so a burst amp is placed in the circuit to beef it up and get rid of other components of the color signal that might interfere with the following operations of automatic color killing.

The amplified burst signal is next applied to the killer detector. Purpose of this section is to convert the burst—a high-frequency RF signal—into a negative DC signal that is more manageable for control purposes. The control signal is next handed to the color killer stage, an amplifier that boosts the negative control signal. Finally, the color

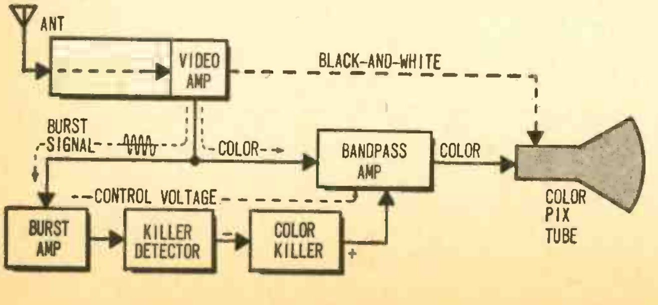


Fig. 2. Block diagram of automatic color killer circuit showing how burst signal is used to operate killer stage which in turn controls bandpass amplifier.

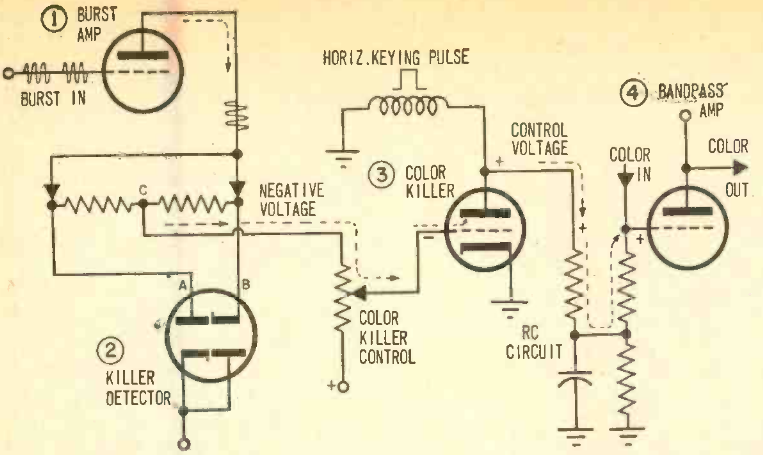


Fig. 3. Simplified schematic of typical killer circuit. Gating of killer stage by horizontal keying pulse makes circuit operation virtually immune to noise.

killer is hooked up to control the bandpass amplifier's operation.

Now when a burst signal appears in the receiver, it's converted to a control signal that electronically switches on the bandpass amp. Color signals may now flow from the video amp, through the bandpass amp and following stages in the long hard trip to the picture tube.

Before looking at an actual schematic, consider another detail in the operation of the color killer stage. Note in Fig. 2 that a negative control signal is entering this stage—but it emerges as a positive signal. The change in signal phase is typical of amplifier stages; when the tube grid is driven negative, the output signal is not only amplified but made opposite in polarity. This is an important effect in the color killer circuit. The positive signal (produced whenever burst is present) is applied to the grid of the bandpass amplifier. This creates a positive bias that turns on the stage, allowing it to pass color signals. When burst is absent, the bandpass grid is very negative and blocks color signals.

Tracing the Schematic. A simplified diagram of the killer circuitry in many of today's color sets is in Fig. 3. We can begin at the burst amp (1) shown receiving the burst signal. After amplification, the burst is applied across the killer detector (2). This stage is a pair of diodes such as might be found in the detector of an FM receiver and the function is similar: it converts a radio signal (here, 3.58 MHz) into DC by acting as a rectifier. Burst voltage is applied across the dual-diode tube, at plate A and cathode B. Resultant current flow through the stage creates a negative voltage between the load resistors (see point C).

The negative voltage is next applied across a potentiometer—the color killer control. Although the total circuit is automatic in operation, the control is adjusted when the color TV receiver is first installed, or when the antenna is changed. It permits the circuit to be set up for a threshold adjustment, or compromise, for stations of different strength. (More on this when killer troubles are considered.)

Next, the negative signal moves to the grid of the color killer (3). Here it is amplified and reversed in phase, as described earlier. Notice a special feature of this tube: its plate is not powered by the usual B+ supply voltage. Plate potential for this stage, rather, is picked by via a winding on the receiver's horizontal output transformer (also known as the flyback or high-voltage transformer). Purpose for this arrangement is to power the color killer only as the burst signal is transmitted. By keying-on the tube during this period only, the killer becomes immune to other signals (picture, noise, etc.) that could sneak through burst and detector stages and operate the killer at the wrong time and allow color to contaminate the black-and-white picture. The horizontal transformer can provide a properly timed keying pulse since it produces voltage in the interval between each picture scanning line, precisely the same time the burst is received.

Output of the color killer, now a positive signal, is applied to the bandpass amplifier (4). It biases the grid positively so the tube is able to conduct normally. The color signal, also applied to the grid, may now be tuned and amplified for further processing. Note that the positive control signal has also passed through a resistor-capacitor (RC) network just before reaching the bandpass

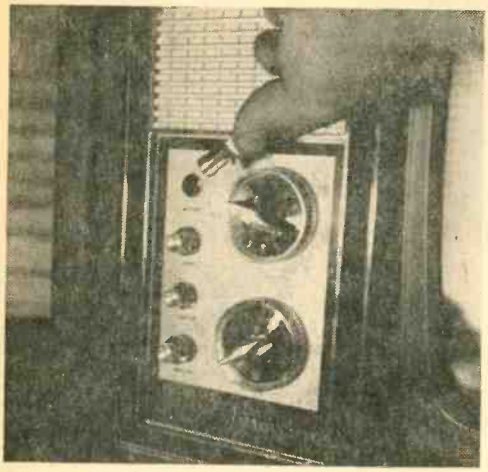


Fig. 4. Adjustment of color killer threshold may be required if antenna installation is changed or as result of aging components. Control may be under front panel knob or on back of set.

grid. This network forms a time-constant, or storage, circuit that extends the length of the positive signal. This delay enables the original, short-term control signal to stretch its effect over one full picture scanning line on the screen. The bandpass amplifier now remains alive for a period far longer than did the original burst.

Controlling A Killer. The color killer control must be properly adjusted for satisfactory operation in the circuit. The adjustment is often done by turning a potentiometer shaft located at the rear of the set or behind a front control as shown in Fig. 4. In a typical receiver, the killer is adjusted in this fashion: Tune to a weak station transmitting a black-and-white program. There should be snow on the screen. If not, tune to an unused channel and observe the snow caused by atmospheric noise. By rotating the control in one direction, you should reach a point where flashing dots of color appear on the screen. Correct adjustment is obtained when the control is turned so the multicolored snow just disappears. Don't turn it too far or you'll affect reception on color telecasts, especially in a fringe area.

The adjustment is checked by turning to all stations you can receive in your area. There should be no colored confetti on any black-and-white program, and no disturbance to the picture during color reception.

Clues To The Killer's Crimes. Before attempting to analyze trouble in the color killer section, be sure the problem isn't originating elsewhere in the receiver. The set should be producing good black-and-white pictures and normal sound. Any problem that weakens the received signal could affect the killer circuits. A weak front-end tube, a damaged antenna or lead in, for example, might cause erratic color-killer operation. These faults, however, usually affect black-and-white reception as well. Thus if color creeps into a black-and-white program that otherwise appears normal, this is a sign of trouble in the color killer.

Four major symptoms, shown in Fig. 5, help spot trouble in the color killer. Always begin by checking to see if the killer threshold adjustment is correctly set, as described above. Inability to obtain the desired action with the control strongly suggests trouble in the killer circuits. Then consider and analyze the following clues.

In the first symptom in Fig. 5 (A) the set is tuned to a station transmitting black-and-white. If the signal is on the weak side, snow might appear as colored confetti flashing over the screen. When a station is strong and no snow appears, a faulty color killer might cause color to appear around the edges of people or objects in the picture. (This shouldn't be confused with mis-convergence, another problem. You can tell it's the killer if the fringes of color consist of rainbow-like hues, rather than single strokes of color.)

In symptom B, the set is receiving a color program. The image on the screen, however, is perfect black-and-white—the same as if you'd turned down the color or chroma control on the front panel. The absence of any hue suggests that the color killer stage is falsely cutting off the bandpass amplifier and interrupting the color signal. A trouble of this kind might be caused by a component that has radically changed value—say a burned-out resistor or open capacitor.

Again in the C, the set is picking up a color telecast. But now the color image is satisfactory only when the signal is strong. Weak color stations are seen in black-and-white. This in-between type fault suggests a component that has changed value (rather than burned out or shorted). Only a strong signal creates enough voltage to open up the bandpass amplifier.

When color reception is intermittent (D)

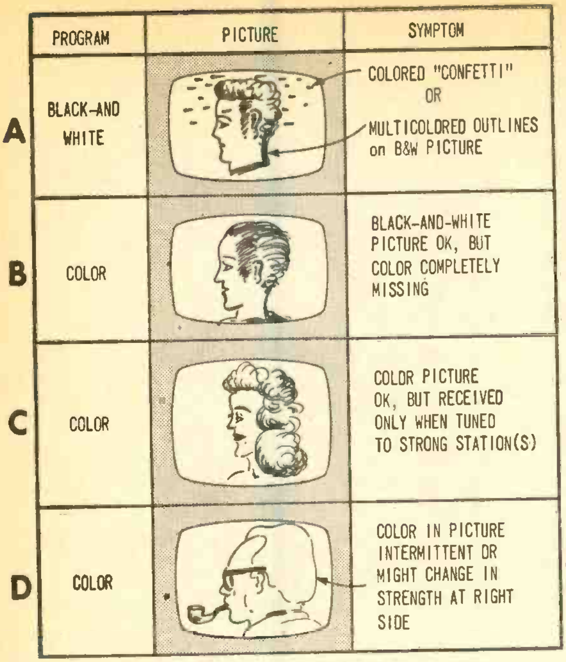


Fig. 5. Four common indications that the time has come for the color killer to be investigated and possibly administered corrective action.

—color fades in and out of the black-and-white image—it could mean there's an intermittent component in the killer circuits. In some sets, fading color toward only one side of the picture might also suggest killer trouble since bias on the bandpass stage may not be holding constant over the span of each picture line.

Find-A-Fault. If all symptoms point toward the color killer stages, begin by checking tubes associated with that section. They're the stages shown shaded in Fig. 6. In many instances, one tube type will contain more than one stage. (For example, color killer and bandpass amp might be in a single 6EA8.) If a tube doesn't cure the trouble, carefully check circuit connections for a cold-soldered joint or hairline crack in the printed-circuit board, if one is used in your set (see Fig. 7).

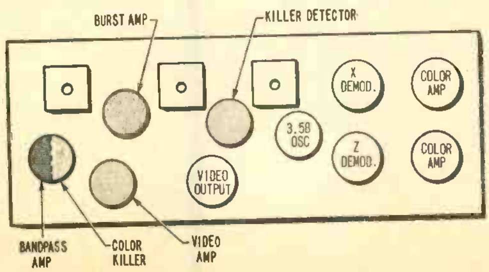


Fig. 6. Typical chroma board found in modern TV sets contain most color tubes. Killer circuit tubes are shown shaded.

Further investigation requires a VTVM and the set manufacturer's service literature giving socket and test point voltages. These items enable you to check for correct DC voltages at each stage. Chances are these readings can help locate many major faults which afflict the killer. These include burned-out and shorted resistors, and shorted, possibly leaky, capacitors. With the receiver turned off, resistance checks with the VTVM's ohmmeter section provide valuable information in finding the fault.

In Fig. 8, there's a typical color killer schematic with voltage points that can be measured by a VTVM. Note that the plate is identified as pin 3 and voltage at this point should be −50V. At the grid, pin 2, voltage reads 0.5V when no signal is in the receiver, but increases to —12V when a color signal is present. These schematics also give such detail as how various controls are set while taking measurements and permissible voltage error (usually about 20 percent). Note in this circuit an additional feature not mentioned earlier. It's the "Color Off" switch. Since the color killer might not remove confetti from extremely weak black-and-white images in fringe areas, this manufacturer adds a manual switch. Operation however, is usually automatic.

Tough Dog Killers. These simple checks will localize most trouble. But those tough

(*Continued on page 118*)

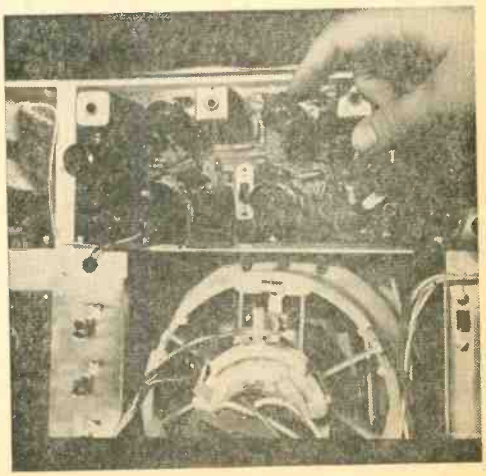


Fig. 7. Problems in color reception can usually be traced to tubes on chroma board. Finger points to killer detector.

By E. Norbert Smith

Make yours a neon Christmas with our

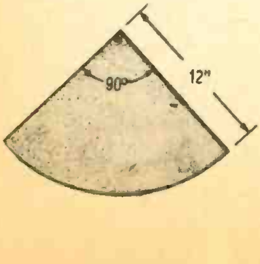
TREE WITH A TWIST

Here's a nifty way to surprise the entire family this Christmas morn—build them a Christmas tree! Our decorative tree is a cinch to build and will cost less than a fifth of Christmas Cheer. And, it can be used year after year after year.

Everyone is familiar with the neon relaxation oscillator. This old economy circuit is primarily used to develop a saw-tooth wave form. By selecting proper circuit values, a very low frequency oscillator can be built which, to the eye, makes the bulb appear as a flashing light.

In the interest of Christmas, two changes are made. First 8 or 10 relaxation oscillators are connected in parallel and mounted in a cardboard tree; and second, argon as well as neon glow lamps are used. Neon lamps give the familiar red-orange glow, but argon lamps emit a soft *Christmas blue*.

Portable Xmas. The builder has the choice of spending slightly more money and including a 90-volt battery for cordless operation, or he can build the thrifty AC supply, eliminating yearly battery change. Either way, current drain is negligible. However, if a battery is stored in a warm place for a year, no doubt it will deteriorate and ruin the tree in the process, so the battery must be removed before storing.



Tree with a twist is made from a single piece of poster board of shape shown. Lamps are cemented into holes in board.

The schematic diagram shows the oscillator and power supply wiring. The thousand-ohm resistor (R1) in the power supply is added as a fuse. Should a short occur, the resistor will open in time to save the diode and perhaps a fire. Of course, as previously mentioned, the entire AC supply can be replaced with a 90-volt B battery if portable operation is desired. You can use as many bulbs as you want.

Construction. With a large compass or simply a pencil with a string tied to it near the point, strike an arc of 90 degrees with a 12-in. radius on a piece of newspaper. Clip out and form into a cone. When a suitable size cone for your tree is found, trace the outline on poster board and cut to shape.

Now with a pencil or similar "tool," punch one hole for each glow-lamp used. Remember to punch from the outside of the tree in. Press-fit a lamp into each hole and apply some epoxy or cement around the base of the bulb and allow to dry overnight.

As soon as the bulbs are firmly in place, wiring can begin. Solder all capacitors across the bulb-wires, using short leads to minimize chance of shorting. Solder a 1-in. piece of insulated wire connecting to one side of each bulb. Clip the bulb-leads short and solder a resistor to each remaining bulb-wire, pointing the resistor away from, or toward, the top of the tree, not across it.

Now connect all the resistors together with a loop of insulated hookup wire and then connect all the 1-in. pieces from the other bulb-wires together. The loops will bend in toward the center of the tree as it is assembled, thereby relieving any strain to the bulb-leads. The two wires used to hook up all the bulbs are then wired to the power supply or battery.

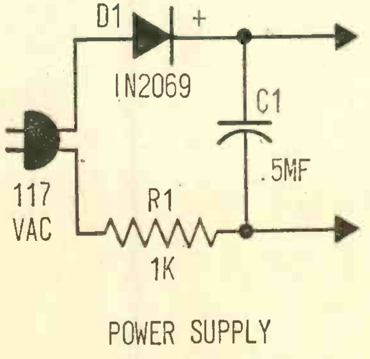
The base is made to fit from a round piece of poster board with tabs, or plywood. The base is glued to the cone when the tree is finished and working.

Last But Not Least. Connect line cord, diode, and capacitor of the power supply together. Simply wrap insulating tape around diode (D1) and resistor (R1) and solder to proper points in tree as shown in schematic. Recheck wiring for possible short circuits, then plug the tree into a wall plug and see if all the lamps are working.

Next, bend the poster-board assembly into a cone shape, then with tape and glue, fasten it to the base. Place a small amount of glue at the base of each glow lamp and run several strips of glue up and down the tree and then around the base. Carefully cover the tree with a thin layer of cotton batting, pressing it firmly over the bulbs so they show through.

From this point on let your imagination guide you to the tree trimming desired. The author used assorted colored paper stars over each bulb and sequin strips as garland, topped with a sprinkle of glitter held in place with clear Krylon spray.

Make variations to suit and you'll end up with your very own tree with a twist to enjoy for this season of making merry. ■



Though optional AC power supply is "fused" with resistor R1, trees can be dangerous since it isn't isolated from AC line.

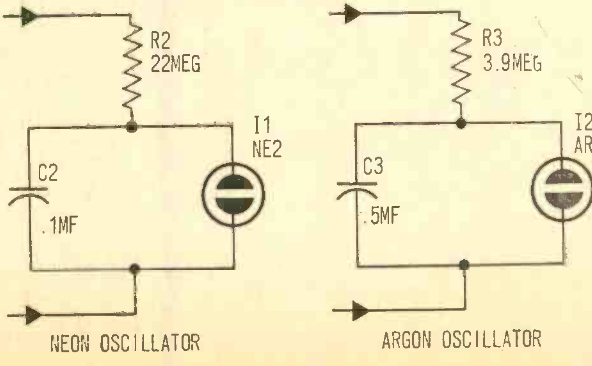
PARTS LIST

POWER SUPPLY
C1—0.5-uF, 200-VDC capacitor
D1—1N2069 diode, 200-piv
R1—1000-ohms, ½-watt resistor

NEON OSCILLATOR
(repeat for each red light used)
C2—0.1-uF, 200-VDC capacitor
I1—NE-2 neon glow-lamp
R2—22-megohm, ½-watt resistor

ARGON OSCILLATOR
(repeat for each blue light used)
C3—0.5-uF, 200-VDC capacitor
I2—AR-9 argon glow-lamp (available from the author: E. Norbert Smith, Rt. 1, Box 396, Wylie, Texas 75098, for 25¢ each postpaid)

Misc.—Line cord, hookup wire, poster board, cotton batting, glue, dime store decorations, etc.



Circuits at left show hookups for two different bulbs employed in tree with a twist—neon and argon. As explained in text, neon bulbs light orange/red, while argon display a soft blue. Two types of bulbs can be placed variously around tree.

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

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

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

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

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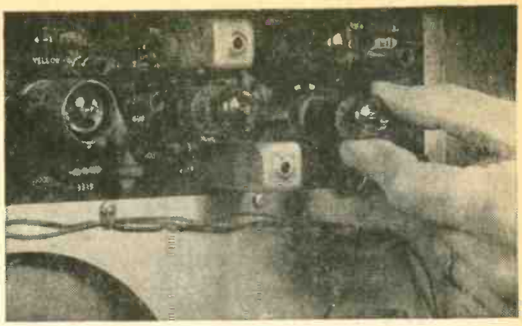

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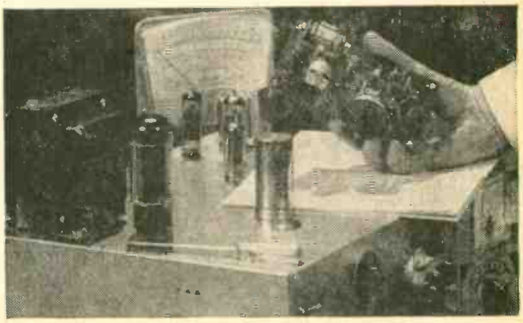

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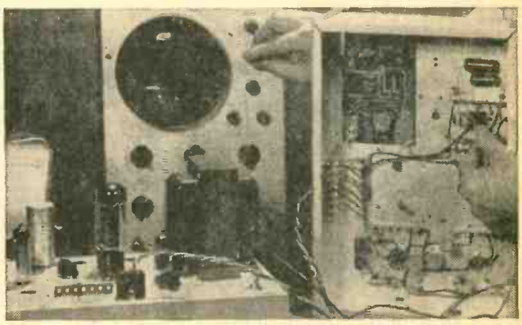

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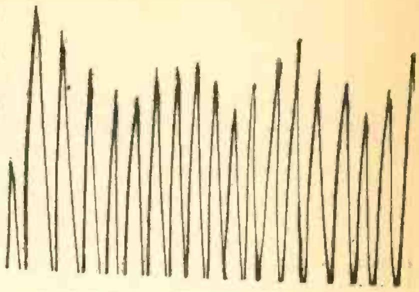
SUPER SNOOP



Great gadget ferrets out those hidden sounds of impending disaster in your ailing buggy.

By Alexander Prokop

Are you a perfectionist? One of those guys that practically goes around the bend if your car has a well-concealed clatter, squeak, or rumble? Have you tried in vain to ferret out a little sound that to your sensitive ear bespeaks impending doom, only to find that neither you nor your local mechanical genius can put a finger on the buggy's hangup? Well, take heart, for the author understands, sympathizes, and has for you an answer to the source of your trepidations; a goody that'll check your transmission at 80 mph or your generator bearings at 30. It can tell you if your clutch is slipping on those five-G take-offs, or locate the source of a mysterious thump, clunk, squeak or rattle. Sound like the Super Snoop is for you? Well, read on, MacDuff.

Heart Of Super Snoop. The heart of the little beastie is a crystal transducer originally designed as a mouth-organ pickup. This pickup was found to be highly sensitive to vibrations of all sorts. As shown in the photos, the pickup is attached with a clamp to the part or area you want to check out.

By virtue of picking up sounds only from the item to which it's attached, Super Snoop will tell you what's going on there without confusing you with extraneous noise. This selective pickup allows you to easily localize the source of the problem. Combined with a little training of the ear, the heap can be given a complete physical in a matter of a dozen or two minutes.

Pickup Construction. The first step in making Super Snoop is to visit your local hardware store and purchase a C-clamp as pictured in the photos. Most stores carry the bar handle type; however, if you can find one whose clamp screw and handle are one solid piece your task is simplified.

Now drill a hole as indicated with a No. 29 or .136 drill through the clamp and tap a (8-32) thread for the crystal mount. Next, if you have bar handle type clamp, wrap electrical tape around the handle so that it can't wiggle and generate extraneous noise in your pickup to confound your ear.

The young lady is checking out her sports-car's transmission with the aid of Super Snoop. Here the transducer is attached right next to the gearshift lever with the C-clamp mount.

Add an 8-32 screw with a washer and the clamp is completed. The crystal transducer can be fastened to the clamp at any time with a screwdriver to complete the pickup. While the pickup is of a sturdy nature, care to prevent mechanical and water damage should be observed as with any sensitive device.

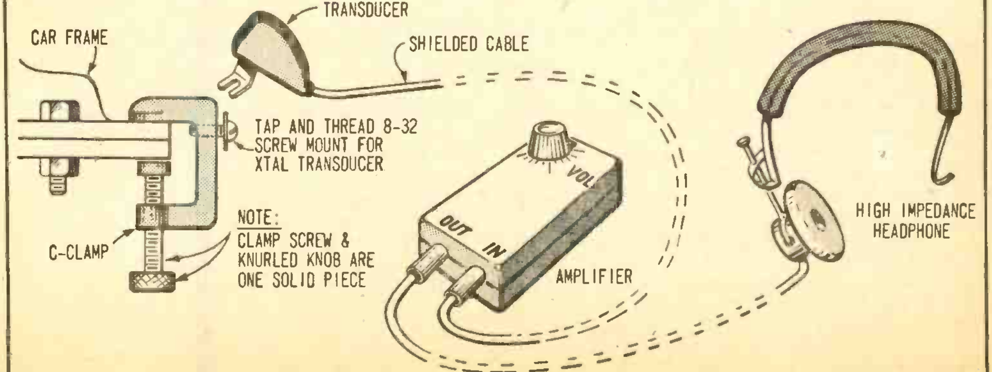
Amplifier—Buy Or Make. Construction of the amplifier should pose no problem as parts layout is not critical and requires no shielding other than the pickup cable.

For the softy who doesn't feel up to making his own amplifier, there are several ready-made, high-gain amplifier modules on the market that are ready to go with the addition of a battery, such as Radio Shack's Super High Gain Amp # 277-251. The amplifier will get knocked around a good deal and placing it in a firm plastic box with padding will insure trouble-free operation for years to come.

If you decide to build your own, the layout shown may be altered as box dimensions demand. Use transistor sockets if you can, and take care to observe polarities on the electrolytic capacitors (C1, C2, C3) when wiring. When perf-board wiring is completed, install it in the plastic box, wire in the phono sockets, volume control, and switch. Then, power the rig with two 9-volt transistor radio batteries in series, and place a voltmeter from ground (B-) to the test point in the schematic diagram. Turn on the amplifier, and adjust potentiometer R8 for a reading of 2 volts on the voltmeter. This completes the only adjustment necessary.

Resistor R2 and capacitor C5 comprise a tone control which has been fixed for a nearly flat response to 15 kHz. By lowering the value of R2, the response will eliminate the higher frequencies. The entire sound spectrum is equally informative over the amplifier's range and a flat response is normally most desirable in tracking down and identifying sources of noise in autos and other applications.

Finally, splice eight feet of shielded cable



Completed Super Snoop hookup. Be sure transducer is firmly attached to clamp before taking trial run.

to that extending from the crystal pickup for a total of about 12 feet. Solder on a phone jack and plug into the amplifier's input, add a pair of 500-ohm phones and Super Snoop is ready for some super snooping.

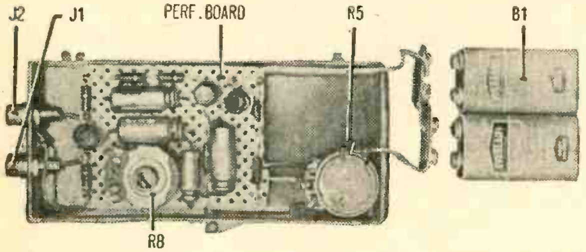
Case History. Perhaps an actual application will best serve as an illustration. Recently, a '59 Buick Le Sabre produced a deep rumbling sound from under the floor when accelerating but otherwise ran quietly. The first suspect was the transmission. Placing the C-clamp pickup on the immediate frame supporting the transmission, the subsequent test run revealed the rumble heard inside to be a sharp ringing sound, not unlike the banging of a thin metal tube, distinctly different from the soft whine of the transmission.

The transmission was cleared of suspicion but what about the noise? A careful inspection revealed a dent in the exhaust pipe next to the transmission. The pipe was moved away as far as possible and the car was taken on a second run. The rumble was gone and with it all the worries.

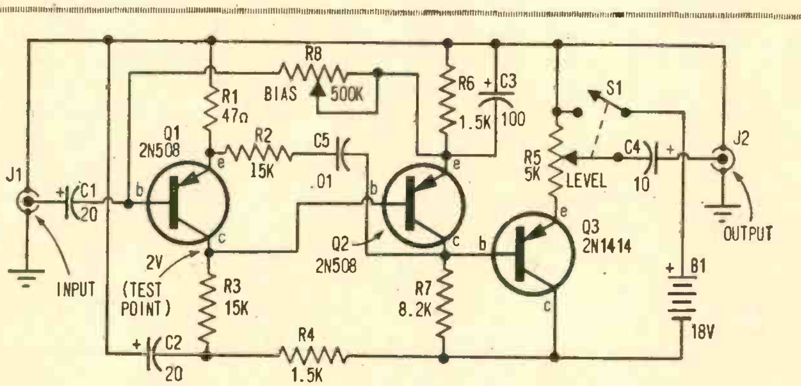
Auto Diagnosis. A good trackdown procedure is to place the pickup on the frame near a suspected noise to obtain a better idea of its position after analyzing its sound.

Repeat this process until the offending part is identified. With a little practice and careful interpretation, Super Snoop will

(Continued on page 118)



Perf-board construction of Super Snoop's amplifier speeds assembly and simplifies layout. Parts arrangement isn't critical and can be modified to suit individual preference.



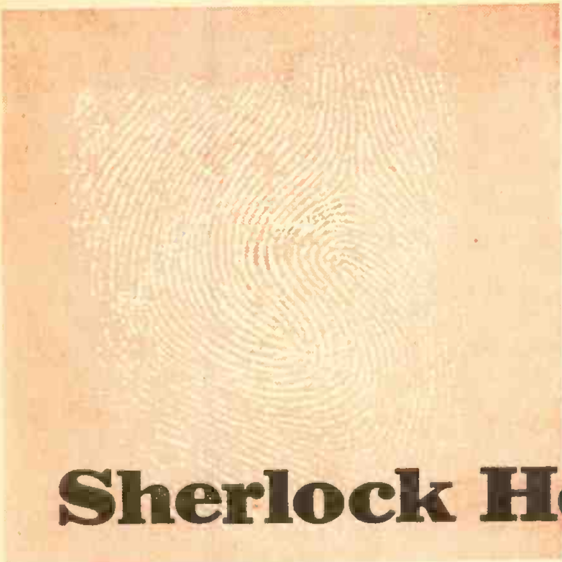
Schematic of Super Snoop amplifier. R8 is used to set bias level of Q1 for maximum linear gain.

PARTS LIST

B1—9-volt transistor batteries, two in series (Eveready 216 or equiv.)
C1, C2—20uF, 20-VDC miniature electrolytic capacitor
C3—100-uF, 20-VDC miniature electrolytic capacitor
C4—10-uF, 15-VDC miniature electrolytic capacitor
C5—.01-uF, disc capacitor
J1, J2—Phono jacks, RCA type
R1—47-ohm, ½-watt resistor
R2, R3—15,000-ohm, ½-watt resistors
R4, R6—1500-ohm, ½-watt resistor
R5—5000-ohm potentiometer (with S1 attached)
R7—8200-ohm, ½-watt resistor
R8—500,000-ohm potentiometer
S1—Switch mounted on R5
Q1, Q2—2N508 transistors
Q3—2N1414 transistor
X1—Crystal transducer, "harmonica mike' (Radio Shack 33-115 or equiv.)

Misc.—3-in. C-clamp, transistor sockets, perf-board, 8-ft. shielded cable, pastic box, wire, solder, etc.

By Jorma Hyypia



Out of the past on thundering laser pulses springs a mighty new champion of justice that outshines them all. . . .

Sherlock Hologram

"**My dear Watson,** it is really quite elementary. All we have done is to shine this laser beam through the seemingly meaningless blur on this piece of photographic film. That bright little spot on the screen at the far end of the equipment identifies our culprit beyond the shadow of a doubt."

"Oh, I say, Holmes!" protests the great detective's friend, "Isn't that a bit too much? What about the fingerprint we found on the salami casing left at the scene of the abominable crime?"

"That, my good friend, is precisely what we are investigating. That spot of light has just told us whose fingerprint it is. All will be clear in a moment. But first allow me to introduce Messrs. Vincent Horvath, John Holeman and Charles Lemmond, the able scientists who have developed this remarkable apparatus here in the General Electric Company's Research and Development Center.

While these gentlemen explain the theory and application of lasers and spatial filters to fingerprint identification, I shall retire to play my violin and contemplate the most expeditious means of apprehending our quarry to bring him speedily to justice."

Holmes to Holography. Sherlock Holmes, the classic private eye of fiction created by Conan Doyle some eighty years ago, was a contemporary of one Ernst Abbe who first suggested the concept of holography and, more specifically, the technique of spatial filtering. But it wasn't until 1951 that Dennis Gabor proved that a photographic image called a hologram, which appears utterly meaningless to the naked eye, can be used to create a wholly recognizable image of the object it represents. At about the same time, other researchers were investigating the technique of spatial filtering in attempts to improve photographic images.

Still, this research remained pretty much on paper since it was hard to prove experimentally because of the lack of a suitable light source. With the advent of the laser in 1960, the subject of holography and spatial filtering received renewed attention because the laser could produce a strong beam of long-sought-after coherent light—light that consists essentially of a single wavelength.

Although holography is now an established fact, it is still confined to the laboratory and the public at large knows about it only through the writings of science reporters. But the potential applications of holography are exciting, to say the least.

3-D movies and stereo slides have been around for a long time, and they create quite realistic effects. But three dimensional images produced by holography are unique in that they are not merely illusions, but actually exist in three dimensions. You can "look around" (up to 120 degrees) the images as you would any solid object—something you cannot do with traditional stereo images.

Spatial Filters. A very special type of hologram, called a spatial filter, has the capability of comparing two patterns to produce a "signal" which indicates the degree of sameness, or correlation, between the patterns. Throughout this article, the method of making and using spatial filters will be discussed in terms of the letter T, which is chosen arbitrarily as the object pattern to be compared and recognized. The use of such a simple pattern makes the principles involved easier to understand.

In practice, it has been found that complicated patterns, particularly natural objects such as fingerprints, can be recognized by the method with greater confidence than man-made objects (like the printed T) which tend to be geometrically symmetrical.

The nature of a spatial filter cannot be described in a word, or even a sentence. The only way to make clear the principles involved is to describe how the filters are made and used. As Holmes might have said, "A logical, step-by-step analysis of the problem will lead us easily around all obstacles and make the whole puzzle seem remarkably simple when we are through."

Diffraction—the Vital Clue. To understand holographic spatial filtering, one must first become familiar with the phenomenon of diffraction of light.

Diffraction occurs when a beam of light passes through any semi-transparent object. When light is partly intercepted by two materials of different optical density, or transmissivity, part of the light is deviated from its original direction because of the wave nature of light.

For example, suppose that a beam of light passes through a periodic grating composed of alternate opaque and transparent lines as is shown in Fig. 1. Part of the light passes directly through the grating, unaltered in direction, and is focused by the lens to form an image of the light source. This

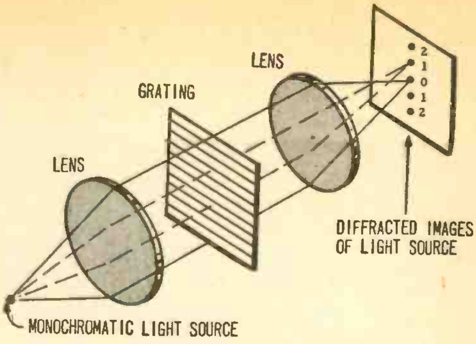


Fig. 1. Monochromatic light passing through one-direction diffraction grating forms a series of images of light source on screen.

image is called the *zero order* image because it is formed by light rays which incur no deviation from their original path by the grating.

But part of the original light is deviated, or "diffracted," by the grating to various angles on each side of the central, undeviated ray. This diffracted light forms an infinite number of images of the light source on each side of the zero order image. These higher order images are identified as 1st, 2nd, etc. order images. The image intensities fall off rapidly with progressively higher orders; however, this is unimportant because the first order image is the only one of interest in this case.

Laser—Clue No. 2. Although the phenomenon of diffraction has been understood and used for a very long time, the development of holographic methods had to await the discovery of a second vital factor, the laser.

If the source of illumination produces a white light, each of the many colors that comprise such light is deviated at a slightly different angle and the images appear as the familiar "rainbow" spectrums. These spread-out images will not do because the holographic spatial filter technique requires that the images be reproduced as points of light of the same size as the originating light source.

The obvious answer is to use monchromatic light—light of a single color that cannot spread. The laser produces the ideal kind of light. Although this technical breakthrough came only a few years ago, the need for such a light was foreseen as early as 1886 by Ernst Abbe.

Abbe pointed out that monochromatic light diffraction would produce what he called the "invariant image" having the following three characteristics: (1) the position of the image does not move if the grating is moved laterally or vertically in the light beam, (2) the size and position of the images are not changed if the grating is moved along the axis of the light beam and (3) the images are exactly the same size as the light source if an ideal lens system is used.

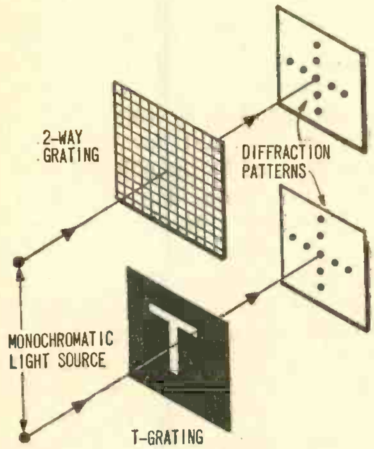


Fig. 2. Monochromatic light passing through a two-direction diffraction grating (similar to letter T) makes two sets of images of light source.

Single Beam System. The so-called "single beam" spatial filter system is not suitable for fingerprint recognition for reasons to be explained later. However, a look at this system makes the basic process more readily understandable.

As already noted, a grating consisting of parallel lines running in one direction produces a single row of diffracted images. If the grating has lines running in two directions, as shown in the upper half of Fig. 2, two rows of images will be produced.

The letter T may be thought of as consisting of two single line grating (slits) at right angles to one another. Thus the diffraction pattern produced by the letter T is basically the same as produced by the usual two-direction grating.

For purposes of explaining the basics of spatial filtering, the letter T is arbitrarily selected as a convenient object pattern.

To make a spatial filter representing the letter T, it is first necessary to prepare a reversed transparency, or negative, as shown in Fig. 3. When a laser beam is passed through this transparency, a characteristic diffraction pattern is produced. This diffraction image is photographed on film, then contact printed onto a second piece of film to reverse the image. The reversed image is the required spatial filter.

This spatial filter is a special variety of hologram, hence it can be used to reconstruct an image of the original object, the letter T, by beaming laser through it.

But the filter can do more. It can recognize the letter T in a group of other letters or patterns as shown in Fig. 4. A transparency containing several different letters is placed into a laser beam so that the light passing through it continues on through the spatial filter representing the letter T.

This filter theoretically, and to a degree practically, permits only light produced by a letter T to pass through it; the light coming from any other letters is stopped by the filter. Note that both Ts are reproduced in the recognition plane and that the images occupy the same positions as in the original object containing the various letters.

Two-Beam Process. Unfortunately, the single beam method does not yield sufficiently clean-cut recognition. Some of the light passed by the unwanted object components (letters A, K, R, S) gets through to form ghost images. These ghosts can cause the desired image to become unintelligible by reducing the contrast of the image and by filling the recognition plane with spurious unwanted light.

It is therefore necessary to prepare a special type of spatial filter utilizing a so-called "two-beam" process. This "complex filter" is used in the same way (Fig. 5), but it has the curious effect of producing spot recognition signals rather than recreating the original object as before. However, note

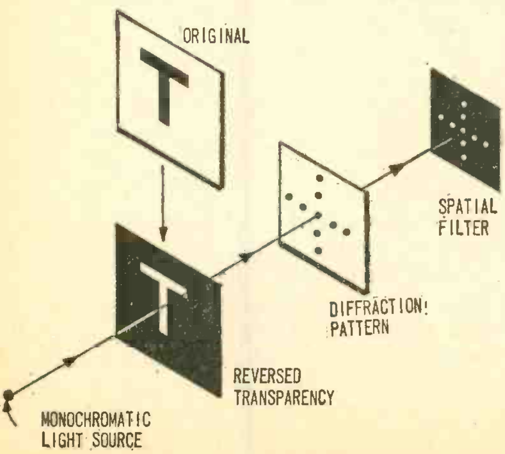


Fig. 3. Diffraction pattern of reversed transparency T is made into a negative which becomes spatial filter capable of recognizing only original T.

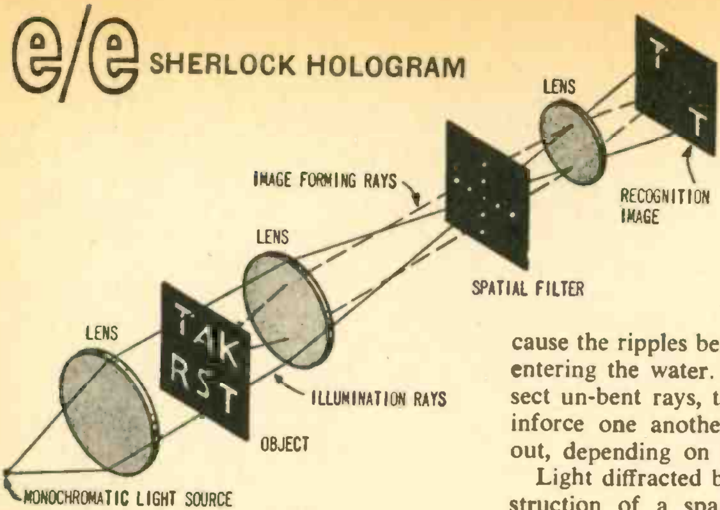


Fig. 4. Single beam spatial filter of letter T lets only light from original letter pass through to form dual images on screen.

that the spots still appear in the same positions on the recognition plane.

The formation of spots, rather than reconstructed images, is not in the least a handicap as far as fingerprint recognition is concerned. This will become clear later. (The shapes of the diffraction images as shown on the diagrams are not significant. Circular spots are used to indicate single beam filters and square spots are used to represent filters made by the two-beam method.)

Exorcising The Ghosts. Interferometry techniques are used to eliminate the troublesome ghost images. Those who are unfamiliar with optical interference phenomena can perform a simple experiment to gain an insight into this interesting property of light. Put about an inch of water into a white enamelled pan, then place the pan under a light bulb. Gently tap the surface of the water with the fingertip to make circular ripples. These ripples will create light and dark rings on the bottom of the pan—these are interference patterns.

Why are the dark rings formed although the water remains wholly transparent? Because the ripples bend some of the light rays entering the water. Where these rays intersect un-bent rays, the light waves either reinforce one another, or cancel each other out, depending on just how they meet.

Light diffracted by the object during construction of a spatial filter contains both *phase* (direction of propagation) and *amplitude* (light intensity) information. Photographic materials can record only the light intensity data, and all the phase information remains unrecorded when the single beam technique is used. If the phase information could be converted into some photographable form, it would provide the spatial filter with just the additional information needed to prevent the ghost light from passing through the filter.

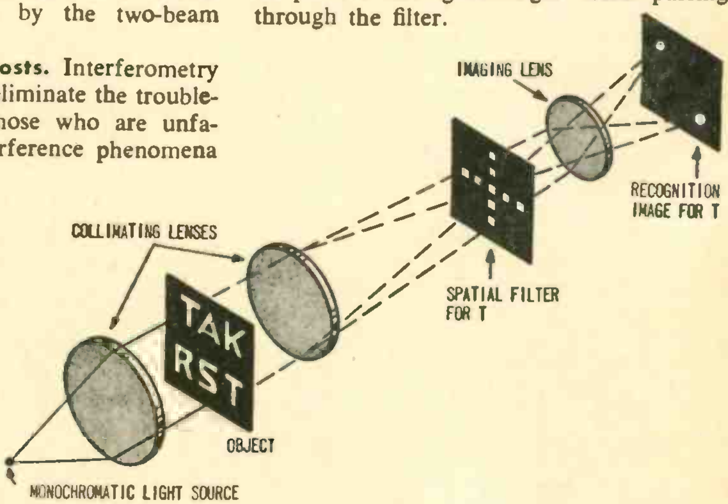


Fig. 5. Special type of spatial filter formed by two-beam system also recognizes letter T but forms recognition pattern instead of recreating letter itself.

Fig. 6 shows how this conversion is accomplished by use of the two-beam interferometric method. By the use of suitable lenses, the light originating from the laser unit is channeled along two paths, one of which passes through the object (in this case the letter T). When two beams intersect to produce the diffraction hologram, both additive and subtractive interference like that observed in the water experiment occurs.

The interference pattern thus produced

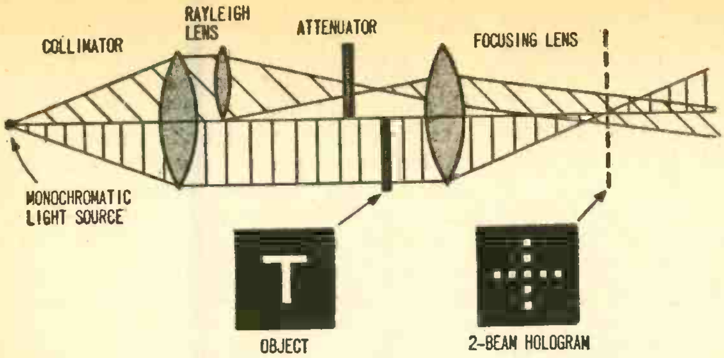


Fig. 6. The two-beam optical system used to produce special hologram and spatial filter for use in fingerprint detection.

consists of many parallel lines, each about one thousandth of an inch wide. This interference pattern is a record of the previously lost phase information. The "complex filter" obtained in this manner is identical to one produced by the single beam method except that it has this fine line interference structure imposed upon it.

What does this fine line structure do? When the filter is used in a recognition system, the lines diffract all the light coming from unwanted portions of the object out of the axis of the instrument so that the light cannot reach the target area. Except for optical "noise" which will be mentioned later, the only light that reaches the recognition screen is that produced by an object identical to the one from which any given spatial filter is constructed.

By scanning the recognition plane with a photo-multiplier or other light-detecting equipment, it is possible to build a system which, when it recognizes the desired information, rings a bell, grinds the object sampling system to a halt, or executes other more sophisticated processes.

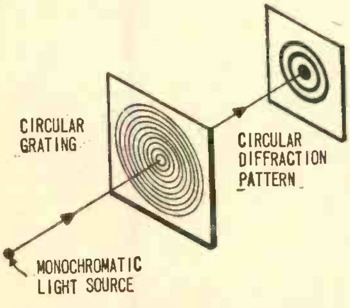


Fig. 7. Circular diffraction grating produces circular pattern. Fingerprints can be considered as curved gratings.

Fingerprint Recognition. Fig. 7 shows the type of diffraction pattern that is produced by a wholly circular grating. A fingerprint is essentially a curved grating, though somewhat elliptical. But, as Fig. 8 shows, a reversed transparency of a fingerprint produces a diffraction pattern quite similar to that formed by a circular grating. Photographic reversal of this diffraction pattern yields a spatial filter specific to this particular fingerprint and no other.

In fingerprint recognition, a complex filter is used in the same way as for the identification of any other pattern, such as the letter T. A fingerprint found at the scene of a crime is converted to its spatial filter form. This filter is placed into the optical equipment and the fingerprints (in transparency form) of various suspects are inserted into the equipment, one at a time, as objects for comparison. When the right fingerprint comes along, the spatial filter instantly forms a characteristic recognition spot on the screen. A fingerprint's characteristic identifying spot is shown in Fig. 9. Another fingerprint very much like the first does not produce a spot, only scattered light flecks called "noise" (see the second photo).

Fig. 8. Reversed transparency of typical fingerprint produces pattern very similar to that of circular diffraction grating.

High Selectivity. To test the reliability of this recognition system, G.E. researchers obtained a number of almost identical fingerprints from the New York State Identification and Intelligence System. All of the test fingerprints had the same classifications according to orthodox indexing systems.

The prints were copied on 35-millimeter film, and a spatial filter was made from one of the prints. The only fingerprint that subsequently produced the intense recognition spot was the one from which the spatial filter had been made (spatial filtering equipment used in these tests is shown in Figs. 10 and 11). Some of the other fingerprints produced scattered light spots ("noise") because they partly correlated with the data on the filter. Light measurements showed that the intensity of the spot produced by the key fingerprint (used to make the filter) was 175 times greater than any light transmitted when other fingerprints were tested.

Other experiments were performed to further substantiate the validity of the method. These proved conclusively that the method is highly selective, and not confused by two very similar prints. This selectivity is largely attributed to the ability of the filter to detect fine details and ridge spacings, not simply the general pattern shapes.

This high degree of selectivity is at once a boon and a handicap. It is advantageous when the need is to recognize one particular print. But it is a disadvantage if the objective is to use spatial filtering as a means of classifying prints automatically into various group categories.

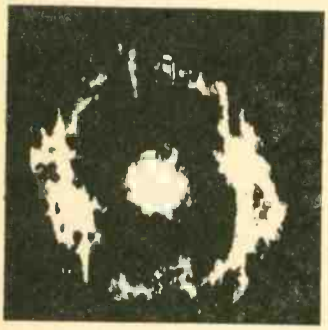


Fig. 9. Fingerprint recognition pattern at left occurs only when prints are exactly alike. Very similar prints produce only flecks of light at right, called noise.

Incomplete Fingerprints. One remarkable advantage of the spatial filtering method is its ability to correlate incomplete fingerprints.

In one experiment, a spatial filter was constructed to recognize a particular thumb print. The intensity of the recognition spot was measured as the object thumb print was progressively masked to obscure successively larger areas until an area only ¼ inch square remained visible. This area represented about 20 percent of the thumb

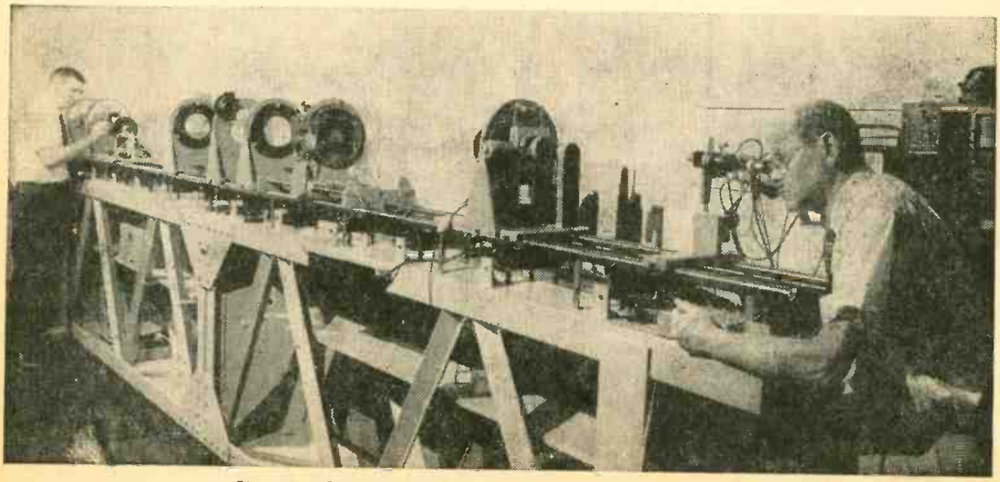


Fig. 10. General Electric's complex four-ton experimental spatial filtering system is used to study fingerprint detection methods.

print used originally in the spatial filter.

Off hand, one might expect that when the fingerprint was 50 percent obscured, the strength of the recognition spot would drop off to 50 percent also. The startling fact is that the intensity fell only to about 91 percent of the maximum! Eventually a point is reached where the recognition spot intensity drops off rapidly; but this does not occur until about 70 percent of the print is obscured.

The significance of this discovery could hardly be exaggerated. Most prints found at the scenes of crimes are incomplete, being perhaps half or less of the area of full rolled prints. Yet this method of identification can reliably match such partial prints with the corresponding complete classified prints.

Equipment. General Electric's spatial filtering units are still experimental and none have yet been designed for manufacture. The unit shown in Fig. 10 is 20 feet long and weighs about 4 tons, and yet, optically it comprises only the parts shown in the diagrams of spatial filtering systems. A unit of this size is not necessary for searching information the size of fingerprints.

Fig. 11 shows a much smaller, semi-portable engineering demonstration unit. It includes the equivalent optical components of the large system and, in addition, a vidicon camera to sample the recognition plane and provide a magnified real-time picture of the recognition signals. This small system is designed to facilitate the search of material recorded in 16-millimeter microfilm and is constructed so that the film is moved through the system conveniently by turning a knob.

Advantages. The spatial filtering method of fingerprint recognition has several advantages over other methods of recognition. Recognition is instantaneous, limited only by the mechanical pattern input of recognizing partial prints.

The lateral, vertical, and longitudinal position in the system of the object to be recognized is not critical as might be expected in light of Ernst Abbe's prediction of the "invariant image." With other techniques such as computer or vidicon scanning techniques, the position of the object can be extremely critical in determining recognition; with spatial filtering it is not. The relative rotational positions of the object and the spatial filter need only be accurate to within plus or minus 3 degrees for correlation to take place. If this error exceeds 3 degrees, alignment can be accomplished simply by rotating the filter or object transparency in the optical system. The usual scanning techniques, on the other hand, require rotational alignment within a fraction of a degree.

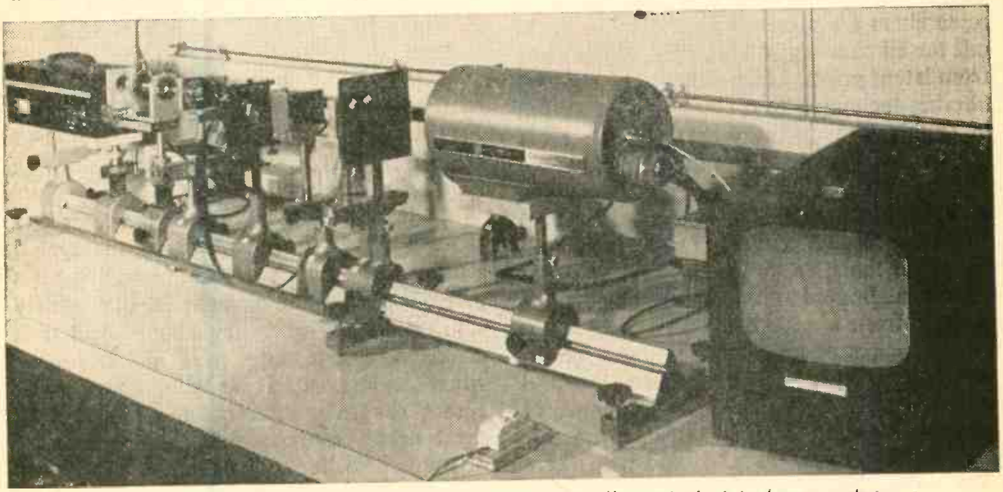


Fig. 11. Semi-portable demonstration unit is optically equivalent to larger system. It utilizes TV system to provide magnified recognition signals.

Drawbacks. At the present time the spatial filtering method has several disadvantages. The input objects must be in transparency form; non-transparent prints would cause too much light scattering to permit the production of good diffraction images. Moreover, law enforcement agencies have accumulated fingerprint files of millions of cards which would have to be copied by standard photographic techniques to transform them into transparencies.

One serious disadvantage is that typical latent prints obtained at the scenes of crimes are very "noisy." The perfect print is obscured by dirt and surface roughness or is distorted and smeared. The human fingerprint technician can compensate for such print imperfections because he follows the patterns of the prints as continuous lines. He can ignore the irrelevant irregularities in the print.

Although it is admittedly difficult to devise any automatic recognition process which will correct for all print defects, the G.E. researchers are presently investigating methods for eliminating at least some of the noise from latent prints. Thus, although the spatial filtering technique has tremendous potential in criminal investigation procedures, there are still some bugs to be ironed out.

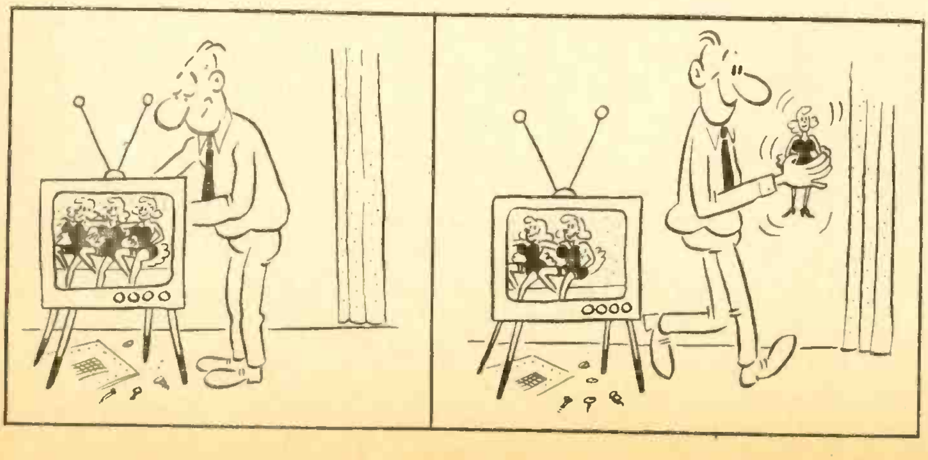
Potential Applications. There are several possible applications for a spatial recognition concept. A technique which might be useful on the state police level would be to search a limited number of fingerprints directly from a special file. The file might include prints of known criminals or criminals recently released from detention and known to be repeaters. It would consist of microfilmed print images or of data processing cards with apertures to hold the microfilm. The latter would have additional information punched on them such as modus operandi, weight, height, etc. which would serve to reduce the number of prints having to be searched.

When a latent print is discovered at the scene of a crime, it would first be converted to a spatial filter. The limited file, or a selected portion of the file described above would then be searched for a match between the spatial filter of the latent print and the known print. If a match is found, the two prints are then compared by eye to eliminate the possibility of a false alarm.

The spatial filtering system alone could probably not be used for a file as large as that accumulated by the FBI in Washington, simply because of the immense mechanical difficulties of searching two billion prints. Even if the system could search the files at a rate of 100 prints per second, it would take many days simply to search the files one time. However, it is conceivable that spatial filtering could be used as a part of some electronic classification system which would reduce the size of the file to be searched by several orders of magnitude. The remaining prints, being the "most probable" matches would then be searched using the spatial filtering process.

All in all, the discovery of the laser and the subsequent development of the spatial filtering system of fingerprint recognition has given the criminal element in our society something new to worry about. And it is conceivable that some time in the future, when devices such as spatial filtering becomes generally available to law enforcement agencies, the almost magical powers of modern technology will all but eradicate crime. After all, Holmes was always one up on his fictional protagonists because they didn't understand his deductive powers. Too, this may be the case with the criminal and science.

As Sherlock Holmes might have put it: "Watson, we now have the means to put the culprits on the spot!" ■



COVER STORY

TRIPLE THREAT

Great little goodie that'll snuggle right up to your rig and make for CBing with a vengeance.

By Ed Morris, WA2VLU

With today's crowded CB and Ham bands, you're just plain hurting if your rig's transmitter or antenna aren't putting out their best for you. Getting through the gobs of QRM takes just about everything you can muster—from a few more milliwatts to another ½-dB antenna gain. If your rig is letting you down, you'll want to know so's you can do something about it. If you don't, the end results will be decreased operating range, and fewer QSOs.

How are you going to find out? Simple, build our whiz-bang Triple Threat, a combination 0 to 5-watt RF power meter, field strength meter, and modulation monitor, all wrapped up in one small, neat package. It's just the thing that'll keep your rig's transmitter and antenna doing the very best they know how for many a CB season to come.

Not only is Triple Threat fun and easy to build (a beginner can do the job in 4-5 hours), but it's inexpensive as well. The total cost is under thirteen bucks, and that's using all new parts throughout.

The input impedance to the RF power meter is 52 ohms—compatible with almost all CB and Ham rigs—and it can be used up to 50 MHz. The field strength meter can be used way up to 150 MHz, as can the modulation monitor.

RF Power Meter. The RF power to be measured is coupled across a dummy load consisting of resistors R2-R6. Notice that the total resistance of this resistor hookup is about 52 ohms. In addition, resistors R5 and R6 serve as an RF voltage divider.

The RF voltage dropped across resistor R5 is applied to germanium diode D2. Here

e/e TRIPLE THREAT

the RF voltage is rectified and converted to direct current. The DC is then filtered by the action of capacitors C2 and C3. Resistors R7 and R8 aid in this filtering action and are also the calibration resistors, controlling the amount of current flowing through meter M1. The rectified and filtered RF voltage is then read by meter M1, which is calibrated in RF watts.

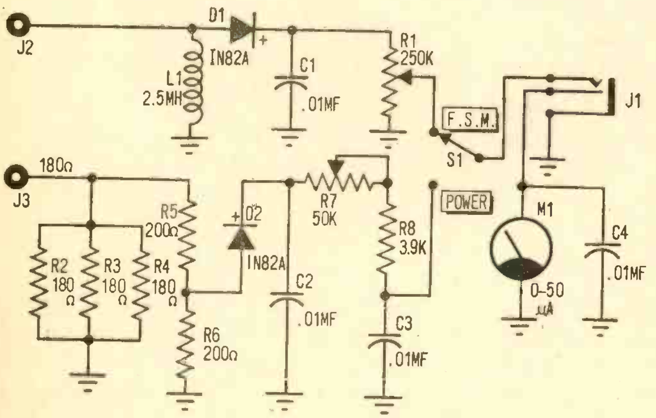
Field Strength Meter. Radio-frequency signals picked up by the antenna are coupled across choke L1, which is a high impedance to ground for these signals. The RF voltage developed across L1 is rectified by diode D1 and filtered by capacitor C1. Potentiometer R1 is a variable voltage divider, and is the sensitivity control.

The output from the wiper arm of R1 is sent to meter M1 through switch S1. M1 will then read the relative strength of the RF signal. Capacitor C4 is an RF bypass capacitor for the meter.

To monitor modulation quality when using Triple Threat as either a power meter or a field strength meter, plug in a medium impedance (500- to 5000-ohms) headset into jack J1. This disconnects the meter, and connects the output directly to the headset so you can hear what's happening.

Mechanical Construction. Triple Threat is built in a standard 4 x 2⅛ x 1⅝ in. aluminum chassis box. Begin mechanical construction by laying out the holes to be drilled with the aid of a T-square. Center-punching the spots to be drilled will result in a more accurate and neater job. The larger holes may be cut by first drilling a pilot hole, then enlarging it with a tapered reamer to the proper size. A hand nibbler will make quick work of the cutout required for the meter. After the mechanical work on the case has been completed, the holes should be de-burred.

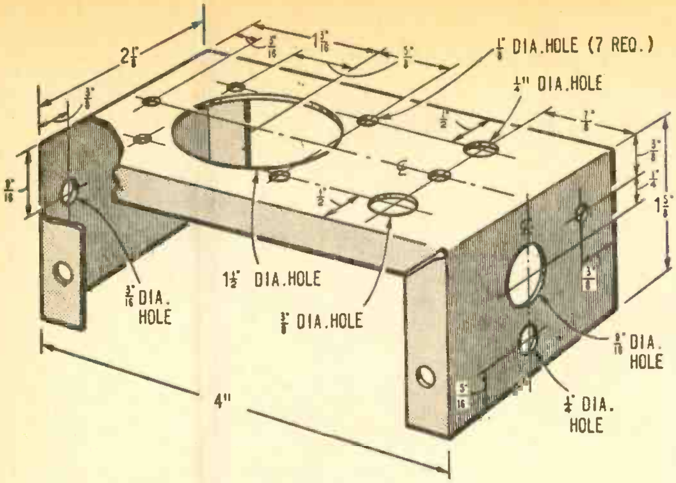
Before the case can be painted, it should be properly prepared by cleaning the aluminum surface. First make sure that the case is clean. Remove all traces of surface dirt and oil by washing with soap and water. Several light coats of primer may then be applied to provide a good base for the finish



Schematic of Triple Threat shows simple, straightforward design that gives you the features you need without the headache of undue complexity. Pot R7 is the set-and-forget power calibration control; R1 is the front panel field strength sensitivity control.

PARTS LIST

C1, C2, C3, C4—0.01-μF, 1000-VDC ceramic disc capacitor
D1, D2—1N82A germanium diode
J1—Miniature closed-circuit jack (Lafayette 99C6211 or equiv.)
J2—Pin-jack, RCA type, single hole mounting (Lafayette 99C6234, Radio Shack 274-295 or equiv.)
J3—UHF-type chassis connector, SO-239 SH, single hole mounting (Lafayette 42C6907, Radio Shack 278-201 or equiv.)
L1—2.5-mH RF choke (National R-50 or equiv.)
M1—50-microampere miniature panel meter (Lafayette 99C5049 or equiv.)
R1—250,000-ohm potentiometer, linear taper (Mallory type UL-46 or equiv.)
R2, R3, R4—180-ohm, 2-watt, 5% resistor. (Do not substitute)
R5, R6—200-ohm, ½-watt, 5% resistor. (Do not substitute)
R7—50,000-ohm potentiometer, linear taper (Mallory type MCL-546 or equiv.)
R8—3900-ohm, ½-watt resistor
S1—S.p.d.t. subminiature switch, toggle type (Lafayette 99C6126, Radio Shack 77-0670 or equiv.)
1—Aluminum chassis box, 4 x 2⅛ x 1⅝-in. (Lafayette 12C8369 or equiv.)
Misc.—Wire, solder, nuts, bolts, ground lugs, paint, decal lettering, etc.



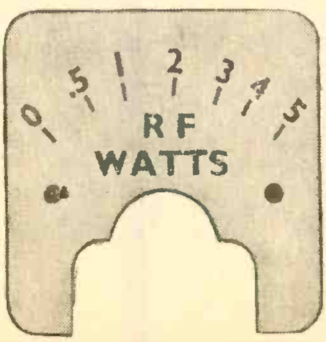
Aluminum chassis box provides plenty of working space but keeps unit compact. While operation of Triple Threat may not be impaired by changing layout, top performance is assured by sticking with design.

coats. When you are ready to apply the final finish coats, use a light touch, as several thin coats will produce a better and longer lasting finish than one or two heavy ones.

After the paint has been allowed to thoroughly dry, suitable transfer lettering can be applied. Transfer lettering, such as that put out by DATAK and others, is both inexpensive and easy to apply. It also usually results in a neater job than decals. In either case, be sure to follow the manufacturer's instructions when applying. An overcoat of clear spray will protect both the lettering and the paint job.

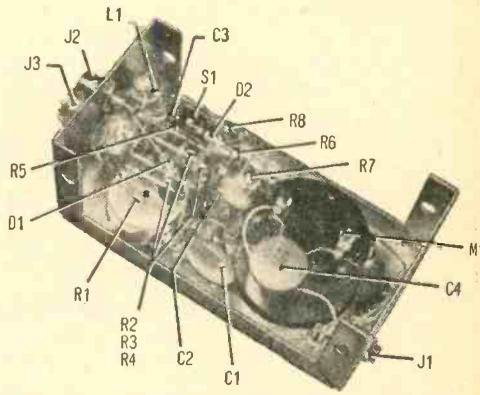
Preparing the Meter Face. Working on a clean surface free from dirt, and in an area free from lint, carefully pop off the plastic face plate of the meter. Using non-magnetic tools, remove the two screws holding the meter scale to the body of the meter.

Spray paint the reverse side of the meter scale white. Exactly copy the actual size precalibrated scale included in this article. Use rubber cement to bond the scale to the side of the meter scale plate which you have just painted. Carefully reassemble the meter.



Using the recommended meter makes dial face above exactly the right size. The non-linear scale is pre-calibrated to match circuit operation; final calibration is made at any power level.

Although the layout for Triple Threat is not critical, best results will be obtained, especially with the power meter section, if the reader follows the layout presented. The more advanced reader should feel free to modify to suit his own needs best.



Internal view of completed Triple Threat indicates careful planning of layout. Resistors R2, R3, R4 are hooked in parallel to provide load for transmitter.

Begin the electrical construction by mounting potentiometer R1 and RF connector J3. When wiring in resistors R2 to R6, follow the photographs for parts placement and positioning.

Next mount meter M1 along with switch S1 and potentiometer R7.

Wire in the remaining circuitry as per the schematic diagram. When soldering diodes D1 and D2 into the circuit, be sure to use a heat sink to preclude possible damage resulting from excess heat. Use a low wattage soldering iron with a well tinned tip. Use the minimum amount of heat necessary to form a good connection.

When you are finished with the wiring of the set, go back and recheck your work. Pay particular attention to the polarity of meter M1 and the diodes D1, D2.

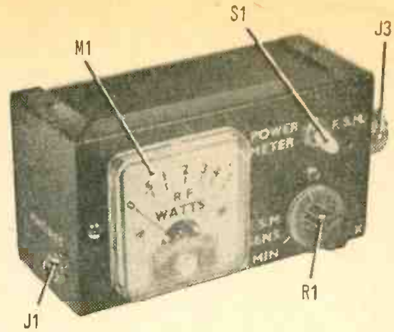
Final Checkout. Place switch S1 in the Field Strength position. Turn the sensitivity control completely counterclockwise. Plug a short antenna (12 to 18-in.) into J3. Key your transmitter and increase the sensitivity by turning R1 until a mid-scale reading on Triple Threat is obtained.

Plug in a medium impedance (500- to 5000-ohms) headset into jack J1. Key your transmitter again and speak into the microphone. You should now be able to monitor your modulation in the headsets.

If a down-scale reading is obtained, reverse the leads to diode D1. If no meter reading is obtained, or if the monitor is inoperative, recheck your work against the schematic, and look for possible shorts.

Now with an ohmmeter, measure the resistance from the center connector of J3 to ground. It should be about 52 ohms. Connect your transmitter, (not exceeding 5 watts output) to J3 with a short length of coax. Set potentiometer R7 to maximum resistance. Key the transmitter and gradually reduce the resistance of R7 until you obtain a half-scale reading. If the meter reads backwards, reverse the leads to diode D1.

Calibration. The calibration procedure for the power meter portion of the Triple



Tidy, professional appearance of Triple Threat front panel makes it nice to have around and a pleasure to use.

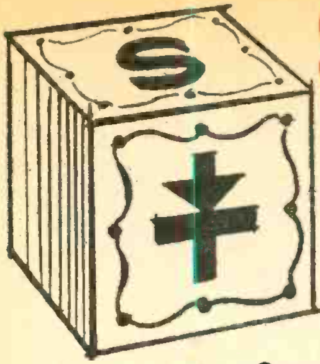
Threat, while not complicated, does require the use of a calibrated RF power meter.

The actual calibration procedure is to adjust calibration potentiometer R7 to match readings on the Triple Threat with those obtained from the RF power meter being used as the standard.

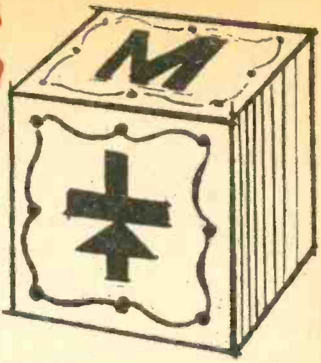
Connect your rig (not exceeding 5 watts output), to the meter being used as the standard. Key your transmitter and note its output on the standard. Now connect your rig, being careful not to change the tuning, to Triple Threat. Key your transmitter again and adjust Triple Threat's calibration control to match the meter reading of the standard.

Let's say the standard says your rig is putting out 2.5 watts. Simply adjust calibration potentiometer R7 so that your Triple Threat reads the same. Only one point of calibration is necessary to calibrate the entire range of the meter. The calibration point should, however, be between 1 and 3.5 watts for best overall accuracy. ■

All hooked up and ready to go, Triple Threat isn't ashamed to be seen in the best of company. Unit's overall good looks and handy features makes it good side kick for any rig in the shack. Here it's shown snuggling up to a Lafayette HB-525 CB rig.



SQUARE MAKER DUO



Our ducky little Duo will put you in great shape any time your wave needs are square

By James A. Fred

It's a well accepted fact that square wave testing is about the only way to realistically check hi-fi amplifiers. Many ways have been devised to make square waves, most of them elaborate and fairly expensive. The most popular way seems to be to start with a sine wave, then clip and shape it into a square wave with various circuit configurations. For the experimenter in need of an occasional square wave or two, traditional methods are pretty complicated and the net result is that he usually does without them. But now, for a few bucks and fewer hours, you can convert the sine-wave output of your oscillator into a good, healthy square wave that's just what the doctor ordered.

The little device we are about to describe does the job in short order and fine shape. Two Amp-Gate diodes are used. These diodes are especially processed to start conducting at a signal level of 1.5-volts rms. No batteries are needed to bias the diodes to this level, and all we need do is to supply a sine wave source of more than 2-volts rms and the diodes will automatically clip it to a square wave. Wave shape will not be as perfect as a big expensive generator, but for the price it can't be beat.

If you have trouble finding Amp-Gate diodes on your dealer shelves, substitute silicon diodes in their place such as the 1N137A or 1N200 to 1N209 series. These diodes conduct at about 0.5 volt so your square wave will not be as high in amplitude. You can buy a surplus diode package of 10 from most mail order parts houses for under a buck and have eight left over for other projects in the making.

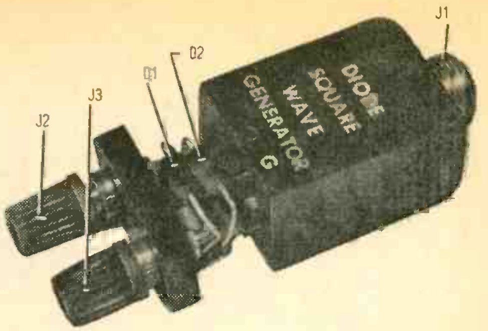
Feeding Square Maker. If your audio signal source puts out less than 2-volts rms, you can use an amplifier to build the signal up to this level. The oscillograph drawings

All you need to make neat little square waves is our Square Maker Duo and a signal generator capable of two to six volts rms output; the higher output will result in almost perfect little squares.

e/e SQUARE MAKER

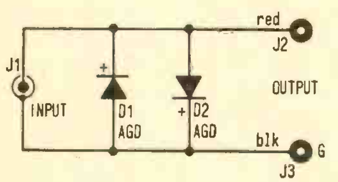
shown are traces taken from the face of an oscilloscope used by the author to check Square Maker's operation. They show what to expect at 1 and 10 kHz. With a 2-volt rms input signal at 1000 Hz, you will get about 1-volt rms output. If you can get 6.5 volts rms out of your oscillator, you will get nearly a perfect square wave at 1.25 volts output.

There are very few parts used and the assembly takes very little time. The aluminum shell of the mike connector comes complete with a phenolic banana plug strip. You use the strip by drilling out the banana plugs and mounting the 5-way binding posts in the same holes. Amp-Gate diodes have heavy wire leads which are formed and soldered to the 5-way binding posts. Use long nose pliers as a heat sink when soldering the diodes since all semiconductors can be damaged by excess heat. Use No. 2 bare wire and insulating tubing to connect the microphone connector and the binding posts.



Construction of Square Maker in mike-connector cover makes handy, neat little unit.

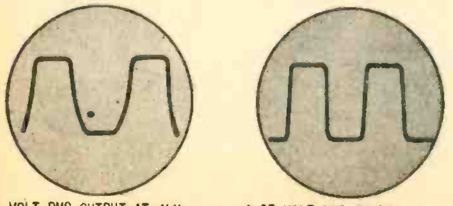
Using Square Maker. To use Square Maker, you simply insert it between the signal generator (audio) and the input to the amplifier under test. Use an oscilloscope to monitor the input signal and trace it on the scope face with a grease pencil. Now connect the scope to the output signal. If the amplifier is linear, then the output signal will be greater in amplitude, but when attenuated, it will be the same shape. If the input and output pattern aren't the same, there is distortion in the amplifier that may have to be tracked down. In any case, however you use it, Square Maker Duo will serve you well for years to come whenever your needs are square. ■



Schematic shows unit is basically a clipper circuit producing essentially square waves by flattening peaks of sine wave.

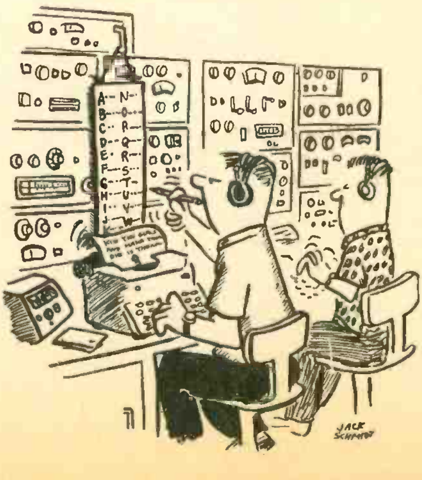
PARTS LIST

D1, D2—Amp-Gate diodes (Mallory AGD, Radio Shack 276-660 or equiv.)
J1—Microphone connector (Keystone 509, Radio Shack 274-1561 or equiv.)
J2, J3—1 red and 1 black 5-way binding post (Lafayette 99C6233, Radio Shack 274-333 or equiv.)
1—Banana-plug strip (Keystone 651 or equiv.) modified as described in the text
1—Aluminum shell (Keystone 4484 or equiv.)
Misc.—Wire, solder, etc.



1 VOLT RMS OUTPUT AT 1kHz   1.25 VOLT RMS OUTPUT AT 10kHz

Scope patterns produced by Square Maker with 2-volt and 6.5-volt rms input.



ACCURACY BY ANY OTHER NAME IS—

CALIBRATION

By Jim Kyle
K5JKX

Whether your workbench boasts a complete collection of exotic test equipment or merely an inexpensive volt-ohm-milliammeter, you can be certain of one thing—your test equipment is either accurate or it's useless.

Of course, the accuracy doesn't have to include fractional-percentage precision such as that featured on expensive lab gear. But if a voltmeter tells you the voltage in a circuit is 66 volts when it's really 100, then you might as well not use the meter.

Regardless of the quality or cost of the equipment when new, accuracy is something that can't be guaranteed as time passes. Unless your test gear has been calibrated within the past six months, you have no way to be certain of its accuracy.

Fortunately, calibration—while it sounds horribly complex—is a simple process and can be carried out rapidly with only a few inexpensive items not already in your junk box. Doing it yourself, moreover, is less costly than sending the equipment away.

A do-it-yourself calibration is also likely to be more accurate, since the equipment doesn't have to undergo the shocks and jars of shipping after the job is finished! For regardless of how well it's calibrated, a piece of test gear will seldom sport much accuracy by the time it's been shipped across the country.

Though exact techniques for do-it-yourself calibration may vary with the different types and makes of test gear, some general principles exist. If the instruction book for your equipment includes instructions for calibration—and those for most kit-built equipment do—follow them. If not, read on, and rely on some ingenuity to help you apply these principles to your own particular gear.

Volt-Ohm-Milliammeters. Since the VOM is probably the most common piece of test equipment around, let's tackle VOM calibration first. Many of the principles used in calibration of a VOM apply to much of the more elaborate equipment as well.

e/e CALIBRATION

Most VOMs, because of their circuit simplicity and compactness, lack internal calibration controls. This needn't be a hindrance; all you have to do is to check against various calibration standards and make notes of the amount of error present in your VOM on its various ranges. You will thus expose any glaring inaccuracies, and you will know what correction factor to apply to the meter reading to determine the actual voltage, current, or resistance present in the circuit.

When performing the calibration, be sure to place the meter in the same physical position it will occupy when you use it. Gravity will affect the meter movement itself, and can introduce minor inaccuracies. These aren't normally bad enough to be a problem, but the whole object of calibration is to discover and remove all possible sources of inaccuracy. Therefore, there's no need to deliberately introduce one.

Also, before beginning the procedure, set all mechanical adjustments properly. This includes setting the meter needle to zero with the zero-adjust screw (if one exists) and tightening set-screws on all adjustment knobs (recentering the knobs on the scales if necessary at the same time).

These two precautions, incidentally, apply to all types of test equipment, not just VOMs. In addition, if the test equipment contains vacuum tubes and new tubes have been installed since the previous calibration, they should be aged by leaving power on for 48 hours continuously before calibrating.

Mercury cell at right is excellent voltage reference source, since open-circuit voltage of 1.3455 remains virtually constant during life of battr
Fresh flashlight cells, though not as accurate, give 1.561 volts.

Calibration Standard. The best, commonly available calibration standard to use in checking either the voltmeter portion of a VOM or a VTVM is the mercury cell. These cells produce an open-circuit voltage of 1.3455 volts, and remain very close to that figure throughout their life. Two or more can be connected in series to obtain calibration points at higher voltages. A two-cell combination will produce 2.69 volts, which is excellent for calibrating voltmeters on the 0-3 VDC range; a single cell suffices for calibration on the 0-1.5 volt range.

If no mercury cells are available, fresh flashlight cells of the zinc-carbon type can be used with some decrease of accuracy. Nominal open-circuit voltage of this cell is 1.561 volts, but the level will vary with age in an unpredictable manner.

Whichever type of cell you choose as a standard, you can perform the low-range calibration by simply measuring its voltage and comparing the meter reading to the voltage expected from the cell. Keep in mind that most meter movements are accurate to only 3 percent of their full-scale reading; this means that on a scale rated 0-3 VDC, the meter accuracy cannot be expected to be better than ±0.09 volt. If you obtain a reading of 1.26 volts from a mercury cell with such a meter, you are within the rated accuracy and shouldn't hope to improve on it.

For the high-range calibrations, you have three choices. You can use VR tubes to provide a reference accurate to ±5 percent (which, when added to the 3 percent tolerance of the meter movement, means your calibration is only accurate to 8 percent); you can assume that any error found on the low ranges is present to the same percentage on higher scales (not always a safe assumption); or you can scale up your standard without loss of accuracy by using what physicists call a potentiometer circuit.

Potentiometer Circuit. Fig. 1 shows the arrangement of a potentiometer circuit. This is not to be confused with term potentiometer as applied to volume controls; some similarity exists—but the potentiometer we're talking about actually does control meter potential (voltage).

Accuracy will suffer if you use ordinary resistors for the voltage divider circuit as shown though, since resistors themselves

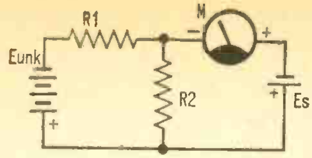


Fig. 1. Schematic of potentiometer circuit. When Es is known, and value of R1 and R2 is such that no current indicates on meter, value of Eunk is known.

have tolerances also. To avoid this problem entirely, obtain a length of Nichrome resistance wire. You can frequently find this in scientific supply houses and occasionally at electrical-appliance repair shops. You'll need enough so you can stretch out a 100-in. length of the wire.

Using strip metal and machine screws, clamp your voltage-source leads to the wire, making the connections exactly 100 in. apart. Now take a third such clamp and connect it to the wire between the two clamps already there, as shown in Fig. 2. Decide what voltage you want to develop across the 100-in. length for a high-level calibration standard. This done, move the middle clamp until it is the same distance from one end as the figure you get by

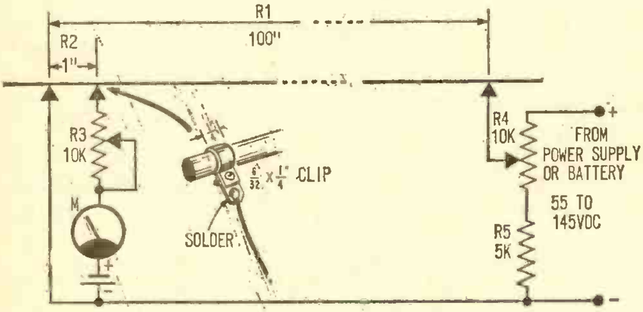


Fig. 2. Practical potentiometer circuit will provide highly accurate voltages for calibrating test equipment. R1 is represented by 100-in. part of the wire and R2 by the 1-in. section. The physical ratios of these lengths when the meter reads zero will be the ratio between the known battery voltage and the unknown voltage from the power supply.

multiplying your standard-cell voltage by 100, and dividing by the desired higher voltage.

For instance, if you are using a mercury cell and want 45 volts in order to check a 0-50 volt range, multiply the 1.3455 volts of the standard cell by 100 to get 134.55. Next, divide by 45 to get 2.99 in. as the distance from the middle clamp to one end.

Connect your meter, set to its most sensitive current range, to the circuit in place of the meter shown. Next, adjust the 10,000-ohm adjustable resistor to maximum resistance (this is simply to protect the meter during initial adjustment). The meter needle will deflect if your hookup is correct; if it doesn't, reverse the meter connections and it probably will. You can now adjust the 10,000-ohm resistor until the meter reads full scale.

Reference Voltage. Apply DC voltage from an outside supply to the two outside clamps, starting with a low value and increasing it slowly. The meter reading should decrease as voltage increases; if it increases instead, reverse the polarity of your high-voltage source. As the meter reading approaches zero, reduce the resistance of the 10,000-ohm resistor to bring it back near full-scale.

As you continue the adjustment, you will find a point at which resistance of the 10,000-ohm resistor has been reduced to zero. Continue increasing the voltage carefully until the meter reads zero. At this point, the desired voltage from the outside supply is present across the two outside clamps. The meter, 10,000-ohm resistor, and standard cell may be removed.

This method is applicable to any voltage, though in order to maintain accuracy when voltages higher than 50 are desired the length of the resistance wire should be increased. What you are doing is substituting accuracy of measurement for accuracy of resistance. Along the resistance wire, the voltage from any point to one end depends on both the voltage across the entire wire and the distance from that point to the end.

If the distance is fixed and the length fixed also, then the wire becomes a voltage divider which is just as accurate as your measurements. If you measure to within 1/10 in. on a 100-in. wire, that's 0.1 percent accuracy—which comes rather expensive if you buy fixed resistors to get it.

As you vary the voltage across the total wire length, the divided voltage also varies. At the start, it's something less than the voltage of your standard cell. As voltage increases, the divided voltage eventually equals the voltage of your standard and then of course becomes higher if you continue to increase the voltage. The purpose of the meter is to determine the point at which the voltages are exactly equal, since at this point no current can flow between them.

Current Calibration. Once you know the accuracy of the voltage scales on your VOM, you can check the current ranges by using Ohm's Law and a handful of precision resistors. Fig. 3 shows the test setup for this procedure. The resistors should be of at least 1-percent accuracy; inexpensive deposited-film units are suitable. Values may range from about 2000 through 200,000-ohms, in about 5-to-1 ratios.

The procedure consists simply of measuring the voltage applied, using the correction factors determined by your voltage-scale calibration. You then divide the voltage by the value of the precision resistor to determine the current flow, and compare the meter reading with this calculated current flow. It is most accurate when high values of resistance are employed, since with low values of precision resistors the resistance of the meter movement itself may introduce inaccuracies.

Calibration of the ohmmeter scales is simplest of all, since only the precision resistors are necessary. Before beginining this calibration, replace the ohmmeter battery and be sure all contacts are free from corrosion. Then zero the ohmmeter by whatever procedure is recommended for your meter, and measure the values of the precision resistors. Compare your readings with the rated values of the resistors.

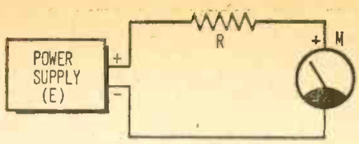


Fig. 3. When the voltage scales of the multimeter are calibrated, current ranges can be calibrated with a power source, precision resistors, and Ohm's Law.

While one resistor offers only one ohmmeter calibration point, two resistors of different values offer a total of four calibration points. Each resistor alone offers one, the two in series offer a third, and the two in parallel offer the fourth. Similarly, three resistors offer even more points, since both parallel and series combinations can be used at the same time. Fig. 4 illustrates the setup and shows some typical multi-resistor connections.

VTVM Calibration. While many VOMs have only one AC scale which frequently is rated at such small accuracy that calibration is hardly worthwhile, most VTVMs and better VOMs feature a full range of AC scales that approach the DC scales for precision and coverage. These offer a special problem when calibrating.

In fact, AC voltage-scale calibration can be so difficult that some kits include instructions for calibration of AC ranges stating simply "connect to a service outlet and adjust to read 117 VAC." Considering that voltage in a typical residence may range from around 105 during peak-load hours to more than 130 volts at light-load times, such a calibration procedure is little better than guessing.

The simplest technique for calibration of AC voltage scales is to obtain another AC voltmeter of known accuracy and compare readings from the same voltage source.

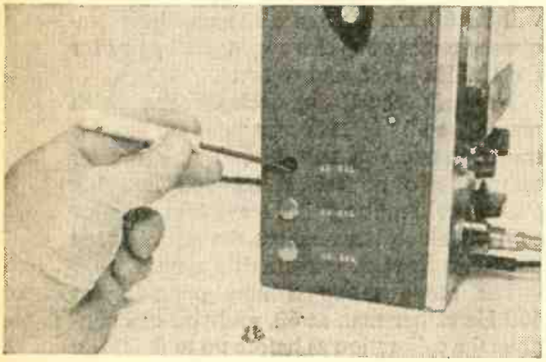
RESISTORS (ohms)	2K	10K	50K	200K	
2K	2000	12000	52000	202000	Resistance in Series (ohms)
10K	1667	10000	60000	210000	
50K	1923	8333	50000	250000	
200K	1980	9524	40000	200000	
	Resistance in Parallel (ohms)				Resistance of One

Fig. 4. Four precision resistors can be hooked up in enough different ways to provide complete ohmmeter check.

However, this technique is often impractical due to the difficulties of locating another voltmeter of known accuracy.

If your VTVM is of the type which features peak-to-peak AC readings as well as the more conventional RMS values, you can employ a short-cut calibration technique. What you do is use the freshly-determined accuracy of your DC scales to assure similar accuracy for the AC readings. However, this technique can't be used with meters which employ meter rectifiers since it depends on the peak-to-peak detection scheme which fixes a definite ratio (2.828 to 1) between peak-to-peak voltage and RMS reading.

The short-cut makes use of a chopper circuit to switch a known DC voltage level



AC voltage calibration is considered more complicated than DC calibration. The simplest way is to obtain a calibrated AC meter and adjust your readings to match.

off and on again 60 times per second, thus converting it into a 60-Hz square wave. The voltage of the DC before chopping can be measured with your meter's DC scales; after chopping, the peak-to-peak value will be identical to the unchopped DC value, and this permits you to calibrate your meter on the AC ranges.

Making A Chopper. Fig. 5 shows the schematic of the chopper. Maximum DC voltage which can be applied is determined

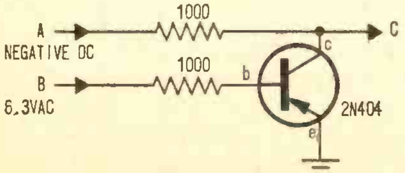


Fig. 5. Transistor chopper can be used for AC calibration if DC voltage fed to it is known. Square-wave AC output will be of almost the same value as DC input.

by the transistor employed; the 2N404 specified can handle up to 24 volts.

To calibrate a meter by this technique, apply the DC voltage to input point A and apply 6.3 VAC from a filament transformer between input point B and ground. Using the DC scales of your meter, measure the voltage from point A to ground and note the reading for reference. Then switch to the AC scale of the meter and measure the voltage from output point C to ground.

If the *peak-to-peak* value of the voltage from C to ground is significantly different from the previous DC reading, your meter is either seriously out of calibration on the AC scales or employs some type of rectifier for which this technique is not valid. If the reading is approximately half that of the DC level, your meter may be reading only *peak* values rather than *peak-to-peak;* reverse the meter leads and re-measure.

If the reading is approximately the same as the DC level but not exactly so, adjust the "AC Calibrate" control of your meter until you obtain the same AC reading as the DC reading. Reverse meter leads and check; if the reading differs, readjust to split the difference and note the errors for future reference.

Regardless of the type of rectifier your meter employs, you can perform a reasonably good calibration of the RMS AC scales by using an intermediate transfer device consisting of a light bulb and a photocell. Enclose both bulb and photocell in a box so that no light can reach the cell except that from the bulb. Apply DC to the bulb and measure its value. Measure and note the DC voltage produced by the photocell.

Remove DC voltage from the bulb, and connect a source of variable-voltage AC which can be varied through the range of the previously applied DC. Adjust the AC voltage until the photocell produces the same reading as before; the RMS value of the AC voltage will now be the same as the DC voltage previously applied to the bulb and furnishes a single calibration point.

Fig. 6 shows the connections for this technique; accuracy will depend primarily on the care you use to take the various readings. The comparison is based on the fact that a DC voltage which is equal in heating effect (and thus in light produced from a bulb) to an RMS AC voltage is also equal in value.

Once a single known RMS value is

achieved by this means, you can check the meter reading obtained from the same DC voltage by the chopper technique in Fig. 5. You should end up with a correction factor that will permit you to use the technique in Fig. 6 with any type of meter. By this means you can obtain other calibration points without the need for several sizes of bulbs.

Oscilloscopes. The oscilloscope's vertical-deflection circuits and display are, in fact, a highly sophisticated VTVM in which an electron beam replaces the mechanical needle of a meter movement. All the calibration techniques used for VTVMs also apply to calibration of scope vertical-deflection channels. What's more, since on the scope you can see the peak point of any waveform, you don't need the chopper circuit to make the peaks visible. If your scope is for use with AC only, however, the chopper will allow it to measure low-level DC as well and can provide an initial calibration point.

The horizontal-deflection circuits of a scope, as most commonly used, measure time rather than voltage. To calibrate this channel, an accurate timing signal is necessary. Such a signal is available from standard power outlets; frequency of ordinary household power is normally held to within ½ Hz of 60 Hz, which means that each full cycle occupies 1/60 second.

To adjust horizontal sweep speed to 1/60 second, all you need do is turn off (or reduce to zero) the internal synchronization of the sweep, connect 60-Hz AC to the vertical input, and adjust horizontal sweep to display a single cycle waveform stationary on the screen. This calibration is so simple, in fact, that whenever necessary, it is normally done just before you use the scope—in the same manner as you normally zero an ohmmeter immediately before use.

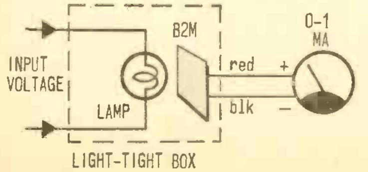


Fig. 6. Equal AC rms and DC voltage will cause same brightness of lamp and photocell output to meter. Therefore, a known DC voltage can be used to find equal AC rms value.

Oscillators. For many experimenters at least one adjustable oscillator, either RF or AF, is necessary and this too should be calibrated. Calibration of an audio oscillator is simplest when done with an oscilloscope but can be done with no additional equipment except a VOM or VTVM. Let's look at the scope method first.

A reasonably accurate calibration can be made by "transfer" from the 60-Hz AC power line. First, calibrate the scope sweep to exactly 60 Hz as described in the preceding section. Then, without touching the scope controls, disconnect the 60-Hz source from the scope and connect the oscillator to the scope instead. Adjust the oscillator frequency until a single stationary cycle is displayed. At this point the oscillator output will be 60 Hz. Increase the oscillator frequency until two cycles appear stationary for the 120-Hz point, and so forth.

Normally, the 10-full-cycle display, which represents 600 Hz, is about the limit for this transfer, but you can extend the transfer upward. To do this, after you find the 600-Hz calibration point, leave the oscillator controls alone but readjust the scope sweep until a single cycle is again displayed.

The scope sweep is now operating at 600 Hz rather than at 60, and you can continue the calibration as before up to 6000 Hz. Another transfer will set the scope sweep to 6000 Hz and allow you to continue calibrating up to 60 kHz, which is nearing the upper-frequency limit for many audio oscillators and experimenters' scopes.

This transfer technique provides reasonable accuracy, but with the same equipment far greater accuracy can be obtained by the use of Lissajous figures. These are the geometric designs generated when one AC signal is applied to the vertical input of the scope and another AC signal is applied to the horizontal input. You can start with 60 Hz applied to the horizontal, and your oscillator connected to the vertical.

Lissajous Calibration. When the two frequencies differ, the screen will display a rapidly moving pattern. As the two frequencies move closer together, the pattern will merge into a circle which appears to be rotating on an axis which is inclined at an angle of 45 degrees from the vertical. (If gain in the two scope channels differs, the circle will appear as an ellipse; the cure is to increase gain in one channel or the other until the ellipse flattens into a near-circle.)

(Continued on page 89)

e/e CALIBRATION

When the two frequencies coincide precisely, the pattern will become motionless. Depending on phase relationships between the two input signals, it may appear as a circle, an ellipse, or a straight line at a 45-degree angle. But in any case, when movement stops the two frequencies are identical.

This provides your first calibration point for the oscillator. After marking it, increase the oscillator frequency slowly. The pattern will first begin to appear to rotate slowly, then faster. Ultimately, a new pattern of great complexity will appear and gradually become stationary.

Fig. 7 shows some of the various patterns. Whenever the pattern is stationary, the oscillator frequency bears some definite ratio to the reference frequency. To determine the oscillator frequency, count the number of full loops appearing across either the top or the bottom edge of the pattern, multiply the reference frequency by this number, then divide the product by the number of full loops appearing along either side.

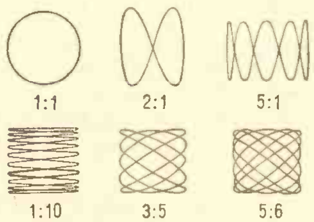


Fig. 7. Typical Lissajous figures seen on scope. Ratios indicate vertical frequency in relation to horizontal sweep frequency. One can be calculated if other is known.

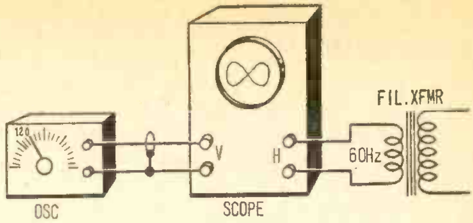


Fig. 8. Known input frequency of 60 Hz can be used to calibrate audio oscillator by using the Lissajous figure relationships.

For example, the 3:5 pattern of Fig. 7 shows three loops across either top or bottom, and five loops along either side. Therefore, if the reference frequency is 60-Hz the oscillator frequency which produces this pattern is the product of three times 60 divided by five or 36 Hz.

Infinite Fractions. Since an infinite number of fractions can be formed by setting one whole number in ratio to another, this technique theoretically provides an infinite number of check points. In practice, whenever the frequency ratio exceeds 10 to 1, or the number of loops on either side or top is greater than 10, it becomes difficult to count them accurately.

Even so, a large number of checks can be made from a single reference frequency. And when the 60-Hz frequency becomes too low, it is always possible to use another oscillator calibrated by transfer techniques from the 600-Hz Lissajous-calibrated oscillator as the new standard and continue upward (see Fig. 8).

RF Oscillators. For calibration of RF oscillators, some type of receiver is essential. Preferably, it should be one capable of receiving the standard-frequency transmissions broadcast continually by the National Bureau of Standards station WWV at fre-

(Continued on page 117)

HOME STUDY BLUEBOOK

e/e's Guide to selected Home-Study Courses now being offered by Electronics Schools

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Listed below are a few courses from several home study schools. For more information, circle those course numbers that interest you on the coupon below, and fill out both sides of the coupon. ELEMENTARY ELECTRONICS will forward your request to the schools and ask that additional data be sent to you directly.

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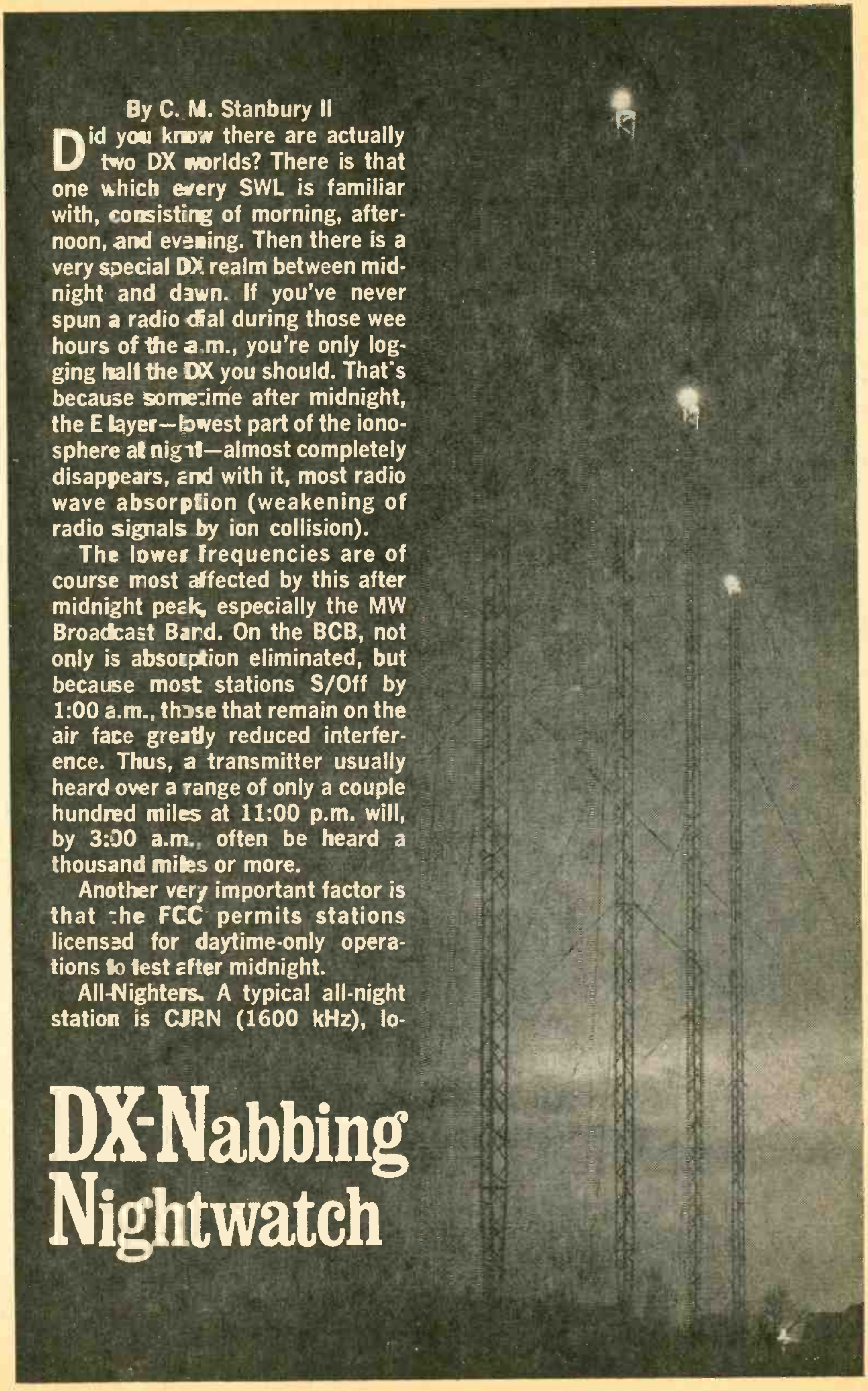


By C. M. Stanbury II

Did you know there are actually two DX worlds? There is that one which every SWL is familiar with, consisting of morning, afternoon, and evening. Then there is a very special DX realm between midnight and dawn. If you've never spun a radio dial during those wee hours of the a.m., you're only logging half the DX you should. That's because sometime after midnight, the E layer—lowest part of the ionosphere at night—almost completely disappears, and with it, most radio wave absorption (weakening of radio signals by ion collision).

The lower frequencies are of course most affected by this after midnight peak, especially the MW Broadcast Band. On the BCB, not only is absorption eliminated, but because most stations S/Off by 1:00 a.m., those that remain on the air face greatly reduced interference. Thus, a transmitter usually heard over a range of only a couple hundred miles at 11:00 p.m. will, by 3:00 a.m., often be heard a thousand miles or more.

Another very important factor is that the FCC permits stations licensed for daytime-only operations to test after midnight.

All-Nighters. A typical all-night station is CJRN (1600 kHz), lo-

DX-Nabbing Nightwatch

cated at world-famed Niagara Falls. Not that CJRN ever has a clear-channel throughout North America, but the number of stations transmitting on 1600 kHz during the small hours is so reduced that logging is possible at remote points. DXers can always fight their way through one or two unwanted signals (except locals, of course) to bag their target. Further, on Monday a.m. (i.e., the period beginning immediately after Sunday midnight), many normally all-night stations are also off. In short, morning is tops for catching tests and Latin American all-nighters in countries like Colombia, Costa Rica, Ecuador, Guatemala, and Cuba.

Other inviting targets are rare stations in Asia and the Pacific—for example, KHVH (1040 kHz), Honolulu, Hawaii. Of course, out in Hawaii, midnight doesn't come until 0500 EST so you will have to hear them during their evening hours and absorption will, in this instance, still be a problem. Best chance for KHVH is Sunday a.m., when powerful WHO, Des Moines, is off the air.

Not only are Asian and Pacific DX available on the BCB exclusively after midnight, but the same rule applies to SWLing. Before midnight, about the only Asian SW transmitters that can be heard are R. Japan, R. Australia, R. Peking, etc.—hardly DX. Remember, however, that in PST areas, Asian and Pacific SW DX does appear a little before midnight and continues well past dawn.

All Night Latin American BCB Stations

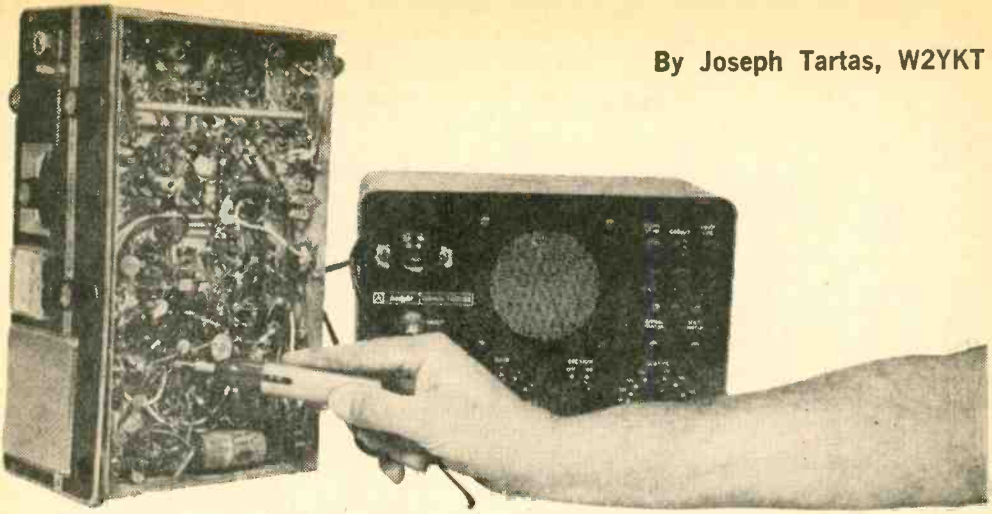
kHz	Call, ID	City, Country
640	"Circuito CMQ"	Habana, Cuba
675	TIJC "R. Musical"	San Jose, Costa Rica
690	XETRA	Tijuana, Mexico (English)
805	HCFV1 "Canal Tropical"	Quito, Ecuador
820	HJED "La Voz de Rio Cauca"	Cali, Colombia
960	ZFB-1 (relays V. of America)	St. Georges, Bermuda
1045	HOJ-2 "Ondas del Canajagua"	Las Tablas, Panama
1050	XEG	Monterrey, Mexico (English)
1060	CMBQ "R. Enciclopedia Popular"	Habana, Cuba
1070	HJCG "R. Sante Fe"	Bogota, Colombia
1090	CMDD "La Voz de Cuba"	Bayamo, Cuba
1090	CX28 "R. Imparcial"	Montevideo, Uruguay

QSL card from Radiodiffusion-Television Francaise; an easy catch from North America.

Midnight DX. To be more specific, the SWL's targets in the world of after-midnight DX are such exotic stations as R. Nepal (4600 and 7105 kHz), the only authentic SWBC station operating in this remote Himalayan kingdom; R. Brunei (4865 kHz—their QSL features a drawing of the Sultan's palace; the R. Republik Indonesia relay at Sorong, West Irian (formerly Dutch New Guinea); and VL9CD, R. Wewak in neighboring Papua. R. Brunei and R. Wewak fight it out for 3335 kHz, though R. Wewak is the one usually heard in North America. All of the above are best heard just before dawn and all are certainly worth several cups of very black coffee.

After-midnight also represents a golden opportunity for the utility DXer because the rarest utility stations operate below 3000 kHz where conditions are similar to those experienced on the standard BCB. And conversely, any utility station logged below 3000 kHz is that much better a catch.

For example, time-and-standard-frequency station WWVH (Maui, Hawaii) is just a fair DX catch if logged on 5, 10 or 15 MHz. But heard on 2500 kHz WWVH becomes an excellent catch. In fact, throughout Eastern North America, even WWV itself rates as fair to middling DX when logged on 2500 kHz. *(Continued on page 116)*



By Joseph Tartas, W2YKT

Before you go probing, you should know how these simple tools become part of the circuit under test and affect your readings

PROBES

Every time you take a measurement, be it voltage with a VTVM or the resonant curve of a tuned circuit with a scope, your test equipment's accuracy is only as good as the means by which you get the signal from the test point to the test gear. And one of the great big factors is the probe; that seemingly innocent device that provides a convenient means of prodding around in the innards of a piece of gear. The fact is that most people think a test probe is just a handy termination on the end of the cable connected to the test equipment. While it's true that probe design borders on simplicity itself, the overall effects on measurement and the complex electrical goings on within the probe turns out to be another color of horse altogether.

To design, build and use the right probe isn't much of a problem once you're well grounded in the basics of what makes a probe tick. To get you headed in the right direction, let's begin by examining probes in general and having a look at what they're used for.

There is an infinite variety of probes that may be used for radio and TV servicing, and RF and IF amplifier servicing in particular, but all of them fall into only four categories. In order of their simplicity, they are:

1. Direct probe
2. Isolation probe
3. Demodulator probe
4. Divider probe

Each category may be subdivided many times, but here they will only be considered to the extent of their applications in measuring RF and IF circuitry.

The Direct Probe. To start things off with a bang, we'll begin by discussing the direct probe's connection to the scope or meter. Although it may seem unnecessary to discuss the direct probe because of its simplicity, it should not be ignored because if it is used improperly, it can introduce noise, hum, or interference into the circuit being tested through direct pickup.

In almost all applications the direct probe should consist of a shielded conductor, with both ends of the shield properly grounded—one end to the scope, the other to the chassis. This prevents pickup of 60 Hz hum which may be larger than the observed voltage at times, interference from nearby equipment, or radiation of signals from the circuit under investigation.

Signal radiation is one cause of oscillation in an IF amplifier chain, and occurs when the output is improperly filtered, is radiated back to the input by the metering lead, and then re-amplified. In some cases the shields should be grounded at the same chassis point for input and output cables; in other cases they should be isolated from each other.

TABLE 1. COAX CAPACITANCE AND IMPEDANCE

Army/Navy Type No.	Nominal Impedance (Ohms)	Nominal Capacitance Per Foot (pF)
RG-8/U	52.0	29.5
RG-55/U*	53.5	28.5
RG-58/U	52.0	28.5
RG-13/U	72.5	20.5
RG-59/U	73.0	21.0
RG-7/U†	100.0	12.5

* Double Shielding Braid. † Low Capacitance Cable.

There is no set rule and the proper method must often be determined by a procedure of trial and error.

Simple It's Not. When a shielded cable is used, the capacitance existing across the cable terminals must never be ignored. A 3-foot piece of a standard 75-ohm cable commonly used has about 75-pF capacity, and this can be of either advantage or detriment, depending upon what kind of circuit it is used in.

If the cable is used for a video or audio input from a detector, the capacity may act as a bypass for any RF that gets through the filter. While this is desirable, it may add to a video time constant to alter the normal frequency characteristics of the following stage and make the reading meaningless.

Note from Table 1 that the capacity of test lead cable is approximately inversely proportional to the nominal impedance of the cable listed.

The Isolation Probe. The isolation probe is next in simplicity, but no less important than the direct probe. There are three general types of isolation probes, the resistive, the capacitive, and the cathode or emitter follower—the resistive being most common.

The resistive probe in Fig. 1 serves three main functions: it helps to reduce the effect of the cable capacity on the circuit under test (A); it provides a high impedance load when a low impedance meter is used (B); and it acts as a part of an RC filter network for high frequencies (C).

The capacitive isolation probe in Fig. 2 is nothing more than a series blocking capacitor to keep DC out of an AC meter. If the blocking capacitor is omitted (A) when measuring voltage that consists of both AC and DC, the voltage measured will be the sum of the rectified AC and the DC that passes through the meter. With a blocking capacitor in series with the meter (B), the voltage read will be the AC component only, providing the reactance of the capacitor is very low at the frequency. The DC component is, of course, read with a DC meter which does not respond to the AC voltage component.

When using a scope, the blocking capacitor is already in the circuit (C), and it will

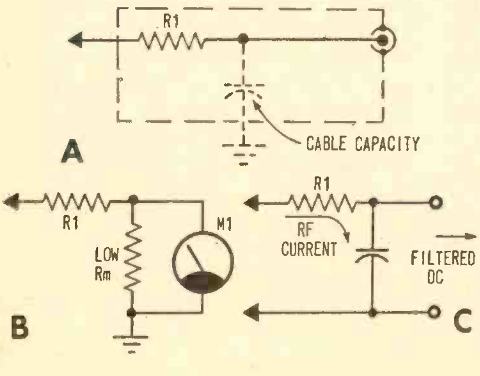
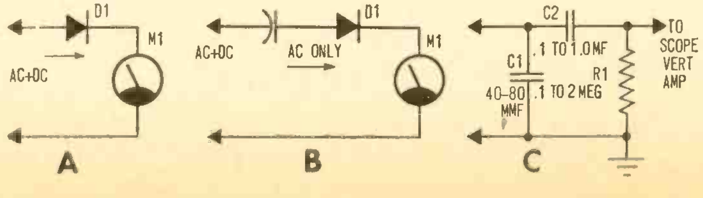


Fig. 1. The value of R1 in these variations of the resistive probe is around 1 megohm, except when a value is selected to act as a matching load resistor. In all three variations, R1 becomes, in effect, part of the circuit under test. In B, low meter impedance is represented by Rm.

Fig. 2. Without a series blocking capacitor, as in A, both AC and DC voltages contribute to a meter reading. Capacitive isolation probe as shown in B, however, only allows the desired AC component to be measured. A typical oscilloscope input, C, is designed with the capacitor built in.



not be necessary to add one for isolation.

The cathode or emitter follower might well fall into the classification of a low-capacity probe, because it is just that. A triode vacuum tube with a grounded plate has a low input capacity and a very high input impedance. The output, taken across an unbypassed cathode resistor, has a low impedance and a low capacity output.

Maximum gain of the cathode follower is always less than unity, although it can be made to approach it quite closely. By adjusting the value of the cathode resistor, the cathode output can be made to match its load. The characteristics of the cathode follower are:

1. High-impedance input, low-impedance output.

2. Input and output has one side grounded (or common).

3. Wide frequency response with minimum phase change.

4. Output is in phase with the input because of the unbiased cathode, and because the cathode follows grid voltage changes.

5. Voltage gain is always less than one, but can be made to approach it very closely.

6. A power gain is possible.

7. Input capacitance is reduced to the value of the tube input capacity alone.

8. The output impedance can be made to match the load impedance closely.

Cathode Follower Design. In designing the cathode follower circuit, three possibilities present themselves—see Fig. 3. The output impedance may be equal to the characteristic impedance of a transmission line Zo (A), under which condition the output voltage is one-half the input voltage. The line impedance Zo, is larger than the output impedance of the tube (B), and a resistor Rs must be added in series with the line so that Rx plus Rs equals Zo. Here again, the output is one-half the input voltage.

The third possibility is when the cathode impedance of the tube is greater than the line impedance Zo (C), and a resistor must be added in parallel with the line, so that the

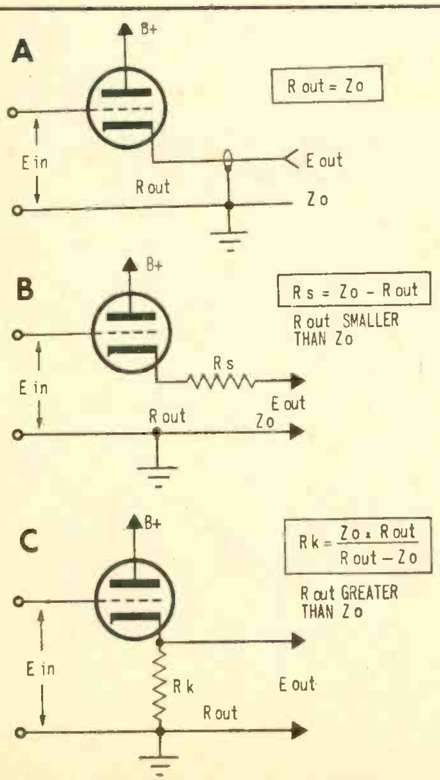


Fig. 3. Cathode follower design for three sets of circumstances: when output impedance equals impedance of transmission line (A), is smaller than line impedance (B), and larger (C).

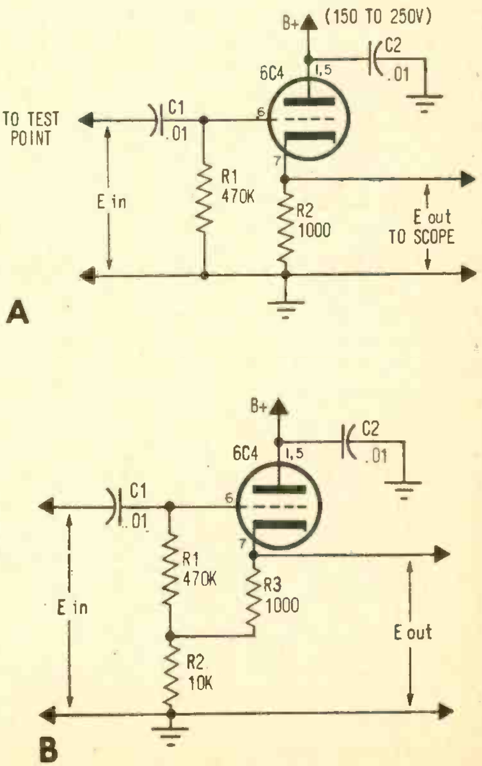


Fig. 4. Typical cathode follower circuits for IF probes. Bias arrangement in B provides larger input signal capabilities. In either A or B, one-half of a 6J6 can be used instead of the 6C4.

proper match is achieved. In this case, the parallel resistor must be of the value $\overline{ZoRo}$ where Ro is the normal cathode impedance, and the ratio of input to output is found by gmZo/2. In any of the above circuits, as well as matching to any other type of load, the output impedance of the tube, Ro is found by:

$$Ro=Rp/u+1,$$

or approximately 1/gm, where gm is the transconductance in micromhos.

The ratio of input to output voltage, often referred to as transfer, is found by approximately) gmZr, and is the resultant cathode to ground impedance, either by itself, or with other resistances in series or parallel.

Because the cathode follower is a very low gain amplifier, it has a very low total current drain, and also has a minimum input lead inductance since the tube may be built right into the probe with the grid terminal as the probe tip itself.

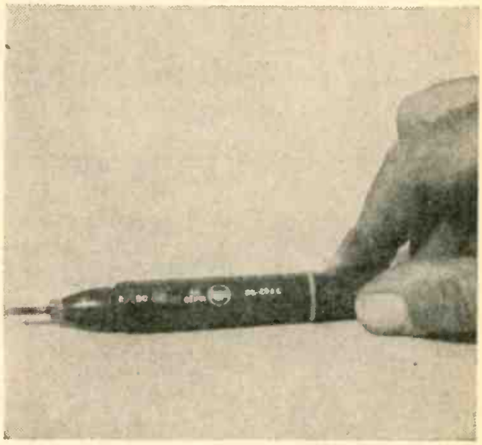
A common-collector, or emitter-follower transistor circuit is similar to the cathode follower, except that the input impedance of a bipolar transistor would be much lower than that of a vacuum tube. A typical silicon transistor has about 50,000-ohms input impedance to the tube's megohm or so. However, an FET (field effect transistor) provides an even higher input impedance than the vacuum tube.

A probe employing an FET would be considerably smaller and lighter than a tube device, with a reduction of power requirements. It also must have a blocking capacitor in series with the input since any accidental overload would permanently damage the transistor, no matter how momentary.

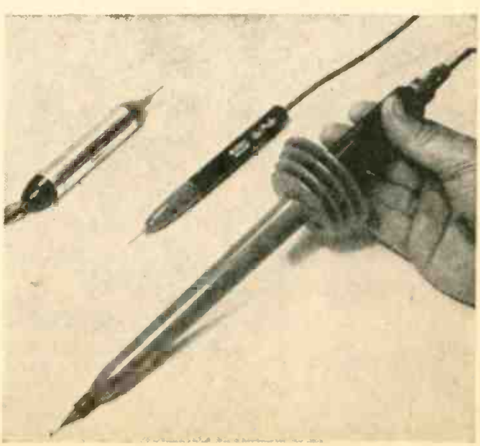
Typical cathode follower circuits are shown in Fig. 4. The transistor circuits are similar to the tube circuits except that the base or gate replaces the grid, the emitter or source the cathode, and the collector or drain, the plate. Supply voltages, of course, are adjusted accordingly. And because the FET uses gm for transconductance, unlike the conventional transistor, its calculations are the same as for the tube.

The Divider Probe. Just as its name implies, the divider probe is used to produce a division of voltage so that a small portion

Low capacity probes usually have trimmer-capacitor adjustment that is set for clean 1 kHz square wave response on scope.



Combination DC/AC, OHMS probes lets user make any measurement simply by flipping probe switch to right setting.



Three common VTVM and scope probes, rear to front: demodulator probe; DC/AC, OHMS probe; very high voltage probe.

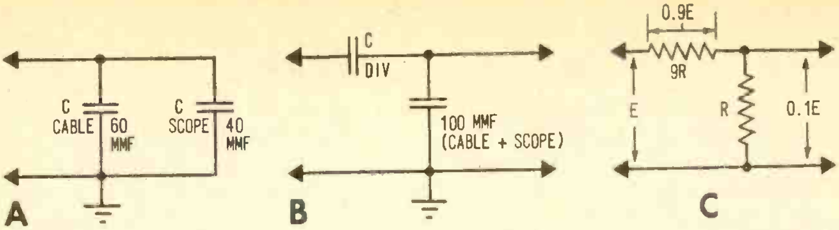


Fig. 5. Design of capacitive dividers must take account of cable and scope capacity (see text).

appears at the indicating instrument. Dividers may be either capacitive, resistive, or inductive, although the latter is not normally used. The divider allows a low voltage indicator to be used to measure a high voltage, or in the case of a capacitive divider, it provides a low-capacity probe which, because of its divider, also acts as another form of isolation probe.

The ratio of division may be any value from 10:1 to 100:1, or in rare cases, 1000:1, though certain voltage breakdown problems can occur when working with very high voltages, unless components have sufficiently high ratings. The ratio of division depends on the voltage to be observed, the limitation of the measuring instrument, and the maximum capacity the measured circuit can tolerate (or resistance, in the case of a resistive divider).

The capacitive divider, Fig. 5, is based on the fact that the equivalent capacitance of a large and a small capacitor in series is essentially the capacity of the smaller (where the smaller is less than 1/10 of the bigger). If the bigger capacity is that of the cable, a bypass, the input of a scope, or the combination of any two, then the divider will be formed by the addition of a series capacity such that the voltage is divided by the ratio of the capacitive reactances.

In Fig. 5A, the capacity of the cable and the scope input are shown in parallel. At (B), the insertion of the divider capacity, Cdiv, will be such that the reactances are in the ratio of 9:1 in order to obtain a 10 to 1 voltage division. For a 10:1 voltage divider, the series-parallel resistance ratio (or reactance ratio) as shown by the equivalent circuit for a resistance divider in (C).

A sample of the calculations used to determine the division follows.

Let us assume that four feet of RG-58/U is used for the cable, with a total capacity of 4x28.5 pF (each cable has a fixed capacity value per foot—see Table 1) and the scope, which has an input capacity of 45 pF (the usual amount), giving a total of 159 pF. If a 10:1 divider is required, then the dividing capacitor of Fig. 5B should have 1/9 of the above capacitor, or about 18 pF, a standard value. If a 20:1 divider is required, the divider capacity must then be 1/19 of 159 pF, or 8.3 pF. Unless extreme accuracy is desired, the nearest standard value may be used. In the above examples, the nearest 10% values of 18 and 8.2 pF may be used. Other values of divider capacitances may be found by the same method, providing extremely small input capacities for the higher signal divisions.

A slight variation of the isolation probe and capacitance divider enables the small capacity normally used for a high divider ratio to be used in a divider probe of as little as 10:1 so that the probe has a very small capacity-loading effect, yet provides the proper division. This is shown in Fig. 6A. The equivalent circuit is shown in (B). The resistance division is the same as the capacitive reactance division, and provides an in-

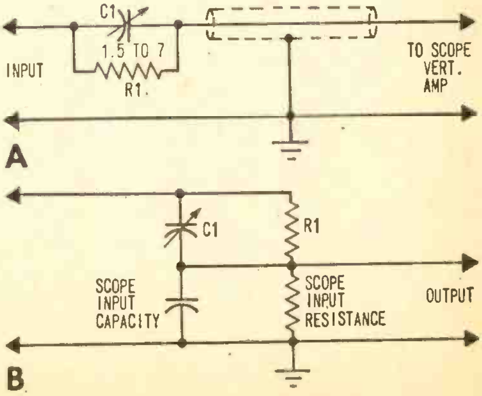


Fig. 6. A low-capacity input divider probe is shown in A and the equivalent circuit which shows how the division is obtained in B.

crease in the scope input impedance with a marked decrease in input capacitance.

The Demodulator Probe. There are any number of demodulator probes that may be used for IF work, but because of required flexibility, impedance, power requirements, and numerous other factors, the vacuum tube diode is rarely used.

Although tubes have higher impedances and greater uniformity, such things as contact potential, filament power requirements, poorer frequency response, poor low-signal efficiency, and general bulkiness have resulted in widespread preference for the crystal diode.

There are many crystal diodes that are usable for high-frequency demodulators, and should be selected for the specific requirements. Where there is no particular requirements, the type used as the video detector in a television set is always a safe bet.

Some typical video detector diodes are listed in Table 2 along with their characteristics. Basically, the diode should have a low forward resistance, with at least a 10:1 forward to backward resistance ratio. When measuring this ratio on an ohmmeter, the range should not be changed as this would effectively bias the diode at a different voltage and its characteristics would change. This can be seen from Fig. 7 which shows the normal characteristics of a typical germanium and silicon diode.

Notice that current flows all the way down to zero volts, and that for small signal currents the output is non-linear for the germanium diode. At higher levels, the output is linear with an increase in input signal. Because of this, it is important to operate this diode above point A.

TABLE 2. DIODE CHARACTERISTICS

Characteristics	1N34A 1N34B	1N38A 1N38B	1N60	1N64	1N69A	1N70A	1N81A	1N198	1N295
Continuous Reverse Working Volts (PIV)	60	100	25	15	60	100	40	80	40
Peak Forward Current (mA)	150	150	150	—	125	90	90	90	125
Peak Forward Current (mA) (1 sec.)	500	500	500	—	400	350	350	300	300
Average Forward Current (mA)	50	50	50	—	40	30	30	30	30
Forward Current at 1.0 Volts-min.	5	4	—	0.2	5	3	3	4	*
MA-Maximum	25	25	—	—	25	25	25	25	—

* Units tested in detection circuit at 50 MHz.

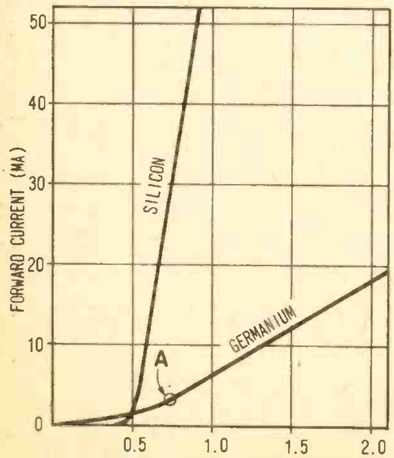


Fig. 7. Forward characteristics of silicon and germanium diodes. Silicon doesn't conduct below .45 volts but is more linear and handles larger current.

The silicon diode has similar characteristics, but requires either a higher initial signal, or an initial DC bias (in the forward direction) to allow conduction to take place at small signal levels. The silicon has better high-temperature characteristics, and because of this, it is often found in military equipment in lieu of germanium, but it requires a biasing arrangement.

Shunt Diode Probes. The shunt diode may be used to provide a peak-indicating rectifying circuit for a VTVM. This type of probe may consist of a single diode with either output polarity, two diodes arranged back to back in a voltage doubler circuit, or two diodes that may be switched to reverse the rectified output polarity.

The single shunt-diode rectifier may be combined with the divider probe to produce a low-capacity detector with high voltage capabilities. Fig. 8A shows a typical shunt diode probe. The output impedance is approximately equal to the 1.5-megohm resistor, since it is in series with the low forward resistance of the diode. The input impedance is equal to the backward resistance of the diode, shunted by the diode capacity, in parallel with the output resistance in series with the cable capacity. The equivalent circuits are shown in (B) and (C).

Because the input capacity of the divider probe is low (approximately that of the diode, 1 pF), it is a high impedance over a very wide range of frequencies. The limitation of frequency will depend on the circuit in which the probe is being used, but this type of demodulator is nearly flat in output response from audio frequencies to around 200-MHz. If the circuit to be measured has an impedance below 10,000-ohms, the probe has no loading effect. If used across tuned circuits, however, the probe has some detuning effect, and the circuit must be retuned with the probe in place in order to compensate for the total probe input capacity. (This is usually 1.5 to 3 pF because the probe body capacity must be added to the capacity of the probe diode.)

By combining capacity and resistance dividers with a shunt diode, as little as three probes may be constructed to cover a useful range of 1-milivolt to 1000-volts. These are shown in Fig. 9.

The input capacity shown in (A) is that of the diode and probe tip in parallel, the reactance of the series capacitor being negligible. In the probe at (B), the capacity is the same as that of (A), since the 20 pF capacitor across the diode is negligible. The trimmer should be adjusted for a 10:1 division of voltage, at which point its capacitive reactance will give the proper division of impedances. The equivalent circuit for both

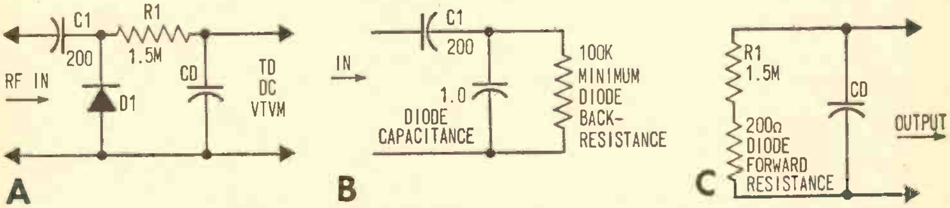


Fig. 8. Basic shunt diode probe is shown at A. C1 is blocking capacitor and CD is distributed capacity.

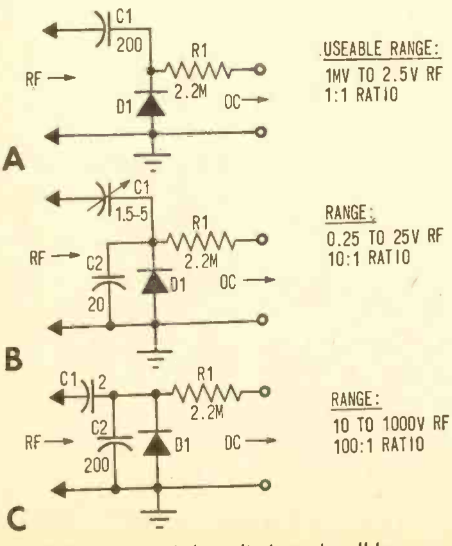
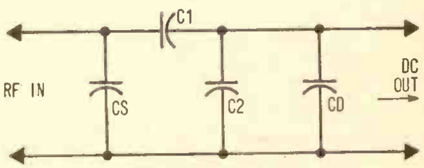


Fig. 9. Variations of shunt diode probe all have low input capacities and high impedance and cover a useful range from 1 millivolt to 1000 volts.



C1 TRIMMER OR DIVIDER
C2 LARGE CAPACITOR IN SHUNT WITH CD
CD THE DIODE CAPACITANCE
CS TIP TO SHIELD CAPACITANCE

Fig. 10. Equivalent circuit for B and C of Fig. 9 shows the effective capacities involved.

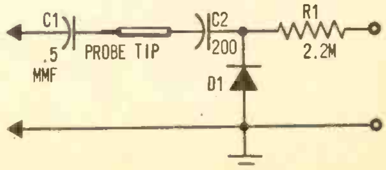


Fig. 11. Series capacitor reduces input capacity and minimizes detuning effects of shunt probe, but output is lower due to higher impedance.

(B) and (C) is shown in schematic Fig. 10.

A probe ideal for use in measuring tuned circuits is shown in Fig. 11. By placing a very small capacitor in series with the normal input capacity of the probe, the amount of detuning is greatly reduced. If the probe capacity is normally 2 pF, the capacity is reduced to 40 percent of the original capacity. The voltage, of course, is also divided by this amount, but its accuracy is not important when used for response and Q measurements because the ratio is constant. By tuning for 0.707 times the peak voltage, the Q can be calculated.

The use of two diodes in a voltage doubler circuit, Fig. 12, allows peak-to-peak measurements, but has a lower input impedance and lower frequency response than the single shunt-diode probe.

Other than these, there is no advantage in using the doubler probe for sine-wave measurements. However, since this type of probe is a peak-to-peak rectifying circuit it

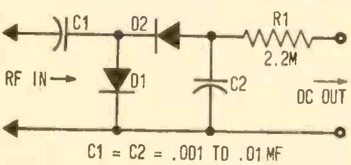


Fig. 12. The doubler probe for taking peak-to-peak measurements is particularly useful for measuring complex waveshapes.

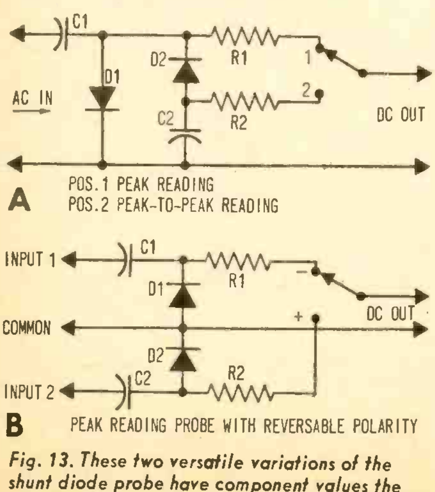
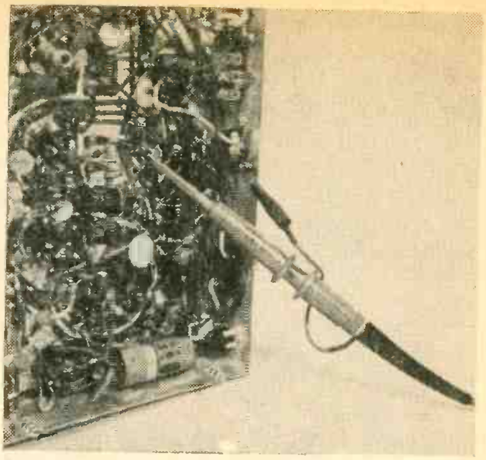
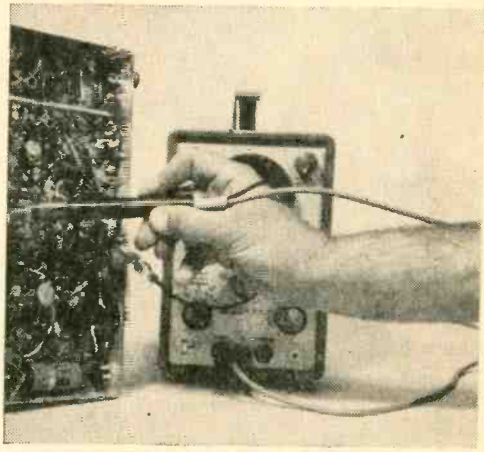


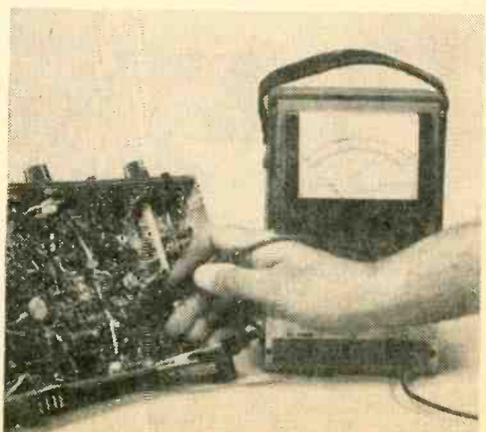
Fig. 13. These two versatile variations of the shunt diode probe have component values the same as those used in previously shown circuits.



Professional scope probes have hooked tips that clamp to components, leaving hands free for other work.



Low-capacity scope-probe can be attached directly to critical RF circuits without serious detuning.



Using RF probe with VTVM allows direct peak voltages to be measured in RF circuitry.

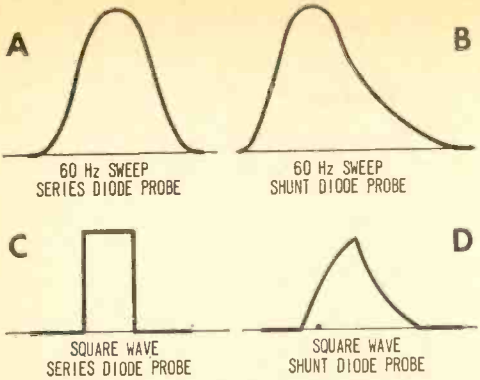


Fig. 14. Distortion of wave shape is introduced when using shunt diode probes as a result of the long time constants in their output circuits.

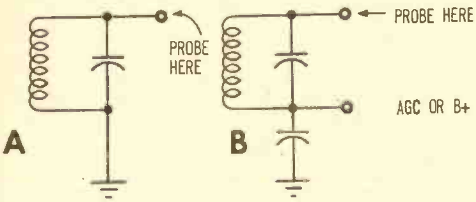


Fig. 15. The circuit at A needs no blocking capacitor in the probe; the circuit at B does in order to limit the DC voltage (and current) in the diode.

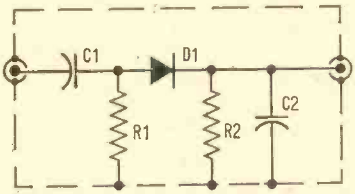


Fig. 16. Component values for this series diode probe are listed in Table 3. Polarity is positive for direction shown but can be reversed by reversing diode.

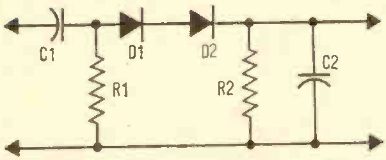


Fig. 17. Using two diodes in series doubles the voltage handling capability for measuring high levels. Both diodes should be the same type.

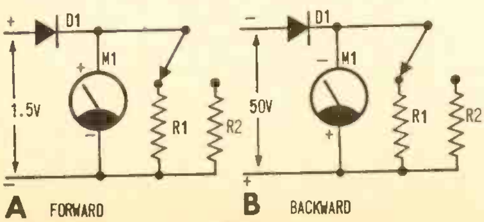


Fig. 18. Arrangement for checking if diode is within characteristic operating range by measuring forward and backward resistance.

is of exceptional value when comparing the values of complex waveshapes with those specified in the manufacturer's service manuals when working on TV or radar equipment circuitry.

By combining two diodes in a single probe with a switch, both peak and peak-to-peak readings may be obtained, or peak readings with reversible polarity.

Looking at the circuit of Fig. 13A, it can be seen that with the switch in position 1, the probe is reading peak. When the switch is in position 2, the probe becomes a peak-to-peak probe. In (B), only the polarity is reversed by the switch.

Series Diode Probes. The most convenient of all detector probes for IF work is the series probe. For general troubleshooting, gain measurements, and sweep alignment, it cannot be excelled as the jack-of-all-trades probe.

Because of the high resistances involved in shunt diode probes, they have extremely long time constants in their output circuitry and their effects on sweep and non-sinusoidal waveshapes prohibit their use in most cases. See Fig. 14.

Fig. 14A is the 60 Hz swept response of a single-tuned parallel-resonant circuit using a series-diode detector and (B) is the same response using a shunt-diode detector. At (C) and (D) are the outputs of series and shunt detectors with a square wave input.

The general configuration of the series diode detector varies slightly depending upon input impedance, potential at the point of measurement (to ground), maximum output capacitance tolerable, maximum time constant useable, and output impedance.

If the circuit under measurement is grounded, as in Fig. 15A, the blocking capacitor of Fig. 16 may be omitted; otherwise it must be included. (See Fig. 15B).

If the impedance across the circuit is low, R1 of Fig. 16 can be any value equal to, or above that impedance. If it is high, but the resonant response is undesired, R1 should be low enough in value to swamp out the resonant circuit.

It is advantageous to make several probes, with high and low impedances, large and small coupling capacitors, and direct and divided output voltage ratios.

The series diode probe of Fig. 16 should be enclosed in a shield with a coaxial output. The polarity indicated provides a positive output, but may be reversed if desired by reversing the diode. C2 may be the cable

TABLE 3. PROBE CIRCUIT VALUES

Impedance	Frequency Range (MHz)	C1 (pF)	R1 (ohms)	C2 (pF)
Low	Low 1-10	100-1000	50-510	510-5100
Low	High 10-100	10-100	50-510	0-51
High	Low 1-10	100-1000	10-100K	51-510
High	High 10-100	10-100	10-100K	0-51
Low*	High 10-500	0	50-510	500

* This probe uses a UHF silicon diode such as a 1N25 (high output, low noise diode) and must not be used where more than 1-volt DC is present because it has no blocking capacitor. It is excellent as a combination load and detector if the resistor is directly across the probe input.

capacity only, but should never be any larger than necessary to properly bypass any RF that is present at that point. Typical values of components are tabulated in Table 3.

Where the signal voltage is higher than the signal handling capability of the diode, two diodes of the same type in series will almost double the safe value of working voltage as shown in Fig. 17. The values in Table 3 still apply.

Probe Ground Returns. When lower frequencies are used, the use of a fairly long ground return is not considered as a contributing factor to regeneration. At the higher frequencies, the use of as short a ground return as possible is extremely important to prevent stray pickup.

The best possible method of grounding a probe is with a wire attached to the probe shield or case itself.

Testing Diodes. As previously mentioned, a quick check with an ohmmeter will tell whether a diode is open, shorted, or working. This is not, however, an accurate check on the condition of the diode.

Shown in Fig. 18 is a diode check out setup that has the advantage of allowing the user to know a diode is well within its characteristic ratings. The normal voltage of a flashlight battery is 1.5 volts, and provides an excellent source for checking forward resistance.

The two circuits in Fig. 18 using the same circuit and method, except for battery polarity and voltage, provides the maximum reverse and minimum forward current at a glance. By Ohm's Law calculations, the diode forward and backward resistance is quickly and accurately determined.

Forward resistance is measured at (A) and the backward resistance is measured at (B). The meter, M1, is a 1 mA DC meter, with R1 and R2 shunts to make the meter read 10 and 100 mA full scale. Since the voltage is accurately known, the resistance of the diode is simply $R=E/I$.

Probe Construction. Building a variety of probes for your particular needs is quite simple using the information you've gained in the preceding pages. Materials for making probes are easily come by and with a little imagination the experimenter shouldn't have any trouble.

A favorite item for making probes, is the slim aluminum casing used for the more expensive cigars. Simply assemble all parts strung out on a Perf Board so the assembly can slide into the cigar casing as shown in Fig. 19. Slip a plastic shield over the parts and slide the whole assembly into the casing. Put on the lid (with a hole for the cable) and you're ready to go. You may then want to pot the whole thing with Epoxy or potting compound. Happy probing. ■

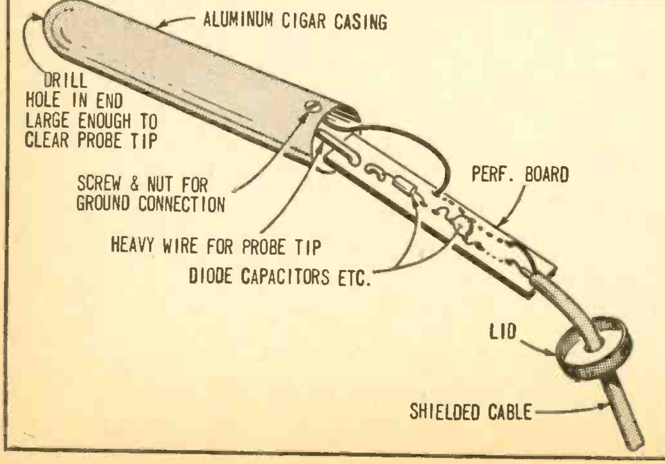


Fig. 19. The best do-it-yourself approach for making your own probes is to start with an aluminum cigar container. Then, using a long, narrow section of perforated circuit board, you can wire up almost any of the probes discussed here. Make sure that the mounted components and board not only will be able to slide into the case, but that they will be adequately insulated as well. This is an inexpensive way to have a probe for every application.

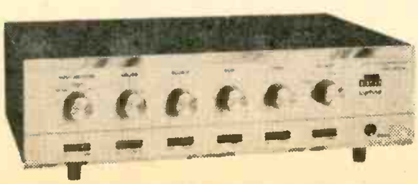
e/e HIGH-FIDELITY

EICO Cortina Series Solid-State Components 3070 Stereo Amplifier 3200 FM-Stereo Tuner

■ Until recently, few hi-fi units took advantage of the true miniaturization possible with solid-state components, and transistorized equipment was often as large and bulky as its vacuum tube predecessors. But true miniaturization is possible, even at budget prices, as witnessed by EICO's Cortina series of hi-fidelity components.

Stacked on one another, the amplifier and tuner take up about half the space of a standard size tube tuner. Remove the mounting feet and the two units can be stacked vertically between a row of books without overhanging the bookshelf since the total dimension of each is only 3⅛ x 12 x 7¾ in. deep. Both tuner and amplifier weigh in at slightly over 7 pounds each.

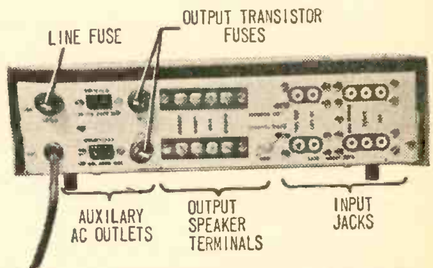
The 3070 Stereo Amplifier. Though the amplifier has been physically miniaturized, it is electronically full-featured. The panel controls are: *Input Selector* for the three inputs: magnetic phono, tuner and auxiliary; single knob *Volume*; amplifier *Balance*, single knob *Bass*; single knob *Treble*; and *Speakers* selector. A row of rocker switches under the controls provide for *Tape, Loudness* compensation, *Mono-Stereo, Lo-cut, Hi-cut* and *Power* on-off. The stereo phone jack is also on the front panel.



EICO 3070 stereo amplifier makes neat appearance and gives good performance in small package.

One panel control that requires greater explanation is the *Speakers* selector. Two sets of speaker terminals per channel are provided on the rear apron; one set is for the normally used (main) speakers and one for remote speakers. The front panel *Speakers* switch selects either the main or remote speakers, all speakers and headphones, or headphones alone.

The rear apron provides connections for the speaker terminals, the three inputs, tape preamp input and output, a switched AC receptacle, and an always-on AC receptacle. A grounding terminal is also provided. The rear apron also contains three fuseholders; one for each channel's output stage and one main fuse. The output transistors cannot be damaged if the speaker leads are shorted together. While 1-amp. fuses are factory supplied for 8- and 16-ohm speakers, 4-ohm speakers may require a 1.5-amp. user-supplied fuse because the 3070 delivers its highest power output with a 4-ohm load.



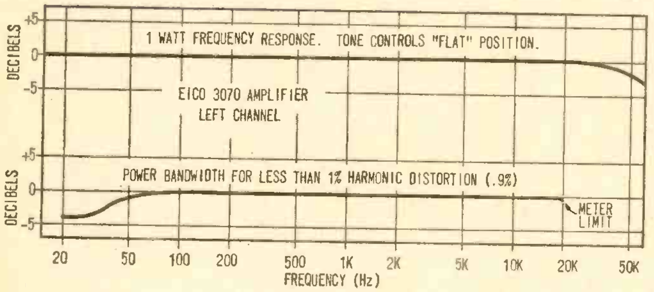
Well arranged rear-apron layout provides easy hookup of speakers and auxiliary equipment.

Performance. The amplifier is rated for (per channel) 20 watts into 4 ohms, 15 watts into 8 ohms, and 13.5 watts into 16 ohms, all at less than 1 percent THD (total harmonic distortion). Our tests exactly confirmed EICO's specifications on this score.

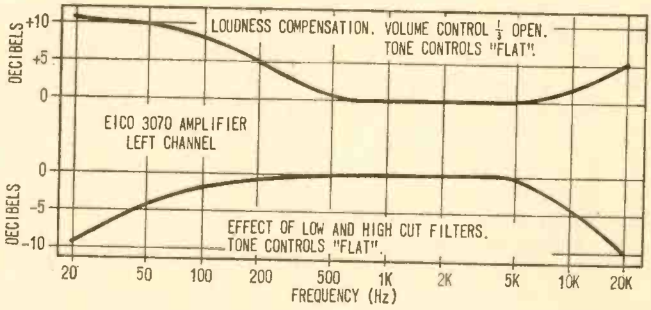
(Continued overleaf.)

At the normal listening level of 1 watt, the response checked out almost ruler flat from 10 to 40,000 Hz, down 3 dB at 60,000 Hz. The power bandwidth for distortion of less than 1 percent with a 1-kHz reference of 15 watts into 8 ohms checked out as 30 to better than 20,000 Hz. (The frequency range of our distortion meter is limited to 20,000 Hz.)

As shown, the low, and high-cut filters do not introduce severe attenuation; they are just about enough to reduce turntable rumble and moderate record noise without cutting deeply into the important music range frequencies (the bass doesn't drop out when the low cut is applied).



Frequency response of 3070 amplifier is virtually ruler flat from 10 Hz to 40 kHz at one watt. Full power response is also quite adequate as indicated by test results.



High and low cut filters on 3070 amp prove to be just about right for rumble and record surface noise reduction. Loudness compensation is in good proportion.

The tone control(s) range, and the loudness compensation (with the volume control ⅓ open) is good—if you require a lot of frequency compensation the 3070 will deliver the goods.

The signal to noise and hum (S/N) ratio is outstanding; even with the volume control wide open, the amplifier is dead quiet (see specs).

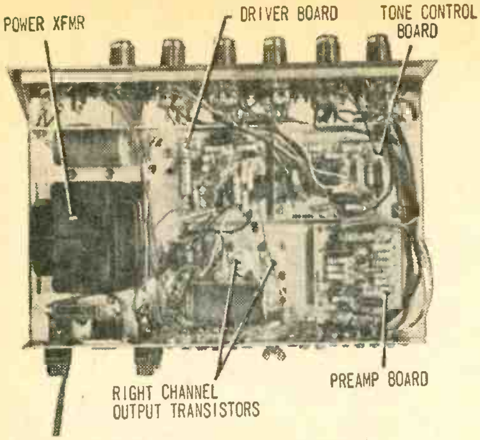
Overall Performance. The overall effect of the 3070 is very good; sound quality is easily the equal of amplifiers priced considerably higher ($89.95 for the kit, $129.95 wired). However, one note of caution. Since the commonly used speaker impedance is 8 ohms, the 3070 will deliver a maximum of 15 watts per channel; above 15-watts output, the distortion rises very sharply. While 15 watts is more than adequate for most speaker installations, it will not produce thundering sound if low efficiency speakers are used —loud sound yes, but window rattling, no.

Building The Kit. As shown in the photographs, the amplifier consists of some chassis wiring with considerable printed circuit assembly and interconnections. The printed circuits for each channel is divided into three sections; one for the phono preamplifier, one for equalizers and associated amplifiers, and one for the output transistor

Lab Test Data: EICO 3070 Stereo Amplifier

Total Continuous Power Output for Less than 1 percent THD
40 watts into 4 ohms, 30 watts into 8 ohms, 17 watts into 16 ohms

Input Sensitivity for Rated Power Output	5-mV phono, 300-mV tuner and auxiliary
S/N Ratio	Better than 70-dB down
Separation	Better than 50 dB
Tone Control	
20 Hz	17-dB cut, 15-dB boost
15 kHz	17-dB cut, 17-dB boost



Majority of 3070 amp is on printed circuit boards making construction of kit simple. Identical PC boards are on top and bottom of chassis for left and right channels.

Lab Test Data: EICO 3200 Stereo Tuner

IHF Sensitivity	3.8 uV at 92 MHz, 4.0 uV at 100 MHz, 4.5 uV at 106 MHz
Mono Frequency Response	+1 −2 dB, 20 to 15,000 Hz
Mono THD	0.36 percent at 1 kHz
Mono S/N Ratio	Better than 70 dB
Stereo Frequency Response, Right	−3 +1 dB, 20 to 12,000 Hz
Response, Left	−3 +2 dB, 20 to 12,000 Hz
Channel Separation Right	33 dB at 1 kHz, 20 dB at 12 kHz
Left	33 dB at 1 kHz, 22 dB at 12 kHz
19 kHz Suppression	45 dB

EICO 3200 FM tuner is designed as companion piece for 3070 amp. Unit turned in good overall performance.

drivers. The output transistors are mounted directly on the chassis, using the entire chassis as a heat sink and the amplifier runs very cool.

The kit wiring is not difficult, the layout lends itself to easy assembly and there are really no tight corners. But there are many individual components and fittings and some components look like others—take extra care to double-check every capacitor before it's installed. The instruction manual and pictorials were good and only one error was found for which a correction sheet was supplied. However, our kit was missing four inexpensive capacitors which we found more convenient to obtain locally. Assembly is simply a mechanical job until completion, but you save $40 by giving up a few evenings.

Within its rated power, the Cortina 3070 amplifier delivers high performance. The utilization of miniaturization makes it particularly attractive when sound quality cannot be sacrificed for compact installation.

The 3200 Stereo Tuner. The model 3200 tuner receives FM only, no AM. It is designed as a companion unit to the 3070 amplifier, matching the 3070 in size, physical appearance, and control layout. The front panel contains only three rocker switches: *Mono-Stereo, AFC* on-off, and *Power* on-off. The rear apron contains only the 300-ohm balanced antenna input and a single set of output jacks, one for the left and one for the right channel; there is no tape recorder connection. To record programs, the recorder is connected to the tape jacks on the rear apron of the matching amplifier.

Concealed behind the dial-plate is a full-time stereo indicator showing when a stereo signal is being received whether the tuner is switched to stereo or not. While the indicator lamp has a tendency to flash on inter-station noise, a stereo signal produces a steady glow and there is never a question whether or not a station is transmitting stereo. Similarly, while the noise accompanying a very weak signal causes the stereo lamp to flash, a weak signal suitable for stereo reception produces a steady glow.

While the tuning control is backed by a modest size flywheel, the complex dial stringing used on the tuner almost eliminates flywheel spin, and the tuning knob has the feel of a standard set-up. However, there is no backlash or tuning problems and the pointer and tuning smoothly follows the operation of the tuning knob.

Performance. While not the hottest tuner available, by no means is it limited to local signals. The average sensitivity for 30-dB total hum, noise, and distortion, was 4 uV (ranging from 3.8 uV at 92 MHz to 4.5 uV at 106 MHz).

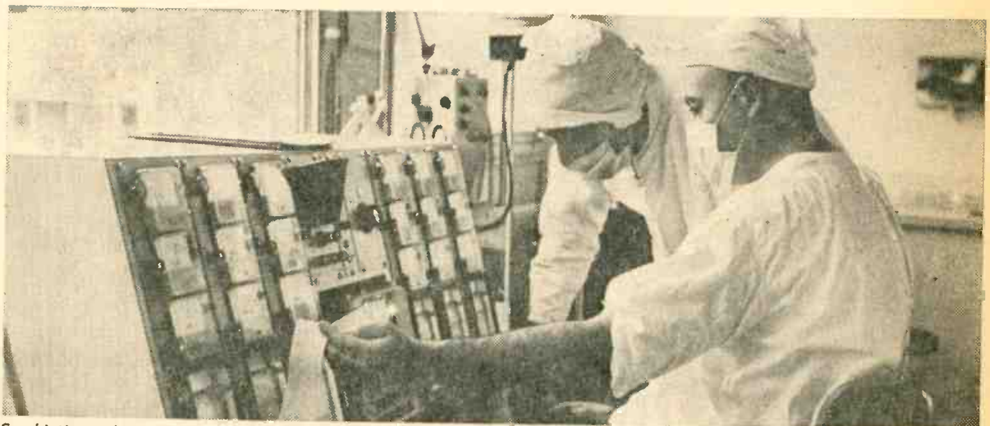
Except for sensitivity, the 3200 is otherwise a hot tuner. Total Harmonic Distortion (THD) in both the mono and stereo mode

(Continued on page 116)

By Joe Craig

When the doctor turns to electronics the results are heap big medicine

The Case of the AUTOMATED M.D.



Sophisticated monitoring console developed to keep constant watch on premature babies is currently used in Paris hospital. The unit is programmed to sound alarm and alert doctor if the slightest change in pulse, blood pressure or breathing rate occurs.

The space age and all it implies is rapidly coming to the world of medicine. Sophisticated hardware, born of an era of missile technology, is beginning to take its place next to the stethoscope and hypodermic as a major tool in the art of healing, both in diagnosis and treatment.

The electronic arsenal of the space-age doctor now encompasses such diverse items as lasers, computers, anechoic chambers, and implanted miniature transmitters. And a variety of disciplines are finding applications in the field of medicine—everything from cryogenics to mathematics, not to mention ultrasonics and microminiature engineering.

Audio To Gamma. Lasers, microwaves, gamma rays, X-rays, and ultrasonics (high frequency audio) are all currently in use as surgical tools or for treatment. The laser, for example, is being used as a self-cauterizing scalpel and to spot-weld on detached retinas. Gamma rays are finding applications in cancer treatment, as are X-rays. Ultrasonics are employed in bone drills; microwaves in nerve, muscle, and joint treatments.

The most recently developed devices are

Surgeons performing eye operation so delicate that work must be carried out under special microscope. At left, bronchoscope is used with motion picture camera to produce movies of patient's insides for later detailed analysis.

Though looking like moon-shot control room, this is a doctor performing complex electronic diagnosis of patient in another part of hospital.

Statokinesimeter explores and provides graphic analysis of variations in patient's center of gravity to diagnose balance defects.

usually of the diagnostic type. For a patient with hearing problems, for example, there are now various examining instruments which a doctor can use to study the patient's reactions to different degrees of sound waves directed at the troubled ears in an anechoic chamber. By studying material provided by the electronic exam, the doctor knows what's wrong with the patient and how to treat it.

Brain Test. In another instance, that of sufferers from epilepsy, the entire examination as to whether brain surgery can remove the cause of the patient's epileptic seizures can be carried out by an electronic exam that may last for as long as 10 hours.

A batho-encephalographic device provides, strictly through electronics, precise information that tells the neurosurgeon everything he needs to know about his patient's brain. He never sees the patient during the exam; instead he examines complicated codings recorded on graphs by the device, which is attached to the patient's brain and relays reaction-to-stimuli messages to the control center elsewhere in the hospital.

In the case of heart ailments, the specialist now has at his disposal numerous electronic devices that tell him the specific cause

Case of the Automated M.D.

Upper right, physician consults computer on diagnosis and treatment by feeding it complete information on patient's case, history and proposed medication. Above, nurses keep tabs on a number of people in different wards by means of remote monitoring console programmed to check each individual condition.

New achievements in the production and understanding of gamma ray technology provide a powerful weapon in the treatment of cancer and a variety of allied diseases.

of the condition and also the exact state of the patient's heart. Unless he wishes, the doctor need ask nothing of the patient—the electronic detective tells all.

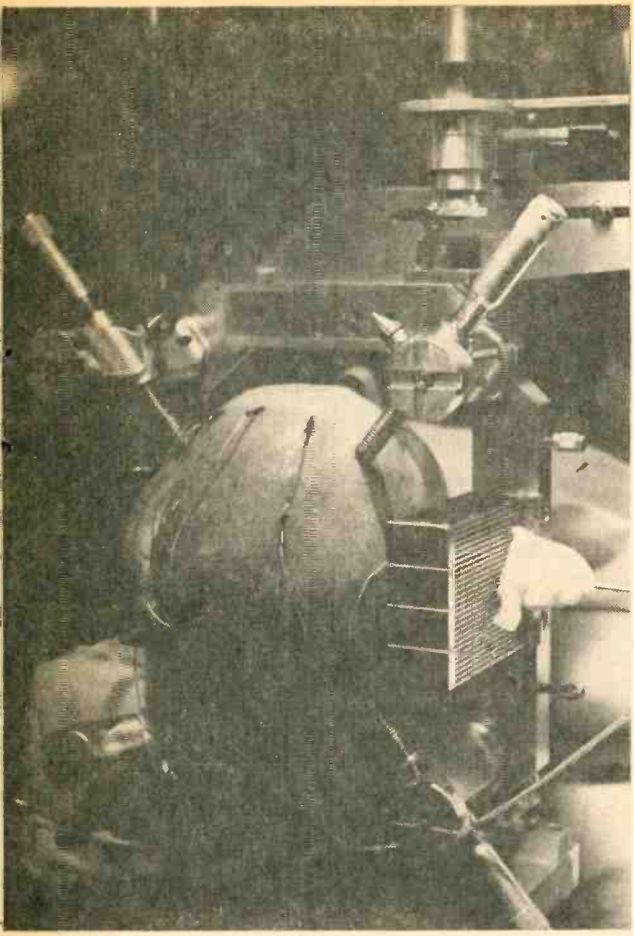
Surgical Forecast. One tremendous advantage of these devices is that before surgery is even contemplated, much less undertaken, the physician knows so much about the case that he can predict his chances of success without much margin of error.

The use of monitoring devices in hospital wards is perhaps the most revolutionary of the changes electronics has brought to the medical field. These devices make possible the complete reorganization of hospital administration—conceivably a hospital could be operated filled with patients but with a minimal staff. All supervision of the patients would be carried out by electronic monitoring machines. The staff would just carry out needed duties when indicated by the devices, which in turn would be attached to the patient or otherwise keep watch over him in the hospital room.

Devices now being tested can continually supervise the state of a patient and sound an alarm when a problem occurs, or, if necessary, even indicate if the slightest change takes place in his temperature, pulse, or breathing.

The great advantage of automated wards is in freeing nurses, internes, and other supervisory personnel for other pressing duties in the hospital, which is inevitably understaffed.

Computerized Consultation. Computers



New electro-encephalographic device is examining epileptic to determine nature of affliction. Brain probes are used to provoke epileptic seizure and record responses. Examination, taking eight to ten hours, tells where in brain seizure originates and whether brain surgery can correct the condition.

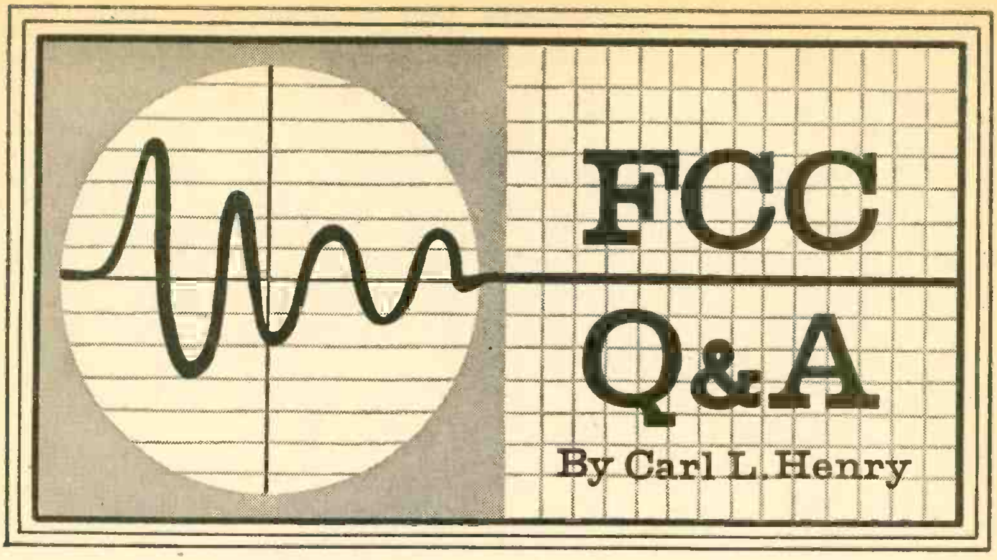
Upper left, artificial kidney operation is supervised by doctor-mechanic. Upper right, mike records patient's sounds during operation. Above, technician observes elaborate console conducting, monitoring, and recording epileptic examination.

are increasingly called on for consultations. When properly programmed and fed details about the physical state of a patient, the computers can tell the physician how a person's metabolism will react to proposed medication or other treatment. The computerized diagnosis is based on thousands of bits of information about the patient and his overall case.

The space-age M.D. needs comprehensive knowledge of electronic technique to be able to use this sophisticated gadgetry to best advantage. In fact, he may well have invented it, for the best medical machines now in use were put together by physicians talented in mechanics and electronics.

All In All. Electronic aids are invaluable to medicine today. Millions of patients can thank them for their good health and even their lives. Unfortunately, the use of these electronic marvels has inherent problems. Using machines, the physician can make errors in judgment where illness is based to a degree on psychological ill health. For the machinery is equipped to record only physiological data. It cannot register man's psychological state, which may be worsened by the very presence of the machine.

So while the future of the automated M.D. seems bright and electronic medicine is here to stay, the days of the good old general practitioner are far from over. But all in all, it's nice to know that behind the G.P. stands a fantastic array of Buck Rogers electronic medical machinery capable of tracking down the most elusive of man's illnesses. ■



Those ultra-high frequencies are here to stay so here're some tips on this timely topic

With UHF television stations going into operation everywhere, all of us are becoming aware of a new terminology in electronics, that of ultra-high-frequencies. Questions on microwave components and operation have been used on FCC license exams for some years, but with the increasing use of microwaves as "state-of-the-art" communications, the license exams will have correspondingly more questions on this medium. You may wonder what is so different about microwave electronics. The answer is nothing is really different, but new solutions are used for old problems; solutions that can only be used when the wavelength can be measured in inches instead of feet.

This issue, we cover questions on microwaves and microwave equipment found on the current FCC commercial and amateur license exams.

Q. *Discuss Lecher wires, their properties and uses.*

A. Lecher wires, or lines, is a term applied to a system of microwave frequency measurement that utilizes two parallel wires. These wires are between one and five wavelengths long and spaced a few inches apart. The input end may be closed and inductively coupled to the source to be measured, or may be open and capacitively coupled. The Lecher line(s) is provided with a movable shorting bar that is used to indicate wavelength by measuring the distance between two maximum voltage points on the line. A suitable indicator, such as a lamp bulb or an RF VTVM, is required to indicate these points. Measuring from the first maximum point to a second maximum point, the distance of the actual wavelength is found and the frequency can then be calculated.

Q. *What are waveguides?*

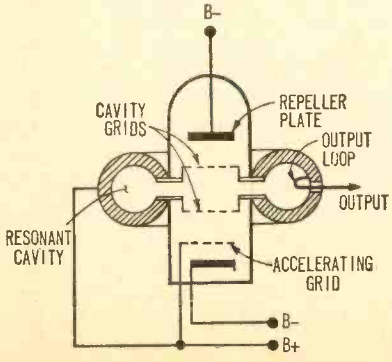
A. Transmission lines are normally used to carry an RF signal between the transmitter and antenna, but as the frequency increases, loss in transmission lines also increases. A waveguide is an RF transmission method employing a rectangular or circular metal pipe that takes the place of a transmission line, and whose advantage lies in having a very small signal loss. The size of the waveguide is directly related to the frequency it will pass, since, for a given cross-section there is a lower frequency limit, or cutoff, below which the guide will not conduct. This generally limits the usefulness of waveguides to frequencies above 1000 MHz. Some advantages of waveguides are that they have a lower loss than an equivalent transmission line; they will handle higher power than a transmission line of equivalent size; and they give complete shielding to the signal. Their disadvantages are high cost and the more complicated mechanical system necessary for proper installation.

Q. *What is meant by VHF, UHF, SHF?*

A. These are frequency ranges, that is, parts of the radio spectrum subdivided into sections. They are as follows: VHF, 30 to 300 MHz; UHF, 300 to 3000 MHz; SHF, 3000 to 30,000 MHz. The designations represent very high, ultra high, and super high frequencies. In the last few years, research has extended the radio spectrum above 30,000 MHz, and a new designation, EHF (extremely high frequency) is being used for this realm.

Q. *Describe the physical structure of a klystron tube and explain how it can operate as an oscillator.*

A. All tubes used in the microwave range suffer from transit time problems. This is the time it takes for an electron to travel across the cathode-to-anode space in a tube. This is no problem at ordinary frequencies since this space is minute compared with the wavelength, but at super high frequencies, transit time becomes a critical factor in tube efficiency. One solution to this problem is in spacing the cathode and anode very close to each other. Another solution is the klystron. Electrons emitted by the klystron cathode are accelerated by the accelerator grid, then pass through the cavity grids and normally would be drawn to the anode. The action in the tube is not conventional, however. When the stream of electrons enters the cavity grids, resonant cavities coupled to these grids are shock-excited and produce an alternating voltage across the cavity grids.

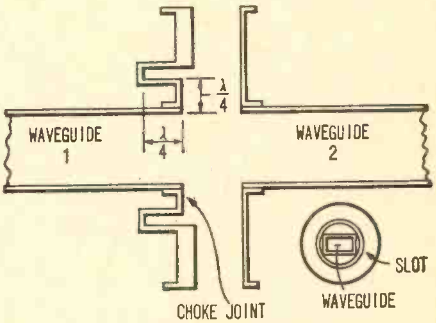


Klystron works on entirely different principle than regular vacuum tubes; studying diagram and text will make operation clear.

This alternating voltage "bunches" the electrons as they pass. These bunches travel on toward the anode, which is biased to repel them. They then return to the cavity grids having the proper spacing and timing to reinforce the alternating voltages that were initially developed. Each bunch of electrons add energy to the resonant circuit, and oscillations are maintained. The signal is removed by a coupling loop in one of the cavities coupled to the cavity grids. Changes in frequency are made by changing the size of the cavities; size determining their natural resonant frequency. See diagram.

Q. *Why are "choke" joints used in waveguides? Explain their operation.*

A. Choke joints are used in preference to simple flange joints because they will tolerate a moderate amount of misalignment of the waveguide sections without excessive signal loss. The diagram illustrates a cross-section of a typical choke joint. The flange section includes a circular slot that has a depth of one-quarter wavelength. The distance from the slot to the inside edge of the flange is also



Choke joint is most commonly used method of joining waveguides because it eliminates need for accurate mechanical alignment of sections.

one-quarter wavelength, effectually causing an RF short circuit in the slot. The short circuit at the bottom of the slot is coupled to the inside edge of the flange and the signal sees the inside edges of the flange as a continuous electrical circuit, even though it may not be an exact mechanical fit. Without this type of joint, the inside surfaces must fit together almost perfectly.

Q. *Describe why rectangular waveguides are preferable to cylindrical waveguides.*

e/e FCC Q&A

A. Cylindrical waveguides have a tendency to change the direction of the signal's electrical field at bends, thus causing an undesirable change in polarization of the wave.

Q. *Describe how waveguides are terminated at antennas.*

A. Microwave antennas are usually parabolic types. The waveguide is brought to the center of focus of the parabola and a horn is then attached to the end of the waveguide. The horn's dimensions and flare are calculated to match the impedance of the waveguide to external space. The horn is usually closed at the end with a polystyrene window to prevent the entrance of moisture into the waveguide. This window also acts as an impedance matching device. The combination of horn and window transmits the signal into the parabolic antenna with a minimum of loss.

Q. *Discuss: the relationship between frequency and size of a waveguide; modes of operation of a waveguide; coupling energy into a waveguide.*

A. *Size*: for a rectangular waveguide, the width must be at least one-half wavelength of the frequency it is to transmit.

Modes: each field configuration in a waveguide is called a mode. Energy travels through a waveguide in the form of electrical and magnetic fields, much as electromagnetic energy travels through free-space. The way the fields travel, i.e., the mode, is divided into two categories:

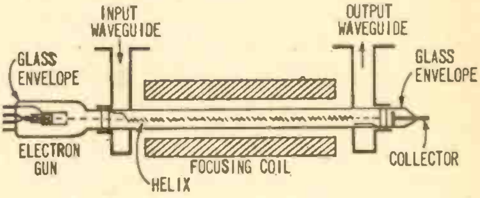
1. the transverse magnetic (TM) mode means the magnetic field is transverse to the direction of travel

2. the transverse electric (TE) mode means the electric field is transverse to the direction of travel.

Coupling: energy may be coupled into or out of a waveguide by several methods. First, a loop of wire inserted in the waveguide is used to couple to the magnetic (TM) field in the waveguide. Second, a probe, usually a quarter-wave long, is placed in the area of maximum TE field intensity to couple to the electric field in a waveguide. And third, a hole or "window" may be used to couple energy directly, but in this case, special design of the walls and materials must be used to prevent mismatch of the waveguide impedance.

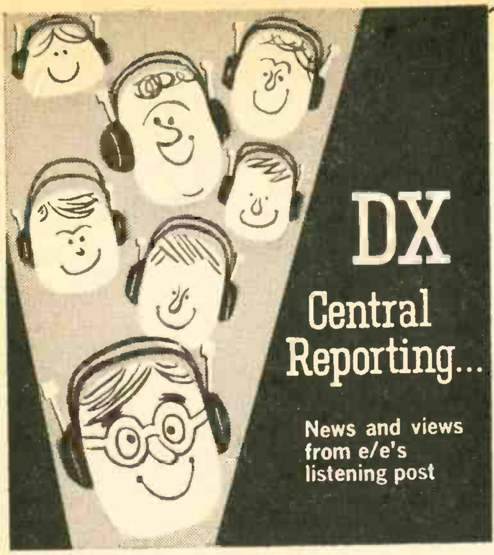
Q. *Explain the principle of operation of a traveling wave tube (twt).*

A. A traveling wave tube is another type of vacuum tube whose method of operation



Complex traveling wave tube works by the effect of interaction of two waves of different velocity.

negates the effect of transit time on ordinary vacuum tubes. It can be used as an amplifier at frequencies up to 10,000 kHz. The tube operation can best be understood by referring to the diagram. The helix, which consists of a tightly wound continuous wire, can be 5 to 6 inches long or even longer in some tubes. The tube is designed to couple directly to waveguides. Operation of the twt requires quite high voltages, usually between 1000 and 2000 volts. Electrons emitted by the cathode are accelerated by this voltage, and focused down the center of the helix by the focusing coil. The collector acts as anode, attracting the electron beam. Imagine now that a signal is supplied to the tube by the input waveguide. The wave of the signal travels down the helix at a slower speed than the beam of electrons traveling down the center of the helix. An interaction now occurs between the wave and the electron beam. The polarity of the wave (in the helix) causes velocity modulation of the beam. When the beam is slowed down by helix modulation, it will give up energy to the wave in the helix tending to reinforce the wave's polarity. This means that the wave signal has been increased in energy and therefore amplified. Amplification is controlled by the velocity of the beam with respect to the wave signal and also by the length of the helix. A longer helix will produce greater gain. The second waveguide at the end of the helix receives the amplified signal and removes it from the tube. ■



France has surrendered most of her empire but it seems that she has retained just enough of it to permit the construction by O.R.T.F. (Office de Radiodiffusion-Television Francaise) of a worldwide network of powerful SW relays. Presently O.R.T.F. has only one relay, at Brazzaville in a former French colony, the Congo Republic. With the Congo's future political course uncertain at best O.R.T.F. plans to replace the Brazzaville station with a new one in French Somaliland. A Pacific relay will be built in New Caledonia, and one for the Americas will operate in French Guiana.

In one respect at least, the projected O.R.T.F. system is more ambitious than any other SW relay network. All the outlying locations will, according to O.R.T.F.'s Public Relations Department, receive programs from Paris via a communications satellite to be known as SAROS. Whether just one relay satellite will provide adequate service for all these distant points remains to be seen, but the French apparently think it will. Either that, or SAROS is simply a science-fiction-type happening designed to get the attention of SWLs.

The present O.R.T.F. international SWBC stations are no great problem to log in North America. To hear French-based broadcasts, look for the transmission to Latin America at 1800-2100 EST on 9755 and 11845 kHz in Spanish, Portuguese and French. If you'd rather tackle a program in English, they have a newscast in our language at 0015 on 9525 for Africa. Meanwhile, English for the Far East is relayed by their Brazzaville station on 21500 kHz at 0800 while another English newscast is carried by Brazzaville on 15245 at 1400 EST (1100 PST), again for Africa.

O.R.T.F. also maintains local broadcast stations in all of those "few remaining" overseas possessions, including stations at the sites of the projected satellite-oriented relays. But until those new transmitters do go on the air, QSLing these exotic settings will provide North-American DXers with plenty of headaches. The rundown is as shown in the table.

KHZ	LOCATION	EST
640	Pointe-a-Pitre, Guadeloupe	Early evening
1375	St. Pierre (Gulf of St. Lawrence)	Early evening
24456	St. Denis, Reunion	2130 S/On
3315	Fort de France, Martinique	Early evening
3355	Noumea, New Caledonia (R. Noumea)	After 0300
3385	Cayenne, French Guiana	Early evening
4780	Djibouti, French Somaliland	2200 S/On
11825	Papeete, Tahiti	After 2200

Reports for these stations should generally be sent to the address given on the air, except possibly for O.R.T.F. Martinique, which is an extremely poor verifier. You might try a report direct to Paris on this one.

Another DX Happening. For the past couple of years electronics editors and writers have been getting fat and rich off the R. Swan/R. Americas location caper, probably the most "in" controversy ever scrawled on the pages of DX history. Now a new spectacular looms on the scene—the CIA again? This one calls itself R. Libertad.

It was leaked by someone close to the CIA that R. America's SW unit was deleted (at the height of that controversy over its location) "because" they were transferring the rig for R. Libertad's use.

To make this story a short short, not only is R. Libertad's location a secret, but in the first place it was probably used to cover the real location of R. Swan, then later was definitely used to cover the real nature of R. Americas' SW station. Now even UNCLE and THRUSH couldn't top that plot of who's who anyway.

Shortwave '68. So what's ahead for next year? Well, while the avid DXer hunts O.R.T.F. St. Pierre, or Reunion (its location in the Indian Ocean is just about the most distant earthbound station any Southern California flower child can log), General deGaulle makes like a space-age Napoleon with his SAROS satellite.

And while UNCLE manipulates—like so many chess pieces—boats, aircraft and even the occasional land-based transmitter in the Caribbean, almost anything else an LSD-fevered mind can conjure up could happen on the 1968 Shortwave Scene.

Maybe you'd believe that the missing R. Americas transmitter is really on its way to Peking, via Pony Express, where it will be used to jam deGaulle's SAROS? Or R. Libertad will actually be found operating in the Indian Ocean where it beams programs to those California flower children along a tunnel right through the center of Mother Earth? In any case, stand by for the next DX Central and we'll keep you posted on the latest mind-bending happenings. ■

LITERATURE LIBRARY

★ Starred items indicate advertisers in this issue. Consult their ads for additional information and specifications.

CB—AMATEUR RADIO—SHORTWAVE RADIO

★93. *Heath Co.* has a new 23-channel, all-transistor, 5-watt CB rig at the lowest cost on the market, plus a full line of CB gear. See their new 10-band AM/FM/Shortwave portable and line of shortwave radios.

101. If it's a CB product, chances are *International Crystal* has it listed in their colorful catalog. Whether kit or wired, accessory or test gear, this CB-oriented company can be relied on to fill the bill.

122. Discover the most inexpensive CB mobile, Citi-Fone II by *Multi-Elmac Company*. Get the facts plus other CB product data before you buy.

50. Get your copy of *Amphenol's* "User's Guide to CB Radio"—18 pages packed with CB know-how and chit-chat. Also, *Amphenol* will let you know what's new on their product line.

121. Going CB? Then go *CB Center of America*. Get their catalog and discover the *big bonus* offered with each major product—serves all 50 states.

107. Get with the mobile set with *Tram's* XL'100. The new Titan CB base station, another *Tram* great, is worth knowing about.

116. Pep-up your CB rig's performance with *Turner's* M+2 mobile microphone. Get complete spec sheets and data on other *Turner* mikes.

48. *Hy-Gain's* new CB antenna catalog is packed full of useful information and product data that every CBer should know. Get a copy.

111. Get the scoop on *Versa-Tronics'* Versa-Tenna with instant magnetic mounting. Antenna models available for CBers, hams and mobile units from 27 MHz to 1000 MHz.

45. CBers, get *World Radio Labs* CB catalog—a big first for *WRL*. If you need anything for base or mobile use, WRL has it. Best catalog buy there is and it's free.

115. Get the full story on *Polytronics Laboratories'* latest CB entry—Carry-Comm. Full 5-watts, great for mobile, base or portable use. Works on 12 VDC or 117 VAC.

100. You can get increased CB range and clarity using the "Cobra" transceiver with speech compressor—receiver sensitivity is excellent. Catalog sheet will be mailed by *B&K Division of Dynascan Corporation.*

54. A catalog for CBers, hams and experimenters, with outstanding values. Terrific buys on *Grove Electronics'* antennas, mikes and accessories.

96. If a rugged low-cost business/industrial two-way radio is what you've been looking for, be sure to send for the brochure on *E. F. Johnson Co.'s* brand new Messenger "202."

103. *Squires-Sanders* would like you to know about their CB transceivers, the "23'er" and the new "SSS." Also, CB accessories that add versatility to their 5-watters.

46. A long-time builder of ham equipment, *Hallicrafters* will send you lots of info on ham, CB and commercial radio equipment.

ELECTRONIC PRODUCTS

★42. Here's a colorful 108-page catalog containing a wide assortment of electronic kits. You'll find something for any interest, any budget. And *Heath Co.* will happily send you a copy.

★44. *EICO's* new 48-page 2-color pocket-size short form catalog is just off the press. Over 250 products: Ham radio, CB, hi-fi—in kit and wired form—are illustrated. Also, discover *EICO's* new experimenter kit line.

★125. Need TV camera kit, touch control lamp, hi-fi component, test unit or shop gear? Then you need *Conar's* latest catalog. Born from NRI, *Conar* has become a major supplier of electronics hobbyist parts.

66. Try instant lettering to mark control panels and component parts. *Datak's* booklets and sample show this easy dry transfer method.

108. Get the facts on *Mercury's* line of test equipment kits—designed to make troubleshooting easier, faster and more profitable.

92. How about installing a transistorized electronic ignition system in your current car? *AEC Laboratories* will mail their brochure giving you specifications, schematics.

109. *Seco* offers a line of specialized and standard test equipment that's ideal for the home experimenter and pro. Get specs and prices today.

ELECTRONIC PARTS

★1. Allied's catalog is so widely used as a reference book, that it's regarded as a standard by people in the electronics industry. Don't *you* have the latest *Allied Radio* catalog? The surprising thing is that it's free!

★2. The new 1967 Edition of *Lafayette's* catalog features sections on stereo hi-fi, CB, ham gear, test equipment, cameras, optics, tools and much more. Get your copy today.

★3. Bargains galore! Parts, tools, test equipment, radios and many more specials at ultra-low prices. *Progressive Edu-Kits* will send latest catalog.

8. Get it now! *John Meshna, Jr.'s* new 46-page catalog is jam packed with surplus buys—surplus radios, new parts, computer parts, etc.

★23. No electronics bargain hunter should be caught without the 1967 copy of *Radio Shack's* catalog. Some equipment and kit offers are so low, they look like misprints. Buying is believing.

★5. *Edmund Scientific's* new catalog contains over 4000 products that embrace many interests and fields. It's a 148-page buyers' guide for Science Fair fans.

★106. With 70 million TV and 240 million radios somebody somewhere will need a vacuum tube replacement at the rate of one a second! Get *Universal Tube Co.'s* Troubleshooting Chart and facts on their $1 flat rate per tube.

★4. *Olson's* catalog is a multi-colored newspaper that's packed with more bargains than a phone book has names. Don't believe us? Get a copy.

7. Before you build from scratch check the *Fair Radio Sales* latest catalog for electronic gear that can be modified to your needs. *Fair* way to save cash.

6. Bargains galore, that's what's in store! *Poly-Paks Co.* will send you their latest eight-page flyer listing the latest in available merchandise, including a giant $1 special sale.

10. *Burstein-Applebee* offers a new giant catalog containing 100s of big pages crammed with savings including hundreds of bargains on hi-fi kits, power tools, tubes, and parts.

11. Now available from *EDI (Electronic Distributors, Inc.)*: a catalog containing hundreds of electronic items. *EDI* will be happy to place you on their mailing list.

120. *Tab's* new electronics parts catalog is now off the press and you're welcome to have a copy. Some of *Tab's* bargains and odd-ball items are unbelievable.

117. Harried by the high cost of parts for projects? Examine *Bigelow's* 13th Anniversary catalog packed with "Lucky 13" specials.

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★61. *ICS (International Correspondence Schools)* offers 236 courses including many in the fields of radio, TV, and electronics. Send for free booklet "It's Your Future."

★74. Here's a double header—*Cleveland Institute of Electronics* offers a 40-page illustrated booklet on "How to Succeed in Electronics" and a 24-pager on "How to Get a Commercial FCC License." Get your copies today!

114. Prepare for tomorrow by studying at home with *Technical Training International*. Get the facts today on how you can step up in your present job.

59. For a complete rundown on curriculum, lesson outlines, and full details from a leading electronic school, ask for this brochure from the *Indiana Home Study Institute*.

105. Get the low-down on the latest in educational electronic kits from *Trans-Tek*. Build light dimmers, amplifiers, metronomes, and many more. *Trans-Tek* helps you to learn while building.

HI-FI/AUDIO

124. Now, *Sonotone* offers you young ideas in microphone use in their new catalog. Mikes for talk sessions, swinging combos, home recording, PA systems and many more uses.

26. Always a leader, *H. H. Scott* introduces a new concept in stereo console catalogs. "At Home With Stereo" offers decorating ideas, a complete explanation of the more technical aspects of stereo consoles.

85. Need a tuner? Preamp? Amp? Tape deck? Then inspect *Dynaco* for kits or wired units. It's worthwhile looking at test reports *Dynaco* sends your way.

119. *Kenwood* puts it right on the line. The all-new *Kenwood* stereo-FM receivers are described in a colorful 16-page booklet complete with easy-to-read-and-compare spec data. Get your copy today!

15. *Acoustic Research* would like to send you a copy of their fact-packed "Stylus Force" booklet—must reading for hi-fi bugs.

16. Discover why Lab 80 by *Garrard* offers top dollar value. 32-page *Garrard* Comparator Guide will make you a wiser buyer.

17. *Electro-Voice* has two new, pocket-size, four-color product guides for you. One covers speakers and components; the other, microphones and accessories.

19. *Empire* has made exceptional advances in speaker cabinet design you should read about. Also, *Empire's* successes in the turntable and cartridge fields are worth discovering.

24. Need a hi-fi or PA mike? *University Sound* has an interesting microphone booklet audio fans should read before making a purchase.

27. 12 pages of *Sherwood* receivers, tuners, amplifiers, speaker systems, and cabinetry make up a colorful booklet every hi-fi bug should see.

95. Confused about stereo? Want to beat the high cost of hi-fi without compromising on the results? Then you need the new 24-page catalog by *Jensen Manufacturing*.

99. Get the inside info on why *Acoustech's* solid-state amplifiers are the rage of the experts. Colorful brochure answers all your questions.

TAPE RECORDERS AND TAPE

123. Yours for the asking—*Elpa's* new "The Tape Recording Omnibook." 16 jam-packed pages on facts and tips you should know about before you buy a tape recorder.

31. All the facts about *Concord Electronics Corp.* tape recorders are yours for the asking in a free booklet. Portable, battery operated to four-track, fully transistorized stereos cover every recording need.

32. "Everybody's Tape Recording Handbook" is the title of a booklet that *Sarkes-Tarzian* will send you. It's 24-pages jam-packed with info for the home recording enthusiast. Includes a valuable table of recording times for various tapes.

33. Become the first to learn about *Norelco's* complete Carry-Corder 150 portable tape recorder outfit. Four-color booklet describes this new cartridge-tape unit.

34. "All the Best from *Sony*" is an 8-page booklet describing *Sony-Superscope* products—tape recorders, microphones, tape and accessories. Get a copy before you buy!

35. If you are a serious tape audiophile, you will be interested in the new *Viking of Minneapolis* line—they carry both reel and cartridge recorders you should know about.

HI-FI ACCESSORIES

112. *Telex* would like you to know about their improved Serenata Headset—and their entire line of quality stereo headsets.

98. Swinging to hi-fi stereo headsets? Then get your copy of *Superex Electronics'* 16-page catalog featuring a large selection of quality headsets.

104. You can't hear FM stereo unless your FM antenna can pull 'em in. Learn more and discover what's available from *Finco's* 6-pager "Third Dimensional Sound."

TOOLS

★78. *Xcellte's* Service Master roll kit puts 23 essential hand tools at your fingertips. Get catalog 166 for complete description of kit and many optional accessories.

118. Secure coax cables, speaker wires, phone wires, etc., with *Arrow* staple gun tackers. 3 models for wires and cables from 3/16" to ½" dia. Get fact-full Arrow literature.

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★70. Need a new TV set? Then assemble a *Heath* TV kit. *Heath* has all sizes, B&W and color, portable and fixed. Build the next TV you watch.

97. Interesting, helpful brochures describing the TV antenna discovery of the decade—the log periodic antenna for UHF and UHF-TV, and FM-stereo. From *JFD Electronics Corporation*.

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119	120	121	122	123	124	125			

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DX Nightwatch

Continued from page 92

Other World Plans. Since most of us will be able to DX into the wee hours only occasionally, such excursions into the other-DX-world should be planned carefully in advance. First, you must decide whether to actually stay up until dawn, or get up at a set hour by the alarm clock. However, if you do simply stay up, things are liable to be pretty dull until about 0300 EST and you'll probably need something to keep you awake. Maybe some of those wild, all-night interviews carried by WNBC (660) and WOR (710 kHz) from New York City. Political extremists and flying-saucer personalities are favorite type guests—we told you it was another world.

Except for BCB DXing (where Monday a.m. is best and Sunday a.m. second best), the day of the week isn't particularly important. What does count is knowing the prevailing DX conditions, and how to take advantage of them. Happily, these can be determined early in the evening. To start with, check the noise level on clear channels between 1605 and 3000 kHz. If it is high, better see whether Northern or Southern (including Latin American) signals predominate. In varying degrees, similar conditions will prevail on all frequencies throughout the night.

Rare Asians Forgotten. If Southern signals are the order of the night, it means that DX reception will pretty well be limited to stations South of the listener. You can forget about rare Asians and even Pacific reception will be marginal. Under such circumstances the DXer need not bother to get up or stay up unless he's looking for all-night BCB stations in Latin America or the Southern states. Of course, special programs and tests are aired Monday a.m. and seldom scheduled more than a month in advance.

For information on special programs we suggest you join either the International Radio Club of America, Box 325, El Cajon, Calif. 92020 (annual dues $4.00) or the National Radio Club, Box 454, Houston, Tex. 77001 (annual dues $5.00). These two organizations pretty well fight it out for leadership in the world of all-night DX. Unfortunately, both pretty well ignore MW DX beyond the BCB itself, though IRCA is more liberal in this respect than the NRC.

Anyway, gang, gist of it is, lose a little sleep over it and have a good one. ■

High-Fidelity

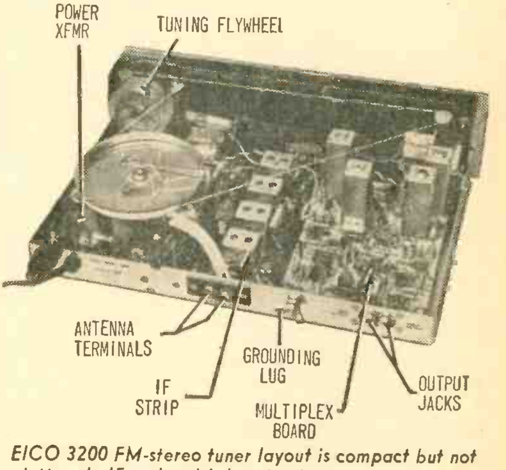
Continued from page 105

was low. Separation, even at 10 kHZ, was excellent to good, and pilot (19 kHz) suppression was very good. Mono frequency response to 15 kHz was excellent, with good stereo frequency response to 12 kHz.

The AFC (automatic frequency control) was excellent. Though its action is very "hard" in the sense that the AFC will lock-on even if the tuner is tuned to the extreme edge of a signal, the AFC does not lock-on to a strong signal adjacent to a weak one.

Selectivity, though not measured, appeared good, with no tendency of strong adjacent stations to cover weak signals.

Kit Or Wired? The Cortina tuner is available in both kit and wired form. Both the tuner and multiplex and IF strip are supplied pre-wired and pre-aligned so the builder will not have to worry about critical circuit construction or alignment. The user does only the mechanical assembly, the power supply, and the interconnecting wiring. Unlike the matching amplifier's many interconnections, the tuner's wiring is minimal and quickly done.



EICO 3200 FM-stereo tuner layout is compact but not cluttered. IF and multiplex circuits are pre-wired and aligned for simple kit assembly.

Summing Up. Both the kit price of $89.95 and the wired price of $129.95 are markedly low for the quality of performance, which, in nearly all respects, complements the notably good sound quality of the matching amplifier. ■

quencies of 2.5, 5, 10, and 15 MHz. However, for calibrating oscillators in the frequency range below 1500 kHz, an ordinary broadcast-band receiver will suffice.

To calibrate, simply tune the receiver to a station of known frequency and adjust the oscillator until you hear an audible beat note. At this point adjust the oscillator more carefully until the beat note falls to a frequency too low to hear (zero beat); the oscillator is then within about 30 Hz of the station's frequency. See Fig. 9.

One station can be used to calibrate several frequencies. A broadcast station at 1000 kHz, for instance, can be used for checking the oscillator at 1000 kHz, at 1000/2 or 500 kHz, at 1000/3 (333.3 kHz), at 1000/4 (250 kHz), and so forth. The higher the oscillator harmonic being compared, the weaker will be the oscillator signal —and the more accurate will be the actual calibration.

If you have no idea at all of the frequency range being covered by the oscillator, then you can't tell which of the many possible points you are zero-beating to the reference

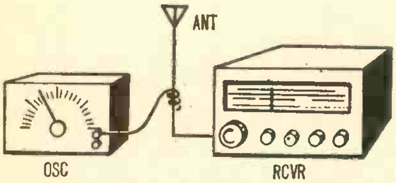


Fig. 9. RF oscillators can be readily calibrated using a shortwave receiver tuned to a station of known frequency, then zero-beating oscillator to it.

signal. However, if you adjust the oscillator to produce its lowest frequency output signal and then use the first calibration point you can locate above this frequency, you can get a fair idea of the frequency by leaving the oscillator alone and tuning the radio.

You will hear the oscillator signal at several points; some of these will be same number of kHz apart, but others won't. Ignore the ones which do not fit the pattern; they are image responses. The spacing between the other signals is approximately equal to the actual oscillator frequency.

Other Test Equipment. This introduction to calibration techniques has been limited to the most common test equipment. Most experimenters have other types of test gear as well, including capacitance meters, capacitor checkers, tube testers, transistor testers, and many other more specialized items. While all can and should be calibrated regularly to assure accuracy, the techniques are so varied that we simply can't describe them all.

However, with a knowledge of the basic principles of calibration, you should be able to figure out ways to calibrate any type of test equipment you may happen to have.

The basic idea is to know the accuracy of the equipment. If the equipment has adjustments which permit you to adjust the readings it provides, you can touch up these adjustments and introduce the accuracy directly. However, if no such adjustments are provided, you can still make up a chart of equipment reading versus true reading. Then when you take a reading, you use the chart to convert the equipment's indication into the corrected reading.

Calibration itself consists simply of comparing the indication given by the equipment to something you already know the value of. Voltmeters are calibrated by comparing their reading to the known voltage of a stable battery. Ohmmeters are compared to the known value of a high-precision resistor. Capacitance meters can be compared against known capacitance values. Bridges are checked out in the same way. Tube testers can be calibrated by testing several tubes which you know are good.

In any event, the care you take is the most important part of calibration, and the accuracy of your known calibration standard is almost as important. If you calibrate an ohmmeter against ordinary 10-percent-tolerance resistors, then your accuracy cannot be closer than 10 percent.

How often you should calibrate depends on many factors. In industry, most critical instruments are recalibrated every three to six months, but a few are rechecked every 30 to 45 days. Any time you suspect that readings are inaccurate, recalibration of that instrument is indicated.

On the other hand, so long as the readings appear to be accurate, the need for recalibration is determined entirely by just how much of a perfectionist you happen to be. A good compromise is to maintain a few standards such as one mercury cell and one precision resistor handy, and check your instruments at every session. If they are off, recalibrate; if not, use them with confidence. ■

Color Killer

Continued from page 57

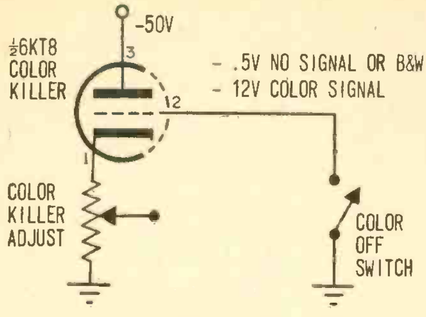


Fig. 8. Color killer stage operating voltages are set up so when no signal comes from burst amp, killer stage will not conduct. Color killer adjust control is set so that weak color signals will just deactivate killer stage.

dog cases require an actual look at the signal as it passes through the killer circuitry. You'll need a reasonably good scope—one rated up to 5MHz—and a low-capacitance probe. This combination permits you to measure the circuit without upsetting its normal operation. Again, the manufacturer's service literature comes to the rescue. As shown in Fig. 9 he supplies actual scope waveforms spotted at important points in the circuit. The scope should not only display the same shape for these waveforms, but voltages must be fairly close as well.

Voltage is almost always shown as P-P, or peak-to-peak, when it refers to a scope waveform. This means the scope must have a built-in calibrator to serve as a reference or you must use an external voltage calibrator to help set up scope controls. An example of scope waveforms in Fig. 9 comes from the burst amp found in an RCA set. You can see that the burst signal applied to the grid should be 65 volts peak-to-peak, while the emerging signal at the plate is 200 volts peak-to-peak. If you see the input signal on the scope, but fail to observe the output, this is a sure sign of trouble in the stage. Note that the +400 volts at the plate (pin 5) is a B+ supply voltage measured with a VTVM. Thus, a combination of scope and meter can track down nearly any killer trouble you're apt to encounter. ■

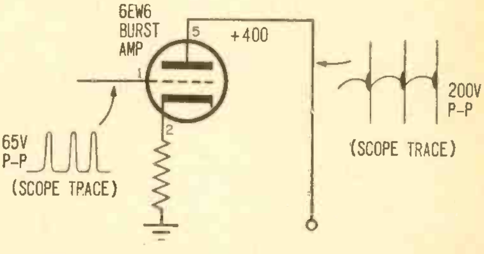


Fig. 9. Tough dog problems can be tracked down with the aid of the manufacturers' service literature showing voltages and waveforms, and a scope.

Super Snoop

Continued from page 66

prove to be a valuable aid in automobile and mechanical diagnosis.

A few points on safety should be observed and remembered. When tracing those squeaks or merely listening to your transmission switch gears, take care that the pickup cable is safely clear of moving parts capable of snagging it on the road and producing a dangerous situation by distracting your attention from driving. Use tape to hold the cable secure to the car body and areas where the cable cannot be strung through.

Similarly, when listening in the phones, keep in mind that a little recognized but important driving aid is removed—your hearing. So be cautious! The best safety measure is to let a friend drive and you can listen with a great deal more attention.

Wide World Of Super Snoop. Super Snoop can be used to detect worn brakes, frozen bearings, chipped gears, and a variety of other problems. It can also be used for listening to walls in 007 fashion; just place the pickup on any attachable wall-framing such as a door jamb, and conversations from the other side are easily monitored. Plaster walls, as far as sound sensitivity is concerned, are the best type of walls. If there is no framing on the wall, remove the transducer from the C-clamp and tape it to the wall. This method may be better in some cases for picking up conversations.

Finally, one last application of Super Snoop is its use in producing sound effects, such as water running through the pipes, marbles being dropped in empty metal pails, or salt being poured onto a card table. The possibilities are endless, and the results make Super Snoop a worthwhile addition to anybody's family. Happy snooping! ■

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"DISTANCE Crystal Set Construction" Handbook—50¢. Catalog. Laboratories, 12041-G Sheridan, Garden Grove, Calif. 92640.

VALUES—Electronics. Write Wendell Waites, 1643 North 55th, Philadelphia, Pennsylvania 19131.

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Gene Frost was "stuck" in low-pay TV repair work. Then two co-workers suggested he take a CIE home study course in electronics. Today he's living in a new house, owns two good cars and a color TV set, and holds an important technical job at North American Aviation. If you'd like to get ahead the way he did, read his inspiring story here.

IF YOU LIKE ELECTRONICS—and are trapped in a dull, low-paying job—the story of Eugene Frost's success can open your eyes to a good way to get ahead.

Back in 1957, Gene Frost was stalled in a low-pay TV repair job. Before that, he'd driven a cab, repaired washers, rebuilt electric motors, and been a furnace salesman. He'd turned to TV service work in hopes of a better future—but soon found he was stymied there too.

"I'd had lots of TV training," Frost recalls today, "including numerous factory schools and a semester of advanced TV at a college in Dayton. But even so, I was stuck at $1.50 an hour."

Gene Frost's wife recalls those days all too well. "We were living in a rented double," she says, "at $25 a month. And there were no modern conveniences."

"We were driving a six-year-old car," adds Mr. Frost, "but we had no choice. No matter what I did, there seemed to be no way to get ahead."

Learns of CIE

Then one day at the shop, Frost got to talking with two fellow workers who were taking CIE courses... preparing for better jobs by studying electronics at home in their spare time. "They were so well satisfied," Mr. Frost relates, "that I decided to try the course myself."

He was not disappointed. "The lessons," he declares, "were wonderful—well presented and easy to understand. And I liked the relationship with my instructor. He made notes on the work I sent in, giving me a clear explanation of the areas where I had problems. It was even better than taking a course in person because I had plenty of time to read over his comments."

Studies at Night

"While taking the course from CIE," Mr. Frost continues, "I kept right on with my regular job and studied at night. After graduating, I went on with my TV repair work while looking for an opening where I could put my new training to use."

His opportunity wasn't long in coming. With his CIE training, he qualified for his 2nd Class FCC License, and soon afterward passed the entrance examination at North American Aviation. "You can imagine how I felt," says Mr. Frost. "My new job paid $228 a month more!"

"CIE training helped pay for my new house,"

says Eugene Frost
of Columbus, Ohio

Currently, Mr. Frost reports, he's an inspector of major electronic systems, checking the work of as many as 18 men. "I don't lift anything heavier than a pencil," he says. "It's pleasant work and work that I feel is important."

Changes Standard of Living

Gene Frost's wife shares his enthusiasm. "CIE training has changed our standard of living completely," she says.

"Our new house is just one example," chimes in Mr. Frost. "We also have a color TV and two good cars instead of one old one. Now we can get out and enjoy life. Last summer we took a 5,000 mile trip through the West in our new air-conditioned Pontiac."

"No doubt about it," Gene Frost concludes. "My CIE electronics course has really paid off. Every minute and every dollar I spent on it was worth it."

Why Training is Important

Gene Frost has discovered what many others never learn until it is too late: that to get ahead in electronics today, you need to know more than soldering connections, testing circuits, and replacing components. You need to really know the fundamentals.

Without such knowledge, you're limited to "thinking with your hands" ...learning by taking things apart and putting them back together. You can never hope to be anything more than a serviceman. And in this kind of work, your pay will stay low because you're competing with every home handyman and part-time basement tinkerer.

But for men with training in the fundamentals of electronics, there are no such limitations. They think with their heads, not their hands. They're qualified for assignments that are far beyond the capacity of the "screwdriver and pliers" repairman.

The future for trained technicians is bright indeed. Thousands of men are desperately needed in virtually every field of electronics, from 2-way mobile radio to computer testing and troubleshooting. And with demands like this, salaries have skyrocketed. Many technicians earn $8,000, $10,000, $12,000 or more a year.

How can you get the training you need to cash in on this booming demand? Gene Frost found the answer in CIE. And so can you.

Send for Free Book

Thousands who are advancing their electronics careers started by reading our famous book, "How To Succeed In Electronics." It tells of the many electronics careers open to men with the proper training. And it tells which courses of study best prepare you for the work you want.

If you'd like to get ahead the way Gene Frost did, let us send you this 40-page book free. With it we'll include our other helpful book, "How To Get A Commercial FCC License." Just fill out and mail the attached card. Or, if the card is missing, write to CIE at the address below.

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All CIE courses are available under the new G.I. Bill. If you served on active duty since January 31, 1955, or are in service now, check box on reply card for G.I. Bill information.

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