ELECTRONICS INSTALLATION & SERVICING HANDBOOK 1970

$1.35

SPECIAL BUYER'S GUIDE FOR

1970 COLOR-TV RECEIVERS ■ FM-TV ANTENNAS
ELECTRONIC IGNITION SYSTEMS ■ TEST EQUIPMENT ■ CB EQUIPMENT

QUIZ-TEST YOURSELF - CAN YOU QUALIFY AS AN ELECTRONICS TECHNICIAN?

COMPLETE REPORT ON 1970 COLOR-TV SETS

BUILD YOUR OWN CLOSED-BOX SPEAKER SYSTEM

MULTI-SET FM-TV DISTRIBUTION SYSTEMS FOR HOME USE

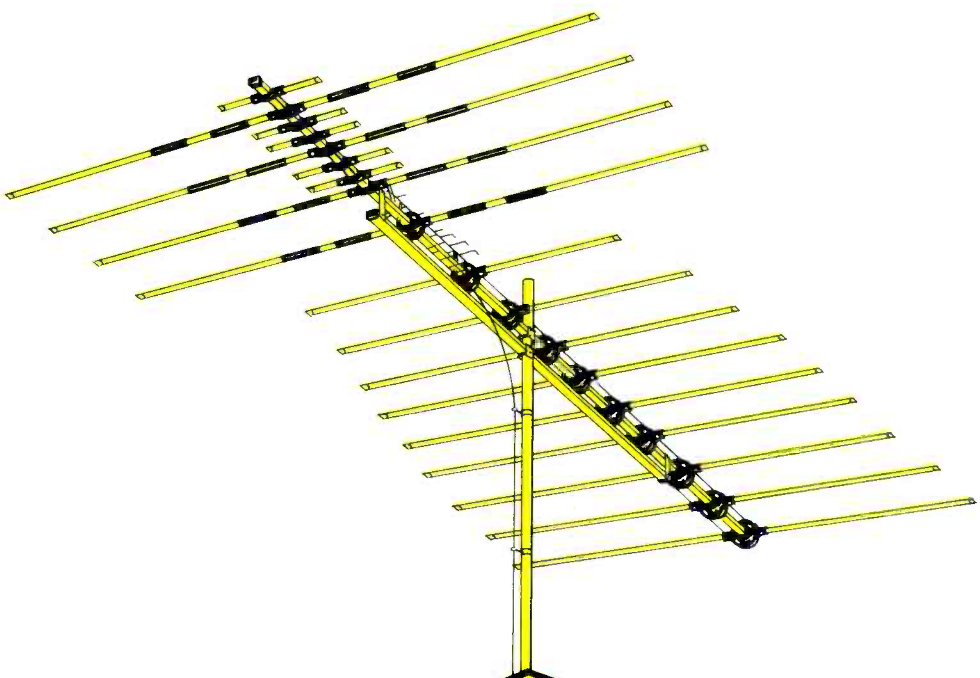
CIRCUIT DIAGRAMS OF 1970 COLOR-TV RECEIVERS

BUILD YOUR OWN ELECTRONIC IGNITION SYSTEM

WHICH P.A. SPEAKER SHOULD YOU USE?

HOW TO ADD MORE SPEAKERS TO YOUR HI-FI SYSTEM

Beautiful TV performance starts here.



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Jerrold VUfinder Plus

Jerrold introduces a new all-channel antenna that looks as good as it works— VUfinder Plus — a clean, straightforward, no-nonsense design that goes up quicker and stays up longer. And it's as strong in customer reception as it is in signal reception. Here are a few reasons:

- More VHF and UHF gain.
- Smoother response over UHF band.
- Simplified VHF section that reduces wind load while strengthening the antenna.
- Factory preassembly that makes installation both quicker and easier.
- And for areas where UHF signals are exceptionally weak—compared to VHF—the optional UHF Power Zoom increases gain up to 60%. Mounts easily on the front of the antenna.
- Snap-on transformer converts any VUfinder Plus from 300-ohm to 75-ohm Coloraxial performance.

Start a rooftop rebellion for fun and profit with Jerrold VUfinder Plus Antennas. Six models from metropolitan to deep fringe. All competitively priced. For more information, see your Jerrold Distributor. Or write Jerrold Electronics Corporation, Distributor Sales Division, 401 Walnut Street, Philadelphia, Pa. 19105.

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Focusing on one thing . . . better reception

CIRCLE NO. 1 ON READER SERVICE CARD

Earn Your DEGREE in Electronics!

Grantham School of Engineering offers an educational program leading to the Degree of Associate in Science in Electronics Engineering – the ASEE. *Beginners in electronics* must take resident classes in Hollywood, Calif., or in Washington, D.C. However, *experienced electronics technicians* may complete the entire degree program by home study, except for the final two weeks which must be taken in Hollywood. There are three different ways the program is offered, referred to as *Daytime-Residence, Supplemented-Correspondence,* and *Home Study*. Each method is discussed below.

Daytime-Residence

The Daytime-Resident program is designed for *beginners*. You may enroll in Hollywood or Washington. Classes meet five days per week, and each semester is 16 weeks long. Three semesters are offered each year. Upon satisfactory completion of the five semester program (about 20 months), you are awarded a Diploma in Electronics Engineering Technology. Then, to complete the requirements for the ASEE Degree, you must attend the associate-degree seminar – a two-week period of review, consultation, and evaluation.

This seminar is held, for Hollywood *and* Washington students, at the main School in Hollywood. For Washington students the School pays the round-trip (to and from Hollywood) airline transportation charges, so that all the graduating students in both schools may participate in each seminar together.

For those who wish to continue their engineering studies beyond the ASEE Degree level, Grantham offers a BSEE Degree program in Hollywood. The Grantham ASEE Degree or other equivalent background is prerequisite to enrollment in the BSEE Degree program.

Supplemented-Correspondence

The Supplemented-Correspondence program is designed for *beginners*. You take the correspondence lessons from the main school in Hollywood, but the supplementary resident classroom and laboratory sessions, one evening per week, may be taken in either Hollywood or Washington. The main part of the program is divided into five semesters, each semester being slightly less than six months long, so that you normally complete the five semesters in 2½ years. Upon completion of this five-semester program, you are awarded a Diploma in Electronics Engineering Technology. Then, to complete the requirements for the ASEE Degree, you must attend the associate-degree seminar – a two-week period of review, consultation, and evaluation – in Hollywood, the same as is explained under "Daytime-Residence" above. Seminar round-trip airline transportation for Washington students is paid by the School.

Home Study

In the ASEE Degree program offered to *experienced electronics technicians,* the entire educational program leading to the Diploma in Electronics Engineering Technology is conducted by home study. It consists of 370 home study lessons, divided into five "correspondence semesters". The prerequisite for enrollment is high school graduation (or equivalent) and at least one year of fulltime experience as an electronics technician.

Upon completion of the 370 home-study lesson (five semester) and receipt of your EET Diploma, you are then eligible to attend the associate-degree seminar—a two-week period of review, consultation, and examination—in Hollywood, as the final requirement for your ASEE Degree.

This *accredited* ASEE Degree program offered to experienced technicians, begins with a review of electrical and electronic principles and systems, and then continues with applied engineering mathematics (including algebra, trigonometry, analytic geometry, and calculus), classical and modern physics, technician writing, computer systems, electrical network design, and semiconductor circuit design.

Accreditation, and G.I. Bill Approved

Grantham School of Engineering was established in Hollywood, California in 1951, and the Eastern Extension Division of the School was opened in Washington, D.C. in 1955.

The School is *approved* in California by the California State Department of Education, is *approved* in the District of Columbia by the D.C. Board of Education, is *approved* under the "Cold War G.I. Bill" to offer resident courses in Hollywood and Washington and correspondence courses from Hollywood, is *accredited* by the Accrediting Commission of the National Home Study Council, and is *authorized* under the laws of the State of California to grant academic degrees.

Grantham School of Engineering EH-11-69
1505 N. Western Ave., Hollywood, Calif. 90027

Please mail your free Bulletin, which explains how the Grantham educational program can prepare me for my Associate in Science Degree in Electronics Engineering.

Name ____________________ Age ______

Address ____________________

City ____________ State ______ Zip ______

I am interested in: ☐ Daytime-Residence
☐ Supplemented-Correspondence, ☐ Home-Study

Grantham School of Engineering

Specializing in Electronics since 1951

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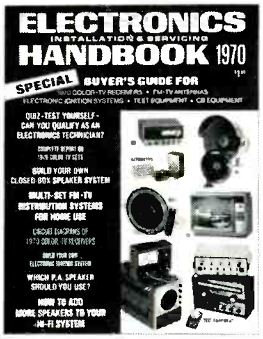

For details on the equipment appearing on the cover, see page 50. Cover photo by Dirone-Denner

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1970 EDITION

ELECTRONICS
INSTALLATION & SERVICING
HANDBOOK 1970

FEATURE ARTICLES

DIRECTORIES OF TEST EQUIPMENT

COLOR-TV CIRCUIT DIAGRAMS

Service Associations

how they help the technician and consumer

By RICHARD L. GLASS, CET
Exec. Vice-President, National Electronic Associations, Inc.

These associations of TV technicians are improving the technician's image and reducing built-in servicing headaches—thus providing better consumer service.

THIS past year the country's service associations held more national meetings than in any time past.

National Electronic Associations (NEA) held its 5th Annual convention and five board meetings; National Alliance of Television & Electronic Service Associations (NATESA) put on its August Chicago convention plus four regional spring conferences. This was the first year the Spring Directors Conference of NATESA was replaced by the four regional conferences. A new addition to the national meetings was an Eastern Service Conference, sponsored by the Pennsylvania Federation of Radio-TV Service Associations. The ESC brought manufacturers and association officers together in a mutual attempt to concentrate on solving some of the industry problems associated with consumer electronic equipment repairs.

The organized state associations increased their meetings in number. They also showed gains in convention attendance, with California, Indiana, Ohio, Nebraska, Kentucky, and Texas meetings reaching record attendance. Part of the reason may be the better promotions of the meetings, along with the increases in business management and technical seminars that accompanied them. This better promotion, no doubt, is partially due to more service associations retaining a paid staff rather than relying entirely on volunteer help. The Nebraska, Indiana, Connecticut, Texas, California, Iowa, and Michigan state associations have paid staffs, as do NEA and NATESA.

Over-all membership in associations is up. Both nationals showed membership increases and several state organizations made big percentage gains. Stimulus for membership this year was in the form of sales commissions to individuals for new membership obtained, insurance programs, special national membership awards offered by NEA and *The Finney Co.*, and a general upsurge in the recognition of the need for association services.

Association Services & Training

Association services expanded in 1969. Several state associations began offering new insurance programs covering accident, health, life, and loss of income for electronic service shops and technicians. NEA started a new national insurance program which can enroll dealer members that do not fall under the existing state plans. NATESA has offered a group program for several years.

NEA utilized a printed form developed originally by the Nebraska Association and began distributing to its members technical service "fixes," or "Techni-Tips," on all brands of consumer electronic products. These are also offered on a subscription basis to non-member shops. The single-sheet "Techni-Tips" are readily filed with manufacturers' service manuals and are a method of using one technician's experience to help many other technicians solve service problems. Some manufacturers have begun supplying service tips to NEA to enhance the value of the "Techni-Tip" program.

And 1969 was the year that the now three-year old Certified Electronic Technician (CET) Program really began to gain stature and members. Total technicians now certified and registered by NEA has surpassed 1000. Several state associations have turned the testing sessions over to public high schools, vocational schools, private trade schools, and colleges, and have begun scheduling CET exams on a regular monthly basis. There are now CET's in every state, plus Viet Nam, Germany, Puerto Rico, Canada, Brazil, and Guam.

Argentina has 11 CET's alone. Besides CET wall certificates and wallet cards, NEA is furnishing identification patches, and recently the *Raytheon Co.* began supplying gold lapel pins to many of the successful CET's. For information on CET, write NEA Certification, 4622 E. 10th St., Indianapolis, Indiana 46224.

Training efforts by the associations are expanding. All 16 vocational high schools in Indiana are instituting an association-designed training program. It is coupled with apprenticeship and certification. The Louisville, Ky. area has an elaborate training program in cooperation with local, state, and federal governments. Twenty apprentices are enrolled at this pilot training project at Ahrens Trade School, in Louisville, and over one hundred technicians are undergoing upgrading training there. Oregon and California state associations have good apprenticeship programs in operation, as does Connecticut.

The experience thus far seems to show the trade association methods being used are excellent. The national associations now will be working to quickly extend these programs into the other states. The associations have gone on record, in nearly every case, as being opposed to recent industry and government training projects that offer "quicky" training in the field of electronics.

Both NEA and NATESA, and practically every state and local service association, have worked hard to attempt to defeat the sensationalism in the consumer press that so often unhappily leaves the technician as the goat of the story. Individually, by word of mouth, at civic club meetings, and through the use of several types of association public-relation pamphlets, members have done a pretty good job of reducing this problem.

Serviceability Program

An NEA project called "Serviceability" gained stature and effectiveness recently. Many individual local groups and state organizations had vainly made attempts, in past years, to influence manufacturers to include minor design changes in home electronic products. These are changes that would eliminate some needless servicing headaches. In early 1969, NEA began work on a six-point serviceability program that combined many previous association ideas and made serviceability beneficial to not only the technician and dealers, but also of assistance to the manufacturers and the public.

It works like this: Members are supplied blank report forms. Dealers and technicians fill in the forms with specific problems as they are encountered in day-to-day repair work. Problem examples are: exposed voltages, sharp edges, and other hazards to a technician's safety; poor parts procurement, and service information problems, inaccessibility of commonly replaced parts, etc. These service complaints are forwarded by NEA to product service divisions of the manufacturers involved.

NEA also supplied all manufacturers with Serviceability Design Guidelines, and began a program whereby an independent service technician is sent to each manufacturer periodically to discuss serviceability features. Another feature of the serviceability project involves random committee inspections of products by groups of technicians (usually at state or national association meetings). These committees objectively inspect products and associated service literature and submit their findings, through the national association, to the set maker.

NARDA (National Appliance Radio-TV Dealers Association) has also become involved in electronic service, in addition to its role as a merchandiser's association. NARDA has conducted regular service-management institutes around the country where service dealers learn improved methods of operating service businesses. NARDA also offers to its members, as well as to NEA and NATESA members, a computer service for analyzing technician performance, on a monthly basis.

Radiation & Safe Service

Radiation from color-TV has been a recurring issue in recent months. Electronics service technicians have been involved and occasionally named as contributors to the problem through poor adjustment procedures or service methods. While federal legislation has been directed towards manufacturers in an effort to eliminate any possibilities of color-TV radiation causing any future problem, the service associations have attacked the radiation problem on all levels.

NATESA has a Safe-Service Program, wh re members study color-TV radiation information and become acquainted with proper adjustment and servicing procedures. They then take a test which qualifies them for a Safe-Servicer Certificate. NEA includes high-voltage and radiation qu stions on the CET examination, and nearly all the as ociations have supplied their members with manufacturers' x-ray safety procedures. Many state

and local association meetings and manufacturers' service seminars have devoted time to the subject of radiation.

Licensing efforts by the associations have not increased appreciably recently, even though association strength is up. California efforts to pass a technician license law to supplement the state dealer registration law, fell short and were delayed for a year. Pennsylvania, New York, and Florida TV licensing efforts failed during 1969. Virginia seems to be the most likely state to pass legislation, having a strong association backing the effort guiding it.

Only a few years ago there was criticism of the electronic service associations for too little action and too much talk. Now the associations are really giving service. For example, the Texas Electronic Association has excellent, college-operated, management institutes and also puts on informative clinics regularly. Nebraska, Indiana, Ohio, Kentucky, and other state associations are including technician-training seminars on new home entertainment products and test equipment at many of their meetings. Many local associations also include technical seminars and movies at their meetings. Dozens of printed aids are being offered by the associations to help improve customer relations and solve business or technical problems. NEA, the Columbus, Ohio Association (ARTSD), the Nebraska Association and others make surveys that help members determine whether their own methods are in line with their fellow dealers around the state or country.

The associations are doing many other things for the profession, such as helping individual dealers and technicians with problems, working with TV-radio stations, influencing legislation that affects the trade, and influencing advertisers and journalists to improve the image of the servicing business and the professional technician. They find competent service dealers in areas where manufacturers need service agents. They supply information to manufacturers, the government, and to interested parties. With services and membership expanding, the association movement looks very healthy for the '70's. ●

COLOR CODE CHARTS

COLOR BAND SYSTEM

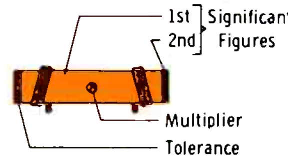
Resistors With Black Body Color Are Composition, Non-Insulated.
Resistors With Colored Bodies Are Composition, Insulated.
Wire-Wound Resistors Have The 1st Digit Color Band Double Width.

RESISTOR CODES (RESISTANCE GIVEN IN OHMS)

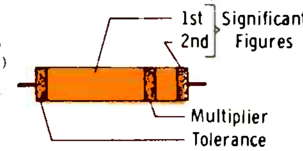
COLOR	DIGIT	MULTIPLIER	TOLERANCE
BLACK	0	1	±20%
BROWN	1	10	±1%
RED	2	100	±2%
ORANGE	3	1000	±3% •
YELLOW	4	10000	GMV•
GREEN	5	100000	±5% (EIA Alternate)
BLUE	6	1000000	±6%•
VIOLET	7	10000000	±12 1/2%•
GRAY	8	.01 (EIA Alternate)	±30% •
WHITE	9	.1 (EIA Alternate)	±10% (EIA Alternate)
GOLD		.1 (JAN and EIA Preferred)	±5% (JAN and EIA Preferred)
SILVER		.01 (JAN and EIA Preferred)	±10% (JAN and EIA Preferred)
NO COLOR			±20%

•GMV = guaranteed minimum value, or -0 + 100% tolerance.
±3. 6. 12 1/2, and 30% are ASA 40, 20. 10, and 5 step tolerances.

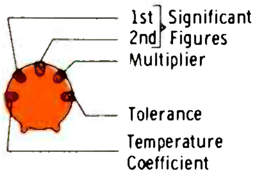
BODY-END-DOT SYSTEM



BODY - END BAND SYSTEM



DISC CERAMICS (5-DOT SYSTEM)



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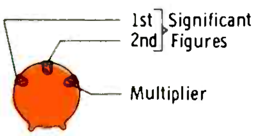
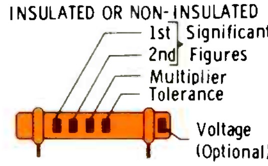


CERAMIC CAPACITOR CODES (CAPACITY GIVEN IN pF)

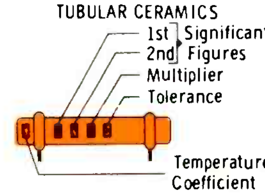
COLOR	DIGIT	MULTI-PLIER	TOLERANCE 10 pF or LESS	TOLERANCE OVER 10MMF	TEMPERATURE COEFFICIENT PPM/°C	EXTENDED RANGE TEMP. COEFF. SIGNIFICANT FIGURE	EXTENDED RANGE TEMP. COEFF. MULTIPLIER
BLACK	0	1	±2.0 pF	±20%	0(NPO)	0.0	-1
BROWN	1	10	±0.1 pF	±1%	-33(N033)		-10
RED	2	100		±2%	-75(N075)	1.0	-100
ORANGE	3	1000		±2.5%	-150(N150)	1.5	-1000
YELLOW	4	10000			-220(N220)	2.2	-10000
GREEN	5		±0.5 pF	±5%	-330(N330)	3.3	+1
BLUE	6				-470(N470)	4.7	+10
VIOLET	7				-750(N750)	7.5	+100
GRAY	8	.01	±0.25 pF		+30(P030)		+1000
WHITE	9	.1	±1.0 pF	±10%	General Purpose		+10000
SILVER					Bypass & Coupling		
GOLD					+100 (P100, JAN)		

Voltage ratings are standard 500 volts for some manufacturers, but 1000 volts for other companies.

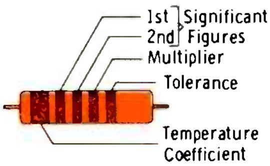
HIGH CAPACITY TUBULAR CERAMIC INSULATED OR NON-INSULATED



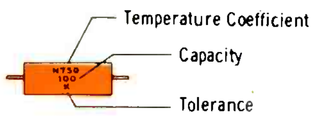
TEMPERATURE COMPENSATING TUBULAR CERAMICS



MOLDED-INSULATED AXIAL LEAD CERAMICS

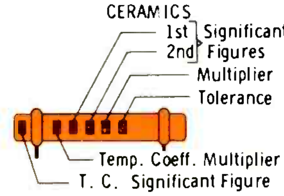


TYPOGRAPHICALLY MARKED CERAMICS



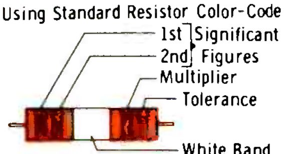
JAN LETTER	TOLERANCE 10 pF or LESS	TOLERANCE OVER 10 pF
C	±0.2 pF	
D	±0.5 pF	
F	±1.0 pF	±1%
G	±2.0 pF	±2%
J		±5%
K		±10%
M		±20%

ENTENDED RANGE T.C. TUBULAR CERAMICS



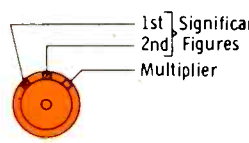
MOLDED CERAMICS

Using Standard Resistor Color-Code



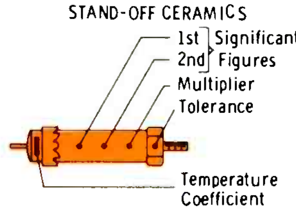
Distinguishes Capacitor From Resistor

BUTTON CERAMICS

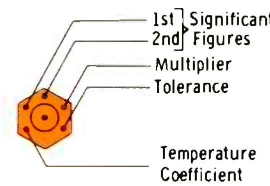


Viewed From Soldered Surface

STAND-OFF CERAMICS



FEED-THRU CERAMICS



MOLDED MICA CAPACITOR CODES

(Capacity Given In pF)

COLOR	DIGIT	MULTI-PLIER	• TOLERANCE	CLASS OR CHARACTERISTIC
BLACK	0	1	20%	A
BROWN	1	10	1%	B
RED	2	100	2%	C
ORANGE	3	1000	3%	D
YELLOW	4	10000		E
GREEN	5		5% (EIA)	F(JAN)
BLUE	6			G(JAN)
VIOLET	7			
GRAY	8			I(EIA)
WHITE	9			J(EIA)
GOLD		.1	5%(JAN)	
SILVER		.01	10%	

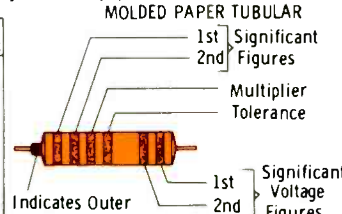
Class or characteristic denotes specifications of design involving Q factors, temperature coefficients, and production test requirements.
All axial lead mica capacitors have a voltage rating of 300, 500, or 1000 volts.
•or ±1.0 pF whichever is greater.

MOLDED PAPER CAPACITOR CODES

(Capacity Given In pF)

COLOR	DIGIT	MULTI-PLIER	TOLERANCE
BLACK	0	1	20%
BROWN	1	10	
RED	2	100	
ORANGE	3	1000	
YELLOW	4	10000	
GREEN	5	100000	5%
BLUE	6	1000000	
VIOLET	7		
GRAY	8		
WHITE	9		10%
GOLD			5%
SILVER			10%
NO COLOR			20%

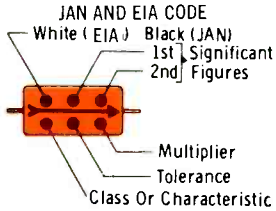
MOLDED PAPER TUBULAR



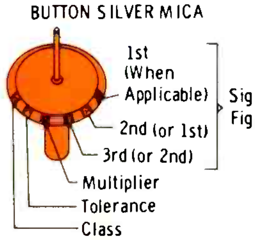
Indicates Outer Foil. May Be On Either End. May Also Be Indicated By Other Methods Such As Typographical Marking Or Black Stripe.

Add Two Zeros To Significant Voltage Figures. One Band Indicates Voltage Ratings Under 1000 Volts.

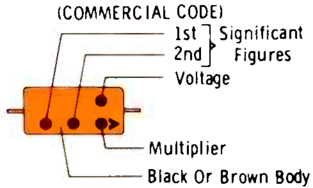
CURRENT STANDARD JAN AND EIA CODE



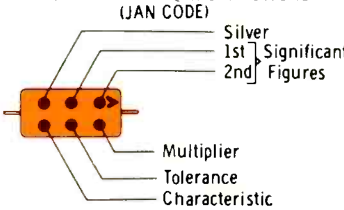
BUTTON SILVER MICA



MOLDED FLAT PAPER CAPACITORS (COMMERCIAL CODE)



MOLDED FLAT PAPER CAPACITORS (JAN CODE)



The first and only solid-state test equipment guaranteed for 5 years.

Now EICO, because of its emphasis on *reliability* in engineering and manufacture, offers the industry this breakthrough.

EICO's new line of solid-state test equipment comes with an unprecedented 5-year guarantee of performance and workmanship. (Send for full details of this EICO 5-year GUARANTEE on factory-assembled instruments.)

Additional advanced features include: new functional design, new color-coordinated esthetics, new PC construction, new easier-to-build kit designs.

New EICO Solid-State Test Equipment

240 379 242 150 330

EICO 240 Solid-State FET-VOM $49.94 kit, $69.95 wired.
One all-purpose DC/AC OHMS Uniprobe®. Reads 0.01V to 1 KV (to 30 KV with optional HVP probe). 7 non-skip ranges, in 10 dB steps. AC or battery operated. RMS & DCV: 0-1, 3, 10, 30, 100, 300, 1000V P-P ACV: 0-2.8, 8.5, 28, 85, 280, 850, 2800V. Input Z: DC, 11 M; AC, 1 MΩ. Response 25 Hz to 2 MHz (to 250 MHz with optional RF probe). Ohmmeter reads 0.2 to 1 MΩ in 7 ranges. 4½" 200 μA movement. HWD: 8½", 5¾", 5". 6 lbs.

EICO 242 Solid-State FET-TVOM $59.95 kit, $79.95 wired.
All the versatility of the EICO 240 plus: AC/DC Milliammeter, 1 ma to 1000 ma in 7 non-skip ranges; single all-purpose DC/AC-Ohms — MA Uniprobe®; and large 6½" 200 μA meter movement.

EICO 150 Solid-State Signal Tracer $49.94 kit, $69.95 wired.
Multi-purpose troubleshooter for TV/FM/AM & Audio Equipment. Independent RF Audio inputs Speaker and meter output indicators. 400 mW continuous power output. Substitution amplifier, output transformer, speaker. Input for rated output: 1 mV RF, 63 mV audio. Hum 60 dB below 400 mW, 105-132 VAC, 50/60 Hz, 5VA. HWD: 7½", 8½", 5". 6 lbs.

EICO 330 Solid-State RF Signal Generator. $59.95 kit, $79.95 wired.
5 fundamental bands 100 kHz to 54 MHz. Vernier control 0-100%. Output 300,000 μV into 50-Ohm load. External signal modulation or internal 400 Hz, 0 to 100%. 105-132 VAC, 50/60 Hz, 1.7 VA. HWD: 7½", 8½", 5". 5 lbs.

EICO 379 Solid-State Sine/Square Wave Generator. $54.95 kit, $74.95 wired.
5 sine wave and 4 square wave bands. Low distortion Sultzer feedback FET circuit. Sine: 20 Hz to 2 MHz; 0-7.5V rms into hi-Z, 0-6.5V into 600 ohms Max. distortion 0.25%. Square: 20 Hz to 200 kHz; 0-10V p-p into hi-Z, pos. direction, zero ground. Rise time at 20 kHz less than 0.1 μ sec. 105-132 VAC, 50/60 Hz, 10VA. HWD: 7½", 8½", 8½". 9 lbs.

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EICO 443 — Semiconductor Curve Tracer $69.95 Kit, $99.95 Wired.
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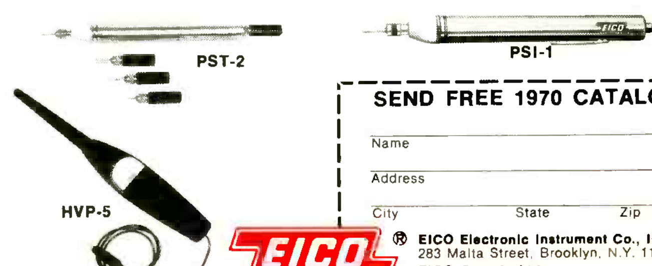

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CIRCLE NO. 8 ON READER SERVICE PAGE

Can you Pass—this

Electronics-Technician Test?

By WALTER H. BUCHSBAUM

(Answers on page 102)

A major electronics firm uses the test below to check on the technical knowledge of the men they hire as technicians. The company's technicians are not production-line workers, testers, or repairmen, but are personnel expected to work with engineers in the development, breadboarding, and prototype construction of sophisticated military and industrial electronics equipment.

Test yourself to see if you can qualify for this type of work. If you find you are rusty or completely unfamiliar with some of these questions, it might be a good idea to study up on that particular area. If you answer 40 or more questions out of a total of 50 (80%) correctly, you could probably get a job with any company hiring technicians for military and industrial equipment development.

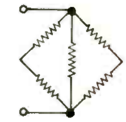
1. The resistors used to convert a current meter into a voltmeter are called:
   (a) shunts *(c) multipliers (in series)*
   (b) decade dividers *(d) multipliers (in parallel)*

2. The internal resistance which permits a voltmeter to measure 12 volts across 2 megohms most accurately is:
   (a) no difference *(c) 20,000 ohms/volt*
   (b) 5 ohms/volt *(d) 50,000 ohms/volt*

3. The ordinary a.c. voltmeter measuring 110 volts is really calibrated to read:
   (a) peak value *(c) average value*
   (b) r.m.s. value *(d) actual value*

4. If a signal generator output of 100 milliwatts is attenuated by 20 dB, the available power will be:
   (a) 50 milliwatts *(c) 100 microwatts*
   (b) 1 milliwatt *(d) 20 milliwatts*

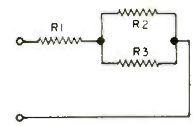
5. If all resistors in the diagram are 40 ohms, the total resistance at the terminals is:
   (a) 20 ohms *(c) 13.3 ohms*
   (b) 40 ohms *(d) 5 ohms*



6. A series circuit consisting of a 32-ohm resistance and an 18-ohm inductive reactance has a total impedance of:
   (a) 24 ohms *(c) 36.7 ohms*
   (b) 240 ohms *(d) 50 ohms*

7. 100-ohm, 200-ohm, and 300-ohm resistors are connected in series across a 100-volt supply. The voltage across the 200-ohm resistor will be:
   (a) 33.5 volts *(c) 22.5 volts*
   (b) 50 volts *(d) 67 volts*

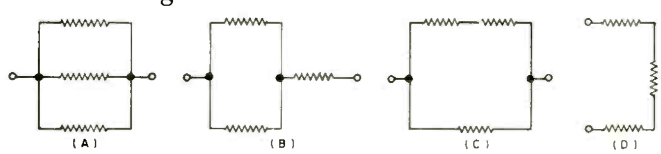
8. A current of 2 amperes flows through R2 in the diagram. If each resistor is 12 ohms, the voltage at the terminals will be:
   (a) 20 volts *(c) 72 volts*
   (b) 65 volts *(d) 96 volts*



9. If a potential of 200 volts is applied across a 47k resistor, the current through it will be:
   (a) 425 milliamps *(c) 94 milliamps*
   (b) 4.25 milliamps *(d) 0.94 amp*

10. The current flowing through a 75-watt lamp with 110 volts applied across the lamp is:
   (a) 8.25 amps *(c) 0.0825 amp*
   (b) 0.75 amp *(d) 0.68 amp*

11. If all resistors in the diagram below have the same value, which network will produce 1.5 times the resistance of a single resistor?



12. If all resistors in the diagram above have the same value, which network will produce 0.66 times the resistance of a single resistor?

13. If a 30-millihenry and a 60-millihenry choke are connected in parallel, their combined inductance is:
   (a) 90 millihenrys *(c) 30 millihenrys*
   (b) 45 millihenrys *(d) 20 millihenrys*

14. A circuit described as having a "lagging power factor" is:
   (a) capacitive *(c) inductive*
   (b) tuned above resonance *(d) high frequency*

15. A purely inductive circuit has a phase angle of:
   (a) 90° *(c) 180°*
   (b) 45° *(d) zero*

16. How many cycles per second occur in a 10-kHz signal?
   (a) 10 *(c) 10,000*
   (b) 1000 *(d) 1,000,000*

17. Microwave frequencies are those from:
   (a) 10 kHz to 100 kHz *(c) 100 MHz to 1000 MHz*
   (b) 30 MHz to 300 MHz *(d) 5 GHz to 20 GHz*

18. The wavelength corresponding to 150 MHz is:
(a) 1.5 meters *(c) 15 meters*
(b) 2.0 meters *(d) 30 meters*

19. If the length of a Hertzian antenna is increased, its resonant frequency will:
(a) increase *(c) remain the same*
(b) decrease *(d) tend to drift*

20. One advantage of a full-wave rectifier over a half-wave rectifier is its:
(a) high output power *(c) higher ripple frequency*
(b) efficiency at high frequencies *(d) lower ripple frequency*

21. For maximum power transfer, the load impedance must be:
(a) twice source imp. *(c) as high as possible*
(b) half source imp. *(d) same as source imp.*

22. An open filter capacitor in a power supply will cause:
(a) high voltage output *(c) higher ripple frequency*
(b) no output voltage *(d) low output voltage*

23. The collector current of an "n-p-n" transistor will be:
(a) less than emitter current *(c) less than base current*
(b) greater than base current *(d) greater than emitter current*

24. The current gain in a grounded-emitter circuit is:
(a) greater than 1.0 *(c) less than 1.0*
(b) always 1.0 *(d) varying with signal level*

25. Excessive leakage current in a transistor can cause:
(a) more amplification *(c) less amplification*
(b) a short circuit *(d) high collector voltage*

26. A diode acts on a.c. by:
(a) amplifying *(c) rejecting*
(b) rectifying *(d) bypassing*

27. The control grid of a vacuum tube is similar to the:
(a) transistor emitter *(c) n-p-n junction*
(b) transistor collector *(d) transistor base*

28. The diagram is the schematic symbol for:

(a) n-p-n transistor *(c) SCS*
(b) p-n-p transistor *(d) SCR*

29. A power transistor can be spotted in a chassis by its:
(a) color coding *(c) insulation*
(b) large size *(d) lead configuration*

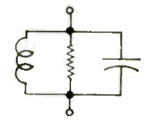
30. In most transistor circuits the emitter-base junction is:
(a) forward-biased *(c) back-biased*
(b) connected to a negative source *(d) grounded*

31. Emitter and cathode followers both have:
(a) low output impedance *(c) low input impedance*
(b) more than unity gain *(d) good regulation*

32. If the capacitance of a tank circuit in an oscillator is increased, the output signal will:
(a) increase in freq. *(c) remain unchanged*
(b) decrease in freq. *(d) decrease in amplitude*

33. A series LC circuit, resonant at 6 MHz, acts as a:
(a) resistance at 7 MHz *(c) capacitive reactance at 7 MHz*
(b) inductive reactance at 7 MHz *(d) inductive reactance at 5 MHz*

34. If the resistor in the diagram is increased in value, then:



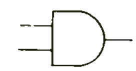
(a) resonant frequency increases
(b) resonant frequency decreases
(c) "Q" is increased
(d) "Q" is decreased

35. The voltage waveform at the horizontal plates of an oscilloscope is usually a:
(a) pulse *(c) sawtooth*
(b) sine wave *(d) combination of (a) and (c)*

36. If the same sine-wave signal is applied to the vertical and horizontal plates of an oscilloscope, the pattern on the screen will be a:
(a) straight line *(c) circle or ellipse*
(b) figure-8 *(d) sine wave*

37. Video frequencies are those between:
(a) d.c. and 10 MHz *(c) 10 MHz and 100 MHz*
(b) 100 Hz and 100 kHz *(d) 40 MHz and 50 MHz*

38. The symbol of the diagram usually means a:



(a) flip-flop *(c) "and" gate*
(b) "or" gate *(d) inverter*

39. IC flat packs usually have a maximum of:
(a) 14 leads *(c) 16 leads*
(b) 8 leads *(d) 6 leads*

40. The one type of logic not yet invented is:
(a) TTL *(c) RTL*
(b) DTL *(d) KLL*

41. The term "fan out" refers to a circuit's:
(a) frequency cut-off *(c) bandwidth*
(b) driving capability *(d) gain*

42. A transformer matching a 1000-ohm source to a 10-ohm load must have a turns ratio of:
(a) 1:100 *(c) 1:4*
(b) 1:10 *(d) 1:2*

43. The iron core of a transformer causes:
(a) good bandwidth *(c) magnetic flux*
(b) heat dissipation *(d) eddy current*

44. A high v.s.w.r. is usually due to:
(a) lossy transmission line *(c) impedance mismatch*
(b) low signal level *(d) lack of gain*

45. A directional coupler usually has:
(a) 3 ports *(c) a diode inside*
(b) no losses *(d) a balanced output*

46. The sound carrier on commercial TV is modulated by:
(a) AM *(c) PCM*
(b) FM *(d) phase modulation*

47. Commercial TV receivers always use a:
(a) circular scan *(c) sequential scan*
(b) interlaced scan *(d) PPI type scan*

48. The short-wave Citizens Band is at approximately:
(a) 30 MHz *(c) 455 kHz*
(b) 10 MHz *(d) 27 MHz*

49. Best tape recording fidelity is obtained at:
(a) 3¾ in/s *(c) 7½ in/s*
(b) 1⅞ in/s *(d) 5½ in/s*

50. The scratch filter in a hi-fi set is a:
(a) bandpass filter *(c) high-pass filter*
(b) low-pass filter *(d) constant-k filter*

RADIO-TV SERVICE ORGANIZATIONS

(Association officers or leaders of state or local groups who may be contacted for additional information on how to become affiliated with a group in your area.)

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Frank J. Moch, Exec. Director, 5908 S. Troy, Chicago, Ill. 60629
NEA, National Electronic Associations, Inc., Dick Glass, Exec. Vice Pres.
7046 Doris Dr., Indianapolis, Ind. 46224. Ph (317) 241-7783

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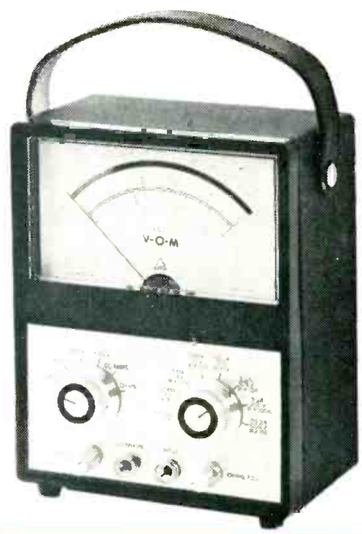

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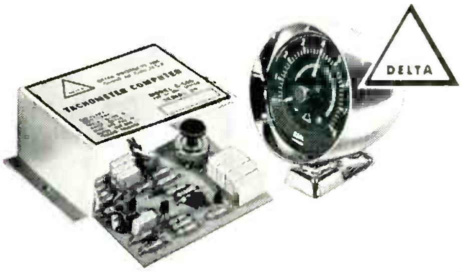

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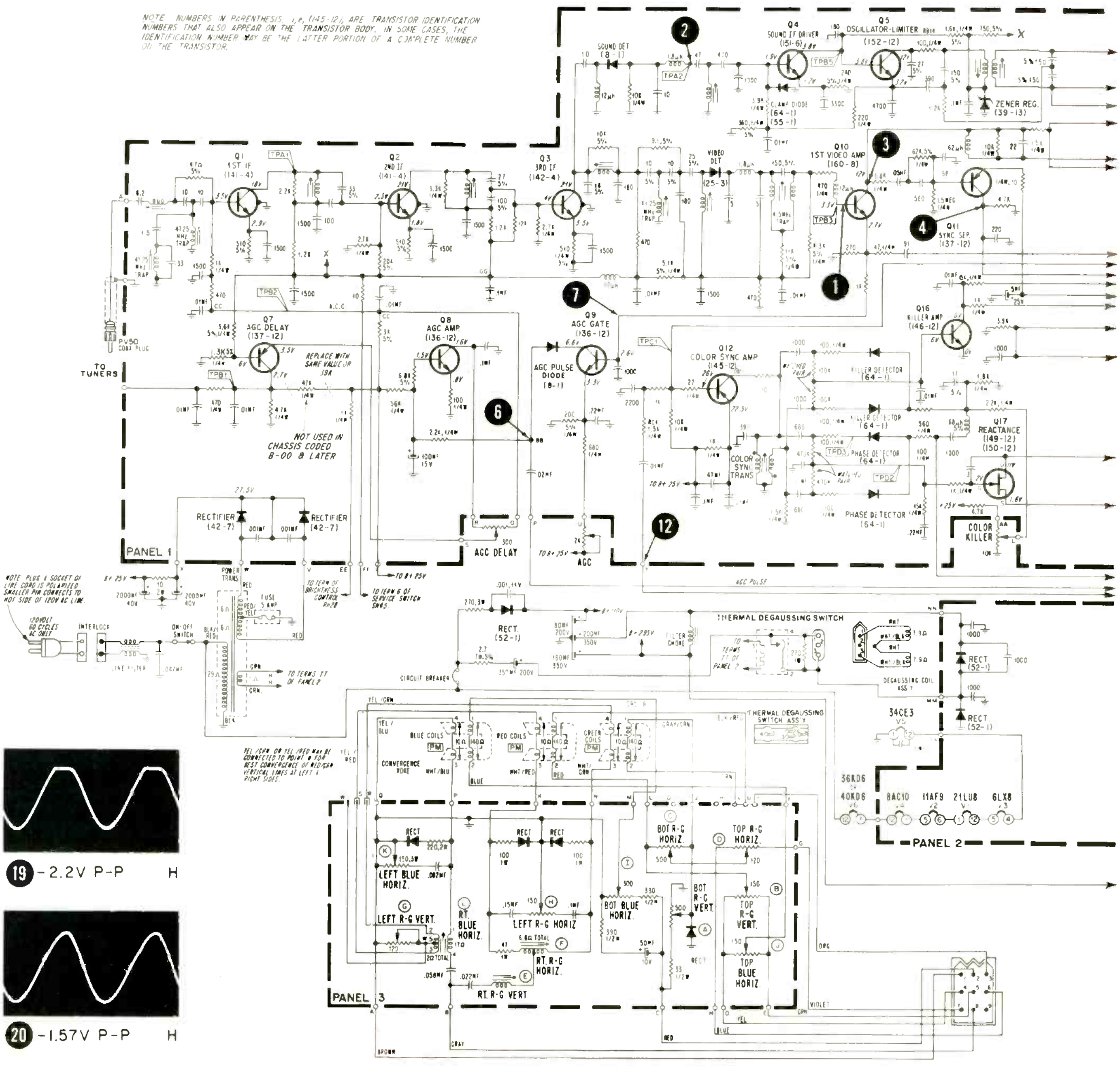
CIRCLE NO. 7 ON READER SERVICE PAGE

MOTOROLA 16TS-930

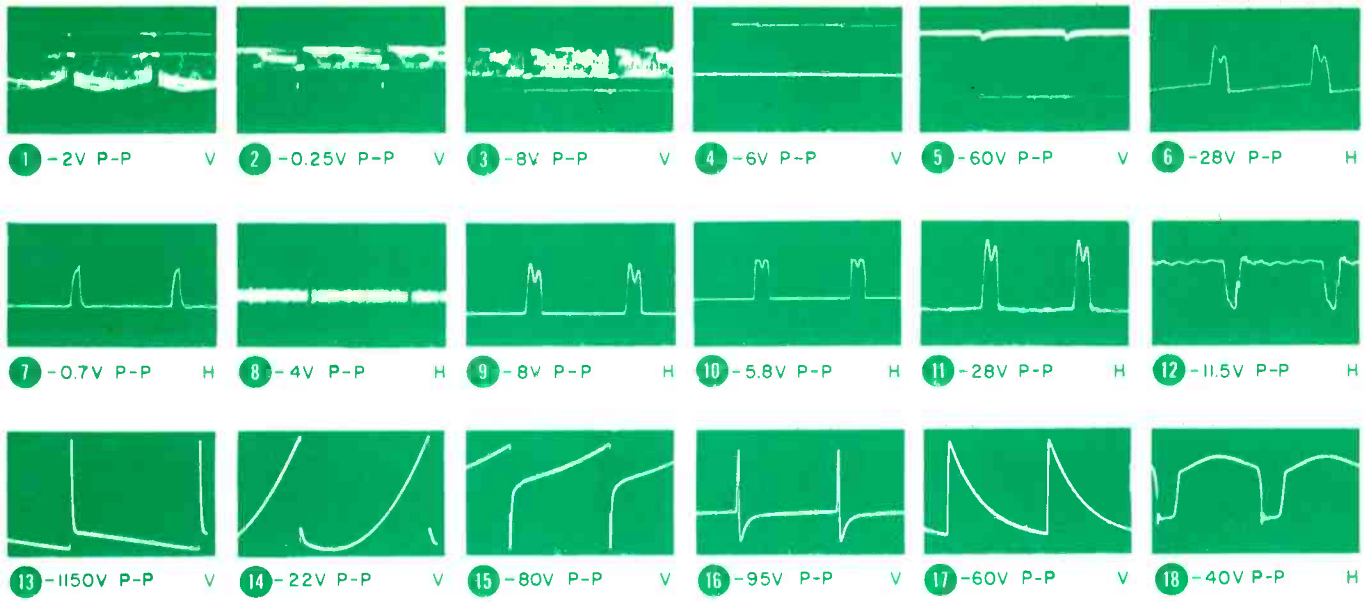
COLOR-TV CIRCUIT

The new 16TS-930 chassis, with its 16-in picture tube, is used in two portable color-TV models, the Model CP462F and the Model CP463F. Two etched panels are used for this hybrid chassis. One of the panels contains all tubes except the horizontal output and damper, and is designed to handle the high-power circuitry. The other panel contains all transistors with the exception of the audio output and handles signal circuits and the low-power stages. A new system of component identification is used in which panels are divided into zones for easy part location.

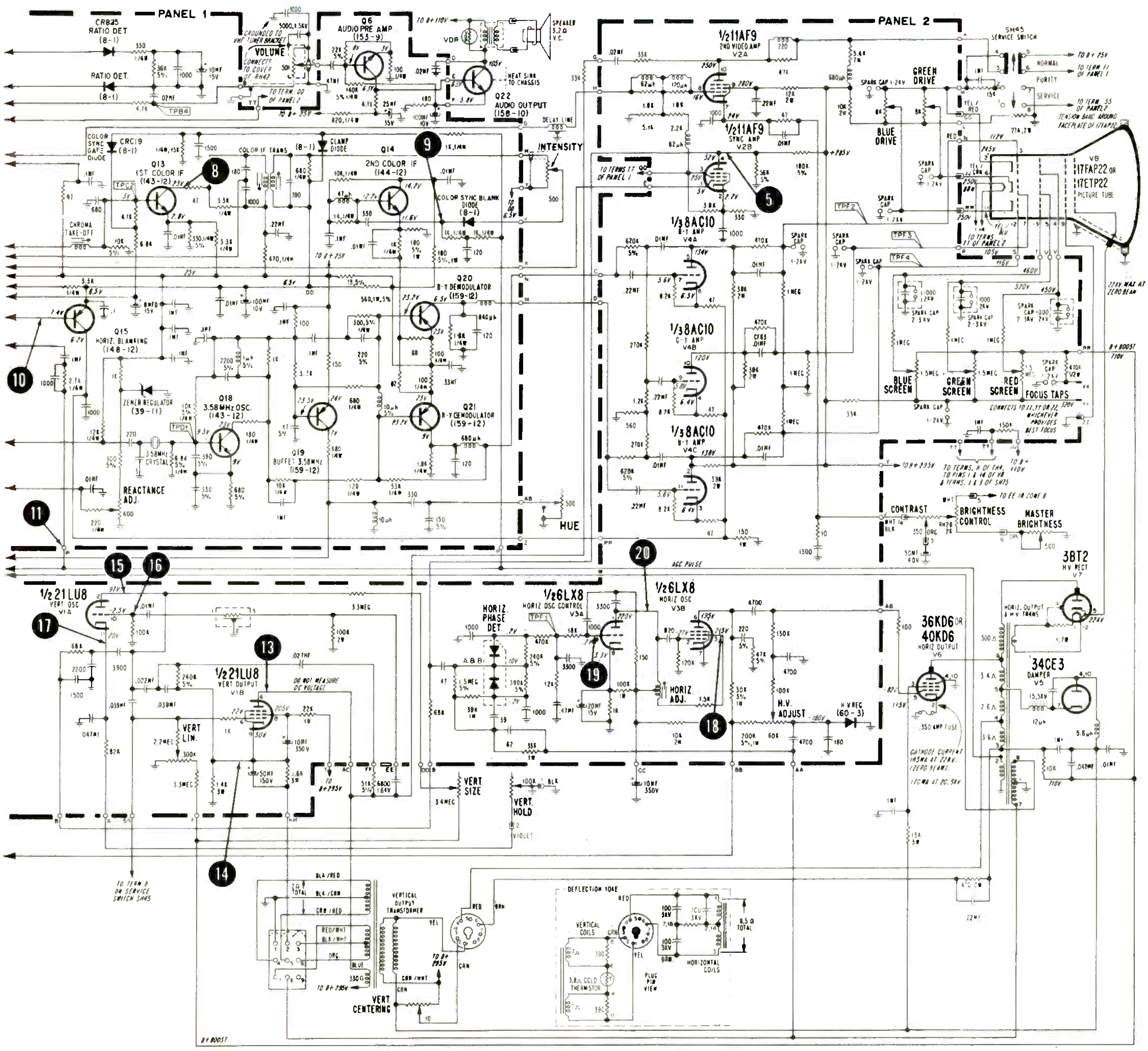


19 - 2.2V P-P H

20 - 1.57V P-P H



1 -2V P-P V
2 -0.25V P-P V
3 -8V P-P V
4 -6V P-P V
5 -60V P-P V
6 -28V P-P H
7 -0.7V P-P H
8 -4V P-P H
9 -8V P-P H
10 -5.8V P-P H
11 -28V P-P H
12 -11.5V P-P H
13 -1150V P-P V
14 -22V P-P V
15 -80V P-P V
16 -95V P-P V
17 -60V P-P V
18 -40V P-P H



PANEL 1
PANEL 2
CRB25 RATIO DET (8-1)
RATIO DET. (8-1)
VOLUME
Q6 AUDIO PRE AMP (153-9)
VDR
SPEAKER 3.2 Ω V.C.
Q22 AUDIO OUTPUT (158-10)
DELAY LINE
INTENSITY
½11AF9 2ND VIDEO AMP V2A
½11AF9 SYNC AMP V2B
GREEN DRIVE
BLUE DRIVE
SH45 SERVICE SWITCH
NORMAL
SERVICE
V8 17FAP22 OR 17ETP22 PICTURE TUBE
COLOR SYNC GATE DIODE
CRC19 (8-1)
Q13 1ST COLOR IF (143-12)
COLOR IF TRANS
CLAMP DIODE
Q14 2ND COLOR IF (144-12)
COLOR SYNC BLANK DIODE (8-1)
CHROMA TAKE-OFF
⅓8AC10 R-Y AMP V4A
⅓8AC10 G-Y AMP V4B
⅓8AC10 B-Y AMP V4C
Q15 HORIZ. BLANKING (148-12)
Q20 R-Y DEMODULATOR (159-12)
ZENER REGULATOR (39-11)
Q18 3.58MHz OSC. (143-12)
Q19 BUFFER 3.58MHz (159-12)
Q21 B-Y DEMODULATOR (159-12)
REACTANCE ADJ.
HUE
BLUE SCREEN
GREEN SCREEN
RED SCREEN
FOCUS TAPS
CONTRAST
BRIGHTNESS CONTROL
MASTER BRIGHTNESS
3BT2 HV RECT V7
½21LU8 VERT OSC V1A
½26LX8 HORIZ OSC CONTROL V3A
½26LX8 HORIZ OSC V3B
HORIZ. PHASE DET.
AGC PULSE
½21LU8 VERT OUTPUT V1B
DO NOT MEASURE DC VOLTAGE
VERT LIN.
HORIZ. ADJ.
H.V. ADJUST
H.V REG (60-3)
36KD6 OR 40KD6 HORIZ OUTPUT V6
34CE3 DAMPER V5
VERT SIZE
VERT HOLD
VERTICAL OUTPUT TRANSFORMER
VERT CENTERING
DEFLECTION YOKE
VERTICAL COILS
HORIZONTAL COILS

Electric Shock

By JOHN FRYE

It is foolhardy for radio/TV technicians, or for that matter anyone, to remain in ignorance about the nature of electrical shock and the methods of resuscitation.

"HEY, Mac," Barney said to his employer as the two of them sat side by side on the service bench drinking a couple of Cokes Matilda, the office girl, had brought in from the drugstore next door, "do you remember our talking two or three weeks ago about the alarming number of people believed to be accidentally electrocuted in homes and at work each year?"

"Yup," Mac answered with a mouth full of cracked ice.

"Well, that started me thinking: here we are working with all sorts of voltages and currents day after day; yet I know precious little about the nature of potentially lethal electric shock or methods of resuscitation. Suddenly that seemed about as smart as for a snakehouse operator to be ignorant of reptiles and to be without snake-bite serum."

"So what did you do about it?"

"Boned up on both departments. Reading helped a lot; but I also checked with Red Cross headquarters, the new intensive-care unit at the hospital, and the emergency squad at the fire department. As a result, I now feel I know a lot more than I did about how electricity can injure the body and how to counteract the effect of such injury."

"And if I know you," Mac said with a pretended sigh of resignation, "I'm about to become the beneficiary of your new knowledge."

"You're darned tootin'," Barney said. "After all, it's more important that you know all this than that I should know it, because what *you* know may save *my* life."

"That's what I like about you: always looking out for the other fellow! But what does electricity do to the body?"

"Lots of things, mostly bad, at least when applied accidentally. A high-voltage current can arc at the point of contact and sear the flesh there. This you can see. But an autopsy often reveals that heavy current literally cooks the flesh along the entire pathway through the body. Currents heavy enough to raise body temperature appreciably produce immediate death. Relatively high currents may produce fatal damage to the central nervous system. Such currents flowing near the heart may cause cardiac arrest, and those flowing through other nerve centers can stop breathing."

"You're talking about heavy currents such as would be produced by contact with a high-voltage line, but a high percentage of electrocutions are produced by household voltages. How much current is really dangerous?"

"That's a good question, and C. F. Dalziel of the University of California and W. R. Lee of the University of Manchester tried to find some answers. Their findings are written up under the title 'Lethal Electric Currents' in the IEEE *Spectrum* for February, 1969. The first thing they wanted to find out was the let-go current for human beings."

"Hold it!" Mac interrupted. "What's a 'let-go current'?"

"It's the maximum current at which a person can still release a conductor by using muscles being stimulated by that current. It's very important because a person can withstand repeated shocks by current below this value—at least stand them long enough to turn loose—but a slightly higher current 'freezes' the victim to the conductor. Since the damaging effect of electric shock is a function of both the amount of current and the length of time the body is subjected to it, you can see the critical let-go current, which determines whether or not the victim can voluntarily free himself from the electrical circuit, is most important.

"Dalziel and Lee exposed 134 men and 28 women to increasing current to determine how much each could take and still be able to release the small wire carrying the shocking current to their hands. The average let-go current was found to be 16 mA for men and 10.5 mA for women. While physiological development, especially in the arms and wrists, greatly influenced the let-go current, psychological factors played a part, too. The highest let-go current was obtained on a physiology student who boasted he was as good as any engineering student."

"I'm not sure average values are of much use in a case like this," Mac objected. "I still remember the guy who drowned in a river that 'averaged' only a foot deep."

"The gentlemen doing the testing agreed with you; so they decided a reasonably safe limit for electric shock would be the 0.5 percentile let-go value. On this basis, it was found safe let-go currents could be considered approximately 9 mA for men and 6 mA for women. Incidentally, no essential difference was found between 50 and 60 Hz as far as let-go current was concerned.

"Next the gentlemen turned to finding the minimum fibrillating current. As you know, the several causes of ventricular fibrillation include the flowing of electric current through the heart muscle. While this current does not actually damage the heart, it deranges the functioning of that organ. Individual muscle fibers are thrown out of sync, so to speak, and are no longer coordinated. Instead of working together to produce the rhythmic, life-giving pumping of blood through the body, they contract individually and at random, resulting in a twitching, trembling of the heart that renders it useless for circulation.

"Ventricular fibrillation is considered the most dangerous electric shock hazard because once it starts in man, it practically never stops spontaneously; *yet the brain begins to die two to four minutes after it is deprived of a supply of oxygenated blood.* If the victim is to be saved, he must receive prompt rescue and immediate and continuous artificial respiration until other resuscitating measures are available."

"I'm curious as to how the minimum fibrillating cur-

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CIRCLE NO. 4 ON READER SERVICE PAGE

Editor's Note: *Early this year a new Standard for Leakage Current for Appliances (C101.1), sponsored by* Underwriters' Laboratories, *was published for trial and study. The proposed standard is for 120-volt appliances, including radios and TV's, that are connected by 2-wire flexible cords to the a.c. power line. The maximum a.c. leakage current is not to exceed 0.5 mA (r.m.s.) between all exposed conductive surfaces of the appliances to the neutral or grounded side of the power line. The measurement is to be made across a meter terminal impedance consisting of a 1500-ohm resistor shunted by a 0.15-μF capacitor. This* RC *circuit simulates the impedance of the human body under such potentially dangerous conditions as when one's fingers are wet. With a leakage current of 0.5 mA flowing through 1500 ohms, the a.c. voltage drop amounts to 0.75 volt. Measurements are taken with the appliance turned on and with the a.c. line applied first one way and then reversed.*

---

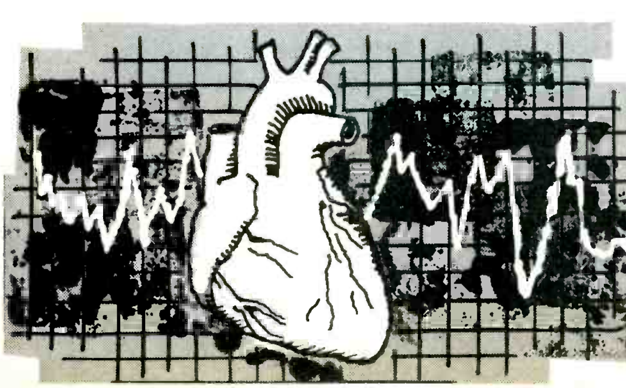
rent for human beings was determined. Sounds like a great place for non-destructive testing."

"You can say that again! Any current above the let-go value is considered dangerous; so the only recourse is to extrapolate results obtained on animals to man. This introduces uncertainties, but it's the best we can do. Most of our previous information came from work done by Ferris in 1936 at Columbia University and the *Bell Telephone Laboratories;* by Kouwenhoven in 1959 at Johns Hopkins University; and by Kiselev in 1963 at the U.S.S.R. Academy of Sciences, Moscow. In 1968 Dalziel and Lee presented a new analysis relating mimimum fibrillating current to both body weight and shock duration.

"The experimenters electrocuted dogs, pigs, sheep, and calves totalling in the hundreds to obtain their information. The test procedure was to apply a series of well-spaced shocks of gradually increasing intensity until fibrillation occurred. Electrodes were applied to the right front limb and the opposite rear limb so current flowed through the animal's chest. The 0.5 percentile values were again used to indicate either the maximum non-fibrillating current or the minimum fibrillating current.

"I'll not try to tell you about the various individual findings, but they boil down to this: the minimum current causing ventricular fibrillation is proportional to body weight and inversely proportional to the square root of shock duration. In 50-kg mammals, the relationship is approximately 116 to $185/\sqrt{T}$ mA. It is believed unlikely that a normal adult will experience fibrillation if the shock intensity is less than $116/\sqrt{T}$ mA, where T is in seconds. For example, this works out to be about 58 mA for a four-second shock."

"So that's how you start fibrillation. I'm more interested in how you stop it, or rather how you revive a victim of electric shock."



Before answering, Barney fished a final piece of ice from his glass with his fingers and popped it into his mouth. "One of the best sources of that information I've found," he said, "is the *Resuscitation Manual, A Guide for Electric Utility Companies,* published by the Edison Electric Institute at 750 Third Avenue, New York City. It stresses that the victim should be freed from contact with the current as quickly as humanly possible with safety to the rescuer for two reasons: (1) the longer the current flows through the victim's body, the greater is the likelihood of irreversible injury, and (2) the sooner artificial respiration is started, the better his chance for survival. If he is not breathing or his blood is not circulating, the possibility of successful revival declines steeply with every passing minute and becomes extremely low after about four minutes.

"The actual method of artificial respiration used will depend on the victim's injuries. Mouth-to-mouth insufflation is the best because it assures positive movement of air into the lungs, but facial injuries sometimes make this impossible. By the same token a broken arm or fractured ribs may make the Back Pressure-Arm Lift method inadvisable. The point is that a person should be acquainted with two or three methods of artificial respiration, and an excellent step-by-step diagrammed source is that *Resuscitation Manual* I mentioned or *A Supplement on Artificial Respiration* issued by the American Red Cross. Better still is to attend a class on this subject put on by the Red Cross or some other safety organization where actual demonstrations on dummies or models are used. Seeing artificial respiration given by an expert or practicing it yourself under supervision is far superior to getting your knowledge from diagrams in a book, for this is a case where a little knowledge can be a dangerous thing. This also applies to external cardiac compression used to start a reluctant heart by compressing the chest with the heel of the hand so the heart is squeezed between the sternum and the backbone some sixty times a minute to provide artificial circulation of the blood because this should not be done if the victim has a pulse, if his ribs are broken, or if his pupils remain widely dilated.

"The main thing is to keep artificial respiration going until the patient starts breathing on his own or until a doctor declares him dead. Rigidity is not necessarily a sign of *rigor mortis* because muscular tension is always present in electric shock cases. All else failing, a 'defibrillator' may be used by a doctor to stop fibrillation. This is a hair-of-the-dog-that-bit-him technique because it syncs the uncoordinated heart muscles with a current of up to fifteen amperes sent through electrodes attached to the chest for from 0.1 to 0.5 second."

"Let's see if I have all this," Mac recapitulated: "A current as low as 9 mA can freeze a man to a current-carrying conductor. Slightly more current can start his heart fibrillating. If his heart is not freed from this condition by external means within four minutes, his chance of survival is very poor. Artificial respiration, external cardiac compression, and the use of a de-fibrillator comprise his best hope of being revived. But artificial respiration and cardiac compression techniques should be properly learned to be really effective."

"You get A on the course!" Barney applauded. ●

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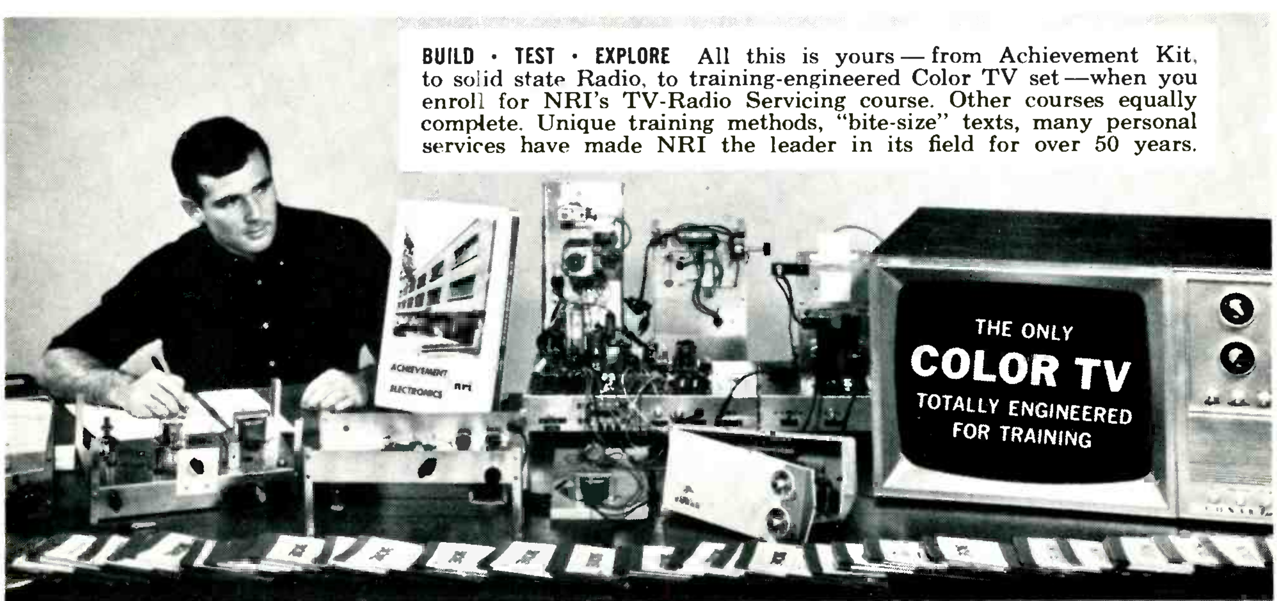
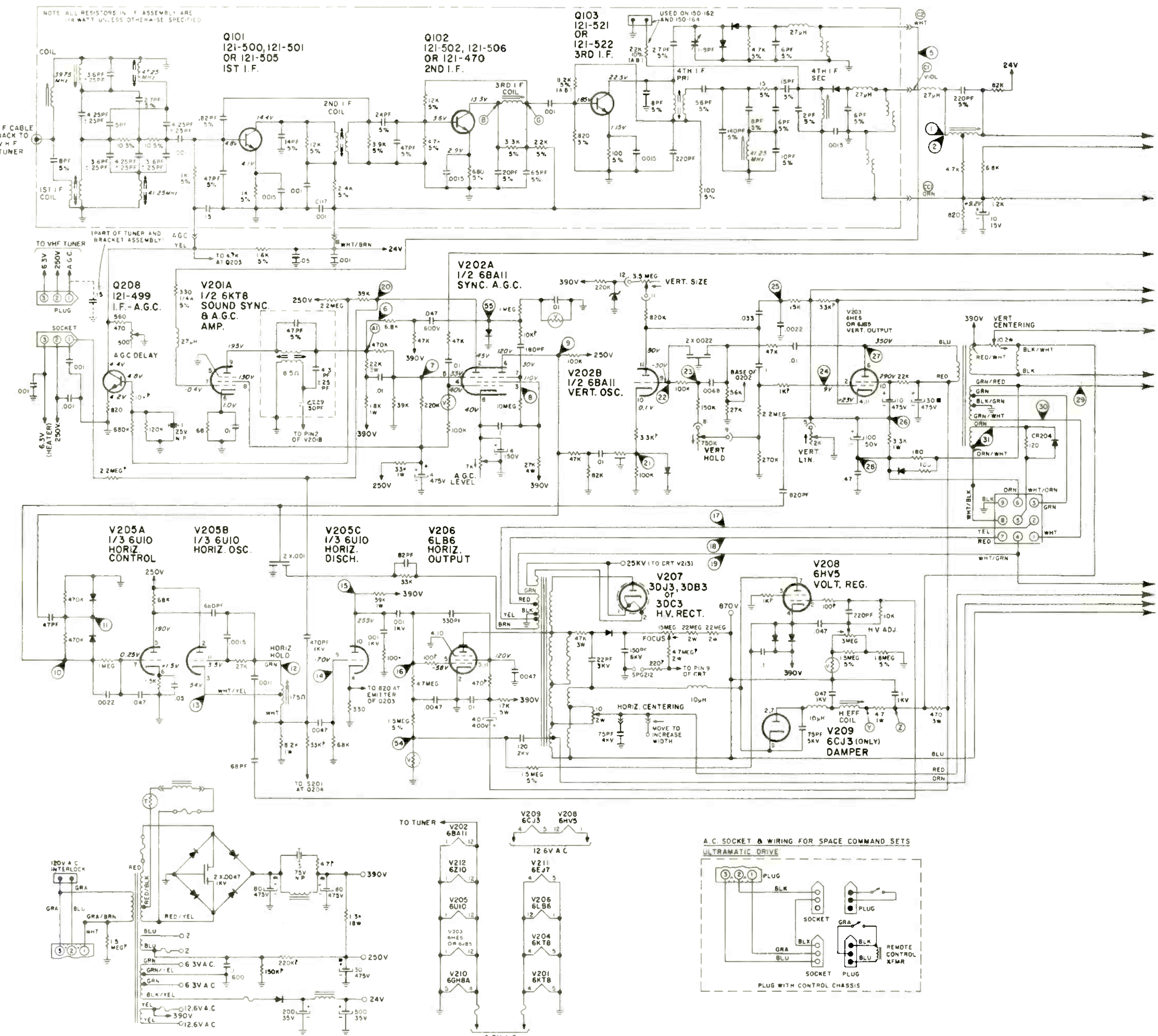
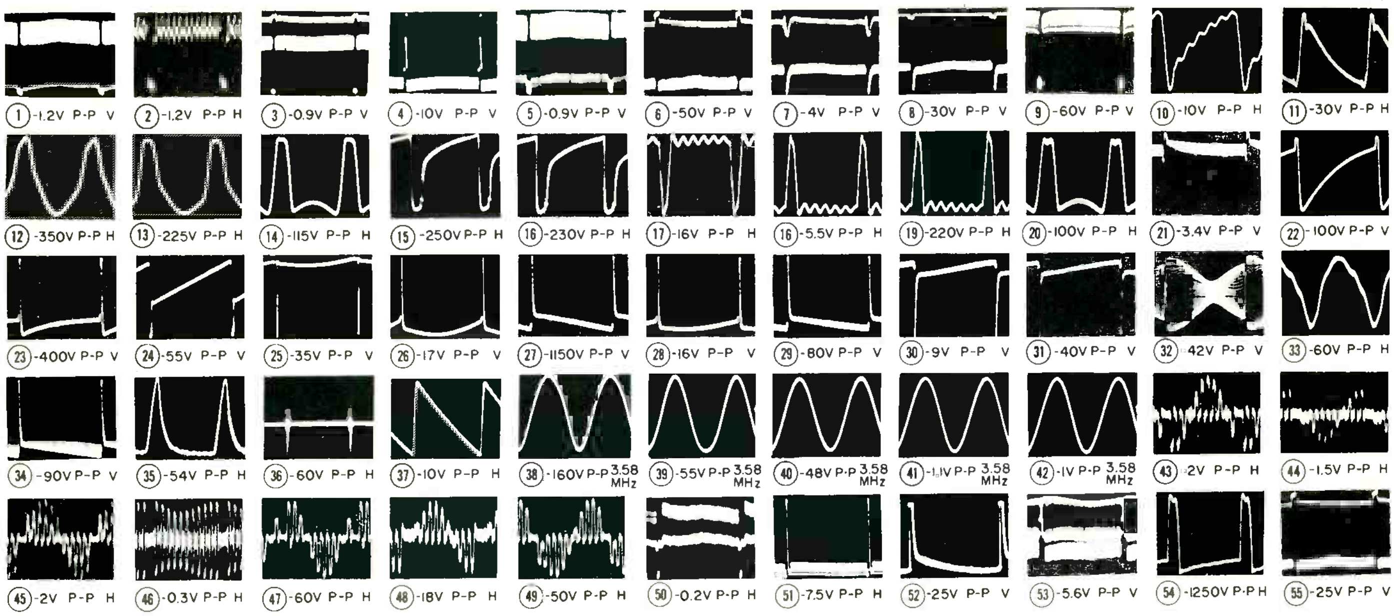


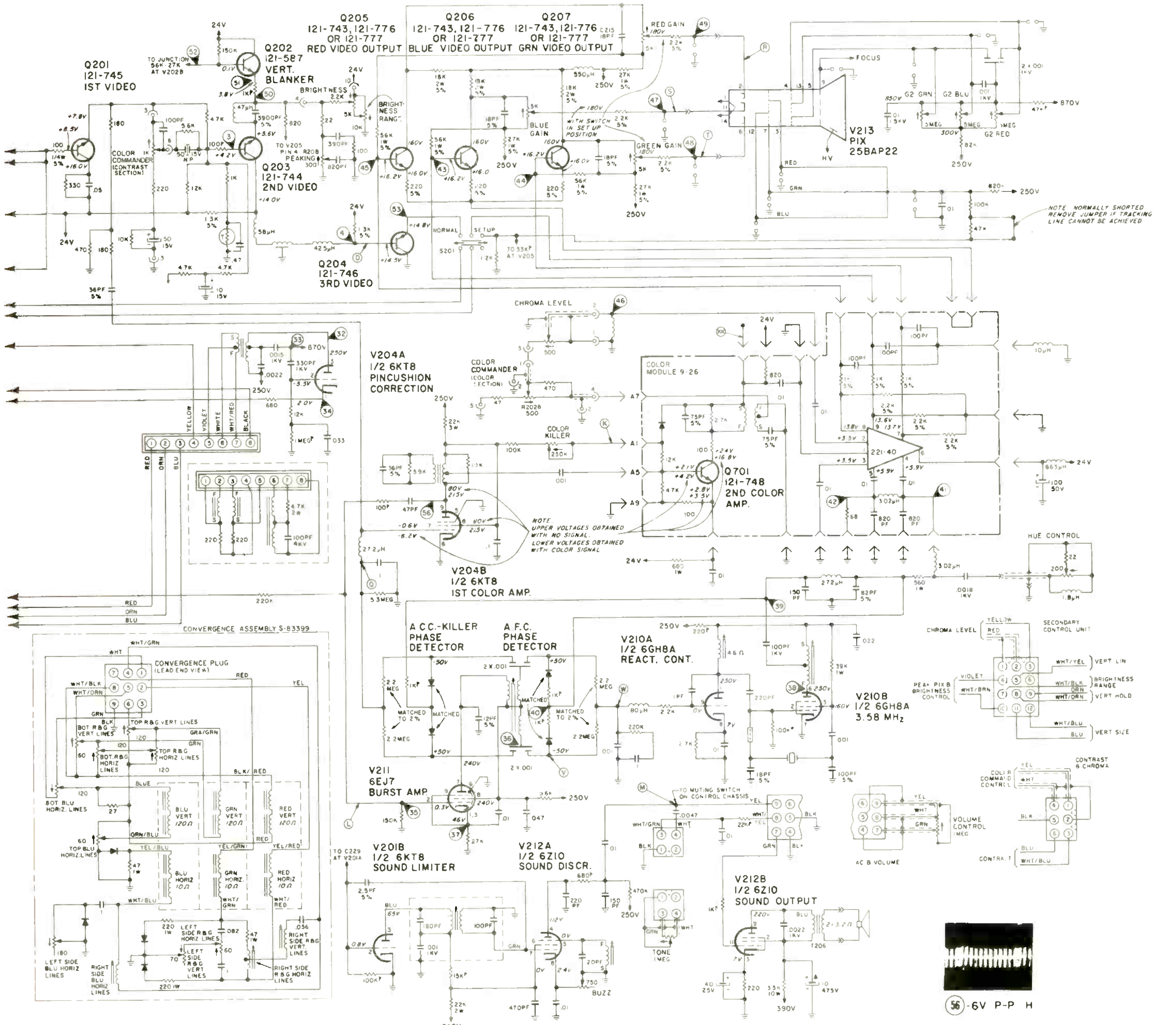
ZENITH 12A12C52

COLOR-TV CIRCUIT

This new hybrid chassis, with its transistors and IC color demodulator, uses a 23-in picture tube. It is employed in a large number of current Zenith top-of-the-line consoles, including some with remote-control provisions. These models are the A4519, -20, -24, -25, -26, -28, -30, -33, -38, -39, -42; A6519, -25, -28, -33, -38, -39, -42, -46, -48; A8532, -34, -70; and T2994, -95, -97. Models with the series of numbers beginning with A65 and T29 are remote-control sets; those beginning with A85 are console-combinations.




1 -1.2V P-P V
2 -1.2V P-P H
3 -0.9V P-P V
4 -10V P-P V
5 -0.9V P-P V
6 -50V P-P V
7 -4V P-P V
8 -30V P-P V
9 -60V P-P V
10 -10V P-P H
11 -30V P-P H
12 -350V P-P H
13 -225V P-P H
14 -115V P-P H
15 -250V P-P H
16 -230V P-P H
17 -16V P-P H
16 -5.5V P-P H
19 -220V P-P H
20 -100V P-P H
21 -3.4V P-P V
22 -100V P-P V
23 -400V P-P V
24 -55V P-P V
25 -35V P-P V
26 -17V P-P V
27 -1150V P-P V
28 -16V P-P V
29 -80V P-P V
30 -9V P-P V
31 -40V P-P V
32 42V P-P V
33 -60V P-P H
34 -90V P-P V
35 -54V P-P H
36 -60V P-P H
37 -10V P-P H
38 -160V P-P 3.58 MHz
39 -55V P-P 3.58 MHz
40 -48V P-P 3.58 MHz
41 -1.1V P-P 3.58 MHz
42 -1V P-P 3.58 MHz
43 2V P-P H
44 -1.5V P-P H
45 -2V P-P H
46 -0.3V P-P H
47 -60V P-P H
48 -18V P-P H
49 -50V P-P H
50 -0.2V P-P H
51 -7.5V P-P H
52 -25V P-P V
53 -5.6V P-P V
54 -1250V P-P H
55 -25V P-P V


Q201 121-745 1ST VIDEO
Q202 121-587 VERT. BLANKER
Q203 121-744 2ND VIDEO
Q204 121-746 3RD VIDEO
Q205 121-743, 121-776 OR 121-777 RED VIDEO OUTPUT
Q206 121-743, 121-776 OR 121-777 BLUE VIDEO OUTPUT
Q207 121-743, 121-776 OR 121-777 GRN VIDEO OUTPUT
V213 PIX 25BAP22
V204A 1/2 6KT8 PINCUSHION CORRECTION
V204B 1/2 6KT8 1ST COLOR AMP.
Q701 121-748 2ND COLOR AMP.
COLOR MODULE 9-26
V210A 1/2 6GH8A REACT. CONT.
V210B 1/2 6GH8A 3.58 MHz
A.C.C.-KILLER PHASE DETECTOR
A.F.C. PHASE DETECTOR
V211 6EJ7 BURST AMP.
V201B 1/2 6KT8 SOUND LIMITER
V212A 1/2 6Z10 SOUND DISCR.
V212B 1/2 6Z10 SOUND OUTPUT
CONVERGENCE ASSEMBLY S-83399
CONVERGENCE PLUG (LEAD END VIEW)
CHROMA LEVEL
HUE CONTROL
56 -6V P-P H

TV-FM Lead-in: What Kind to Use?

By THOMAS R. HASKETT

How to select the right kind of lead-in for your antenna. A complete rundown of all the various types now available, their performance, and cost.

IN some localities, an indoor TV or FM antenna works fine. But in most locations, you need an outside antenna to get a clean TV picture or good FM sound. To use an outdoor antenna, you need lead-in wire, to carry the r.f. signal from the antenna to the receiver. But you cannot simply connect any type of wire between the antenna and receiver. You have to use the right kind, and there are several types on the market. Here's how to select the right one for your installation.

Lead-in Requirements

To do the job properly, lead-in wire must meet certain requirements.

1. The lead-in must match the impedance of the antenna, and that of the receiver's antenna-input circuit. Most TV and FM receiving antennas are 300-ohm types, and most TV and FM receivers similarly have 300-ohm inputs. You can get either 300- or 75-ohm lead-in, and you can get transformers to match 300 ohms to 75, and *vice versa*.

2. The lead-in should attenuate the r.f. signal as little as possible (or cause as little signal loss as possible), because if the signal is too weak when it reaches the receiver, you'll get a snowy picture or a noisy FM signal. If you live in a high-signal area near the broadcast stations, this may be no problem. But if you live in a near-fringe or fringe area, you may need lead-in with the lowest possible loss. And color-TV and stereo-FM are even more sensitive to signal attenuation.

3. The lead-in should not add anything to the signal it gets from the antenna, that is, the lead-in itself should not pick up any direct r.f. signal, whether from TV or FM stations, or other radio signals, or noise (ignition or otherwise). If the lead-in does pick up other signals, such signals cause interference in the TV picture or FM sound. Of course, no lead-in is perfect, and all pick up *some* spurious signals. But some pick up less than others. If you live in a sparsely settled area you won't have to worry much about unwanted lead-in pickup, for there won't be much r.f. around. But if you live in an urban area, spurious r.f. and noise may be heavy in your neighborhood. Even if spurious r.f. and noise are no problem, direct pick up of the TV signal by the lead-in causes ghosting to the picture or multipath distortion with FM.

4. The lead-in should be durable, since it's outside the house and exposed to wind, snow, ice, sun, rain, soot, and salt. All of these elements deteriorate the plastic insulation or jacket of the lead-in eventually; some go bad sooner than others. Also, with some lead-in types, rain, snow, and ice make the TV picture or FM sound worse. Obviously, long life is a desirable lead-in characteristic, as you have to replace the lead-in less often, and it costs you less in the long run.

5. The lead-in should be easy to install. A lead-in which is sensitive to nearby metal objects (6″ or closer) is more difficult to install than one which is not, because most houses have such metal objects as rain gutters and downspouts on the eaves and corners, and you have to avoid them when running the lead-in. The same consideration applies to lead-in types which are sensitive to nearby a.c. lines. With some lead-in types, also, the use of metal-ring stand-off insulators can be detrimental to signals; you have to use nonmetallic stand-offs.

6. The lead-in should be reasonably priced. You can buy very good lead-in which will do quite well in meeting all the preceding requirements. But it may cost several times what more common types do.

Stereo-FM, Color-TV, and U.h.f.

All lead-in types attenuate the signal somewhat. This attenuation increases as the length of the lead-in does, and it also increases with the signal frequency.

Since the noise level is generally constant at the receiver r.f. input, the greater the signal losses in the lead-in, the noisier the signal, or the snowier the picture.

For good stereo-FM, you need a fairly clean r.f. signal, for noise degrades stereo separation by interfering with the relatively weak 19-kHz pilot and the stereo-AM sidebands around 38-kHz. Similarly, for good color-TV you also need a fairly clean signal, for noise easily degrades the 3.58-MHz color subcarrier and the color difference signals. In both stereo-FM and color-TV, the additional information is multiplexed on the main carrier at a lower level than main-channel information, making it more susceptible to interference. Also, stereo-FM and color-TV receiver bandwidths are usually greater than those of mono-FM and black-and-white TV. The greater the bandwidth of any system, the more susceptible to noise that system is.

In the days of only mono-FM and black-and-white TV, considerable lead-in loss was tolerated. Ghosts and noise weren't so noticeable. Today, unless you don't plan to enjoy stereo or color, you should install lead-in capable of handling both.

U.h.f.-TV signals also make stringent demands on lead-in. V.h.f.-TV signals range from 54 to 216 MHz, while the u.h.f. band runs from 570 to 890 MHz. Since lead-in losses increase with frequency, this means that some types will work satisfactorily at v.h.f., but not at u.h.f.

Nearly every part of the country has at least one u.h.f. station on the air, and more are coming on every month. By federal law, all new TV receivers sold in interstate commerce must be capable of receiving both v.h.f. and u.h.f. Therefore, any new antenna and lead-in installation should be all-channel.

Basic Lead-in Types

The most common type of TV-FM lead-in for many years has been ordinary *flat twin-lead,* as shown in Fig. 1A. It has a characteristic impedance of 300 ohms, to match the impedances of most antennas and receivers. It is balanced to ground (that is, neither side is grounded) and unshielded.

Less popular until recently is *coaxial cable* (Fig. 1B). Its impedance is in the range of 72-75 ohms. Since few antennas and receivers can match this impedance, transformers are usually required at both ends of the cable, to match the 300-ohm terminals. Coax is unbalanced (the outside conductor is grounded) and shielded. (Since the matching transformer used with coax converts a *bal*anced *line to un*balanced, it's often called a *balun.*)

More recently, a lead-in has been developed which combines the best feature of both twin-lead and coax. Called *shielded twin-lead* (Fig. 1C), it has 300-ohm impedance, is balanced to ground, and is also shielded.

As Fig. 3 shows, there are differences between coax and the two types of twin-lead in the distribution of the electromagnetic and electrostatic lines of force which surround the conductors. These lines are produced by the current and voltage of the signal moving through the lead-in, and if the lines are disturbed, the signal may be impaired.

In ordinary twin-lead (Fig. 3A), many of the lines of force extend away from the conductors, which is why you cannot run twin-lead near metal objects. Coax overcomes this difficulty (Fig. 3B), as most of the lines are concentrated within the shield. The same is true of shielded twin-lead (Fig. 3C).

But there is a significant difference between coax and shielded twin-lead, regarding construction and performance. There are only *two* conductors in coax. In most types the outer conductor is a woven metallic braid; in others, it is a solid sheet of metal foil. The foil is slightly more effective as a shield. But since there are only two conductors, the shield carries current, which means that any interference is present in the signal circuit.

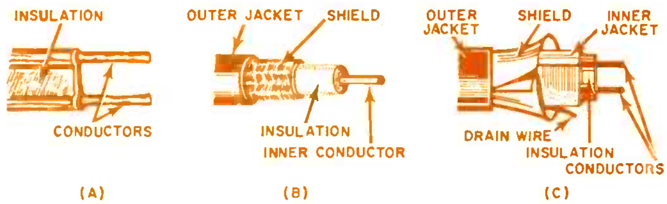


Fig. 1. Common types of lead-in include (A) flat twin-lead, (B) coaxial cable, and (C) shielded twin-lead cable.

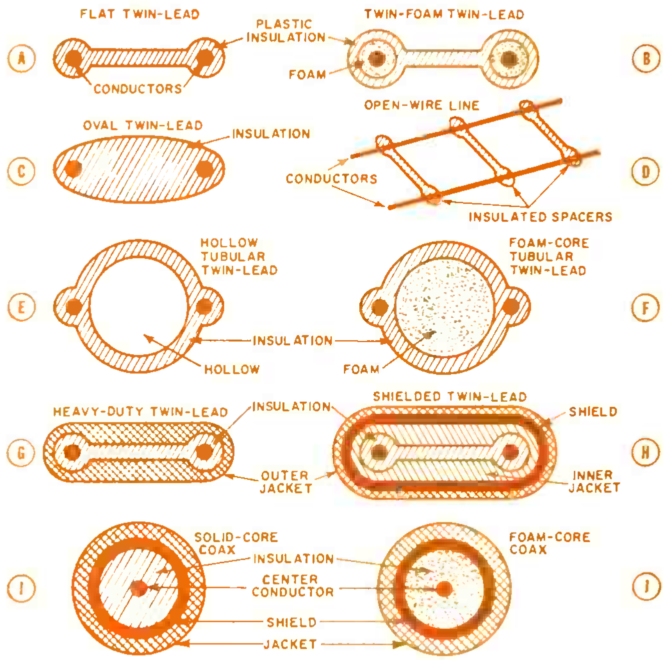


Fig. 2. Cross-sections of various types of lead-in.

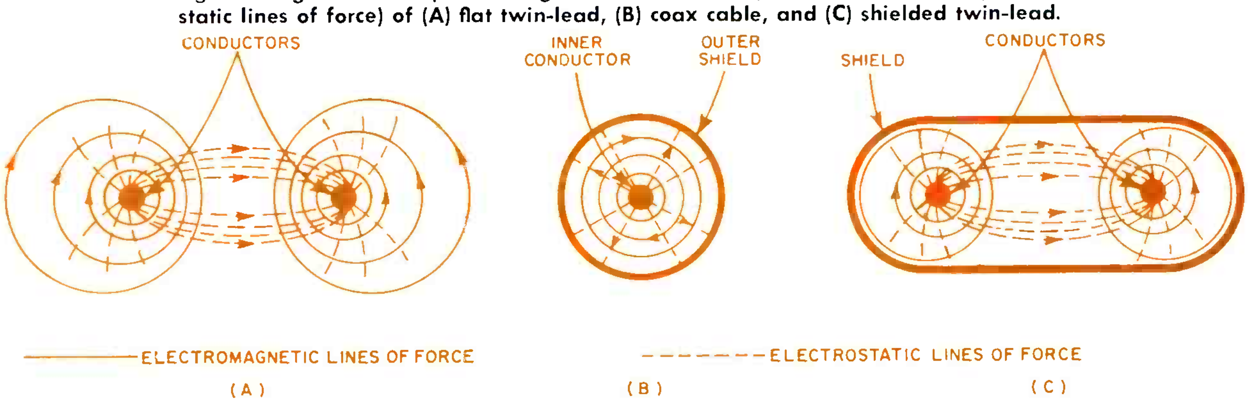
In shielded twin-lead, on the other hand, there are *three* conductors. The two inner conductors carry the signal and nothing more. The outer shield carries only interference. To install shielded twin-lead properly, you should tie the shield and drain wire to chassis or ground at the receiver only, and let it float at the antenna. Any interference picked up by the shield is thereby drained to ground at one end only, and doesn't get into the signal circuit.

Shielded twin-lead, then, is somewhat more immune to noise and spurious r.f. pickup than ordinary coax. This feature can be useful in high-noise locations.

Comparison of Lead-in Types

A number of different types of lead-in are available today. Fig. 2 shows cross-sections of these types.

Fig. 3. Magnetic fields (electromagnetic lines of force) and electric fields (electrostatic lines of force) of (A) flat twin-lead, (B) coax cable, and (C) shielded twin-lead.



Flat twin-lead (A) has been the most common type for many years because it's inexpensive. The conductors are surrounded by a polyethylene plastic insulator, which is available in either of two colors. Clear or white twin-lead is usable only indoors, where it blends with wall baseboards. It can't be used outdoors for the ultraviolet in sunlight rapidly deteriorates the poly. Brown twin-lead lasts longer outdoors, as the color keeps the ultraviolet light out. In *twin-foam twin-lead* (B), a core of foam poly surrounds each conductor. Foam poly is simply a mixture of polyethylene and air bubbles. Since air has lower dielectric losses than poly, foam twin-lead has less loss than solid poly.

Oval twin-lead (C) was designed to keep contaminating moisture, soot, etc., farther from the lines of force surrounding the conductors. *Open-wire line* (D) has insulating spacers which maintain the conductors at the proper distance and keep the line impedance constant. Since the dielectric is chiefly air (except for the spacers), open-wire line has the lowest losses of all – at least when the insulators are clean and dry.

Hollow tubular twin-lead (E) is also designed to keep contaminating deposits away from the area between the conductors. The plastic insulator is formed in a tube, and since the core is hollow, the dielectric is mainly air. Unfortunately the hollow tube gathers moisture, which increases losses. In an effort to overcome this disadvantage, *foam-core tubular twin-lead* (F) was developed. The foam core gathers very little moisture.

Heavy-duty twin-lead (G), which is also called "jacketed" or "encapsulated" is surrounded by a tough, plastic, insulating jacket which resists the effects of weather and soot. *Shielded twin-lead* (H), as previously described, contains two conductors with insulation between, covered with a metal shield, and covered over-all with a tough, weather-resistant jacket.

Solid-core coax, at (I), as its name implies, has solid poly between the center conductor and the outer conductor (shield). Two types – RG-59/U and RG-6/U – are suitable for home installations; RG-6/U is slightly larger and has less loss. *Foam-core coax* (J) has an air-bubble-filled core which reduces losses. Most coax is covered with a weather-resistant, polyvinyl-chloride jacket.

Comparison by Signal Losses

Table 1 compares the various lead-in types by signal losses, at three frequencies. 100 MHz is roughly the middle of the FM and the v.h.f. TV bands; 500 MHz is near the bottom, and 900 MHz near the top, of the u.h.f. TV band.

As mentioned before, open-wire lead-in has the lowest loss of any lead-in, roughly 1/7th of the lossiest type at 100 MHz, if it can be properly installed. Exact figures were not available at 500 and 900 MHz for open-wire, but average losses are around 2 dB for u.h.f. But open-wire lead-in is seldom used for TV or FM reception. It is difficult to install, not the least expensive, and highly susceptible to noise pick-up, as well as losses if installed close to loss-inducing objects. It won't withstand weather conditions: you get a nice picture on a clear, dry day, but you may lose the signal when it rains or snows. Years ago, if the receiver were a great distance from the antenna, open-wire line was the only solution; any other type of lead-in would attenuate the signal too much. Today, you can use a preamplifier and conventional twin-lead or coax.

Losses for the other unshielded types are very similar. Unshielded-line losses increase roughly three times at 500 MHz, and five times at 900 MHz. (Hollow tubular twin-lead isn't shown because it has been superseded by foam tubular type.)

Note that shielded lead-in losses are generally two to three times those of unshielded. But losses of shielded types don't increase as rapidly with frequency as those of the unshielded types. RG-59/U is the worst offender. With losses of 12 dB at 900 MHz, it is the least desirable in all-channel installations.

But the figures given in Table 1 were derived by measuring the various lead-in types under laboratory

Type of Lead-in	Signal losses in dB per 100 feet at:		
	100 MHz	500 MHz	900 MHz
Unshielded 300-ohm twin-lead			
Open-wire	0.5	—	—
Oval	0.9	2.6	3.9
Foam-core tubular	1.1	3.0	4.3
Flat	1.1	3.0	4.5
Twin-foam	1.1	3.5	4.5
Heavy-duty	1.2	3.5	5.1
Shielded			
300-ohm twin-lead	2.5	5.4	7.7
75-ohm foam coax	2.7	6.4	8.0
75-ohm RG-6/U coax	2.7	6.4	8.4
75-ohm RG-59/U coax	3.8	8.5	12.0

Table 1. Lead-in comparison by signal loss at the various frequencies indicated, under ideal conditions.

Table 2. Lead-in comparison by signal loss for a typical home installation. Naturally, these figures are only very approximate and vary widely depending on the installation.

Type of Lead-in	Signal losses in dB at:		
	100 MHz	500 MHz	900 MHz
Shielded 300-ohm twin-lead	3	6	8
Heavy-duty 300-ohm twin-lead	5	8	9.5
Foam or RG-6/U coax, with two transformers	5	8.5	10
RG-59/U coax, with two transformers	7	11	16
Foam-core tubular 300-ohm twin-lead	10.5	16	20
Flat 300-ohm twin-lead	25	>35	>35

conditions, when the cables were dry and clean and removed from nearby objects. What happens to the various types at a typical home installation? The lead-in is run through stand-off insulators, perhaps routed through walls and near metal gutters or a.c. lines, and exposed to rain, snow, soot, and possibly salt spray. Inside the house, the lead-in may even be attached to walls with metal staples. All these factors cause greater losses in some types of lead-in than in others.

Table 2 compares the various types by losses in a typical installation. Shielded 300-ohm twin-lead has the least loss, followed by 300-ohm heavy-duty twin-lead. Foam-core coax isn't bad. All three are usable at u.h.f. Ordinary RG-59/U 75-ohm coax works fairly well at 100 MHz, poorly at 500 MHz, and badly at 900 MHz. Foam-core tubular and flat 300-ohm twin-lead don't work as well at any frequency in this particular case, although foam-core tubular is better than regular flat twin-lead. Naturally, these figures will vary widely, depending on the kind of installation.

Coax suffers from an additional disadvantage in the typical installation. Very few antennas and receivers will work directly with 75-ohm coax. Thus you must use matching transformers, which add 2 or 3 dB of loss to the over-all cable figure. Table 2 coax-loss figures include approximately 2 dB of balun loss.

Noise Immunity and Durability

An unshielded line is more susceptible to interference pickup than a shielded one. Thus most coax pick up less interference than most twin-lead. But twin-lead is balanced to ground, avoiding hum pickup more than coax, which is unbalanced to ground. This disadvantage partially offsets the noise immunity of coax. Shielded twin-lead is both balanced to ground and shielded.

Some flat twin-lead isn't very durable, because the insulation deteriorates from the effects of the weather. When this happens, the insulation may fall apart, changing conductor spacing and line impedance. Standing waves are produced, causing ghosts on TV and loss of separation in stereo-FM. Oval and tubular twin-lead are a bit more immune than flat to such deterioration. The most immune types are heavy-duty and shielded twin-lead, and most coax. They are encapsulated in a material very impervious to weather and contamination.

Ease of Installation

To run ordinary flat twin-lead from antenna to receiver you have to use stand-off insulators every 5 feet or so, and pull the line taut. Flat twin-lead whips easily in the wind and this flexing may break the conductors, requiring you to replace the line. It is also a good idea to twist the twin-lead in order to minimize noise and signal pickup.

If you use an ordinary metal-ring stand-off, you bring metal near the twin-lead, possibly causing ghosts. It's better to use all-poly-head types, which don't surround the line with metal. Also, you must run twin-lead carefully to avoid gutters and rain downspouts, for the same reason. You must likewise be careful when running flat twin-lead through the house wall so that it is not too close to pipes and electrical wiring.

Oval and tubular twin-lead aren't much better than flat in this respect.

All shielded lead-in types are inherently easy to install, simply because you can run them nearly anywhere with no deleterious effects. The shield prevents nearby metal objects from disturbing line impedance, and minimizes noise pickup. You can use any type of stand-off to hold the line, and you can even tape it to the antenna mast, or run it inside pipe or conduit, which you should not do with most twin-lead. You must not deform shielded line – or any other type, for that matter. When you deform the line you change conductor spacing and you may reduce signals and create ghosts.

Type of Lead-in	Approx. price per 100 ft
Unshielded 300-ohm twin-lead	
Flat	$1.70
Hollow tubular	2.50
Heavy-duty	2.63
Open-wire	3.27
Twin-foam	3.68
Foam-core tubular	4.65
Oval	5.35
Shielded	
75-ohm RG-59/U coax	5.58
75-ohm foam coax	6.07
300-ohm twin-lead	10.15
75-ohm RG-6/U coax	16.80

Table 3. Comparison of various lead-ins by price. The price varies somewhat depending on quality and source.

Comparison by Price

After comparing various lead-in types on the basis of how well they perform, there remains the matter of price. There isn't much point in paying more than you have to, for your particular installation.

Table 3 compares the various lead-in types by price. The least expensive is flat twin-lead. Since most of the other types perform better, they cost more. Shielded types generally cost more than unshielded. RG-6/U, the most expensive, costs nearly 10 times as much as flat twin-lead.

Just as you cannot buy lead-in solely for its loss figure, or for its noise immunity, you cannot simply buy for price. You should consider all the previous criteria before making a choice. Even with flat twin-lead there are various qualities of insulation, several conductor sizes and several conductor types (copper or copper-coated steel, for high strength) to choose from.

Over-all Lead-in Comparison

Table 4 shows an over-all comparison of six lead-in types, assuming a 100-foot run from antenna to receiver, some snow or rain, soot or other contamination, and a few metal objects and wiring near the lead-in.

Shielded twin-lead is preferred in all installations. Its only drawback is price, which is moderate compared to the least and most expensive shown in the table. Shielded twin-lead has the lowest loss at u.h.f. under poor outdoor conditions, has excellent noise immunity, durability, and contamination immunity. It is also easy to install.

Foam coax is also good. The cost figure shown in Table 4 is a bit higher than for shielded twin-lead because it includes the cost of two baluns.

Type of Lead-in	dB Losses @ 900 MHz	Noise Immunity	Durability, Contamination Immunity	Approx. Total Cost
Shielded twin-lead	8.0	Excellent	Excellent	$10.15
Foam coax	8.5	Good	Excellent	12.25*
RG-6/U coax	10.0	Good	Excellent	22.98*
Heavy-duty twin-lead	9.5	Poor	Excellent	2.63
RG-59/U coax	16.0	Good	Excellent	11.76*
Foam tubular twin-lead	20.0	Poor	Good	4.65

*Includes cost of two matching transformers, average total price $6.18

Table 4. Over-all comparison for 100-ft typical installation.

RG-6/U has only fair performance and is more than twice as expensive as shielded twin-lead. Thus it doesn't seem very desirable for a home installation.

Heavy-duty twin-lead is very inexpensive and durable, with excellent contamination immunity and moderate losses at u.h.f. in a typical installation. But it has poor noise immunity. If station signals are strong and interference and noise minimal at your location, heavy-duty twin-lead is probably a very good bet.

RG-59/U coax costs about the same as shielded twin-lead and performs as well, except it has less noise immunity and greater losses at u.h.f.

Similarly, foam tubular twin-lead has higher u.h.f. loss and is also susceptible to noise pickup.

Table 4 doesn't show the other lead-in types previously discussed, because they do not usually perform quite as well in a stereo-FM, color-TV, all-channel installation. Oval, twin-foam, hollow-tubular, and flat twin-lead usually have higher u.h.f. losses in a typical installation, and are susceptible to interference pickup.

Although price is a factor in lead-in choice, don't forget one thing: The user has already invested $300 to $600 or more in a color-TV receiver, perhaps $30 to $60 in an antenna, and additional dollars for stereo-FM. Saving only a few dollars on lead-in cost may not be wise, for then the lead-in may be the weakest link in your equipment chain.

Antenna Preamps and Multi-set Couplers

In a fringe area, a high-gain antenna often picks up enough signal to provide a good picture or FM sound. But if the antenna is up on a tower, the downlead run may be long enough to negate the antenna advantage through line loss. And if you have noise and/or weather problems, the only solution is a mast-mounted preamplifier driving shielded line.

The preamplifier (or booster) is even more useful if you have more than one TV or FM receiver driven by the antenna, because to drive several sets you must connect them through multi-set couplers which introduce additional signal losses. In this case, an amplified booster may be located at the point where the lead-in enters the house and individual lead-in runs made to the separate receivers. ●

A listing of some representative lead-in types along with their manufacturers and catalogue designations.

Unshielded, 300-ohm, flat twin-lead
Alpha 5150
Amphenol 214-056
Belden 8225
Columbia 1010
Lafayette 32T8912
Winegard 8200

Unshielded, 300-ohm, twin-foam twin-lead
Allied 11C1657
Columbia 5790 Durafoam
Lafayette 32T3604

Unshielded, 300-ohm, oval twin-lead
Belden 8235

Unshielded, 300-ohm, hollow-core tubular twin-lead
Columbia 1555
Lafayette 32T3608

Unshielded, 300-ohm, foam-core tubular twin-lead
Belden 3275 Celluline

Unshielded, 300-ohm, heavy-duty twin-lead
Alpha 5153
Amphenol 214-103
Belden 8230 Weldohm
Belden 8285 Permohm
Columbia 5050 Permaline
Lafayette 32T3605

Unshielded, 300-ohm, open-wire lead-in
Allied 11C1473
Lafayette 32T3610

Shielded, 72-75-ohm coax, RG-59/U
Alpha 9810
Amphenol 21-025
Belden 8241
Columbia 5750
Dearborn 59/U
Lafayette 32T1715

Shielded, 72-75-ohm foam coax, RG-59/U
Alpha 9820
Amphenol 621-186
Belden 8228 Duofoil
Columbia 1112
Dearborn 59/U
Finco CX-283-100
Jerrold Coloraxial
Lafayette 32T3134
Winegard 2700

Shielded, 72-75-ohm foam coax, RG-6/U
Alpha 9006A
Amphenol 21-330
Belden 8215
Winegard 2800

Shielded, 300-ohm twin-lead
Belden 8290

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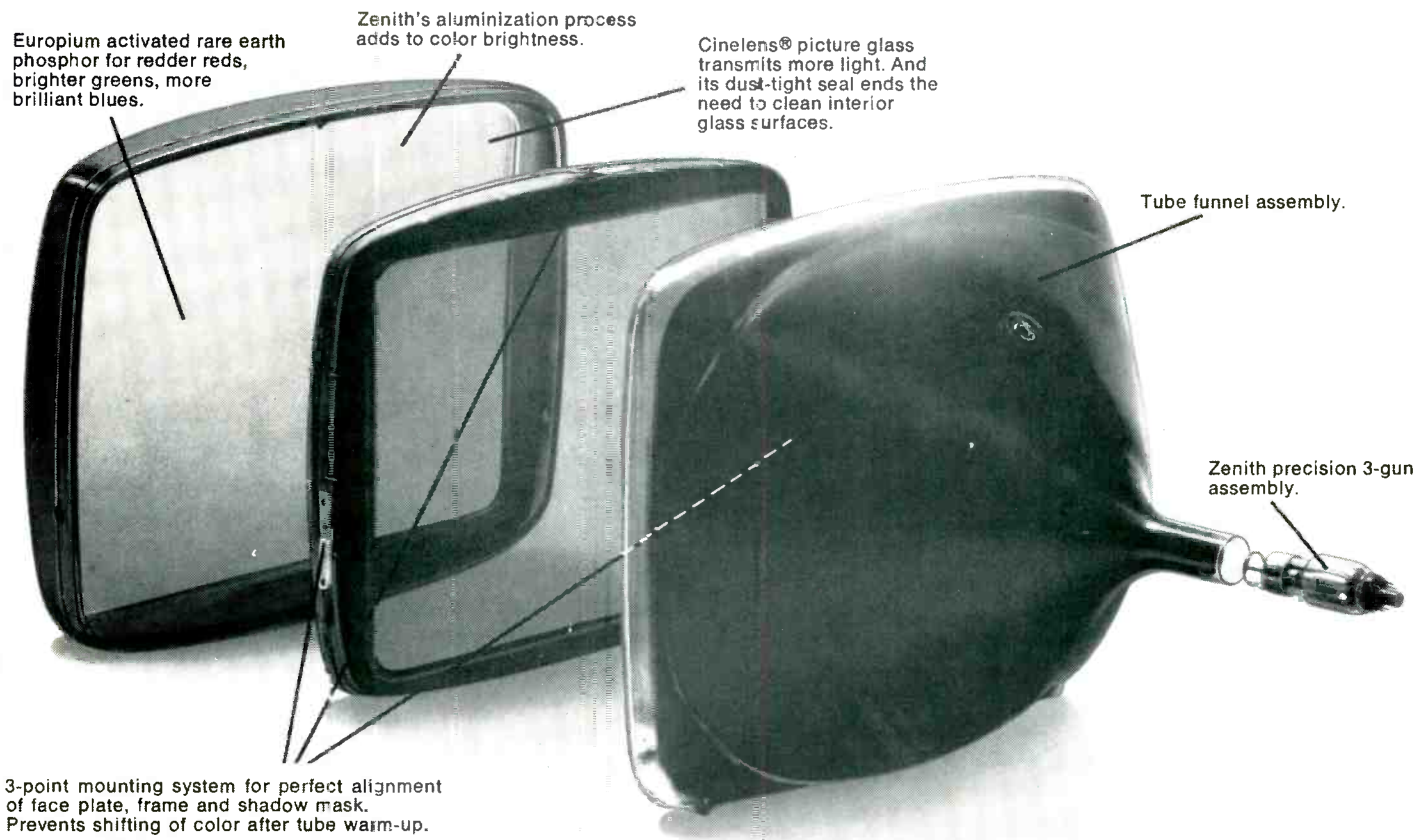

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CIRCLE NO. 20 ON READER SERVICE PAGE

TV Channel Assignments

Channel No.	Frequency Range (MHz)	½ Wave-length* (inches)	Picture Carrier (MHz)	Color Subcarrier (MHz)	Sound Carrier (MHz)
V. H. F. LOW-BAND CHANNELS					
2	54-60	103.8	55.25	58.83	59.75
3	60-66	93.8	61.25	64.83	65.75
4	66-72	85.7	67.25	70.83	71.75
5	76-82	74.8	77.25	80.83	81.75
6	82-88	69.5	83.25	86.83	87.75
FM	88-108	60.3	—	—	—
V. H. F. HIGH-BAND CHANNELS					
7	174-180	33.4	175.25	178.83	179.75
8	180-186	32.3	181.25	184.83	185.75
9	186-192	31.3	187.25	190.83	191.75
10	192-198	30.3	193.25	196.83	197.75
11	198-204	29.4	199.25	202.83	203.75
12	204-210	28.5	205.25	208.83	209.75
13	210-216	27.7	211.25	214.83	215.75
U. H. F. CHANNELS					
14	470-476	12.5	471.25	474.83	475.75
15	476-482	12.4	477.25	480.83	481.75
16	482-488	12.2	483.25	486.83	487.75
17	488-494	12.0	489.25	492.83	493.75
18	494-500	11.9	495.25	498.83	499.75
19	500-506	11.8	501.25	504.83	505.75
20	506-512	11.6	507.25	510.83	511.75
21	512-518	11.5	513.25	516.83	517.75
22	518-524	11.3	519.25	522.83	523.75
23	524-530	11.2	525.25	528.83	529.75
24	530-536	11.1	531.25	534.83	535.75
25	536-542	11.0	537.25	540.83	541.75
26	542-548	10.8	543.25	546.83	547.75
27	548-554	10.7	549.25	552.83	553.75
28	554-560	10.6	555.25	558.83	559.75
29	560-566	10.5	561.25	564.83	565.75
30	566-572	10.4	567.25	570.83	571.75
31	572-578	10.3	573.25	576.83	577.75
32	578-584	10.2	579.25	582.83	583.75
33	584-590	10.1	585.25	588.83	589.75
34	590-596	10.0	591.25	594.83	595.75
35	596-602	9.9	597.25	600.83	601.75
36	602-608	9.8	603.25	606.83	607.75
37	608-614	9.7	609.25	612.83	613.75
38	614-620	9.6	615.25	618.83	619.75
39	620-626	9.5	621.25	624.83	625.75
40	626-632	9.4	627.25	630.83	631.75
41	632-638	9.3	633.25	636.83	637.75
42	638-644	9.2	639.25	642.83	643.75
43	644-650	9.2	645.25	648.83	649.75
44	650-656	9.1	651.25	654.83	655.75
45	656-662	9.0	657.25	660.83	661.75
46	662-668	8.9	663.25	666.83	667.75
47	668-674	8.8	669.25	672.83	673.75
48	674-680	8.7	675.25	678.83	679.75
49	680-686	8.7	681.25	684.83	685.75
50	686-692	8.6	687.25	690.83	691.75
51	692-698	8.5	693.25	696.83	697.75
52	698-704	8.4	699.25	702.83	703.75
53	704-710	8.4	705.25	708.83	709.75
54	710-716	8.3	711.25	714.83	715.75
55	716-722	8.2	717.25	720.83	721.75
56	722-728	8.1	723.25	726.83	727.75
57	728-734	8.0	729.25	732.83	733.75
58	734-740	8.0	735.25	738.83	739.75
59	740-746	7.9	741.25	744.83	745.75
60	746-752	7.8	747.25	750.83	751.75
61	752-758	7.8	753.25	756.83	757.75

V.h.f. and u.h.f. TV channel assignments, including video, audio, and the color-subcarrier frequencies.

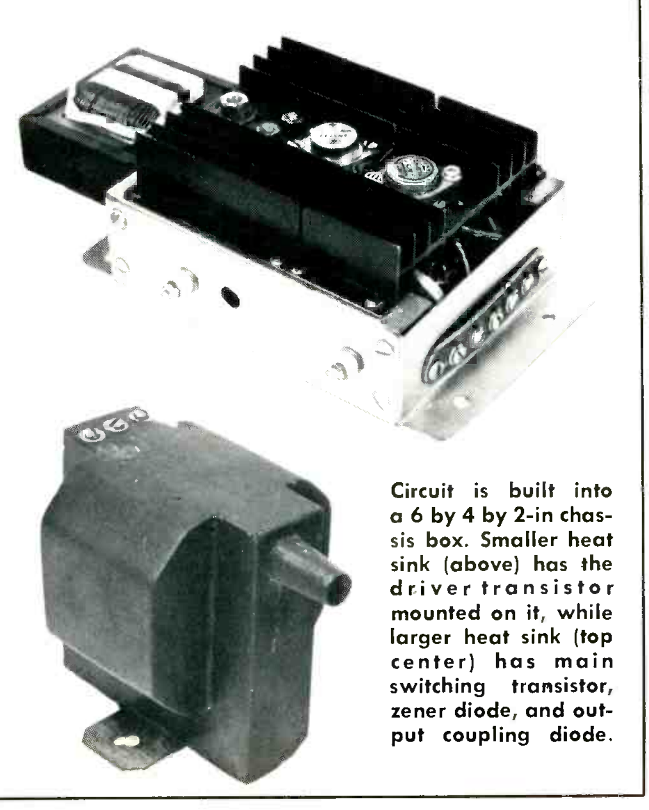
Channel No.	Frequency Range (MHz)	½ Wave-length* (inches)	Picture Carrier (MHz)	Color Subcarrier (MHz)	Sound Carrier (MHz)
62	758-764	7.7	759.25	762.83	763.75
63	764-770	7.7	765.25	768.83	769.75
64	770-776	7.6	771.25	774.83	775.75
65	776-782	7.5	777.25	780.83	781.75
66	782-788	7.5	783.25	786.83	787.75
67	788-794	7.4	789.25	792.83	793.75
68	794-800	7.4	795.25	798.83	799.75
69	800-806	7.3	801.25	804.83	805.75
70	806-812	7.3	807.25	810.83	811.75
U. H. F. TRANSLATOR CHANNELS					
71	812-818	7.2	813.25	816.83	817.75
72	818-824	7.2	819.25	822.83	823.75
73	824-830	7.1	825.25	828.83	829.75
74	830-836	7.0	831.25	834.83	835.75
75	836-842	7.0	837.25	840.83	841.75
76	842-848	6.9	843.25	846.83	847.75
77	848-854	6.9	849.25	852.83	853.75
78	854-860	6.8	855.25	858.83	859.75
79	860-866	6.8	861.25	864.83	865.75
80	866-872	6.8	867.25	870.83	871.75
81	872-878	6.7	873.25	876.83	877.75
82	878-884	6.7	879.25	882.83	883.75
83	884-890	6.7	885.25	888.83	889.75

*Free-space half wavelength. For antenna length, use 95% of these values; for twinlead use 82%; for coax use 66%.

High-"Q" Inductive Electronic Ignition System

By HERBERT I. KEROES
President
Quaker City Transformer Co.

Maintaining good performance at high engine speeds, this highly efficient transistor system uses a special storage choke coil and pulse transformer to generate high spark-plug voltage



Circuit is built into a 6 by 4 by 2-in chassis box. Smaller heat sink (above) has the driver transistor mounted on it, while larger heat sink (top center) has main switching transistor, zener diode, and output coupling diode.

From the time of their inception transistor ignition systems have changed but little in form or design. It has become standard practice to use either a single or pair of switching transistors to make or break the current in an ignition coil. The coil is usually of conventional design but modified with an increased turns ratio. The idea is to increase the amount of coil current, reduce its inductance, and thus obtain a smaller time constant that is more favorable for rapid buildup in the primary. From a performance standpoint, some improvement is effected in obtaining a hotter spark at high engine speeds, but the relatively slow acceptance of the system by the public and even by automotive enthusiasts indicates that the amount of improvement in performance is not great. (*Not to be overlooked with transistor ignition systems is reduced maintenance and increased life for the breaker points which carry much less current.—Editor*)

Electronic ignition diehards remain convinced, and for good reason, that a great deal of improvement is possible with a good ignition system. Early in the development of the present system the author, an engineer, did not believe that performance could be greatly improved over that of a conventional system in good repair. This assumption has since been thoroughly disproved, since performance with the system to be described has been startlingly better in areas that will be discussed later.

Clearly, what is required is a system that will take care of engine requirements in a more sophisticated way than the simple switched-coil method. The concept behind the development of the present system was that an ignition system is actually a type of high-voltage pulse generator, hence an improved system should result if developed along these lines. By using pulse methods a great improvement in efficiency is possible, and the power recovered from the portion normally lost can be put into the spark discharge.

The objective of any ignition system is to put the right amount of spark power in the right place at the right time. The last two requirements depend on proper engine timing, good wiring, and reasonably good plugs. Plugs may be fouled or poorly gapped, but a good spark generator will soon burn away dirt and oil, and will provide sufficient voltage to jump a worn gap.

At this point it is reasonable to inquire how much voltage and spark power the ignition system should provide. The voltage is about 20 kV with little spark advance. At high speeds the advance may be as much as 40 degrees before dead center, and less voltage will be needed. With regard to power, one authority states that as little as 0.002 joule (watt-second) of energy is needed to start combustion. It is reasonable to multiply this figure by a factor of 10 to account for losses due to leakage across fouled plugs and loading due to wiring capacitance. The actual spark power developed by the system described is 0.05 joule as measured across a one-megohm load.

Further considerations regarding ignition requirements, and taking into account factors of spark advance, fouled plugs, and ignition capacitance, leads to the following set of desirable objectives. These figures are representative of a typical high-compression eight-cylinder automobile engine.

1. Voltage in excess of 22 kV across a 50-pF load below 2000 r/min.

2. Voltage in excess of 17 kV across 1 megohm and 50 pF at 2000 r/min.

3. Voltage in excess of 15 kV across 1 megohm and 50 pF at 5000 r/min.

4. An open-circuit voltage not exceeding 30 kV to prevent insulation breakdown.

These requirements are similar to those outlined by others and form a reasonable estimate of what an ignition system should provide. They are not easily met and among the systems tested by the author, other than the one described, all have failed to meet the third requirement and many the second.

To these requirements the author wishes to add another factor that seems desirable. The arc period should be sufficiently long to assure complete ignition of the explosive charge in the cylinder. This is another way of saying that the spark should be "hot" and have high energy content.

Description of System

This system differs in many ways from others previously covered in the literature. It may best be understood by referring to the block diagram of Fig. 1. Ignoring for the moment the drive circuit, the energy that ultimately goes into the spark is first stored in a choke coil that is supplied by current from a transistor switch. When the transistor switch is shut off, the inductive energy of the choke is transferred to the primary of a pulse transformer that steps up the voltage to ignition potential.

The combination of storage choke and pulse transformer constitutes an efficient form of pulse generator, in fact far more efficient than the conventional induction-type ignition coil. These coils are made with essentially an open magnetic circuit which is neither an efficient energy-storage device nor a good pulse transformer. Separating the functions permits the use of closed magnetic circuits for an optimum design.

The use of a separate pulse transformer provides another improvement. The discharge of an induction coil is oscillatory and takes considerable time to damp out. Ignition may occur in the first few oscillations; the balance of the discharge then represents wasted energy. In contrast, the discharge of this system is of typical pulse form and mainly rectangular in shape. Energy is thus concentrated during the firing interval.

The balance of the system consists of a drive circuit and a programming circuit that controls the transistor switch. The action of the circuit is as follows. When the ignition points open, a positive voltage is delivered to the input trigger circuit. The trigger, in turn, delivers a negative pulse to the input of a monostable multivibrator which develops a rectangular output pulse of short duration. This pulse is directly applied to the main transistor switch turning it "off." The choke and pulse transformer then "fire."

It will be noted that in the absence of the firing pulse delivered by the multivibrator the transistor switch is always "on." Therefore, the choke is always energized except for the firing interval. This has the advantage of providing more time to achieve a maximum buildup of current in the choke. By contrast, other systems

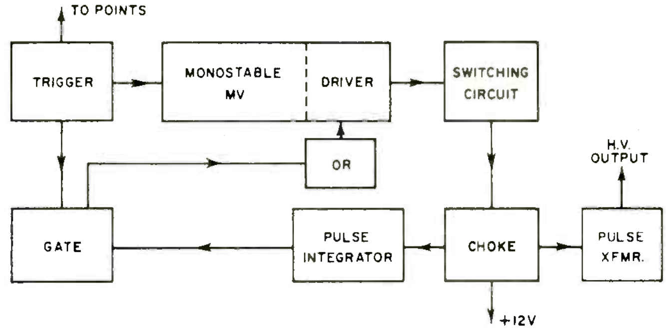


Fig. 1. Block diagram of inductive electronic ignition system.

switch the ignition coil "on" and "off" in unison with the points. The points are usually closed only about 60% of the time, and much less than that at high speeds due to inertia and contact bounce. Because of the effects of the time constant of the ignition coil, maximum current is severely limited.

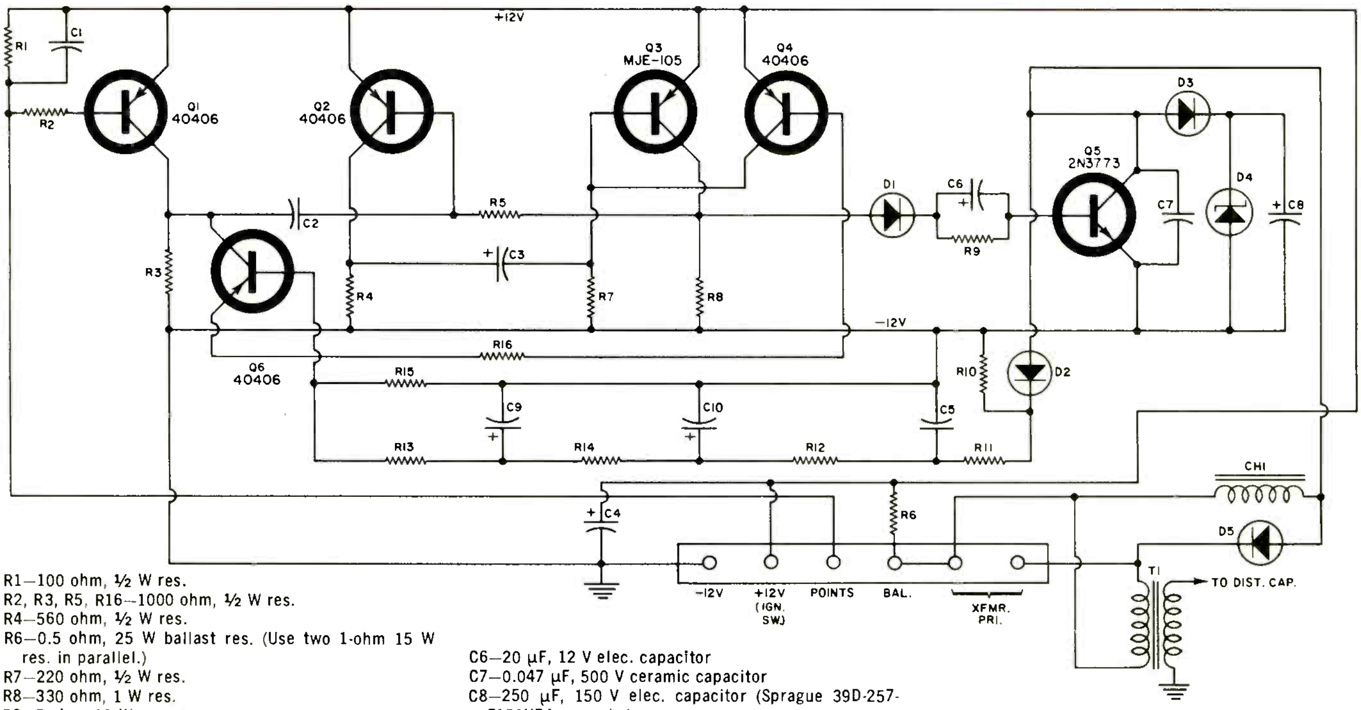
This allowance of additional time is of importance only at high speeds where the firing interval, cylinder to cylinder, is of the same order of magnitude as the time constant of the choke. At low or moderate speeds it is relatively unimportant, hence a programming circuit has been added that defeats the multivibrator drive in this speed range. In the absence of a positive voltage delivered by the pulse-integrating circuit, the trigger circuit also provides a negative replica of the positive waveform generated by the points. This signal is transmitted through a gate and energizes the drive circuit through an "or" transistor. The driver then operates in unison with the points. With an increase of speed, the pulse integrator builds up a positive signal that at some preset speed disables the gate. The multivibrator then takes over. Actually, the multivibrator is never really shut off, so that the transition from one mode to the other is continuous and has no affect on ignition during the transition period.

This control feature has several advantages. At normal driving speed the battery drain is nominal and only slightly more than that of a conventional point and coil system. Thus, the battery is not subjected to an excessive load which might occur under adverse conditions, such as starting in cold weather. Moreover, heating in the critical transistor, the main switch, is much reduced, and it does not run hot even in crawling city traffic during hot weather. At high speeds the transistor does not run hot because maximum current is reduced due to the influence of the time constant of the choke and also because of the greater cooling draft in the engine compartment.

Practical Circuit Arrangement

The circuit of the system is shown in Fig. 2, and the transistors and associated circuits can be readily identified with the elements in the block diagram. The trigger is $Q1$, the multivibrator $Q2$ and $Q3$, the latter also being the driver. The main switching transistor is $Q5$, and the pulse integrator is formed by $D2$ and its associated RC filter network. The gate is $Q6$ and the "or" transistor $Q4$.

In the base circuit of $Q1$ it will be noted that there is a 0.1-μF capacitor ($C1$) across resistor $R1$. Its purpose is to suppress a spurious trigger signal due to point bounce, and its effectiveness has been proven.



R1—100 ohm, ½ W res.
R2, R3, R5, R16—1000 ohm, ½ W res.
R4—560 ohm, ½ W res.
R6—0.5 ohm, 25 W ballast res. (Use two 1-ohm 15 W res. in parallel.)
R7—220 ohm, ½ W res.
R8—330 ohm, 1 W res.
R9—5 ohm, 10 W res.
R10—33,000 ohm, ½ W res.
R11—56 ohm, ½ W res.
R12, R13—15,000 ohm, ½ W res.
R14—56,000 ohm, ½ W res.
R15—22,000 ohm, ½ W res.
C1, C5—0.1 μF, 100 V paper capacitor
C2—0.01 μF, 100 V paper or ceramic capacitor
C3—1 μF, 12 V elec. capacitor
C4—20 μF, 12 V elec. capacitor
C6—20 μF, 12 V elec. capacitor
C7—0.047 μF, 500 V ceramic capacitor
C8—250 μF, 150 V elec. capacitor (Sprague 39D-257-F150HP4 or equiv.)
C9, C10—1 μF, 50 V elec. capacitor
D1, D2—1 A, 200 p. i. v. diode (IR 10C2 or equiv.)
D3—3 A, 200 p. i. v. diode (IR 3F20 or equiv.)
D4—10 W, 120 V zener diode (1N3008 or equiv.)
D5—15 A, 100 p. i. v. diode (IR 16F10 or equiv.)
*CH1—5 mH, 10 A choke (Quaker City Type 703-5059, $4.75)
*T1—Pulse ignition trans. (Quaker City Type 506-5060, $22.50)
Q1, Q2, Q4, Q6—Silicon p-n-p transistor (RCA Type 40406)
Q3—Silicon p-n-p transistor (Motorola Type MJE-105)
Q5—Silicon n-p-n transistor (Westinghouse Type 2N-3773)
Note: Heat sinks may be made using Delco Type 7270606 blanks.
*CH1 and T1 can be ordered direct from Quaker City Transformer Co., 369 Shurs Lane, Philadelphia, Pa. 19128

Fig. 2. Complete schematic of unit. Ballast resistor R6 and high-voltage pulse transformer are externally mounted.

The main switching transistor is given somewhat more-than-usual zener-diode protection. Zener diodes have a certain impedance and, at the current levels in the circuit, the V_{CEO} rating of Q5 might be exceeded. Therefore, *D*3 and *C*8 have been added. Any voltage surge is now absorbed by *C*8 and it, in turn, is effectively clamped to the potential of the zener diode. The 0.047-μF capacitor (*C*7) across Q5 is for the purpose of correcting the load line, thus preventing the excursion of voltage and current into the region of high dissipation where secondary breakdown might occur.

The choke (*CH*1) is of high-"Q" construction, rated at 5 mH, and is fed from an external ballast resistor of 0.5 ohm. This limits the collector current to 8 A maximum with Q5 continuously "on," and also limits the transistor dissipation to 14 watts. Therefore, no damage can occur if the ignition key is left on when the car is idle, other than the possibility of finding a dead battery when you try to start.

The choke is diode-coupled *via* D5 to the primary of the pulse transformer (*T*1). The purpose of this arrangement is to block d.c. out of the primary where its presence would reduce the total inductive energy storage around the discharge loop. A 15-A diode is used because the instantaneous current flowing into the primary is 10 A and under pulse conditions there is some heating.

All transistors are *p-n-p* units except for the main switching unit. This selection was made to facilitate the use of the drive circuit shown. This has the advantage of driving Q5 more readily into saturation thereby minimizing heating.

The layout of the system is perfectly straightforward. The circuit is contained in a 6″ × 4″ × 2″ high chassis. Two heat sinks are mounted side by side on the top, one about double the area of the other. The driver transistor is mounted to the smaller heat sink. The larger heat sink carries the main switching transistor, the zener diode, and the output coupling diode. All other parts of the circuit are mounted on a printed-circuit board housed inside the chassis. The choke is mounted at one end of the chassis and since it develops a considerable amount of heat, its base is offset from the chassis by spacers of low thermal conductivity. The ballast resistor is a separate item mounted away from the chassis.

This particular arrangement of parts makes it possible to locate each item in the most favorable position. Placement of the chassis should be studied carefully. The ideal location is in a fairly cool spot, away from the direct heat of the engine. An unobstructed draft from the fan is beneficial. Usually the choice resolves itself to a location either on the inside fender wall or on the firewall. Another location worth considering is in back of and to one side of the radiator. The ballast resistor may be mounted in any convenient spot, usually next to the old one.

The distributor point-to-coil connection is reconnected to the input trigger terminal of the control box. It is advisable, but not essential, to remove the capacitor from the distributor. Its presence affects performance at high speeds, and it will result in some voltage being lost due to point bounce. The filter in the control box normally deals with this; however, its operation is affected by the presence of the distributor capacitor.

The pulse transformer should be mounted close to the distributor so that the lead from the transformer to the distributor cap is short and direct. There is no heating in the pulse transformer and heat can do it no damage, so it may be mounted near the engine.

One should make certain that ignition wiring is in good condition, and semi-rotted or oil-softened lines should be replaced with cable of good quality. Plugs should be properly gapped with a 0.030-in or recommended gap. It is not required that they be cleaned, since the system will do that in short order. Some maintain that gap spacing may be increased to 0.050 in with beneficial results. The author's experience does not confirm this, and all that really seems to happen is that the ignition voltage increases to a point which puts undue stress on the distributor wiring.

There seems to be little information available regarding test methods, apparatus, and procedure, and the author had to more or less feel his way along and improvise.

Testing & Bench Performance

One essential item of equipment is a peak-reading electrostatic voltmeter. Although simple in principle, it is a costly item to purchase, and the author got around this problem by constructing and calibrating his own. At first, measurements were made using a variable ball-electrode spark gap with published tables to convert from gap spacing to voltage. It was soon discovered that these tables are grossly inaccurate, since they do not take into account the surface condition of the balls and the material of which they are made. For a given voltage, the gap spacing is also greatly affected by the incidence of ultraviolet light. However, a simple fixed gap is a useful loading device in testing.

The 1-megohm load resistor is constructed from nine individual 2-watt resistors of 1 megohm each, arranged in a series-parallel configuration. They are immersed in a jar filled with mineral oil. The addition of an aquarium-type thermometer to the oil bath also permits the load resistor to serve as a calorimeter for use in measuring efficiency. The 50-pF load capacitor is of Leyden-jar construction using a small pickle jar. To reduce corona, it is also filled with oil. Capacitance is adjusted to value with the aid of a bridge.

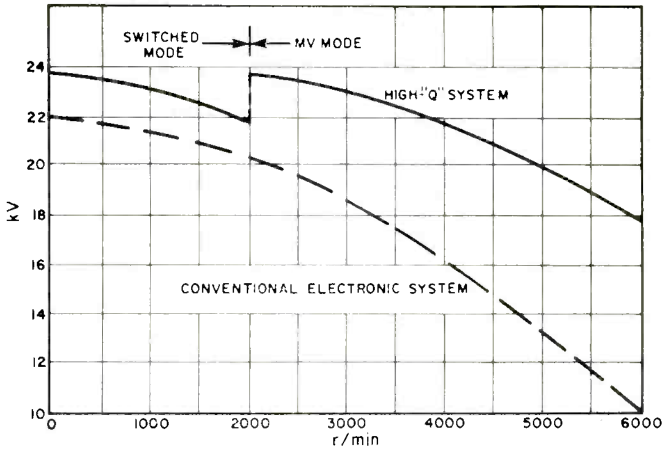


Fig. 3. Voltage measured on high-"Q" system described compared to conventional transistor ignition system.

The input driving signal is obtained in either of two ways. In normal testing, a variable-frequency square-wave generator is used. A graph permits rapid conversion of hertz to r/min. A distributor driven from a variable-speed motor is also available, and is useful in evaluating the effects of point bounce and dwell.

Results are shown in Fig. 3 and it can be seen that the high-voltage objectives are more than adequately met. In fact, 18.5 kV is available at 5000 r/min under conditions of combined resistive and capacitive loading. When a spark gap is added to this, for some reason not yet clear, there is an additional 1500 volts developed, bringing the total to 20 kV.

The author has not run tests on all other systems available at this time; however typical results for one of the better grade transistor ignition systems are shown in the dashed curve of Fig. 3. This system develops a maximum of 13.5 kV at 5000 r/min and the waveform of the dis-

DIRECTORY OF ELECTRONIC IGNITION SYSTEMS

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DELTA INTERNATIONAL, LTD.
Box 1946, 730 Independent Ave.
Grand Junction, Colo. 81501

EXCEL ELECTRICAL PRODUCTS, INC.
Box 442, Hicksville, New York 11802

JUDSON RESEARCH & MFG. CO.
E. Hector St., Conshohocken, Pa. 19428

KNIGHT-KIT (ALLIED RADIO CO.)
100 N. Western Ave., Chicago, Ill. 60680

MOTOROLA AUTOMOTIVE PROD. DIV.
9401 W. Grand Ave., Franklin Park, Ill. 60131

SYDMUR ELECTRONIC SPECIALTIES
1268 East 12 St., Brooklyn, N.Y. 11230

MFRS.	MODEL	TYPE*	VOLTAGE (V)	GND. (+, −)	PRICE ($) (K = kit)
ANDERSON	AD8A	T	6, 12	−	19.00 15.00 (K)
	AD8AP	T	6, 12	+	21.00 17.00 (K)
BAY	SW 100	C-D	12	−	29.95
DELTA	Mark Ten	C-D	6, 12	−, +	44.95 29.95 (K)
DELTA INT. LIM.	Tiger SST	C-D	12	−	39.95 28.95 (K)
EXCEL	X-L Trigger	T	12	−	14.95
JUDSON	Electronic Magneto	T	6, 12	−, +	49.50
KNIGHT-KIT	KG-372	C-D	6, 12	−, +	28.95 (K)
MOTOROLA	CDI 12	C-D	12	−	56.95
SYDMUR	Fyreball	C-D	6, 12	−, +	84.75
	Maraner	C-D	6, 12	−, +	79.95 54.50 (K)
	Flyaway	C-D	6, 12	−, +	60.00 44.50 (K)
	Compac	C-D	6, 12	−	34.75 24.95 (K)

* T = transistor; C-D = capacitor-discharge

charge is of the unfavorable oscillatory type.

Performance in the Car

The author's car is a 1966 *Jeep* Wagoneer which has a six-cylinder overhead-cam engine. The engine is rated at only 135 hp, and it is anything but a "hot" car. It is, however, a pleasant car to drive at moderate and high speeds.

Since the car weighs 4000 lbs, it is a little sluggish at low speeds, and if ignition is not just right it becomes difficult to handle. It was in one of these difficult periods when the car was in real need of a tune-up that the high-"Q" electronic-ignition system was installed. Prior to installation timing appeared to be off, since the engine knocked and balked during acceleration. Hill climbing was very poor, and the gears had to be shifted frequently. It also appeared that a carburetor adjustment was required since the exhaust was excessively smoky. The plugs were not removed for inspection but it is a fair guess that they were partially fouled and misgapped.

When the system was installed, the first thing immediately apparent was much better acceleration through the gears—and with no knock. Balkiness had disappeared, and although it is hard to believe, performance seemed as good or better than when the car was new. In addition, the smokiness of the exhaust was greatly reduced.

The author cannot altogether account for this vivid improvement in performance. Engine experts claim that knock is caused by predetonation of the mixture, and that this is controlled by engine timing. In this case, engine timing was unchanged so that the knock should still have been present. One can, however, conjecture that under conditions of pre-ignition, combustion is not complete, and that enough of the mixture is still available to produce power if the spark is of sufficient duration. The reduction of smoky exhaust would confirm this, since a good portion of the smoke consists of unburned mixture.

The most interesting test of the system has been in the area of drag racing. Here, engine speeds of 8500 r/min are common, not only at high speeds, but also during periods of acceleration and shifting of gears. The transmission is almost always a four-speed box. The engines contain special high-rise cams and are stiff and difficult to start. With the very high speed of the engine and with starting difficulties, adequate ignition has long been a problem. Many drag-racing enthusiasts have tried and abandoned electronic systems and have instead favored the use of extra-hot coils drawing a primary current of 10 amps or better. They are used with a special set of dual points. Despite this brute-force approach, plugs must be removed and cleaned between runs.

At a recent meet the system was installed in a V-8 *Chevrolet* that had, on a previous run, turned up a top speed of 114 mi/h. This was a stock car with engine and exhaust system modifications. An extra-hot coil and dual points were used for ignition. Direct substitution of ignition systems resulted in an increase of speed to 116 mi/h. There was an increase of torque during pickup that at first caught the driver by surprise. Its effect was to break the force of traction of the driving wheels, causing them to spit. However, most surprising, when the plugs were removed at the end of the run, they were perfectly clean. It seems clear that the increase in torque and speed were due to complete ignition as evidenced by the lack of unburned residue on the plugs.

Further tests are planned of a more precise nature, using dynamometer equipment. However, the results to date have been so encouraging that it is planned to market the system shortly. It will be manufactured under the name "High-'Q'" to denote high efficiency and low loss.

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3.50 –	4.00 MHz	80 meters
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28.00 –	29.70 MHz	10 meters
50.00 –	54.00 MHz	6 meters
144.00 –	148.00 MHz	2 meters
220.00 –	225.00 MHz	
420.00 –	450.00 MHz	
1,215.00 –	1,300.00 MHz	
2,300.00 –	2,450.00 MHz	
3,300.00 –	3,500.00 MHz	
5,650.00 –	5,925.00 MHz	
10,000.00 –	10,500.00 MHz	
21,000.00 –	22,000.00 MHz	
All above 40,000 MHz		

CITIZENS BANDS

26.9600 –	27.2300 MHz
462.5375 –	462.7375 MHz
467.5375 –	467.7375 MHz

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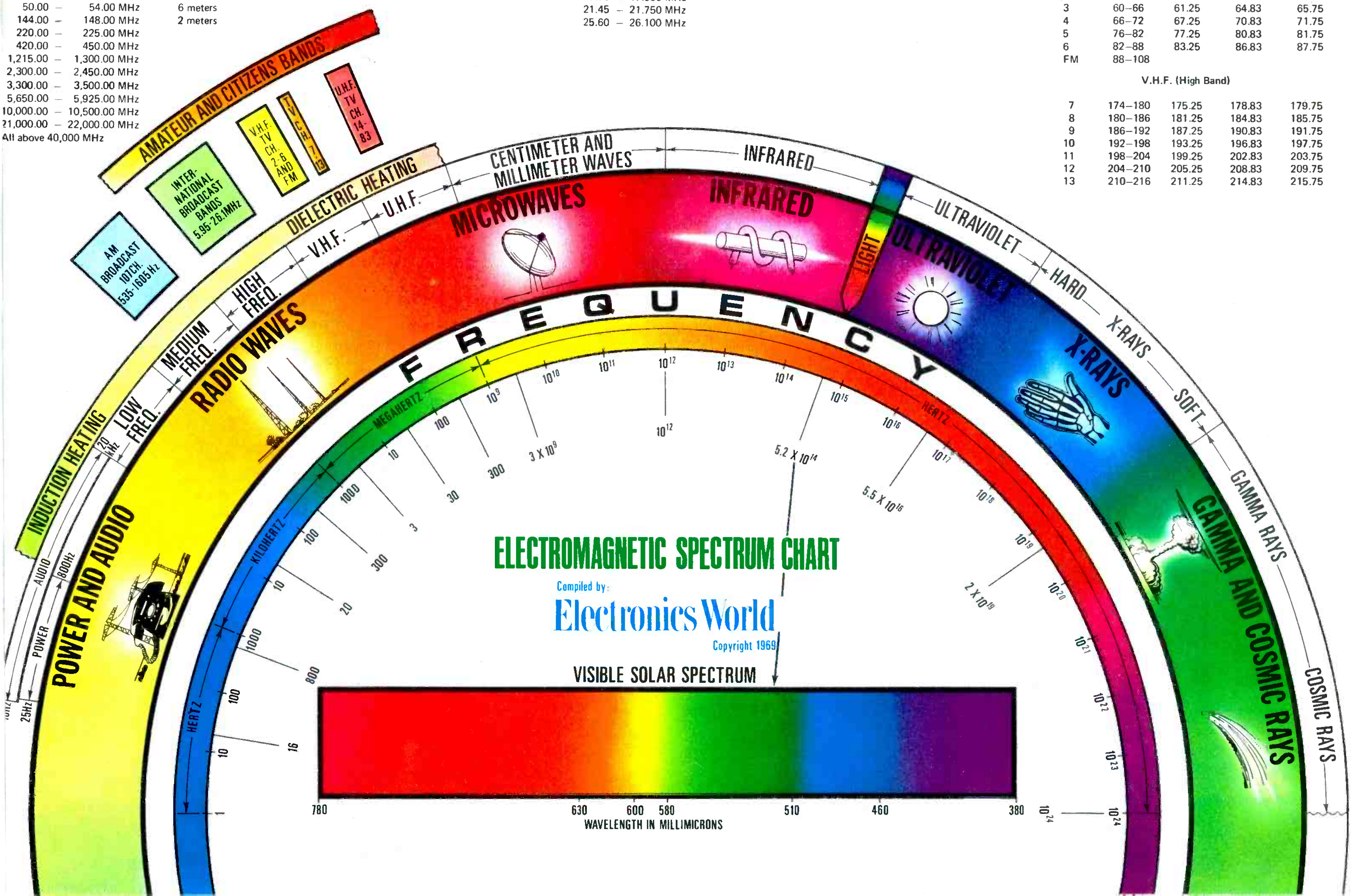
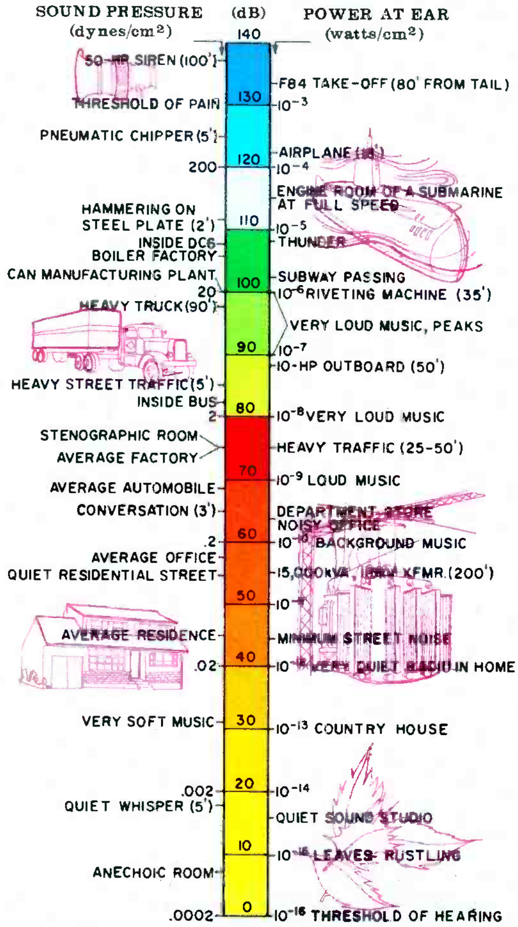
TV CHANNEL ASSIGNMENTS

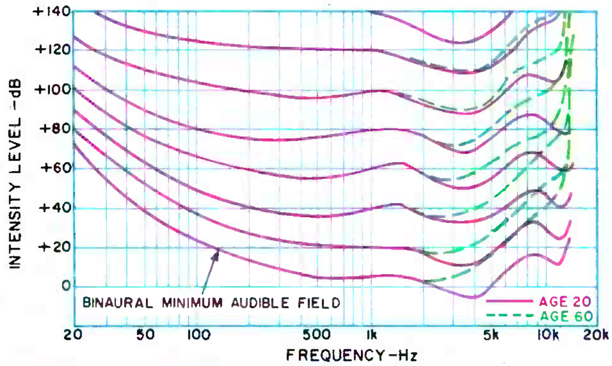
Channel No.	Freq. (MHz)	Video (MHz)	Color Subcarrier	Sound (MHz)
V.H.F. (Low Band)				
2	54–60	55.25	58.83	59.75
3	60–66	61.25	64.83	65.75
4	66–72	67.25	70.83	71.75
5	76–82	77.25	80.83	81.75
6	82–88	83.25	86.83	87.75
FM	88–108			
V.H.F. (High Band)				
7	174–180	175.25	178.83	179.75
8	180–186	181.25	184.83	185.75
9	186–192	187.25	190.83	191.75
10	192–198	193.25	196.83	197.75
11	198–204	199.25	202.83	203.75
12	204–210	205.25	208.83	209.75
13	210–216	211.25	214.83	215.75



SOUND

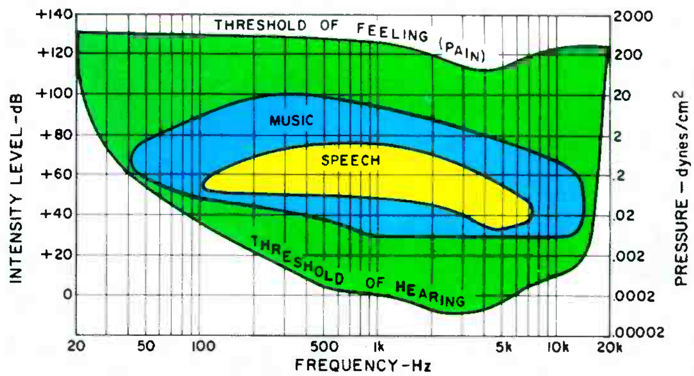


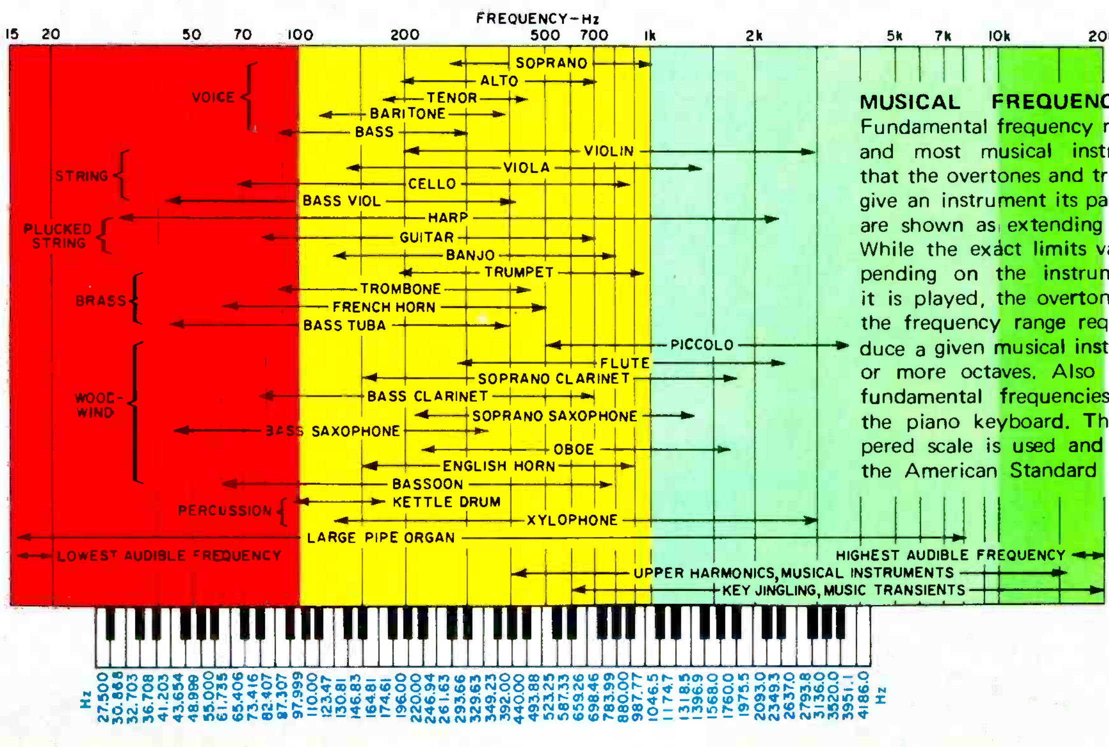
RELATIVE SOUND LEVELS. Some of the most common sounds and noise—from the threshold of hearing out to beyond the threshold of pain.



EQUAL LOUDNESS CURVES. Sound intensities required to produce equal loudness at various sound levels. These curves, obtained by Robinson and Dadson, are slightly different from the older Fletcher-Munson data. Both these curves and the Fletcher-Munson curves of equal loudness show the need to boost bass frequencies substantially and to boost the treble slightly when listening at reduced volume levels. If this is not done, bass and treble tones will appear to be lost during reproduction.

FREQUENCY and VOLUME RANGES. The approximate boundaries of normal hearing based on Fletcher-Munson data. No sound is heard below level indicated by the lower contour. Sound levels that are above the upper contour are felt rather than heard and may be accompanied by a sensation of pain. Also shown are volume levels and the frequency ranges of music as well as of speech.





MUSICAL FREQUENCY RANGES. Fundamental frequency ranges of voices and most musical instruments. Note that the overtones and transients, which give an instrument its particular timbre, are shown as extending to 20,000 Hz. While the exact limits vary widely, depending on the instrument and how it is played, the overtones may extend the frequency range required to reproduce a given musical instrument by two or more octaves. Also shown are the fundamental frequencies for notes on the piano keyboard. The equally tempered scale is used and it is based on the American Standard Pitch (A=440).

Closed-Box Speaker Systems

By HUGH G. MORGAN / Acoustical Section Head
University Sound (Div. of LTV Ling Altec, Inc.)

Here are complete details on building your own acoustic-suspension speaker system. All the factors that go into the design are covered along with practical information on cabinet structure and proper proportions.

Typical commercially available closed-box speaker system with grille removed. Unit is University "Project M."

Editor's Note: Many of our readers have requested information on the construction and design of the acoustic-suspension speaker system. This is among the most popular enclosures for stereo use since it provides good bass efficiency in a reasonably sized cabinet. Although the system appears simple, there are a good many factors that must be taken into account. Our author has described all these factors in the following article for those who want to take the time and effort required to design and build their own closed-box speaker system.

The woofer and its marriage to its enclosure have been subject to almost as much research, contention, and misunderstanding as has marriage itself. Several types of woofer-enclosure marriages are currently practiced. Each type brings forth its special advocates who tend to fault other types. This is unfortunate, since each type offers a set of virtues not entirely encompassed by any other type; and further, each type embraces some limitation not common to others. Of the various types, one of the most popular and most honored is the closed box, or acoustic-suspension system, which employs an enclosure having no openings except those into which the speaker or speakers are mounted. The woofer is highly compliant and the "springiness" of the air within the enclosure helps to support or "suspend" the cone.

Virtues of the closed box are: it may be very small in size; it never "unloads" the speaker even at very low frequencies; its penultimate bass response falls off at a slower rate than does that of other widely used types; and it can be extremely economical. However, every type achieves its virtues at the cost of some limitation. The limitation of the closed-box system is that it must operate at relatively low efficiency if it is to have flat response and good bass performance. This flat response, efficiency, and bass extension are controlled by Q_t (composite resonance magnification factor), which is graphed in Fig. 1.

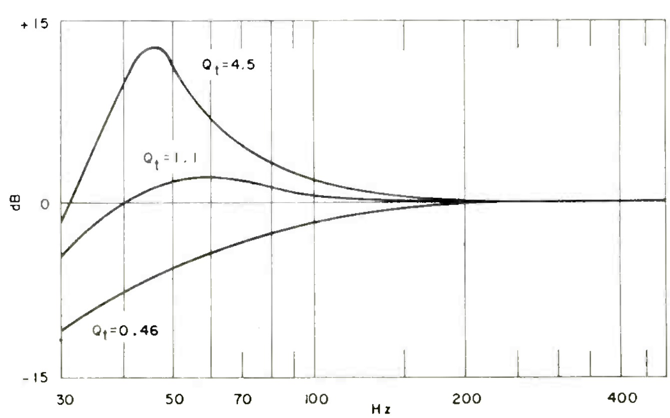
Why Build Your Own?

But before we go further, perhaps we should consider a question which may be troubling you at this very moment: Why should you build your own systems? After all, you can buy them complete and as designed by an expert. Undeniably, the practicing professional has access to a lore of acoustical know-how, as well as access to an industrial speaker design laboratory with very sophisticated facilities for analysis and test. But the hobbyist has access to other important factors: his own living room, his own taste, and his own ears. Also, even if he goes astray, the hobbyist generally has an out—a luxury seldom allowed the professional, for whom, if he makes a mistake, it's back to the drawing board (or back to the farm).

To perform our speaker-enclosure marriage, we will require the purchase of one of its partners, the woofer. But we can get a much better feel for the requirements for this partner if we first lay out the requirements for our ceremony. Step-by-step, we must determine: (1) speaker bass resonant frequency, f_{os}; (2) speaker stiffness, S_s; (3) cabinet stiffness, S_c; (4) composite resonant frequency f_{oc}; and (5) composite resonance magnification factor, Q_t.

First, then, we will find the speaker fundamental bass resonance, f_{os}. This is determined by the setup and method of Fig. 2.

Fig. 1. Closed-box bass response as a function of Q_t. Large values of Q_t produce humped bass response, small values produce "tight" but rolled-off bass. Optimum is around 1. Curves are normalized to show same high-end response.



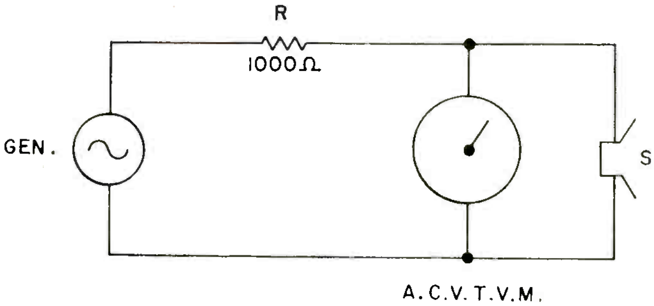


Fig. 2. Method of finding f_{os}. Woofer is suspended freely by a cord far from walls or other reflectors. As audio generator is tuned in through its low-fequency range, a peak in meter reading will occur at bass resonant frequency, f_{os}.

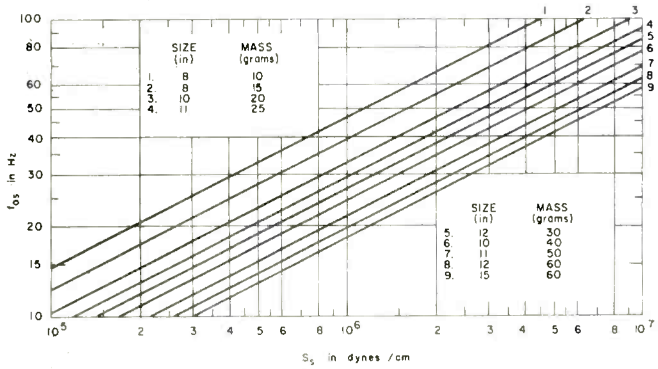
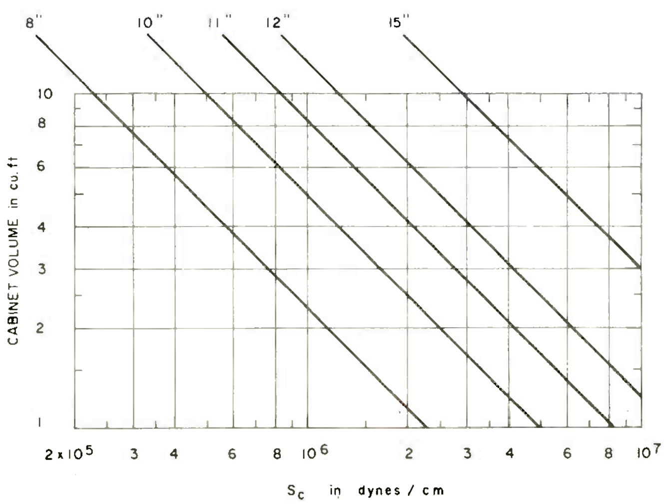


Fig. 3. Speaker stiffness, S_s, is a function of fundamental resonance, f_{os}, and speaker moving mass m. Curves are identified by numbers for typical speaker sizes and mass.

Speaker stiffness, S_s, is determined by reference to Fig. 3. However, in order to use the graphs, we must find speaker moving mass m.

Having already determined speaker fundamental resonance f_{os}, we attach to the cone a known weight m' which should be non-magnetic and may take the convenient form of a roll of soft, sticky clay. For accurate measurement of weight, use a good balance, or make one by placing a round pencil across the center of an ordinary wood ruler, adjusting until the ruler balances exactly when laid pencil-side-down upon a smooth, level surface. The roll of clay is placed at one end of the ruler. Nickels and/or pennies are placed at the other end. The amount of clay in the roll or the size of the money pile is adjusted for exact balance. Nickels weigh 5 grams each, and

Fig. 4. Cabinet stiffness, S_c, for all the common speaker sizes for enclosures with internal volumes from 1-10 cu ft.



pennies are 3 grams each. Thus the m' may be found with sufficient accuracy, its magnitude being unimportant as long as it is known.

The clay roll is then gently but firmly pressed onto the cone around the dust cap. A new resonant frequency f_{o2} is then taken, again using the method of Fig. 2. Then the following is computed:

$$m_t = \frac{m' f_{o2}^2}{f_{os}^2 - f_{o2}^2}$$

where: m' = added weight in grams, f_{os} = initial resonant frequency in Hz as before, f_{o2} = new resonant frequency in Hz, and m_t = total moving mass including radiation reactance mass.

Then, $m = m_t - m_{xr}$, where $m_{xr} = (3.23 \times 10^{-3})\, a^3$ = radiation reactance mass, and a = radius of effective speaker piston in cm. (Take the width of one side of the surround, add to distance across the top of the cone, and divide by 2.)

Now we have speaker moving mass m and hence can estimate speaker stiffness from the curves of Fig. 3.

When the speaker is cabineted, the cabinet-enclosed air stiffness will add to the speaker stiffness. We now find cabinet stiffness S_c from Fig. 4.

When the speaker is mounted into its cabinet a composite speaker-enclosure resonance, f_{oc}, will occur. This is graphed in Fig. 5 for 8-inch woofers in a one-cubic-foot box; in Fig. 6, for six different speakers in a 1.6-cubic-foot box; and in Fig. 7 for two different 12-inch woofers in boxes from 1 to 10 cubic feet.

Thus we see that f_{oc} may be set at will by changing cabinet volume, speaker moving mass, and speaker size. This is of great significance, for f_{oc} determines bass cut-off; that is, f_{oc} determines the frequency below which bass will fall off rapidly.

Looking again at Fig. 1, we see that, while cut-off is defined by f_{oc}, about 40 Hz in this case, that is by no means the whole story. The shape of response down to cut-off is determined mainly by Q_t. Since we are at the mercy of Q_t, as it determines what we are allowed to hear, its importance cannot be overstated. It is measured by the method of Fig. 8.

The value of Q_t is determined by the characteristics of the woofer used (resistance of voice coil, magnetic flux density, length of voice coil) as well as the mechanical and acoustic parameters of the speaker system. Since the hobbyist cannot change the design of the woofer he will use, the most he can do is to add mass to the speaker, alter enclosure size, and add damping material within the box.

Any fuzzy substance like a furry blanket, cotton, rock "wool," Tufflex wood-fiber "wool," or fiber glass can absorb sound. Fig. 9 shows a section of response of an experimental speaker: (A) with box lined with ½-inch Tufflex, and (B) with no lining. Notice notches in response in (B) due to sound reflections within box. This demonstrates absorption at the wall.

But damping material has another function—enclosure volume expansion. With the speaker cabinet completely filled with fuzz, the material acts as a heat sink and reduces the effective velocity of the sound; hence, the speaker "sees" an acoustic volume substantially larger than the volume measured by a ruler.

But we do not get something for nothing. The speaker drives energy into the box. The fuzz converts some

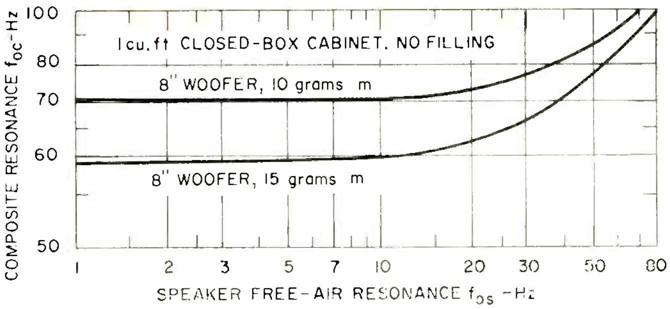


Fig. 5. Composite resonance as function of free-air resonance and moving mass of 8-in woofer in 1-cu-ft closed box.

amount of that energy into heat. That amount never returns to the speaker, never gets into the room, often shows up as overdamping of the low end of the woofer (energy lost), and can cause low-end distortion. Thus indiscriminate fuzz-stuffing has ruined many a system. If the woofer requires stuffing of its enclosure, by all means stuff. But try different amounts of stuffing—¼ full ½ full, and so on. Measure Q_t and listen. Be sure to do both. When the bass begins to sound constricted or overdamped, remove some stuffing (regardless of Q_t). When the bass sounds ample and relaxed (but not sloppy), you have it.

For closed-box operation, the woofer should have a very soft, compliant surround, preferably a half-round shape. As you examine a woofer, press in and out on the cone. It should move at least ¼ inch in both directions. Nothing should make a dragging, scraping, scratching sound. Indeed, when operated like this, the speaker should make no sound whatever. Then feel the cone. It should be fairly thick (perhaps 1/32 to 1/16 inch) and not too hard.

Sometimes, by experimenting with a beam from a small, bright flashlight, you can manage to see through the spider and observe the frontward extension of the voice coil. If the magnet is open in the back except for a cover or covers, you may be able to observe the rearward extension of the voice coil. If the end of the coil does not extend out of the pole pieces as you watch it and move the cone, that speaker is not for this application. The coil should overhang the magnetic gap by at least 3/16 inch. If you can, get the salesman to run an f_{os} for you or get this information from the manufacturer. The proper value should be from about 15 Hz to 25 Hz.

If you require a lower f_{oc} than you get initially, then you may try a bigger box. But take care, you can make it nice and big and wind up with a low f_{oc} but with a Q_t of 0.5 or less and *no* satisfactory bass.

Perhaps weighting the woofer will provide just the degree of trimming you need. Add some putty to the cone as you did before until you get the desired f_{oc}. Resist the temptation to go farther down in frequency than 50 Hz. And about 20 grams added weight is probably maximum, as too much added mass tends to decouple the main body of the cone from that section immediately adjacent to the coil. This produces a peak in response at or above the speaker high-end cut-off. A coil of rosin-core solder wire fitting the cone-dust-cap juncture can furnish the added mass. Affix into place with something like *Duco* cement. Let it dry overnight, and don't use epoxy as you might want to get the weight off. Start with 10-grams and, if you need to, add another 10 grams.

As a piece of woodwork, a loudspeaker cabinet leads a very rough life. Sound power is continuously attacking it. Even if its walls are very strong, they are flexed by changes in enclosed air pressure and this absorbs much more energy than it transmits to the outside air. Hence wall flexure should be minimized. This can be accomplished by use of thick, stiff walls.

Another problem is that of panel resonances—which can also be minimized by sturdy wall materials. Struts or braces are advisable where panels are wider than one foot. For six- and eight-inch woofer enclosures, panel material may be plywood or dense particle board of ½-inch thickness. For larger speakers, walls should be at least ¾-inch thick.

Small holes and cracks should be avoided. They make a hissing, puffing noise which robs the bass of measurable power. Therefore, good, tight, glued-and-screwed

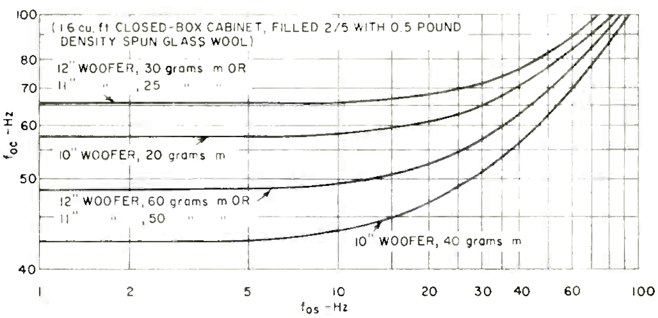


Fig. 6. Composite resonance of various 10, 11, and 12-inch woofers in 1.6-cubic-foot closed box with damping material.

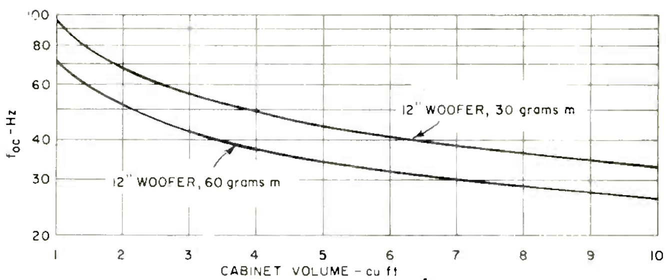
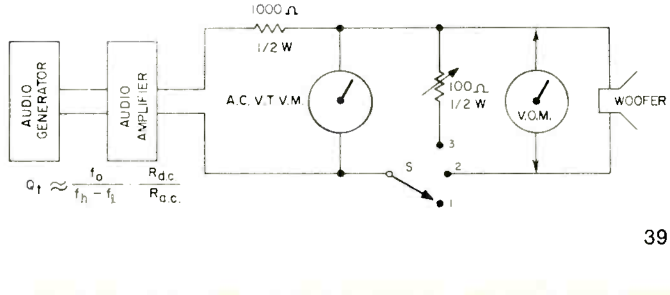


Fig. 7. Composite resonance for 12-in woofers with bass-resonant frequencies of 15 Hz in various cabinet sizes.

Fig. 8. Method of measuring Q_t of speaker enclosure. First place switch at 1 and measure resistance of woofer voice coil (R_{dc}) with v.o.m. Then, disconnect the v.o.m., set audio generator at 1000 Hz, and move switch to 2. Adjust amplifier gain for a reading of 10 volts on v.o.m. Sweep generator from about 20 to 100 Hz and note peak reading on v.t.v.m. This is f_o. Move switch between 2 and 3 and adjust variable resistor until there is no change in voltage. At this setting and with S at position 2, measure value of variable resistor with v.o.m. This value is R_{ac}. Then slowly increase frequency until voltage reads 0.707 of its peak value. Generator now indicates f_h. Finally, decrease generator frequency below the peak until the voltage again falls to 0.707 of the maximum. Generator is at f_l. Substitute the resultant values in equation shown with the diagram in order to obtain the value of Q_t.



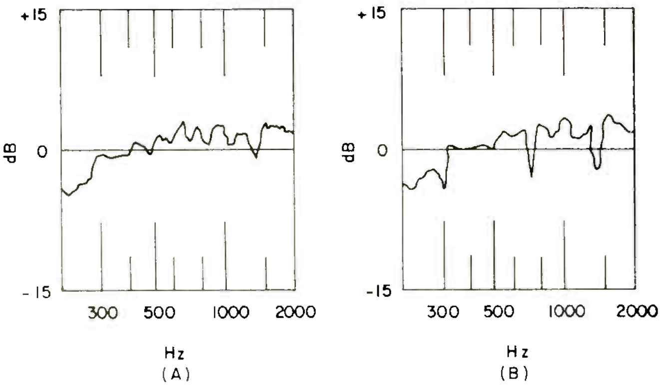


Fig. 9. (A) Portion of response of experimental closed-box system with ½-in Tufflex lining. (B) Same but with lining removed. Notches in response around 300, 720, and 1400 hertz are caused by internal reflections of the sound.

joints are a must. Even better, are well designed lock-joints such as those employed in some commercial closed-box systems. Such joints make cabinet assembly difficult and costly, but produce leak-proof, virtually destruct-proof cabinets.

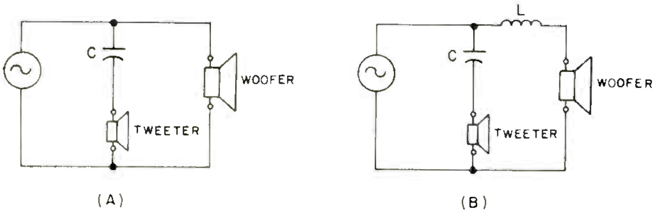
Because it can be small in size, the closed-box speaker is particularly well-suited to shelf mounting. This suitability, in turn, tends to be enhanced by typical cabinet proportions, which generally present a front rather long and narrow and a depth seldom greater than a foot. Typical outside dimensions in inches are:

System Woofer Size	Length	Width	Depth
6	15	9½	6
8	19	10½	9½
10	23½	11½	10
11	24	13	12
12	25	14	13
15	30	19	16

High-quality high-fidelity loudspeaker systems generally employ two or more separate speakers, each designed to handle a different band of frequencies; the division of energy is accomplished by a frequency-dividing or crossover network.

Two-way systems can sound excellent and present fewer problems to the home constructor than do more complex systems. Let us then limit the number of speakers to two, a woofer and a tweeter, and the number of network components to a minimum. (Research shows sound quality deteriorates with increase in network components.)

Fig. 10. Diagrams of simple crossover networks. If speaker impedance is 4 ohms, multiply C by 2 and divide L by 2. If speaker impedance is 16 ohms, divide C by 2 and multiply L by 2. Nonpolarized electrolytics can be used for capacitor, and air-core chokes for inductor. Values are computed; final values depend on speaker responses.



CROSSOVER FREQ (Hz)	VALUES FOR NOMINAL 8Ω SPEAKERS	
	C (μF)	L (mH)
500	40.0	2.500
1,000	20.0	1.250
2,000	10.0	0.625
4,000	5.0	0.312
8,000	2.5	0.156

The simplest network is shown in Fig. 10A. The capacitor provides a low-impedance path for high frequencies to the tweeter and at the same time, blocks low frequencies, forcing them to pass only through the woofer. A slightly more elaborate network (Fig. 10B) include a series choke to keep the highs out of the woofer.

As a speaker becomes smaller, its operation approaches that of a point source, uniformly distributing sound over the listening area. Conversely, as a speaker becomes larger, it "squirts out" more of its top frequencies in a narrow beam. So we want the smallest possible tweeter. But we would like the tweeter to go down far enough in frequency so that it can take over from the woofer at a low enough crossover to avoid the beaming of the woofer at its top end. So we want the largest possible tweeter.

The best compromise is presently reached by using a long-throw, high-quality woofer of modest size, thus minimizing woofer top-end beaming, and the smallest possible, widest-range tweeter. One means of accomplishing the latter is to provide the tweeter cone with a series of strategically placed holes which allow the tweeter cone to operate at full size at the bottom of its range, but which cause it to operate as a progressively smaller unit with rise in frequency. (Patent applied for by *University Sound.*) The tweeter is usually connected to the woofer in-phase so as to avoid cancellation around the crossover frequency.

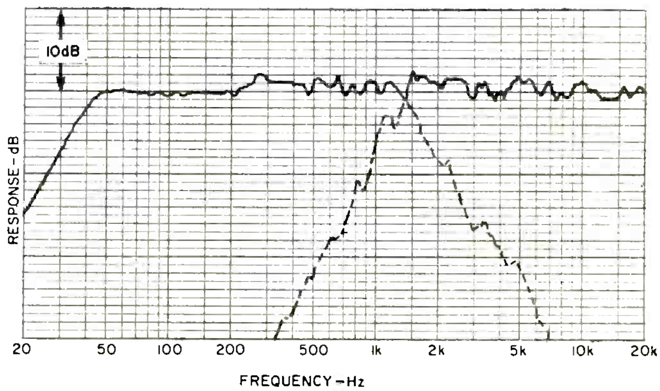


Fig. 11. Anechoic-chamber on-axis pressure response of closed-box speaker system, University Sound's "Project M." Dashed curves are outputs of speakers separately.

Considering all factors, the optimum crossover point for a two-way system is about 1000 Hz.

If the network is to be minimized, its frequency-contouring function must be supplanted. That can be the contouring of the response of the speaker itself. Such contouring is difficult, but it can be done, as is shown in the shapes of the curve of the woofer top-end and of the tweeter bottom-end in Fig. 11 where only one capacitor is used as the network.

It is important to purchase speakers in matched sets from one manufacturer, and purchase the very best.

Speakers should be mounted from the front. Back mounting introduces unnecessary irregularities due to the "tunnel effect" of the speakers "looking through" the thickness of the cabinet front panel. Also the two speakers should be mounted as close together as possible. ●

Motorola HEP Line Replacement Parts

THE need for replacement lines of semiconductors for consumer equipment developed when manufacturers began using transistors and diodes in their products. However, a pattern developed early that was unlike the familiar vacuum-tube situation: the semiconductors used were generally not well-known, readily available types, but were marked with special code numbers known only to the semiconductor manufacturer, the equipment manufacturer, and his authorized distributors. Thus, when the service technician had to replace a bad part, he could get a replacement only from the equipment manufacturer and this often entailed ordering from out of town, resulting in a long wait that slowed service and irritated customers.

An obvious solution to this problem was specific replacement lines with cross-reference guides. Early replacement lines contained only a few different devices to replace thousands of original products. This is the "universal" replacement concept. Because this meant that many of the replacements were actually not close equivalents, problems often arose.

Another approach to the problem of replacements is taken by the *Motorola* HEP program "Equal or Better" series. This line includes many more devices than the universal series, making it possible to provide a transistor with characteristics equal or superior to those of the transistor replaced.

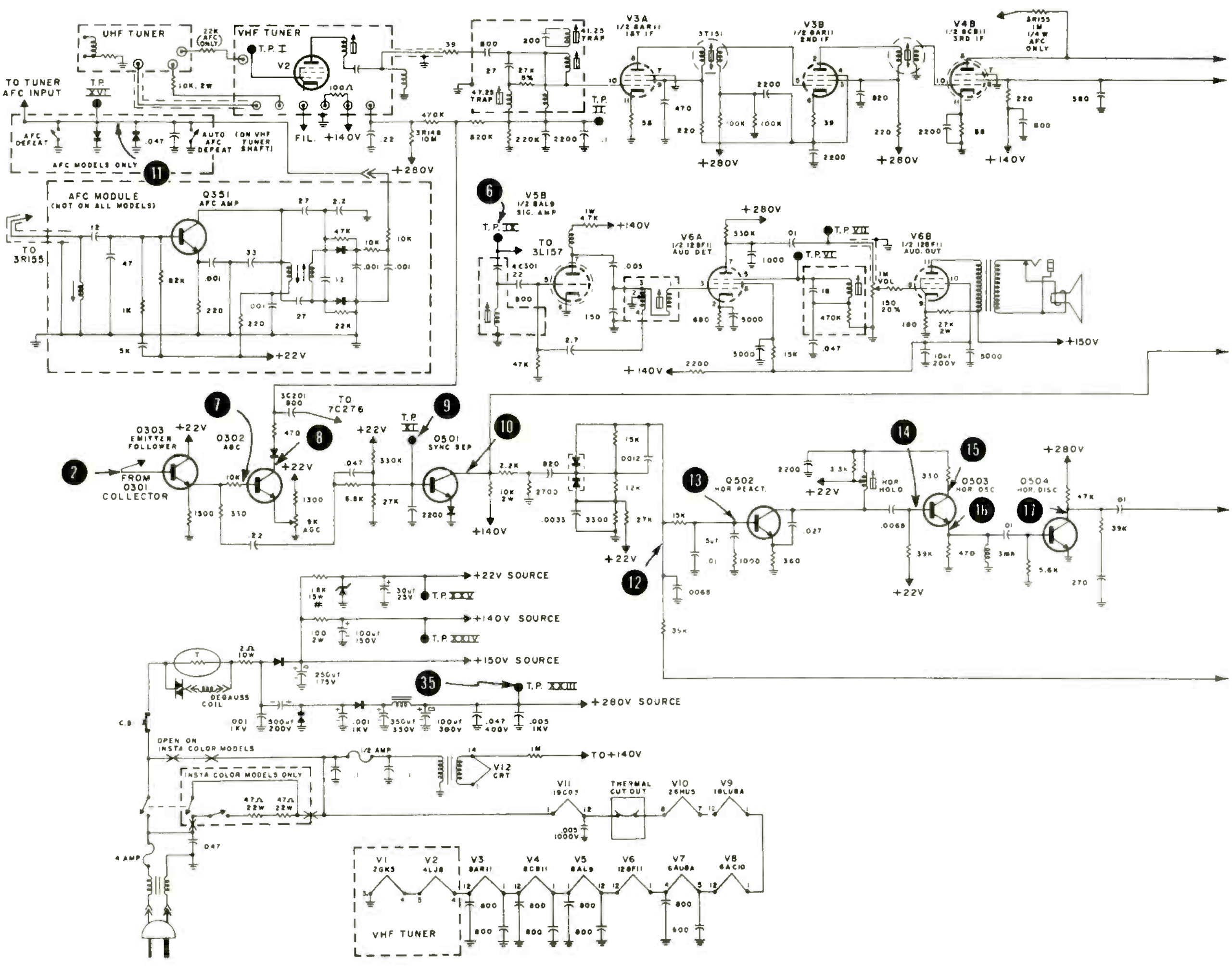
HEP semiconductors are readily available from over 1100 distributors in all areas of the United States.

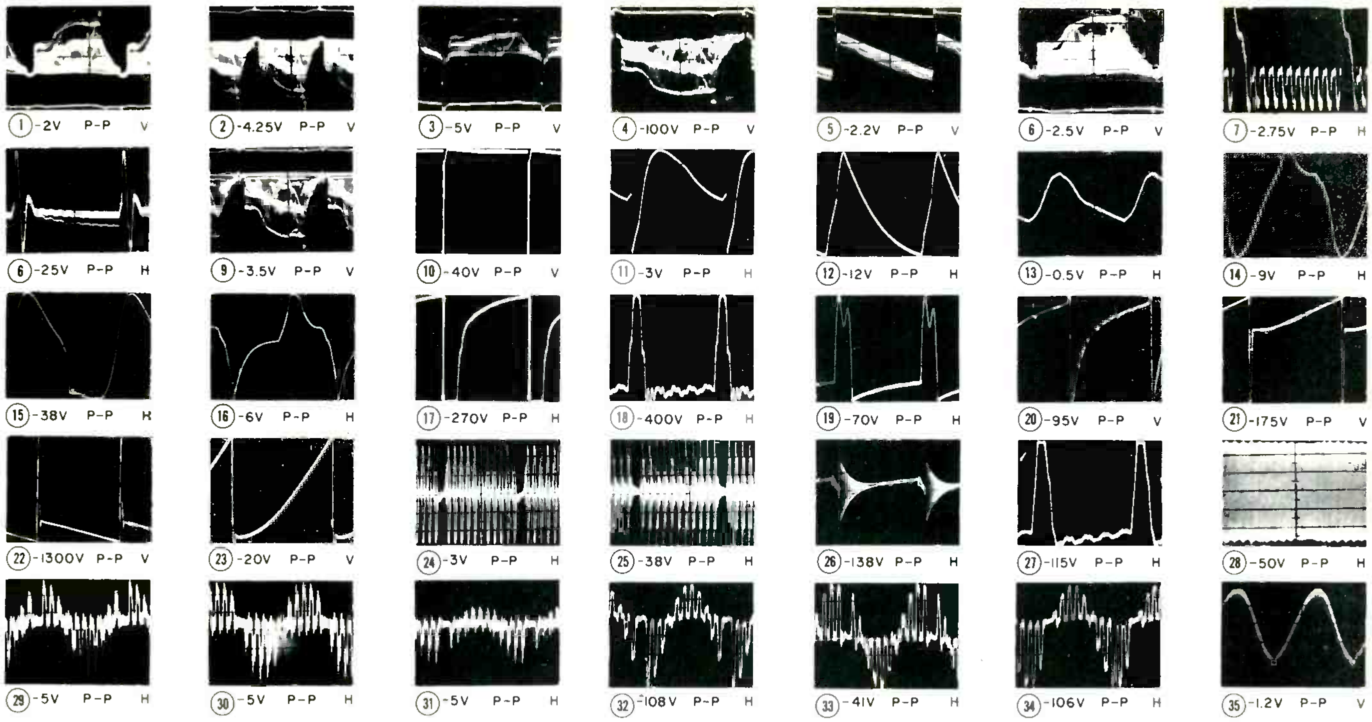
Replacements for over 20,000 semiconductors are listed in the "HEP Cross-Reference Guide." The equivalents are carefully selected from the extensive specifications at the *Motorola Semiconductor Products Division*, the world's largest producer of semiconductors. The "HEP Cross-Reference Guide" and the HEP catalogue, which lists detailed specifications on all HEP devices, are available from HEP distributors or the Technical Information Center, *Motorola Semiconductor Products Inc.*, Box 20924, Phoenix, Arizona 85036. ●

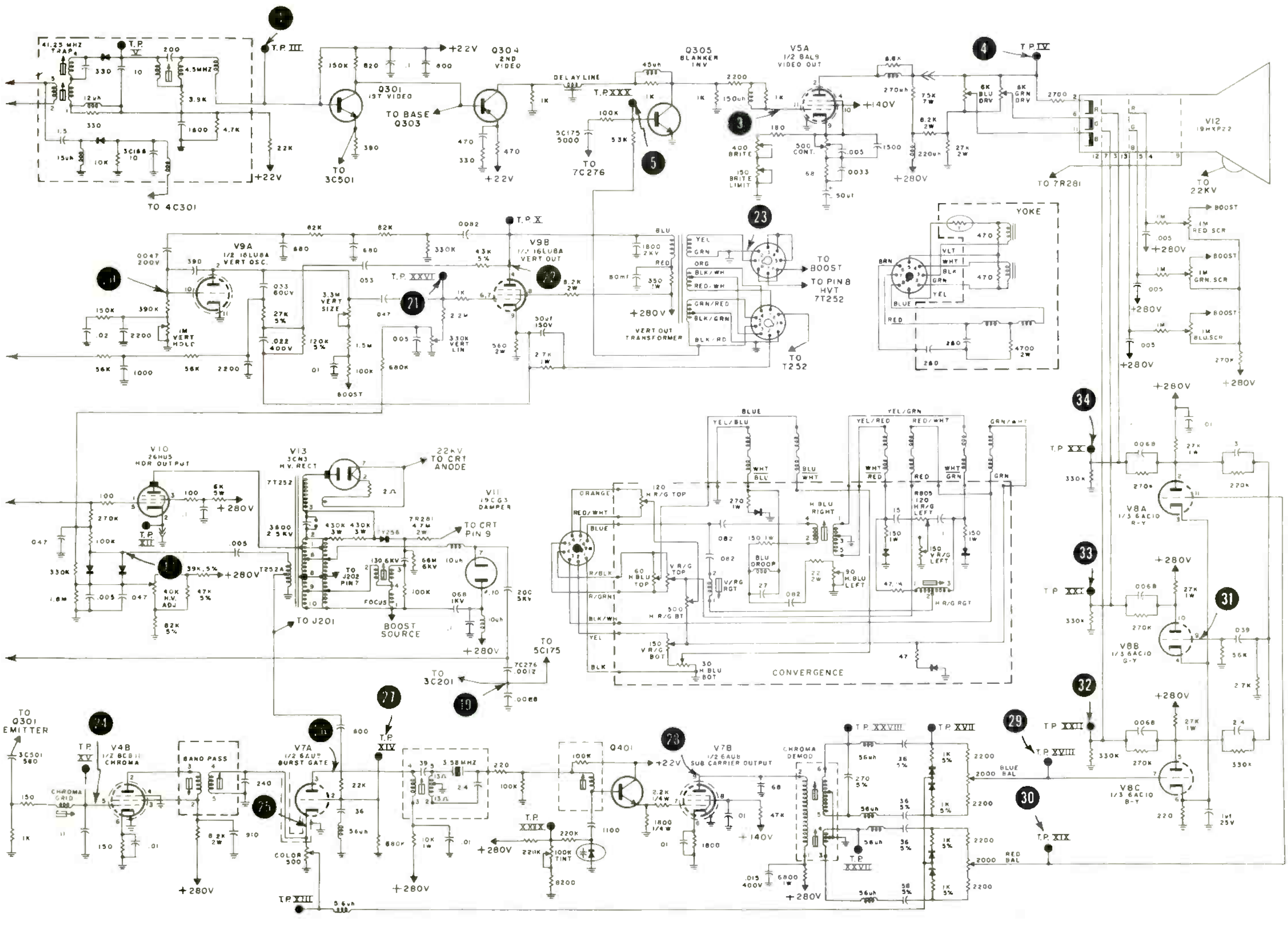
GENERAL ELECTRIC C-1

COLOR-TV CIRCUIT

Models using this new G-E chassis feature an 18-in picture tube, a lighter weight (60 lbs), and a high-impact polystyrene cabinet. A removable sliding panel allows easy access to the copper sides of the four separate circuit boards that are used. The portable color models with this chassis are WM260CBG, WM262CBG, WM264CWD, WM266CWD, WM269CMD, and CBM261CWD.




(1)-2V P-P V
(2)-4.25V P-P V
(3)-5V P-P V
(4)-100V P-P V
(5)-2.2V P-P V
(6)-2.5V P-P V
(7)-2.75V P-P H
(8)-25V P-P H
(9)-3.5V P-P V
(10)-40V P-P V
(11)-3V P-P H
(12)-12V P-P H
(13)-0.5V P-P H
(14)-9V P-P H
(15)-38V P-P H
(16)-6V P-P H
(17)-270V P-P H
(18)-400V P-P H
(19)-70V P-P H
(20)-95V P-P V
(21)-175V P-P V
(22)-1300V P-P V
(23)-20V P-P V
(24)-3V P-P H
(25)-38V P-P H
(26)-138V P-P H
(27)-115V P-P H
(28)-50V P-P H
(29)-5V P-P H
(30)-5V P-P H
(31)-5V P-P H
(32)-108V P-P H
(33)-41V P-P H
(34)-106V P-P H
(35)-1.2V P-P V


V5A 1/2 8AL9 VIDEO OUT
V9A 1/2 16LU8A VERT OSC.
V9B 1/2 16LU8A VERT OUT
VERT OUT TRANSFORMER
YOKE
V10 26HU5 HOR OUTPUT
V13 3CN3 H.V. RECT
V11 19CG3 DAMPER
CONVERGENCE
V4B 1/2 8CB11 CHROMA
V7A 1/2 6AU8 BURST GATE
V7B 1/2 6AU8 SUB CARRIER OUTPUT
V8A 1/3 6AC10 R-Y
V8B 1/3 6AC10 G-Y
V8C 1/3 6AC10 B-Y

CLASS-D CITIZENS-BAND EQUIPMENT DIRECTORY

CB transceivers licensed under Class D of the FCC Rules & Regulations (Part 95) are designed to operate with five watts input to the final r.f. amplifier stage of the transmitter. This is the maximum allowed for 27-MHz licensed operation.

In the tabulation that follows, it can be assumed that all transceivers listed are five-watt units (with output to the antenna falling into the 2½ to 3½ watt category). With 23-channel operation, the maximum allowable, many transceivers here utilize the full-band capability. Others are limited to, for example, five of the 23 available channels. This means that any five of the 23 can be used, although the manufacturer usually includes transmit and receive crystals for channel 9 (or 11) and leaves it at that. The user then buys compatible crystals for the balance of the available channels, specifying which channels he desires. This is indicated under "CHAN." in the directory. Most transceivers with a "23" rating come either equipped with all necessary crystals or have a built-in frequency-synthesizing circuit to permit the same thing.

Furnishing power to Class-D units is a subject of increasing controversy in the CB industry. A few years back, nearly all units came equipped with "Univ." (for universal) power supplies. This meant the set could be used both at home and in a vehicle (with built-in 12 V d.c./6 V d.c./117 V a.c. capability). Today, however, there is a definite trend to 12-volt-only sets. Reason? There are nearly four mobiles to every base station purchased. With competitive pricing constantly in mind, manufacturers now provide base capability as an option, through purchase (at varying prices) of a 117-V a.c. supply. These power adapters are usually designed to be used only with specific CB units.

Although the trend to solid-state continues, a few manufacturers continue to produce tube-type units. These are indicated in the directory by a "—" under the "SEMI." category.

Guide to notes: [1]In kit form only. [2]All transmit and receive crystals included.

MFG.	MODEL	CHAN.	VOLT.	SEMI.	PRICE ($)
Allied	A-2564	23	12	X	149.95
	A-2567	23	Univ.	X	179.95
	A-2568	23	Univ.	X	199.95
B&K	CAM-88	23	Univ.	—	219.95
	Cobra V	5	12	X	99.95
	Cobra 24	23	12	X	169.95
	Cobra 27	23	Univ.	X	179.95
	Cobra 98	23	Univ.	—	239.95
Browning	Eagle	23[2]	117	—	359.00
	Eaglette	23[2]	12	—	209.50
	Eaglette 2	23[2]	12	X	204.50
	Golden Eagle	23[2]	117	—	395.00
	Golden Eagle Mark II	23[2]	117	—	495.00
Courier	Classic	23	12	X	199.00
	Royale	23	Univ.	—	299.00
	Traveller	23[2]	12	X	159.00
	TR-5	5	117	X	99.00
	23	23[2]	Univ.	—	199.00
	23 Plus	23[2]	Univ.	—	229.00
Heath	GWW-14A	23	12	X	109.95
	GW-14	23	12	X	76.95[1]
	GW-22A	5	117	—	49.95[1]
	GW-22D	5	12	—	54.95[1]
International Crystal	MO-23	23	12	X, —	205.00
Johnson	Messenger 1	5	Univ.	—	124.95
	Messenger 100	6	12	X	129.95
	Messenger 110	5	12	X	109.95
	Messenger 111	12	12	X	149.95
	Messenger 123	23	12	X	179.95
	Messenger 124	23	Univ.	X	289.95
	Messenger 125	5	12	X	99.95
	Messenger 223	23	117	X	224.95
	Messenger 320	23	12	X	199.50
	Messenger 323	23	12	X	239.95
Kaar	Skylark 1-336	11	12	X	159.95
	Skyhawk 11-337	23	12	X	229.95
Lafayette	Comstat 19	9	117	—	59.95
	Comstat 23 Mark VI	23[2]	Univ.	—	99.95
	Comstat 25B	23[2]	Univ.	—	139.95
	HB-23	23	12	X	99.95
	HB-525C	23[2]	12	X	149.95
	HB-600	23[2]	Univ.	X	219.95
	HB-625	23[2]	12	X	189.95
	HE-20T	12	Univ.	X	89.95
	Telsat-23	23[2]	Univ.	X	59.95
	Telsat-150	23[2]	12	X	199.95
	Dyna-Com 5a	3	12	X	79.95
	Dyna-Com 12	12	12	X	99.95
Messenger	Fieldmaster TR-15	8	12	X	69.95
	Fieldmaster TR-16	6	12	X	49.95
Messenger	Fieldmaster TR-17	12	12	X	79.95
	Fieldmaster TR-18A	23[2]	12	X	139.95
	Fieldmaster TR-20	23[2]	12	X	149.95
Midland	13-855	6	12	X	69.95
	13-870C	23	12	X	139.95
	13-872	23	12	X	159.95
	13-876	23	Univ.	X	169.95
	13-877	23	Univ.	X	189.95
	13-880	23	Univ.	X	329.95
	13-890	23	117	—	129.95
Olson	CB-88	23	12	X	149.98
Pace	Pace 100	6	12	X	129.95
	Pace 2300	23[2]	12	X	199.95
	Pace Base Station	23[2]	Univ.	X	319.95
Pearce-Simpson	Companion II	5	Univ.	—	159.90
	Companion IV	10	12	X	139.90
	Director 23	23	12	X	269.90
	Guardian 23	23	Univ.	—	269.90
	Panther	5	12	X	99.90
Penny	Pinto 23	23[2]	12	X	129.00
	Pinto Jr.	6	12	X	69.00
	Pinto 23B	23[2]	Univ.	X	159.00
Realistic (Radio-Shack)	TRC-10	6	12	X	69.95
	TRC-18	12	12	X	99.95
	TRC-23B	23	Univ.	X	119.95
	TRC-24	23[2]	12	X	139.95
	TRC-29	23	Univ.	X	169.95
	TRC-100	6	12	X	99.95
Regency	Imperial II (SSB)	23	Univ.	—	349.00
	500	12	12	X	99.95
	GT-523	23	12	X	189.00
	Formula 12	12	117	X	99.95
	Formula 23	23	117	X	189.00
Robyn	TR-123B	23[2]	12	X	139.95
Sears Roebuck	6556	5	12	X	99.95
	6562	23	12	X	199.95
	7531	23	12	X	159.95
	7535	23	117	—	199.95
Sonar	FS-23	23[2]	Univ.	—	299.95
	H	7	Univ.	—	159.95
	J-23	23[2]	12	X	239.95
	J-23-1	23	12	X	169.95
	T6	6	12	X	139.95
Squires-Sanders	Skipper	23	12	X	159.95
	Flagship	23	117	X	299.95
Tram	Titan	23	117	—	410.00
	Titan II	23	117	—	482.00
	Corsair	23	Univ.	—	415.00

How to Add Remote Speakers to Your Stereo System

By VICTOR BROCINER
Vice President, Planning
H. H. Scott, Inc.

Adding speakers to a solid-state stereo amplifier may cause serious damage to the amplifier. Here is how it can be done safely.

WE have become so used to the convenience of our constant-voltage power line, into which one may plug household appliances almost at will, that it is sometimes difficult to remember that the output of a high-fidelity amplifier must be treated somewhat differently. Even in the case of the power line, one has to be careful not to plug in too many appliances, or the fuse will blow. A similar precaution must be exercised when connecting multiple loudspeakers to amplifiers, with the difference that in the case of solid-state amplifiers it can be the power transistors that blow instead of the fuse. However, if a few simple precautions are observed, no problems need arise.

Every household appliance is marked with a power rating, in *watts*. This figure specifies the amount of power that the appliance draws from the regular 120-volt line. It also determines, together with another factor – the efficiency – how much power the device produces. In the case of an electric fan, for example, it is directly related to the amount of air that the fan is capable of moving.

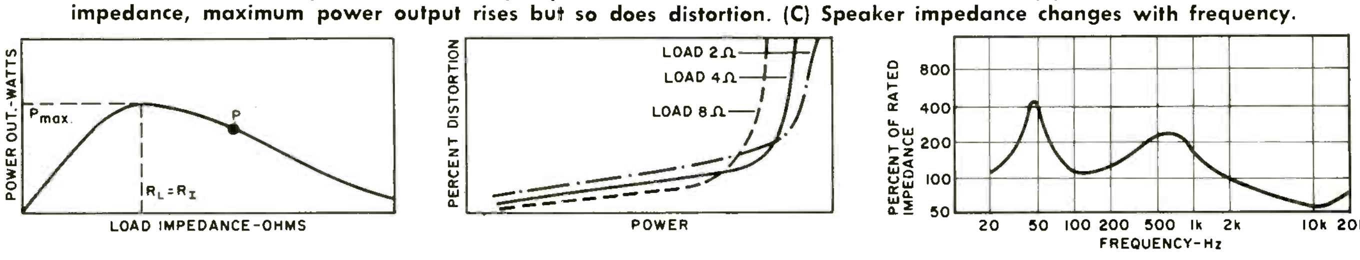
Loudspeakers, unlike household appliances, are not connected to a source of fixed voltage like the 120-volt line. The output voltage of an amplifier varies with the setting of the loudness control, and also from instant to instant as it follows the rapid variations in the program material, be it voice or music. Consequently a means different from wattage rating had to be found to express the capacity of the speaker to absorb power from the amplifier. The term so used is *impedance*, and it happens that its value is in inverse ratio to the power absorbed: the greater the impedance, the less the power input to the speaker, and *vice versa*. If you apply less power to the speaker, then its acoustic output power is reduced in proportion.

The impedance of a circuit is equal to the voltage across the circuit divided by the current through the circuit: $Z = E/I$. When this is rearranged as follows: $I = E/Z$, it becomes a little clearer that impedance is the current-determining element for a given applied voltage and, in the case of amplifiers, it is the current drawn that we are concerned about. The internal heating in the power devices of an amplifier increases rapidly as the current drawn from them goes up. Of course, there is a point beyond which this heat damages the device. With solid-state devices the allowable time for an extreme overload may be on the order of microseconds.

With any output device, the power output varies as the load impedance is varied. At zero impedance the power output is obviously zero, as it is at infinite impedance. As the impedance is increased from zero value, the power output increases to a maximum and then decreases (Fig. 1A). Maximum power output is delivered when the load impedance is equal to the internal impedance of the amplifier. For impedance values near this optimum, the variation in power output is relatively small.

With transistor amplifiers the internal impedance of the amplifier is so low that if a matching impedance were used to obtain maximum power, the current drawn from the transistors would be far in excess of their maximum capability. Consequently transistor amplifiers

Fig. 1 (A) As load impedance rises, output power rises to a maximum and then falls. (B) At lower than rated impedance, maximum power output rises but so does distortion. (C) Speaker impedance changes with frequency.



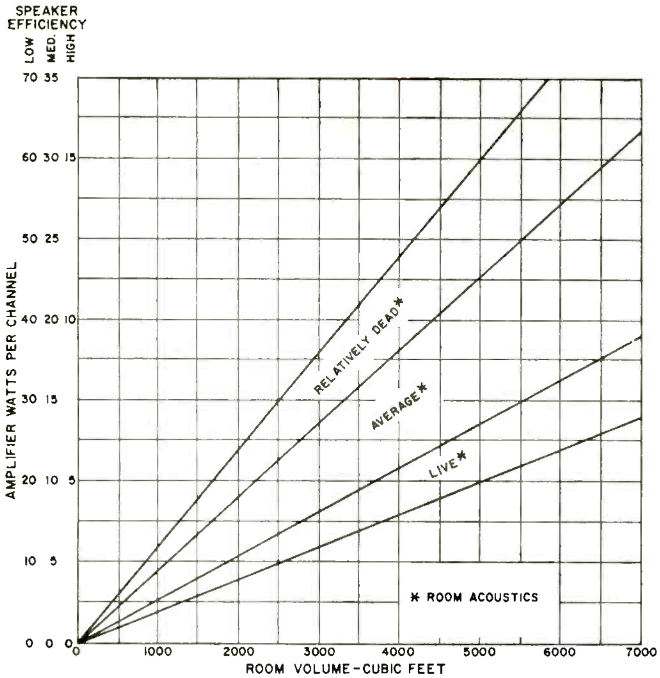


Fig. 2. Continuous power requirements for various room sizes and acoustics, for speaker systems of different efficiencies. In general, completely closed acoustic-suspension systems are fairly low in effiiciency while closed and ported systems with efficient speakers and horn systems are high in efficiency. If most listening is done at high levels, somewhat more power is needed; for listening at low background levels, somewhat lower power is required.

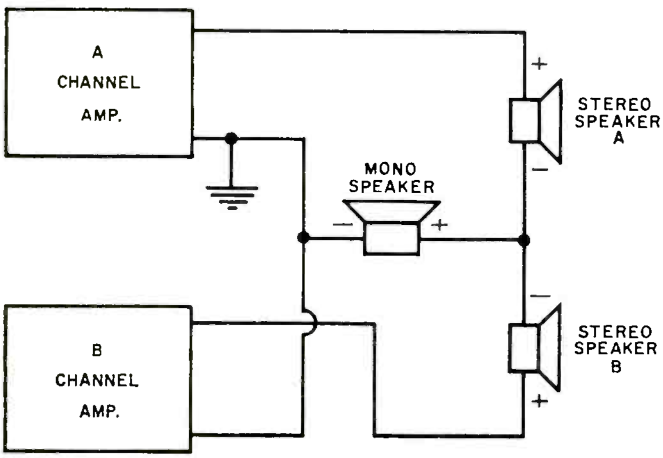


Fig. 3. Novel method of obtaining center mono channel. Special network ahead of amplifiers maintains separation.

are designed to operate into impedances considerably higher than the optimum impedance (point *P* in Fig. 1A); furthermore, since they are almost invariably output-transformerless, the power delivered is determined by the value of the load impedance and there is not much one can do about it.

Suppose that a solid-state amplifier is designed to deliver its rated power into a 4-ohm load. If it is well-designed, the current drawn by this load will be such as to keep the internal heat dissipation in the output devices appreciably below their maximum. However, the safety margin is not made so great that a 2-ohm load, for example, which would draw double the current of the rated load, would be safe. Fuses do not act quickly enough to protect against the effects of extremely brief overloads. Electronic protective circuits may do so, but they add considerably to the cost of the amplifier if they are designed to provide adequate protection.

Even when the danger of damage to the power transistors is small — and today's solid-state amplifiers are remarkably rugged — there is another factor that must be taken into account: distortion. Operating a solid-state amplifier into a load impedance lower than the rated value results in increased distortion, and not only at very high power; the performance is deteriorated even at ordinary listening levels (Fig. 1B). Hence, it is important to keep the load impedance equal to or greater than the rated value.

We have been referring to the impedance of a speaker as if it were a fixed quantity. Actually, it isn't. The impedance of a loudspeaker is different at different signal frequencies throughout the audible spectrum. The range of variation can be on the order of 10 to 1 or more.

A curve showing a typical variation of speaker impedance over the frequency range is shown in Fig. 1C. If this were a speaker rated at 8 ohms, it can be seen that the impedance has a minimum value of slightly over 4 ohms at 10 kHz. The combination of two such speakers in parallel would be rated at 4 ohms but would actually present a load of 2 ohms to the amplifier at 10 kHz, a value below the minimum recommended for most amplifiers. It is important for the value of speaker impedance to be carefully controlled over the entire frequency range to avoid detrimental effects. (See "Problems of Matching Speakers to Solid-State Amplifiers," Victor Brociner, ELECTRONICS WORLD, January 1967.)

Assume now that we want to connect one or more sets of loudspeakers to a hi-fi system, with the thought of operating more than one at a time. How shall we proceed?

Amount of Power Required

When several speakers are operated from the same amplifier, the power output of the amplifier is shared among them. This limits the number of speakers that can be operated from a given amplifier, depending on the levels at which they are to be operated. If an amplifier is just adequate to provide the desired levels in the main listening room, it will not be satisfactory to provide full room volume in an additional room as well. On the other hand, if the remote installation is intended to provide soft background music only, the arrangement will be quite acceptable.

In making judgments of the adequacy of the power available, it should be kept in mind that doubling the output, or increasing it by 3 dB, does not double the loudness. A 7-10 dB power increase, the exact amount depending on the nature of the program material, is required to double loudness. Looking at it the other way, halving the power results in a noticeable but not pronounced change in loudness. Halving the loudness involves a decrease in power of 1/5 to 1/10. Of course, this information has to be applied with a certain amount of judgment; otherwise it might well lead to the connection of 50 additional speakers, based on the argument that each speaker that is added results in an only slightly noticeable decrease in loudness!

The amount of amplifier power required in an average living room depends, among other things, on the

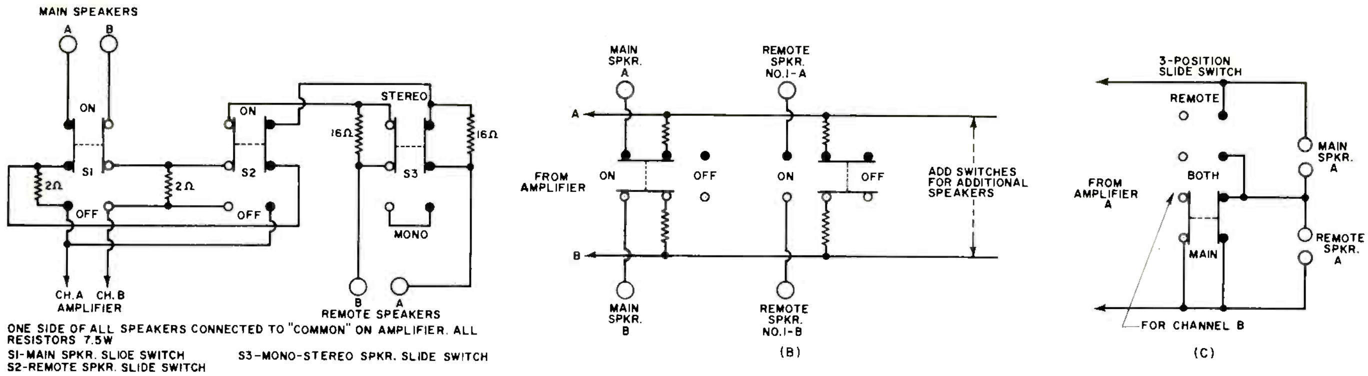


Fig. 4. Various switching circuits used to operate a remote loudspeaker system.

efficency of the loudspeakers used. A guide to power requirements is given in Fig. 2. From this chart it is easy to determine the power requirements for each speaker station, and from this to find the total power required. If all of the loudspeakers are not going to be used simultaneously at any time, the power should be determined for the combination requiring the greatest total power.

Remote Speakers: Stereo or Mono

If stereo reproduction is desired wherever additional speakers are installed, each installation requires a pair of speakers for the two stereo channels. If monophonic reproduction is desired, things are a little less simple. Connecting a speaker to only one of the channels is obviously not a good solution. It is necessary to obtain the sum of the left and right channels in some manner to recover the monophonic program content. Many amplifiers have a low-level "center-channel" output connection which provides such a signal. While originally intended primarily to provide a center channel for widespread stereo using three speakers, it is eminently suitable for the purpose we have in mind. This connection provides sufficient voltage to drive a separate power amplifier for the remote speakers.

Where sufficient power is obtainable from the main amplifier, it is far more convenient to use an arrangement which does not require an additional power amplifier. Bridging speakers across the respective outputs of the left- and right-channel amplifiers is not a satisfactory solution because, among other things, this provides a difference rather than a sum signal. Nor is it possible to remedy this by reversing the output of one of the channels because they have a common ground connection internally.

A novel system for obtaining a center channel is shown in Fig. 3. The part of the circuit illustrated, if used alone, has a detrimental effect on the separation of the stereo channels. In practice, a special input network is used ahead of the two channels of the amplifier to compensate for this.

A very simple and convenient provision for obtaining a powered monophonic channel is embodied in *H. H. Scott* amplifiers and receivers (Fig. 4A). The remote speakers are connected directly to the amplifier terminals marked "Remote" and switch S3 set to "Mono." For amplifiers not equipped with such conveniences, it is possible to use a high-quality 1:1 transformer to reverse phase, as shown in Fig. 5A. For those who do not wish to go to the expense and trouble of using a transformer and are willing to tolerate a 6-dB loss in level when using a single remote 8-ohm loudspeaker, the circuit of Fig. 5B offers a simple solution.

Impedance "Matching"

Although the term "matching" has been used in this section heading in accordance with common practice, it should be pointed out that it is not really matching that we are concerned with, but rather the connection of the correct value of total load impedance to the amplifier. Additional speakers must be connected in such a way as not to present a total load impedance of less than the minimum value specified for the amplifier being used. Since hi-fi loudspeakers are made with impedances of 4, 8, and 16 ohms, depending on the model and manufacturer, and since most solid-state amplifiers have a minimum specification of 4 ohms for load impedance: (1) up to four 16-ohm speakers may be used in parallel, (2) two 8-ohm speakers may be used in parallel, (3) multiple 4-ohm speakers represent a problem.

If speakers of different impedances are paralleled, the resulting impedance can be found from the formulas:

For two speakers: $$Z_{TOT} = \frac{Z1Z2}{Z1 + Z2}$$

For three or more speakers: $$Z_{TOT} = \frac{1}{1/Z1 + 1/Z2 + 1/Z3 \ldots\ldots}$$

When using a combination of speakers which present an unacceptably low value of impedance if paralleled, one is tempted to consider putting the speakers in series so that their impedances add. This is permissible provided the speakers are identical – and this means identical not only in impedance, but in all respects. With dissimilar speakers, interaction takes place between the two speakers, resulting in deteriorated per-

Fig. 5. (A) Using 1:1 transformer to power remote mono speaker. (B) Simple circuit but with a 6-dB power loss.

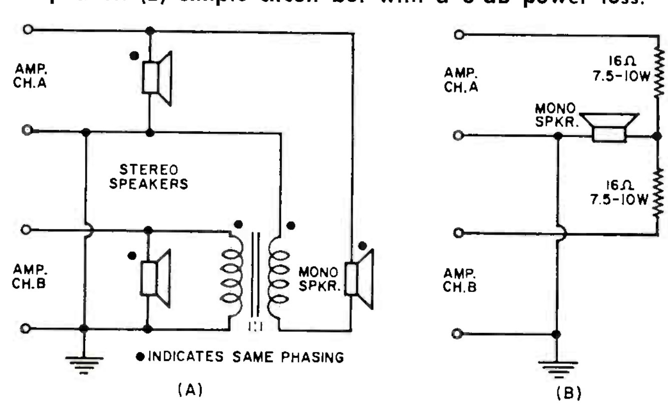
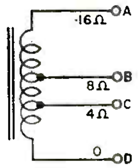


Fig. 6. Using the transformer secondary taps for matching.



AMPLIFIER		SPEAKER(S)	
CONNECT TO	FOR LOAD VALUE	IMPEDANCE	CONNECT TO
B–D	8Ω	16Ω	A–D
B–D	"	4Ω	C–D
A–D	"	2Ω	C–D
B–D	"	1.44Ω	A–B
B–D	"	.64Ω	B–C
A–D	"	.32Ω	B–C
B–D	4Ω	8Ω	A–D
B–D	"	2Ω	C–D
A–D	"	1Ω	C–D
B–D	"	.72Ω	A–B
B–D	"	.32Ω	B–C
A–D	"	.16Ω	B–C

formance for both. The same consideration also holds true, of course, for series-parallel arrangements.

To avoid the problem presented by speaker combinations that would result in too low an impedance, as in case (3) above, one can resort to a transformer. Fig. 6 shows the large number of impedance transformations that can be obtained with a 0-4-8-16-ohm transformer. A high-quality output transformer designed for tube amplifiers can be used for this purpose, provided care is taken to cut off and insulate the high-impedance primary winding connections. The transformer *must* be a high-quality unit. Ordinary transformers have a low value of primary inductance. Since this shunts the line to which the transformer is connected, it becomes a very low impedance at low frequencies, defeating the very reason for which the transformer was used in the first place.

Switching of Speakers

Most of today's receivers and amplifiers are provided with terminals for extra speakers and some form of front-panel switching. The more eleborate units provide switching to permit changing from the main to the remote speakers and also to operate both at the same time. A series resistor is usually switched into the circuit when both sets of speakers are in operation to provide for the use of 4-ohm speakers for both main and remote positions. This protects the amplifier against possible overload; it also results in a loss of total power available, usually on the order of 6 dB, plus a reduction of damping factor to around 1. These effects are proportionally less with speakers of higher impedance.

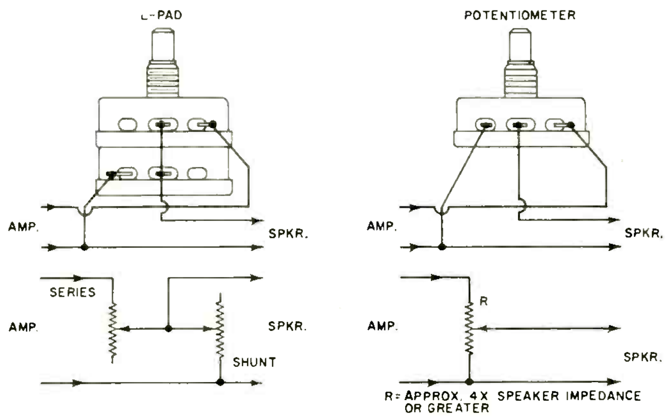
The decreased damping factor results in a slight exaggeration of the very deep bass with low-efficiency speakers, and actually improves the bass response of high-efficiency speakers. The loss in power is unfortunate, especially since it takes place when extra power is needed for the operation of the additional speaker system, but this is the penalty one pays for using low-impedance speakers without provision for "matching."

If switching is not provided in the amplifier, or if the switching that is present does not include operation of both sets of speakers simultaneously, the circuit of Fig. 4A can be incorporated into a separate switch box and connected between the standard amplifier output terminals and the speakers. The third switch and associated resistors (for stereo-mono operation) may be omitted if desired. Slide switches rated at 2 amperes or more are satisfactory. If the total load presented by all the speakers that are going to be operating at the same time is no lower than the minimum value specified for the amplifier, the protective resistors may be omitted.

If more than one set of additional speakers is to be used, all of them can be wired in parallel to the "remote" terminals, unless it is desired that they be independently controlled by switches. In this case, a series of double-pole switches, wired as shown in Fig. 4B, is the simplest arrangement. If the load presented by all the speakers in parallel is too low, individual resistors should be used in series with all the speakers. If the main speaker impedance is appreciably greater than the recommended minimum, it need not have a series resistor. Circuits to switch these resistors in and out as needed would be excessively complicated.

When two speakers are operated in series, the switch can be connected most simply to short out the unwanted speaker (Fig. 4C).

Fig. 7. Connections of L-pad and potentiometer in order to control the volume of sound of remote speaker.



Operating Levels and Controls

Since modern amplifiers are essentially constant-voltage devices, the same voltage is applied to all speakers operated in parallel. The power fed to a given speaker is inversely proportional to its impedance, while its output is directly proportional to its efficiency. For example, if an 8-ohm and a 16-ohm speaker of equal efficiency are paralleled, the 8-ohm speaker receives twice as much power as the 16-ohm speaker. When series resistors are incorporated into the amplifier, the effect is to reduce the discrepancy. In the circuit previously described for monophonic operation of remote speakers (Fig. 5B), there is a loss of about 9 dB for a 4-ohm speaker, 6 dB for an 8-ohm speaker, and 2 dB for a 16-ohm speaker. The 6-dB loss, incidentally, is desirable when the additional speaker is operated as a center channel for stereo.

Fig. 7 illustrates two methods of individual volume control for remote speakers. The L-pad is the more elaborate and expensive of the two, but it offers the advantages of no loss of power when set to maximum, and preservation of a high damping factor. The potentiometer uses up some of the available power even when set to a maximum (about 1/5) and reduces the damping

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PAYMENT MUST BE ENCLOSED WITH ORDER IS-70 factor to a value of 1 at 50% of full rotation. A really elegant but expensive method is to use a small (1.0-ampere) variable transformer as a level control. A close approach to this is a tapped transformer plus a switch. Suitable units are available in pairs with a ganged switch, for stereo use. Individual controls for all speakers provide means for balancing each stereo pair.

When using local controls other than variable or tapped transformers, care should be exercised to avoid operating them at unnecessarily low setting with the amplifier volume control turned up high, which wastes power and increases distortion.

Power ratings on controls need not be as high as one might think. Heating in the controls is determined by the relatively long-term power dissipated. The average power, even of highly compressed program material, is well below 10% of the amplifier rating. Consequently, a control rating of 10% of the power fed to the speaker is satisfactory. This means 2 to 5 watts in most systems.

Tap switches are actually preferable to continuous controls. The reason is that speaker controls are likely to be left at one setting for long periods of time. Variable controls tends to develop faulty contacts under these conditions and become noisy. The crackling noise can usually be eliminated by rapid rotation of the control forward and back several times, or through the use of special contact cleaning fluids available in liquid and spray-can form. Switches do not usually require such maintenance. However, suitable assemblies of switches and resistors are not as generally available as continuous controls. For those interested in constructing step-type level controls, Fig. 8 shows the circuit and resistor values for 3-dB steps. For stereo, two such assemblies ganged together are required.

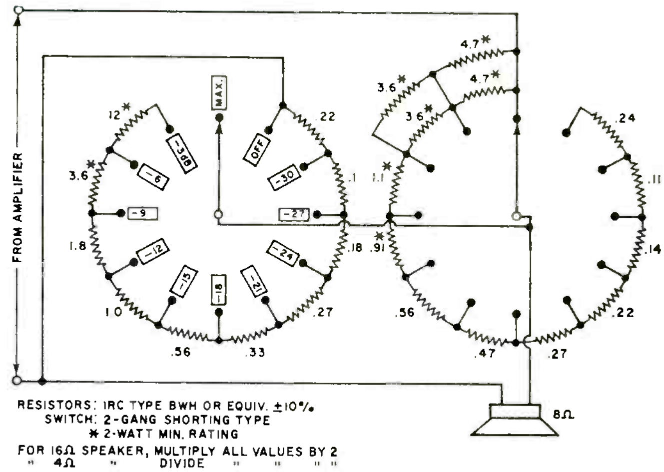
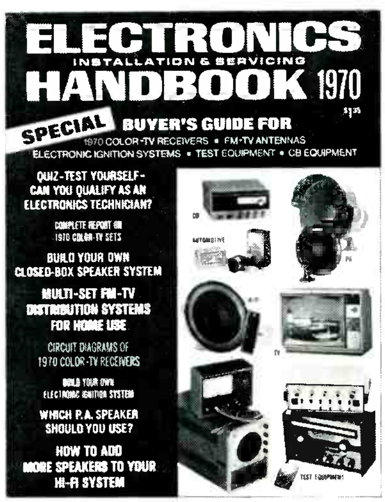


Fig. 8. Switch and resistor combination to provide step type level control for a remotely located loudspeaker.

Connections to speakers must be made with wire having sufficiently low resistance to avoid appreciable power loss. This is of importance only with long leads.

Ordinary lamp cord is suitable. Use a wire thickness of 18 gauge or less (smaller number, thicker wire) for lengths between amplifier and speaker of 50 feet or less. Over 50 feet, use 16 gauge. Where phasing is important use a color-coded wire, one with a marker yarn, or some other means of distinguishing one wire of the pair from the other. (SP-1 "zip cord" usually has one wire identified by a thin outside rib on the insulation.) ●

COVER STORY



OUR COVER shows a number of new products that typify the contents of this year's Handbook. In taking the photograph, we have grouped together the products by category. For example, the largest grouping of items at the bottom of the picture are pieces of test equipment. Beneath the CB transceiver at the top left is a small group of electronic automotive products. Below this group is a pair of hi-fi loudspeakers while a pair of p.a. loudspeakers is at the top right. Finally, the color-TV set typifies our coverage of this important topic.

The CB transceiver is the *E. F. Johnson* "Messenger 124," a solid-state, 23-channel unit with a double-conversion receiver and transmitter featuring audio compression and clipping for maximum "talk power." The group of automotive products includes *Delta Products* Mark Ten capacitive-discharge electronic-ignition system, the *Knight-Kit (Allied Radio)* KG-340 electronic tachometer, and the *Knight-Kit* KG-303 junior auto analyzer for measuring dwell, r/min, and voltage.

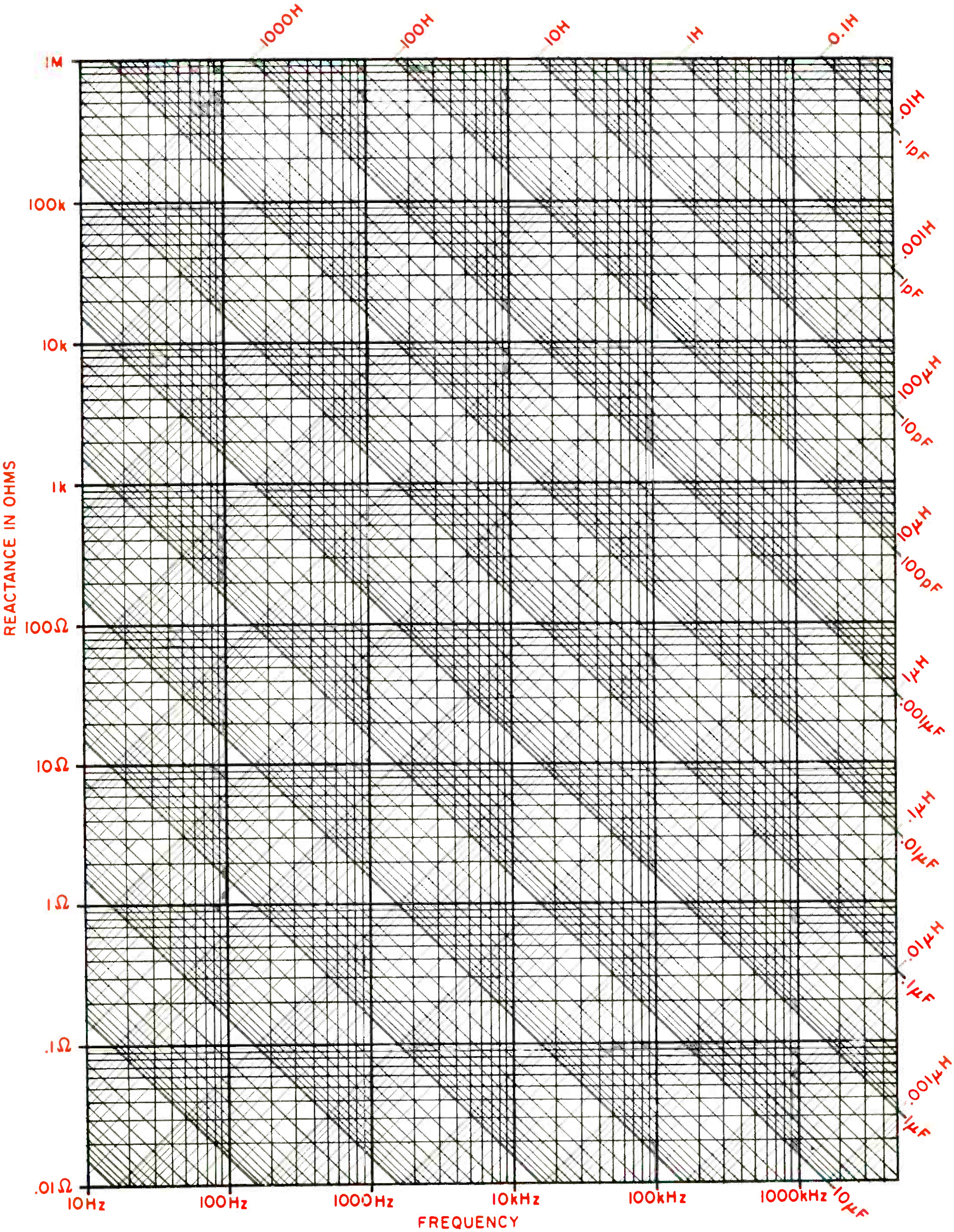
The two p.a. speakers at the top right are *University Sound* high-efficiency, re-entrant horns designed for paging and talk-back applications. The upper unit is Model UH-T; the lower one is Model MIL-A. The pair of hi-fi speakers at the left are *Electro-Voice* models. The larger one is a 12-in coaxial loudspeaker (Model SP12B); the smaller one is a horn-loaded tweeter (Model T350) for very high audio frequencies.

The table-model color-TV set is an *RCA* Fraser (Model FM-477) with an 18-inch diagonal screen and automatic fine tuning.

Moving now to the group of test equipment at the bottom of the photo, we show a *Leader* Model LBO-53B wide-band oscilloscope. The scope covers the frequency range from d.c. to 10 MHz at a sensitivity of 10 mV(p-p)/cm; hybrid circuitry using both transistors and tubes is employed. Atop the scope is the new *B&K* Model 162 transistor tester that can check conventional transistors, FET's, UJT's, SCR's, and triacs. At the right is the solid-state *Sencore* SM-152 sweep and marker generator with its six frequency bands and nineteen crystal-controlled markers. Atop this instrument is the *Heathkit* IG-28 color-bar generator, which uses computer-type integrated circuitry to produce twelve patterns and a clear raster. The small meter in the foreground is the *Triplett* Model 310FET, a handy, pocket-sized v.o.m. that uses FET's to achieve a high input impedance of 10 megohms. ●

Cover photograph by Dirone-Denner

REACTANCE CHART



DECIBEL TABLE

Voltage Ratio (Equal Impedance)	Power Ratio	← − db + →	Voltage Ratio (Equal Impedance)	Power Ratio
1.000	1.000	0	1.000	1.000
0.989	0.977	0.1	1.012	1.023
0.977	0.955	0.2	1.023	1.047
0.966	0.933	0.3	1.035	1.072
0.955	0.912	0.4	1.047	1.096
0.944	0.891	0.5	1.059	1.122
0.933	0.871	0.6	1.072	1.148
0.923	0.851	0.7	1.084	1.175
0.912	0.832	0.8	1.096	1.202
0.902	0.813	0.9	1.109	1.230
0.891	0.794	1.0	1.122	1.259
0.841	0.708	1.5	1.189	1.413
0.794	0.631	2.0	1.259	1.585
0.750	0.562	2.5	1.334	1.778
0.708	0.501	3.0	1.413	1.995
0.668	0.447	3.5	1.496	2.239
0.631	0.398	4.0	1.585	2.512
0.596	0.355	4.5	1.679	2.818
0.562	0.316	5.0	1.778	3.162
0.531	0.282	5.5	1.884	3.548
0.501	0.251	6.0	1.995	3.981
0.473	0.224	6.5	2.113	4.467
0.447	0.200	7.0	2.239	5.012
0.422	0.178	7.5	2.371	5.623
0.398	0.159	8.0	2.512	6.310
0.376	0.141	8.5	2.661	7.079
0.355	0.126	9.0	2.818	7.943
0.335	0.112	9.5	2.985	8.913
0.316	0.100	10	3.162	10.00
0.282	0.0794	11	3.55	12.6
0.251	0.0631	12	3.98	15.9
0.224	0.0501	13	4.47	20.0
0.200	0.0398	14	5.01	25.1
0.178	0.0316	15	5.62	31.6
0.159	0.0251	16	6.31	39.8
0.141	0.0200	17	7.08	50.1
0.126	0.0159	18	7.94	63.1
0.112	0.0126	19	8.91	79.4
0.100	0.0100	20	10.00	100.0
$3.16x10^{-2}$	10^{-3}	30	3.16x10	10^{3}
10^{-2}	10^{-4}	40	10^{2}	10^{4}
$3.16x10^{-3}$	10^{-5}	50	$3.16x10^{2}$	10^{5}
10^{-3}	10^{-6}	60	10^{3}	10^{6}
$3.16x10^{-4}$	10^{-7}	70	$3.16x10^{3}$	10^{7}
10^{-4}	10^{-8}	80	10^{4}	10^{8}
$3.16x10^{-5}$	10^{-9}	90	$3.16x10^{4}$	10^{9}
10^{-5}	10^{-10}	100	10^{5}	10^{10}
$3.16x10^{-6}$	10^{-11}	110	$3.16x10^{5}$	10^{11}
10^{-6}	10^{-12}	120	10^{6}	10^{12}

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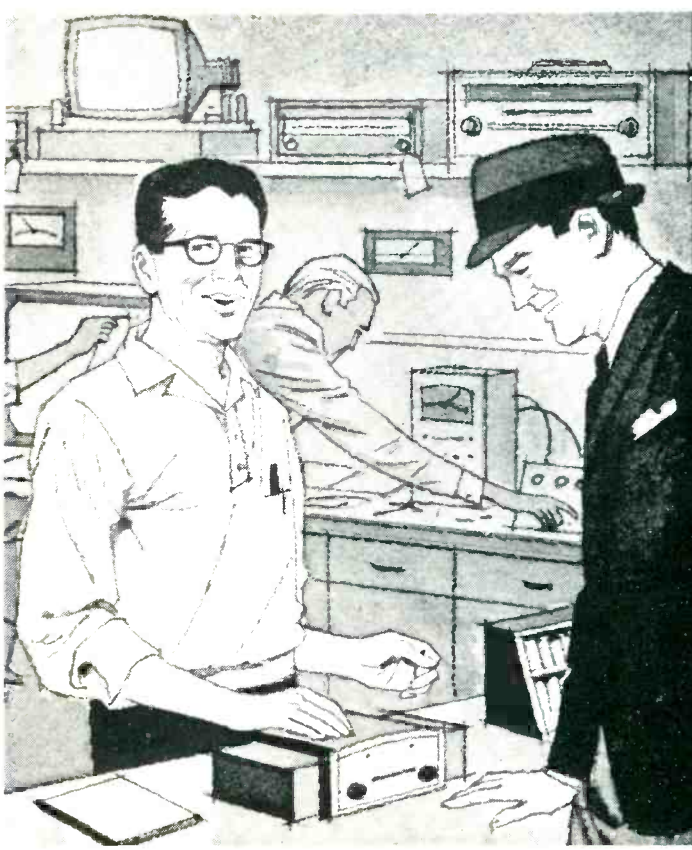


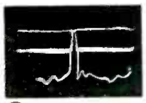
"My shop's been loaded... since I got my FCC License."

CIRCLE NO. 5 ON READER SERVICE PAGE

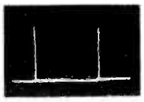
RCA CTC 40

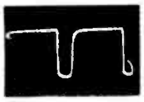
COLOR-TV CIRCUIT

This completely solid-state chassis (except for high-voltage rectifier) includes transistors, SCR's, and IC's to operate a 23-in picture tube. It is used in a large number of new console models including some featuring remote control. Models currently using the chassis include FM-513, GM-663, -669, -675, -681, -687, -693, -699, -705, -711, and -717. In addition to these, a large number of combination consoles, many with remote control, use this particular chassis.

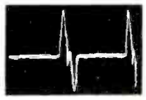

(1)-3V P-P V


(2)-3V P-P V


(3)-1V P-P V


(4)-180V P-P H


(5)-15V P-P V


(6)-0.3V P-P H


(7)-3V P-P V


(8)-3.8V P-P V


(9)-3.8V P-P H


(10)-30V P-P V

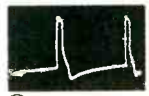

(11)-30V P-P H

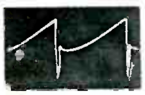

(12)-25V P-P H


(13)-12V P-P H


(14)-14V P-P H


(15)-5V P-P H

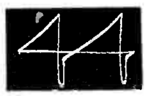

(16)-20V P-P H

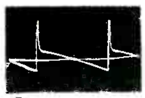

(17)-4V P-P V

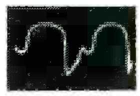

(18)-0.75V P-P V


(19)-4.3V P-P V

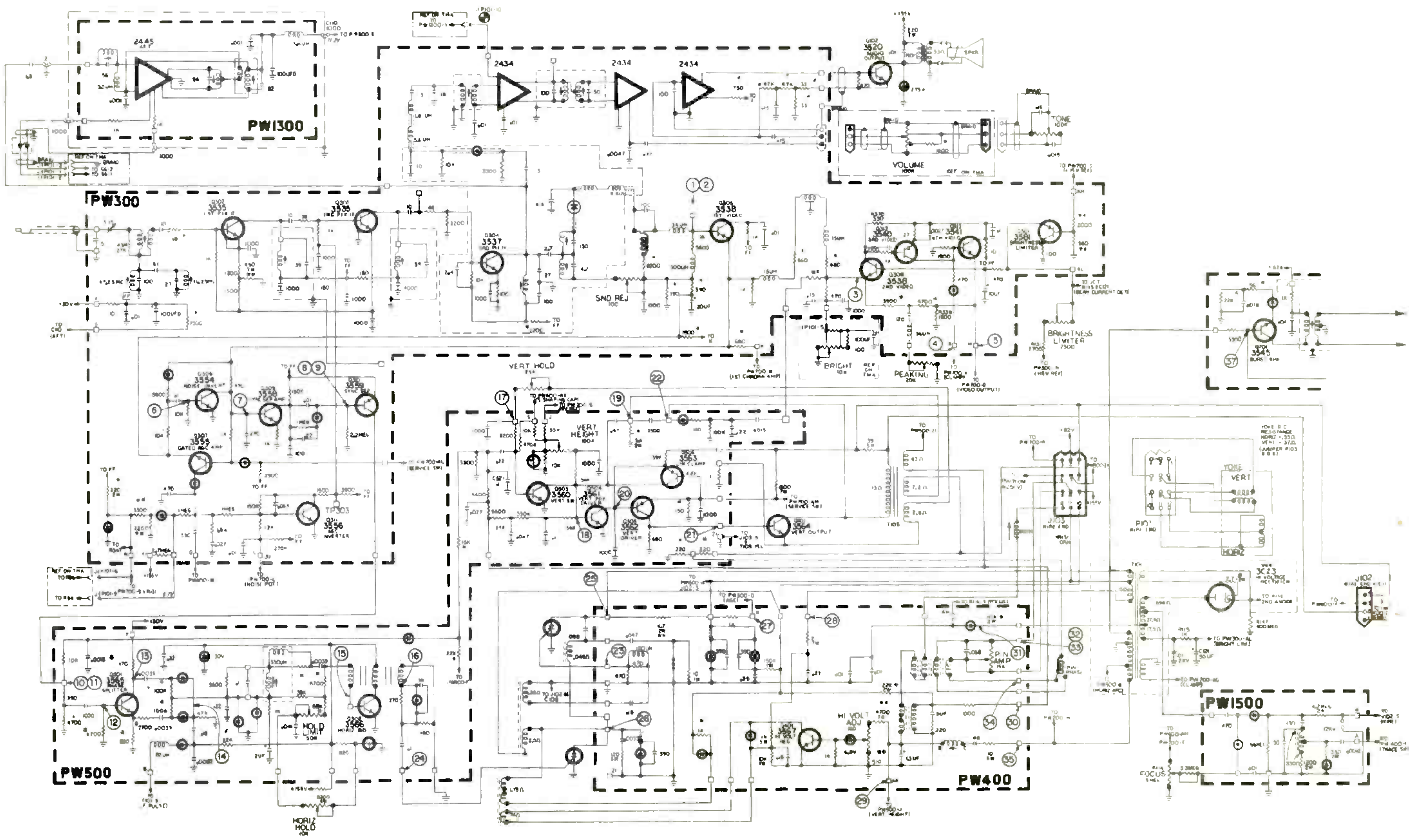

(20)-3V P-P V


(21)-1.5V P-P V


(22)-200V P-P V


(23)-42V P-P H


(24)-12.5V P-P H



(25) -400V P-P H (26) -350V P-P H (27) -400V P-P H (28) -110V P-P H (29) -30V P-P H (30) -100V P-P V (31) -1500V P-P H (32) -55V P-P H

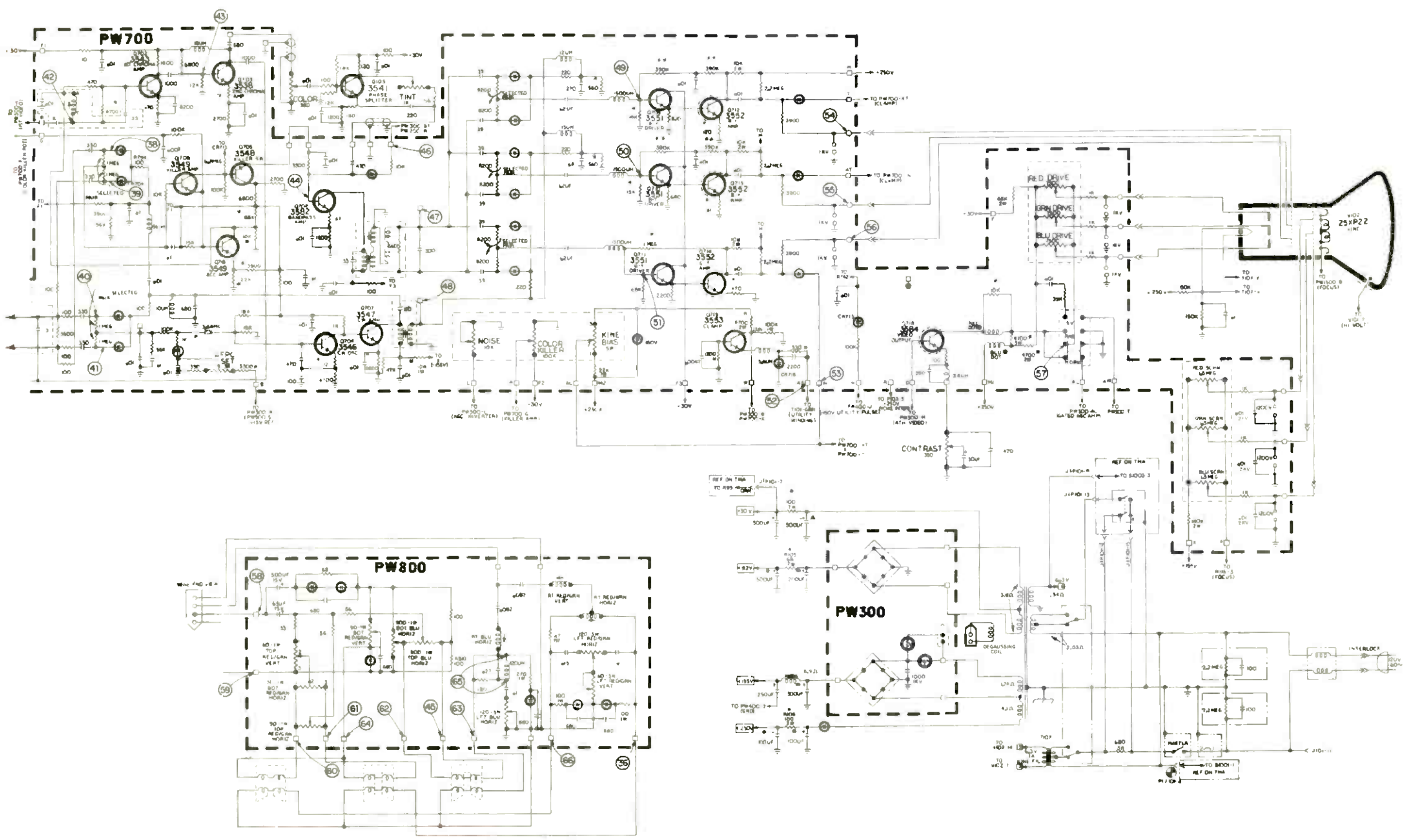
(33) -70V P-P V (34) -50V P-P V (35) -140V P-P H (36) -28V P-P H (37) -20V P-P H (38) -32V P-P H (39) -38V P-P H (40) -30V P-P H

(41) -30V P-P H (42) -.04V P-P H (43) -0.4V P-P H (44) -4.2V P-P H (45) -7V P-P V (46) -180V P-P H (47) -5V P-P H (48) -8.5V P-P 100 kHz

(49) -3.2V P-P H (50) -3.5V P-P H (51) -4.2V P-P H (52) -25V P-P H (53) -135V P-P H (54) -120V P-P H (55) -130V P-P H (56) -36V P-P H

(57) -90V P-P H (58) -15V P-P V (59) -2.8V P-P V (60) -7V P-P V (61) -6V P-P V (62) -9V P-P V (63) -40V P-P H (64) -9V P-P V

(65) -12V P-P H (66) -20V P-P H



Television's Built-in Test Signals

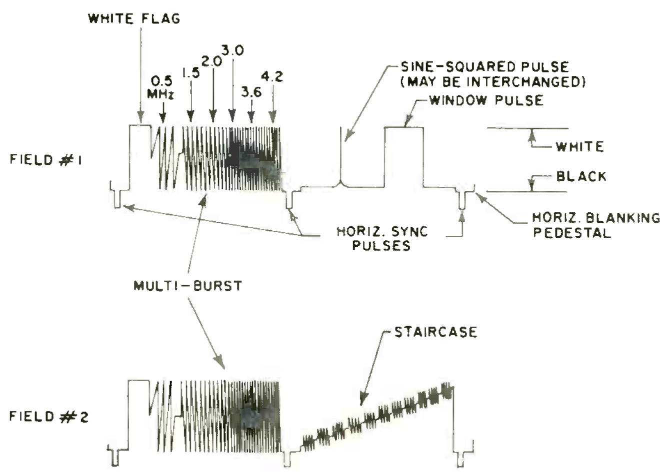
By IVAN MERTES / Design Engineer
The Heath Company

Vertical-interval test signals transmitted by TV networks can help evaluate TV receiver and provide a check of alignment or need to repair.

ALL television signals carry a great many built-in means for testing a receiver to pin down a variety of troubles. One set of a special testing signals transmitted by the three major networks are the *vertical interval test signals*, or VIT's. These signals will help you decide whether to repair the antenna system, troubleshoot and re-align the r.f. tuner or i.f. amplifier, or troubleshoot and repair the video amplifier. Making use of VIT's may help you avoid the tedious connecting of all your sweep-alignment equipment, only to find the real trouble is elsewhere in the system. VIT's signals also fill the void left today by rarely seen test patterns. Evaluation of receiving systems may be accomplished without regard to the quality of the picture content as seen on the set's screen.

VIT's are primarily intended for evaluation of network transmission equipment. You probably have seen these signals before and wondered in passing, "What are these bright lines here for?" Well, these bright lines can help you. They appear in nearly all network color telecasts and will be found in the vertical-blanking interval of the transmitted signal.

Fig. 1. VIT's (vertical-interval test signals) are added to the last two horizontal lines of the vertical blanking



Contents of VIT's

To make use of these signals we must know what they contain. Fig. 1 shows VIT's as they appear in two consecutive fields of the TV signals. The multi-burst is composed of a white flag and six groups of video frequencies. The white flag extends from black level to maximum white level. This appears on the TV screen near the bottom left side of the vertical blanking pulse as a solid white portion about 2 inches long on a 295-square-inch screen.

When viewing multi-burst on an oscilloscope, the white flag serves as a reference. Immediately to the right of this pulse come sine-wave frequencies in groups at 0.5, 1.5, 2.0, 3.0, 3.6, and 4.2 MHz, respectively, with the 4.2-MHz burst near the right side of the TV screen. Each of these multi-burst frequencies is transmitted at equal strength. Therefore, by comparing the strength of each of these frequencies after the receiver has worked on them, we have the means to measure the frequency response of the receiving system.

The other parts of VIT's – the sine-squared pulse, window, and staircase – are not nearly as useful to us in servicing color sets. These signals are useful mainly to engineers with very high-priced equipment. For example, the sine-squared pulse has a particular shape that makes it valuable for checking ringing and such things in video amplifiers. Hopefully, the sets we come across in servicing are designed to keep ringing to an acceptable level. If one shows excessive ringing we will start looking for broken resistors across peaking coils, coils shorted by solder blobs, etc., rather than looking at a test pulse that only confirms what we see on the screen. The same goes for the window pulse – it is fine for checking amplifier tilt, smearing, and response, but its use is quite limited for servicing applications.

The staircase signal consists of ten or eleven equal steps, beginning with the first step at black level and proceeding up to the white level. Each step is modulated an equal amount by 3.58-MHz energy. By comparing the amount of 3.58-MHz signal on each of the steps, a check of the receiver's linearity may be made. Meaningful test results from the staircase require very elaborate equipment beyond the means of service shops.

Fig. 2 shows the horizontal sweep lines during two consecutive vertical-blanking intervals. As shown, there are two horizontal lines of VIT's in each vertical blanking pulse: lines 17 and 18 in field number 1, and lines 279 and 280 in field number 2.

As seen on the screen of a TV receiver, field 1 will be interlaced with field 2 and you will find line 17 followed by line 279, then line 18 and finally line 280, followed by the first line of video at the top of the picture. In other words, near the bottom of the vertical blanking pulse you will see four bright lines among the dark lines of the pulse. The upper bright line will be line 17 carrying the multi-burst, then line 279 also carrying multi-burst. Third comes line 18 carrying the pulse and window, then line 280 carrying the staircase signal. Immediately below these bright lines will come the picture information.

To see the VIT's just described, the set's height and/or vertical linearity controls are adjusted to reduce the picture size vertically. Now carefully adjust the vertical hold control to interlace the two fields of the picture and prevent "pairing" of the horizontal sweep lines. The multi-burst signals will now appear just above the picture as two "beaded" white lines, followed by two more mostly white lines.

On some sets recently manufactured this procedure may not work and you will see nothing but black in the blanking pulse even when VIT's are present. This is because of a very effective vertical blanking signal, produced in the set itself and designed to completely eliminate vertical retrace lines from the picture. To sidestep this, roll the blanking pulse into view on the screen with the vertical hold control, "riding" the control to keep things as nearly stationary as possible. Now, however, VIT's will probably show as only two bright lines instead of four, because the set is not interlacing when the vertical-hold control is misadjusted as we have just done. This is no problem, though, because lines 17 and 279 will pair up. Since these lines carry the same multi-burst signal, nothing is lost. The multi-burst signal is the part of the VIT's we are most interested in, and pairing the pulse and window signals and the staircase on the next line will not lose much for us.

Estimating System Response

Now let's see how to measure frequency response with VIT's. Fine-tune the set as accurately as possible. View VIT's by either of the methods just described. If the station being received is transmitting the test signals you should see them as in Fig. 3. What you see here will represent the frequency response of the entire receiving system from antenna to CRT. In the photograph of Fig. 3, separate white dots are seen resulting from the peak of each multi-burst sine wave reaching an amplitude great enough to make the CRT screen white. Where the amplitude of the multi-burst is lower, each sine-wave peak will be more gray, and with very weak multi-burst the screen will remain nearly black.

The highest frequency response of the set will correspond to the multi-burst frequency group which can just be resolved as separate dots on the screen. In Fig. 3 this is at about 3 MHz, where the dots begin to run together. So we can say the response of this receiver is good to about 3 MHz. *(Note that the actual TV picture shows more detail than the small photo reproduced here. —Editor)*

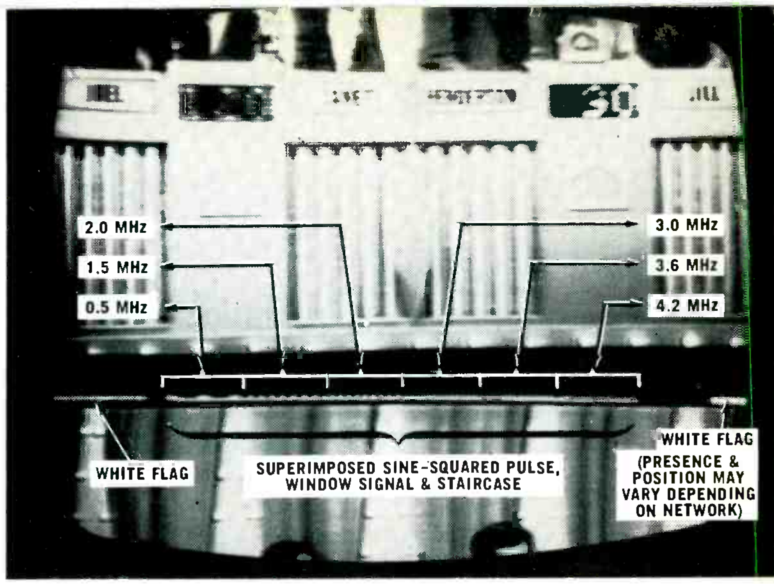


Fig. 3. Photo of TV screen with vertical blanking bar rolled to center of screen in order to show the VIT's.

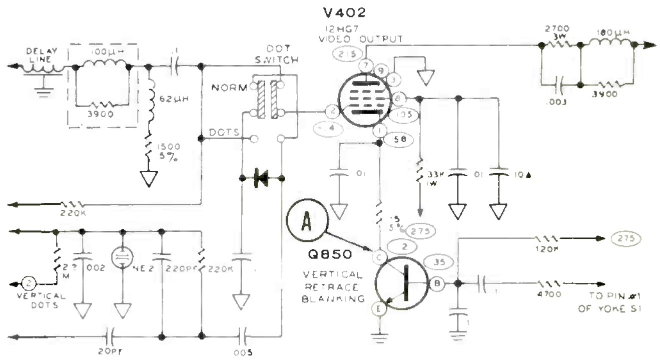
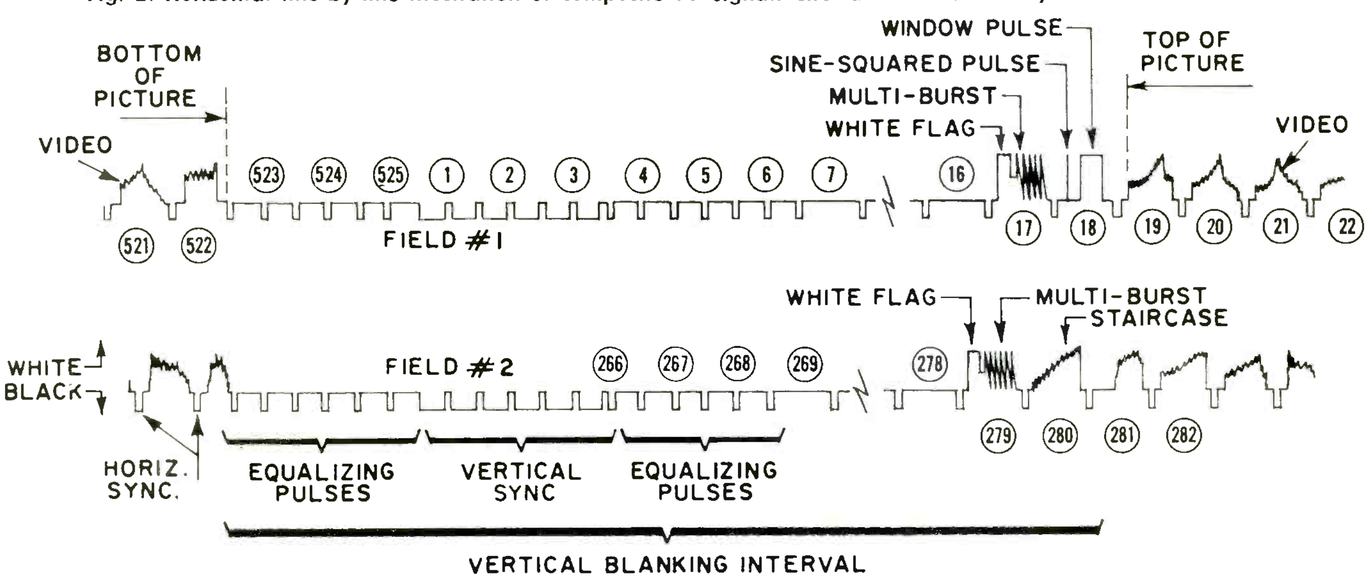


Fig. 4. Partial schematic of video amplifier of Heathkit GR-681. Short "A" to chassis to disable blanking.

Of course, the set's high-voltage and focusing circuits must be operating and adjusted properly. Also, some touch-up of brightness may be called for.

A more satisfactory way to look at VIT's is with an oscilloscope. The first requirement for the scope is that its frequency response must be good at least up to 4.5

Fig. 2. Horizontal line-by-line illustration of composite TV signal. Circled numbers identify each horizontal line.



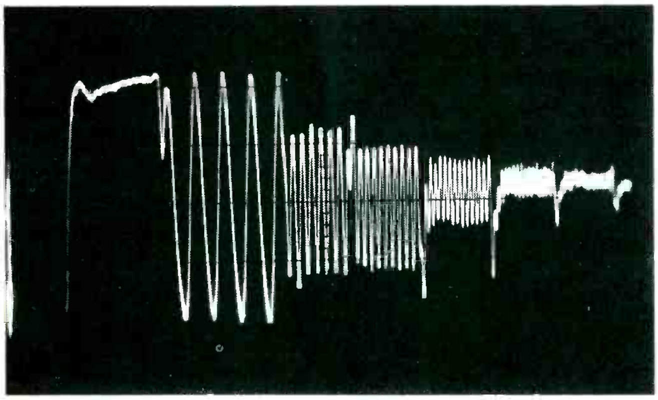


Fig. 5. Photo of multi-burst waveform at CRT red cathode.

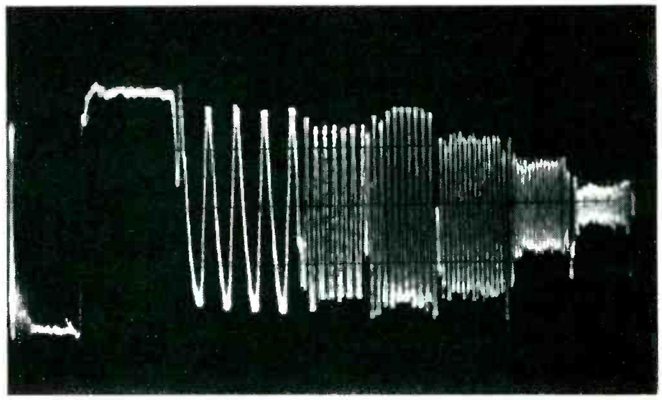


Fig. 6. Multi-burst waveform at picture-detector output.

MHz before it rolls off, or it will influence the results. Second, it must have a triggered sweep. What this means is that with no signal into the scope vertical input there will be no sweep generated. When composite video from a TV receiver is fed to the scope, it may be adjusted to start a sweep only each time a vertical or horizontal sync pulse comes along. The advantage of this is that the waveform seen on the scope screen will be very stable and free of jitters or drifting. This is what we require if we are to look at VIT's multi-burst.

Another important requirement of the scope used is that it have enough gain to allow use of a 10-to-1 isolation probe. The isolation probe lets you hook on to high-impedance points in a circuit without loading the circuit down or detuning it too far. The loss in these probes is usually ten times and this must be made up by the gain in the instrument's vertical amplifier. Minimum sensitivity needed is about 25 millivolts per screen division.

More satisfactory scopes for VIT's viewing have sweep-delay provisions. With these instruments any portion of the displayed waveform may be selected, expanded to fill the trace, and swept at any desired rate. This means you are able to take the VIT's part of a TV signal display on the scope and, in effect, expand this tiny part enough to fill the entire baseline without loss of brightness and the jittering that would be present with simple sweep-expanders.

Measuring Frequency Response with Scope

Using a 10-to-1 probe, clip it on to the color CRT red cathode. Using a scope without delay provisions, adjust the Sweep Stability and Trigger Level controls on the scope to obtain a stable trace with two horizontal lines of the TV signal (two horizontal sync pulses should be visible). Now turn the scope brightness up and very carefully adjust the stability control to either end of the range where the trace brightness drops suddenly. With sufficient patience, the horizontal lines carrying the VIT's will come into view as in Fig. 1. Look first for the staircase pattern, the most easily identified portion of VIT's. Some varying video information from other parts of the signal will also be visible but a usable multi-burst pattern will appear.

If you are using an instrument with sweep delay, results will come much easier. Follow the manufacturer's instructions for selecting and expanding the desired part of the waveform – in this case the portion showing the VIT's.

One thing that may stop us at this point is vertical blanking in the set. Some recent sets, such as the *Heathkit* GR-681, have a very effective blanking circuit which operates in the video amplifier. This will remove VIT's information, so the blanking will have to be defeated. A partial schematic of the GR-681 video-output stage is shown in Fig. 4. By shorting point *A* to the chassis with a clip-lead, blanking will be defeated and VIT's will come through to the CRT cathodes.

Now that we have VIT's captured on our scope screen, let's continue. We can expect to see the multi-burst appearing somewhat as shown in Fig. 5. This is a photograph of the multi-burst response at the CRT cathodes of a normally operating color set. The maximum resolution of the set is at the frequency where the multi-burst height is about half that of the lowest frequency multi-burst groups. This response shows 2 MHz to be ½ of that at 0.5 MHz, or 6 dB down. Likewise, 3 MHz is 10.3 dB down, 3.6 MHz is 17.6 dB down, and 4.2 MHz is so far down we can't measure it. This response measured on a scope is from the same set used for the photo in Fig. 3. Response to VIT's shown by our scope connected to the picture detector will appear similar to Fig. 6 with a normal color receiver.

Effect of the I.f. Response

The most often asked question concerning VIT's is, "What sort of response should a normal color set have as measured by the multi-burst?" To answer this, let's do some digging.

The multi-burst is applied to the picture carrier at the transmitter as amplitude modulation. Each group of multi-burst frequencies will form sidebands at the frequency of the picture carrier plus and minus the multi-burst frequency. Since the TV transmitter uses mainly the upper sideband (carrier plus modulation frequency), we can forget the lower sideband. As the TV signal is passed through the receiver's tuner it is converted to the i.f. frequency range and also flipped over frequency-wise due to the conversion action of the tuner. The picture carrier frequency is now 45.75 MHz regardless of which channel is being received (if the fine-tuning control is adjusted right).

Imagine a TV station transmitting on channel 4. The picture carrier is at 67.25 MHz, the color sub-carrier is at 70.83 MHz, and the sound carrier is at 71.75 MHz. This is upper-sideband transmission because the picture, color, and sound information show up at higher frequencies than the picture carrier. This channel-4 signal is sent to the tuner input from the antenna, where it is amplified and heterodyned with the r.f. oscillator.

The r.f. oscillator is on 113 MHz when receiving channel 4. 113 MHz minus 67.25 MHz, the picture carrier frequency, comes out to 45.75 MHz. This is now the frequency of the channel-4 picture carrier as sent on to the i.f. amplifier. The r.f. oscillator frequency, 113 MHz, minus 70.83 MHz, the color sub-carrier, comes out to 42.17 MHz, the frequency of the color sub-carrier in the i.f. amplifier. Likewise, the sound carrier at 71.75 MHz is converted to 41.25 MHz. If the multi-burst at 2.0 MHz, for example, is being transmitted, it will appear in the i.f. amplifier at 43.75 MHz.

After many decibels of amplification in passing through the i.f. amplifier, our channel-4 signal reaches the picture detector and is converted back to the same form it started with at the studio: video frequencies. Next, the video amplifier amplifies the TV signal in video form sufficiently to drive the picture tube.

The i.f. amplifier of the receiver has a great effect on the over-all frequency response. Fig. 7 is the familiar i.f. response curve of an ideal color-TV receiver. Note that the picture carrier and the color sub-carrier are both down by 6 dB.

Expressed in fractions of the maximum amplification, or in terms of voltage as would be seen on an oscilloscope screen, the curve of Fig. 7 would look something like Fig. 8. The picture carrier and color sub-carrier would be half-way down the curve, but the frequencies around the lower skirts of the curve would be compressed to almost nothing, so that a representation of the trap action would be lost. In effect, putting this curve in decibels instead of percentage amplification shows more of the interesting details. One more point: 6 dB is a factor of two only when talking voltage. When talking power, the magic number is 3 dB to show half or twice power.

Referring again to Fig. 7, we see that the VIT's multi-burst frequencies of 0.5, 1.5, 2.0, 3.0, 3.6 (3.58), and 4.2 MHz will appear at 45.25, 44.25, 43.75, 42.75, 42.17 and 41.55 MHz, respectively.

These multi-burst frequencies will come from the picture detector at full strength at 1.5 and 2.0 MHz, down slightly at 3.0 MHz, down 6 dB at 3.6 MHz, and down 28.5 dB at 4.2 MHz. Missed 0.5 MHz, you say? Well, that's a special case. We said earlier that only one sideband is used in our TV system. That is not quite true because a second sideband is transmitted at frequencies near the picture carrier. So these frequencies must receive less amplification in the receiver to prevent these "double-sideband" frequencies from humping up the final response. This works out just right with the picture carrier set at 6 dB down, and 45 MHz at or very near to maximum amplification.

We can sum up by saying that the frequency response of a properly operating and aligned color-TV set at the output of the picture detector will be flat from below 0.5 MHz to about 3 MHz. At 3.6 MHz the response will be down about 6 dB, and at 4.2 MHz the response will be down far enough to allow us to forget it. The r.f. tuner response is supposed to be sufficiently wide and level on each channel so that the response of the rest of the set will not be changed. (*Editor's Note: The video amplifier is between the picture detector and CRT cathodes; it handles the brightness component of the signal and affects picture resolution. Hence, it should have a fairly wide response. The chroma section also has an effect on the response but only for the color signals applied to the CRT grids. This portion of the receiver need handle only sideband frequencies up to 0.5 MHz, or at the most 1.5 MHz, and need not be discussed when considering picture resolution.*)

This leaves only the video amplifier to further affect results. Ideally, this part of our set will not upset the response either. However, such is not usually the case. In designing color sets for home use, much thought is given to what the majority of customers will consider a "good" picture. With local live telecasts and a strong signal into a viewer's set, full advantage may be taken of the response available. But, with a slightly snowy

Fig. 7. I.f. amplifier response of modern color-TV receiver showing placement of VIT's multi-burst modulation.

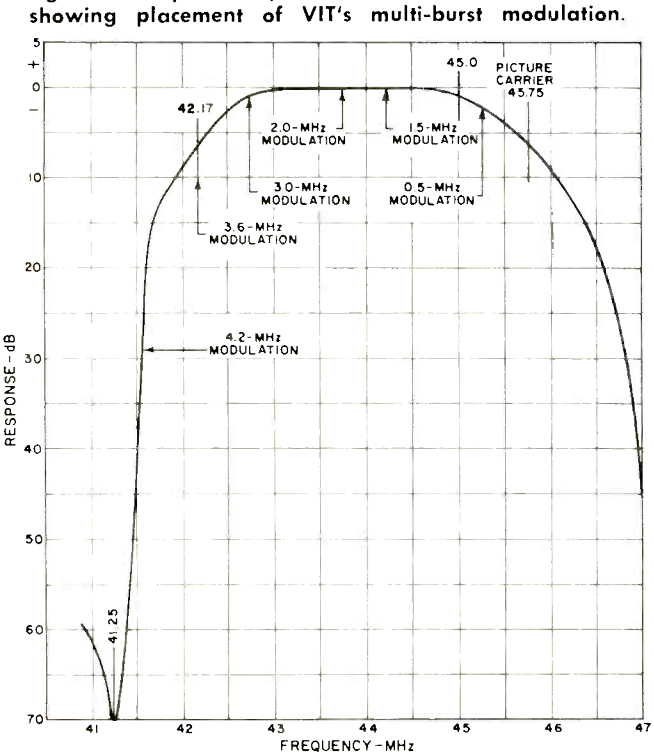
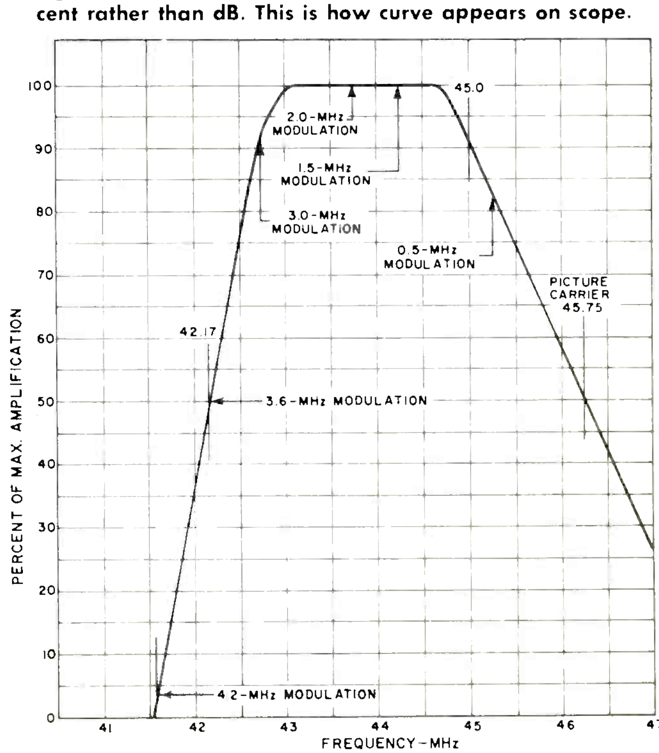


Fig. 8. Same response as Fig. 7 except expressed as per cent rather than dB. This is how curve appears on scope.



picture and a movie from 1940 being programmed, there will be a revolting mess. Wide frequency response will bring out every flaw in the whole chain, from dirty and scratched film and noisy preamps at the studio, to snow from an over-aged antenna and lead-in, overshoot and ringing in the receiver, and dozens of other possible problems.

With these responses in mind, most set designers tailor the response of their video amplifier to produce a picture sharp enough to satisfy the average set buyer, but not so sharp that pictures appear grainy. As an added feature, several sets now appear with resolution, or sharpness, controls. This control lets the customer adjust the sharpness (frequency response) of his set to suit himself.

Actual measurements on several sets show over-all responses to be typically down from 1 to 5 dB at 1.5 MHz, 1 to 7 dB down at 2 MHz, 8 to 14 dB down at 3 MHz, and 15 to 29 dB down at 3.6 MHz. These responses are all compared to 0.5 MHz. On paper this kind of drooping response appears terrible, but the sets that were measured were late models, and all had very acceptable pictures.

Use of VIT's in Troubleshooting

The idea for rapid localization of trouble is to observe set response at the picture detector first by use of VIT's. This will localize trouble to a point either before or after the detector. If the multi-burst is not normal at the detector, check VIT's on other channels. If all channels appear about the same, the trouble is in the i.f. amplifier. If some channels look okay, you probably have tuner or antenna-system troubles. Don't overlook the chance of the antenna system causing "holes" or tilted responses on some channels.

Say that we have a set on the bench with a very bleary looking picture. Hooking our scope to the picture detector output shows VIT's to be about normal except that the burst at 2.0 MHz is way down compared to the bursts on either side. This suggests an i.f. trap is detuned into the passband, chopping out frequencies about 2 MHz below the picture carrier frequency. Switch to another channel carrying VIT's. If the same thing is seen, then our reasoning is right, and the i.f. amplifier requires realignment. If the poor response at 2 MHz is not seen on other channels, maybe an FM trap at the tuner input is misadjusted, causing a bite on only one channel. Other traps at the input of the set could similarly be misadjusted or faulty.

If the VIT's response at the detector output is normal, the trouble will be in the video amplifier. Look for open peaking coils, off-value resistors, solder bridges across foil patterns, etc. ●

TRANSISTOR TESTERS

MFR.	MODEL	TESTS: SHORTS (yes, no)	TESTS: GAIN TYPE & RANGES	TESTS: LEAKAGE TYPES & RANGES	TESTS: FWD & REV. I (yes, no)	TEST VOLTAGE-CURRENT RANGES	PRICE $(K=kit)	REMARKS
B & K	162	yes	a.c. beta 1–5000	I_{CBO}, I_{CEO}, I_{CES} 0–1A	yes	0–2V 210mA	99.95	In-circuit or out-of-circuit Tests triacs, SCR's, UJT's FET'S.
EICO	443	yes	d.c. beta 0–500	I_{CBO}, I_{CEO} 1µA–1A	yes	0–1400V 0–1A	99.95 69.95(K)	Out-of-circuit only Curve tracer with scope. Also zeners, SCR's.
	680	yes	d.c. beta 2–300	I_{CBO}, I_{CEO} 0-500mA	yes	0–50V 0–500mA	49.95 34.95(K)	Can be used as v.o.m.
HEATH	IM–36	yes	d.c. beta 0–400	I_{CBO}, I_{CEO} 15µA	yes	1.5–150V 15µA–15A	90.00 60.00(K)	
	IT–18	yes	d.c. beta 2–1000	I_{CBO}, I_{CEO} 5000µA	yes	1.5V 4mA	26.95(K)	
	IT–27	yes	d.c. beta	I_{CEO}	yes	3.0V, 3mA	6.95(K)	
HICKOK	870 890A	yes yes	beta 300 beta 200	I_{CBO}–10mA I_{CBO}–50µA	yes yes	5mA, 200mA, 2A, 5V 1.5V, 3V, 4.5V, 10mA	425.00 235.00	Built-in roll chart In-circuit
JACKSON	810	yes	a.c. beta 500	I_{CBO}–5000µA	yes	2mA	89.95	In- or out-of-circuit
LECTROTECH	TT–250	yes	d.c. beta 500	I_{CBO}–5mA	yes	6Vd.c., 2Va.c.	89.50	
RCA	WT–501A	yes	d.c. beta 1–1000	I_{CBO}–2µA I_{CEO}–1A	yes	1.5V @ 1mA 10mA, 100mA, 1A	66.75	Adjustable current
SECO	260	yes	beta 0–1000	I_{CBO}–200µA I_{CEO}–100mA	yes	6.8V 1A	69.50	Dynamic test for in-circuit
SENCORE	TF–17	yes	a.c. beta, G_m 1–500, 0–50,000	I_{CBO}, I_{GSS} 0–5000µA	yes	200µA, 2mA, 20mA	109.50	In- or out-of-circuit Also checks FET's
	TF–151	yes	a.c. beta, G_m 1–500, 0–50,000	I_{CBO}, I_{GSS} 0–5000µA	yes	200µA, 2mA, 20mA	129.50	In- or out-of-circuit Also checks FET's
	TR–115	yes	d.c. beta	I_{CEO}–50mA	yes	3V	24.95	Out-of-circuit only
	TR–139	yes	a.c. beta 2–500	I_{CBO}–5000µA	yes	2mA	89.50	In- or out-of-circuit
	FT–155	yes	G_m 0–50,000	I_{GSS}–0–200µA	yes	50mA	94.50	FET'S only
SIMPSON	650	yes	d.c. beta 0–10, 50, 250	I_{CO}–100µA	yes	100µA	41.00	Out-of-circuit only Adapter for Model 260
TRIPLETT	2590	yes	d.c. beta 5–100	I_{CBO}, I_{CEO} 1mA	yes		71.00	
	3490A–2	yes	a.c., d.c. beta 600 h parameters	I_{CBO}, I_{CO}, I_{CEO} 6mA	yes	0–120V 0–3A	441.00	Also checks FET'S, tetrodes

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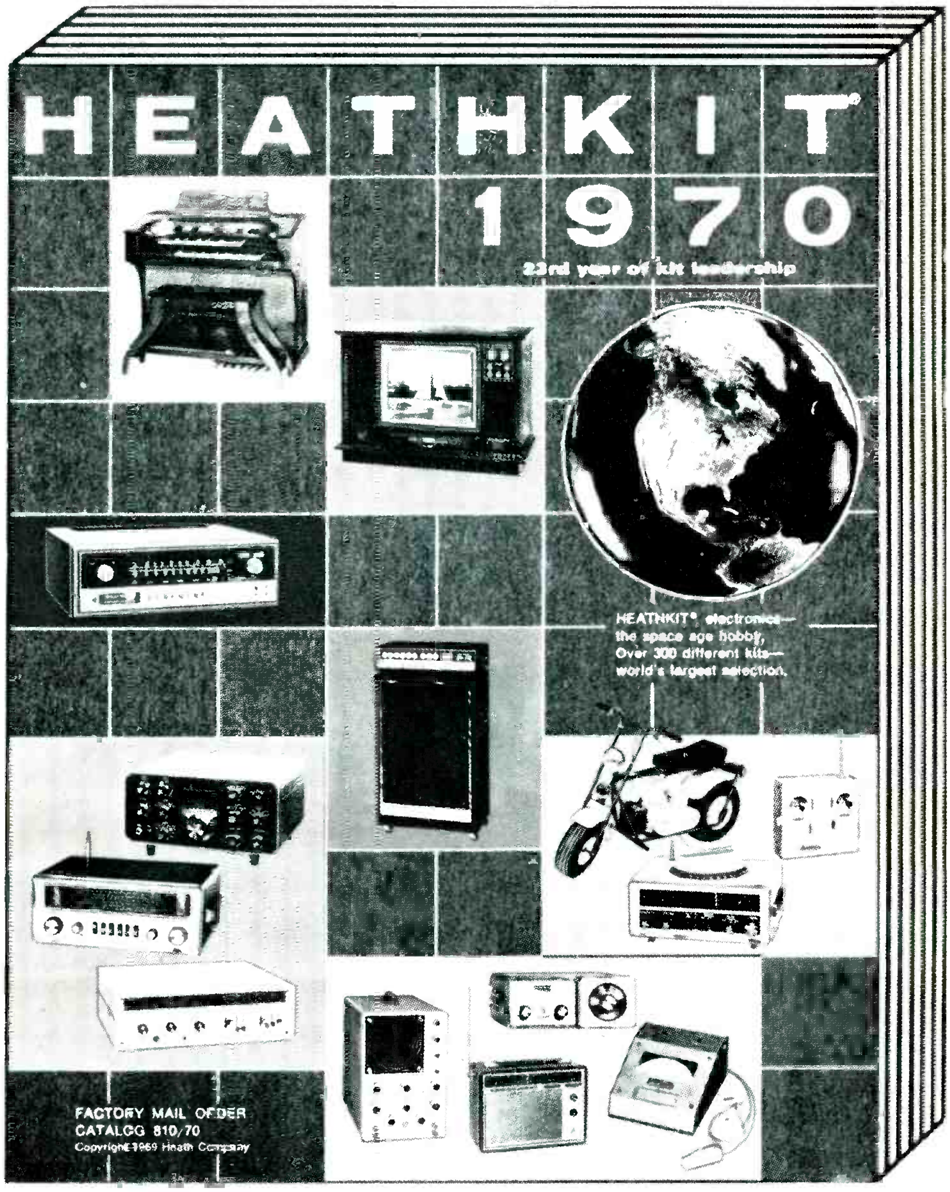

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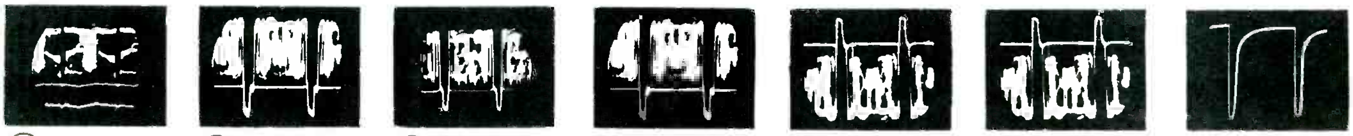
CIRCLE NO. 10 ON READER SERVICE PAGE

PHILCO 20KT40B/41B

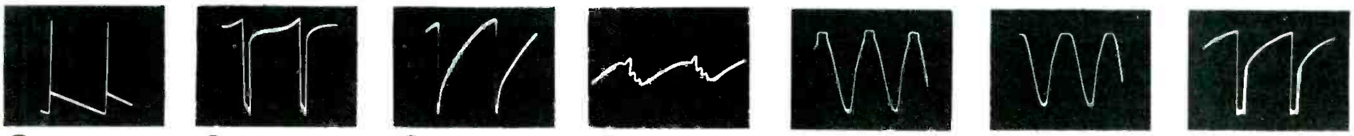
COLOR-TV CIRCUIT

This new hybrid chassis is part of Philco-Ford's new "T" line for this year. The chassis uses an 18-in picture tube in a compact, portable configuration. Some models that use this chassis include Models C4540TBE, C4550TWA, C4560-TWA, and C9260TWA. This circuit is similar to the 19KT40 chassis except for some component values and differences in the tuners that are employed.



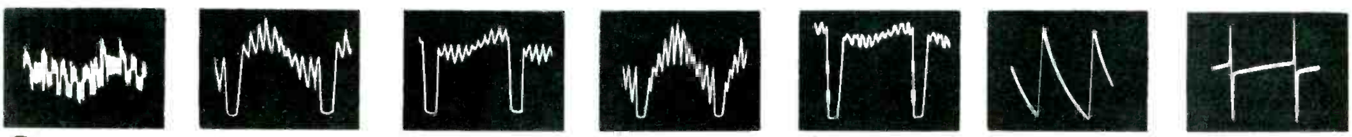
(1) -2V P-P V | (2) -2V P-P H | (3) -0.2V P-P H | (4) -2.8V P-P H | (5) -135V P-P H | (6) -40V P-P H | (7) -30V P-P H

(8) -35V P-P H | (9) -50V P-P H | (10) -45V P-P H | (11) -45V P-P V | (12) -39V P-P V | (13) -130V P-P V | (14) -14V P-P V



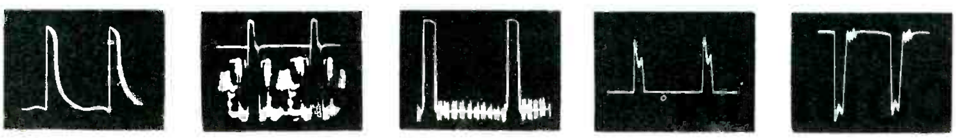
(15) -900V P-P V | (16) -8.5V P-P H | (17) -17V P-P H | (18) -5.5V P-P H | (19) -50V P-P H | (20) -140V P-P H | (21) -180V P-P H

(22) -170V P-P H | (23) -LOOSE COUPLED H | (24) -12V P-P 3.58 MHz | (25) -2.5V P-P H | (26) -60V P-P H | (27) -0.5V P-P H | (28) -15V P-P H

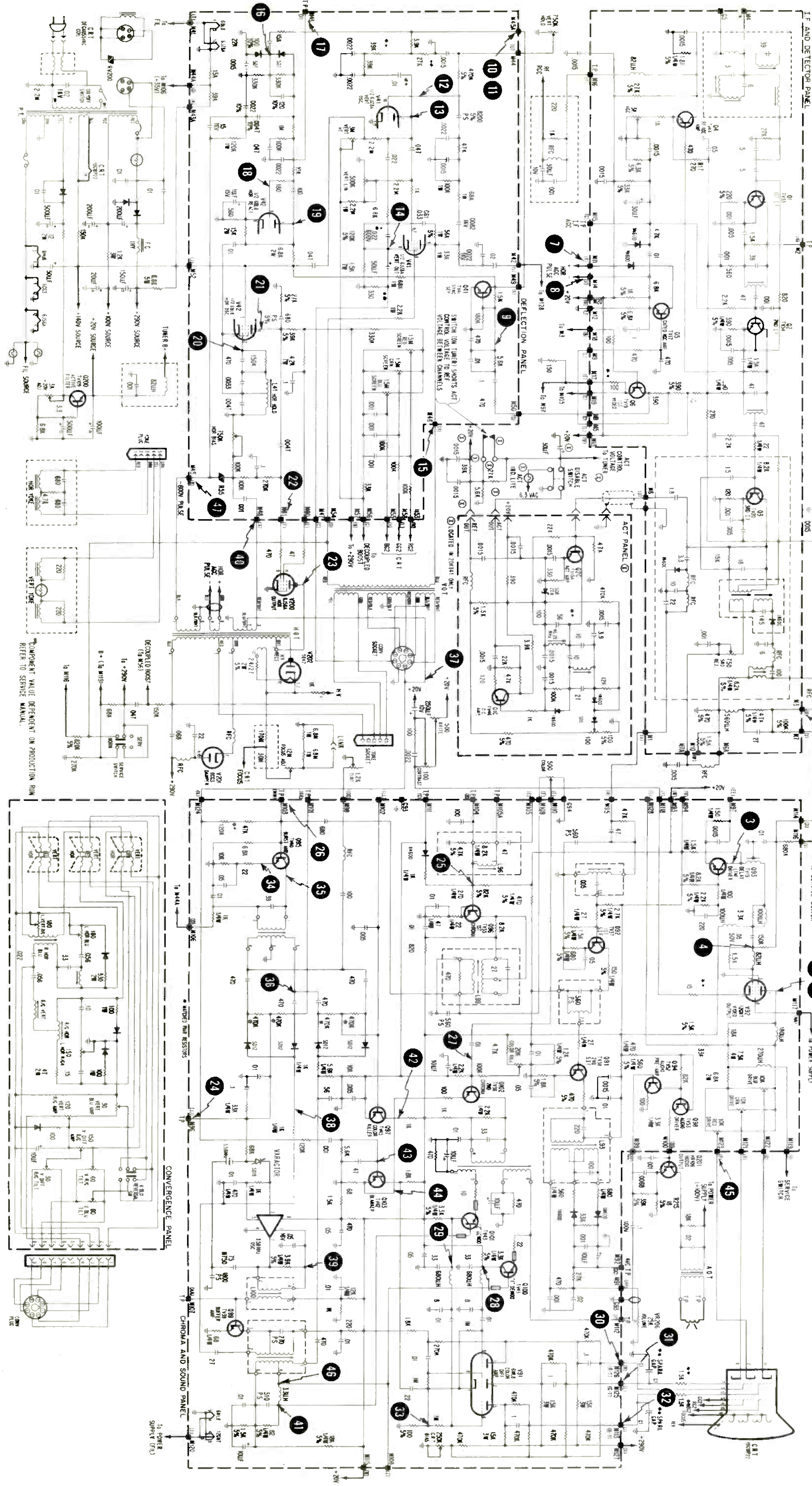


(29) -20V P-P H | (30) -70V P-P H | (31) -70V P-P H | (32) -70V P-P H | (33) -5V P-P H | (34) -6V P-P H | (35) -120V P-P H

(36) -50V P-P H | (37) -640V P-P H | (38) -17V P-P 3.58 MHz | (39) -140V P-P 3.58 MHz | (40) -400V P-P H | (41) -11V P-P 3.58 MHz | (42) -100V P-P H



(43) -80V P-P H | (44) -135V P-P H | (45) -13V P-P H | (46) -28V P-P H | (47) -570V P-P H


I.F. AND DETECTOR PANEL
DEFLECTION PANEL
ACT PANEL
CONVERGENCE PANEL
CHROMA AND SOUND PANEL

Color TV for 1970

By FOREST H. BELT

There are more solid-state components including IC's in the new models. Here's a complete roundup of all new color sets and their various circuit innovations.

THE year just past – the last of the sixties – has practically broken the long chain of yearly increases in color TV sales. The number of sets sold seems to have hit a plateau. Here's the statistical picture:

1964 – 1.4 million color sets sold
1965 – 2.7 million
1966 – 4.7 million
1967 – 5.2 million
1968 – 5.8 million
1969 – 5.7 million (est.)

At press time, final figures for the year aren't in. But the trend is fairly well established.

Sales through 1969 were erratic, that is, seasonal patterns of prior years meant little. Week by week, as the year progressed, sales went above normal, then below, then high again, then low again. Seasonal forecasts became tough.

By mid-July, one thing was obvious: 1969 would be disappointing in over-all sales of color TV. Big yearly gains were apparently at an end.

Market saturation can't be blamed, at least not directly. True, 97 percent of all U. S. homes have television of some sort. But only 32 percent (a little higher now) had color last July.

Some analysts say the *actual* market for color *is* saturated. It's a matter of prices. Color sells best to middle- and upper-income groups. That market is near its limit – is in fact becoming a second-set market. That explains the popularity of portable color sets. But medium- and lower-income families still wait for an under-$100 color set. They'll have a long wait.

Others who study the color-sales picture blame 1969's "poor" showing on bad publicity. Servicing, warranty, x-rays – all got bad headlines. Worst was the x-ray thing. It ran out of hand until late in the year. That's when the Bureau of Radiological Health finally did two things: (1) Established standards and procedures for measuring x-radiation from color TV receivers, and (2) concluded there is no danger to the average viewer from normal color-set radiation.

But newspaper stories had taken their toll. Doubt – and even outright fear of damage to eyes, skin, unborn offspring, and health in general – kept prospects away from showrooms. Unfair and unnecessary though it was, the x-ray worry had a real dampening effect on color-TV enthusiasm. And it continues into 1970.

Extra effort has gone into planning color sets for 1970. Prices aren't lower, but aren't much higher either. More meaningful, selling prices for color TV are rising much slower than for other consumer goods. Inflation is rolling along, but it isn't affecting color TV.

Instead of skimping and trying to lower prices for 1970, manufacturers – especially lesser known ones – have piled on innovations to woo the hesitant buyer. Some chief attractions are discussed in this article. *Solid-state* is the big word; and simplicity of operation is probably next in importance, giving rise to lots of automatic circuits. Finally, extra attention is being given to safety, dependability, and ease of servicing.

There's extra promotion effort, too. There are lots more brands, as the chart shows. Heavy advertising budgets are planned by those who'll discuss it. Some are even boasting about it, to boost enthusiasm among dealers (and attract more).

Designers cater to every need, real or created, they can think of. There's almost every screen size (except, oddly enough, for those two favorites of long ago, 17 and 21). There's 9, 11, 12, no 13 of course, 14, 15, 16, 18, 19R (formerly 21-inch-round), 20, and 23. A 10-inch is expected.

(Editor's Note: The above are all actual diagonal picture sizes, which are apt to be an inch or two smaller than the diagonal measurement of the entire picture-tube faceplate, as designated in the tube type number. This is in accordance with an FTC ruling, which also permits picture size to be given in terms of square inches. For example, a 23-in picture is 295 sq in, a 20-in picture is 227 sq in, an 18-in picture is 180 sq in, and a 14-in picture is 102 sq in.)

So, what to expect for 1970? Technical features, we know about. Sales are something else. Our educated guess is that sales will hold about the same, maybe rise just a little. It's pointless to expect a revival of the boom years. So let's say about 6 million sets will be sold in 1970.

Now, if you're selling or buying, here are some of the things you'll run into.

The Trend Is Solid

Transistors are what's happening this model year. The trend is manifest in several ways. In the first place, there are more hybrids – receivers that use several transistors in jobs formerly handled by tubes. Only about 40 percent of the color chassis listed in our 1969 model chart (*Electronics Installation & Servicing Handbook 1969*, pages 22–23) were of hybrid construction. This year almost half (see Chart, page 70) are hybrids.

More significant, the hybrids this year contain more transistors than ever. In 1969 hybrids, transistors averaged only 18 per set. In 1970 hybrid chassis, the average is 22. There are correspondingly fewer tubes; they averaged more than 14 in 1969 hybrid models, fewer than 12 in 1970.

How come set makers stick with hybrids instead of going all-transistor? For several reasons. Cost is the most important. Semiconductor prices are lower than ever and dropping steadily, but some transistors for color still cost more than tube equivalents.

Another reason: It takes time and research to design new transistor circuits – and some companies are far behind others. With a basic hybrid design, tubes can be replaced one or two at a time by solid-state designs. The expensive or critical stages are kept with tubes: horizontal sweep and high voltage, vertical sweep, video output, color-difference amplifiers, blanker, and some audio-output and sync-separation stages. The i.f. sections in hybrids are mostly transistor, but most v.h.f. tuners are still tube versions.

Tooling up is another holdback on all-solid-state color. It costs a lot of money to make drastic changes in assembly lines and set-makers understandably hesitate. The small improvement in performance and dependability doesn't sound glamorous enough to be salable – except of course in models that would be high-priced anyway.

In the meantime, an occasional transistor or two is used in tube chassis. Some examples: Dozens of receivers use a transistor or even an IC a.f.t. stage.

The *Arvin* 60K34 chassis has a transistor second video amplifier. Its 80K54 uses three transistors; one triggers a light to signify need for fine tuning, and the other two are audio amplifier and output.

In the *Magnavox* T940 chassis, predominantly a tube design, five transistors are used in the unique new automatic tint control (a.t.c.) board. *(Editor's Note: For a thorough description of this automatic hue corrector see* ELECTRONICS WORLD, *September 1969, page 30, or the condensed summary on page 69 of this Handbook.)*

There are other examples. *Motorola* has a two-transistor pincushion corrector stage in some versions of the TS-921 chassis. *Packard Bell* uses a transistor for a noise inverter and gate stage in the sync section of its CQ-634 chassis; three transistors are used in the CQ-622 chassis, but no detailed information for this chassis was supplied. Two transistors in the *Westinghouse* V8001 chassis, an imported version since that company has decided to quit making its own, are color killer and automatic chroma control (a.c.c.).

Despite the trends, there seems little likelihood of a grand rush to solid state. Instead, set designers and manufacturers continue to peck away at the vacuum tube, replacing it with transistors, integrated circuits, and other solid-state devices as they become available in dependable quantities and at practical prices.

New All-Transistor Color Chassis

You may recall that for 1969 there were only two transistor color-TV chassis. One was the *Motorola* "Quasar" TS-915/919 chassis series, a modular design in which all stages relating to a function are grouped on a plug-in printed-board module; *Motorola* scooped the industry back in 1967 with its introduction (for the 1968 model year). For the 1969 model year, *RCA* brought out its all-transistor CTC 40 (it has a tube h.v. rectifier).

For 1970 at least seven all-transistor sets are promised. *Motorola's* popular works-in-a-drawer chassis, the TS-915 "briefcase" version, continues the same. The chassis is laid out vertically and slides out to the front for easy access to both sides of all the modules. The early TS-919, which is electronically the same as the TS-915, was virtually discontinued over a year ago; its flat-chassis horizontal layout wasn't as popular as the TS-915. However, a new idea in chassis accessibility, called the "*Fast-Back*™" concept, has revived the TS-919. The concept, shown in Fig. 1, was tried successfully with last year's TS-921 tube-type. It makes servicing as convenient as with the "drawer" idea.

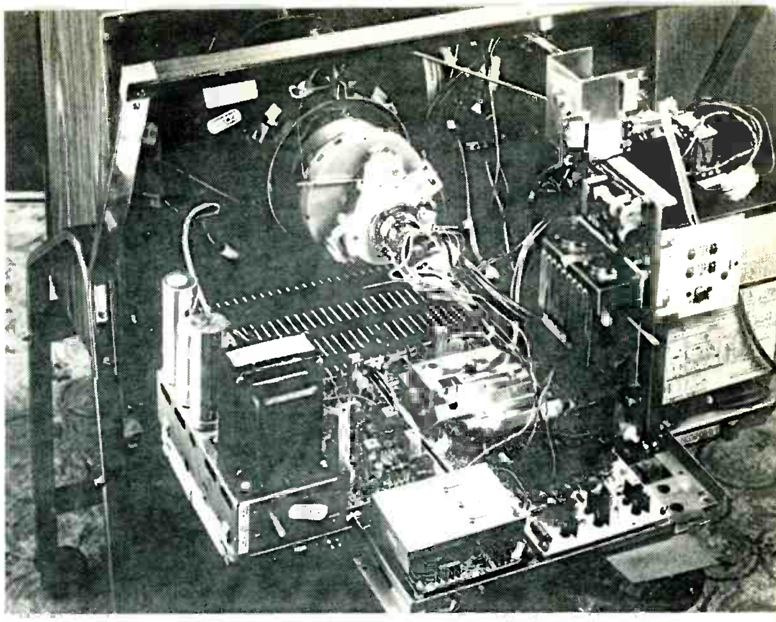


Fig. 1. The "Fast-Back" arrangement used by Motorola.

Also continued into 1970 is the now well-known *RCA* CTC 40. Almost no changes have been made. Technicians all over the country are at least acquainted with this chassis, through an extensive program of seminars and clinics carried on by *RCA* field engineers and distributors. The CTC 40 contains the most unusual innovation of last year: a horizontal-deflection system using silicon controlled rectifiers (SCR's) as the main sweep drivers. So far, no one has duplicated the feat. The system works well as long as *RCA* hand-picked switching diodes and SCR's are used for any repairs.

The other five transistor color chassis promised for 1970 are from outside the U. S. Four are from Japan and one from Canada. At press time, none of the five is available in quantity. Two of the Japanese chassis are from *Hitachi*, the only company which supplied data on the new transistor chassis.

One *Hitachi* set is a 14-inch portable, the CFA-450; the other, the CWA-200, is a 12-inch. Both use ordinary shadow-mask picture tubes, with color-dot triads arranged about the same as in larger screen U. S. color sets.

One difference between the CWA-200 and what you might expect starts in the video i.f. amplifier section. See Fig. 2. There are four video i.f. amplifier transistors. Two of them amplify the entire video i.f. signal. However, past the second, the signal is split up. One of the third amps is aligned for a band-pass curve that accentuates the 45.75-MHz i.f. picture carrier and the vestigial sideband frequencies for about 2.75 MHz below it – down to about 43 MHz. Sound and chroma i.f. carriers are almost eliminated by this i.f. stage. It feeds a video (or *luminance*, if you prefer) detector, which feeds video (Y) signal to video amplifiers.

The other third video i.f. amp is aligned for a response

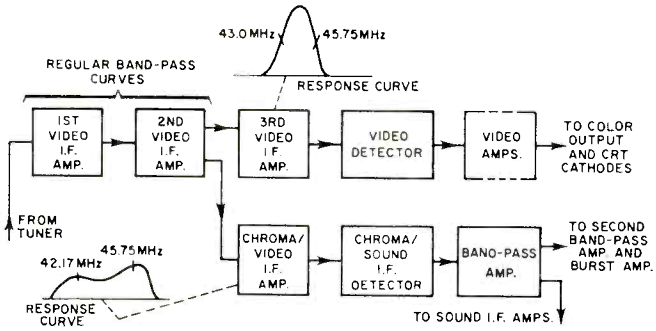


Fig. 2. Video section of Hitachi CWA-200 12-in set.

that accentuates both 42.17 and 45.75 MHz. The 42.17-MHz frequency, as you probably know, is the i.f. "center" for the color-subcarrier sidebands. This video i.f. stage must also pass the 45.75-MHz picture carrier so the subcarrier sidebands have something to "beat" against in the chroma detector that follows. The 42.17-MHz sidebands become 3.58-MHz sidebands. From the chroma detector, the sidebands go to bandpass amplifiers as in any other color set.

The 41.25-MHz i.f. sound carrier also gets through the wide-band video i.f. stage. In the chroma detector, it beats with the 45.75-MHz i.f. picture carrier and creates a 4.5-MHz intercarrier sound signal, just as in a conventional video detector. (They don't beat in the video detector of this set because the narrow bandwidth of the i.f. stage preceding that detector won't pass the 41.25-MHz signal.) The 4.5-MHz signal accompanies the 3.58-MHz chroma sidebands through the first band-pass amplifier and then is taken off and fed to the usual 4.5-MHz sound i.f. amplifier stages.

There isn't much information available at press time about the other two Japanese brands. *Panasonic* insists it will have a 9-inch all-transistor color portable ready for U.S. import early in 1970. The company has displayed a prototype, but offers no other significant details.

Sony, too, has shown a few 12-inch color portables using the unusual Trinitron color picture tube. The Trinitron uses shadow-mask construction, with grids instead of holes. The color phosphors are deposited in vertical stripes instead of dot triads. The tube has only one gun but three beams. The set is to be solid-state. This is the third year *Sony* has promised an all-transistor set for U. S. sale; a few sets are in the country at press time.

A couple of other Japanese companies have talked about a set, but have neither shown a set nor given details. *Hayakawa* is one; it has even described an on-screen indicator for setting chroma hue accurately. None of the sets was available at press time.

Clairtone of Nova Scotia, Canada, has shown a transistor color receiver that may be as big an event as the Quasar was. The unique feature is modular construction. The modules are in the form of circuit cards, similar to those used in computers. These are about 6 inches square, made of fiber glass, with etched wiring. The chassis frame is oblong and horizontal, and the cards slide into it vertically. The boards, eight of them, contain 80 transistors and diodes and four integrated circuits. *Clairtone* spokesmen express high hopes the new MSS 71 chassis will be available, in a cabinet with a 23-inch picture tube, by early spring of 1970.

Features in Solid State

And then there are the many odds and ends of new solid-state gimmicks. One example is several transistor v.h.f. tuners. For 1969 only eight brands of color sets have transistor v.h.f. tuners (u.h.f. tuners have been solid state since 1964). The 1970 lineup shows 13 brands with transistor v.h.f. tuners in more than 30 chassis. That's a healthy increase. Here are the brands and the chassis numbers:

- *Admiral* — all K10 chassis
- *Broadmoor* — all chassis
- *Clairtone* — MSS 71
- *Electrohome* — C8
- *Hitachi* — CWA-200, CFA-450
- *Magnavox* — T936, T947
- *Motorola* — TS-915, TS-919
- *Packard-Bell* — CQ-322, CQ-522, CQ-524
- *Panasonic* — CT-23P, -24W, -64P, -65W, -991
- *Philco-Ford* — all chassis
- *RCA* — CTC 40, CTC 47 (2000 series)
- *Sylvania* — D12
- *Toshiba* — all chassis

Some of these tuners include a varactor diode or a backward-biased transistor junction to control oscillator frequency with a d.c. voltage from the a.f.t. system in the chassis.

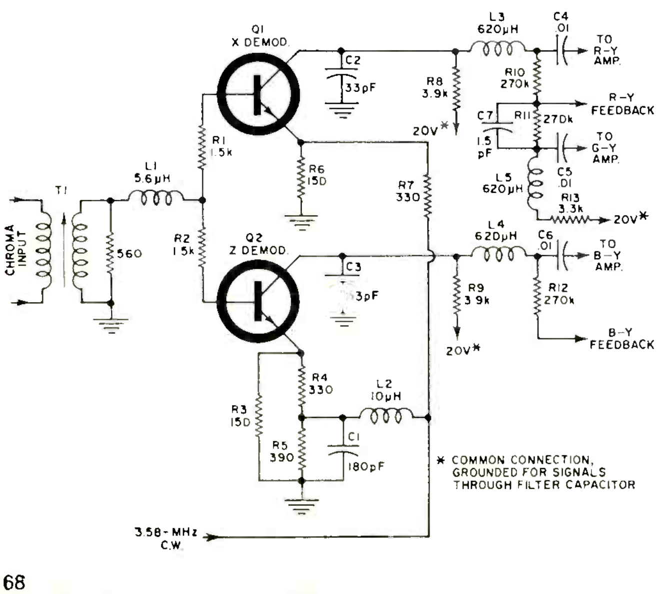
The *Electrohome* C8 chassis has a tuner that is completely varactor-tuned. A finger-resistance-activated diode switching system permits touch tuning: a fingertip between a terminal and bus bar triggers tuner logic circuits, which in the blink of an eye tune the set to the desired channel. There are terminals for all twelve v.h.f. channels; six additional ones permit a choice from among six pretuned u.h.f. channels.

A special diode-switched transistor tuner is used in a limited-run *RCA* called the "2000" series, using the CTC 47 chassis. The chassis is put into a fancy cabinet with a special high-brightness color CRT, a special instant-action remote-control system, and a price tag of $2000. The advanced technology is interesting. Only 2000 are to be produced.

All of a sudden, several chassis sport transistor color demodulators. In past years, demodulators have been

(*Continued on page 72*)

Fig. 3. Transistor demodulator in Sylvania D12 chassis.



NEW AUTOMATIC TINT CONTROL FOR COLOR-TV

A properly adjusted color-TV receiver is a joy to behold. But when people's faces turn sickly green or garish purple, the owner of an expensive color set begins to have doubts about his receiver's performance. In a good many cases, however, the fault is not with the receiver but with the transmitting station. The user can tell that the station is at fault if he can get good colors and the proper flesh tones much of the time. Once his set is properly adjusted, the user has every right to expect the colors to stay that way. But let a commercial come on, or let the program director switch cameras, and sometimes the people look as though they came from another planet—with greenish or magenta or purple faces.

A new automatic tint control (a.t.c.) circuit in the *Magnavox* top-of-the-line colors sets recently introduced does a good job of keeping the flesh tones the proper hue at all times.

The reason for the hue change is slight changes in phase of the chroma signal as transmitted by the color station. It doesn't take too many degrees of phase change to alter a hue from yellow-orange to magenta or greenish-yellow.

Transmitting stations are hard at work to minimize the hue changes that occur when switching cameras or when going to film or video tape. But it requires experienced, careful technicians with a very good color sense to set up all the cameras just exactly right and to make sure that film and video-tape units produce precise skin colors even though the original colors on the film or tape may not be quite right.

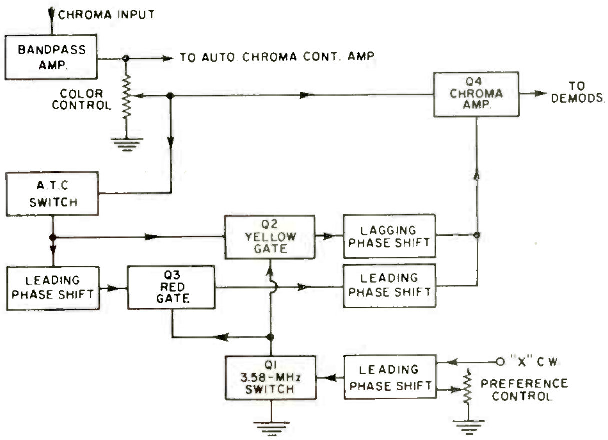
The new *Magnavox* a.t.c. circuit is able to correct phase errors of up to ±30 degrees of the proper flesh hue. No doubt other set manufacturers are working on their own a.t.c. circuits, but the *Magnavox* circuit is the first we know of in actual production receivers.

The receiver with a.t.c. has a three-position front-panel switch marked "Off," "Partial," and "Full" correction, along with a rear-panel control marked "Preference." The user simply switches the a.t.c. to Full and adjusts the Preference control for the shade of flesh tones he prefers. (Most viewers in California, for example, like to see their people a little more suntanned than viewers in New York.) Then the automatic circuit will operate to keep the flesh tones at the preferred setting at all times.

The company recommends that the a.t.c. switch be left in the Partial position for normal viewing. The circuit is still effective over the same ±30 degrees of phase except that the correction voltage produced is about half as large. This prevents too much color compression around the yellow, orange, and red phases that might reduce the proper color range to be reproduced at these hues. Colors that are more than 30 degrees from orange (which is 57 degrees from burst) are not affected at all by the a.t.c. circuit.

The circuit itself consists of four transistors, a pair of diodes, and various *R, C,* and *L* components all mounted on a small printed-circuit board in a metal box attached to the tuner mounting assembly. The circuit is located between the bandpass amplifier and the color demodulators (Figs. 1 and 2). The chroma signal, before being demodulated, is a 3.58-MHz sine wave whose amplitude and phase vary in accordance with the saturation and hue of the transmitted scene. This signal is applied to the chroma amplifier. Also applied to this amplifier is a 3.58-MHz correction signal from the a.t.c. circuit. The total output to the demodulators is then the result of the two inputs and is phase-corrected for variations in skin tones.

Fig. 1. Block diagram of automatic tint control circuit.



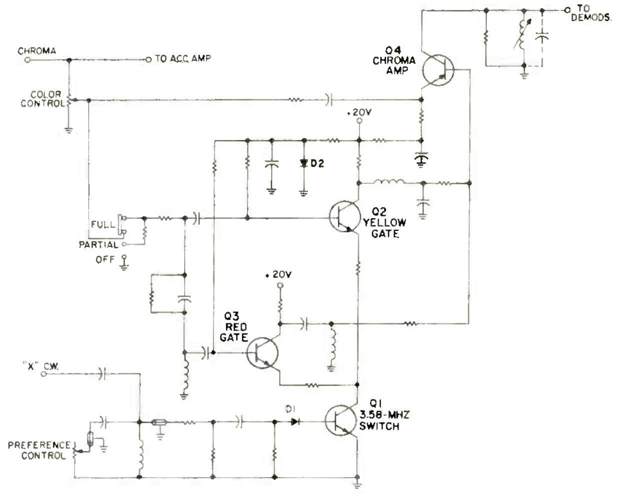


Fig. 2. Schematic of a.t.c. circuit showing two gating and one switching transistor which alter the phase of the chroma signal by applying a correction signal to the base of the Q4 chroma amplifier. The uncorrected chroma signal is applied to the emitter of this transistor, whose output is the vector sum of these two signals. The various LC circuits are for phase-shifting. Diode D1 allows switching transistor Q1 to conduct only during the positive peaks of the c.w. signal, while D2 clamps the base bias voltage of Q2 and Q3 to 0.6 V above ground. This assures that the positive portions of the low-level chroma signals forward-bias the gates during sample time. D.c. voltage for the circuit is derived from cathode of vertical-output tube via resistor and zener (not shown).

In order to make sure that only those hues that influence flesh tones are altered, a pair of gating transistors are used in conjunction with a 3.58-MHz switch. Phase-shifting circuits are used to make sure that gating occurs at exactly the proper phase of the chroma signal. The gates are turned "on" and "off" by the switch which, in turn, is turned "on" and "off" by a phase-shifted X-axis c.w. signal. A yellow chroma signal produces maximum output from the yellow gate and low output from the red gate. A red chroma signal produces maximum output from the red gate and low output from the yellow gate.

The output signal from the yellow gate passes through a phase-shifting network and is applied to the chroma amplifier to correct flesh tones which appear yellowish or greenish. The output from the red gate is phase-shifted in the opposite direction and applied to the chroma amplifier to correct flesh tones which appear reddish or magenta. When the skin colors are correct, the correction signals from both the yellow and red gates are equal and opposite and cancel each other. Therefore, the chroma signal passes through the chroma amplifier unchanged.

The "on" times for the gates are very short since the switch conducts only on the positive peaks of the c.w. signal. When this occurs, both gates are turned on by completing the emitter circuits of *Q2* and *Q3* through the now conducting switch *Q1*. While the gates are turned on, the chroma signals applied to the bases of the two gating transistors must also be positive to produce an output from the collector circuits. Chroma signals that affect flesh tones (between yellow and magenta) are positive-going during sample times and hence correction signals are produced. On the other hand, blue, cyan, and green chroma signals are negative-going at this time, so no correction signal is produced for these colors. ●

COLOR TV for 1970

MFR	CHASSIS	CRT[1] SIZE	DESIGN[2]	IC's	FINE-TUNE AID	V.H.F.[3] TUNER	REMOTE CONTROL	QUICK WARMUP	DEGAUSSING[4]	H.V. REG	NO.[24] VIDEO I.F.'s	NO.[24] CHROMA B'PASS	TYPES[5] DEMOD	COLOR DIFF AMPS	HEATERS
ADMIRAL	6H10	18, 20	tube			tube	7-function	Instant Play	auto	pulse	3	2	X-Z hi		parallel
	12H10	18, 20	tube		a.f.t.	tube	7-function	Instant Play	auto	pulse	3	2	X-Z hi		parallel
	19H10	23	tube		a.f.t.	tube	7-function	Instant Play	auto	pulse	3	2	X-Z hi		parallel
	15H10	23	tube			tube			auto	pulse	3	2	X-Z hi		parallel
	—K10's	12, 14, 16	7/25[2]			xstr			auto[17]	pulse	3X	2X	R-Y, B-Y X	yes	series
	11H12	23	tube		a.f.t.	tube	7-function	Instant Play	auto	shunt	3	2	X-Z hi		parallel
AMBASSADOR (Allied Stores)	2907A	See JVC-Nivico 151													
	2914A	See JVC-Nivico 7208													
ANDREA	VCX-325-1 to 6	23	hybrid	sound sect, remote	eye, meter, or a.f.t.	tube	7-function		auto	n.a.	3	2	X-Z lo	yes	n.a.
	VCX-325-7	23	hybrid	sound sect, remote		tube[6]	7-function		auto	n.a.	3	2	X-Z lo	yes	n.a.
ARVIN	60K—	15	tube			tube			auto	pulse[18]	3	2	X-Z lo	yes	[19]
	70K—	20	tube			tube			auto[13]	pulse	3	2	X-Z lo	yes	series
	78K—	18	tube			tube			auto[13]	pulse	3	1	X-Z lo	yes	series
	80K—	20, 23	tube	sound sect.	light	tube		yes	auto	shunt	3	1	X-Z lo	yes	parallel
BELL & HOWELL	2945	20	hybrid			tube			n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	parallel
BROADMOOR	6911C	11	9/25[2]	sound i.f.	a.f.t.	xstr		yes	auto	pulse	3	2	X-Z X	yes	series
	6915C	15	9/25	sound i.f.	a.f.t.	xstr		yes	auto	pulse	3	2	X-Z X	yes	series
	6918C	18	9/25	sound i.f.	a.f.t.	xstr		yes	auto	pulse	3	2	X-Z X	yes	series
CLAIRTONE	MSS 712[1]		xstr[20]	four		xstr				n.a.	n.a.	n.a.	n.a.	n.a.	
CONAR (kit) (N.R.I.)	600	18	tube			tube			none	pulse	2	1	R-Y, B-Y	G only	series
CRAIG	6303-04	15, 18	tube		a.f.t.	tube		yes	auto	n.a.	n.a.	n.a.	n.a.	n.a.	series
DELMONICO	See JVC-Nivico														
ELECTROHOME	C6	18, 20, 23	hybrid		a.f.t.[7]	tube		Insta-Vu	auto	pulse	3	2	R-Y, B-Y	yes	series
	C8	23	tube		a.f.t.	varactor[8]	wired	Insta-Vu	auto	pulse	3	2	R-Y, B-Y	yes	parallel
ETHAN ALLAN (Baumritter)	See General Electric KE series														
GENERAL ELECTRIC	C1	18, 19, 20	12/11[2]		a.f.t.	tube			auto	pulse	3	1	X-Z D	yes	series
	G1	14	tube			tube			auto	pulse	3	1	X-Z D	yes	series
	H3	10	tube			tube			manual	pulse	3	1	X-Z D	yes	series
	KE	18, 20, 23	16/5[2]		a.f.t.	tube			auto	shunt	3	1	X-Z D	yes	parallel
HEATH (kit)	GR-180	18	tube			tube	6-function		auto	shunt	3	2	X-Z lo	yes	parallel
	GR-227	20	tube			tube	6-function		auto	shunt	3	2	X-Z lo	yes	parallel
	GR-295	23	tube			tube	6-function		auto	shunt	3	2	X-Z lo	yes	parallel
	GR-481	18	tube	a.f.t.	a.f.t.	tube	6-function		auto	shunt	3	2	X-Z lo	yes	parallel
	GR-581	20	tube	a.f.t.	a.f.t.	tube	6-function		auto	shunt	3	2	X-Z lo	yes	parallel
	GR-681	23	tube	a.f.t., remote	a.f.t.	tube	6-function		auto	shunt	3	2	X-Z lo	yes	parallel
HITACHI	CNA-25T	18	hybrid			tube			auto	shunt	3	1	X-Z lo	yes	series
	CWA-200	12	xstr			xstr		yes	auto	[22]	4X	2X	R-G-B D	[12]	
	CFA-450	14	xstr	a.f.t.		xstr			auto	pulse	n.a.	n.a.	n.a.	n.a.	
HOFFMAN	leaving color-TV business														
JVC-NIVICO	151	18	tube			tube			auto	shunt	3	2	X-Z D	yes	n.a.
	7208	14	10/28[2]			tube			auto	pulse	3	2	X-Z D	yes	n.a.
	7408	18	12/27[2]			tube			auto	shunt	3	2	X-Z D	yes	n.a.
	7438	18	12/28[2]		a.f.t.	tube			auto[13]	shunt	3	2	X-Z D	yes	n.a.
MAGNAVOX	T934	19R[9]	tube			tube		Quick-Picture	auto	pulse	3	1	R-Y, B-Y	G only	n.a.
	T936	14	9/20[2]	sound		xstr		Quick-Picture	auto	pulse	3X	3X	R-Y, B-Y	G only	series
	T939	18, 20	tube		a.f.t.	tube	4- & 8-function	Quick-Picture	auto	pulse	3	1	R-Y, B-Y	G only	n.a.
	T940[10]	23	tube		a.f.t.	tube	8-function	Quick-Picture	auto	shunt	3	1	X-Z lo	yes	parallel
	T947	11	12/15[2]	sound		xstr			auto	pulse	4	2	R-Y, B-Y	G only	

MOTOROLA	TS-915[23]	20, 23	xstr	sound sect.	FTI/FTL[11]	xstr	7-function	yes	auto	pulse	3	2	R-B-G D	yes[12]	
	TS-921	18, 20, 23	tube		FTI/FTL	tube	4-function		auto[13]	pulse	3	2	X-Z hi		parallel
	TS-924	14	tube			tube			manual	pulse	3	2	X-Z D	yes	series
	TS-930	16	hybrid			xstr			manual	pulse	3	2	X-Z lo	yes	n.a.
OLYMPIC	CTC-30, 31	22, 23	tube		eye	tube		Rapid-On	auto	shunt, pulse	3	1	X-Z lo	yes	parallel
	CT911	18	tube			tube			auto	shunt	3	2	X-Z hi		series
	CT400	14	tube			tube			auto	pulse[18]	3	2	X-Z hi		series
PACKARD-BELL	98C21	23	11/18[2]	CW osc, sound sect.	a.f.t.	tube	optional	Instant Action	manual	shunt	3X	2X	R-Y, B-Y X	yes	parallel
	98C22	23	11/18[2]		a.f.t.	tube	VHF only	Instant Action	manual	shunt	3X	2X	R-Y, B-Y X	yes	parallel
	CQ-322	12	10/25[2]			xstr			manual	pulse	3	2	X-Z D	[14]	n.a.
	CQ-522-524	15	10/24[2]			xstr			manual	pulse	3	2	X-Z D	[14]	n.a.
	CQ-622	18	tube			tube			manual	pulse	3	1	X-Z lo	yes	n.a.
	CQ-634	18	tube			tube	3-function		auto[13]	pulse	3	1	X-Z lo	yes	series
PANASONIC	CT-23P	12	10/47[2]			xstr		yes	auto	pulse	3	2	X-Z D	[14]	n.a.
	CT-24W	12	10/46[2]		a.f.t.	xstr		yes	auto	pulse	3	2	X-Z D	[14]	n.a.
	CT-64P	15	10/58[2]			xstr		yes	auto	pulse	3	2	X-Z D	[14]	n.a.
	CT-65D	15	10/60[2]		a.f.t.	xstr		yes	auto	pulse	3	2	X-Z D	[14]	n.a.
	CT-93P	19	tube			tube		yes	auto	pulse	3	1	X-Z lo	yes	n.a.
	CT-94T	19	tube			tube		yes	auto	pulse	3	1	X-Z lo	yes	n.a.
	CT-95D	19	tube			tube		yes	auto	pulse	3	1	X-Z lo	yes	n.a.
	CT-991	9	xstr		a.f.t.	xstr		yes	auto	n.a.	n.a.	n.a.	n.a.	n.a.	—
PHILCO-FORD	19FT60	14	8/25[2]	CW osc	eye	xstr			auto	pulse	3X	2X	X-Z X	yes	parallel
	19KT40	18	8/25[2]	CW osc	eye	xstr			auto	pulse	3X	2X	X-Z X	yes	parallel
	20KT40	18	8/25[2]	CW osc		xstr			auto	pulse	3X	2X	X-Z X	yes	parallel
	20KT41	18	8/25[2]	CW osc	a.f.t.[15]	xstr			auto	pulse	3X	2X	X-Z X	yes	parallel
	20QT87	23	16/12[2]		a.f.t.[15]	xstr			auto	pulse	3X	2	X-Z lo	yes	parallel
	20QT88	23	16/12[2]		a.f.t.[15]	xstr			auto	pulse	3X	2	X-Z lo	yes	parallel
	20QT90	23	16/12[2]		a.f.t.[15]	xstr			auto	pulse	3X	2	X-Z lo	yes	parallel
RCA	CTC22	14	tube			tube			auto	pulse	2	1	X-Z lo	yes	series
	CTC36	18	tube			tube	5-function		auto	pulse	2	1	X-Z lo	yes	series
	CTC38	20, 23	17/8[2]	a.f.t.	a.f.t.	hybrid	7-function		auto	shunt	3X	2	X-Z D	yes	parallel
	CTC40	23	xstr	a.f.t., sound	a.f.t.	xstr		yes	auto	pulse	3X	3X	R-B-G D	[12]	—
	CTC42	16	13/?	a.f.t., sound sect.	a.f.t.	hybrid	8-function		auto	pulse[18]	3X	2	R-Y, B-Y D	yes	series
	CTC47	23	xstr	several	a.f.t.	xstr[25]	10-function	yes	auto	none	3X	4X	n.a.	n.a.	—
SETCHELL-CARLSON	no longer in consumer television														
SHARP	CU-50P	12	tube			tube			auto	n.a.	n.a.	n.a.	X-Z D	yes	n.a.
	CY-61P	15	tube		a.f.t.	tube			n.a.	n.a.	n.a.	n.a.	X-Z D	yes	n.a.
	CN-62T	18	tube		a.f.t.	tube			n.a.	n.a.	3	n.a.	X-Z D	yes	n.a.
SONY	Plans to introduce 12-inch Trinitron, but no information was supplied.														
SYLVANIA	D05	18	tube		a.f.t.	tube			auto	pulse	3	2	X-Z lo	yes	series
	D06	20	tube		a.f.t.	tube			auto	shunt	3	2	X-Z lo	yes	parallel
	D11	14	tube		a.f.t.	tube			auto	pulse	3	2	X-Z lo	yes	
	D12[16]	23	9/28[2]	sound i.f.	a.f.t.	xstr	10-function	Instant-Color	auto	shunt	3X	3X	X-Z D	yes	parallel
TOSHIBA	C6A, 7A, 8A	15, 18	13/18[2]			xstr		yes	auto	pulse[18]	3X	2X	R-G-B D	yes	series
	C41A, 51A	15	13/18[2]			xstr		yes	auto[13]	pulse[18]	3X	2X	R-G-B D	yes	series
WEBCOR	CTV-15 CTV-18	15 18	tube		a.f.t.	tube			auto	shunt	3	2	X-Z lo	yes	n.a.
WESTINGHOUSE	V-2655	18, 23	tube		on-screen bars	tube			auto	pulse	3	2	X-Z lo	yes	
	V-2656	23	24/11[2]			tube		Instant-On	auto	pulse	3	2	X-Z lo	yes	series
	V-8001	14	tube			tube		Instant-On	auto	pulse	3	2	R-Y, B-Y	yes	series
ZENITH	12A10C15	14, 16	14/10[2]	demod		tube			auto	pulse	3X	IT, IX	IC	yes	parallel
	12A12C52	23	14/12[2]	demod	a.f.t.	tube	6-function		auto	pulse[18]	3X	IT, IX	IC	yes X	parallel
	14A9—, A10—	18	16/9[2]	demod	a.f.t.	tube	4-, 6-function		auto	pulse[18]	3X	IT, IX	IC	yes	parallel
	14A9C50, 51	20, 23	16/9[2]	demod	a.f.t.	tube	6-function		auto	pulse[18]	3X	IT, IX	IC	yes	parallel
	16Z8C19	18	18/8[2]		a.f.t.	tube	4-, 6-function		auto	pulse[18]	3X	2T, IX	R-Y, B-Y	yes	parallel

Information was not received from the following companies: Airline (Montgomery Ward), Channel Master, Curtis Mathes, DuMont-Emerson, Hayakawa, Penncrest (J. C. Penney), and Sears/Silvertone.

NOTES: n. a. = information not available; 1. viewable diagonal inches; 2. some hybrids show how many tubes/transistors, includes tuners; 3. all u. h. f. tuners are transistor; 4. auto = automatic; 5. lo = low level, hi = high level, D = diodes, **X** = transistors; 6. motor-driven, but push-button operated; 7. called "Electrolok;" 8. all varactor-tuned tuners are solid-state; 9. designation for 70-degree, 21-inch round CRT; 10. has a. t. c. (automatic tint control) which is Magnavox exclusive this year; 11. Fine Tuning Indicator and Fine Tuning Lock; 12. two stages for each color; 13. using thermal timer relay; 14. has X and Z amps, plus R, G, and B amps; 15. called Autolock Channel Tuning (a.c.t.); 16. has signal-seeker u.h.f. tuning; 17. some use thermal timer, 4K10 uses special circuit; 18. pulse-load type (see text); 19. mainly series, but some fed in parallel by transformer; 20. modular construction on plug-in circuit boards; 21. only limited information available; 22. special parallel-reactance regulating circuit (see text); 23. changes from last year's TS-915/919 are slight—most notable is "Fast Back" chassis layout (see text); 24. **X** = transistors instead of tubes; 25. uses unique diode switching for channel changing.

(*Continued from page* 68)

limited to tube versions of several types, and a few kinds of diode demodulators.

One transistor demodulator is shown in Fig. 3; it's in the *Sylvania* D12 chassis. Chroma sidebands are applied to both bases in parallel, or in the same phase. The 3.58-MHz c.w. signal from the reference oscillator is applied to the emitters, but it is phase-shifted about 80 degrees by *C*1-*L*2 before it is applied to *Q*2.

Here's what happens. The high-amplitude c.w. signal applied to the emitters drives each transistor as a grounded-base amplifier. The output, in the collector circuit of each, is a large-amplitude 3.58-MHz signal. Remember, though, the signal across *R*9 is 80 degrees out-of-phase with the signal across *R*8. Chroma sidebands in the base circuit of each "modulate" the 3.58-MHz c.w. signals. The outputs are different, however, because of the phase difference in the c.w. signals.

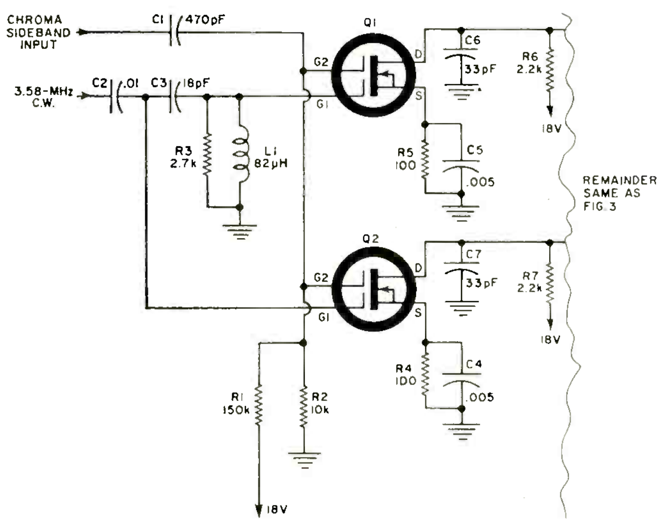
The mixed signals are smoothed out by a low-pass filter in the output of each demodulator stage. All r.f. products of the mixing are eliminated, and the demodulated chroma signal is passed along to the color amplifier that follows. The coupling capacitors in Fig. 3 are *C*4 and *C*6. The signals in *Q*1 produce, after filtering, a red or R-Y signal; the signals in *Q*2, since the c.w. has an 80-degree phase difference, produce a blue or B-Y signal.

Small portions of the color signals are fed back from the collector to the bases of the two demodulators. This is done by resistors *R*10 and *R*12. A sample of R-Y signal is phase-shifted by *C*7 and *L*5 and fed to the G-Y amplifier by *C*5.

Other chassis have transistor X-Z demodulators, too. All *Broadmoor* color chassis and the *Philco-Ford* 19FT60 chassis use circuits similar to the one just described. The demodulation angle may vary slightly, but is chosen to render best color for that chassis. The *Admiral* K10 chassis have transistor demodulators, too, working on the R-Y and B-Y axes. There's almost no difference in operation.

There's something different in the *Packard-Bell* 98C21 and 98C22 demodulators. They have field-effect transistors — dual-gate FET's, in fact. They're shown in Fig. 4. The c.w. signal goes directly to gate 1 of *Q*2, but is phase-shifted by *L*1-*C*3 before it gets to *Q*1. The chroma sidebands are applied to gate 2 of both FET's, equally and in the same phase. Operation is the same as in Fig. 3.

Fig. 4. Demodulator in Packard-Bell's 98C21 and 98C22 employs dual-gate field-effect transistors as shown here.



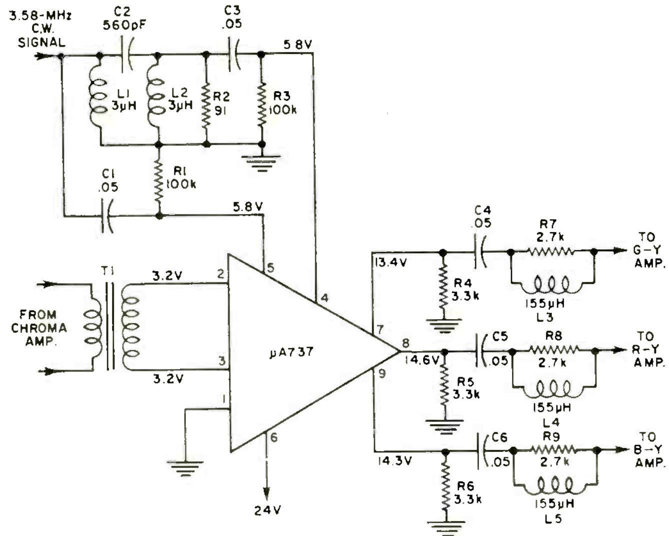


Fig. 5. Zenith color demodulator uses integrated circuits.

All *Zenith* chassis for 1970, except the 16ZSC19, have an integrated circuit for the color demodulator. The IC is a *Fairchild* μA737. Operation is very much like the 6LE8 type of beam-switching demodulator. The diagram is shown in Fig. 5.

One set of switching amplifiers inside the IC receives a 3.58-MHz signal through *C*1 and terminal 5. Their job is to switch a pair of differential amplifiers alternately on and off at the 3.58-MHz rate. Phase-shift network *L*1-*C*2-*L*2 alters the phase of the 3.58-MHz signal applied through *C*3 to terminal 4 of the IC. This phase-shifted signal goes to another set of switching amps, which control a second pair of differential amplifiers.

Chroma signals are applied to terminals 2 and 3 of the IC, with both sides balanced to ground. Inside the IC, the chroma sideband signals are applied to the two pairs of differential amplifiers in parallel, in the same phase. Since the halves of the differential amps are being alternately switched off and on at 3.58 MHz, their outputs are a product of mixing 3.58-MHz signals with the chroma sidebands. The r.f. is eliminated.

What remains is a demodulated color signal. From the differential amplifier that gets the c.w. signal directly, a B-Y signal is developed. From the one that gets the phase-shifted signal through terminal 4, an R-Y signal results. A resistive matrix inside the IC extracts a G-Y signal, too. Each color-difference signal is amplified by a single-ended transistor amplifier inside the IC and brought to an external terminal. B-Y comes to terminal 9, R-Y to terminal 8, and G-Y to terminal 7. Resistors *R*4, *R*5, and *R*6 are external load resistors for the color-difference amplifiers.

The 3.58-MHz signal is naturally eliminated in this balanced-type demodulator. However, a rather strong second harmonic is generated near 7.2 MHz. That's the reason for trap chokes *L*3, *L*4, and *L*5 in the output circuits.

Field-effect transistors, which we've already mentioned in the *Packard-Bell* demodulator stage, are new to color TV. We know of only two other chassis that use FET's.

The r.f. amplifier in the *RCA* CTC 40 is a dual-gate field-effect transistor. Its circuit is simple — see Fig. 6. The dual-gate FET is like two FET's in "cascode." The r.f. signal is applied to gate 1, and is amplified. A d.c. voltage on gate 2 is for gain control of the r.f. amplifier. Notice that gate 2 is decoupled by 1000 pF of capacitance, but the coaxial capacitor at gate 1 is only 5 pF – part of the input tuning.

The other chassis that has an FET is the *Admiral* K10. The field-effect transistor is a reactance control stage for the 3.58-MHz oscillator. The dual-gate units in the *RCA* above are insulated-gate FET's or IGFET's. The one in this *Admiral* chassis is a junction FET, or JFET. There's a diagram of how it's used in Fig. 7.

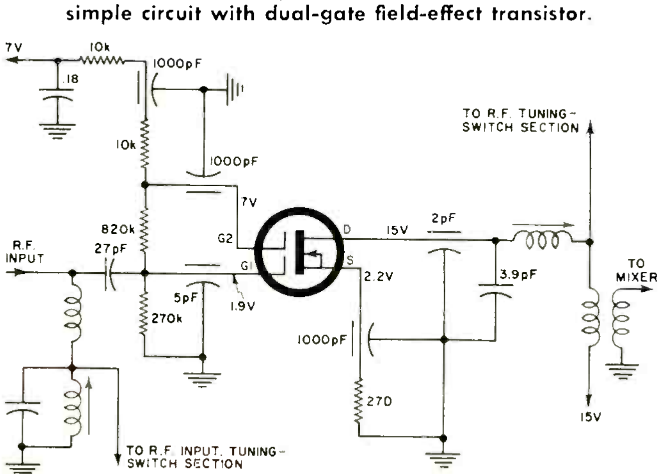
In effect, the *n*-channel of the JFET is in series with the 220-pF capacitor. The d.c. voltage on the gate, coming from the burst phase detector, controls effective resistance of the channel. When it's low, the capacitor loads down the crystal, altering its frequency slightly. When it's high, the capacitor has little affect on the crystal. The stage's nominal effect on frequency of the c.w. oscillator is set by the Reactance Adjust control in the source circuit of the JFET. It merely sets the bias voltage between gate and source.

Speaking of new solid-state technology being used in the 1970 color chassis, the *Broadmoor* sets have something that is a *first* for color sets, as far as we can determine. There are *no tuned circuits* in the sound i.f. system. A diode detects the 4.5-MHz intercarrier as usual. The signal is then passed to an extremely high-"*Q*" ceramic filter and coupled by the filter to the integrated circuit that is the sound i.f. amplifier. Another 4.5-MHz ceramic filter follows the IC. It's a special one, with a capacitance tap between the ceramic element and ground. A pair of back-to-back diodes are connected to the tap for phase detection of the FM sound.

A fairly recent solid-state device is the integrated circuit. In 1969, of 63 chassis surveyed, 16 had integrated circuits. This year we surveyed 97 chassis and found 27 with IC's. On a percentage basis, that's very little increase. Except for a little initial glamor, IC's haven't added much to color TV.

The fact is, it is no more – and often less – expensive to do the job with other solid-state components. Only 13 that we know of use IC's. They are: *Andrea, Arvin, Broadmoor, Clairtone* (with four IC's in one chassis), *Heath, Hitachi, Magnavox, Motorola, Packard-Bell, Philco-Ford, RCA* (first brand to use IC's in color sets and with six in one chassis this year), *Sylvania,* and *Zenith.* The circuits in which IC's appear are: sound i.f. and

Fig. 6. The r.f. amplifier in RCA's CTC 40 is a simple circuit with dual-gate field-effect transistor.



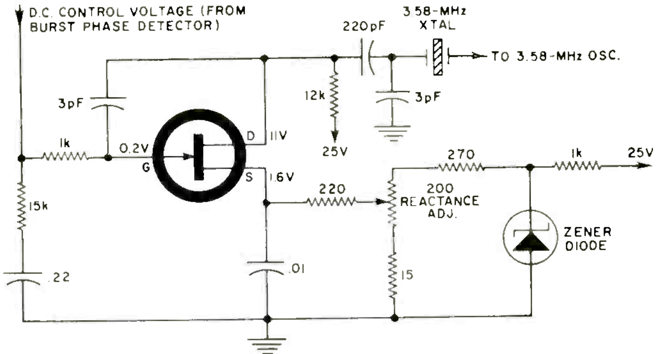


Fig. 7. Admiral uses JFET in reactance control stage.

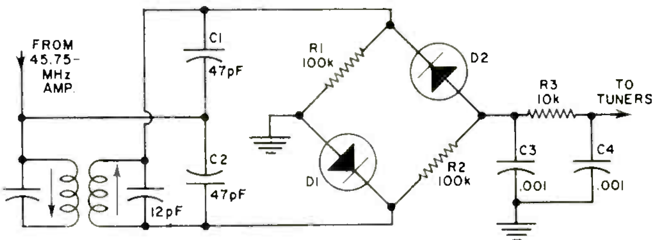


Fig. 8. Ring phase detector in Packard-Bell 98C21.

discriminator, sound i.f. alone, color demodulator, a.f.t., 3.58-MHz oscillator, and remote receiver. One tuner-maker has an integrated-circuit tuner for v.h.f., but no set-maker has put it into a receiver yet. The future for IC's in color-TV looks slow, at best.

Lots of Automatic Features

One problem among set owners is that they don't know how to operate a color set. If fine tuning, brightness, contrast, color, or hue is set wrong, the picture doesn't look right.

The answer is to have the set make all those adjustments for itself. And so, 1970 color chassis are loaded with automatic circuits and stages to take the effort out of color-TV watching. These include automatic brightness limiter (a.b.l.), automatic fine tuning (a.f.t.), automatic chroma control (a.c.c.), and automatic degaussing circuits (a.d.c.).

And last, but far from least, is an automatic tint control (a.t.c.) pioneered this year by *Magnavox.* It senses phase of chroma signals that cause flesh tones on the picture tube. If demodulator phase drifts a few degrees one way or the other, the a.t.c. corrects the error. It does this even if the error is in the chroma when the signal arrives at the set.

Top billing among all brands goes to automatic fine tuning, or a.f.t. The basics are the same as ever. The a.f.t. gets a 45.75-MHz signal from the third video i.f. A tuned 45.75-MHz amplifier feeds a discriminator centered at that frequency. The discriminator senses any frequency drift from precisely 45.75 MHz, and produces a d.c. error voltage. That's fed back to the tuner, where it works on a varactor diode that is part of the oscillator tuning circuit. The oscillator is thus kept exactly 45.75 MHz away from the station picture carrier.

The a.f.t. in the *Packard-Bell* 98C21 has an unusual error-sensing circuit. Instead of a standard discriminator, this one has a ring phase detector – called "ring" for the way the diodes are wired. The circuit is shown in Fig. 8.

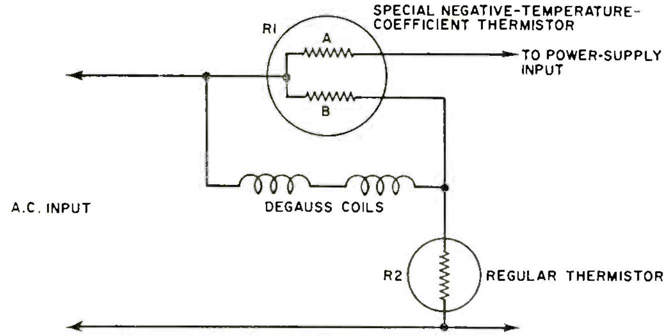


Fig. 9. Late runs of the Admiral 4K10 chassis employ a negative-temperature-coefficient thermistor for degaussing.

A transistor amplifies the 45.75-MHz signal. The ring input transformer is a simple two-winding type. Its output is applied to the diode ring at two opposite corners. A matched pair of 47-pF capacitors form a divider across the transformer. Signal from the top of the transformer *primary* is fed to the center tap of the capacitive divider, which gives it a quadrature (90-degree) phase shift with respect to the secondary signal. In effect, there is a quadrature signal fed in parallel to both sides of the ring phase detector at the same time a push-pull signal is being applied at the input "corners."

The ring circuit is balanced when the frequency of the signal is exactly at 45.75 MHz, because both diodes conduct the same. Any shift in signal frequency upsets the balance. The signal entering the center tap of the capacitance divider is phased differently at the ends, compared to the secondary signal. One diode conducts more than the other. The normally zero voltage at the output "corner" of the ring detector shifts either positive or negative, depending on direction of the frequency shift. The amount of d.c. output voltage depends on how far the frequency shifts. Output filter network *C3-R3-C4* smooths the resulting d.c. correction voltage and keeps i.f. signal from the tuner a.f.t. lines.

Automatic fine tuning is popular. At least 18 manufacturers have it, for over 40 chassis. Some that don't have it offer an alternative, such as a meter or an "eye" to help the viewer know when fine tuning is set properly.

Automatic color control is old hat, although its importance is often overlooked. Its job is to level out any variations in chroma sideband signal. The demodulators need a fairly steady chroma sideband signal. A.c.c. senses the amplitude of the color sync burst and develops a gain-controlling d.c. voltage which it applies to a bandpass or chroma amplifier stage.

Automatic degaussing circuits (a.d.c.) aren't new, either. But there are a couple of unfamiliar ones in 1970 chassis.

One degaussing circuit, in the *Hitachi* CWA-200, operates as the set is turned off. Special degaussing contacts on the power switch close when the set is turned off. They apply a.c. power to the degaussing coil through a thermistor. At first, current – and demagnetizing action – is large. But the current heats up the thermistor and reduces the current through the series circuit; demagnetizing dwindles. Equilibrium current is very low.

Automatic degaussing in late runs of the *Admiral* 4K10 chassis is based on the use of a special negative-temperature-coefficient thermistor. As you can see in Fig. 9, part of the circuit is an ordinary thermistor, with positive temperature coefficient. The dual unit, with the negative coefficient, is actually two thermistors in a single case. As power-supply current flows through *R1A*, it heats up *R1B*, connected across the degaussing coils. *R1B* gets lower and lower in resistance, finally so low it bypasses all current around the coils. Meanwhile, the positive-coefficient thermistor resistance is increasing – enough to keep the coils from being a low impedance across the power line.

Then there's the automatic brightness limiter (a.b.l.). It keeps beam current in the color picture tube from becoming so high it saturates the phosphor and causes blooming.

Motorola has had an a.b.l. in its transistor chassis since it was introduced. High beam current loads down the horizontal sweep circuit, through its relationship to CRT high voltage. The a.b.l. stage senses the change and converts it to a d.c. bias. The correction voltage goes to the brightness-control transistor, then to the video drivers and outputs, and finally to the CRT cathodes. Beam current is reduced enough to keep the picture from blooming. The secret is to set the a.b.l. adjustment for no blooming with highest video (white picture content).

In the *Hitachi* CWA-200 transistor chassis, an a.b.l. stage protects the horizontal-output transistor from too much loading. A diode at the grids of the CRT (all three G1's are tied together) conducts if beam current goes beyond a certain value. The slight current thus generated is passed through a large-value resistor. The voltage across the resistor is applied to the output transistor and damper circuit stage and opposes conduction there enough to avoid overload.

The auomatic tint control (a.t.c.) invented by *Magnavox* has already been mentioned. (See page 69.)

The Armchair Viewer

Remote controls have been around too long to really be news. Even that solid-state "wonder," *Motorola's* Memory Module remote system without motors on the controls, is more than a year old but still in the line this year.

One new remote-control idea is the search tuner. It sweeps the u.h.f. and v.h.f. spectrum, stopping only when it finds an active channel.

An example is the *Magnavox* Instant Automatic Remote Control. The heart of it is one little printed board with circuits that drive the motor of v.h.f. or u.h.f. tuner on and on, stopping only on a station signal. If there's no station on the air, an automatic shut-off stops the whole operation. The board is called the *search and auto-off* board.

For v.h.f. a 40-kHz remote signal trips a relay that applies power to the tuner motor. A latching system, part of which is a search relay with contacts normally closed, keeps power applied and the motor turning. When the tuner reaches a station, circuits on the board open the search relay contacts, stopping the motor.

For u.h.f. a 43-kHz signal actuates an up-relay. It applies power to the up winding of a bidirectional motor. The tuner dial moves up-frequency. When the motor reaches the top limit, a reversing switch shifts power to the down winding. Direction reverses again at the bottom limit. A 41.5-kHz signal from the remote transmitter operates the down relay, making the initial movement down-frequency.

You can trace the main functions of the search and auto-off board in Figs. 10 and 11. When a TV station signal is picked up by whichever tuner is operating, the 45.75-MHz i.f. picture carrier is coupled to the search and auto-off board. A tuned transformer applies the signal to a diode and filter. The resultant d.c. goes to the base of *Q*1, the i.f. gate. If the u.h.f. tuner is searching, a a delay voltage from *Q*10 keeps transistor *Q*1 cut off when there is no signal; that voltage must be overcome by the rectified voltage from the diode when a signal is picked up.

Meanwhile, sync signals are applied to the search and auto-off board, too. A tuned transformer doubles their frequency and couples the 31.5-kHz signal to *Q*3. Since *Q*3 is in series with *Q*1, both transistors have to be active to operate search relay *K*1. Thus, both sync and i.f. signal have to be present to pull the contacts of *K*1 open.

The power contacts at the top of Fig. 10 belong to function relays in the remote-control receiver. Depending on which relay closes, a.c. is applied to one motor winding. Either *D*1, *D*3, or *D*4 rectifies the voltage, and applies it to *C*8 and *K*2; the capacitor smooths it out to about 28 volts d.c. If *D*4 is rectifying, because the v.h.f. motor is active, *D*2 blocks the d.c. from the u.h.f. side of the system. Relay *K*2 is a muting relay and part of a u.h.f. latching circuit (not shown) that works with the reversing switches.

With a motor turning its tuner, the first station signal encountered applies both i.f. and sync to the board inputs. *Q*1 and *Q*3 operate *K*1 and remove power. The tuner stops on-station, and the receiver's a.f.t. system fine-tunes the signal precisely.

The automatic-off operation is diagrammed in Fig. 11. A tap on the 31.5-kHz transformer (Fig. 10) feeds the auto-off section. The regulator on-off system operates from a 38.5-kHz remote signal. The signal fires *Q*208 and steps *RL*204. *RL*204 is a multiple-step relay, and if the set is on, it keeps cycling until the off position is reached.

Silicon controlled switch (SCS) *Q*2 is wired to operate *RL*204 when the SCS turns on. The SCS gate remains at 15 volts as long as the SCS is quiescent. Large-value capacitor *C*11 charges slowly from the 200-volt line through resistances *R*1 and *R*3. Left alone, the charging time is about 80 seconds.

Transistor *Q*4 amplifies incoming sync pulses when a station is present. Diode *D*5 lets the amplified negative-going pulses through to buck the normally positive voltage at the anode of the SCS. The SCS can't fire as long as this keeps up, because the charge on *C*11 never gets high enough; it is regularly discharged by the negative pulses.

Without sync, *C*11 continues charging undisturbed. So, if no signal is found by the tuner, voltage on *C*11 finally builds up to the 15-volt firing potential of the silicon controlled switch. (An SCS fires when its gate and anode are at the same potential.) *Q*2 fires, the gate goes to ground potential or nearly so, and *RL*204 operates, turning the receiver off (or steps once each time the SCS fires, until it reaches off position).

Magnavox has no corner on u.h.f. search systems. Several other set-makers have them. Another that stands out is in a limited-run *RCA* chassis, the CTC 47. When the v.h.f. selector is in its channel-1 position, a motor drives the u.h.f. tuner up and down the band until a signal is

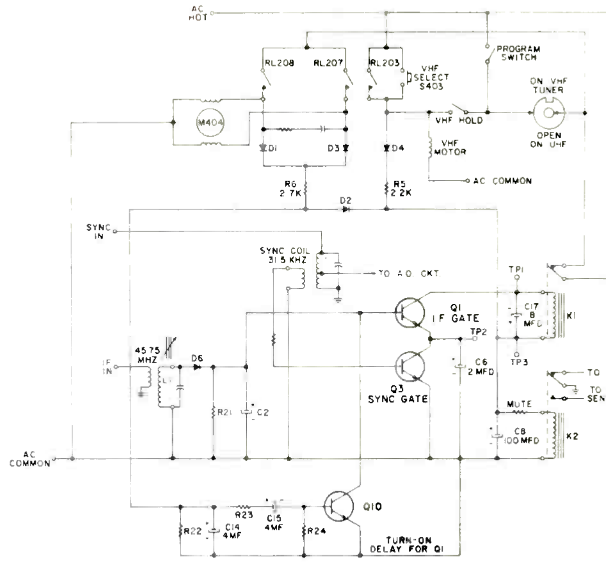


Fig. 10. The Magnavox automatic search circuitry.

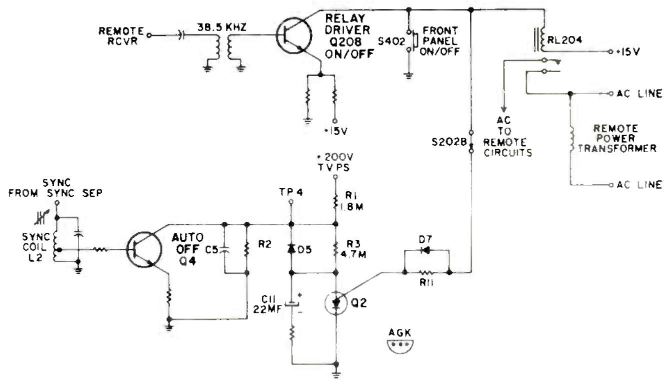


Fig. 11. Automatic-off operation of the Magnavox circuit.

encountered. A group of circuits in the special remote-control system utilize sync, a.g.c., and a.f.t. to sense when a signal is tuned in, and stop the motor. The a.f.t. does the final precise tuning.

This is part of an *RCA* remote system that has similarities to *Motorola's* non-mechanical one. Memory modules supply voltages to the main chassis to control color gain, hue phase, and volume. The memory modules are controlled by signals from a 10-function remote-control transmitter.

Unique to this *RCA* chassis is a switchless v.h.f. tuner. It and its remote switching are too complex to cover in detail, but here are the highlights. Selecting a channel is a matter of applying 16 volts to one of the 13 channel-activating input terminals of the tuner. Inside the tuner, the voltage forward-biases a group of switching diodes that connect inductors and capacitors (not varactors) for the channel chosen. On the remote control boards, logic switching carries out an electronic search operation that stops on the v.h.f. station that has been dialed by the viewer. This search is finished in a fraction of a second, so tuning appears instant.

With the cry about x-radiation ringing loudly in their ears, engineers have just about wiped out the main possible source: shunt-type high-voltage regulators. Of 98 chassis, only 22 have shunt regulators (last year about half did). And some of those have hold-down circuits that prevent high voltage from becoming too high even if the shunt regulator fails.

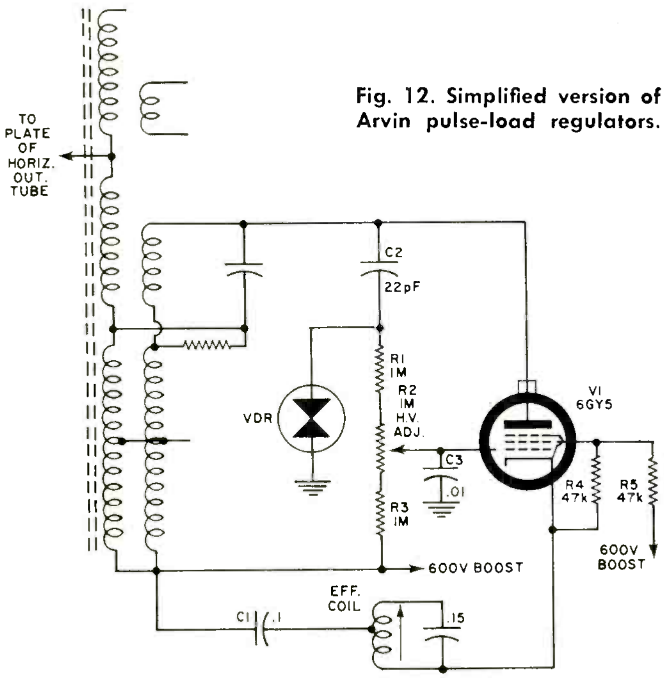


Fig. 12. Simplified version of Arvin pulse-load regulators.

Most sets today use pulse-type high voltage regulation. Anything which controls the amplitude of flyback pulses in the deflection yoke also controls high voltage. A feedback pulse from the flyback transformer is rectified and the negative d.c. applied to a potentiometer. The pot applies just the right amount to the horizontal output grid to control its gain. The pot can thus set the desired high voltage (which usually depends on CRT size).

If high voltage goes up for any reason, more pulse reaches the pulse rectifier (sometimes a voltage-dependent resistor, instead). Bias on the output tube goes higher, reducing gain and cutting the flyback-pulse amplitude back down. High voltage is lowered. If h.v. goes down, opposite reactions raise it. This *pulse-feedback* system works well, and it eliminates the shunt regulator.

There's another type of pulse regulator. Forms of it were used occasionally last year, by *RCA* and *Zenith* in particular. Several are using it this year. It can be described as a *pulse-load regulator*. There's an example in Fig. 12, in simplified form.

This is in an *Arvin* 60K34 chassis. The plate connection is direct to the flyback winding; the cathode connection is through the efficiency coil and *C*1. The tube plate impedance loads down the flyback transformer. Plate impedance is determined by bias on the control grid.

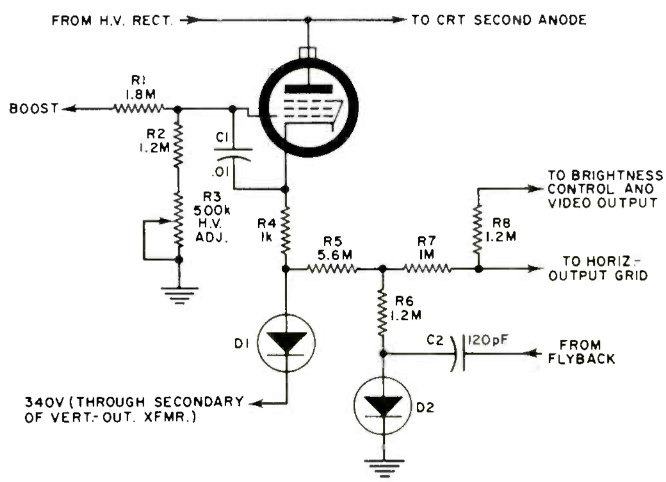
Bias depends on how much pulse voltage reaches the voltage-dependent resistor (VDR). Pulses are applied from the flyback winding by *C*2. The VDR is part of a divider – comprising *R*3, *R*2, *R*1, and the VDR – between the 600-volt boost line and ground. *R*1 applies part of the voltage to the grid of the 6GY5 pulse-load regulator tube.

Imagine the high voltage going down. The flyback pulse amplitude goes lower, reducing VDR resistance. That develops less positive voltage at all points in the divider, because there is less resistance to ground. So the voltage at the slider of *R*2 is lower. With the control grid of *V*1 less positive, the tube loads the flyback winding less.

If the high voltage goes higher, the VDR resistance increases because of the higher flyback pulse. More positive grid bias lets *V*1 conduct more. That loads down the winding and reduces the pulses to normal amplitude.

The *Olympic* CT-400 uses a 6BQ5 beam pentode as a pulse-load regulator. However, there's no VDR to sense

Fig. 13. Pulse-load regulator used in Olympic receiver.



R. F. SIGNAL GENERATORS

MFR.	MODEL	FREQ. RANGE (FUNDAMENTALS) (MHz)	NO. OF BANDS	CAL. HARMONICS FREQ. (MHz)	CAL. HARMONICS NO. OF BANDS	OUTPUT VOLTAGE (V)	OUTPUT Z (Ω)	MODULATION FREQ. (Hz)	PROVISION FOR EXT. MOD.	CALIB. ACCURACY (%)	AUDIO OUTPUT VOLTS	PRICE $(K=kit)	REMARKS
CONAR	280	.170–60	6	–	–	0.5	50	400	no	±1	2	43.95 29.95(K)	
EICO	324	.150–145	6	110–435	1	1.0	high	400	yes	±1.5	10	44.95 32.95(K)	
	330	.100–54	5	–	–	0.3	50	400	yes	±2	–	79.95 59.95(K)	Solid-state
HEATH	IG–42	.100–30	5	–	–	0.1	50	400	yes	±3	–	61.95(K)	
	IG–102	.100–100	6	100–220	1	0.1	50	400	yes	±2	10	29.95(K)	
KNIGHT-KIT	KG–650	.160–112	5	to 224	–	0.4	–	400	yes	±3	10	29.95(K)	
	KG–686	.100–54	5	–	–	0.12	50	400	yes	±1.5	–	140.00 79.95(K)	Solid-state Built-in xtal calibrator
PRECISION	E–200C	.088–110	10	110–440	3	1.0	50	400	yes	±1	80	149.95	Built-in a.v.c. supply
RCA	WR–50B	.085–40	6	–	–	0.05	high	400	yes	±2	8	65.00	10.7-MHz, 455-kHz sweep outputs
TRIPLETT	3432A	.160–110	7	68-220	1	–	–	400	–	–	–	144.00	

the changes. Instead, the cathode is returned to "B+" and the control grid ties to a divider across boost. Anything that lowers high voltage also reduces boost. The result: less-positive bias and less loading by the tube; the amplitude of the flyback pulse returns to normal, and so does high voltage.

Toshiba's C6A chassis has a 23JS6A tube in virtually the same arrangement. The 12A12C52 *Zenith* chassis has a stage something like the *Arvin* described above, but with a thermistor instead of a VDR.

A really odd one is in the *Hitachi* CWA-200. A special saturable reactor is included in the collector circuit of the horizontal-output transistor. The greater the pulse amplitude, the more average d.c. current the transistor draws — it's the nature of that class of transistor amplifier. The reactor begins to saturate. It becomes less efficient in coupling energy to the flyback transformer, and high voltage drops to normal.

Two things are generating heat among manufacturers, service technicians, and customers this year. They are: *warranties* and *serviceability*. There are at least three sides to the story, with no real answers visible yet. Now, a fourth side is added—that of the government "consumerists."

The trouble over warranties began because buyers couldn't understand the terms. Government decided customers aren't getting the kind of products or guarantees they should have.

Take warranties. Demands range from merely clarifying the wording to at least 2 years' warranty—covering all faulty parts, all labor to replace them, and all transportation and shipping that relates to making the warranty good. That latter notion will probably win out, too—with the time limit perhaps only a year. Another year or two will tell.

But a warranty has no value unless there are competent people to make whatever repairs become necessary. That's a constant problem in most parts of the country. Technicians in the field blame the more and more complex chassis, with parts in hardly accessible locations. This isn't an idle complaint. You have only to open the backs of some of the chassis mentioned in this article and listed in our chart; some sections cannot be reached for anything, even minor testing, without time-consuming and annoying disassembly.

A lot has been done through 1969 to train more and better technicians, and more will be done in 1970. But the best over-all gains are the construction improvements that simplify servicing. *Motorola* has taken a long stride with the modular concept; the company has also prepared a whole bookful of excellent suggestions for testing and repairing the modules. *Clairtone* has a similar idea that will work well if they provide sufficient information for technicians all over the country, as *Motorola* has. *Sylvania* broke the barrier to in-home service on transistor receivers by plugging transistors into sockets; they can be tested and substituted as simply as a tube, now.

More companies need to change their thinking in chassis layout and design. That will lower costs for owners, without chiseling service shops out of a fair and honest profit or technicians out of a decent wage. And think of the dollars that would be saved on in-warranty repairs. We hope our report next year can name a lot more manufacturers who have made color TV chassis easy and inexpensive to repair. Set-buyers will love them. ●

Japanese Trade-Name Directory

A listing of the most popular Japanese transistor radios and hi-fi equipment, along with the addresses of U.S. representatives offering sales and servicing.*

BRAND NAME	COMPANY
AGS	Sterling Hi Fi Inc., 22-20 40th Ave., Long Island City, N. Y.
AKAI	Camart Products, 1845 Broadway, New York, N. Y.
AIRCASTLE	Spiegel Inc., 1061 W. 35th St., Chicago, Ill.
AIRLINE	Montgomery Ward, 619 W. Chicago Ave., Chicago, Ill.
AIWA	Rand Assoc., 1270 Broadway, New York, N. Y.
AIWA	Selectron International, 4215 W. 45th, Chicago 60632
AMBASSADOR	Allied Stores Purchasing, 401 Fifth Ave., New York, N. Y.
AMD	World Mark Electronics, 663 Dowd Ave., Elizabeth, N. J.
ASTROTONE	Lafayette Radio Electronics, 111 Jericho Turnpike, Syosset, N. Y. 11791
AUTOSONIC	Martel Electronic Sales, 2339 S. Cotner Ave., Los Angeles, Cal. 90064
AZTEC	Aztec Sound Corp., 2140 S. Lipon, Denver, Colo. 80228
BRADFORD	W. T. Grant Co., 1441 Broadway, New York, N. Y.
BRENELL	Fen-Tone International, 106 Fifth Ave., New York, N. Y.
CIPHER	Metric TV Parts, 65 Lexington Ave., Passaic, N. J.
CORONET	Arrow Trading Co., 5 West 26th St., New York, N. Y.
CRAIG	Cardinal Elect., 5069 Broadway, New York, N. Y.
CRAIG	Craig Corporation, 2302 E. 15th St., Los Angeles, Cal.
CROWN	Industrial Suppliers, 755 Folsom St., San Francisco, Cal. 94107
DELMONICO	Delmonico International, 50-35 56th Rd., Maspeth, N. Y. 11378
DEMPA[1]	Delta International, Ltd., Box 1946, Grand Junction, Colorado
DENON	Nippon Columbia (Corp. of America), 501 Fifth Ave., New York, N. Y. 10017
EBNER	Fen-Tone International, 106 Fifth Ave., New York, N. Y.
ELECTRA	Electra Radio Corp., 30 W. 23rd St., New York, N. Y. 10010
ELECTROPHONIC	Electrophonic Corp., 92-00 Atlantic Ave., Ozone Park, N. Y. 11416
ESSEX	Lloyd's Electronics Corp., 59 N. Fifth St., Saddle Brook, N. J. 07662
EVERPLAY	Gulton Industries, 212 Durham Ave., Metuchen, N. J.
FLEETWOOD	Transworld Industrial Corp., 5204 Hudson Ave., West New York, N. J.
GLOBE	GC Electronics Co., 400 S. Wyman St., Rockford, Ill.
GRANADA	Fried Trading Co., 423 Bedford Ave., Brooklyn, N. Y.
HIGHWAVE	Marvel International, 30 E. 42nd St., New York, N. Y. 10017
HITACHI	Hitachi Sales Corp., 48-50 34th St., Long Island City, N. Y. 11101
JADE, REALTONE	Realtone Electronics, 34 Exchange Place, Jersey City, N. J.
JVC	JVC America Inc., 50-35 56th Rd., Maspeth, N. Y. 11378
KENWOOD	Kenwood Electronics Inc., 3700 S. Broadway Place, Los Angeles, Cal. 90007; 69-41 Calamus Ave., Woodside, N. Y. 11377
LLOYDS	Lloyd's Electronics Corp., 59 N. Fifth St., Saddle Brook, N. J. 07662
MASTERWORK	Masterwork Audio Products, 51 W. 52nd St., New York, N. Y. 10019
MAYFAIR	Artic Import Corp., 666 W. Kinzie, Chicago, Ill. 60610
MERCURY	Mercury Record Corp, 35 E. Wacker Dr., Chicago, Ill. 60601
MIDLAND	Midland International Corp., 1909 Vernon St., North Kansas City, Missouri 64116
MIRANDETTE	Allied Impex Corp., 300 Park Ave. S., New York, N. Y.
MITSUBISHI	Mitsubishi International, 277 Park Ave., New York, N. Y.
NATIONAL	Panasonic, 200 Park Ave., New York, N. Y. 10010
NIVICO	Delmonico International, 50-35 56th Rd., Maspeth, N. Y. 11378
ORION	Orion Electric Co., 1199 Broadway, New York, N. Y. 10001
PANASONIC	Panasonic Parts & Repair, 43-30 24th St., Long Island City, N. Y.
PENNCREST	J. C. Penny, 1301 Ave. of the Americas, New York, N. Y.
PIONEER	Pioneer Electronics USA Corp., 140 Smith St., Farmingdale, N. Y. 11735
PLAYTAPE	Playtape Inc., 1115 Broadway, N. Y. 10010
RANGER	Tenna Corp., 19201 Cranwood Pkwy., Cleveland, Ohio
REALISTIC	Radio Shack Corp., 730 Commonwealth Ave., Boston, Mass.
REMBRANDT	All Channel Products, 47-39 49th St., Woodside, N. Y.
RHAPSODY	B & B Import-Export, 15755 Wyoming Ave., Detroit, Mich. 48238
ROBERTS	Roberts Electronics, 5922 Bowcroft St., Los Angeles, Cal. 90016
ROSS	Ross Electronics Corp., 589 E. Illinois St., Chicago, Ill. 60611
SANSUI	Sansui Corp., 34-43 56th, Woodside, N. Y. 11377
SANYO	Sanyo Electric Co., 350 Fifth Ave., New York, N. Y.
SATELLITE	Best of Tokyo, 11 W. 42nd St., New York, N. Y.
SHARP	Sharp Electronics Corp., 178 Commerce Rd., Carlstadt, N. J. 07072
SONY	Sony Corp. of America, 47-47 Van Dam St., Long Island City, N. Y.
SONY/SUPERSCOPE	Superscope, 8150 Vineland Ave., Sun Valley, California 91352
STANDARD	Standard Radio Corp., 36-09 39th Ave., Woodside, N. Y. 11377
SUPEREX	Superex Electronics, 4 Radford Pl., Yonkers, N. Y. 10701
SUPERSONIC	Spiegel Inc., 1061 W. 35th St., Chicago, Ill.
TEAC	Teac Repair Center, 404 Jericho Turnpike, Syosset, N. Y.
TECHNICORDER	Oki Electric Industry Co., 202 E. 44th St., New York, N. Y.
TELMAR	Martel Electronic Sales, 2339 S. Cotner Ave., Los Angeles, Cal. 90064
TOSHIBA	Toshiba America, 477 Madison Ave., New York, N. Y. 10002
TRUETONE	Western Auto Supply, 2107 Grand Ave., Kansas City, Mo.
UNICORD	American Geloso, 251 Park Ave. S., New York, N. Y.
VISCOUNT	Consolidated Merchandise Corp., 520 W. 34th St., New York, N. Y. 10001
VISTA	Craig Corp., 2302 E. 15th St., Los Angeles, Cal. 90021
WILCO	Sanyo Electric Co., 350 Fifth Ave., New York, N. Y.

*For a more complete list of Japanese consumer electronic products, write Electronics Div., Japan Light Machinery Information Centre, 437 Fifth Ave., New York 10016.

[1] Publishers of Japanese television schematic diagrams.

Antenna System for Your Home

By RICHARD A. LINNERT / Engineering Mgr.
Systems Products Div., The Finney Co.

A single antenna can serve a number of TV and FM sets. Here are the hook-ups that can be used for home MATV systems.

WITH the advent of color television and the availability of low-cost black-and-white sets, we now have millions of homes in need of an antenna to feed a color set, the black-and-white set, and possibly a small portable TV, as well as an FM tuner for the hi-fi system. Many homeowners are trying to accomplish all this with the antenna that has served the original black-and-white receiver for many years.

The solution to the problem of multi-set operation in the home is the MATV, or Master Antenna Television, system. This is a system where a single antenna or, if needed, a group of antennas used with appropriate hardware and amplifiers, can provide the necessary signal to feed several sets.

For many years, we have used such systems to supply television signals to the many TV-antenna outlets in hotels and motels as well as in apartment buildings. By reducing the complexity of such a large system and therefore reducing cost, we can apply this technique in an individual home. With today's solid-state amplifiers we can create a system for the home which is effective in performance and low in cost.

In past years, virtually all television was transmitted on channels 2 through 13, the v.h.f. television band. Today, reception should be on the basis of 82-channel operation, in which all v.h.f channels—2 through 13 plus FM—and all the u.h.f. channels—14 through 83 are received. Although every channel is not available in your area, it is necessary to design a system so that it will require no modification as any new channel, either v.h.f. or u.h.f., comes on the air. Therefore, in planning any installation for the home, it should be an all-channel system.

Antenna & Distribution Wiring

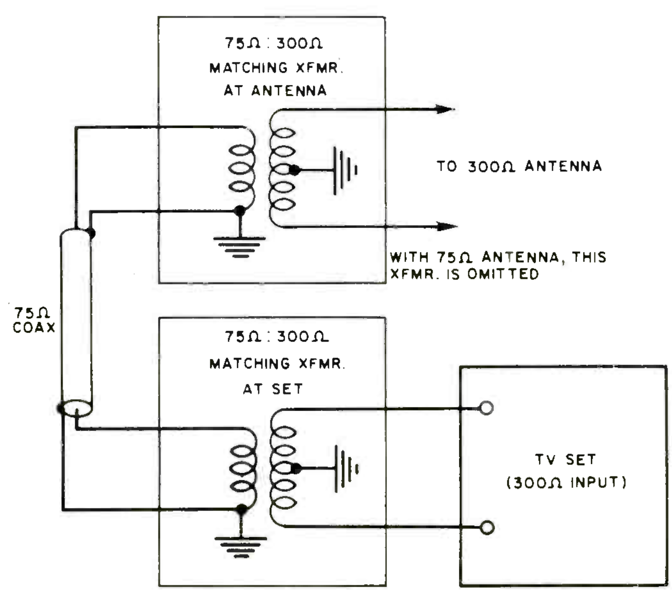
No picture anywhere in the system will be any better than that which can be received at the antenna. Therefore, we must use an antenna which is properly designed to give top performance on all channels, as well as provide for the reduction or elimination of snow and ghosting. If we start with the premise that we will use the best possible antenna and pay reasonable attention to hooking up the system, there is certainly no reason why we should not have an excellent picture at any desired location in the home. The output from the antenna is connected to an r.f. amplifier unit which amplifies the signal and distributes it by wire to the various antenna outlets in the rooms of the house.

Let us for a moment look at the wire which we will use to distribute the signal from the amplifier to the outlets throughout the house. Regular, flat 300-ohm twin-lead, which has been used for antenna installations for many years, is quite satisfactory for v.h.f. channels 2 through 13 and has reasonably low losses. The greatest drawback to its use is the lack of shielding which allows the line to pick up interference from local sources (as well as picking up a slightly delayed signal from the station) and transfer it to the TV set where it appears as noise or interference, and possibly ghosts, on the screen. In most normal installations, flat twin-lead has extremely high losses at u.h.f. frequencies and should not be used.

Shielded 300-ohm transmission line overcomes the disadvantages of the older type twin-lead. It has significantly less loss at u.h.f. in a practical installation and is shielded to prevent the pick up of interference.

Foam-filled 82-channel coaxial cable has the shielding advantages of shielded twin-lead plus being only approximately ¼-inch in diameter and therefore easier to handle in crowded areas. It does, however, require the use of a transformer to match the 75-ohm unbalanced cable to the 300-ohm balanced input of the TV set. Also, if a 300-ohm antenna is used, a sec-

Fig. 1. Use of matching transformers for coax cable.



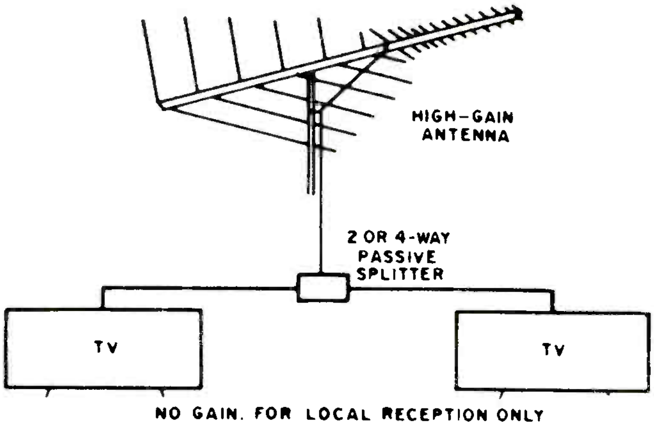


Fig. 2. Simplest, non-amplified system for local signals.

ond transformer is required at the antenna to convert to 75 ohms for the coaxial cable (Fig. 1). These cause some additional losses in the system but the over-all convenience and excellent shielding of the coax more than make up for this. Also, if an amplifier is used in the system, coaxial cable losses become unimportant.

The Various Systems

Now let us consider the basic systems that might be used to feed multiple sets in the home. The simplest system (Fig. 2) would consist of an appropriate antenna, the necessary lead-in line to bring the signal from the antenna into the attic crawl-space or other central location, and then a two-way or four-way splitter to divide the signal with a separate line to each set. This is by far the least expensive system. It is, however, restricted to areas where there are strong signals to provide adequate signal to each set after being divided for the different receivers. If you live more than 35 miles from the TV station, it is doubtful that satisfactory operation of the TV sets could be obtained using splitters alone, even with a high-gain antenna. Additional u.h.f./v.h.f. splitters would be needed at each receiver to divide the signal into these two bands for the two separate sets of input terminals.

In installing the splitters, pick a central location that keeps the transmission line as short as possible between the antenna and the splitter and the splitter and all TV sets. When using unshielded line, care must be taken so that it does not run close to metal ducting, water pipes, or wiring for the house power circuits. Use of stand-off insulators, wherever possible, is recommended.

Fig. 3 shows an amplified splitter type of system that would be used in those areas where a slight increase in signal level is needed to make up for the loss in the cables to each set and for splitting losses. This type of system would be desirable for the suburbs or in near-fringe areas. An a.c. outlet is required to power the amplifier. Here, again, have the amplifier as centrally located as possible.

The typical amplified splitter used in such a system produces approximately twice as much signal at each output as it receives from the antenna and has a built-in splitting device which generally consists of four outputs. The four-output system might easily, under most circumstances, be expanded to six- or eight-outputs by the addition of two-way splitters.

Fig. 4 shows the third basic system which is a combination of a preamplifier and the amplified splitter. The system is used in areas where there is not enough signal available to operate the amplified splitter. This, of course, means that this type of system would be used in fringe and far-fringe reception areas. This system should not be used in suburban or metropolitan areas.

Again, as in the previous systems, we start off with an antenna appropriate to the area and the preamplifier mast- or boom-mounted at the antenna. Bring the lead-in line down to the remote preamplifier power supply, which would be located near an a.c. power source; transfer the signal from the preamplifier to the amplified splitter; and distribute the signal as before.

Other Accessories

Wall-outlet plates are available to meet the mechanical requirements of the installations as well as electrical convenience. Wall-outlet plates with built-in transformers which have coaxial cable coming in from the back and a 300-ohm output for set use are also available. In addition, "straight-through" types of wall plates may be had, in 300-ohm and 75-ohm cable versions. Wall plates that will mount flush on the dry-wall surface, as well as those which mount directly on the surface and extend outward, are on the market.

Finally, a behind-the-set splitter or splitting device, which divides the v.h.f. and u.h.f. so that they may be fed to the indicated terminals on the back of the TV set, is needed. This splitting device is available for 300-ohm lead or coaxial-cable feed. In the case of the coaxial-cable type splitting device, a matching transformer as well as a u.h.f.-v.h.f. dividing network are available in one small package which fits on the back of the television set.

Whether there is a u.h.f. channel on the air in your locale today or not, there will be one or more soon.

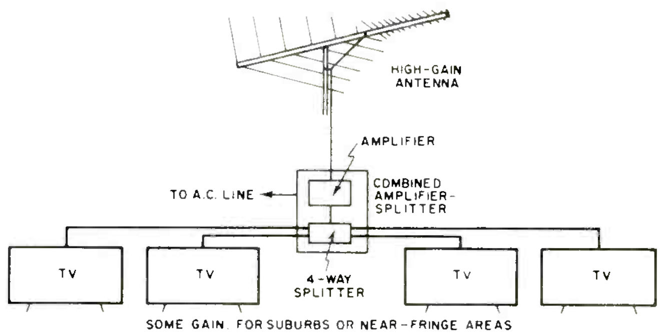
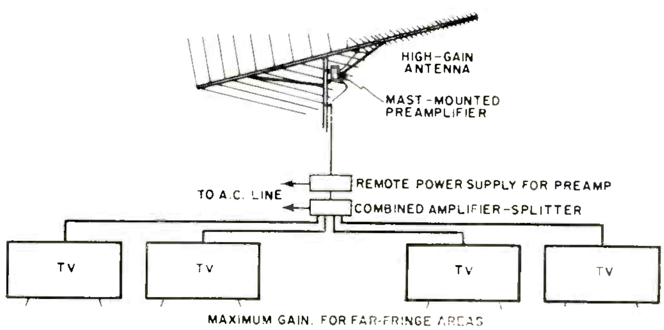


Fig. 3. Use amplifier-splitter for suburbs and near-fringe.

Fig. 4. For highest gain use a mast-mounted preamplifier.



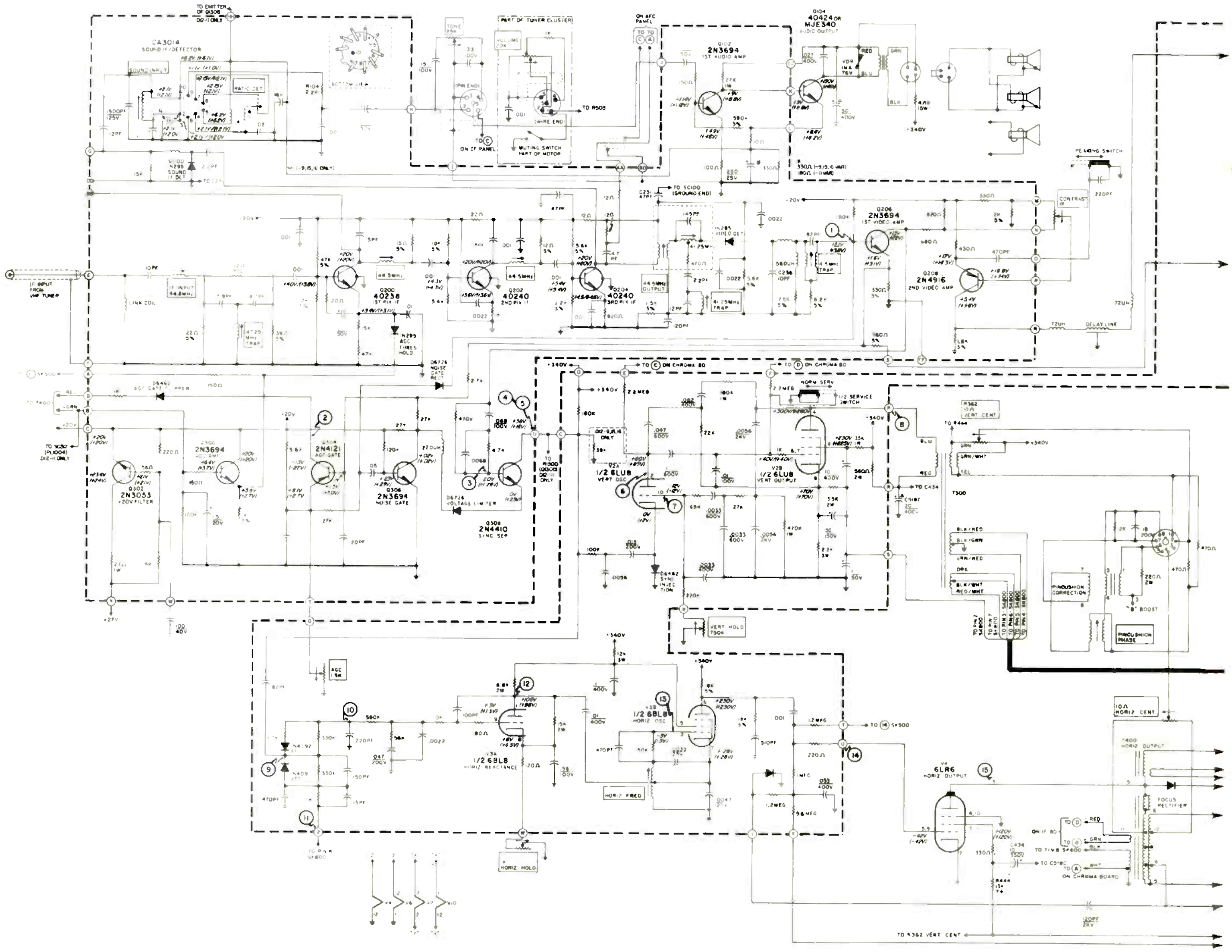
By installing an 82-channel system, you may look forward to many years of viewing and listening. Recently, wiring kits which include all the necessary material to install a four-outlet system in the home have been made available by several manufacturers at a very nominal cost. These kits have complete instructions, the necessary tools, and diagrams to make the job simple and straightforward. ●

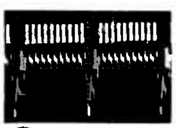
OSCILLOSCOPES

MFR.	MODEL	VERTICAL CHANNEL			HORIZONTAL CHANNEL			SWEEP RANGE	CRT SIZE (in)	PRICE $(K=kit)	REMARKS
		FREQ. RESP.	SENSITIVITY	DIRECT INPUT Z (MΩ—pF)	FREQ. RESP.	SENSITIVITY	INPUT Z (MΩ—pF)				
B & K	1450	5Hz—5.5MHz	25mV$_{rms}$/in	3—47	2Hz—750kHz	0.5V$_{rms}$/in	5—30	5Hz—500kHz	5	279.95	Vectorscope Intermit. analyzer
CONAR	250	10Hz—4.5MHz	23mV$_{rms}$/in	1—30	20Hz—250kHz	1.0V$_{rms}$/in	3—20	10Hz—500kHz	5	139.50 99.95(K)	
EICO	427	d.c.—500kHz	3.5mV$_{rms}$/cm	1—30	2Hz—450kHz	0.15V$_{rms}$/cm	10—40	10Hz—100kHz	5	139.95 99.50(K)	Auto sync.
	435	d.c.—4.5MHz	18mV$_{rms}$/cm	1—35	1Hz—500kHz	0.7V$_{rms}$/cm	4—40	10Hz—100kHz	3	169.95 119.95(K)	TV V&H sweeps
	460	d.c.—4.5MHz	5mV$_{rms}$/cm	3—35	1Hz—400kHz	0.24V$_{rms}$/cm	5—35	10Hz—100kHz	5	149.95 99.95(K)	TV V&H sweeps
	465	d.c.—10MHz	12mV$_{rms}$/cm	1—35	d.c.—1MHz	17mV$_{rms}$/cm	1—35	10Hz—100kHz	5	249.95 179.95(K)	TV V&H sweeps
HEATH	10—14	d.c.—8MHz	50mV$_{p-p}$/cm	1—15	d.c.—200kHz	1V$_{p-p}$/cm	0.1—	0.5 s/cm to 1μs/cm	5	399.00 275.00(K)	Triggered sweeps
	10—17	5Hz—5MHz	30mV$_{p-p}$/cm	1—25	2Hz—300kHz	0.3V$_{p-p}$/cm	10—15	20Hz—200kHz	3	79.95(K)	
	10—18	3Hz—5MHz	25mV$_{rms}$/in	3.3—	1Hz—400kHz	0.3V$_{rms}$/in	4.9—	10Hz—500kHz	5	149.95 92.50(K)	Preset sweep freqs.
HICKOK	677	5Hz—4.5MHz	40mV$_{rms}$/in	3—10	5Hz—350kHz	0.25V$_{rms}$/in	5—30	10Hz—500kHz	5	269.50	
	770A	d.c.—4MHz	10mV$_{rms}$/cm	1—45	d.c.—500kHz	1V$_{rms}$/cm	2.2—25	0.5 s/cm to 1μs/cm	5	475.00	Triggered sweeps
JACKSON	CRO—3	20Hz—5MHz	18mV$_{rms}$/in	1.5—25	20Hz—100kHz	0.4V$_{rms}$/in	1.1—	20Hz—50kHz	5	254.95	Wide or narrow band; lo or hi gain
KNIGHT-KIT	KG—635	d.c.—5.2MHz	17mV$_{rms}$/in	3—35	1Hz—400kHz	0.6V$_{rms}$/in	7—25	10Hz—400kHz	5	119.95(K)	Probes extra
LEADER	LBO—5SC	d.c.—10MHz	10mV$_{p-p}$/cm	1—50	d.c.—300kHz	0.3V$_{p-p}$/cm	1—50	5 s/cm to 0.5μs/cm	5	375.00	Triggered sweeps
	LBO—31M	3Hz—1MHz	80mV$_{p-p}$/cm	2—	30Hz—400kHz	2.5V$_{p-p}$/cm	—	10Hz—100kHz	3	99.00	
	LBO—32B	d.c.—7MHz	10mV$_{p-p}$/cm	1—35	1Hz—400kHz	0.3V$_{p-p}$/cm	1—50	1Hz—200kHz	3	189.50	
	LBO—53B	d.c.—10MHz	10mV$_{p-p}$/cm	1—35	1Hz—400kHz	0.3V$_{p-p}$/cm	1—50	1Hz—200kHz	5	229.00	
LECTROTECH	TO—50	d.c.—10MHz	20mV$_{p-p}$/cm	1—30	d.c.—500kHz	0.5V$_{p-p}$/cm	0.1—30	0.02 s/cm to 0.2μs/cm	5	329.50	Triggered sweeps; solid-state; vectorscope
	V5								3	79.50	Vectorscope only
MERCURY	3000	10Hz—5.2MHz	4.6mV$_{rms}$/cm	2.7—20	5Hz—400kHz	0.25V$_{rms}$/cm	3.2—20	5Hz—500kHz	5	179.95	Vectorscope connections and graticule
PRECISION	ES—550B	10Hz—5MHz	10mV$_{rms}$/in	2—20	10Hz—2MHz	0.1V$_{rms}$/in	2—22	10Hz—100kHz	5	289.95	Auto sync.
RCA	WO—33A	5.5Hz—5MHz	3mV$_{rms}$/in	1—50	3.5Hz—350kHz	0.9V$_{rms}$/in	10—	15Hz—75kHz	3	139.00	Wide or narrow band; lo or hi gain
	WO—91C	10Hz—4.5MHz	18mV$_{rms}$/in	1—40	10Hz—500kHz	0.18V$_{rms}$/in	2.2—30	10Hz—100kHz	5	269.00	Wide or narrow band; lo or hi gain
SENCORE	PS—148	10Hz—5.2MHz	17mV$_{rms}$/in	2.7—20	5Hz—400kHz	0.6V$_{rms}$/in	3.2—18	5Hz—500kHz	5	219.50	Vectorscope connections
SIMPSON	458	10Hz—5MHz	15mV$_{rms}$/in	3.3—20	10Hz—300kHz	115mV$_{rms}$/in	—	14Hz—250kHz	7	420.00	Wide or narrow band; lo or hi gain
	466	15Hz—100kHz	30mV$_{rms}$/in	0.5—35	15Hz—100kHz	0.7V$_{rms}$/in	0.25—40	15Hz—80kHz	5	190.00	
TELEQUIPMENT (TEKTRONIX)	S51B/E	d.c.—3MHz	100mV$_{p-p}$/cm	1—47	d.c.—500kHz	0.1V$_{p-p}$/cm	1—100	0.1 s/cm to 1μs/cm	5	225.00	Triggered sweeps
	S52	d.c.—3MHz	10mV$_{p-p}$/cm	1—44	d.c.—3MHz	10mV$_{p-p}$/cm	1—44	0.5 s/cm to 1μs/cm	5	490.00	X-Y scope; wide or narrow band; lo or hi gain; triggered sweeps
	S54A/U	d.c.—10MHz	10mV$_{p-p}$/cm	1—47	d.c.—1MHz	0.6V$_{p-p}$/cm	1—30	2 s/cm to 0.2μs/cm	5	435.00(A) 615.00(U)	Triggered sweeps; S54U is battery-operated

SYLVANIA D12-9 to -16

COLOR-TV CIRCUIT



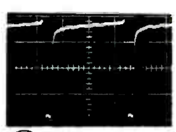


1 -1V P-P V

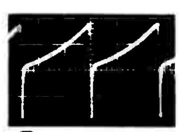
2 -26V P-P H

3 -3.5V P-P V

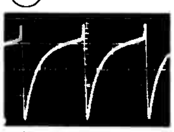
4 -58V P-P V



5 -58V P-P H

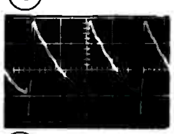


6 -110V P-P V

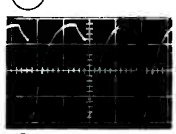


7 -50V P-P V

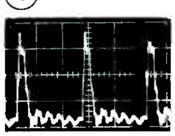
8 -1200V P-P V



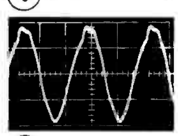
9 -38V P-P H



10 -98V P-P H



11 -270V P-P H



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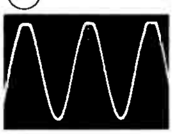
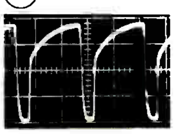
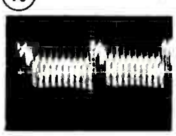


13 -200V P-P H

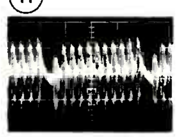


14 -240V P-P H

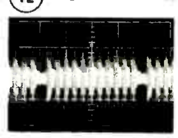
15 -200V P-P H



16 -70V P-P V

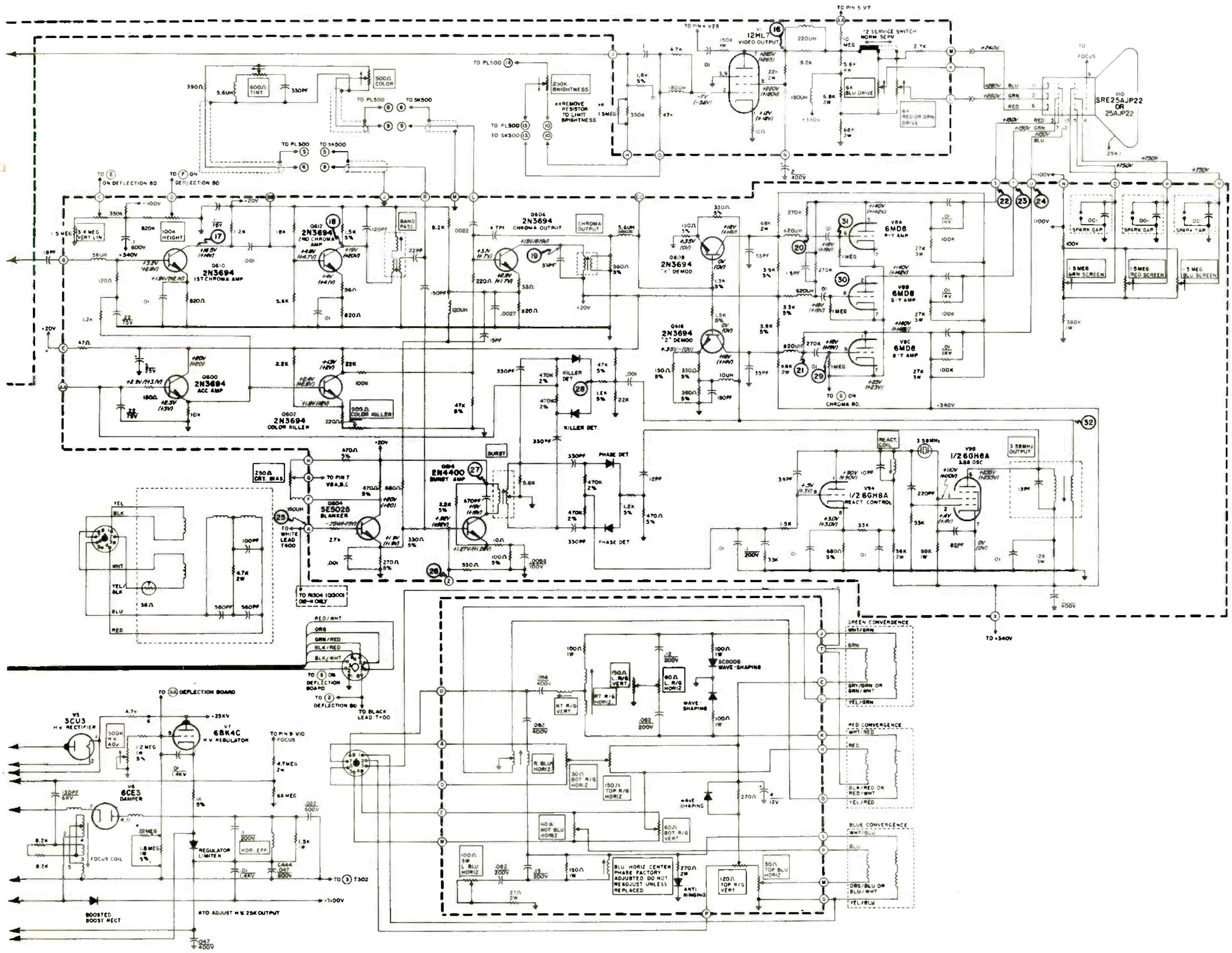


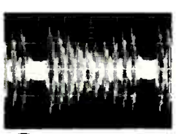
17 -.56V P-P H

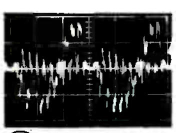


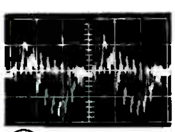
18 -3.5V P-P H

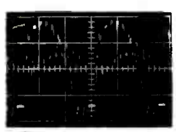
The circuit shown is a "universal" diagram that is used for quite a few new Sylvania models. All models include a.f.c., incorporate hybrid circuitry, and are built around a 23-in picture tube, Chassis D12-11 includes remote control with u.h.f. search. Chassis D12-12 and D12-14 are used in the company's home-entertainment unit, with the latter chassis including remote control with u.h.f. search. Models using D12-9 and D12-15 are basic chassis without remote control while D12-16 has remote control but without search.

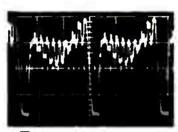


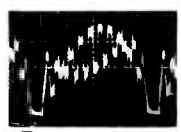

(19) -4.2V P-P H

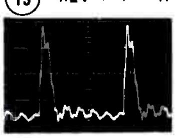

(20) -19V P-P H

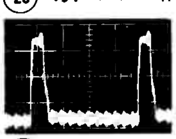

(21) -16V P-P H

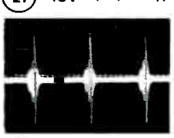

(22) -138V P-P H

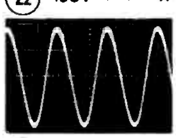

(23) -120V P-P H


(24) -160V P-P H

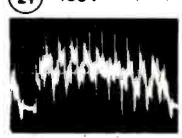

(25) -25V P-P H

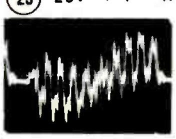

(26) -4.5V P-P H

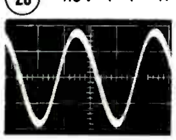

(27) -19V P-P H


(28) -16V P-P H


(29) -16V P-P H


(30) -2.8V P-P H


(31) -16V P-P H

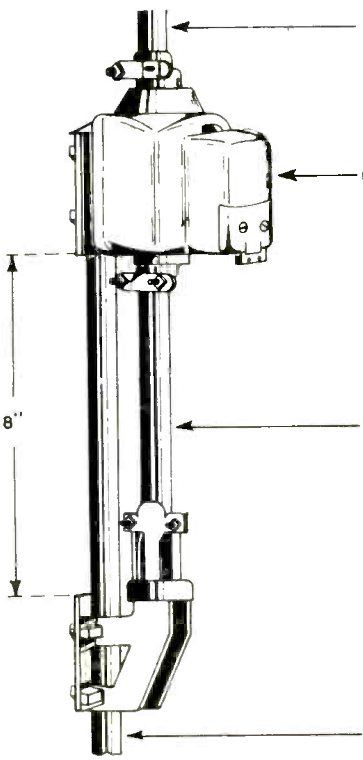

(32) -20V P-P 3.58 MHz

Antenna Rotators for TV and FM

By PAUL NORMAN

A survey of what's available along with practical information on installing a rotator for your television or FM antenna.

Fig. 1. Proper installation employing a thrust bracket.



AT many home receiving installations, it's difficult to get sharp TV pictures or clean FM sound from all the stations that put a usable signal in your area. The reason is simply that the stations are located in several different directions. If you aim the antenna at one station you get a poor signal from the others.

There are three ways you can get good signals from stations in different directions. The simplest is to use an omnidirectional (or nondirectional) antenna. Unfortunately, such an antenna has very little gain and is therefore usable only in urban areas. Even in such high-signal locations, an omni often doesn't work well for stereo FM or color-TV, because it is very prone to multipath pickup. That is, the antenna picks up not only the direct TV or FM signal, but also signals reflected from nearby buildings or hills. The reflected signals cause ghosts to TV and loss of separation to stereo FM.

Furthermore, an omni can't reject interfering signals from other stations on the same or adjacent channels. The only way to reject co-channel or adjacent channel interference is to use a highly directional antenna, which must be aimed carefully at the desired station. This is also the only way to avoid multipath pickup.

Therefore, the second solution is to put up several antennas. Suppose you can receive 3 stations from the northwest, and 4 from the east. You erect two antennas, picking up 3 stations on one, and 4 on the other.

But this solution is rather expensive, as you must erect two or more antennas and make two or more runs of lead-in. And you have to switch antennas or buy a combining network.

If station signals are weak in your area, if you have co-channel or adjacent-channel problems, or if you have multipath trouble, you will probably have to use a high-gain, narrow-beamwidth antenna. Such an antenna must be oriented very carefully toward the desired station, and a compromise heading between two stations may be poor on both.

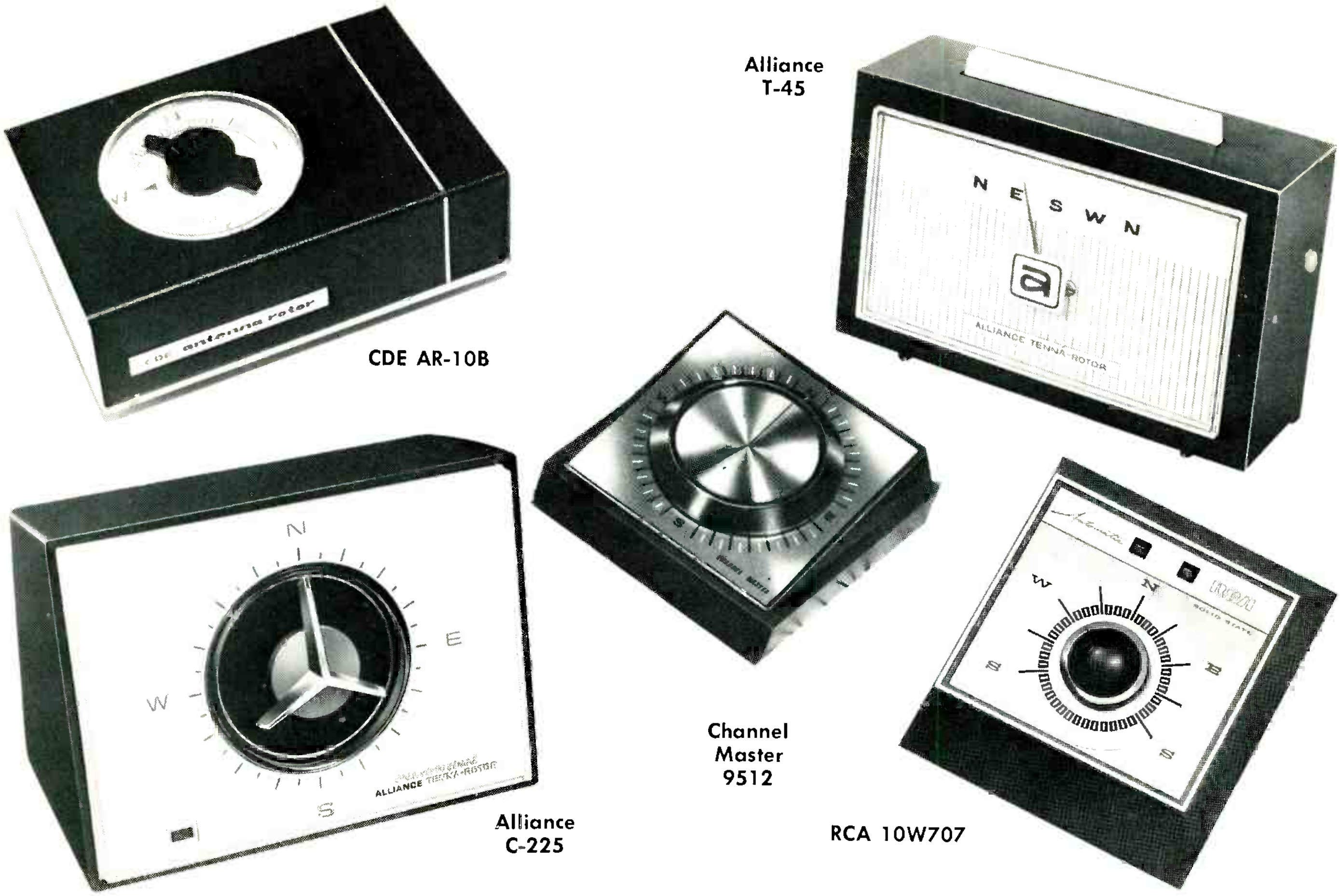
Therefore, the third solution is probably the most practical in the above cases – *a single antenna and an antenna rotator*. You can turn the antenna to each specific station direction as you change stations. You only have to put up a single antenna, and make a single run of lead-in. There's an additional advantage: Sometimes when a fixed antenna is erected and oriented for best picture in the fall or winter, the picture becomes snowy in the spring or summer. Warm-weather foliage interferes with the signal, especially at u.h.f. Often an antenna rotator makes it possible for you to re-orient the antenna slightly for a usable picture.

Manual Rotators

Basically, there are two types of rotators – *manual* and *automatic*. In each case, there are two units. The *control unit* is located at the receiver, and the *motor unit* is mounted on the antenna mast, where it turns the antenna.

Fig. 2 is a simplified diagram of a typical manual rotator. The operating control is a bar. When you depress one end, the antenna turns one way. When you depress the other end, antenna turns the other way.

When the control bar is depressed, either to the left or right, it closes switch S1, applying power to power transformer *T*1. S1 and S2 are ganged, so that depressing the control bar also connects *T*1's secondary winding



Grouping of typical control units that are used for antenna rotators.

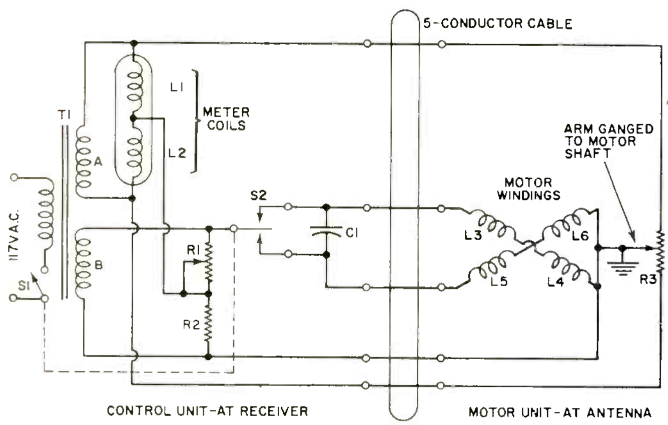


Fig. 2. Simplified diagram of typical manual rotator.

B to either of two sets of motor windings (*L*3-*L*4 or *L*5-*L*6) at the antenna. One set of windings turns the antenna clockwise, the other, counterclockwise. You must keep the control bar depressed to keep the antenna turning. Both S1 and S2 are normally off, so when you release the control bar, the antenna comes to a stop.

But how to know which way the antenna is oriented? That information is furnished by the indicator meter, whose windings are shown as *L*1 and *L*2 in Fig. 2, connected across secondary *A* of transformer *T*1. Also connected across this secondary is potentiometer *R*3, mounted in the motor unit at the antenna. Note that *R*3's arm is connected to ground, or one side of secondary winding *B* on *T*1. Note also that the junction of meter windings *L*1 and *L*2 is connected to the junction of *R*1 and *R*2, which are across secondary *B*.

The arm of *R*3 is mechanically ganged to the motor shaft, or the antenna mast. Thus as the antenna turns, so does the arm of *R*3. By so doing, it varies the voltage applied to the indicator meter, causing that meter to deflect more or less. The meter dial is marked in compass headings.

*R*1 is a variable calibration pot, so the meter can be precisely adjusted to a known heading.

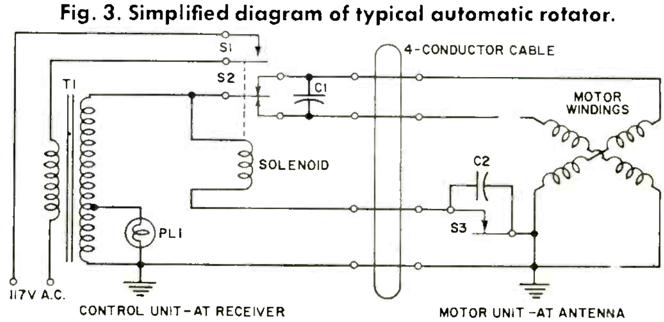
By the way, some manual rotators don't have indicating meters. Some use lights marked "N-E-S-W," and with some you must simply turn the antenna for best picture or sound.

Automatic Rotators

In Fig. 3 you see a simplified diagram of a typical automatic rotator. At the control unit, the operating control is a knob with an index mark, which turns around a dial marked with compass headings. You simply turn the knob to the desired compass heading, and the electric motor will automatically turn the antenna to that direction.

When you turn the knob, the shaft closes S1, applying power to power transformer *T*1. At the same time, the shaft *opens* one side of S2, applying power to either of

Fig. 3. Simplified diagram of typical automatic rotator.



two sets of motor windings, and turning the antenna either clockwise or counterclockwise.

But pulsing switch S3 is in both motor-winding circuits. As current flows through S3, its contacts open and shut. This pulsing action activates the solenoid at the control unit, which turns a pawl across a ratchet in the indicator switching assembly. When the antenna reaches the desired direction, the pawl opens S1 and returns S2 to its center position. The antenna stops rotating.

Indicator lamp *PL*1 lights when S1 is closed, or when you turn the control knob to a desired heading. When the antenna reaches the desired heading, S1 is opened and the indicator lamp goes off.

The *Alliance* C-225 "Tenna Rotor" is unique; it contains a phase-sensitive bridge and two control transistors. The circuit is all-electronic and uses no mechanical switching. The operation of the control unit is silent, and the antenna orientation is controllable within 3°. This particular feature is especially useful with stereo FM, color-TV, and u.h.f.

Installing the Rotator

Table 1 lists the rotators which are generally available today. Most require 4- or 5-conductor cable; representative types are listed in Table 2. It makes little difference whether you use flat or round cabl

Length of the cable run *is* important, though. A single #20 cable is good to about 125 feet; beyond that, wire-resistance losses are too great and the rotator system won't operate properly. Two #20 cables paralleled are good to about 250 feet. You can also use #18, a single length of which is good to about 180 feet. Doubled, it's good to about 360 feet.

It's a good idea to use a *thrust bracket,* as shown in Fig. 1. The bracket takes the antenna load off the rotator. Modern all-channel antennas are large and heavy, and you won't overwork the rotator by using a thrust bracket. (Some motor units don't require this bracket, as they are heavy-duty.)

Because of the motor unit's weight, you should always guy the antenna mast. Without the rotator, you might be able to get by with a short mast and merely a couple of chimney straps. But to be safe, when using a rotator, use three or four straps and three guy wires. Anchor them securely, using lag bolts. And be sure to waterproof the bolt heads and holes with bathtub caulk or something similar.

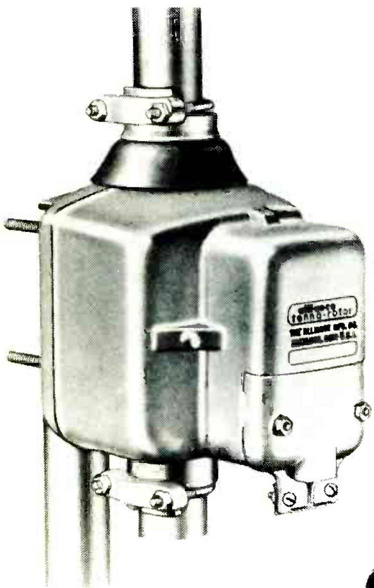
Try to do most of the work on the ground. Mount the antenna, motor unit, and thrust bracket on the mast.

Before you climb the roof with the equipment, check everything out on the ground, to discover any wiring errors. Brace the mast, rotator, and antenna against a fence, picnic bench, stepladder, or other safe support, so it's self-supporting and won't fall over. Then connect the cable between the control unit and the motor unit. Plug the control unit into the a.c. line and operate the control. Make sure the antenna turns freely. Once you get the assembly installed on the roof, correcting any wiring errors can be a real hassle.

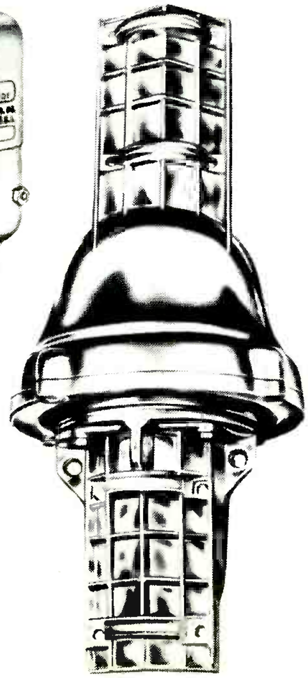
Don't use more than 5 feet of mast between the motor unit and the antenna; one foot is preferable. You cannot guy the mast above the rotator, for it must be free to turn. Most current TV and FM antennas have many elements and constitute a fairly high wind load. Thus you need a short mast to minimize wind-shear effect, which could bend or break the mast.

Be sure you leave enough slack in the lead-in to allow the antenna to rotate a full 360°. Mount your first stand-

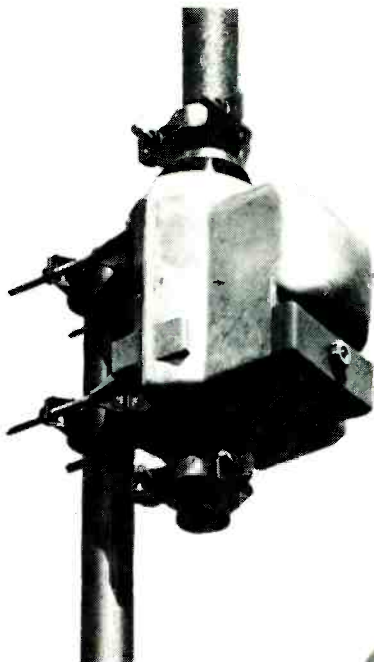
Some typical motor units that are employed for antenna rotators.



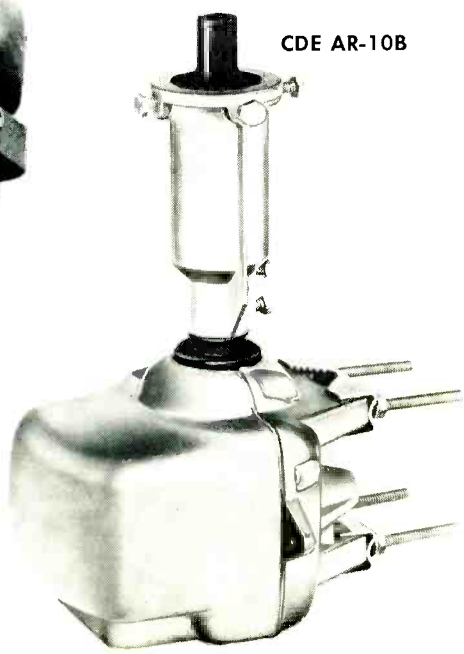
Alliance U-100



CDE AR-22R



RCA 10W505



CDE AR-10B

Manufacturer	Type No.	Mode	Cable Required	Sugg. List Price
Alliance	C-225	Automatic	5-conductor	$59.95
	U-100	Automatic	4-conductor	49.95
	T-45	Manual	5-conductor	39.95
	K-22	Manual	4-conductor	29.95
CDE	AR-33	Automatic	5-conductor	79.95
	AR-22R	Automatic	4-conductor	54.95
	AR-10B	Automatic	4-conductor	49.95
Channel Master	9512	Automatic	3-conductor	49.95
	9513	Semi-automatic	4-conductor	39.95
	9503	Manual	4-conductor	39.95
RCA	10W707	Automatic	5-conductor	54.95
	10W505	Manual	4-conductor	39.95

Manufacturers' Addresses:

The Alliance Mfg. Co., Mahoning Ave. at Lake Park Blvd., Alliance, Ohio 44601

Channel Master Corporation, Ellenville, N.Y. 12428

Cornell-Dubilier Electronics (CDE), Division of Federal Pacific Electric Co.
50 Paris Street, Newark, N.J. 07101

RCA Parts and Accessories, 200 Clements Bridge Rd., Deptford, N.J.

Table. 1. A listing of antenna rotators that are currently available.

off on the mast while you've got it on the ground, and tape the control cable to the mast also. Then operate the control unit and swing the antenna to be sure the lead-in clears.

By the way, when you attach the rotator cable, twist the strands of each conductor and tin them with solder. This minimizes the possibility of a stray strand shorting at the motor unit terminals.

You'll need a helper to get the assembly up on the roof. It probably won't clear a window, so use a rope and haul it up.

After you've installed the mast, run the lead-in and control cable down the roof, wall, and into the house. If you use any kind of unshielded twin-lead, keep the lead-in and control cable at least a foot apart, or you'll cause interference or ghosts in the picture or noise in FM sound. If you use shielded lead-in, you can tape the cables together.

Most of the preceding advice also applies to a tower installation, where you need height. You will still use a short mast at the top of the tower, but the motor unit should be no more than a few inches above the top of the tower, to reduce wind-shear effects.

Once you've finished the installation, you will need to calibrate the system. While you're up on the roof, manually orient the antenna in a known direction. For instance, you might use a pocket compass to head the antenna north. Then follow the manufacturer's instructions about calibrating the indicator. ●

Wire type		Manufacturer and No.	Approx. price per 100 ft
5-conductor	Flat #20	Belden 8463 Columbia 5072	$4.65
	Round #20	Belden 8485 Columbia 5082	4.85
4-conductor	Flat #20	Belden 8464 Columbia 5066	3.72
	Round #20	Belden 8484	4.05
	Round #18	Belden 8489 Columbia 5084	7.15

Note: #20 wire is 7 x 28 strand; #18 wire is 16 x 30 strand.

Table 2. Four- and 5-conductor cable for rotator uses.

How to Service Solid-State TV-Receivers

By CONAN GORMAN
Engineering Program Mgr., Color TV Products
Motorola Inc.

The author shows a way—a technique—a philosophy of servicing that can be applied to any circuit in any television receiver.

THE complete subject of servicing solid-state television receivers is too large to attempt to cover in one article as far as specific what-to-do suggestions are concerned. Even a thorough analysis of one major symptom in one chassis demands more time and space than can be allowed here. Ironically, it is a fact that the receiver can often be serviced in less time than it takes to tell about it! So, it was decided to use one solid-state color television receiver as a model to demonstrate a *service technique*. The receiver is *Motorola's* "Quasar", which incorporates in one unit the circuits that are found, in one form or another, in most other solid-state TV receivers. The purpose here is to show a method—a technique—a philosophy—that can be applied to any circuit in any solid-state TV receiver. We will explore one rather familiar symptom, that of "no raster"—which can occur in what is probably the most complex consumer product ever manufactured.

We will assume that our readers are familiar with technical language, that they understand what goes on in a television receiver, and that the fine details of how transistors function have been mastered. On this basis, we can get down to cases.

With a tube-type receiver, the tubes plug into sockets. Having a predictable and limited useful life, tubes have not offered any great challenge to the technician with a little experience and a good memory for similar tube failures in other TV receivers. No harm comes from wrong guesses as to which tube is at fault. At worst, the technician keeps replacing tubes until the defective one is located. We've been told that tubes are responsible for the majority of television-receiver service calls. Miscellaneous minor repairs and adjustments constitute a good share of the rest, leaving only a small percentage of service faults requiring the skills of advanced technicians and their more complex test equipment.

We're not hinting that TV service is a snap. We *are* saying that TV service is a new ball game today. Transistors, diodes, and IC's, are usually not found in sockets, are not universally available or interchangeable (to the extent tubes are), and damage *can* result from wrong guesses. Also, the probability of relating specific symptoms to particular circuits is often remote. As an example, no raster on a tube-type receiver is most frequently caused by a defective high-voltage rectifier tube. Then, in order of decreasing probabilities the damper tube, horizontal-output tube, or another in the horizontal sweep section. The idea that a defect in another part of the receiver could cause a lost raster is remote. Yet, in a solid-state receiver, it is not beyond the realm of possibility that the seemingly non-germane video detector can cause this symptom, making troubleshooting the high-voltage/deflection circuits an unproductive exercise. The uniqueness of solid-state receiver troubleshooting techniques, compared to those for tube receivers, eliminates the concept of "transistor jockeys" as we have known "tube jockeys" who make in-home service calls.

Most solid-state consumer products are portable and, therefore, are carried to the shop by customers. It is here that skilled technicians perform their service. Large-screen consoles and some table models are being "pulled," with little or no attempt at servicing in the home—each unit being a shop job. Most technicians, particularly the owners and managers of shops, realize this is not an ideal way of doing business because of the time and money wasted in picking up and delivering receivers. Faced with this dilemma, some shops refuse solid-state business. This approach writes the customer off to a competitor who picks up the customer's other business along with that of his friends, neighbors, and relatives. If a servicer is not interested in transporting sets to his shop and is unwilling to lose this business to competitors, his house-call techniques will require improvement.

The fact that more transistors than tubes are needed to perform many functions creates an impression of complexity. However, a solid-state system is made up of sections which are, in turn, composed of circuits. Circuits operate on fundamental principles, the transistor being less complicated than the vacuum tube. The only problem may be in understanding the interface between direct-coupled devices. A logical point-by-point process of elimination can lead the technician to one or two specific stages which, in turn, can be checked out simply.

Toting a transistor tester to the job and checking every transistor arbitrarily is foolish because of the large number of solid-state devices. For example, in the Quasar there are over 100 such devices. Testers do serve a useful purpose as an additional input to the technician. Surely a tester is a means to an end but not an end in itself. The easiest way to service solid-state products is with a good grasp of fundamentals and their logical application. Test equipment is important when readings are correctly interpreted and when its limitations are understood.

The "No-Raster" Symptom

Let us now consider the problem of no raster. First let's be sure the symptom is identified correctly. "No raster" means that the set is "on," the circuit breaker is not tripped, and there is either audio on an assigned channel or a hissing noise off-channel. All relevant controls have been tried without effect on brightness. The CRT is unlit. In a solid-state receiver, a transistor far removed from the picture tube can cause cut-off, especially if there is considerable direct-coupling in the design.

Drawing an arc from the plate of the high-voltage rectifier to determine the presence of high-voltage d.c. is an old stunt used in tube sets *but not recommended for solid-state products*. An arc generates energy (r.f. fields, voltages, currents) which will be dissipated somewhere—usually to the detriment of transistors and IC's. Arc-protection devices are fine insurance against accidental arc-overs in the CRT or high-voltage rectifier, but do not provide safeguards against an arc drawn from the rectifier to the screwdriver. There are better ways of determining the presence or absence of CRT operating voltages. (See simplified schematic on page 91.)

A suggested procedure is to ground one of the three cathodes through a 10k-ohm resistor. Clip leads will be useful in this test, as well as in others to be described.

By grounding one of the three cathodes through the resistor, the CRT will light up in the color associated with that cathode (assuming other operating voltages are correct).

If the CRT does not come to life with this test, the possibility of faulty bias can be eliminated, at least temporarily. The next step is to measure G2 voltage(s). G2 is comparable to the screen grid of an ordinary receiving tube. G2's are often labeled "screen" or sometimes "screen background." At any rate, lost or missing G2 voltage will kill brightness on any CRT—color or monochrome.

G2 voltages are most often derived from the horizontal deflection system. The +600-800 volt d.c. G2 voltage in *Motorola's* Quasar line results from dividing the second anode voltage. If G2 voltage is low, or missing, it's a safe guess that the second anode voltage is also missing, because this is the source. It's very rare to lose all three G2 voltages unless there's a defect common to all three. Measuring G2 voltage is probably the fastest, safest way of determining the status of high voltage in the Quasar. Similarly, there is a point in other receivers that could be used for the same purpose. One could "brute force" his way by going directly to the high-voltage rectifier tube and replacing it. This might be a good idea in early Quasar models but the solid-state rectifier in more recent models is so reliable it's safe to assume it is functioning properly and that loss of high-voltage is caused elsewhere.

A useful rule of thumb is to note the 5-to-1 ratio between second anode and focus voltage and the 10-to-1 ratio between the focus voltage and that applied to the G2 elements. It works out to 25 kV to 5 kV to +500 volts d.c., in rough numbers. Actually, the screen voltage is closer to +800 volts d.c. (depending on screen control setting)—but even the high-input impedance of the v.t.v.m. loads down the extraordinarily high resistive divider causing lower readings.

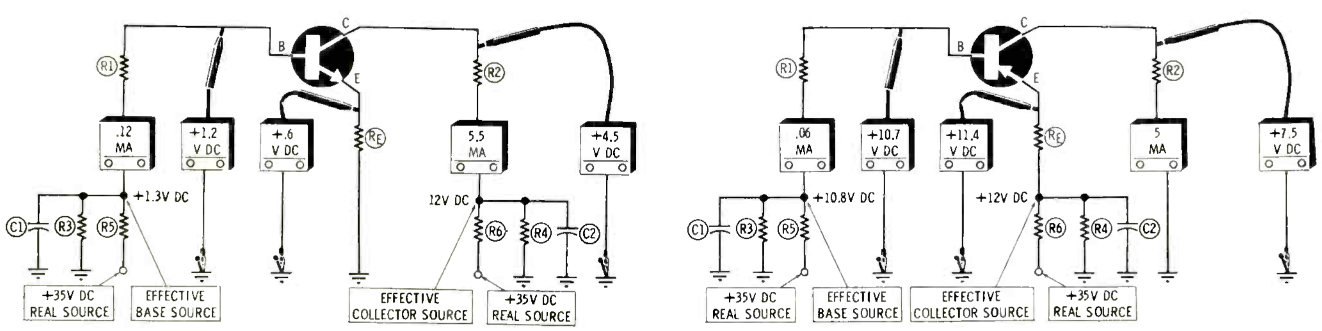
Another point not to be overlooked is that a defect in the focus divider can cause loss of those voltages derived from it. The +5 kV focus voltage is a little tough to measure except with a high-impedance, high-voltage probe. Experience dictates that G2 voltage be checked first. Overlooking the focus voltage and the high-voltage rectifier, a determination should be made whether or not the horizontal-deflection system is functioning since this is the high-voltage generator.

But what if G2 voltage is present. (After all, we've already learned there is no bias problem and G2 voltages can be present only when focus and second anode voltages are also present.) We'd worry about the CRT in this event. With all voltages present, the CRT should light up when one cathode is grounded through the 10k-ohm resistor. (It seems unnecessary to suggest that the CRT heater circuitry be checked, too.)

Checking Horizontal-Deflection System

A quick way to determine whether or not the horizontal-deflection system is functioning is to check the voltage at the pulse-limiter diode. Checked at the cathode, the voltage should be about +500 volts d.c. if the sweep system is generating pulses. Not all solid-state TV's have a pulse-limiting diode. However, there is a

Fig. 1. (Left) Normal static voltages and currents for "n-p-n" and (right) "p-n-p" transistors with negative ground supply.



R1—Input resistor
R2—Output resistor

R3, R5—Base voltage dividers
R4, R6—Collector voltage dividers

R_E—Emitter resistor
C1, C2—A. c. bypass capacitors

(Left) Collector voltage is lower than its effective source, indicating current through R2. Likewise, base voltage is lower than the effective base source, indicating current through R1. Voltage at the emitter indicates current through R_E. The stage is not saturated as evidenced by collector voltage slightly less than half the source value. Note the base-emitter forward bias of 0.6 V d. c. with base positive with respect to the emitter. This constitutes forward bias. The collector is the most positive element in an "n-p-n" device.

(Right) Since "p-n-p" transistors require negative collector voltage (as seen by the emitter), this is obtained by connecting the positive source voltage to the emitter, thus making the collector negative relative to the emitter. By appropriate divider action, the base is made 0.7-V d. c. negative as seen from the emitter. Note the voltage drops across R1, R2 and R_E, indicating current through these components. The fact that the stage is not in saturation is shown by the difference between the collector and the emitter voltage. The IR (voltage) drops across R2, the transistor, and R_E, add up to the 12 V d. c. source—a demonstration of basic Ohm's Law for series circuits.

point in every sweep system that can be used as an indicator of system function. It may be a damper diode, a boost rectifier, or a focus diode—which operate on pulses.

If the system is functioning (as revealed by the +500 volts d.c. at the cathode of the diode) and if there is no G2 voltage at the CRT, then the high-voltage rectifier, flyback, or focus bleeder are suspect. If the +500 volts d.c. is missing, the next logical step is to determine whether or not the horizontal-output devices have collector voltage. Measured on the metal case or heat sink, the collector voltage should be +74 volts d.c. or slightly higher. If the voltage is present despite the fact that the pulse limiter diode tells us there is no action, then the sweep system is non-functional, which is why the CRT doesn't light up.

If the pair of output devices have normal collector voltage, the "B+" points for preceding stages should be checked. Transistors cannot operate without supply voltage. In the case of Quasar, there is a +35-volt d.c. supply to the horizontal oscillator and the succeeding pre-driver. The horizontal driver which succeeds the pre-driver operates from a +28-volt d.c. supply. Missing source voltage indicates a power-supply problem, just as in tube sets. The Quasar, with its pluggable panel concept, provides convenient source measurement points at the various panel connector pins.

Having determined that the sweep system is non-operative, the technician has several options beyond that of outright panel replacement. One option is to check the transistors in the horizontal system with a tester. Another is to check the transistors with an ohmmeter. Third, the transistors can be checked with a voltmeter. Which way to go depends on circuit accessibility. The horizontal-deflection panel does not allow convenient hot checks when the panel is connected in the chassis. It's easier to unplug the panel to check the various stages with an ohmmeter or tester. Another alternative is to connect an external power supply (or batteries) of about +12 volts d.c. to the "B+" points and proceed to turn transistors on and off. This can be done with the panel on a bench. For the purpose of demonstrating a technique that can be applied universally, we'll explore the tactic of turning transistors on and off as we go along. This is a reliable way of proving out a system.

Returning to the collector of the horizontal-output devices, we'll pursue a line based on a missing collector voltage. The nearest source of this voltage is the horizontal regulator circuit which is the power supply for the horizontal-output devices. In series with the source and the output devices is the flyback transformer primary. The most likely component to suspect is the horizontal-regulator transistor. This device, in turn, depends upon additional regulator circuitry which is checked in the standard manner of verifying source voltage—checking transistors with an ohmmeter or tester and, depending upon accessibility, turning stages on and off.

Back to the CRT

Now let's back up and trace this "no-raster" complaint from where we started—except that this time, when we ground one of the CRT cathodes, the tube lights up, indicating all CRT operating voltages are present, but there is incorrect bias.

When faced with a CRT bias problem in a direct-coupled system, a technician has the option of making large preceding jumps to eliminate sections or going stage-by-stage until he locates the stage which does not restore brightness when turned on.

The nearest preceding stage to the CRT is the video output. There are three such devices—one for each of the guns. For total brightness to be lost all three guns would have to be biased off, indicating all three video output devices to be defective, unless something common to all three is causing cut-off. It isn't likely all three devices would be defective at once. In this receiver, the emitter of each output device is common to the blanker circuit. The common point can be grounded directly to the chassis with a clip lead. If brightness returns, the blanker circuit is defective—most probably the blanker-output device which is supposed to ground the emitters (except during blanker intervals). In other words, the blanking-circuit defect could possibly blank off the CRT 100 percent of the time.

The loss of one video-output device will cause the related CRT cathode to cut off, leaving the remaining two on (provided the device is open). This results in a raster of predominantly secondary color (magenta, cyan, yellow) rather than a total brightness loss. If the output device is shorted, then the related CRT gun will predominate, causing a raster in the particular primary color (red, blue, or green)—depending upon which output device is shorted.

Assuming the previous check is unproductive (grounding emitter tie-point) the next move is to try to get something turned on. Bridging a 10k-ohm resistor from collector to base at one of the three output devices should cause the CRT to light up in the primary color related to the device.

To digress a bit, it's always all right to short directly the emitter to the base of a transistor. All this does is remove forward bias, turning the transistor off. On the other hand, shorting from collector to base—even momentarily—may destroy the device instantly. To turn a transistor on, bridge a 10k-ohm resistor from collector to base. That's what we've done in this last test.

Getting back to turning on the video-output stage, if the screen doesn't light up in the associated primary color, you have located the defective stage. There are a number of alternatives in this case. Visual checks, voltmeter checks, and ohmmeter tests will pin-point the defect quickly. There really isn't much in the circuit.

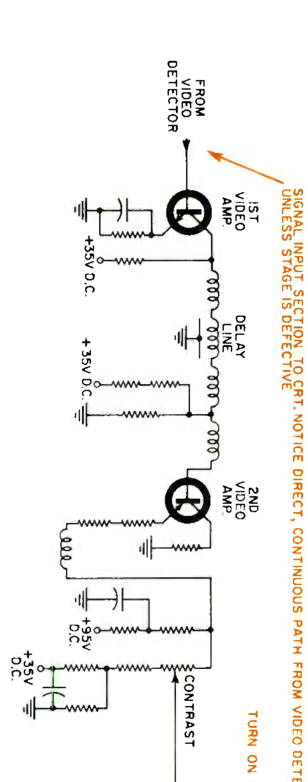
Should the screen light up when the selected video-output stage is turned on, then the next step is to go to the preceding stage which is, in this case, a video driver. Turning this stage on requires grounding the base to the chassis through a 10k-ohm resistor. Normally, grounding a base turns a stage off. In the case of the video driver, this *p-n-p* device requires a base that is negative (or less positive than the emitter). The 10k-ohm resistor accomplishes this. Grounding the base through a 10k-ohm resistor has the same effect as bridging the collector to the base, because the collector of a *p-n-p* stage goes to ground.

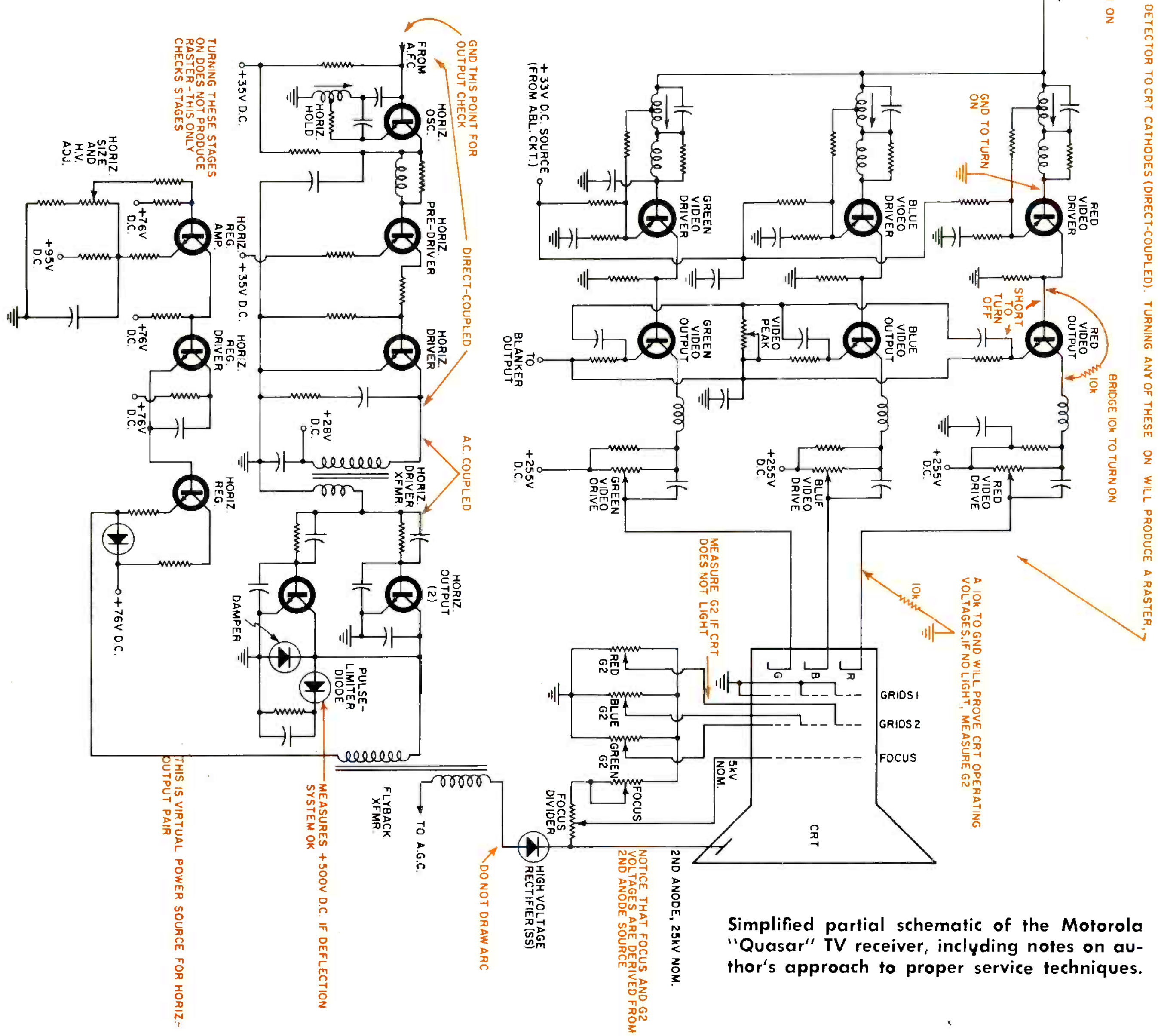
If turning the driver on produces a raster in the related color, then it can be assumed the drivers are operating, as is everything following them. Each preceding stage is checked in the same fashion until one is reached that doesn't produce a raster. That will be the defective stage.

It is important to stress that the "turn-on" technique is successful in direct-coupled circuits. We hope it is understood that a coupling capacitor (or transformer) isolates or breaks a d.c. path in the *RC*-coupled system. Therefore, the fact that a transistor can be turned on and off in a selected stage has no bearing on preceding or succeeding stages. The "turn-on" technique will still determine if a single stage is capable of functioning, even though only the stage under investigation is affected. All that need be done is to short the base to the emitter of a device that is normally "on." This should turn the stage "off." As proof, the collector voltage will rise and be equal to the supply.

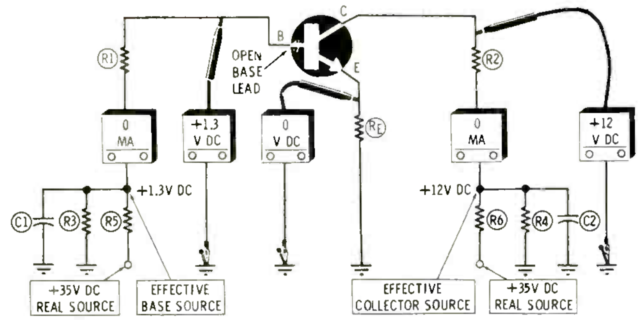
In those stages that are normally "off," shorting the base to the emitter proves nothing. In this case, however, the device is checked by turning it "on" (bridging the 10k-ohm resistor from collector to base). The collector voltage will drop if the device is functioning.

But how do we know whether or not a device is normally supposed to be "on" or "off?" One way is to know the basics and the system. The schematic will also reveal this. Another way is to compare the collector voltage to its supply. If they are the same, the stage is off, whether or not it is supposed to be. Turn it on. If the collector voltage stays put, then the stage is not functioning. In similar fashion, if the collector voltage is lower than its supply (usually about half) then the stage is conducting whether or not it is supposed to be. (It could be leaky.) Shorting the emitter to the base should shut off the device. As proof, the collector voltage will rise to its supply value. If it does not, the stage is defective. The base must control the stage, one way or another. However, don't overlook the fact that many things can cause



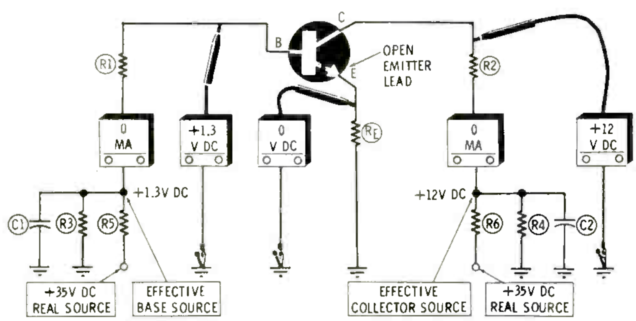


Simplified partial schematic of the Motorola "Quasar" TV receiver, including notes on author's approach to proper service techniques.

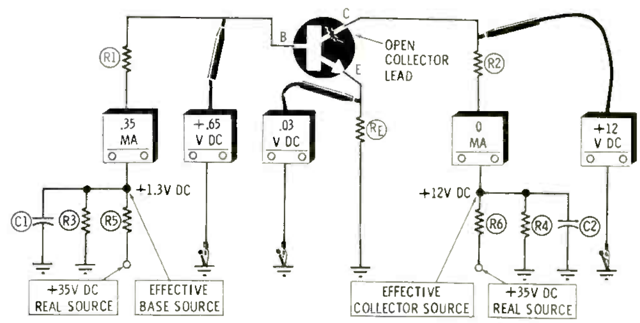


How to differentiate between an open in the base circuit and an open inside the device. The key here is what appears to be unusually high forward bias (1.3 V d. c.) that does not produce conduction. There are no voltage drops anywhere in the circuit. Base voltage is close to normal. 12 V d. c. on the collector indicates this must come from the source rather than from inside the transistor. If R_E were open, the emitter would take on the base voltage, but there is zero voltage at the emitter. The rule applies: When the stage has high forward bias but doesn't conduct, there's an open base or emitter lead inside unit.

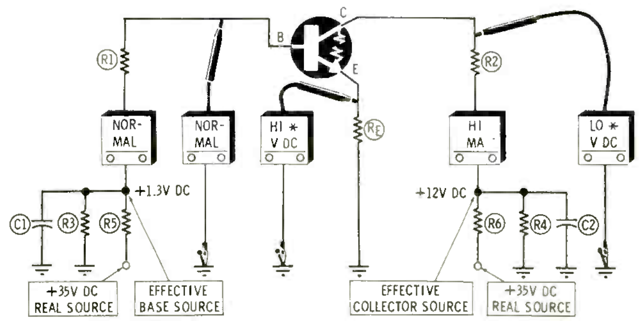
★ ★ ★



No voltage drops anywhere indicate no base current which results in no collector current. If the defect were an open R_E the emitter would assume the base voltage. With 1.3 V d.c. on the base and 12 V d.c. on the collector, it is safe to assume that R1 and R2 are good. The voltages are available and the components check out according to the rules. There's nothing left in the circuit but the transistor, which in this case has an open emitter lead inside of the transistor housing.



Full source voltage on the collector reveals the stage to be cut off and that R2 is not open. Forward bias voltage is normal with base current a little higher than normal, indicating a satisfactory base-emitter circuit. With all voltages present and the stage inoperative, the conclusion must be that the device itself is defective. In this instance, the collector lead of the transistor is open internally.



It is difficult to do more than generalize about the effects of a leaky transistor because so much depends on the extent of leakage and the circuit application. For example, a transistor normally forward-biased into saturation for a specific application could be critical to the functioning of the complete product. In most instances, a leaky transistor seriously affects signal flow. This is because the base loses control of collector current. Base bias measures nearly normal because it is attached to its divider supply. Collector current increases, causing a voltage drop across R2. The emitter resistor, R_E, has an increased voltage drop and, in severe cases, can develop enough voltage to go higher than the base, setting up a reverse bias condition. When the transistor conducts high collector current despite what appears to be normal or reverse bias at the base-emitter junction, suspect a leaky device. A final clue is that all voltages read very nearly the same. (*These voltages are close or same in value.)

Fig. 2. (Top left) An "n-p-n" transistor with base lead open internally: (bottom left) with emitter lead open internally, (top right) with the collector lead open inside case; and (bottom right) a leaky "n-p-n" transistor.

a particular stage to be inoperative, other than the device itself. These checks prove out not only the device, but its related circuitry as well.

About the Transistors

Forward bias is required to make a transistor conduct. Applied to the base through a divider network, forward bias is only about +0.7 volt d.c. for an *n-p-n* silicon transistor; –0.7 volt d.c. for a *p-n-p* silicon transistor. The latter can foul you up because few consumer products have a negative output power supply—the emitter voltage is raised +0.7 volt d.c. over that of the base by the circuit design. Measuring forward bias from base to emitter with a v.t.v.m. will require the selector switch to be on the –V d.c. range—provided, of course, that the meter's ground lead is on the emitter and that the input lead is touched to the base. A good rule to remember is that incorrect base voltage is almost always caused by a defect in the base circuit itself. (See Fig. 1.)

Collector voltage is also required to make a transistor conduct. Applied to the collector through de-coupling networks, dividers, and the load—the collector voltage is positive in an *n-p-n* transistor; negative in a *p-n-p*. With a single positive-output power source, the collector of a *p-n-p* device is usually connected to ground—which is the negative side of the power supply. The emitter is connected to the positive side. Measuring the collector voltage with the meter ground lead on the emitter will require use of the –V d.c. range.

Transistors can open, short, or leak. In all cases, the base does not control the stage. Here are two more rules that are helpful: When forward bias is normal, or slightly high, but the stage does not conduct—the device has an open lead internally. If forward bias is low, or missing altogether, but the transistor conducts anyway—the device is leaky (Fig. 2).

We have demonstrated a universal troubleshooting tactic that: (1) depends on a basic understanding of circuits, transistor action, and systems—since the probability of relating specific symptoms to specific stages is remote; (2) traces the fault to a section in an orderly fashion; (3) includes checking supply voltages, although complex; and (4) calls for checking transistors with an ohmmeter, voltmeter, and by turning on and off. ●

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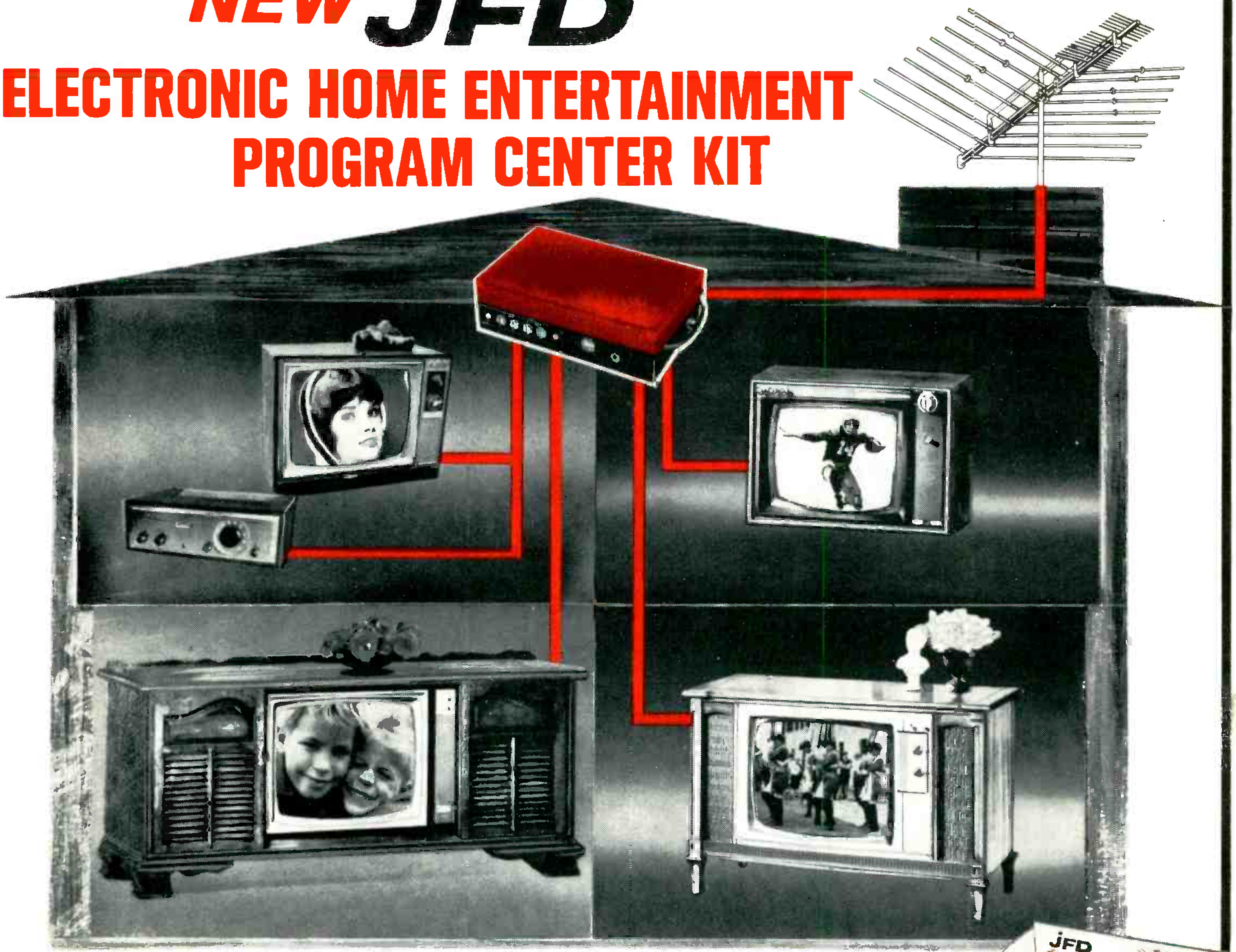

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Antennas for Stereo FM

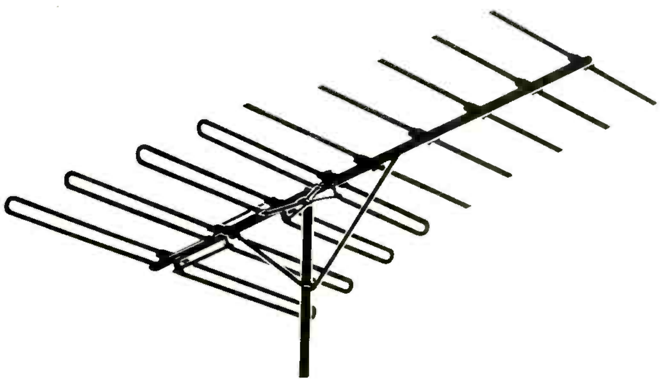
By LON CANTOR

Stereo is more difficult to receive than mono FM, hence a good antenna installation is required, especially to minimize any multipath distortion.

IN the days before stereo FM, FM antennas were generally quite simple. Most people got by with the indoor or built-in antennas supplied with the receiver or a "rabbit-ear" type TV antenna. If they used an outdoor antenna at all, they usually settled for an omnidirectional turnstile or "S" type of antenna.

However, stereo FM is a lot harder to receive. Pulling in good stereo-FM signals compared to good monophonic signals is a lot like the difference between color TV and black-and-white. Like color TV, stereo FM requires an extra signal carrier which is detected and whose phase is important. To make matters worse, stereo FM requires more antenna gain and is more susceptible to multipath distortion.

Channel Master Model 4408-G is designed for fringe and far-fringe reception of FM signals. The antenna uses five parasitic elements along with four series-fed folded-dipole driven elements. Antenna lists for $34.95.

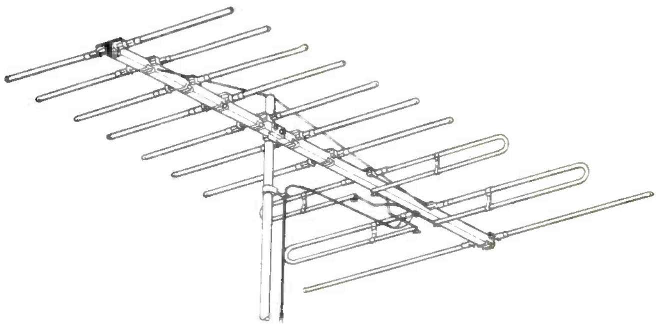


Because FM is transmitted at much higher frequencies than AM, signal propagation is relatively limited. The frequency difference could be overcome, to some degree, if transmitter power were increased. However, output power is limited by the FCC. What's more, the FCC allows no more effective radiated power for a stereo broadcast than they do for a monophonic broadcast.

The extra stereo-FM carrier, as well as other characteristics of the stereo signal, effectively reduces the signal-to-noise ratio. If you receive the stereo-FM signal on a mono tuner (or a stereo tuner working on mono) you only lose about 4 dB. However, you lose a full 20 dB (which means that you pick up only $\frac{1}{10}$th as much signal voltage) if you receive an FM broadcast in stereo.

A stereo-FM tuner uses the sum frequency (left plus right) and the difference frequency (left minus right) to reproduce the two separate channels. A mono tuner uses only the sum frequency, which is considerably stronger than the difference frequency.

All of this boils down to the fact that with a given antenna at a given location, monophonic broadcasts can be received from about twice as far as stereo broadcasts.



Finco Model FM-5 is for fringe-area reception of FM signals. Eight parasitic elements are employed along with two folded-dipole driven elements. List price is $37.95.

In addition to requiring stronger antenna signals, stereo FM is also more susceptible to multipath distortion and crosstalk.

Multipath distortion causes the most severe problems. It is caused in the same way as a TV "ghost." The signal goes from the transmitter to the receiving antenna by two paths simultaneously — one direct and the other reflected from a hill or a tall building. Since the reflected signal arrives later than the direct signal, it is frequently out of phase.

Not only does the reflected signal weaken the direct signal when it arrives out-of-phase, but it also causes distortion. You get a poor signal-to-noise ratio, reduced stereo separation, or perhaps no stereo effect at all. What is more, the stereo "image" that was on the original disc or tape may be altered or completely destroyed.

Many of the problems of stereo-FM reception can be solved by a good antenna installation. And, fortunately, the type of antenna that's good for pulling in weak stations is also good for eliminating multipath distortion.

There are three important factors to consider when choosing a stereo-FM antenna:

1. *Gain.* The gain of an antenna is a comparison of

that antenna's sensitivity with a theoretical dipole. Gain is expressed in decibels (dB). The higher the gain the more sensitive is the antenna. Using a higher gain antenna has the same effect as moving the antenna closer to the transmitter. A standard dipole has a gain of 0 dB (unity gain), while a good commercially available FM antenna may provide up to about 10-dB gain.

2. *Directivity.* To eliminate multipath distortion, you must be able to reject reflected signals. You can do this with a directive antenna, properly aimed. The angle from which a given antenna can pick up signals is indicated by its half-power beamwidth. The narrower the beamwidth, the better, if you are trying to eliminate signals from other than one direction.

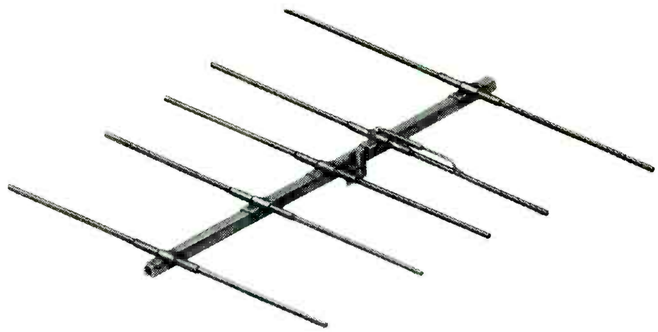
A narrow beamwidth can also be quite effective in eliminating interference from stations near the same frequency, since stations close in frequency almost never broadcast from the same direction.

Fortunately, high gain and narrow beamwidth go hand in hand. As you add elements to an antenna, you generally increase both gain and directivity, as well as improving the front-to-back ratio.

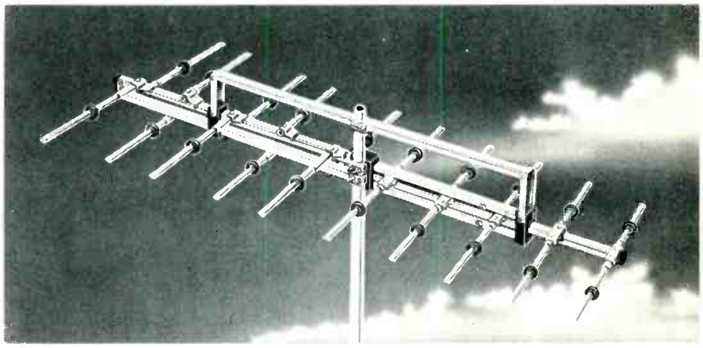
3. *Impedance Match.* Because phase is important in detecting signals, impedance is important. Poor antenna match can ruin stereo reception. This applies not only to the antenna, but to the lead-in wire as well. If you use inexpensive twin-lead with metal stand-offs, you not only lose signal, you may also cause standing waves. And these can reduce signal strength, produce reflections, and shift the phase of stereo-FM signals.

Two antenna types that have been widely used for stereo FM are yagis and log periodics. The photos in this article show representative examples of high-gain stereo-FM antennas.

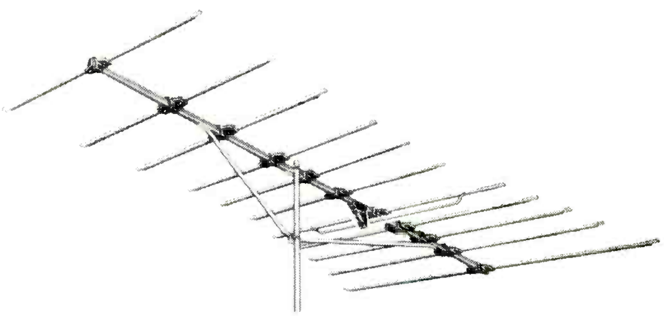
We've talked about using high-gain, highly directive antennas and aiming them properly to eliminate multipath distortion and interference. But how do you aim an antenna if you want to receive stations that are not all located in the same direction? The obvious answer is an antenna rotator. With a rotator, you can zero in on the best possible signals. In fact, with a high-gain antenna on a rotator, you can probably pick up stereo-FM broadcasts from over 100 miles away.



For commercial and industrial MATV systems, Jerrold Model J-55-FM is available. This heavy-duty antenna is a 75-ohm yagi with a gain of about 6 to 7 dB on the FM band. Front-to-back ratio is 18 dB. List price is $62.50.



An example of a log-periodic FM antenna for far-fringe use is the JFD Model LPL-FM10A. This ten-element antenna has a gain of 9.9 dB, a half-power beamwidth of 43 degrees, front-to-back ratio of 26 dB. List price $52.45.



Winegard Model SC-65 is eleven-element FM antenna for deep-fringe areas. Gain is 9.9 dB, half-power beamwidth is 44 degrees, front-to-back ratio is 23 dB. List $36.95.

TV and FM Antennas

Some people don't want to spend the money for a separate antenna and a rotator just to pick up FM. Since the v.h.f. TV range (54 to 88 MHz and 174 to 216 MHz) surrounds the FM band (88 to 108 MHz), a combination TV and FM antenna is not too much of a problem to design. A good TV-FM antenna works as well on stereo-FM as all but the very best of FM-only antennas. For most installations, therefore, a combination antenna is an excellent idea.

If you do decide to use a separate FM antenna, you can still save time and money by mounting the TV and FM antennas on the same mast. It doesn't matter which antenna goes on top, except that the higher antenna usually works better. If you're in a strong TV area, but a weak FM area, you'll probably want to put the FM antenna on top. Or, if you're more interested in FM, you might want to keep the FM antenna on top even if the situation is reversed. In either case, you should allow at least three feet between the two antennas. Textbooks generally call for greater distances between two antennas, but we must be practical. If we try to separate the antennas by a wavelength, the installation becomes top-heavy, especially for a rotator. Experience shows that antennas separated by about three feet work quite well together.

The outputs of the two antennas can be combined into a single downlead. We recommend a hybrid coupler for this application, even though it causes about 3.5-dB mixing loss. Frequency-sensitive couplers, tuned to pass FM with a minimum of loss can also be used. However, these couplers do cause severe TV frequency loss and don't really make that much difference on FM. If FM signals are very weak, use an FM preamplifier and/or separate v.h.f. and FM downleads.

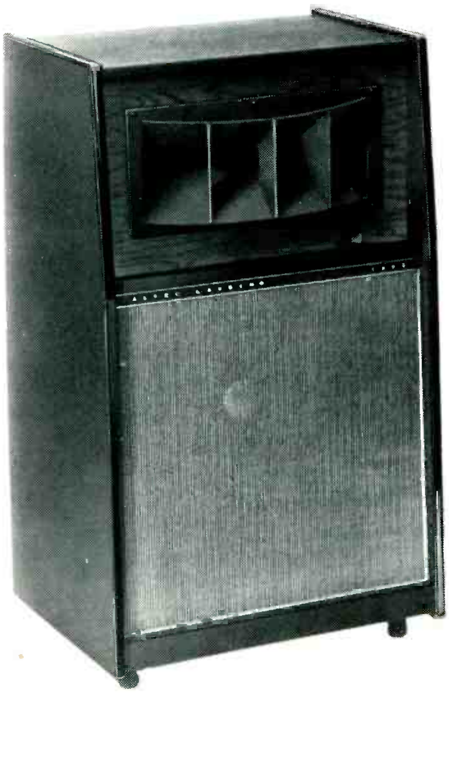
A good stereo-FM antenna installation is not inexpensive. But it's an investment that can pay for itself many times over in years of superb hi-fi and stereo reproduction. ●

Which P.A. Speaker Should You Use?

By ABRAHAM B. COHEN, ISC/Telephonics
Division of Instrument Systems Corp.

Description of the various types of p.a. speakers that are available, their comparative characteristics, and practical information on making the best choice.

Fig. 1. An example of a direct-radiator cone enclosure with a sectoral high-frequency horn at the top for use in gyms or in small auditoriums. (Altec Lansing 1202A)



THE choice of loudspeakers for p.a. sound systems is determined by four factors: (1) the specific area to be covered by each speaker, (2) the acoustic properties of the area to be covered, (3) the propagation characteristics of the speaker, and (4) its efficiency.

A paging system intended to cover many different rooms of a manufacturing plant will obviously need as many speakers as there are rooms to be covered, with at least one speaker to a room, or more as the size of the room requires. On the other hand, an open-air concert shell or high-quality concert hall or theater may require only one master system placed over the center of the stage.

In a stockroom, where the area is broken up into aisles, storage shelves, bins, storage nooks and crannies and the like, the chances are that the area is generally free from disturbing reverberation. Hence, no special performance is required of the speaker other than it radiate enough sound so that people in the stockroom area can hear it comfortably. In a plant where there is a very noisy and large manufacturing area with cinderblock walls and high glass turreted roof, a network of small speakers placed near where the people paged are most likely to be found, such as at machines or foremen's stations, would be required. Here, the pattern from the individual loudspeakers should concentrate the radiated sound more directly toward the area to be covered, since sound dispersion into the high-ceilinged area might set up disturbing reverberation which could reduce the intelligibility of the message.

If the speaker is intended to reproduce a wide range of music, then the system would generally have to have the characteristics of a "hi-fi" system. If it were to be used for paging purposes, only a narrow band of frequencies must be reproduced to get the message across.

Finally, the speaker selected will determine the amount of audio power necessary to drive the system; direct-radiator speakers having about one-fifth the electro-acoustic efficiency of horn-type reproducers.

Cone Speakers

The cone-type loudspeaker is generally used as a direct radiator. As direct radiators, they "sound out" directly into the area to be covered. As shown in Fig. 2, they may be mounted in simple small enclosures just large enough to accommodate the loudspeaker being used (usually no larger than a 8" unit), with just enough inner volume to give some semblance of bass reproduction. These are used mainly for low-level paging systems where frequencies below 250 Hz are unnecessary for speech reproduction and for background music where musical "sedation" rather than fidelity is the goal.

Often these cone speakers will be housed in baffles which are flush-mounted in the ceilings or walls. When mounted in walls, the back of the enclosure is often left open to allow the speaker to produce lower frequencies because the diaphragm is acoustically unclamped, making the enclosure appear larger. However, when mounted in the ceiling, the speaker is usually closed in by a rear box to prevent bits of plaster from falling into the back of the cone. In these small rear-enclosed ceiling mounts, the low frequencies are considerably attenuated. The enclosures need quite a bit of sound damping applied to their inner walls to minimize disturbing resonances within the enclosures.

Bi-directional baffles are often mounted in corridors or on walls, with sound coming out of the back as well as the front. This reduces the number of speakers required, however, quality is sacrificed over and above the limited quality of the small enclosure itself. Since it is virtually open on both sides and is housed in a small enclosure, the cone is, for all practical purposes, unbaffled. This results in severe drop out of low frequencies. In addition, the high frequencies from the rear of the speaker are considerably attenuated with respect to the highs coming out of the front of the speaker. Yet despite these characteristics, bi-directional enclosures provide usable paging service and low-level background music in low-noise areas.

For a wider frequency range than that used for paging or background music, and where only moderate sound powers are required, the cone speaker may be mounted in a vented cabinet of the bass-reflex type, or in a sealed enclosure of the acoustic-suspension type. In both cases, the cone acts as a direct radiator, open and facing the audience. With a high-quality woofer, good low-frequency reproduction is possible. However, in almost all instances, a tweeter is a part of the enclosure system to augment the high frequencies of the main cone and to provide better dispersion of the highs.

With the reflex-type enclosure, the tweeter is generally a wide-angle horn to match the efficiency of the cone speaker, and may frequently consist of a multicellular or sectoral horn to ensure wide-angle coverage of the higher frequencies (Fig. 1). In the case of the sealed acoustic-suspension system, the enclosure invariably comes as a complete system with the built-in tweeter utilizing either one or two direct-radiator hard-shell dome-type structures to match the woofer efficiency. This tweeter system gives uniform high-frequency distribution rather than directional control of the radiation.

The power requirements of these two systems and the mode of deploying them are very different. Due to the much higher efficiency of the vented enclosure with its tweeter system, satisfactory coverage of an auditorium may be obtained by elevating two such systems on either side of the stage. In the case of the acoustic-suspension type, with its much lower efficiency, perhaps four or five of these enclosures would have to be strung along the footlight area to cover the auditorium.

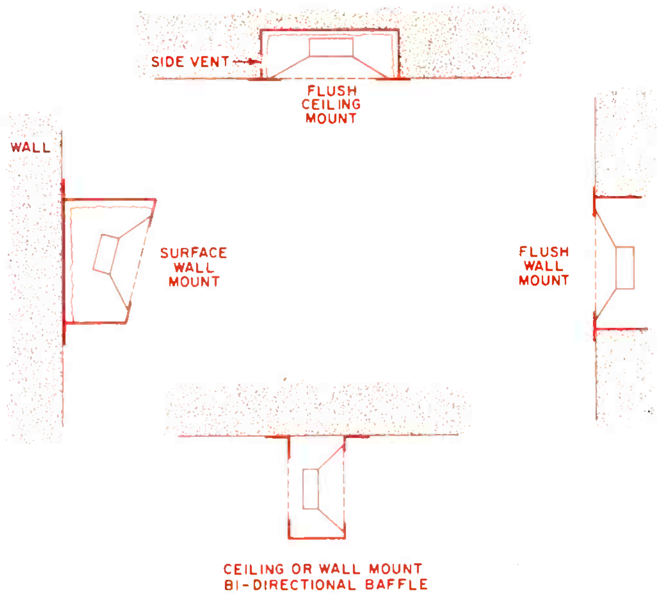


Fig. 2. Cone speakers for paging and utility purposes are housed in small compact metal or wood baffle enclosures.

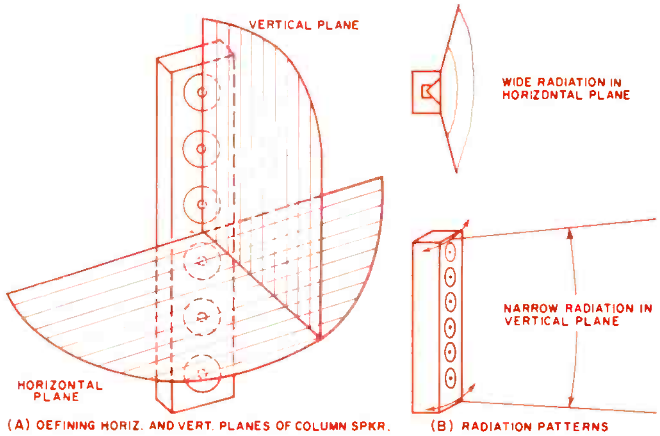


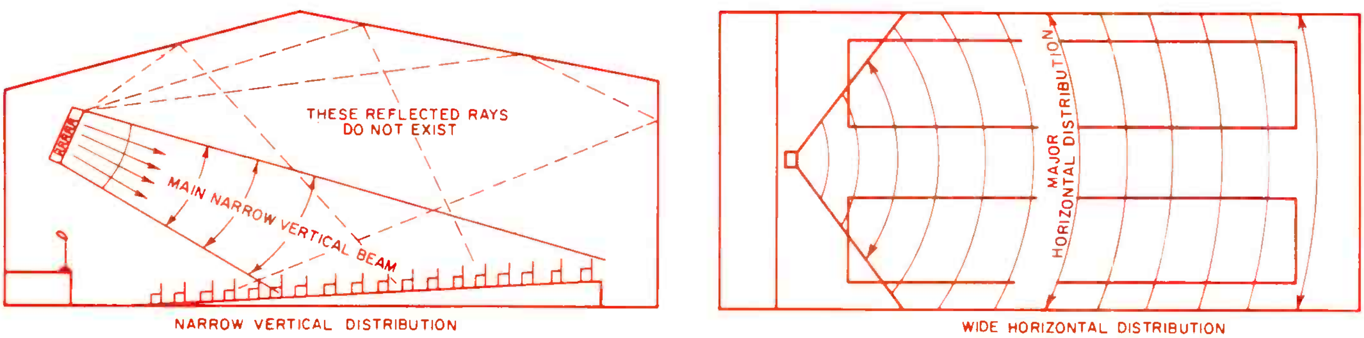
Fig. 3. The column speaker produces a wide-angle wedge of sound energy in horizontal plane at right angles to the column length. Sound wedge is narrow in vertical plane.

Column Speakers

The column speaker bridges the gap between the simple cone-radiator structure and the horn system. It will provide sharp directional control patterns but will also retain a good measure of cone-type quality not available from standard horns.

The column, as shown in Fig. 3, is a group of speakers mounted in an array, one above the other, and all facing the same direction. They are usually enclosed in one over-all structure which is made as small as possible without deteriorating the bass response below that of which the speaker is capable. Regardless of the physical size of the column, the structure is designed to hold a minimum of four speakers, most frequently six, and not infrequently eight. The major function of the column array is to radiate most of the sound into a rather narrow

Fig. 4. Narrow vertical beam from column speaker system can be used to reduce generation of reverberant sound.



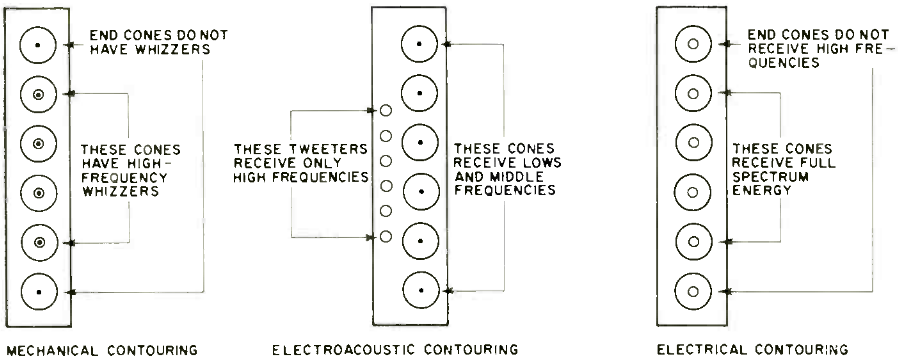


Fig. 5. Three ways of contouring or equalizing column in order to get same directivity pattern at high frequencies.

wedge lying in a plane at right angles to the axis of the column itself, with the arc of coverage of this horizontal wedge often well over 120 degrees. Minimum sound is projected in the vertical direction into the area outside of this comparatively narrow horizontal wedge.

As illustrated in Fig. 4, it is possible to orient the speaker to throw the sound directly into the seating areas to be covered and to minimize the sound beamed at the upper hard-ceiling areas where the sound would otherwise bounce down to the audience with bothersome reverberation. It is surprising how a tilt of just 10 to 15 degrees from the vertical, can focus the sound down on the area to be served and permit so little of it to get into the vertical plane.

Sound columns are not very efficient. The column is just a bit more efficient than the cone speaker in the column, but is not as efficient as a horn projector, power for power. However, putting aside the directional control advantage of columns, they have the secondary advantage of being able to handle as much more power than a single cone as there are cones in the array. Where one of the unit cones may be capable of handling 10 watts by itself, it will still take 10 watts in the column configuration, but the whole configuration made up of perhaps six cone will now be able to take a total of 60 watts.

It is possible to design column speakers for large-area applications where the power-handling capacity may be on the order of 100 watts or more. There is great demand for this type of speaker not only in gymnasiums and large auditoriums, but even for small pop music gathering places where there is apparently no limit to the volume that people can tolerate irrespective of the resultant distortion. The fact that large amounts of power can be fed into the column and a band of frequencies that will cover the electronic instruments used by pop groups can be gotten out of it makes the column a very important system to the sound specialist. Fig. 6 is an example of a two-section break-away column with the top tweeter designed specifically for pop-music use.

In general, the larger the column, the better the low-frequency reproduction and the sharper the horizontal wedge of sound distribution. Another rule-of-thumb in judging the sharpness of the horizontal pattern is the number of speakers in the column and the means of →

contouring the high-frequency response. The more speakers in the column, assuming them to be closely spaced, the flatter will be the horizontal wedge; eight radiators will produce a flatter horizontal wedge of sound than will a four-speaker column. When designing column speakers an attempt is made to keep a constant ratio of radiated wavelength to the physical length of the column. Theory shows that if this condition can be maintained, then the wedge divergence will be uniform at all frequencies. It is obviously impossible to physically shorten the column as high frequencies (shorter wavelengths) are transmitted. The only feasible alternative is to make the column appear to be electro-acoustically shorter for the higher frequencies as they occur.

This automatic contouring is accomplished by one of the three following methods, or combinations of them, as in Fig. 5. (Left) The high-frequency capabilities of the two end speakers are reduced by either choosing their cone design so that they are not as inherently good high-frequency reproducers as the central radiators, or by removing any high-frequency elements, such as whizzers or tweeters from these end speakers. (Right) Electrical filters, such as crossover networks, may be used to prevent the high frequencies from getting into the end speakers. (Center) A separate line of tweeters located at the center of the column will make the tweeter column length to wave-length ratio at the high frequencies similar to that at middle and low frequencies. In some instances, the column itself is slightly arced to keep the highs from dispersing vertically.

Horn Projectors

The horn-projector family will continue to be one of the sturdy building blocks of public-address sound systems. The reasons are not hard to understand. The ease of directing sound where it is desired by merely pointing the horn in that direction is readily apparent. The ability of the horn to produce sound that penetrates into very noisy areas is universally recognized. The economy of amplifier power it permits because of its high-efficiency characteristics is a matter of record. That they have time-proven reliability under the most adverse conditions of temperature, humidity, and precipitation is borne out by their use out-of-doors almost to the exclusion of other types of p.a. loudspeakers.

Most high-efficiency horns used by the p.a. technician are of the re-entrant type. They can be recognized by a central member, resembling a long nose structure, as in Fig. 7. This

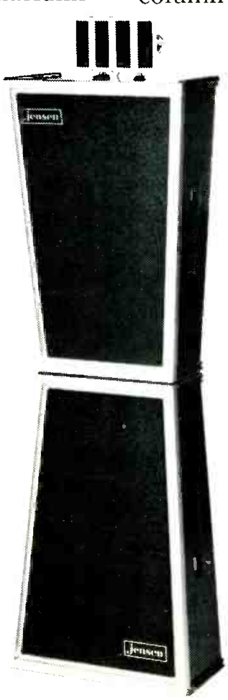


Fig. 6. Break-away high-power handling sound column for portable pop-music use. Multi-horn tweeter on top of the column spreads high frequencies. (Jensen Models LPC-152, HLV-40)

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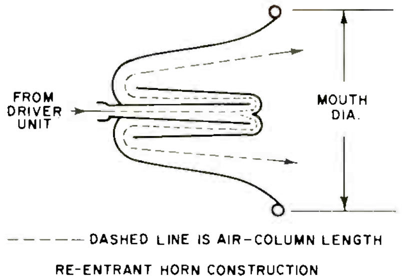

AIR-COLUMN LENGTH	MOUTH DIA.	CUT-OFF FREQUENCY	ANGULAR DISPERSION	RELATIVE ACOUSTIC GAIN
2 1/2' NOM.	16" NOM.	250Hz	95° NOM.	REFERENCE
3 1/2'	21"	175Hz	85°	+ 1dB
4 1/2'	26"	120Hz	75°	+ 2dB
6 1/2'	32"	85Hz	65°	+ 4dB

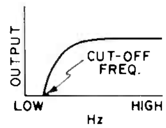

Fig. 7. Construction and performance of re-entrant horns.

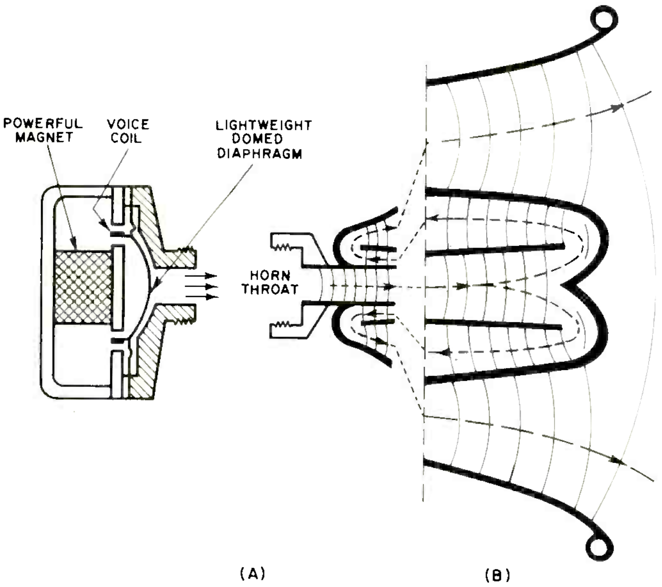

Fig. 8. The high sound output from efficient compression driver and the good impedance match provided by the horn result in an over-all high efficiency of output.

member is one of three separate sections of the horn, folded around the other, for which the word "re-entrant" was coined.

Such horns, because of their design-controlled geometric expansion, have well-defined specifications, of which the most important is the low-frequency cut-off point below which the horn theoretically will not transmit any acoustic energy. In this context, every horn is thus a simple high-pass filter. Looking at a group of horns, the larger the mouth of the horn and the longer the air column of the unfolded horn, the lower frequencies it will reproduce. One would expect that the larger horns would have a better sound-level output due to their improved acoustic loading on the driver unit energizing them and their better mouth-to-air impedance match. The table in Fig. 7 gives a general idea of the improvement in sound pressures that may be expected from typical horn sizes. A second rule-of-thumb is that the smaller the mouth of the horn, the wider its angle of sound dispersion. This characteristic stems from basic radiation theory that states that the smaller the radiator, the more it approaches a point source of energy and becomes a spherical radiator. As the radiator becomes larger, it deviates from the character of a point source and begins to develop directional characteristics. Hence, while a large horn mouth may produce better low frequencies and more sound power output, its upper frequency radiation becomes quite beamed with resultant loss of intelligible wide-angle projection.

A horn is a passive device; it does not produce power. The sound it transmits is the sound it receives from some other source of power, in this instance, the compression driver shown in Fig. 8A. The back of the unit is completely closed off from the outside air. The rear of the vibrating sound-producing diaphragm in the structure is thus under compression of the air trapped behind it. The front of the diaphragm, mounted in the acoustic head, delivers its acoustic energy into the narrow throat end of the horn which is coupled to the driver unit.

The driver unit has a powerful magnetic system which provides the initial source of power to cause a comparatively small diaphragm (usually about 2" in diameter) to be energetically vibrated as a result of the signal current to the voice coil immersed in the magnetic gap and attached to the diaphragm. This powerful magnetic drive (magnetomotive force) acting on the low mechanical impedance of the lightweight diaphragm, produces high sound output.

The acoustic energy feeds into the throat of the horn and is allowed to expand at a controlled rate by the design flare of the horn until the sound power emerges from the horn mouth as in Fig. 8B. The horn is basically an acoustic transformer, as well as a high-pass filter. Its controlled expansion permits the high-intensity sound, originating at its throat, to gradually follow the horn expansion and to emerge from a large mouth area into the acoustic space in front of it. The large horn mouth thus provides an improved acoustic match to the air around it and accordingly "grabs hold of" that space in front and transfers its emerging power to it. This is the second high-efficiency step to take place in the process.

The high output of the compression driver, aided by the acoustic-matching properties of the horn, provides a combined efficiency of about 25% as compared to that of the cone system whose efficiency is seldom higher than 5%. Because compression-driven horns are very efficient doesn't necessarily mean that they are to be used only where large amounts of power are required. There are horn projectors rated as low as 5 watts input and there are some systems rated at 1800 watts input. The need determines the power requirement.

Various Types of Horns

While the choice of a driver unit (or units on multiple-drive horns) is made on the basis of sound power required out of the horn, the horn in turn is chosen on the basis of the type of field coverage required and the frequency response needed for the application. The horn family is divided into three general categories: (1) paging and talk-back type; (2) high-power long-throw type; and (3) wide-angle dispersion type, covering both of the previous varieties.

Paging and talk-back horns are relatively small, ranging from 6" to 8" in horn-mouth diameter and about the same corresponding physical lengths (see Fig. 9A). They are easy to handle, being generally provided with some sort of a universal swivel mount. They may be conveniently affixed to walls, ceilings, ceiling cross beams, or any convenient abutment near the area to be covered.

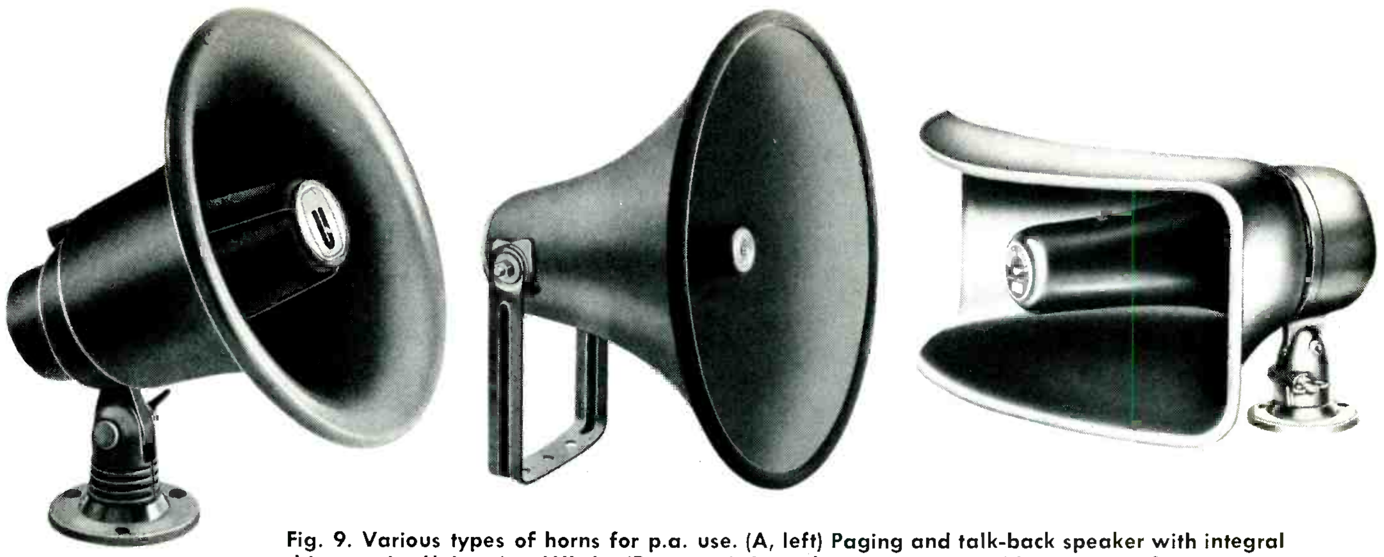

Fig. 9. Various types of horns for p.a. use. (A, left) Paging and talk-back speaker with integral driver unit, University MIL-A; (B, center) long-throw projector with provision for screw-on driver unit, University GH; (C, right) contoured horn for wide-angle distribution, Atlas CJ-30B.

Their response characteristics may start anywhere between 250 Hz for the 8″ type to 500 Hz for the 6″ size, and extend well beyond the upper limit of the speech spectrum. This brackets the band of approximately 250 to 5000 Hz. Articulation with these paging units is exceptionally high. They are placed close to the particular areas where the people to be paged are most likely to be found, and often are located close to or within an area where high noise generating equipment and its operating personnel are stationed.

Successful paging into these areas may be accomplished with moderately small amounts of power per speaker, usually about 5 watts, although such speakers are rated at and will handle as high as 20 watts for extreme conditions. Speakers of this sort may also be found on open-air platforms or in long-corridor systems such as at airports and in subways where ambient noise may be quite high.

More even sound distribution may be obtained by spotting small speakers at short intervals down the corridor, rather than providing a single high-level source at one end of the corridor. The latter would merely introduce undesirable reverberation and extremely spotty and unevenly distributed sound.

Because the small speakers may be scattered over an area, they serve as high-efficiency microphones when incorporated in a sound system with intercom calling and listening facilities. One may speak quite a distance away from such a speaker and be understood back at the intercom-control station.

The high-power, long-throw horn system (Fig. 9B) is usually represented by the family whose acoustic column lengths may range from 2½ to 6½ feet and whose mouth diameters may be anywhere from 16 to 32 inches. The standard round horn of this group has a symmetrical distribution pattern of sound energy emerging from its mouth, beamed directly along its axis. Such patterns make it highly suitable for long-throw sound projection as far ahead and in front of the horn as possible, a sort of acoustic "spotlight" type of service. For such application, it is wise *not* to spread the available energy out over a large area in such a manner that it will have to fight its way, under adverse conditions of air and humidity conditions, only to be lost at the listening area, but rather to beam it ahead for maximum usability.

In long-distance sound throws we cannot hope for real highs as they are absorbed by the air and buffeted about by wind currents. However, considering that we can get usable articulation from the middle frequencies, the symmetrical horn, with its normal beaming, provides excellent acoustic spotlighting of reasonably distant areas. Naturally, a cluster of such horns mounted at a common center can provide high-intensity spots of acoustic energy, one merging with the other to give wide-area coverage.

Focusing of the sound by the round horn may even be a useful adjunct to the horn designed for wide-angle throw (next up for discussion) where the listening audience may be in a park which has heavy outcroppings of "soft" foliage and other brush. The beaming round horn may transmit enough extra acoustic energy into that area to overcome any loss of the original wide-angle distribution at that point.

Using the same high-efficiency techniques as employed in the standard round horn, other shapes and modifications that produce wide-angle distribution of the sound pattern have been developed. These horns tend to "pancake" the sound pattern into those areas needing the sound energy and minimize the energy into those areas where it would be wasted or cause destructive interference. These problems are precisely the ones that the column speaker was designed to overcome; the horn, however, provides higher efficiency.

One method of obtaining this wide-angle dispersion is by reshaping the horn so that it will throw more sound in one direction than another (Fig. 9C). Another method of improving dispersion is by mounting a high-frequency horn in the center of the mouth of the larger horn (Fig. 10A). The smaller horn, operating as a p.a. tweeter, may be oriented for the direction in which the dispersion is desired. In this case, diffraction effects cause the beam to spread perpendicular to the larger dimension of the mouth of the horns. A third method (Fig. 10B) uses an external multi-mouthed, or multicellular, horn to direct the high frequencies into those areas where the main radiator cannot project. (For maximum horizontal dispersion of high frequencies, the horns in Figs. 9C, 10A, and 10B are mounted as shown in the illustration.)

Because of the relative lack of low frequencies from horn projectors, they are not by themselves suitable for

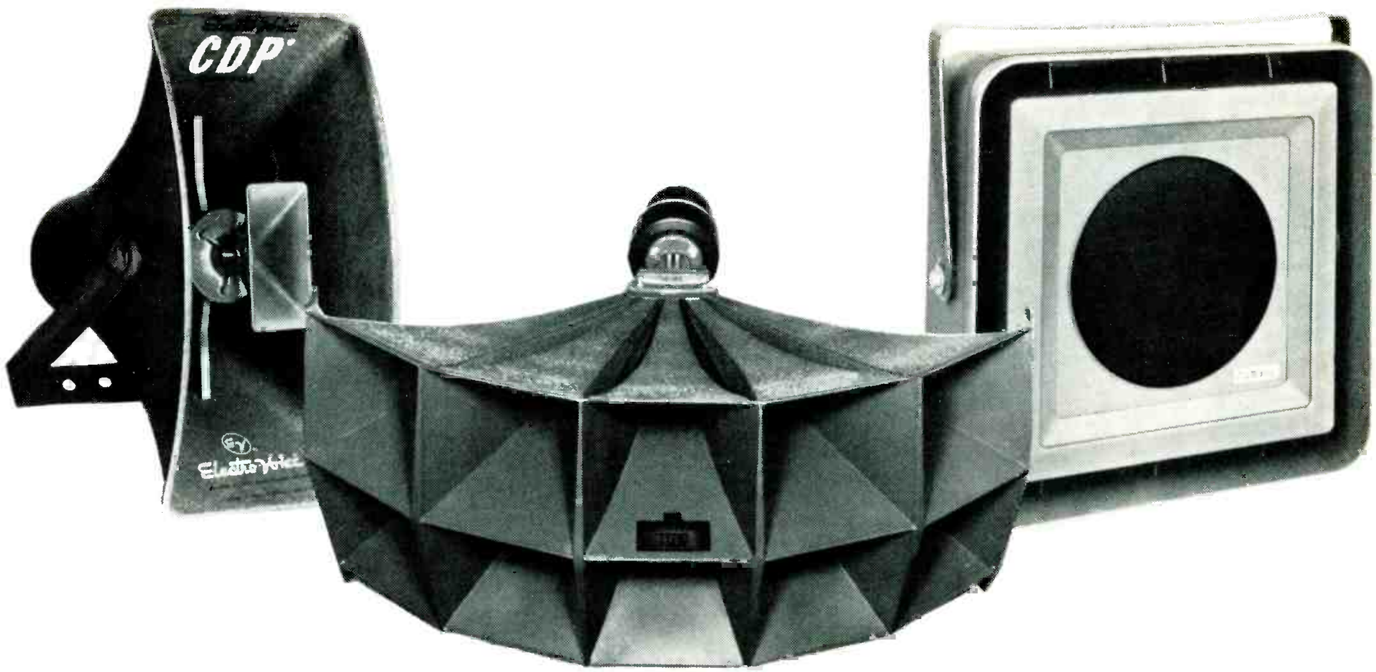

Fig. 10. Additional horns for p.a. use. (A, left) Horn tweeter in mouth of large horn provides wide-angle high-frequency distribution, Electro-Voice 848A; (B, center) 2 x 5 multi-cellular horn for wide-angle distribution, Altec 1003B; (C, right) rear horn-loaded outdoor speaker, Electro-Voice 1A.

wide-range "hi-fi" p.a. systems, but are used frequently as the upper frequency elements of a system designed for concert work, especially in applications where distances are to be covered. The multicellular unit may be designated as a 2 x 5 unit or a 3 x 6 unit. This indicates how many rows of small horn are stacked one on top of the other, and how many small horns are in each row. The configuration of such a horn will determine the radiation pattern.

These horn clusters are rated for several cut-off frequencies, so that one has a choice of bandwidth and dispersion characteristics. In some well designed systems there may be two clusters of horns, a mid-frequency and a high-frequency cluster, both working in conjunction with multiple high-efficiency cone radiators. The multiple low-frequency cones are housed in a bass-reflex enclosure large enough to reproduce very low frequencies cleanly and efficiently. In addition, the cones may be front-loaded with a short horn to raise the efficiency of the lower middle frequencies to be compatible with the efficiencies of the upper frequency clusters. Crossover networks are used and there is a choice of 6, 12, or 18 dB per octave roll-off. Systems such as these are found in theaters for high-quality sound-track reproduction, in large multi-use auditoriums, and for concerts in open shell areas.

We shall next take up the matter of the outdoor installations for patios, outdoor shopping areas and malls, sidewalk restaurants and esplanades, where good fidelity must be obtained from unobtrusive weatherproof speakers. The unit (Fig. 10C) frequently takes the form of either an 8″ or 12″ cone speaker whose diaphragm is treated with impregnating resins to make the paper stock water-resistant. The structure is that of a forward direct radiator, with the rear of the cone loaded by a short one-bend horn. This rear horn provides some acoustic loading on the back of the speaker so that the cone may radiate low-frequencies consistent with the size of the structure. The second purpose of the horn is to protect the cone from rain or wind.

Because the horn is of limited length and since its mouth area is quite small, the low-frequency capability of the horn is limited, although quite adequate for the application. Accordingly the cone-speaker driver is of fairly high resonance, probably between 75 and 100 Hz for a typical patio unit. The front of the cone may be protected by water-impervious cloth, protective screens, and metal grillework which may be decorative as well as protective. One can equate this type of speaker in terms of quality with the column speaker. In this case, however, the patio speaker is almost always omnidirectional, with no important horizontal over vertical advantage. The mouths of such speakers may range in size from approximately 10″ across to 33½″ with the choice, as in all p.a. work, determined by the area to be covered and the quality of performance desired. In the case of the larger models, the systems are usually woofer-tweeter combinations for maximum fidelity.

Any sound system must be approached on the basis of a system philosophy where the system consists not only of an amplifier, distribution system, and loudspeakers but, and most important, the audience to be reached. And to reach it successfully, the industry has designed and provided dozens of specialized loudspeakers for as many varied needs. ●

Answers to Electronics-Technician Quiz appearing on page 8

1. c	11. b	21. d	31. a	41. b
2. d	12. c	22. d	32. b	42. b
3. b	13. d	23. a or b	33. b	43. d
4. b	14. c	24. a	34. c	44. c
5. a	15. a	25. c	35. c	45. a
6. c	16. c	26. b	36. a	46. b
7. a	17. d	27. d	37. a	47. b
8. c	18. b	28. a	38. c	48. d
9. b	19. b	29. b	39. a	49. c
10. d	20. c	30. a	40. d	50. b

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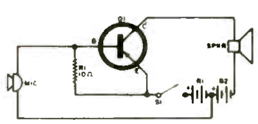

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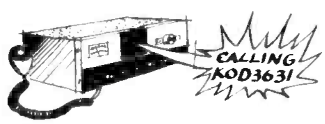

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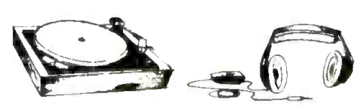

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How to Choose the Best TV Antenna

By LON CANTOR

With so many good TV antennas available, making a decision on which to use is difficult. This article should help to narrow down the choice to one that will do the best job for your particular reception needs. A complete listing of recommended antennas for various signal areas is also included in this article.

VIEWERS are becoming more and more critical of the quality of the TV pictures they watch. Early TV viewers were satisfied to get any kind of a recognizable picture. Ghosts, smears, snow, and interference were cheerfully ignored. However, just as radio listeners moved from tinny, staticy sound to high fidelity, so TV viewers are now demanding cleaner, truer pictures.

There are three factors behind the demand for top-quality TV reception.

1. *Color-TV*. Color-TV has already surpassed black-and-white TV in annual sales volume. And defects that were barely noticeable in monochrome really pop out in color.

2. *Cable TV*. As CATV moves into more and more areas and more buildings use quality MATV systems, many viewers are seeing how good TV reception can really be—often for the first time. Many dealers, for example, are investing in excellent MATV systems for their showroom sales floors. Once people see top-quality TV pictures, they are unwilling to settle for less in their homes.

3. *Better home antennas*. Manufacturers have been making bigger and better home TV antennas each year, and sales continue to rise. Thus, viewers can see good pictures in more and more of their neighbors' homes.

The most important step on the road to top-quality TV reception is to select the right antenna. Unfortunately, this is not as easy as it sounds. There are quite a few well-known manufacturers and each makes a bewildering variety of antennas. No one type of antenna is "best" for all reception conditions. There are, however, a number of guidelines that can help you to choose the right antenna for each specific reception area.

Some antennas are made for v.h.f. only (channels 2 through 13), others for u.h.f. only (channels 14 through 83), and still others receive all 82 channels. Many installers prefer to use 82-channel antennas even in v.h.f.-only areas in order to accommodate any new u.h.f. stations that might go on the air.

TV signals get weaker as they travel away from the transmitter. Table 1 indicates the approximate distances at which TV signals can be received. Remember, however, that these distances are based on nearly perfect, problem-free areas. Put a hill, a tall building, or, in some cases, even a few high trees, between the transmitting antenna and the receiving antenna and these distances may have to be revised downward.

Also, the distance from which a TV signal can be received is affected by the channel frequency. The higher the frequency, the greater the signal loss. Thus, while you may be able to receive channel 14 at 90 miles, you probably can't receive channel 70 at that distance. The same sort of effect would occur in comparing reception of channel 2 with that of channel 13.

TV signals travel through space in at least three ways: 1. line-of-sight, 2. surface waves, and 3. waves reflected from ionized layers in the upper atmosphere.

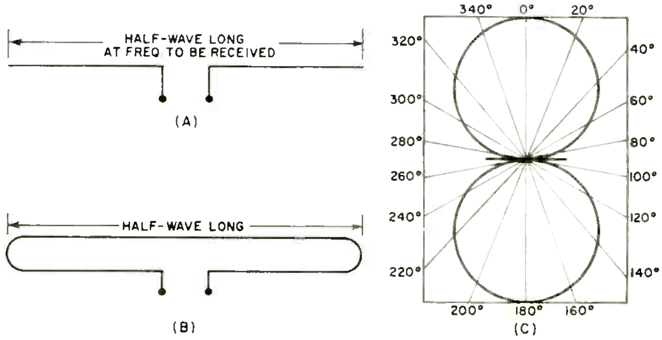
Surface waves follow the curvature of the earth. They are very reliable at AM radio frequencies, which is why AM antennas are so small and simple. Surface waves at TV and FM frequencies, however, are very quickly absorbed.

Reflected waves are unreliable and unpredictable. The ionized layers in the upper atmosphere shift from

	V. H. F.	U. H. F.
Local Signal	0 to 15 miles	0 to 15 miles
Medium Signal	15 to 40 miles	15 to 30 miles
Fringe Signal	40 to 80 miles	30 to 60 miles
Deep Fringe Signal	80 to 120 miles	60 to 90 miles

Table 1. Approximate distances for good TV reception.

Fig. 1. (A) Basic center-fed 75-ohm half-wave dipole. (B) Folded half-wave dipole has 300-ohm impedance. (C) Top-view polar chart of half-wave antenna.



dB	Voltage Times(X)	dB	Voltage Times(X)	dB	Voltage Times(X)
1	1.12	6	2	11	3.55
2	1.25	7	2.25	12	4
3	1.4	8	2.5	13	4.5
4	1.6	9	2.75	14	5
5	1.8	10	3.16	15	5.6

Table 2. Decibel (dB) to voltage gain conversions.

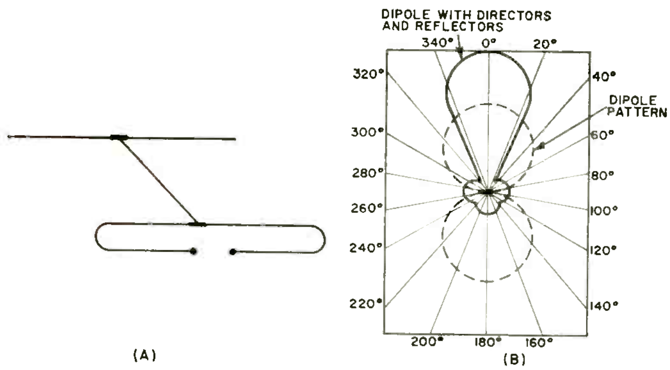


Fig. 2. (A) Folded dipole with reflector. (B) Polar pattern of dipole with reflector, director elements.

day to day and hour to hour. Reflected waves are primarily responsible for the amazing distances at which both radio and TV signals are occasionally received. Reflected waves are friends of the patient DX-er, but we just can't count on them for consistent TV reception.

This leaves us with straight line-of-sight waves. At low v.h.f. frquencies, some bending does occur due to refraction of the atmosphere, but to a great extent, you can't get good TV reception over the horizon. Of course, you can always increase the effective horizon by increasing the height of your receiving antenna.

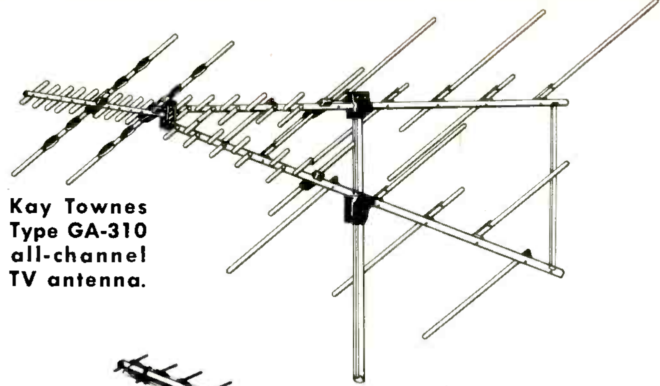
Some antennas pick up more signal than others. To make uniform, valid comparisons of relative antenna efficiency, engineers have chosen the simple half-wave dipole (see Figs. 1A and 1B) as a standard.

The amount of signal picked up by a standard half-wave dipole at any given location or distance from the transmitter is known as unity gain or 0 decibels (dB). An antenna that picks up twice as much signal voltage as a standard dipole at a given location is said to provide 6-dB gain. Of course, the antenna is a passive device. It doesn't actually amplify the signal; it simply captures more of the signal available in that area, in a given direction, at the expense of signal in other directions.

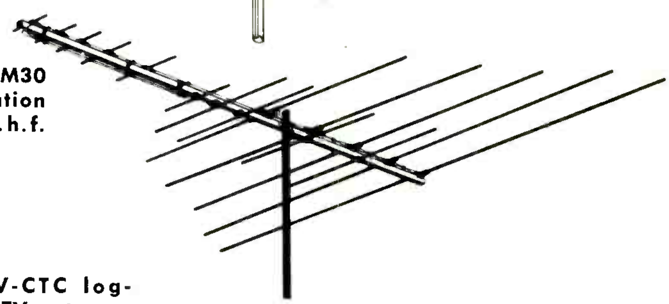
Table 2 shows how to convert dB to signal voltage. Remember that 0 dB is *not* equal to zero signal or zero times. It is equal to 1 time. From Table 2 you can see that an antenna specified at 10-dB gain picks up about three times as much signal voltage as a standard dipole.

All TV antennas, including the simple dipole, are directional. In other words, they must be aimed or oriented in the right direction in order to pick up maximum signal.

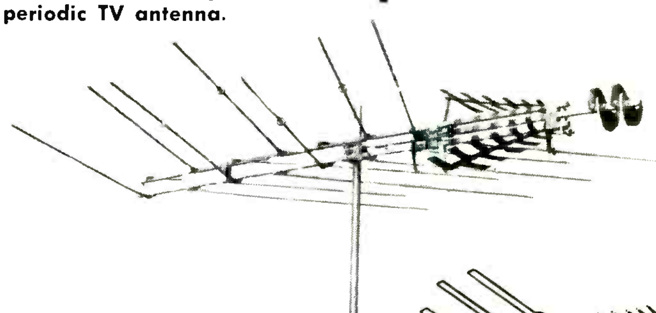
The directivity of an antenna is generally indicated by a polar plot. A polar plot is derived by rotating an antenna and measuring signal pickup for each direc-



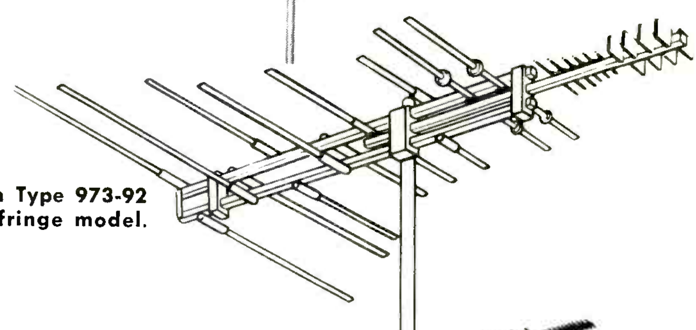
Kay Townes Type GA-310 all-channel TV antenna.



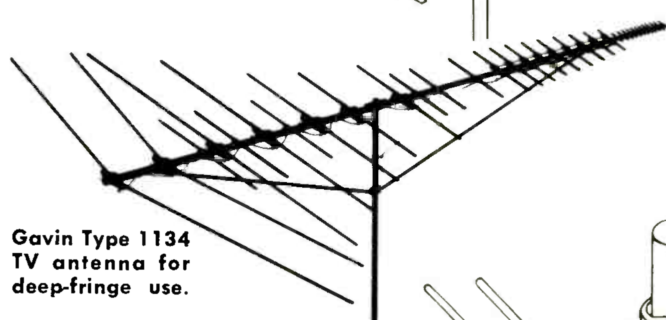
S & A UVM30 combination v.h.f./u.h.f.



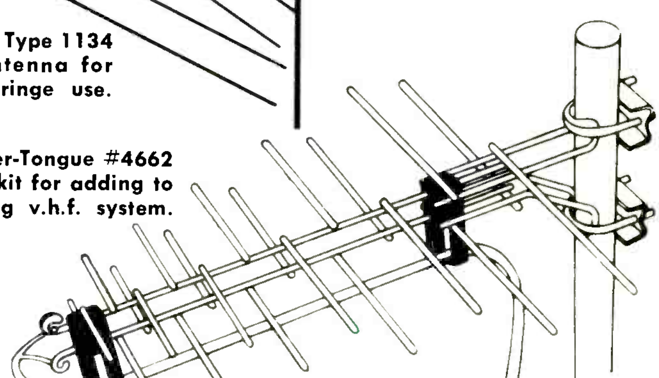
JFD LPV-CTC log-periodic TV antenna.



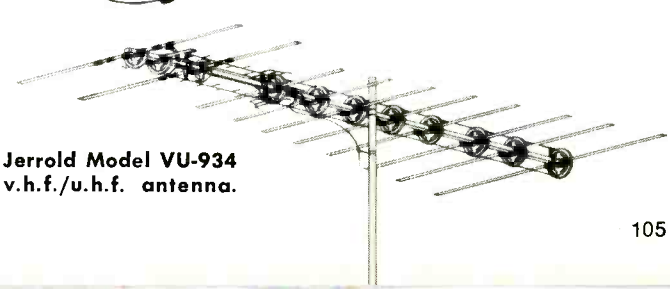
Zenith Type 973-92 near-fringe model.



Gavin Type 1134 TV antenna for deep-fringe use.



Blonder-Tongue #4662 u.h.f. kit for adding to existing v.h.f. system.



Jerrold Model VU-934 v.h.f./u.h.f. antenna.

Ch.	Full Wavelength In Air (in)	Ch.	Full Wavelength In Air (in)	Ch.	Full Wavelength In Air (in)
			V.H.F.		
2	205	6	138	10	60½
3	186	7	66½	11	58½
4	170	8	64½	12	57
5	148	9	62¼	13	55¼
			U.H.F.		
14	25	44	18	64	15¼
24	22¼	54	16½	74	14¼
34	19¾			83	13¼

Table 3. Frequencies of the various TV channels along with the lengths of a full wave measured in air. To find the length of a half-wave antenna for the various channels, simply halve the length shown and take about 95% of your answer. Because of "end effect," antenna element operates as though it were about 5% longer.

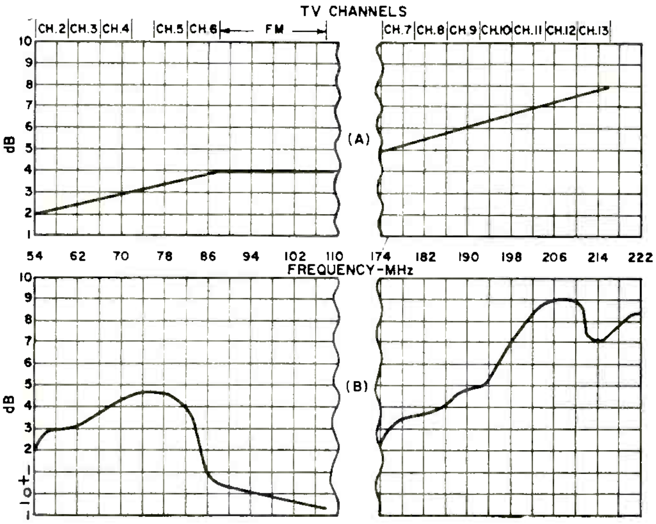


Fig. 3. (A) Idealized gain curves for v.h.f.-FM antenna. (B) Actual curve of an older antenna once widely sold.

tion in which it is aimed. Fig. 1C shows the polar plot of a standard dipole. Notice that the dipole (dotted pattern) receives signals equally well from front (0°) and back (180°). However, it doesn't receive signals from the sides (90 and 270 degrees). The curves on the polar plot are called "lobes." Notice that the front and back lobes on a half-wave dipole are equal in size.

In almost all cases, the back lobe is worse than useless. However, we can eliminate the back lobe and increase the forward pickup of the antenna by adding elements to the antenna. Fig. 2A shows a dipole with a reflector element behind it. There is no electrical connection between the dipole and the reflector. Its function is similar to that of a flashlight reflector. Some of the TV signal from the transmitter hits the reflector, which bounces it back into the dipole. Director elements can also be used in front of the dipole, to focus more signal energy into the dipole. The effect of adding directors and reflectors to the dipole is shown in Fig. 2B.

It is impossible to eliminate the back lobe entirely. But one criterion of a good antenna is that it have a high front-to-back ratio. In other words, the front lobe should be much greater than the back lobe, to prevent pick-up of unwanted signals.

Antenna Flatness

Up to this point, we have assumed that the antenna worked equally well on all TV channels. However, this is not the case. As indicated in Table 3, a full-wave dipole for channel 2 is about 205 inches long while a full-wave dipole for channel 13 is only 55¼ inches long. Therefore, a dipole cut for channel 13 won't be very efficient for picking up channel 2.

Rather than use antennas cut for a single channel, most antenna manufacturers use elements cut to compromise lengths in order to produce broad-band antennas covering all channels. However, no broad-band antenna is perfectly flat, picking up all channels equally. Most antennas, in fact, are deliberately designed to provide more gain at the higher frequencies where it is usually needed.

Fig. 3A shows an idealized curve for a v.h.f.-FM antenna. Notice that gain gradually increases from channels 2 through 6 and then from 7 through 13. Fig. 3B, on the other hand, is an actual curve of an older type of antenna once sold widely. Notice that gain fluctuates rather wildly. This causes little difficulty with black-and-white reception, especially if the low-gain channels are not used in the area. But uneven response can ruin a color picture, especially if there is a severe drop-off in gain at the color-carrier frequency. The color carrier is detected in phase, so that any significant tilt in frequency response shifts the phase of the color signals, changing colors on the TV screen. If there is not enough gain at the color-carrier frequency, then color will be lost altogether.

Antenna engineers generally agree that response within any single TV channel should be flat within 1 dB for really good color pictures.

Height and Position

In general, the higher you get the antenna, the more signal it will pick up. Extra height means fewer obstructions in the way of the signal. However, it is not at all

Table (right) shows antennas recommended by various antenna manufacturers for different signal areas. All antennas are outdoor types. We have limited each manufacturer to a single choice; in many cases, there are other antennas in the company's line with somewhat different gains and directional characteristics but at least we have given our readers a good starting point. Most of the antennas are general-purpose types where no special installation or interference problems exist. The suggested retail prices are given below each model. Although it is difficult to give exact mileage figures for local, medium, and fringe areas; in general, local signals are received in metropolitan areas within about 15 miles of the TV transmitters, medium signals are for suburban areas from about 15 to 40 miles, and fringe signals are for distances from about 40 to 80 miles and beyond. It is frequently possible to combine a v.h.f. antenna with a u.h.f. antenna provided a splitter and/or stacking bars are used. We have not listed such arrangements in our combination antennas, however. Our listings are only for those combination antennas that are sold in a single package or as a single antenna kit. Most of these antennas, although designed mainly for color-television, can be used for FM reception as well.

RECOMMENDED ANTENNAS FOR VARIOUS SIGNAL AREAS

	V.H.F. ONLY			U.H.F. ONLY			V.H.F.—U.H.F. COMBINATIONS								
							V.H.F. LOCAL SIGNAL			V.H.F. MEDIUM SIGNAL			V.H.F. FRINGE SIGNAL		
MANUFACTURER	Local Signal	Medium Signal	Fringe Signal	Local Signal	Medium Signal	Fringe Signal	U.H.F. Local Signal	U.H.F. Medium Signal	U.H.F. Fringe Signal	U.H.F. Local Signal	U.H.F. Medium Signal	U.H.F. Fringe Signal	U.H.F. Local Signal	U.H.F. Medium Signal	U.H.F. Fringe Signal
Antennacraft Co.	CS-500 $12.95	CS-800 $39.95	CS-1000 $69.95	Y-11G $9.95	Y-20G $14.95	Y-28G $19.95	Big Shot 8 $9.95	CDX-650 $24.95	CDX-750 $34.95	CDX-750 $34.95	CDX-850 $44.95	CDX-1050 $69.95	CDX-1050 $69.95	CDX-1050 $69.95	CDX-1050 $69.95
Blonder-Tongue Labs. Inc.	0610 $16.97	0611 $24.56	0613 $30.48	3518 $8.46	0511 $14.00	0512 $22.00	0711 UR-6 $32.76	0711 UR-6 $32.76	0712 UR-11 $41.73	0713 UR-6 $39.36	0713 UR-6 $39.36	0714 UR-11 $47.75	0718 UR-6 $44.98	0718 UR-6 $44.98	0719 UR-11 $54.95
Channel Master	3615 $17.50	3612 $46.95	1210 $79.95	4315 $11.80	4313 $18.48	4314 $25.56	3668 $20.95	3667 $23.95	1262 $30.95	3665 $32.95	1252 $49.95	1251 $56.95	3662 $69.95	3661 $82.95	1211 $96.95
Finney Co.	CS-V5 $18.95	CS-V10 $39.25	CS-V18 $61.95	CS-U1 $10.95	CS-U2 $16.95	CS-U3 $24.75	CS-A1 $21.95	CS-A2 $26.50	CS-A3 $34.50	CS-B1 $33.75	CS-B2 $44.95	CS-B3 $55.95	CS-C1 $49.50	CS-C2 $58.25	CS-D3 $78.50
Gavin Instruments	1011 $23.95	1019 $41.95	1026 $62.50	CR-5 $6.75	CR-5 $6.75	CR-10 $11.50	1106 $17.50	1113 $29.95	1122 $47.95	1110 $22.95	1118 $39.95	1122 $47.95	1118 $39.95	1122 $47.95	1134 $67.95
Jerrold Electronics Corp.	VIP-301 $16.95	VIP-303 $32.95	VIP-306 $59.95	PAU-450 $9.95	PAU-700 $14.95	PAU-900 $25.95	VU-931 $22.95	VU-932 $30.95	PXB-48 $27.95	VU-932 $30.95	VU-933 $41.95	PXB-65 $47.95	VU-934 $51.95	VU-934 $51.95	VU-935 $64.95
JFD Electronics Co.	LPV-6L $24.70	LPV-11L $46.70	LPV-17L $68.80	LPV-UCL 13 $16.30	LPV-UCL 22 $29.90	LPV-UCL 26 $35.26	LPV-CL55 $20.95	LPV-CL240 $27.95	LPV-CL260 $44.52	LPV-VU30 $25.15	LPV-CL400 $48.25	LPV-CL600 $73.45	LPV-VU180 $60.85	LPV-CTC1600 $64.95	LPV-CTC1800 $79.95
Kay-Townes Ant. Co.	GA-600G $18.90	GA-300G $42.53	GA-100G $65.33	AAU-5G $11.10	C-1G $11.15	AAU-21G $27.85	GA-720G $21.27	GA-720G $21.27	GA-510G $46.70	GA-520G $40.87	GA-310G $55.32	GA-210G $66.72	GA-520G $40.87	GA-210G $66.72	GA-110G $79.51
Lance Industries	LC-880 $20.30	LC-881 $29.90	LC-884 $59.80	KW4S $7.95	LU-820 $13.65	LU-840 $34.35	LC-80 $19.05	LC-81 $27.65	LC-81 $27.65	LC-81 $27.65	LC-82 $32.00	LC-83 $58.25	LC-38 $39.90	LC-117 $50.75	LC-119 $62.40
RCA Parts & Accessories	10B807 $15.95	10B814 $33.95	10B825 $62.95	10B705 $8.95	7B140 $8.95	7B141 $11.75	10B907 $14.95	10B912 $24.25	10B917 $29.95	10B910 $19.95	10B917 $29.95	10B925 $49.95	10B920 $39.95	10B925 $49.95	10B930 $64.95
RMS Electronics, Inc.	STP-7 $14.45	STP-11 $20.95	STP-28 $56.95	BT-4 $7.95	U-9 $9.95	U-15 $19.95	DYN-33US $19.95	DYN-54US $29.95	DYN-118US $44.95	DYN-54US $29.95	DYN-66US $34.95	DYN-118US $44.95	DYN-88US $44.95	DYN-118US $44.95	DYN-158US $49.95
S&A Electronics Inc.	ST-6 $13.50	ST-11 $22.95	ST-20 $49.50	UPW-12 $8.20	UPW-26 $19.25	UPW-36 $26.95	UVM-20 $19.70	UVM-30 $32.95	UVM-35 $44.70	UVM-25 $29.10	UVM-30 $32.75	UVM-35 $44.70	UVM-35 $44.70	UVM-35 $44.70	UVM-40 $58.75
Sylvania Electric Products Inc.	007-SG $16.95	1010-SG $34.95	2525-SG $54.95	2U $11.95	2U $11.95	4U $19.95	7VUSG $34.95	7VUSG $34.95	10VUSG $44.95	10VUSG $44.95	10VUSG $44.95	22VUSG $54.95	25VUSG $64.95	32VUSG $74.95	32VUSG $74.95
Winegard Co.	SC-51 $24.95	SC-52 $34.95	CW-46 $49.95	U-965 $14.95	U-975 $22.95	U-995 $32.95	SC-79 $22.95	SC-80 $29.95	SC-81 $39.95	SC-81 $39.95	CW-96 $55.50	CW-98 $72.50	CW-96 $55.50	CW-98 $72.50	CW-1000 $100.00
Zenith Sales Corp.	973-83 $19.95	973-85 $39.95	973-87 $59.95	973-101 $8.95	973-8 $14.95	973-10 $31.95	973-89 $21.95	973-90 $29.95	973-91 $36.95	973-92 $49.95	973-92 $49.95	973-92 $49.95	973-93 $59.95	973-93 $59.95	973-94 $79.95

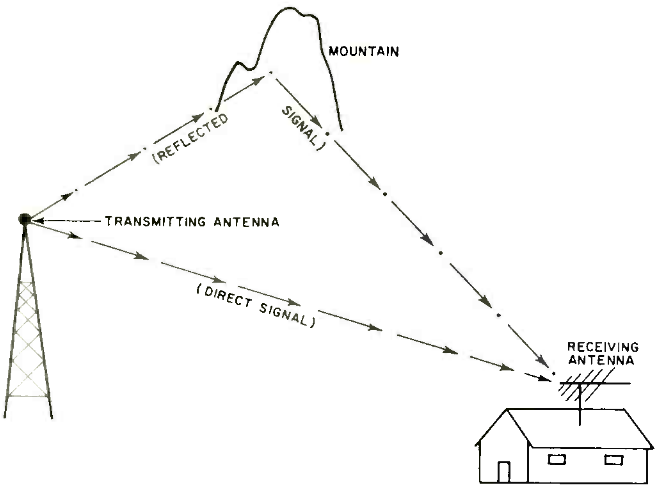


Fig. 4. Ghosts result from direct and reflected signals.

unusual to find "hot" and "dead" spots at various heights, especially at u.h.f.

The only accurate way to determine how high the antenna should be mounted is to make a signal survey, using a test antenna connected to a field-strength meter. Unfortunately, this is a difficult, time-consuming process. To do a really good job, you have to survey the signal reaches the receiving antenna *via* two paths— a period of 24 hours or more, for each channel to be received. MATV and CATV system installers can go to this trouble and expense, but it is generally not practical for a home installation.

For mechanical simplicity, you're better off to keep the antenna as low as possible. A 5- to 10-foot mast is a lot easier to install than a 20-foot mast. In fringe and deep-fringe areas, you'll need quite a bit of height, but it's not a bad idea to start off low and add 5-foot sections only if they are needed. Of course, once you have made a few installations in a given area, you'll know how high you need to go.

Incidentally, in metropolitan and surburban areas, it's a good idea to consider attic installations. Keeping the antenna indoors simplifies the installation and makes it last longer.

Eliminating Ghosts

More TV pictures are ruined by "ghosts" or multiple images, than by any other cause. Ghosts are caused by reflections, as shown in Fig. 4. The same transmitted signal reaches the receiving antenna *via* two paths— one direct and one reflected from a building, hill, water tower, or some other obstruction.

The trouble is caused by the fact that the reflected signal travels farther, therefore it reaches the antenna a split second later. Since TV signals travel through the air so rapidly (about 1000 feet per microsecond), you might think that the delay would not be important. But the horizontal oscillator in a TV receiver sweeps the electron beam across the picture tube very rapidly too, at about 53 microseconds across the screen. If the picture is 20 inches wide and if the reflected signal travels only an extra 1000 feet, the "ghost" is displaced by about 1/53 of 20 inches or almost 4/10th of an inch to the right of the direct image.

Closely spaced ghosts appear on the screen as fuzzy smears that can be ignored on a monochrome receiver. But on a color screen, not only is the ghost displaced to the right, but it introduces extraneous new colors to the picture. That's why it's so important to eliminate ghosts for good color reception.

The best way to eliminate ghosts is to get an antenna that is highly directive, with good front-to-back ratio and a single, narrow front lobe. Then, orient the antenna for minimum ghost pickup, rather than maximum direct signal pickup.

In really difficult signal areas, you can try horizontal stacking of two identical directional antennas. If you space and orient the two antennas properly, they pick up reflected signals that are equal in amplitude, but 180° out-of-phase. Thus, reflected signals cancel each other out; the direct signals are received in-phase.

Types & Construction

One type of antenna used for today's color installations, the yagi, is noted for high gain and excellent directivity. However, many early yagi designs were not flat enough for good color reception.

It was primarily for this reason that the log-periodic antenna was developed. Like the yagi, the log periodic uses groups of elements tuned to specific channels. The distinguishing feature of the log periodic is that the elements are spaced logarithmically and tapered from front to back. Log-periodic antennas are noted for flatness.

In both types of antennas, a single element may resonate in two or more modes to pick up two or more channels. For example, an 80-inch element is about a half wavelength long at channel 4 and about 3/2 wavelengths long at channel 12. Using double-duty elements makes today's antennas more efficient, but it does cause some problems. Elements resonating the 3/2 wavelength mode pick up signals quite well, but they have side lobes, which can easily pick up unwanted signals.

To eliminate side lobes, manufacturers use a number of devices, such as angling elements forward or using special resonating devices. In any case, there is little to choose between modern, well-designed yagis and log periodics. Most of today's yagis are quite flat and most of today's log periodics are designed to pick up just as much signal as equivalent yagis. In addition, there are other elaborate types produced by some manufacturers that are neither yagis nor log periodics but use an array of interconnected and driven elements to produce the desired gain and directivity.

Another type of antenna is designed specifically for metropolitan areas. In metropolitan areas, gain is no problem. Signals are, if anything, too strong. Metropolitan type antennas are designed to overcome the problem of ghosts. Therefore, they are made not to pick up weak signals, but they use reflectors, phasing harnesses, traps, and other devices to minimize pick-up of reflected signals.

When you put up an antenna, you want it to last— to deliver top-quality pictures for many years. Therefore, mechanical construction is vitally important. Booms and antenna elements should be as heavy and strong as possible. Elements should be braced internally. Contacts should be secure—the type that tightens rather than loosens in the wind. And the entire antenna, including mounting hardware, should be protected by a corrosion-resistant coating. ●

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KITS . . . KITS . . . KITS

Over 300 electronic kits — literally something for everyone — are pictured and described in a new 116-page 1970 product catalogue now being distributed.

The line includes stereo/hi-fi components; ham radio gear; marine gear; test, service, and lab equipment; Citizens Band radios; short-wave receivers; photographic aids; educational kits; electric guitar amplifiers and accessories; plus a wide range of home and hobby items, including color and black-and-white TV sets, electric organs, AM/FM table model receivers; home protection systems; garage door openers; intercoms; stereo compacts; automotive kits; and control equipment for models.

If you can't resist the lure of trying your hand at building your own equipment, a copy of this catalogue is a "must." Heath

Circle No. 41 on Reader Service Card

* * *

TEST EQUIPMENT

A quick reference catalogue (69D4) providing brief descriptions of an extensive line of test equipment for the service shop is available.

Included in this 8-page publication is information on color-bar generators, CRT testers, scopes, probes, radio analyzers, signal generators, sweep generators, transistor testers, tube testers, v.o.m.'s, and v.t.v.m.'s.

If after reading the capsuled comment on each item you want additional specifications on any model, the company will supply the information you require. Hickok

Circle No. 42 on Reader Service Card

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SOLID-STATE CB RADIO

What is billed as the "world's smallest 5-watt radio" is now available for service in the 27-MHz Citizens Band. The solid-state mobile "Messenger 125" features push-button station selection, slide-lever squelch and volume, plus a unique solid-state "talk-power" circuit for high-performance two-way communications.

This 5-channel unit measures only $1\frac{9}{16}$" high x $4\frac{19}{32}$" wide x 7" deep and weighs about 5 pounds. With its small size it can be installed in virtually every automobile, including 1970 models. The radio can also be used as a portable with an accessory battery pack and carrying case. E. F. Johnson

Circle No. 43 on Reader Service Card

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SERVICE-TYPE INSTRUMENTS

A four-page data sheet covering nine "service-engineered" test instruments is ready for you.

Each of the instruments is pictured and pertinent electrical and mechanical specifications provided. Included in the line are a dynamic tube tester, CRT tester/booster, solid-state color generator, an audio sine/square-wave generator, a variable regulated power supply, a dynamic output tube tester, a vacuum-tube voltmeter, an in-circuit transistor tester, and a wide-band oscilloscope-vectorscope. Jackson

Circle No. 44 on Reader Service Card

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DISTRIBUTION-SYSTEM KITS

Four new home kits, designed to make any home a complete entertainment center, have just been introduced. Each kit is capable of providing one FM or up to four TV programs, in as many locations, from a single antenna. Each kit contains a solid-state amplifier, wall plates, surface mounting housings, and all necessary signal splitters and matching transformers. Kits are available for city, suburban, and fringe reception areas, using 300-ohm twin-lead or 75-ohm coax.

The Model HS41-300 is for 300-ohm installations in the city or suburban areas; Model HS41-75 is for 75-ohm installation in city or suburbs; Model HS42-300 is for 300-ohm installation in fringe or weak signal areas while the Model HS42-75 is the 75-ohm version of the fringe model.

A colorful 8-page brochure covering these systems is available. JFD

Circle No. 45 on Reader Service Card

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ANTENNAS FOR EVERY NEED

The company's line of "Golden Arrow" antennas for u.h.f./FM/v.h.f. or FM/v.h.f. channels 2 to 13 are pictured in a four-color folder which is yours for the asking.

There are models for deep fringe, near fringe, city, and near-fringe v.h.f./deep-fringe u.h.f.—in any combination required. Each antenna is supplied with a bandsplitter at no additional charge. Kay-Townes

Circle No. 46 on Reader Service Card

* * *

IGNITION SYSTEM SPECS

Performance specifications on the "electronic magneto" ignition system are included in a one-page data sheet and a reprint from "Speed & Custom Dealer."

This silicon transistor system is designed to be used in cars, trucks, buses, boats, tractors and lift trucks, and in industrial engines. It measures $7\frac{1}{2}$" x $3\frac{1}{2}$" and the system is zener-diode protected. It provides a minimum of 30,000 volts with a rise time of 0.5 microsecond. The same unit can be used on either 6- or 12-volt systems, single- or dual-point ignition distributors. Both negative- and positive-ground systems are available. Judson

Circle No. 47 on Reader Service Card

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TV/FM ANTENNAS GALORE

A lavish new 28-page catalogue, covering all-channel v.h.f./FM/u.h.f.; v.h.f./FM; FM, indoor, and u.h.f. antennas for any reception contingency, is ready for distribution.

In addition to providing complete technical information on each type and model antenna, the catalogue lists a line of antenna installation aids, antenna preamps, a TV camera, 300-ohm products, home systems, 75-ohm products, and outlets, connectors, and transformers. Each antenna is pictured, polar patterns and gain charts are supplied on each model, and recommended applications are outlined to make it easy to pick the right antenna for the job. Jerrold

Circle No. 48 on Reader Service Card

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TECHNICIAN'S TEST EQUIPMENT

You can usually spot a "pro" by the equipment he uses and a complete line of equipment for the professional service technician is pictured and decribed in a new 8-page brochure you can have.

Included is a vectorscope/color-bar generator, a color-bar generator, separate vectorscope to be used with any 10-bar color generator, picture-tube analyzer, an in-circuit transistor tester, a transistor TV sweep circuit analyzer, CB analyzer and frequency meter, an oscilloscope/vectorscope, regulated power supplies, and various accessories. Lectrotech

Circle No. 49 on Reader Service Card

* * *

23-CHANNEL CB TRANSCEIVER

An 18-transistor, 23-channel CB transceiver has been introduced as the "Fieldmaster" Model TR-18.

It features 5 watts input and 3½-4 watts output. Suppression of spurious signals is 40 dB and frequency tolerance is ±0.004%. Receiver sensitivity is 0.7 μV at 10 dB and image rejection at 28 MHz is greater than 30 dB. Audio output is 3 watts and squelch sensitivity is 1 dB or less.

The transceiver comes with a dynamic microphone with integral matching transformer. The set is housed in a heavy gauge steel cabinet with baked lacquer finish. The unit measures 5⁵⁄₁₆" wide x 2¼" high x 9" deep. It operates from 12.5-13.6 volts d.c. Chas. A. Messenger

Circle No. 50 on Reader Service Card

* * *

KITS/WIRED TEST GEAR

A 12-page brochure which lists a wide assortment of electronic test instruments in both kit and wired versions is available.

It provides complete specs on an oscilloscope/vectorscope, an FET meter, a mutual-conductance tube tester and grid-circuit analyzer, a tube tester, a picture tube analyzer/rejuvenator, a professional v.t.v.m., a compact tube tester, a solid-state generator, an in-circuit capacitor tester, a component substitutor, a wide-band scope, a regulated power supply, and a line of self-service tube testers and indoor antennas. Mercury

Circle No. 51 on Reader Service Card

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CB LINE BROCHURE

A pocket-size brochure that pictures and describes an extensive line of CB equipment is available as EP-6001.

Included are hand-held transceivers of various wattages and channel capacities, base/mobile units, mobiles, and a line of CB accessories.

You can have a copy of this handy folder on request. Midland

Circle No. 52 on Reader Service Card

* * *

ANTENNA & ROTATOR GUIDE

A handsome four-color foldout chart, suitable for posting on the shop wall, is now available as a "Guide to Complete Reception with Antennas and Rotators."

The chart is divided into four main sections covering v.h.f./FM outdoor antennas, u.h.f./v.h.f./FM outdoor antennas, FM outdoor antennas, and u.h.f. outdoor antennas. Each model is illustrated and information on element lengths, boom lengths, boom supports, and kit/assembled availability given. Companion rotators and controls are also illustrated and described. RCA

Circle No. 53 on Reader Service Card

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TEST EQUIPMENT FOR SERVICE

Sixteen pages crammed with information on general-service test equipment for industrial electronic and electrical testing is what you will find in Bulletin 20788.

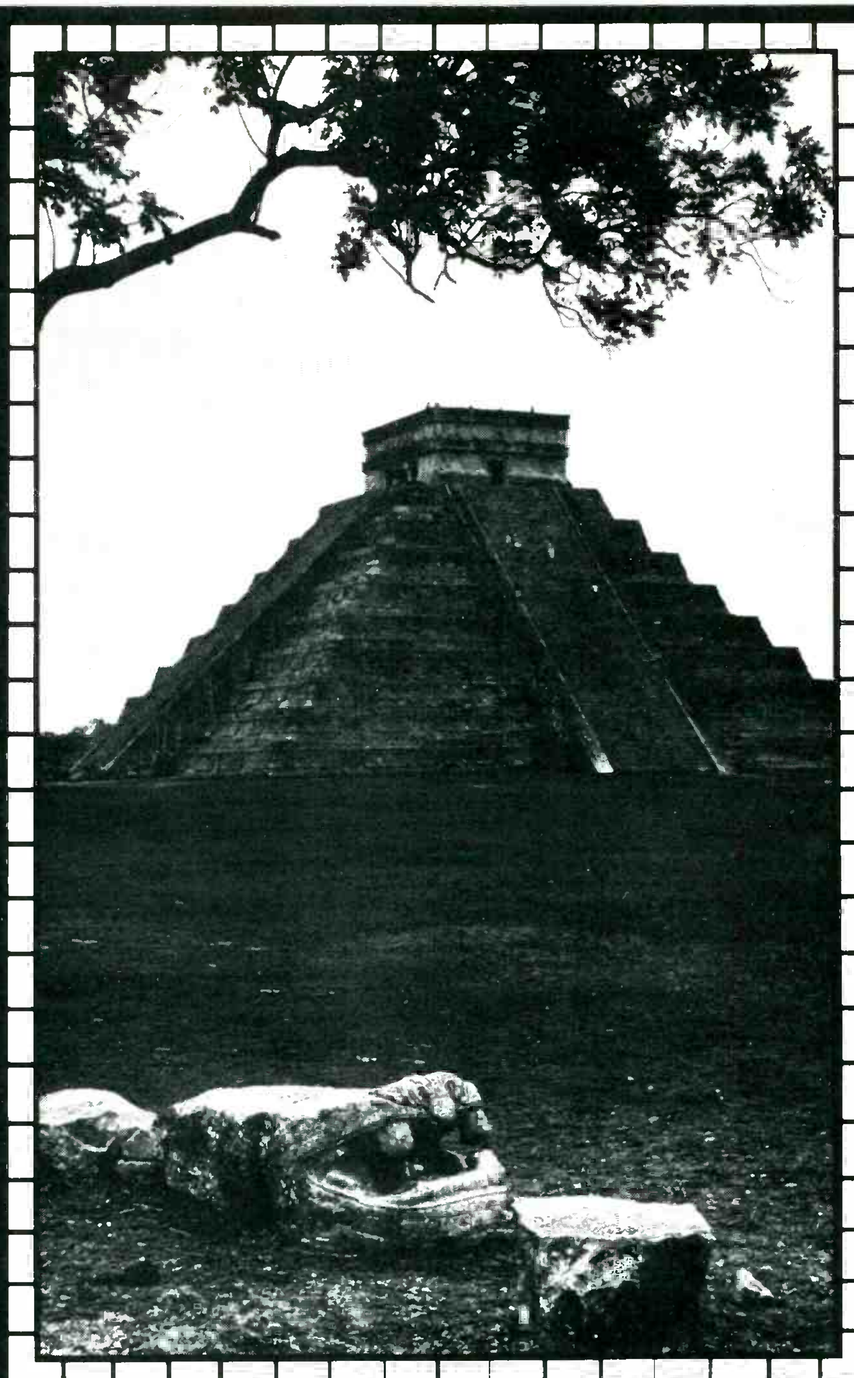
There are v.o.m.'s, v.t.v.m.'s, multitesters, micro-testers, 5" oscilloscopes, a 7" colorscope which displays colorburst frequency, an in-circuit capacitor

TRANSISTORIZED V. M.'s/V. O. M.'s

MFR.	MODEL	RANGES* D.C., A.C. (r.m.s.) VOLTS	OHMS/ MID-SCALE	A.C., D.C.† CURRENT	D.C. INPUT RES. (MΩ)	A.C. INPUT Z (MΩ—pF)	ACCURACY % (FULL-SCALE) D.C.	A.C.	A.C. FREQUENCY RESPONSE	PRICE $(K-kit)	REMARKS
B & K	176	0.1—5000 d.c. 0.5—1500 a.c.	10—	150µA— 5A						99.95	Uses FET
DELTA	3000	0.3—1000	10—10M	0.03µA— 300mA	10	10—	±2	±3	—	59.95	Uses FET, IC
EICO	240	1—1000	10—10M	—	11	1—	±3	±3	25Hz—2MHz	69.95 49.95(K)	Uses FET
	242	1—1000	10—10M	1mA—1A†	11	1—	±3	±3	25Hz—2MHz	79.95 59.95(K)	Uses FET 6½-in meter
HEATH	IM—16	0.5—1500	10—10M	—	11	1—	±3	±5	20Hz—1MHz	69.95 46.95(K)	Line or batt. operated
	IM—17	1—100	10—10M	—	11	1—	±3	±5	10Hz—1MHz	21.95(K)	Portable
	IM—25	0.15—1000	10—10M	15µA— 1500mA†	11	10—150	±3	±5	10Hz—100kHz	120.00 85.00(K)	Line or batt. operated
MERCURY	4000	0.3—1000 d.c. 1—1000 a.c.	10—10M	300µA— 1000mA	11	2—30	±3	±5	10Hz—1MHz	79.95	Uses FET Line or batt. operated
RCA	WV—500B	0.5—1500 d.c. 1.5—1500 a.c.	10—10M	0.5—1500 mA	11	0.8—70	±3	±3	30Hz—3MHz	79.00	Battery operated
SENCORE	FE—14	1—1000	10—10M	1mA— 1A	15	10—29	±3	±5	10Hz—10MHz	69.95	Uses FET'S
	FE—16	1—1000	10—10M	1mA— 1A	15	10—29	±1.5	±3	10Hz—10MHz	84.50	Uses FET's
	FE—149	0.5—1500	6—60M	150µA— 5A	15	15—	±1.5	±3	10Hz—10MHz	149.50	Uses FET's
SIMPSON	313	0.3—1000	10—10M	100µA— 1A	11	10—	±3	±3	20Hz—100kHz	125.00	Uses FET's Push-buttons
TRIPLETT	310—FET	0.3—600 d.c. 3—600 a.c.	50—50M	0.12— 1.2mA	10	5—	±3	±4	—	70.00	Uses FET's hand-size
	600	0.4—1600 d.c. 4—800 a.c.	10—10M	—	11	0.75—	±3	±3	—	82.00	Uses FET'S
	601	0.1—1000 d.c. 0.01—1000 a.c.	10—10M	10µA— 10mA†	11	11—	±2	±3	50Hz—50kHz	150.00	Uses FET's Low-pwr. ohms

* Full-scale readings for lowest and highest ranges. † A.C. and d.c. current ranges

Take this picture to your travel agent.



Chichén Itzá, Mexico/ Photo by Les Barry

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leakage tester, temperature-measuring instruments, appliance testers, carrying cases, test leads, high-voltage probes, temperature leads and probes—all pictured and described in meticulous detail. Simpson

Circle No. 54 on Reader Service Card

* * *

SOLID-STATE BASE STATION

The "Flagship" is a completely transistorized 23-channel CB transceiver with an exclusive pulse eliminator designed especially for base-station use. This patented circuit eliminates electrical impulse noise that often blanks out weak signals.

The design incorporates an ultra-sensitive double-conversion receiver, a flat a.g.c. response, sharp crystal lattice filter skirts to attenuate signals in adjacent channels, and an effective squelch circuit which permits sensitive threshold adjustments from 1 to 50 µV.

The transceiver features an "S" meter, push-button controls, a digital clock, transmit indicator, a p.a. volume control, delta tuning, and silencer gain. It is housed in a vinyl cloth covered cabinet with teakwood panel and measures 5¼" high by 13¾" wide by 10¾" deep. Squires-Sanders

Circle No. 55 on Reader Service Card

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TV ANTENNA CHART

A four-color TV antenna chart showing all of the models in the "Super Colortron" line is now available for distribution.

Each model is pictured and its features are spelled out in tabular form to make it easy to pick the right antenna for the job. Included are 82-channel/FM, v.h.f./FM, v.h.f./u.h.f./FM, v.h.f./FM, u.h.f., and FM/stereo models. The back of the chart contains information on accessories, preamps, and special features of the line. Winegard

Circle No. 56 on Reader Service Card

* * *

SOLID-STATE CB RADIO

The Model J23-1 is a solid-state CB radio which can operate on all 23 channels and comes complete with one channel installed. The companion model J23 comes with all 23 channels installed.

The unit features dual conversion, provisions for external speaker and p.a. operation, an external speaker jack, and heavy-duty all-aluminum construction.

There are 21 silicon transistors and six diodes. The circuit is built on a glass-epoxy military type PC board. It has triple amplified a.g.c., noise-immune adjustable squelch, a high-volt-

SOLID-STATE COLOR-BAR GENERATORS

MFR. & MODEL	POWER		R.F. CHANNELS	SOUND CARRIER	OUTPUT		COLOR PATTERNS			VIDEO PATTERNS							DIMENSIONS (in)			WT. lb	PRICE $(Kit=K)
	BATT.	A.C.			R.F. (µV)	VIDEO V_{p-p}	KEYED RAINBOW	NTSC BAR	OTHER	H LINES	V LINES	CROSS-HATCH	DOTS	SINGLE DOT	CROSS-HAIR	OTHER	H	W	D		
B&K 1242		✓	3 or 4		5k		✓			13	9	13 X 9	117				2¼	7	9⅜	3	99.95
B&K 1245		✓	3, 4, or 5		5k		✓							✓	✓		2⅞	8½	8⅞	3	139.95
CONAR 680	4 D-CELLS	✓	2 only or 3 only	✓	50k		✓			15	20	15 X 20	300	✓	✓	single H line / single V line	3	10	9	5	121.50 89.50(K)
EICO 380A		✓	3	✓	50k	10		✓		13	10	13 X 10	130				8½	5¾	6⅜	4	225.00
EICO 385	6 C-CELLS	✓	3		50k		✓			7	8	7 X 8	56				3	8½	8½	3	109.95 79.95(K)
HEATH IG-28		✓	2 thru 6	✓	50k	1	✓		3 bars	9	9	9 X 9	81			3 X 3, shading bars	5½	13½	8	6½	114.95 79.95(K)
HICKOK GC660		✓	3, 4 or 5	✓	50k	2	✓			18	18	18 X 18	324				10⅜	10¾	5	6¼	179.50
JACKSON X 100		✓	2 thru 6		50k	4		✓		15	20	15 X 20	300				6¼	10	4½	9	149.95
KNIGHT-KIT KG-685		✓	3, 4 or 5	✓	10k	2	✓			13	9	13 X 9	117			stair-step	4⅝	12	9⅝	12	79.95(K)
LEADER LCG 388		✓	5 or 6		10k	3	✓		3 bars, rainbow	15	21	15 X 21	315	✓	✓	2 X 3	3⅛	7¾	7¾	4½	149.00
LEADER LCG 389		✓	5 or 6		10k	3	✓			15	21	15 X 21	315				2¼	7¾	7¾	3	99.00
LEADER LCG 390		✓	5 or 6		10k	3	✓		3 bars	15	21	15 X 21	315		✓		2¼	7¾	7¾	3	119.00
LECTROTECH V6-B		✓	3, 4 or 5		100k		✓			13	9	13 X 9	117				3½	7⅝	9	5½	99.50
LECTROTECH V7[1]		✓	3, 4 or 5		100k		✓			13	9	13 X 9	117				7½	8¼	12⅞	13	199.50
MERCURY 1900 (1901)	8 C-CELLS	✓	3, 4 or 5		100k		✓			13	9	13 X 9	117				6¼	10	4½	5	89.95 (84.95)
RCA WR-502A	4.2V MERC.		3 or 4	✓	10k		✓			13	10	13 X 10	130				6½	7½	4	4	148.50
SENCORE CG18	8 C-CELLS		2, 3, 4, 5 or 6		2k		✓			13	9	13 X 9	117				3¾	9½	7¾	7	129.95
SENCORE CG19	2 5.6V MERC.		2, 3, 4, 5 or 6		2k		✓			13	9	13 X 9	117				2½	8¼	5½	3	84.50
SENCORE CG153		✓	2 thru 6	✓	2k		✓			13	9	13 X 9	117	Mov-able	Mov-able		10¼	9½	4	9	169.95

[1] Hybrid (includes tubes). Also includes vectorscope.

age-regulated receiver, and an exclusive isloated series noise gate. An a.c. power supply for base-station applications is available. Sonar

Circle No. 57 on Reader Service Card

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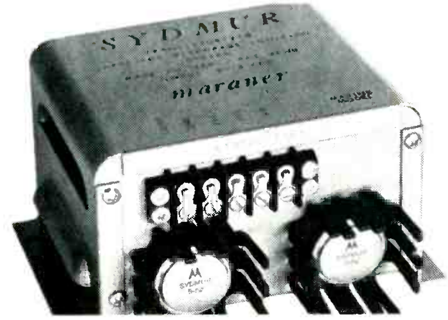
CD IGNITION SYSTEM

A capacitor-discharge ignition system that is available for cars, marine



engines, or motorcycles is offered in kit and assembled versions, positive- or negative-ground, 24-, 12-, or 6-volt systems.

All models feature solid-state circuitry, treated fiber glass PC boards, all necessary hardware, and complete instructions for installing the unit in less than 15 minutes. Sydmur

Circle No. 58 on Reader Service Card

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INSTRUMENT CABINETS

A four-page catalogue covering a complete line of multi-purpose instru-

ment cabinets is available. It includes dimensions, prices, and choices of colored vinyl.

This line, which includes 32 basic cabinet sizes, lends itself to the needs of the electronic, medical, industrial, and automotive industries. Beechwood

Circle No. 59 on Reader Service Card

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P.A. HORNS & DRIVERS

A single-page data sheet (Form 1251) covering an extensive line of p.a. horns and drivers is available. Pictured and described are compound horns, re-entrant horns and accessory line transformers, convertible drivers, high-power speaker systems, sound-reinforcements speakers, and paging speakers. Complete technical specs are included. Electro-Voice

Circle No. 62 on Reader Service Card

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SOLDERING TIPS

A single-page data sheet which lists

an extensive line of long-life soldering tips is available as Form No. 1152-B.

These are Duotherm non-freezing tips, iron coated and immunized, which the manufacturer claims prevents tip sticking and will outlast copper tips up to 20:1.

All standard tip styles are included in the line to fit any soldering iron and soldering requirement. Hexacon

Circle No. 65 on Reader Service Card

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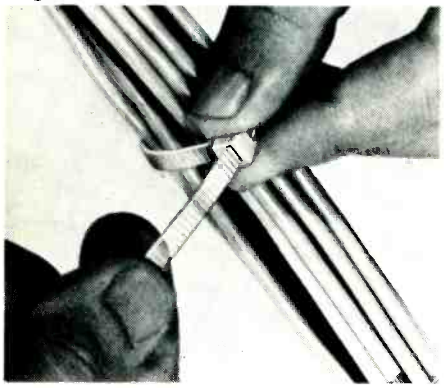
NYLON CABLE TIE

A new line of cable ties, called "Quik-Wrap," has been introduced. The 4" and 6¾" long ties are available in natural nylon and other colors. Designed to save time on all kinds of



wire and cable bundling, the new units may be used indoors or outdoors.

The lock or head of the wrap is molded with a nylon tooth inside the mouth. When pulled tight around a bundle, the tooth is forced into saw-shaped serrations on the inner surface of the tie. Locking is said to be positive and permanent.

A data sheet which lists all available types will be forwarded on request. Holub

Circle No. 66 on Reader Service Card

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SINGLE-CABINET STEREO

The new "Stereo 1" speaker system is said to provide full-range, true stereo reproduction in a single cabinet. Designed especially for music lovers with a limited budget and even more limited space, the new system is based on a unique "Acousti-Matrix System" in

which precisely metered sum-and-difference outputs are fed to carefully directed arrays.

Frequency range is 30-20,000 Hz and power rating is 35 watts per channel integrated program material. Impedance is 8 ohms. The system uses an array of full-range, high-compliance, heavy-duty "Flexair" speakers in a specially designed, air-suspension enclosure, which measures 13" high x 21¾" wide x 11⁹⁄₁₆" deep. Jensen

Circle No. 67 on Reader Service Card

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MATV DISTRIBUTION KITS

Four simple and easily installed MATV distribution amplifier kits have been introduced to meet virtually any system requirement. Each kit consists of all components necessary for a two-outlet amplified system. A kit for each of the most widely used types of lead-in wire is available: RG-59/U coax, BC6/U coax, flat 300-ohm twin-lead, and encapsulated or shielded twin-lead. Each kit contains a broadband 25-dB amplifier designed to handle additional outlets if a larger system is desired.

The coax kits include two wall taps and two matching transformers; the twin-lead kits contain two wall plates and a coupler. All necessary mounting hardware is included. Mosley

Circle No. 68 on Reader Service Card

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TEST INSTRUMENTS

A brand-new catalogue listing test instruments for TV, FM radio, and audio servicing is now ready for you.

It lists and describes color-bar pattern generators, scopes, scope/vectorscopes, an FET multimeter, a v.t.v.m., in-circuit transistor checker/circuit tracer, TV field-strength meter (v.h.f. and u.h.f.), r.f. signal generators, sine/square wave generators, TV-FM sweep/marker generator, grid-dip meter, and probes. Leader

Circle No. 69 on Reader Service Card

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SOLID-STATE SOLDER GUN

A new solid-state, transformerless soldering gun, designed for professionals, is now available as the Model 6760.

Weighing only five ounces, the gun is especially suited to soldering operations on integrated circuits and FET's. This is insured by electrically isolating the soldering tip from the heating element with a grounded three-wire cord set to render the tip electrically inert.

The user has a choice of two tip temperature ranges: 500 or 900 degrees F, selectable by a thumbswitch on

the handle. The heat cartridge locks into the gun barrel by means of a knurled nut which permits the rotation of the entire cartridge to orient the thread-on tips. Three interchangeable tips are included: short chisel, pyramid, and long-chisel types. Ungar

Circle No. 70 on Reader Service Card

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HOME ENTERTAINMENT GUIDE

A special 68-page, full-color catalogue covering a complete line of home-entertainment electronics has been issued and is ready for distribution.

Included are speaker systems, stereo music systems, tape players, stereo receivers, p.a. speakers, headphones, turntables and changers, recording tapes and accessories, tape recorders and decks, cassette recorders and players, cabinets for equipment and record storage, kits, component speakers, replacement tubes for radio & TV, antennas, rotators, lead-in, distribution systems, and musical instruments and accessories of all types. Sears

Circle No. 71 on Reader Service Card

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COMPREHENSIVE CATALOGUE

It is hard to think of an electronic item that is not covered in the new 1970 catalogue (No. 700) just issued.

It is a complete buyer's guide to brand name stereo amps, tuners, changers, speakers, tape recorders, CB equipment, ham gear, marine and test equipment, auto accessories, tools, books, and an extensive line of electronic components.

All of this is yours without charge for the asking. Lafayette

Circle No. 72 on Reader Service Card

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COLOR TV SERVICING

Information on buying, installing, and servicing a color television receiver is provided in a new booklet just published.

Entitled "Color TV—What You Should Know About Purchase, Installation, Service," the booklet contains hints on conditions that could affect the quality of picture reception, factors that determine charges for a service call, and what to expect from a service call.

Single copies will be provided free of

charge while quantity orders at 3 cents per copy are available from National Better Business Bureau at 320 Park Avenue, New York, N.Y. 10017.

Single copies will be supplied on request. EIA

Circle No. 73 on Reader Service Card

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LOW-FREQUENCY SPEAKERS FOR P.A.

A compact, high-power, low-frequency speaker assembly designed specifically to fit minimum space over the procenium or front of the stage in auditoriums or theaters is now available as the Model 6A392.

This 80-watt unit, which measures only 34 inches high, uses four-inch voice coils driven by 11-pound magnet assemblies through two 15-inch diaphragms to provide the power levels. Front horn loading eliminates folds or bends in the diaphragms for added smoothness.

The cabinets are constructed of ¾-inch plywood rigidly braced and damped for minimum vibration and weigh 250 pounds with speakers installed. DuKane

Circle No. 74 on Reader Service Card

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AUDIO ACCESSORY LINE

Catalogue #116 provides complete information on an extensive line of audio accessories for hi-fi, stereo, and cassette tape recorders and players. Of special interest are a special line of DIN cable assemblies, sockets, plugs, and universal microphones for the cassette market. Workman

Circle No. 75 on Reader Service Card

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REPLACEMENT COLOR TV TUBES

A new series of replacement color-television picture tubes has been introduced recently as the "Ultracolor" line. Available in 13 different CRT types in six basic rectanglular tube sizes, 11, 19, 21, 22, 23, and 25 inch, the new tubes feature rare-earth phosphor, have new electron guns, and may or may not incorporate used glass and other materials. New and rebuilt tubes are identified as such. General Electric

Circle No. 76 on Reader Service Card

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FM-STEREO DECODER SYSTEM

A free 6-page construction article describing a monolithic integrated FM stereo decoder system is now available. Designed around a Motorola MC1304 IC, the unit provides excellent channel separation across the entire audio range, according to the company.

Series 1359 coils have been used to assure optimum channel separation characteristics. J. W. Miller

Circle No. 77 on Reader Service Card

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SERVICING CHEMICAL CATALOGUE

A new two-color, 8-page catalogue covering chemical products designed exclusively for the electronic service industry is now available.

The line includes tuner sprays, contact and control cleaners, insulating sprays, lubricants, circuit coolers, and a variety of other servicing aids.

Prepared for service technicians, a copy of Catalogue No. 6970 will be forwarded on request. Chemtronics

Circle No. 78 on Reader Service Card

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PRECISION TOOLS FOR ELECTRONICS

A new 24-page catalogue, No. 200A, covering an extensive line of precision tools for electronics, telecommunications, and industry is now ready for distribution.

Over 500 spring adjusters, gages, burnishers, and miscellaneous precision hand tools are illustrated with detailed drawings, dimensions, and specifications. Jonard

Circle No. 79 on Reader Service Card

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TEST EQUIPMENT/SERVICE AIDS

A four-page data sheet listing a number of professional test instruments and service aids can be yours for the asking.

Included are portable and shop tube testers, an in-circuit current checker, a transistor analyzer, an SCR analyzer, solid-state a.c.-d.c. motor controllers, and various tube-tester accessories. Seco

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SERVICE TEST GEAR

A new 12-page, two-color brochure which covers an extensive line of test equipment for service technicians and industry has been issued.

There are FET multimeters, FET meters, dynamic mutual-conductance tube testers, CRT checkers, sweep circuit analyzers, scope/vectorscopes, sweep and marker generators, color-bar generators, an in- or out-of-circuit transistor and FET tester, battery eliminators, filament checkers, substitution boxes, field-strength meters, and a transistor-diode checker—all pictured and described in complete detail. Sencore

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TOOLS AND MORE TOOLS

A new 114-page catalogue listing hundreds of tools and related accessories can be used both as a buyer's guide and as a reference manual as to what is available for any and all jobs.

All types of production and servicing tools are listed with details on construction and applications. There are pliers, cutters, tweezers, scissors, small parts holders, vacuum systems, skin-packaging units, inspection mirrors and magnifiers, optical comparators, assembly lamps, screwdrivers and hex drivers, wire strippers, lead benders and formers, soldering irons and accessories, tool kits, and assembly accessories. Techni-Tool

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SOLDERING TOOL

The new "Tempmatic" temperature-controlled soldering tool has trigger-action heat control, weighs only 7

ounces, can handle both light and heavy soldering jobs, has a long-reach stainless steel barrel, and comes with an exclusive temperature-controlled "Powerhead." A convenient ejection button makes switching Powerheads quick and easy. Weller

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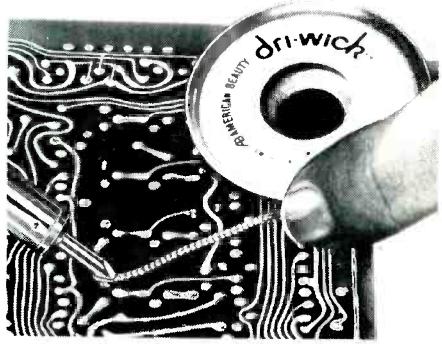
DE-SOLDERING TOOL

A "tool on a spool" describes the handy new "Dri-Wick" de-soldering unit which makes it possible to rework expensive circuitry without sucking devices, prolonged head or wet-flux contamination.

To use, Dri-Wick is placed on the soldered joint, then the tip of a 30-40 watt soldering iron is placed on the top side of Dri-Wick for one second, and then the wick and iron are lifted from



the work together. The connection is clear of solder and ready for component removal, replacement, or resoldering. American Beauty

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HAND TOOLS IN ABUNDANCE

Catalogue No. SD-76 is a 24-page compendium of hand tools for virtually every type of professional service work. There are round-blade, square-blade, Phillips, specialty, and bull drivers; hollow shaft nut drivers; ratchet and spiral ratchet screwdrivers and launchers; electrical testers; "problem solving" tools; tool kits; snap rings and pliers; power riveters; wrenches and pliers; steel tape rules; along with merchandising displays for the various products. Vaco

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ELECTRONICS INSTALLATION & SERVICING HANDBOOK 1970

ADVERTISERS INDEX

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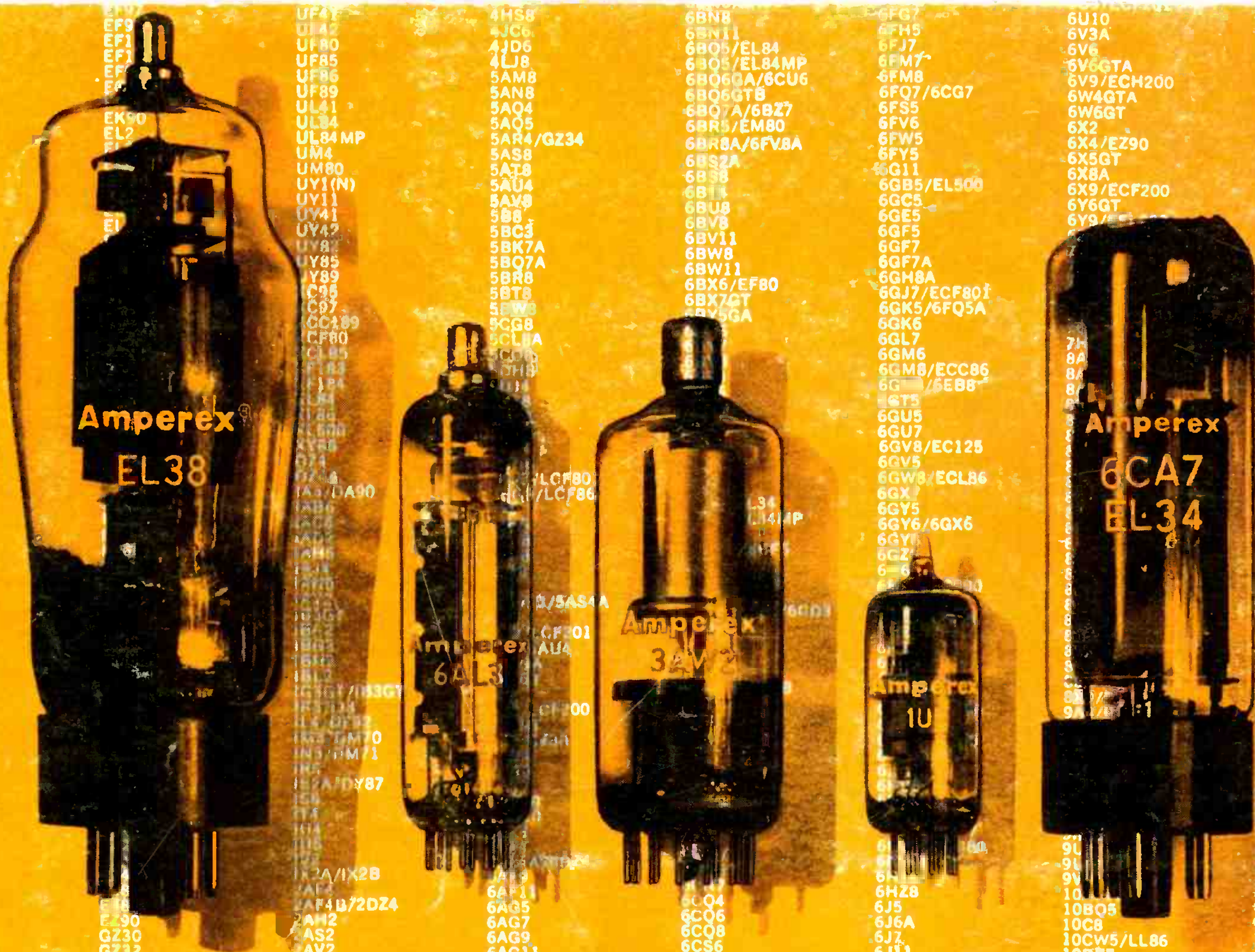

Amperex
EL38
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6CA7
EL34