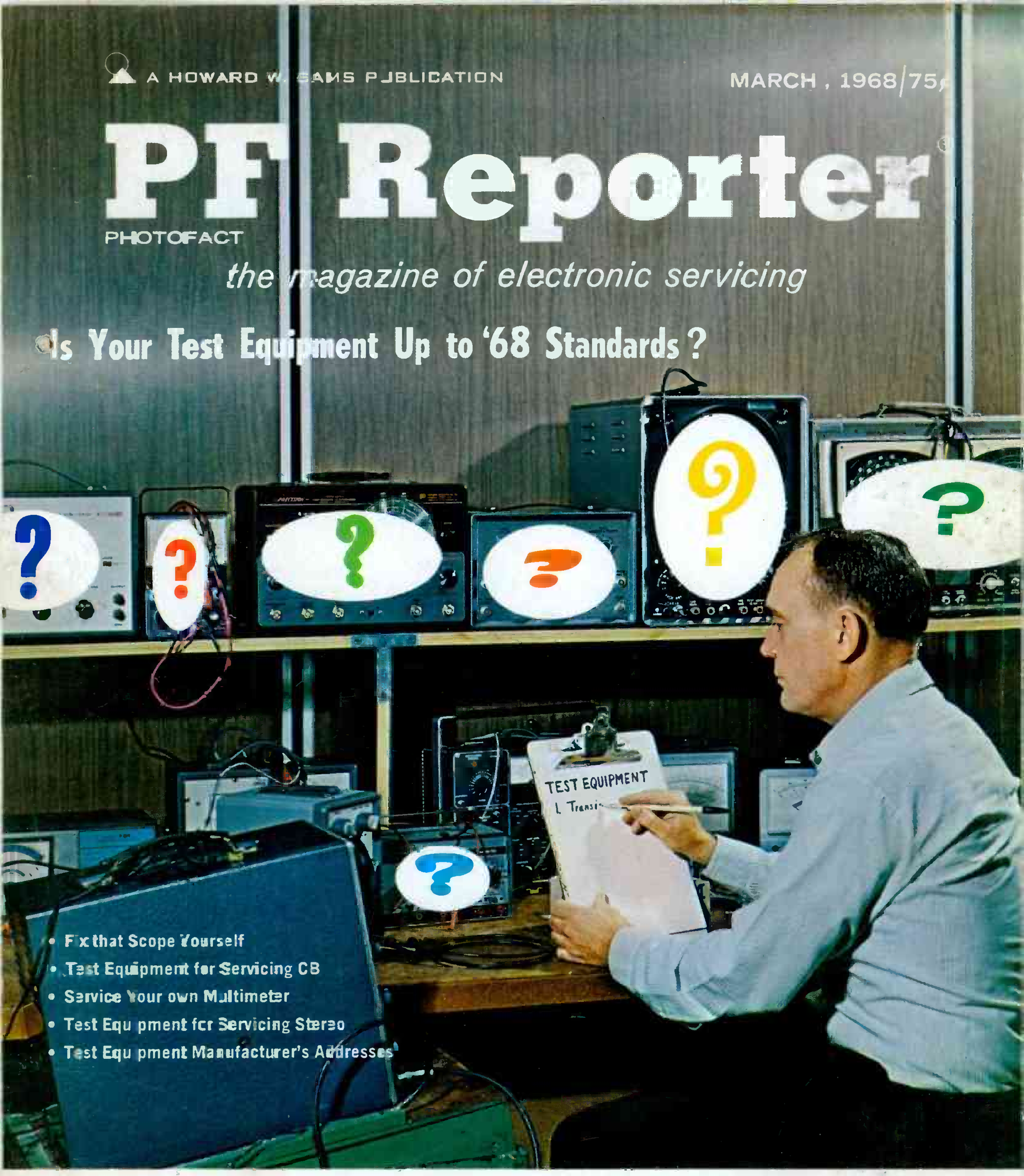
A HOWARD W. SAMS PUBLICATION
MARCH, 1968 / 75¢

PF Reporter

PHOTOFACT

the magazine of electronic servicing

Is Your Test Equipment Up to '68 Standards?



- Fix that Scope Yourself
- Test Equipment for Servicing CB
- Service Your own Multimeter
- Test Equipment for Servicing Stereo
- Test Equipment Manufacturer's Addresses

IA SD 3879 S68
SAMUEL SACHS
2244 NORTH 10TH ST.
PHILADELPHIA, PA. 19133

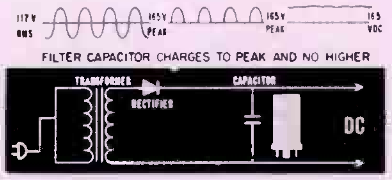
REMEMBER TO ASK —

"What else needs fixing?"

ELECTROLYTICS ARE DIFFERENT THE WAY A WET BATTERY DIFFERS FROM A DRY CELL.

- A wet battery rated at 100 amp hours versus a dry cell rated at .01 to 1 amp hour.
- An electrolytic rated at 1 to 10,000 mfd versus a tubular or wrap or film at .000001 to 1 mfd.
- Wide tolerance (−10 to +150%) versus close tolerance (+2%).

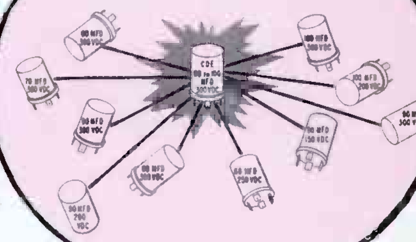
ELECTROLYTICS ARE USED AS FILTER CAPACITORS FOR POWER SUPPLIES — IN CIRCUITS WHERE CLOSE TOLERANCES ARE NOT NEEDED.



FILTER CAPACITOR CHARGES TO PEAK AND NO HIGHER

INCREASING CAPACITY WILL NOT RAISE VOLTAGE BEYOND PEAK VALUE

ONE CAN REPLACE MANY; NO NEED FOR EXACTITUDE.



EIA TOLERANCES PROVE THIS.

3.4.5 The tolerance from nominal rated capacitance shall be:

Rated DC Voltage	Capacitance Tolerance
From 3 to 50 volts, inclusive	−10% to +150%
From 51 to 350 volts, inclusive	−10% to +100%
From 351 to 450 volts, inclusive	−10% to + 50%

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Six straight shots from the Wide Ranger.

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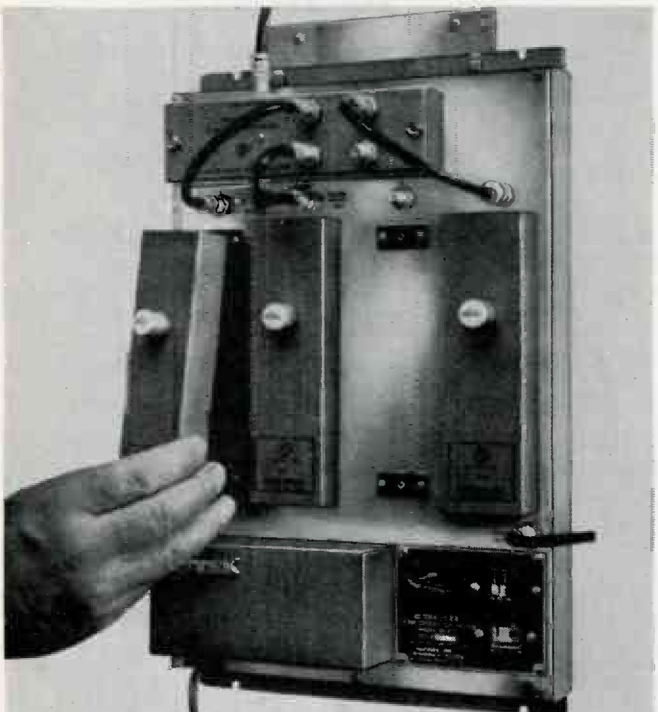
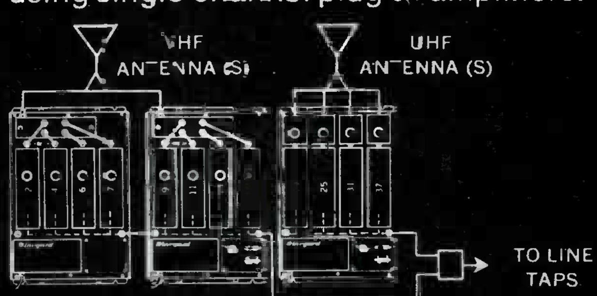


82-Channel Ultra-Plex System
using lo band plug-in VHF amplifier ...hi band plug-in VHF amplifier... and broad band UHF amplifier.

82-Channel Ultra-Plex System
using single channel plug-in amplifiers.



Winegard Ultra-Plex is a unique 82-channel, modular plug-in distribution system with all components matched to work together perfectly. The system never becomes obsolete, because you can add new UHF or VHF channels quickly, easily and inexpensively whenever needed.

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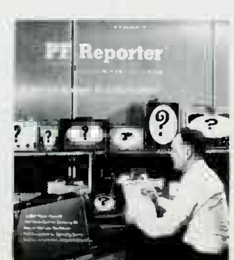
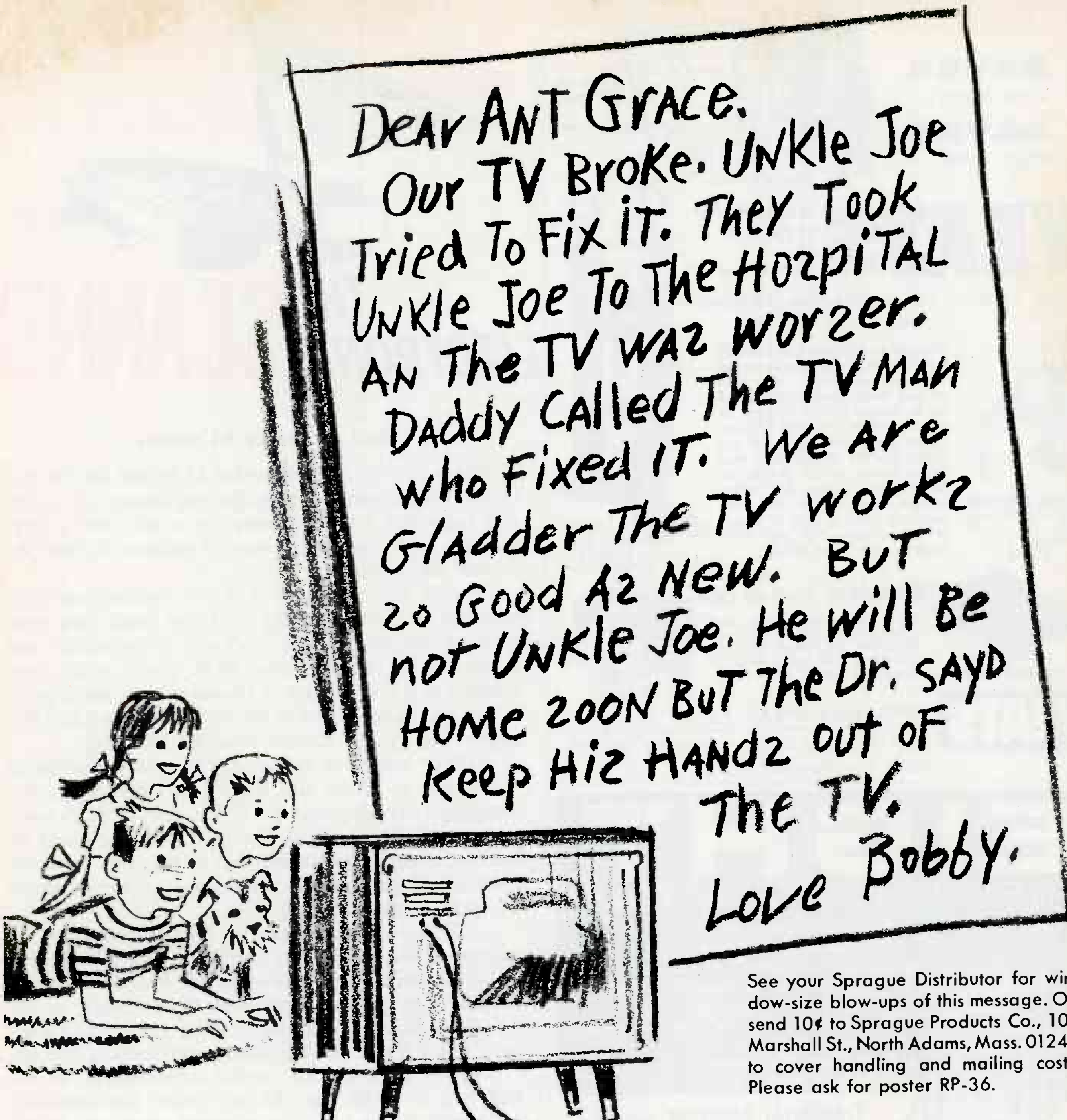
VOLUME 18, NO. 3 MARCH, 1968

CONTENTS

ABOUT THE COVER

The switch from tube to solid-state components in nearly all areas of electronic design has affected the service technician's test equipment requirements. Not only must the technician keep abreast of the latest development in circuit design, but he must also continually evaluate his test equipment to assure that its capability matches the servicing demands of new circuitry and components. Our cover this month illustrates this point and indicates the featured contents of this annual test equipment issue.





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DON'T FORGET TO ASK YOUR CUSTOMERS "WHAT ELSE NEEDS FIXING?"

GS-7107

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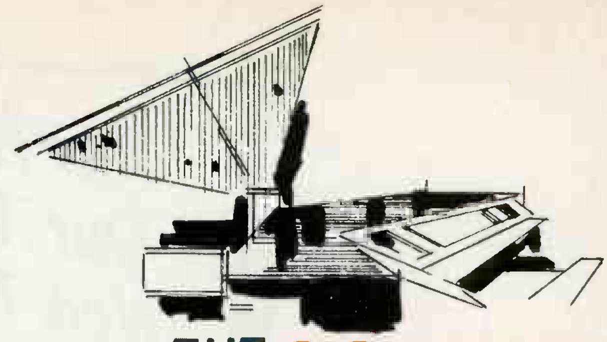

THE ELECTRONIC SCANNER

RCA Sales Top $3 Billion

RCA's sales in 1967 exceeded $3 billion for the first time in the company's forty-eight year history and profits also registered a slight advance to a new record level for the sixth successive year, President Robert W. Sarnoff announced.

He told the company's 330,000 shareholders in a year-end statement that the sales and profit rises were achieved despite general economic uncertainties and a month-long strike at nine RCA plants which contributed to a 21% decline in second quarter earnings.

Among the highlights of RCA's performance in 1967 singled out by Mr. Sarnoff were the following:

—Color television manufacturing and broadcasting "continued to make the largest contribution to the company's overall progress." Dollar sales of RCA color sets were 20% ahead of 1966. RCA strengthened its traditional position of leadership in the color industry. Its share of the total set market was greater at year's end than at the beginning.

—NBC revenues exceeded the $500 million mark for the second successive year, reaching a new sales peak.

—The Hertz Corporation, which became an RCA subsidiary in 1967, registered its highest sales, as did the RCA Serfvice Company, RCA Communications, Inc., and sales of RCA products and services abroad.

—RCA continued its capital expenditures at the high rate of 1966. For the two years, approximately $400 million was spent for domestic plant and equipment, "representing the greatest investment effort in the history of the company."

Looking to the future, Mr. Sarnoff said RCA will intensify its emphasis on the company's development as a broadly based and diversified communications, electronics, and service organization with an increasingly international orientation.

Auto Sound Sales Exceed $1 Billion

Automotive sound equipment—radio and tape player systems—has passed the billion-dollar mark in world wide annual sales and already exceeds the growth rate of color television.

Oscar P. Kusisto, vice president and general manager of **Motorola's** automotive products division, reported that automotive sound sales—AM, FM, multiplex radio,

and tape cartridge systems—have increased 25% in the past year and could exceed a third of color television's dollar volume by the end of 1968. Kusisto made his predictions at a press briefing during the annual Automobile Accessories Manufacturers of America (AAMA) show in Chicago. He based his comments on Motorola studies of the original equipment, distributor, and retail markets in the U.S. and abroad.

Kusisto said automotive sound equipment involves a total world market this year of 13 million units, at least three-fourths of which are sold in the United States. His figures exclude cassette and PlayTape players. He said this burgeoning market is the result of an "audio explosion," which is attributable to the interaction of three major marketing forces: (1) youth, (2) affluence, and (3) the availability of a variety of new audio equipment.

"An ever-increasing percentage of population—not only in the United States but in other nations as well—is under 25 years of age. These young people are an audio, verbal, mobile group," he said.

"Combined with this is our more affluent society and the broad range of new audio equipment. A great percentage of the market is 'trading up' from simple AM radio, for example, to FM and tape players."

Kusisto said Motorola studies have shown that the rate of growth of worldwide sales of automotive sound systems will continue to increase substantially for the foreseeable future.

In 1968, he pointed out, retail value of the estimated 2,750,000 automotive tape units to be sold will reach $220 million. He predicted sales of more than 2,300,000 after-market car radios for $160 million, and 8,000,000 radio and tape players will go into new cars at an estimated cost of $600 million.

Further, Kusisto said, automotive tape player systems have fostered a new market for other units which use the same tape cartridges. The result, he said, is that from 1,000,000 to 1,500,000 four- and eight-track portable, battery-operated tape players and home tape players will add up to $80 million to the market total.

Beyond that, he said, "will be sales of a wide range of related products—speaker, tuners, multiplex, reverb units, and other hardware—which easily will amount to another $200 million.

Littelfuse To Sell

The Board of Directors of **Littelfuse** has approved the definitive agreement for the sale of substantially all of its assets of **Tracor Inc.**, of Austin, Texas. The transaction had been approved in principle on November 30, 1967.

The Agreement will now be submitted for approval by the Board of Directors of Tracor. Under the terms of the agreement, Littelfuse shareholders will receive one share of Tracor convertible preferred stock for each two common shares of Littlefuse.

FTC Renders Opinion

The Commission was recently requested to render an advisory opinion with respect to the legality of a trade

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Part #	Intermediate Frequency	AF Amp Tube	Osc. Mixer Tube	Heater
MFT-1	41.25 mc Sound 45.75 mc Video	6GK5	6LJ8	Parallel 6.3V
MFT-2	41.25 mc Sound 45.75 mc Video	3GK5	5LJ8	Series 450 MA
MFT-3	41.25 mc Sound 45.75 mc Video	2GK5	5CG8	Series 600 MA

Genuine Sarkes Tarzian universal replacement tuners with Memory Fine Tuning—UHF Plug in for 82-channel sets—Pre-set fine tuning—13-position detent—Hi gain—Lo noise—Universal mounting

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SOUTH-EAST......**938 GORDON ST., S. W., Atlanta, Georgia** ....**TEL: 404-758-2232**
WEST..................**SARKES TARZIAN, Inc.** ***TUNER SERVICE DIVISION***
10654 MAGNOLIA BLVD., North Hollywood, California ....**TEL: 213-769-2720**

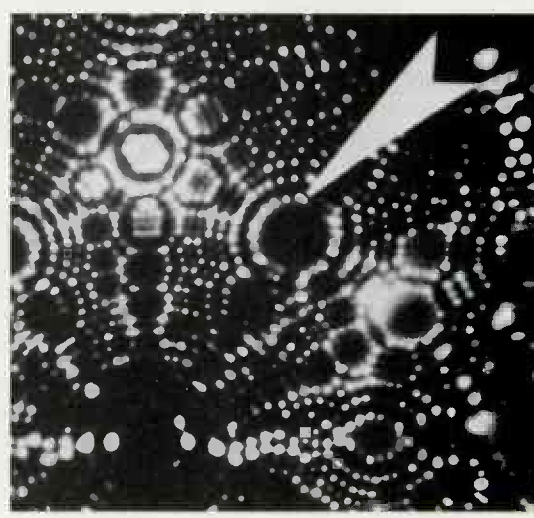
Circle 8 on literature card

association preparing and distributing a standard rate and service pricing manual for common use by electronics servicemen in dealing with the general public.

It was represented that a major problem in the industry is the lack of guides by which the public can determine whether prices charged for various repair services are fair and equitable. This lack has led to many customers complaints and to fradulent operations by unethical repairmen. The association took the position that a standard rate schedule would protect the public and free ethical servicemen from unjust accusations.

The Commission advised that it could not give its approval to the proposed common use of a standard rate and service pricing manual by competing electronics servicemen. While the adoption and dissemination by the association of such a manual may be motivated by a purpose to remove evils affecting the industry, it appears to go further than is reasonably necessary to accomplish the desired result. Even though use of such manual be accompanied by disclaimers, there is implicit therein too grave a danger that it will serve as a device through which service rates and fees would become uniform and stable throughout the industry. While adoption of a means likely to create competitive uniformity in terms of service pricing may be a convenience to trade association members, this factor is far outweighed by the benefits to the public of the intense competition between competing servicemen, and it is this competition which the law protects. *Editor's note: The above is a copy of a recent news release from the Federal Trade Commission. In essence it says that the FTC holds the opinion that a trade association cannot legally issue a pricing guide.*

Mighty Microscope



In the photo above, the arrow points to a single atom of tungsten. The new microscope, called the atom-probe, field-ion microscope, is currently being developed by Professor Erwin Mueller at the Pennsylvania State University.

This new microscope can not only focus on a single atom, but also separates it from thousands of surrounding atoms and then identifies it in a spectrometer. The above photo represents a magnification of approximately 2.1 million times. ▲

*Optional with dealer

RCA's Headliner: first and finest of the 14-inch portable color TVs.

First because it's pulled the most sales of any 14-inch diagonal color set made. Finest because it's got the big features. Like advanced circuitry that won't go haywire. Like true room-to-room portability. And a 102 sq. in. picture that's true to life—and true to the reputation of the pioneer name it bears. Sell the first and finest, the Headliner. It's one reason we say: When you're the first name in home entertainment there's got to be a reason.

RCA

BOOK REVIEW

Lasers and Masers: Charles A. Pike; Howard W. Sams and Co., Inc., Indianapolis, Indiana, 1967; 176 pages, 8½" x 5½", soft cover; $4.95.

Although an understanding of the laser (Light Amplification by Stimulated Emission of Radiation) and maser (Microwave, etc.) is hardly essential to the TV technician, many will enjoy having some knowledge of this subject. Physics is introduced only to the extent necessary for explaining the subject at hand, and the treatment of the material in this book is remarkably concise for so complex a subject. The author has employed the style of programmed instruction. That is, each subtopic is treated in a page or two, and a few pertinent questions are asked at the end of the page. The answers are at the top of the next page, allowing the reader to check himself before proceeding.

The text is divided into seven chapters as follows: Chapter 1 is introductory and covers atoms and molecules, the elements, chemical combinations and valence bonds, wave motion, and some of the basic principles of light. Chapter 2 is a short (10 pages) resume of early developments in atomic theory, and Chapter 3 proceeds to quantum theory, quantum numbers, and the dual nature of the electron.

The principles of masers and lasers are explored in Chapter 4. This chapter is divided into sections, such as population of energy levels, maser and laser action, and application of these principles to specific materials: gas, solid-state, and semiconductor. Chapters 5 and 6 explain the actual construction and operating characteristics of masers and lasers, respectively. The final Chapter discusses applications of both lasers and masers. ▲

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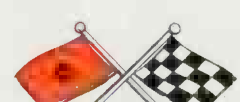
The all-new **CHAMPION** is equipped with plug-in sockets for fast testing and easy updating. Rugged vinyl-clad steel case has spacious lead compartment.

For a sure thing, put your money on the champion — **the Sencore CR143 CHAMPION.**

CR143 CHAMPION



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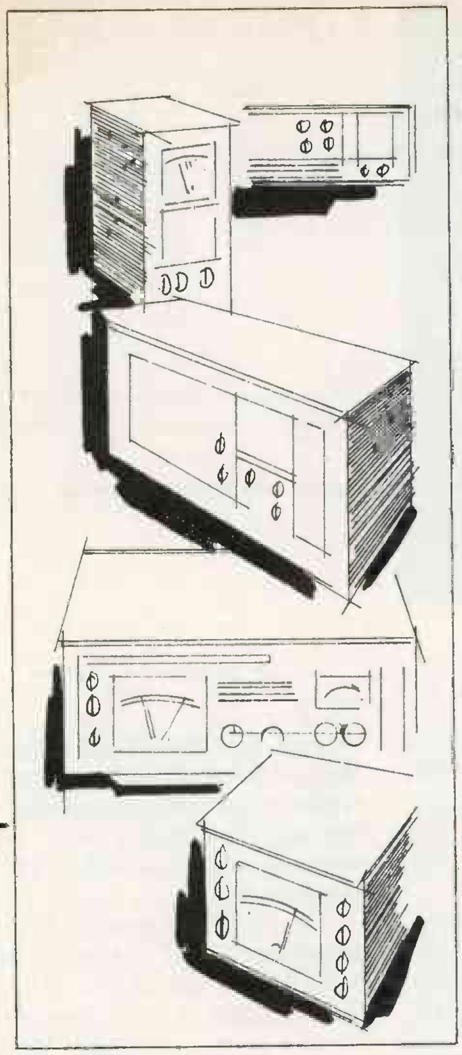

IS YOUR TEST EQUIPMENT UP TO '68 STANDARDS?

by T. T. Jones

Nearly all test equipment has changed during the past few years; some have changed drastically, while others reflect only minor alterations. Also, a few types are gradually disappearing from the list of available equipment. The following paragraphs relate the most significant changes evident in service-type test instruments.

The 1968 service business is quite different from that of even two years ago, and customers are changing just as radically as the sets they bring in for service. Though there are still many customers who shop around for the cheapest service, more and more of your customers are discovering that the cheapest repair is not necessarily, and in fact is seldom, the best repair. So the 1968 customers are willing to pay realistic prices for your service. But they do demand value received for payment rendered—a fast repair, and most important, an accurate repair. Good test equipment can help you effect a quick, accurate repair.

There are some instruments on the market today which are considered essential to a well-equipped shop, yet had not even been invented a few years back. An FM Stereo generator is a good example. Other instruments on the market today are not especially new in concept, but the features available today make it mandatory that you compare your present equipment with the new models. Perhaps some of the new features are valuable enough that you will wish to buy the new instrument, even though your old one is operating perfectly. Let's take a closer look at the features available in 1968 test equipment.

Meters

An entirely new breed of meter has recently taken its place alongside the VTVM and VOM. We're talking of course, of the solid-state voltohmmeter. Nearly all of these use a field-effect transistor in the input stage, with a resulting input impedance quite similar to that of a VTVM. FET meters, therefore, can replace the VTVM in most applications, with the added advantage that they're normally battery-operated.

For the most part, FET meters have been designed to cover the same ranges as the contemporary VTVM. Fig. 1 shows the ranges of an FET Voltohmmeter that is atypical, in that the designer has added two very low AC-DC voltage ranges and two extremely low AC ranges. This instrument, therefore, is much more sensitive to DC than the usual meters of a few years back, and its AC scales are as good as yesterday's AC VTVM—formerly a specialized instrument.

The AC input impedance of most FET VM's is as good as the DC impedance. Usually both are about 10 to 11 megohms, but some instruments have DC inputs as high as 15 megohms, while others have AC inputs as low as ½ megohm. In general, the FET meters are a decided improvement over VTVM's or VOM's in one area, while possibly

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FIX THAT SCOPE YOURSELF

Any technician who is proficient at servicing b-w and color television should be capable of repairing the scope he uses. The only additional knowledge needed is a basic understanding of scope circuits and a systematic troubleshooting procedure. Both are provided in this article.

by Ellsworth Ladyman

In many of the letters received by the editor from technicians seeking aid in solving a stubborn problem with a television chassis, the writer mentions that his scope is defective. Usually the existing problem can only be solved through a waveform analysis, or signal-tracing process, that requires the use of a scope. The only possible answer to letters of this nature is: first fix your scope—then your knotty TV problem will diminish in stature. In all electronic devices that depend on voltage pulses for timing and sync to insure proper operation, a scope is an indispensable tool when service is required.

There is nothing intimidating about the circuitry of the average service scope. Circuits employed in laboratory and medical instruments are more sophisticated, but even these should present very few problems to a technician experienced in troubleshooting such complex instruments as color television receivers.

Scope Theory

Scope circuits in general can be compared to a television receiver, but without such circuits as video, audio, and chroma stages. An analysis of the circuits employed in your particular scope should reveal a

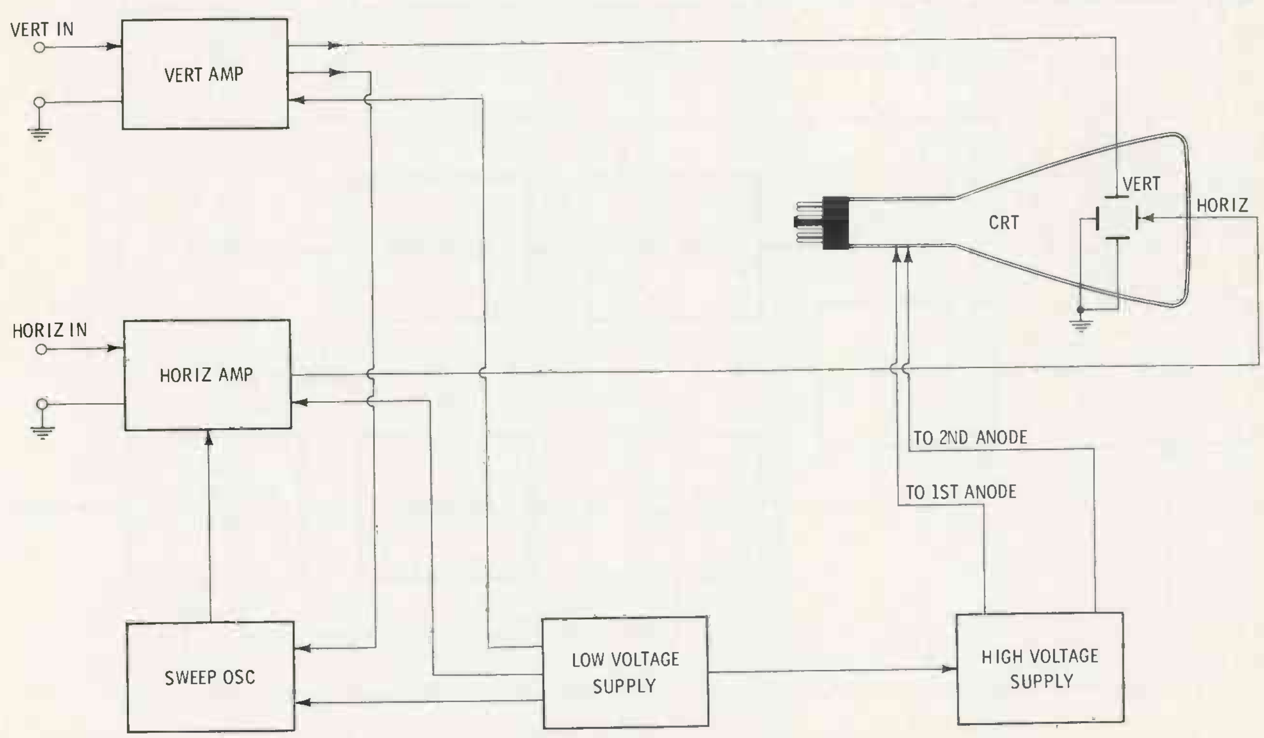


Fig. 1. Basic block diagram of a scope.

comparatively basic instrument composed of familiar electronic circuits. A comparison of basic block diagrams of a scope and a black-and-white receiver should remove all doubts you might have concerning your ability to effectively repair your own scope (Figs. 1 and 2).

A quick glance at the block diagrams should point up the fact that there are similarities in the design of the two instruments, and that the TV receiver is much more complex. Troubleshooting procedures are much the same for a scope as for other electronic devices. The first step is a careful analysis of the trouble symptom (to prevent the possibility of lost time checking properly functioning circuits) followed by a point-to-point check of the suspect area. A brief description of oscilloscope theory, followed by typical scope circuit diagrams may help in relating this information to your particular scope. As is the case with radio and television manufacturers, test equipment manufacturers can find many different methods of doing the same job, and this fact precludes the use of specific scope circuits for illustration purposes.

What Is A Scope?

In a final analysis a scope is simply an electronic graph, which plots variations in voltage amplitude against time. This electronic graph indicates two (and sometimes more) separate and distinct values (amplitude and time) simultaneously, thus allowing the operator to view changes in voltage amplitude at any given or specific instant. The importance of this tool is incalcuable. Without a scope, it is virtually impossible to check the operation of a stage (such as an AGC amp) that depends on two simultaneous voltage pulses for proper operation.

Theory of Operation

Any functional scope found in an electronic repair shop will contain:

1. Input circuits.
2. Vertical amplifier and control circuits.
3. Horizontal amplifier and control circuits.
4. Horizontal sweep oscillator (to establish a time base).
5. Indicating circuits (CRT and associated circuitry to control brightness, focus, etc.).

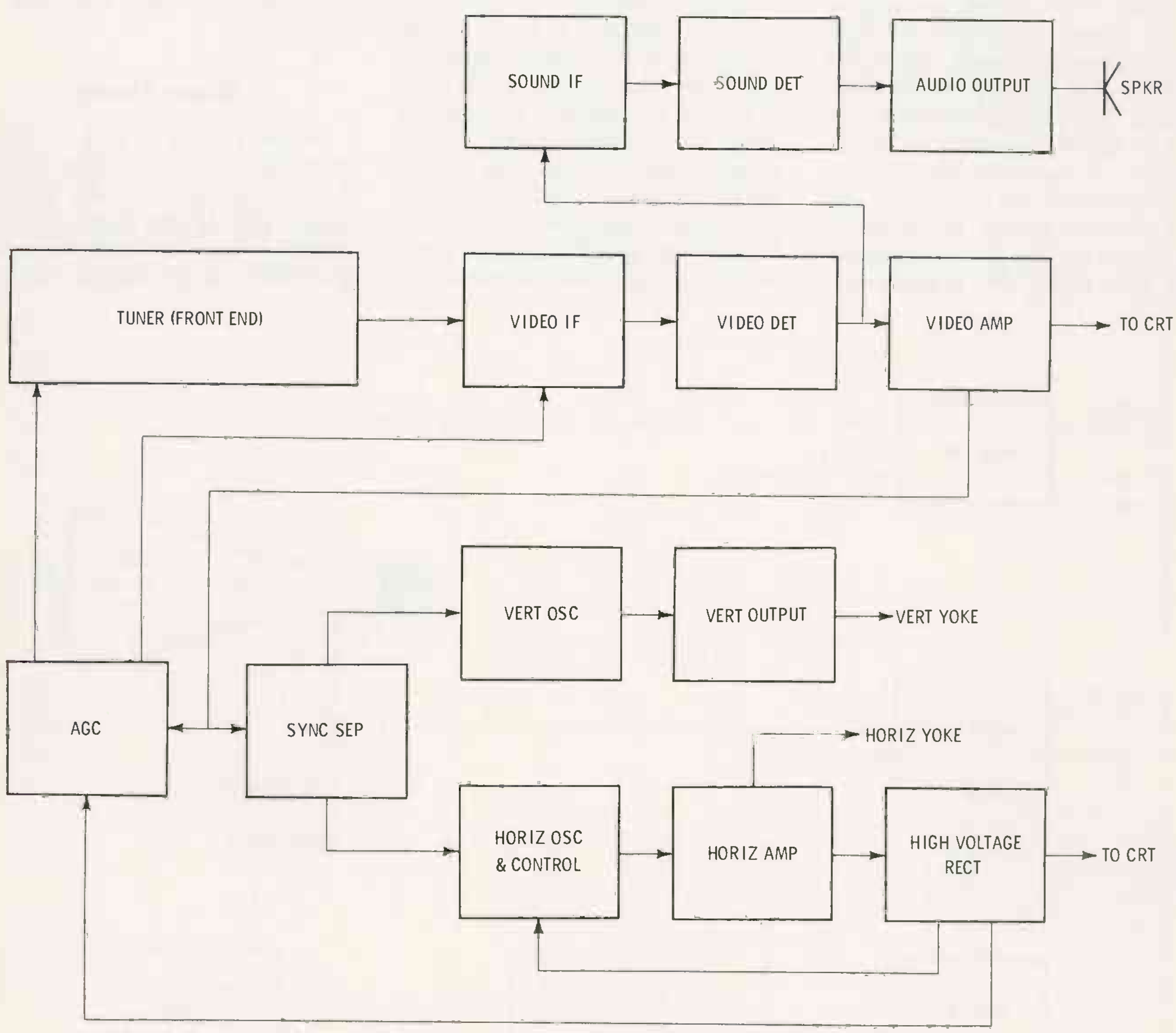


Fig. 2. Basic block diagram of a black-and-white receiver.

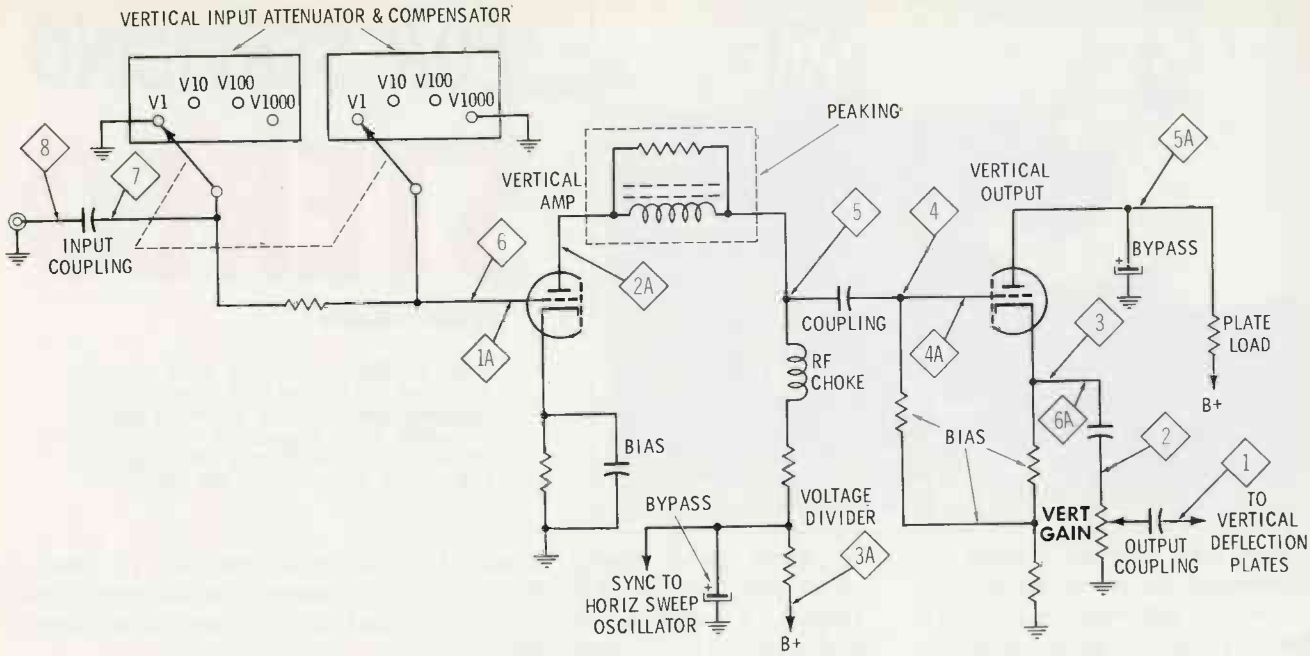


Fig. 3. Typical simplified vertical amplifier circuit.

6. Low-and high-voltage power supplies (many times combined in one section).

The vertical amplifier, or the output of the vertical section, is connected directly to the vertical deflection plates (Fig. 3). It makes very little difference, from a servicing standpoint, whether there is one or a half-dozen vertical amplifier stages before the CRT. In the initial analysis, if you do not have vertical gain, you do have trouble in the vertical circuit. The only reason for employing vertical amplifiers in the design of a scope is *increased sensitivity.* In fact, in most scopes you can apply the input directly to the vertical deflection plates of the CRT. If the signal is of sufficient magnitude, vertical amplification is not necessary. Most ignition analyzer scopes used by automobile mechanics do not have vertical amplifier stages, since the voltage spikes or pulses from the plugs and coils of modern high-compression engines are of sufficient magnitude to drive the vertical plates.

Vertical amplifier stages are usually operated Class A to insure the most faithful reproduction possible of the voltage signal under analysis. A careful check of the simplified, partial schematic of a typical vertical section will not introduce any new terms. The bias networks, decoupling capacitors, coupling capacitors, peaking coils, plate loads, voltage dividers, and other circuits will all be found in the most simple of electronic devices.

The sawtooth voltage applied to the horizontal deflection plates of the CRT is usually derived from a horizontal sweep oscillator stage, such as shown in Fig. 4. This voltage provides a linear time base. The sweep oscillator is variable in frequency so that you can adjust the sweep to display the desired number of cycles on the CRT screen. The terminology applied to these controls will vary from scope to scope. Names such as horizontal sensitivity, horizontal amp, horizontal frequency, microseconds-per-centimeter, etc. will be found. Regardless of the name, the function remains the

• *Please turn to page 41*

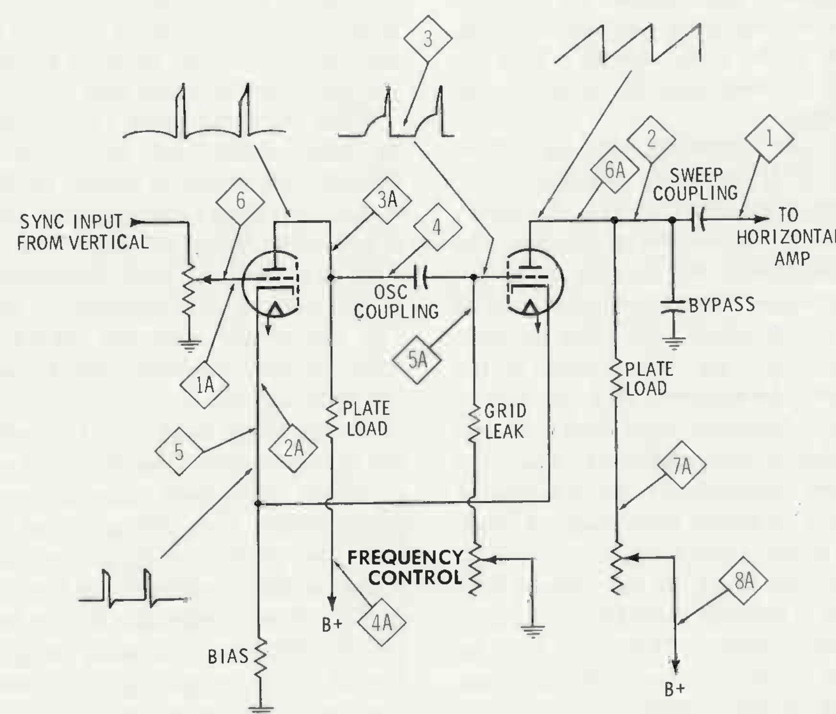
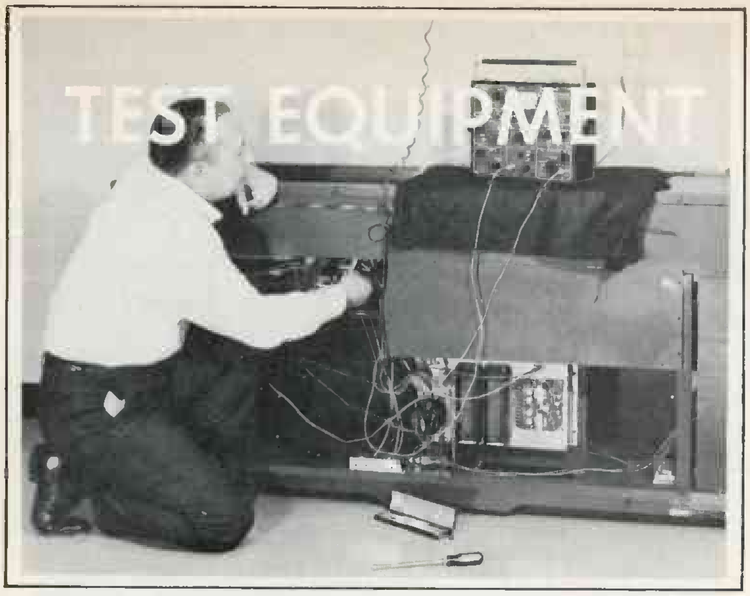


Fig. 4. Typical sweep oscillator circuit.

TEST EQUIPMENT FOR SERVICING STEREO



by Carl F. Moeller

While a VTVM, scope, and signal generator will permit you to solve most defects in stereo equipment, proper servicing demands a few test instruments designed specifically for audio and FM applications. The following article discusses both common and specialized test instruments.

Once upon a time, a farm boy unharnessed the team, greased the plow share, and went to town. He rented a room, bought a multimeter, seven vacuum tubes (one 12SA7, one 12SK7, one 12SQ7, and a pair of 50L6's and 35Z5's), a tube tester, and a board. On the board, he painted "Clyde's Radio Repair." Some months later, our hero added a 5Y3 and a pair of 6V6's to his inventory and repainted the board. "Clyde's Radio and Phonograph Service" was the most successful (and only) complete shop within a twenty-mile radius. During the "Big War," Clyde made a wad of money which he invested in Electric Canoe common, and, when TV hit the market, he hung up his soldering iron so he could devote all of his time to managing his finances and fishing.

Today, breaking into the stereo and hi-fi business requires a lot more effort than it did in Clyde's time. The evolution of the five-tube superhet into the modern color TV is perhaps more spectacular, but of no greater magnitude, than the evolution that has taken place in the sound reproduction field. To service stereo receivers, tape decks, record changers, and amplifiers, you need highly specialized test equipment plus a thorough knowledge of modern sound equipment.

At this point, we can almost hear what is running through many shop-owners' minds—"This guy must be some kind of a nut. People have been dragging their record players and FM radios into my shop for years and I fix them, no sweat. Now he wants me to buy a bunch of exotic test gear that I'll never use. Besides, a customer squawks like mad over a $12.00 repair bill; after all, his radio cost only $39.95, brand new."

These low-priced radios and phonographs are always going to be a nuisance to the service industry, but there is a brighter side. During 1967, about 1,600,000 console phonographs were sold in this country. This is 200,000 less than in 1966, but the fact remains that in the past two years alone, almost 3.4 million phonographs, ranging in price from $150 to $2000, were delivered to their owners. In addition to these, a sizable number of stereo component systems were sold. All in all, there is a large, growing market for service in the stereo field.

Since the purchase of a high-quality radio/phonograph represents a considerable outlay of money by the owner, two things are apparent: (1) a legitimate repair bill (say, $30 to $50) is a relatively small percentage of the cost of the equipment, and (2) the owner who can afford a $500 stereo is probably able to pay for good service.

On the other hand, a person who has invested several hundred dollars in stereo equipment expects good performance. Just getting sound to come out of the speakers does not complete the servicing procedure on quality stereo equipment. Before the job is completed, you must be certain that the original specifications concerning frequency response, sensitivity, distortion, hum, power output, wow and flutter, and separation have been restored. To meet these requirements, some rather specialized test equipment is necessary.

General Electronic Test Equipment

Before enumerating the instruments which have very specialized functions, let's review the ways in which you can service stereo with the equipment you already have—or should have. These are the scope, VTVM, VOM, transistor tester, capacitor tester, and tube tester.

Since the highest modulating frequency you will encounter in a stereo system is the SCA carrier at 67 kHz, there is no particular reason for the scope you use on the stereo bench to have a wide-band vertical amplifier. On the other hand, the vertical amplifier must have good low-frequency response, and a DC vertical input is very convenient. A high-impedance vertical input and a stable time base are also important. Since there are no sync pulses in a stereo, the scope has to "lock on" to sine waves, which is difficult.

Nearly all modern stereo equipment is transistorized. Therefore, you will require a VTVM with a low-voltage scale (no higher than 1 volt, full scale, and preferably lower). Since you will want to measure signal voltages, your VTVM must have flat frequency response up to 20 kHz. The same requirement applies to your VOM. It is also desirable that these meters have dB scales and built-in blocking capacitors to allow measurement of signals which are "riding" on a DC level. Since solid-state power ampli-

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fiers often have resistors with values of one ohm or less, one of your meters should have a low ohms scale.

The transistor tester you are using now is probably adequate for servicing stereo. However, since the output transistors of power amplifiers are paired, replacement transistors should be checked for matching characteristics. This will minimize amplifier distortion, but a fairly accurate transistor tester is required.

A capacitor tester is more necessary for servicing audio amplifiers than it is for servicing RF and video amplifiers. While the latter rarely operate with a bandwidth of more than 5 octaves, a high-quality stereo amplifier must pass almost 9 octaves. For this reason, audio coupling circuits are critical in design, and a small loss in capacity of a coupling capacitor can seriously affect the frequency response of the amplifier. Leaky capacitors may be located by numerous methods, but it is quite difficult to locate a below-tolerance capacitor without a capacitor tester.

Vacuum-tube stereo equipment is becoming so passe that there is little need for a tube tester on the stereo bench. For the occasional tube-type sets that are still around, nearly any tube tester will suffice. However, it should have a sensitive grid-emission test.

Turntables

Four pieces of test equipment are essential for servicing turntables. The one you should use most often is the simple strobe disc. Since many of the problems you encounter will involve speed variations or incorrect speed, every turntable that goes out of your shop should be checked with a strobe. Next comes the test record. This is a recording of pure tones at specified levels, making it useful for several purposes. Using it in conjunction with a scope (the third essential instrument) connected to the cartridge output, you can check the cartridge for frequency response, output level, and, roughly, for distortion. (A distortion meter connected to the cartridge via a linear amplifier gives a better check of distortion, of course.)

The last essential instrument is a stylus scale or pressure gauge. Today's cartridges perform best at their specified stylus tracking force. More important, stylus and record wear is directly proportional to tracking force. If a cartridge and its stylus are designed for 1 gram of pressure against the record, 4 grams of pressure will quadruple the wear. Damage a couple of record albums for a customer, and you'll be convinced that you need this instrument.

A microscope is not essential, but it is an excellent tool for boosting your stylus sales. The profit margin on styli is very attractive, so it is just good business to invest a few dollars to help you sell them. A 30X to 60X microscope will let you show the customer that his present stylus is worn. When you explain how a worn stylus can ruin a record in a single playing, you are almost certain to make a sale. Sell a stylus a day, and your light bill is paid. Incidentally, even a diamond stylus finally wears out.

Tape Transports

About the only test device you require specifically for tape decks is a test tape. This has standard recorded tones for head alignment and also may be used for checking the frequency response and distortion of a complete tape recorder. Strobe tapes are also available for checking tape speed. A strobe tape has alternate black-and-white transverse stripes and is used in the same manner as a strobe disc is used for turntables.

Although they are not items of test equipment, several other items are necessary for tape-deck maintenance. Tape-care kits are available from several manufacturers. These contain solvent, brushes, etc., and they may be sold as well as used in the shop. Another handy item is a lubricating tape. Running a lube tape through the tape deck lubricates the heads and guides. This is another item which you can also sell. Finally you will need a tape-head demagnetizer to degauss the tape heads before you return the deck to your customer.

Audio Amplifiers

Getting a signal through a dead amplifier is not particularly difficult for a qualified technician. Assuming that the power supply is functioning, it is a simple matter to find the faulty stage by injecting a signal at the input of each stage, starting at the output. Simple, that is, if you have a signal generator. Any audio generator may be used, but one of the pen-sized, transistorized harmonic generators is by far the most convenient. This little gadget is one of the greatest time-savers since sliced bread, so if you don't already have one, get one.

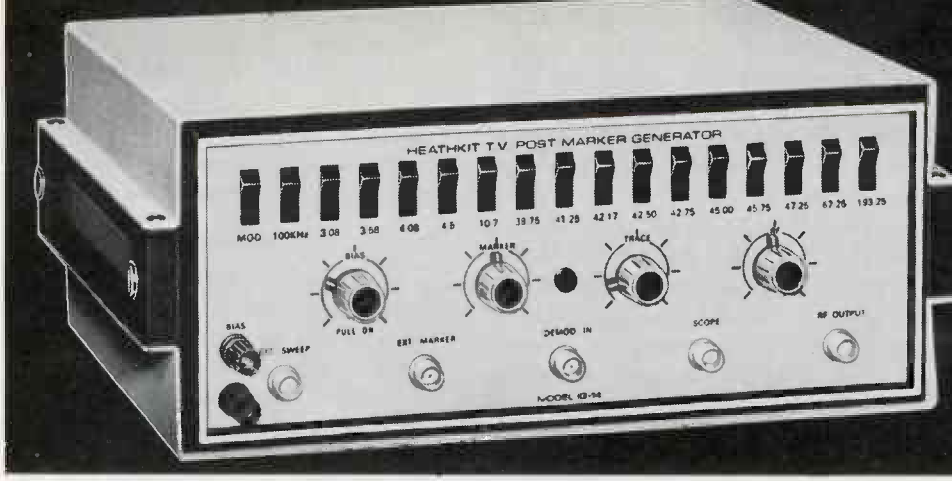
For checking frequency response and distortion, an audio signal generator is necessary. It should cover the entire audible frequency range (at least from 30 Hz to 15 kHz) and have a distortion content of no more than 1%. It is desirable that the generator have a built-in output meter, although this increases the cost. Naturally, any meter having a suitable range and flat frequency response may be used to monitor the generator output. Some audio generators are equipped with a calibrated output attenuator; others are not. Separate variable and step attenuators are available. For that matter, fixed attenuators are easily constructed from ordinary resistors.

A haromonic-distortion meter is essentially an audio output meter (VTVM) with a variable-frequency high-Q trap in its input circuit. To measure harmonic distortion, a pure sine wave is fed into the amplifier under test. The analyzer is connected to the output, and the trap is tuned to the frequency of the input signal. If there is no distortion, the trap completely rejects all of the signal and the meter reads zero. Naturally, if the amplifier under test generates any harmonics or spurious frequencies such as hum or noise, these pass through the trap to the meter.

Most harmonic-distortion meters also may be used as AC VTVM's. Depending on the particular make and model, the VTVM may have full-scale ranges from .01 volt to 300 volts. Thus, it may be used for noise and output measurements.

For reasons which are beyond the scope of this article, the intermodulation-distortion characteristics of an amplifier are of greater importance than the harmonic-distortion characteristics. However, equipment for measuring intermodulation (IM) distortion was not available at a moderate price until fairly recently. This equipment is now available separately or as part of a packaged stereo test set designed for the complete servicing of stereo receivers and amplifiers.

The usual method of measuring IM distortion is to feed two signals of



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No Trace Distortion. One of the big values to using a post marker generator like the IG-14 is that markers are injected after the sweep signal passes through the set being tested, thereby eliminating the 'scope trace distortion usually found when injection or absorption type marker generators are used.

Crystal-Controlled Markers For Any TV Alignment Task. Four marker frequencies are provided for setting color bandpass, one marker for TV sound, eight at the IF frequencies between 39.75 and 47.25 MHz, and markers for channel 4 and channel 10 picture and sound carriers for checking tuner RF response. With the ability to use up to six markers at once, such as picture and color carriers at 6 dB points, corner marker and trap frequencies, alignment is fast and precise. Trap alignment is just a matter of selecting the appropriate trap frequency, applying the 400 Hz modulation, and tuning the trap for minimum audio on a scope or meter.

Easy FM IF and Discriminator Alignment. The IG-14 provides *visible* markers at the 10.7 MHz center frequency plus 100 kHz markers on each side . . . visible because they are applied to the trace after detection and so are not attenuated by the discriminator. Use of harmonics, fully explained in the manual, provide tracking markers as well.

Trace and Marker Amplitude Controls . . . on the front panel permit using a regular service type 'scope instead of a wide-band, ultra-sensitive model . . . and stage by stage alignment is easier.

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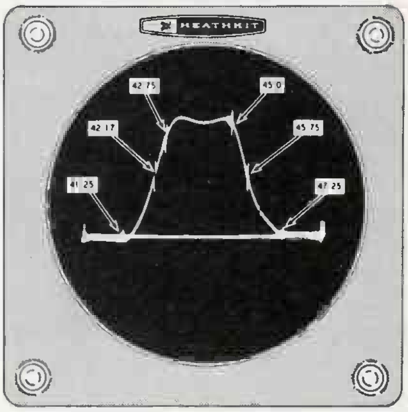
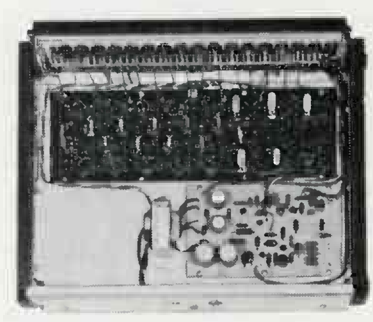
Kit IG-14, 8 lbs., no money dn., $10 mo. **$99.95**

IG-14 SPECIFICATIONS—Crystal Marker Frequencies: 3.08, 3.58, 4.08, 4.5, and 10.7 MHz @ .01%; 39.750, 41.250, 42.170, 42.500, 42.750, 45.000, 45.750, 47.250, 67.250, and 193.250 MHz @ .005%. **FM Bandwidth Marker:** 100 kHz. **Modulation:** 400 Hz. **Input Impedance:** External sweep, 75 ohm; External marker, 75 ohm; Demodulation input, 220K ohm. **Output Impedance:** RF output, 75 ohm; Scope output, 22K ohm. **Bias Output Voltage:** Variable from 0 to 15 VDC @ 10 MA. Isolated from chassis for either negative or positive bias. **Type of Marker:** "Birdie." **Controls:** Bias voltage with AC on/off; Trace size; Marker amplitude; RF output; Modulation on/off; Markers, individual switches for each frequency. **Semiconductors:** Transistors: (16) 2N3692; (6) 2N3395; (3) Silicon diodes; (1) Zener diode, 13.6-V. **Power requirements:** 105-125 volts, 50/60 Hz AC @ 7.5 watts. **Net weight:** 8 lbs.



SIX MARKERS SIMULTANEOUSLY. The scope trace above shows how six markers can appear at the same time. Note the trap markers, 6 dB points, and picture and sound carriers . . . all on one trace with the IG-14.



EASY TO BUILD. Note how everything except the front panel switches and controls mount on two circuit boards . . . even the crystals.

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different frequencies into the amplifier under test and then measure any intermodulation products which are developed in the amplifier. Using the SMPTE methods of measurement, a signal between 40 Hz and 100 Hz (F1) and a second signal between 1 kHz and 12 kHz (F2) with one-fourth (−12 dB) of the amplitude of the low-frequency signal are fed into the amplifier. The output of a perfect amplifier would consist of F1 and F2, and nothing else. Outputs having frequencies of (F2 − F1), (F2 + F1), (2F2 ± F1), (F2 ± 2F1), ... (F2 ±5F1) are intermodulation products. The IM-distortion meter filters out the desired frequencies with a series of filters and measures only the intermodulation products which remain.

The lack of stereo separation is not usually a problem in stereo power amplifiers; however, separation may be measured by feeding a signal into one channel and comparing the outputs of the two channels. This requires a signal generator and an output meter, the same instruments required for measuring frequency response.

Many audio servicemen prefer to use a square-wave generator, rather than a sine-wave generator, for observing the performance of an audio amplifier. While quantitative measurements of distortion and response are difficult or impossible using a square-wave signal, an experienced observer can estimate the performance of an amplifier quite accurately by observing the appearance of its square-wave output. For example, if the output square wave has a sloping leading edge, the high-frequency response is poor. If the flat top of the waveform sags at the trailing end, the low-frequency response is poor. Overshoot and ringing are indications of peaks in the response curve, excessive distortion, or instability.

The square-wave generator and scope are also valuable in isolating faults to a particular stage. It is difficult to inject a signal into an amplifier at any point except the input while still maintaining a good impedance match, and a mismatch at the point of injection will, in itself, introduce distortion. Thus, signal-tracing techniques, rather than injection tracing, are required for finding sources of distortion and incorrect response. Unfortunately, output meters and distortion meters usually require low-impedance, high-level inputs. However, a scope may be used at any point in the circuit, and, by using it in conjunction with a square-wave generator connected to the amplifier input, the faulty stage may be quickly isolated.

Several audio-signal generators on the market today will produce either square waves or sine waves at the flick of a switch. This is especially convenient since it makes both waveforms available without changing connections. A word of caution: If you are operating the amplifier "full bore" with a sine-wave input, switching to the square-wave input may seriously overload the output transistors if the peak-to-peak amplitude of the input signal remains the same or increases.

Tuners and Decoders

Since most modern FM stereo tuners also contain the multiplex decoder, the test equipment required for each of these is included under one heading. For servicing the tuner, two signal generators are necessary. One generator must be tunable across the FM broadcast band (88 to 108 MHz) and is used to align the RF stages of the tuner. Since the RF bandpass of an FM receiver is not usually critical, servicing of the front end rarely requires the use of a sweep generator; however, the IF section of the tuner does require sweep alignment. This requires a sweep generator with a center frequency of 10.7 MHz and a 10.7-MHz marker, in addition to a scope.

Several stereo testers currently on the market generate the above-mentioned signals and also the composite stereo modulation. Generally, the RF carrier which they generate may be tuned only slightly above or below 100 MHz by a screw-driver adjustment. This carrier is frequency modulated by a choice of a monaural tone, a pilot subcarrier with tone modulation, unmodulated pilot subcarrier, 67-kHz or 72-kHz subcarriers for adjusting SCA traps, and external modulation. Some of these instruments generate separate left and right signals simultaneously, others generate "left only" or "right only" signals. Still other instruments have additional features such as a VTVM, impedance bridge, square wave-generator, IM-distortion tester, etc.

Again, depending on the complexity of the particular test set, all of the modulating signals may be available separately. At least one tester on the market peforms all the functions of a miniature FM stereo transmitter, requiring only a stereo tape deck or turnable to modulate it.

Summary

In the limited space available, we have attempted to enumerate the types of test equipment required for servicing stereo receivers, amplifiers, turntables, and tape decks. The selection of specific instruments can be made only by the shop owner. Personal preferences will affect each individual's choice, and, of course, the cost of the various instruments is an important consideration. For example, prices of audio signal generators range from less than $100 to nearly $1000.

Until the advent of stereo FM broadcasting and the rising popularity of high-quality stereo, there was little or no market for "middle-grade" audio test equipment. "Lab-quality" equipment was available—at a price—but equipment having reasonably good accuracy and stability at a moderate cost just was not available. (Of course, the all-in-one stereo test set has appeared only since the inauguration of FM stereocasting in June, 1961.)

Today, however, the situation is rapidly changing. A wide selection of audio signal generators, distortion analyzers, and all-in-one test instruments designed for service work is available at reasonable prices. In selecting your stereo test equipment, we suggest that you proceed along these lines:

1. Take inventory of your test equipment and determine which of the tests we have mentioned you can perform with the equipment you already have.
2. Estimate the amount of additional service you can sell by augmenting your present equipment.
3. Study the specifications, features, and prices of the various instruments that will satisfy your needs. Remember that your stereo service business will grow as you establish a reputation and promote this new service.
4. Buy your new test equipment, repaint *your* board, and cash in on the growing market of stereo service. ▲

TEST EQUIPMENT FOR SERVICING CB

Although the test equipment requirements for servicing a particular type of electronic equipment usually overlap those for another type, most require a few items of specialized gear. Such special test equipment is needed for proper servicing of Citizens-Band equipment.

by William E. Daupert

When the old 11-meter amateur band was reassigned to the Citizens Radio Service, the American public immediately took advantage of it. The earliest equipment for this service was neither plentiful nor fancy, but now both the manufacturers and users have greatly increased in number and just about any kind of equipment is available. This equipment ranges from simple two-or three-tube superregenerative receivers to single-sideband, suppressed-carrier equipment, and at a price to fit any pocket book.

There are four classes of Citizens Band Stations. Class A stations are licensed to operate on an assigned frequency in the 460 to 470-MHz band with an input power of 60 watts or less.

Class B stations are licensed to operate on an authorized frequency in the 460 to 470-MHz band with an input power of 5 watts or less.

Class C stations are licensed to operate on an authorized frequency in the 29.96 to 27.23-MHz band or on the frequency of 27.255 MHz, for the control of remote objects or devices by radio, or for the remote actuation of devices which are used solely as a means of attracting attention, or on an authorized frequency in the 72 to 76-MHz band for the control of model aircraft only.

Class D stations are licensed to operate on an authorized frequency in the 26.96 to 27.23-MHz band or on the frequency 27.255 MHz with input power of 5 watts or less, and for radiotelephony only. Class D stations are authorized to use amplitude voice modulation including single sideband and/or reduced or suppressed carrier for radiotelephone communications only.

Power measurements must be made during maximum peaks of modulation, and with meters having

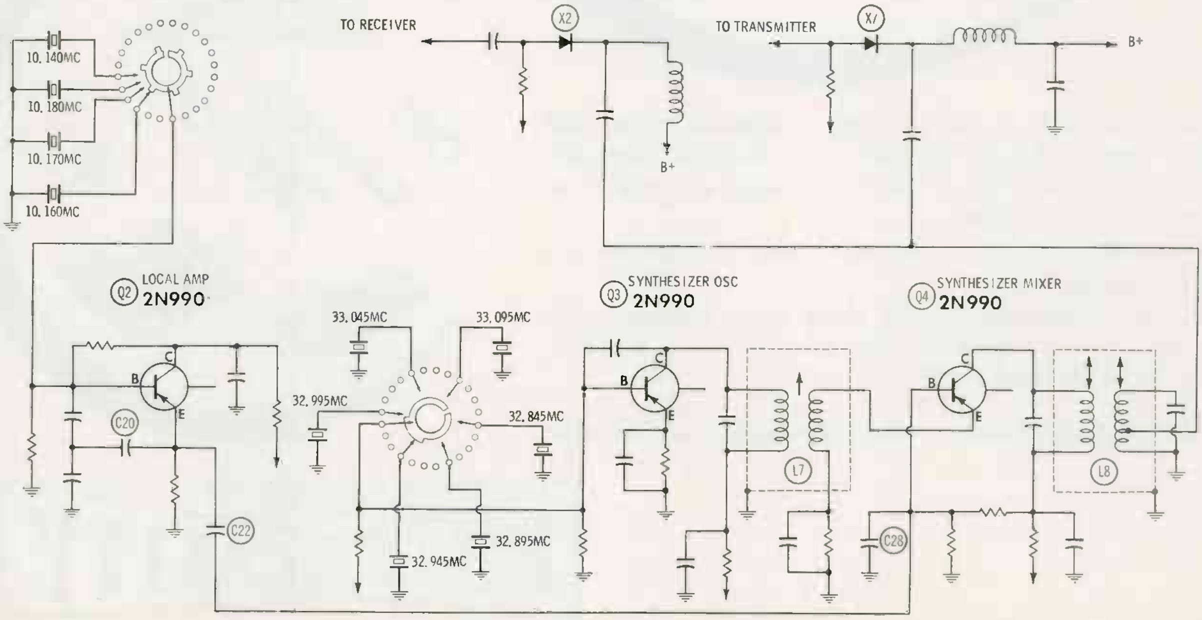


Fig. 1. Schematic of typical synthesizer stages.

Fig. 2. Lectrotech CB analyzer.

full scale accuracy of 2% or better. The frequency of the Class D transmitter must be maintained within ±.005%.

Equipment Features

Among the latest auxilliary features of the Citizens Band equipment are built-in standing-wave-ratio bridges, output meters, and S-meters. Lately there have also been tremendous improvements in the main equipment; more receivers are using dual conversion, crystal filters, and mechanical filters, and transmitters are using compression amplifiers in the speech section. Ring modulators are popular in sideband equipment.

One of the latest additions to Citizens Band equipment is the frequency synthesizer circuit which maintains the transmitter and receiver on the same frequency at all times. Fig. 1 is a diagram of a typical frequency synthesizer circuit.

The synthesizer section consists of a low-frequency local oscillator (Q2) and its 4 crystals, the high-frequency oscillator (Q3) with its crystals, and the mixer (Q4). As shown in Fig. 1, the synthesizer is set for operation on Channel 11. Here's how it operates:

The 10.160-MHz crystal is connected directly into the base of Q2, a Colpitts oscillator. C22 and C28 form a capactive voltage divider for the output. The high-frequency oscillator Q3 operates on third overtone crystals, in this case a 32.895-MHz crystal. The signal from Q3's collector is fed into L7 and thence to the emitter of the synthesizer mixer, Q4. At Q4, the low frequency signal, 10.160 MHz, is fed to the base and subtracted from the high frequency signal of 32.895 MHz. The resulting frequency is 22.735 MHz. The 22.735-MHz signal is coupled through L8 to switching diodes X1 and X2.

In receive position X1 is cut off and X2 couples the synthesizer mixer signal to the emitter of the receiver mixer transistor. The receiver IF amplifiers are tuned to 4.3 MHz (channel 11 minus 22.735 MHz). During transmit, X2 is cut off and X1 will conduct the signal from the synthesizer mixer to the transmitter mixer emitter The transmitter oscillator, which always operates at 4.3 MHz. will add to the synthesizer mixer frequency and become the channel frequency.

Available Test Equipment

For bench service of Citizens and Business Band radio equipment, different types of test instruments are needed depending upon the band class of the radio equipment. Since most modern Citizens Band equipment is completely transistorized, care should be taken in the selection of test equipment.

The DC power supply on the service bench does not need to be very heavy for most class D Citizens Band equipment, since most of these rigs draw from 100 ma to about 1 amp in the transmit position. However, for Business Band equipment you will need a considerably heavier power supply. These transmitters run up to 60 watts input and draw from 10 to 30 amps. The ripple content should be less than 2% with good regulation.

The DC bench supply should be metered for voltage as well as current, as voltage is often a determining factor in locating a trouble quickly. The meter accuracy should be at least ±4% or better. The supply voltage should be variable at least in two ranges. The smaller supplies, suitable for Citizens Band radios, run from 0 to 6 volts in one range and 0 to 20 volts in the second range. The larger DC supplies used in Business Band and other services usually run from 0 to 15 volts and 0 to 35 volts DC at about 30 amps.

In most cases it is beneficial to have a variable DC supply, since you can check the vibrator in vibrator power supplies to see whether it will start, and at what voltage. In the case of small DC supplies with poor regulation, try putting a small value resistor across the output terminals. A resistor of 20 to 30 ohms with 20 watts capacity will often help regulation problems.

There are several types of frequency meters available to meet FCC requirements. Available types range from comparatively inexpensive heterodyne meters to lab-type counters with digital display. Buy the most accurate you can afford.

Fig. 2 shows one of the newest instruments for CB servicing. This instrument is a combination frequency, power output, and modulation meter. Note that the frequency measurement is read by setting the

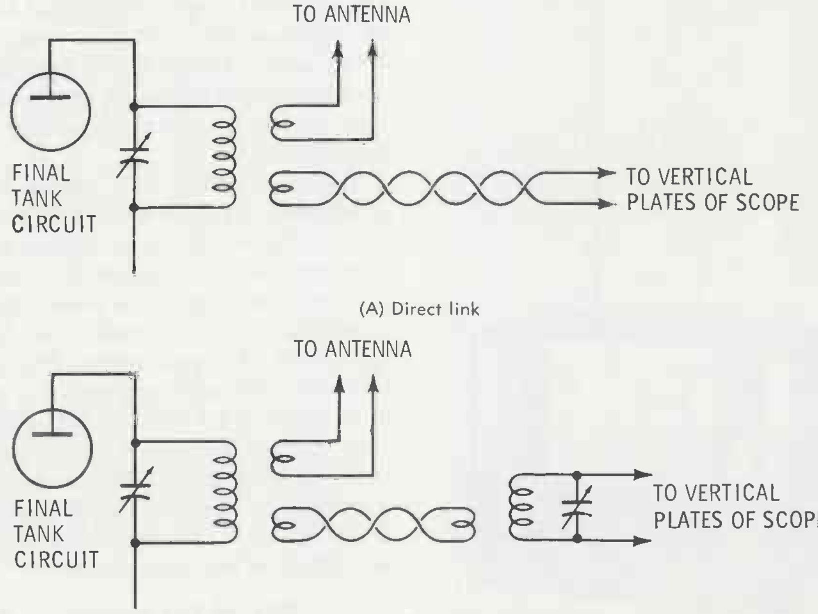


Fig. 3. Connecting scope for modulation envelope.

channel selector to the desired channel, and then reading the error in Hz on the meter. This instrument's frequency accuracy is .0015%, which is fine for CB work

A good oscilloscope or output analyzer is helpful in checking modulation and/or percentage of modulation with A2 or A3 emission. Fig. 3 shows two methods of checking the modulation of a Citizens Band rig with an oscilloscope.

The circuit in Fig. 3A is a convenient way in which to couple the transmitter output to an oscilloscope. However, if you do not have enough deflection on the vertical plates of the scope, the circuit in Fig. 3B will increase deflection. The tuned circuit in Fig. 3B should be tuned to the output frequency of the transmitter, and the height of the scope pattern increased or decreased by adjusting the coupling of the line to the final tank coil.

A somewhat simpler way of checking approximate modulation percentage is with a transceiver tester such as that in Fig. 4. This instrument also checks a number of things including VSWR of the antenna. Most of these transceiver testers are limited to instruments of 5 watts output or less; but they are relatively inexpensive. Many features are available in these testers, so it is best to compare specifications before purchase.

The instrument in Fig. 5 is designed for VSWR and power mea-

Fig. 4. B&K Cobra transceiver tester.

surements alone. However, it can handle transmitters up to 1 kw output, which makes it useful for testing all classes of Citizens and Business Band operations.

A well-equipped service shop should not be without a good VTVM or FET meter. Low range volt and ohm scales are essential, as transistor circuitry is common. Meters are now available with scales as low as .01 volt and up to 1000 volts DC, and ohms scales which read from .1 ohm to 50 megohms. Some of these meters are battery operated, which is very handy in servicing of units in the car. An AC VTVM is a good addition to any service shop, for alignment of ordinary home radio equipment as well as Citizens and Business Band equipment. Most AC VTVMs have ranges from .001 volt to 300 volts AC and a dB scale from −72 dB to +50 dB—which is very helpful in measuring the stage gain of a receiver.

A good in-circuit transistor tester should be considered standard equipment in any modern communications shop. Most of these instruments are completely trustworthy; if the meter says "good," then the transistor can be eliminated as a possible trouble source. These instruments are also useful for checking power rectifiers and signal diodes.

Another must in servicing Citizens Business Band radios is a good signal generator for aligning RF and IF circuits. The generator should have a dial calibrated with an accuracy of 1% or better, and a modulated output continuously variable down to about .1 μv. Quite a few of the latest transistor receivers can be overloaded with a strong signal, resulting in misalignment.

When selecting and using test equipment, attention should be given to such characteristics as impedance, insertion loss, attenuation etc. Also, it should be noted that these characteristics will vary with the frequency of the equipment. For instance, a wattmeter may read 5 watts at 27 MHz and 3 watts at 150 MHz, even though the power input is the same in both cases. The manufacturer usually furnishes specification charts to show the frequency characteristics of his equipment.

Use of Equipment

The first check for trouble in a unit should be visual. Look to see if

Fig. 5. Seco antenna tester.

there are any burned components, and check for cracked or blistered resistors. The circuit board should be carefully checked for cracks or breaks. Sometimes in a mobile installation there is a tendency for parts to vibrate out of their sockets.

The frequency meter is very useful in troubleshooting, especially when checking synthesizers and local oscillators. Care should be taken not to couple too much signal from an oscillator into the frequency meter. Never key the transmitter directly into the frequency meter as serious damage could result.

Power consumption checks should be made while the unit is on the bench, in both receive and transmit modes. Excessive input current could indicate leaky filters or transistors. The radio will operate more or less normally, but will soon cause trouble.

When any parts have been replaced that might affect the operating frequency of the equipment, such as any part that will affect the input of the transmitter or modulator, the frequency and the modulation percentage should be checked. Also, the input power to the final stage should be checked to see that it does not exceed legal limits.

Conclusion

The use of good test equipment will ease troubleshooting in most Business or Citizens Band radio equipment, and will do a more efficient job of putting the equipment back on the air. Time will be saved by the serviceman who is using the best equipment. Customers will be satisfied and the customer's equipment can be kept within the legal limits as set forth by the Federal Communications Commission. ▲

SERVICE YOUR OWN MULTIMETER

Don't shove that defective VOM, VTVM, or transistorized multimeter into a corner to collect dust while you ponder whether it's worth the effort and expense involved in sending it away for repair. If the meter movement isn't damaged, you can repair any multimeter yourself.

by Ellsworth Ladyman

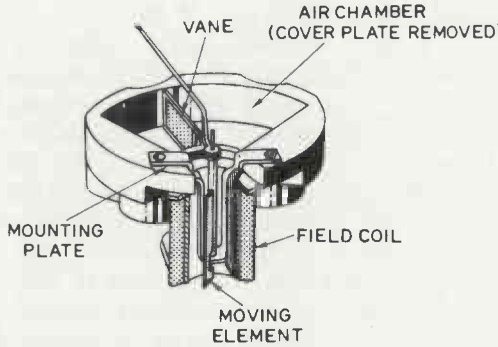
Effective and profitable repair of electronic devices can be accomplished only by using the proper test equipment. The successful service shop displays an imposing array of test instruments designed to perform specific tests to isolate defective components in electronic gear. This array of test equipment represents a considerable monetary investment, and as such, should be carefully maintained. Careful maintenance and repair of test equipment can add greatly to the efficiency of the average service organization. Rare is the shop that doesn't have a defective VOM, VTVM, scope, or generator lying around. Although it may not be completely defective, in many cases only the people well acquainted with its peculiarities can operate it.

Test instruments that probably rank highest on the casualty list are meters, VOM's and VTVM's. This is primarily due to the rough handling they get on the bench and the many rides they get in the service truck. Also, it is not too uncommon for a technician who is absorbed in a particularly difficult servicing problem to unknowingly attempt to measure B boost with the function switch in "ohms" position. Regardless of what causes the failure, the instrument must be returned to service as soon as possible.

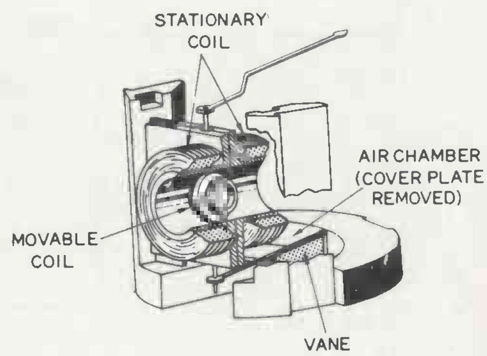
Servicing VOM's

The first step in the repair of a meter is to decide whether it is repairable in the shop or whether it must be returned to the factory. This usually is not a difficult decision; if the meter movement is damaged, it should be returned to the factory; if not, the instrument in all probability can be repaired in the shop. Referring to Fig. 1 (an illustration of two types of meter movements) will quickly point up the folly of attempting repair of the meter movement itself.

After deciding to repair the instrument yourself, remove it from the case, being careful to prevent scarring or scratching the clear plastic or glass covering the meter face. The rear cover or back of the case is usually secured by four retaining



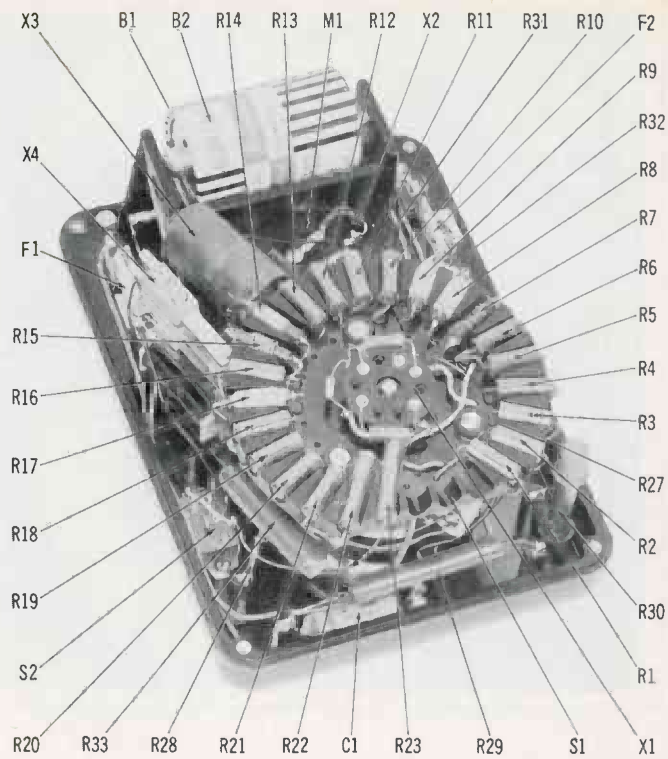
(A) Moving iron vane



(B) Dynamometer

Fig. 1. Drawings of two basic types of meter movements illustrate intricate parts.

(A) Meter includes resistance, DC, AC, and dB scales.



(B) Component layout reflects compact size.

Fig 2. Front-cabinet and internal views of typical volt-ohm-milliammeter.

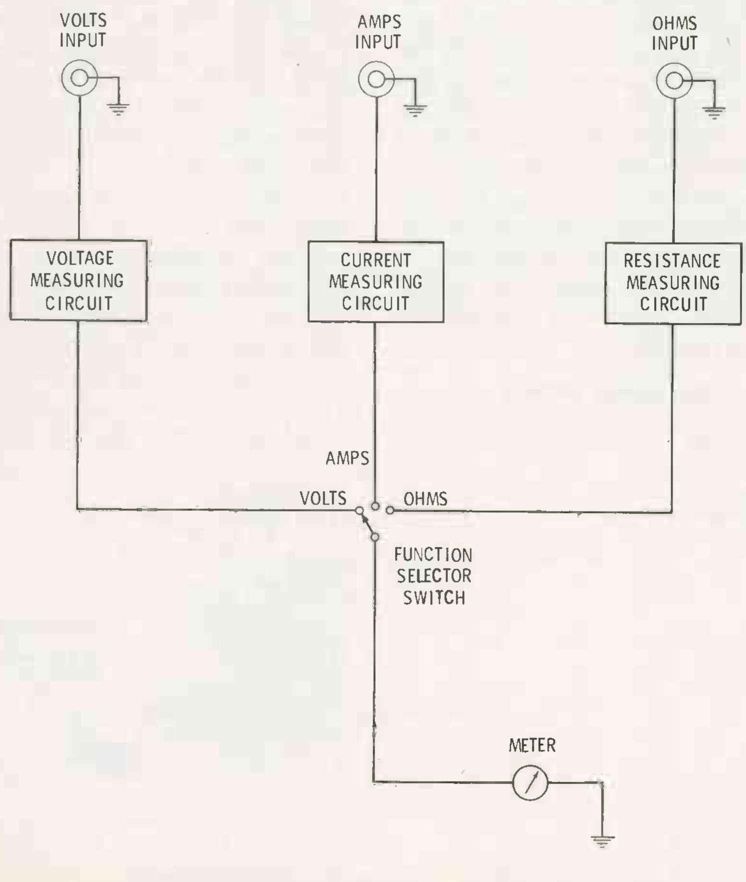


Fig. 3. Block diagram of VOM emphasizes isolation between functions.

screws. These screws are sometimes recessed and not visible until four rubber fet are removed.

When removal from the case is completed, make a careful visual inspection of all components; look specifically for evidence of overheated parts, defective contacts, etc. At first glance, the layout of the components will appear to be a complicated conglomeration of parts (Fig. 2), but an analysis of the trouble symptom(s) will, in most cases, automatically eliminate a major portion of the components from further consideration as the probable cause. The block diagram in Fig. 3 bears this out. If the meter readings are erratic during resistance measurements, the voltage and current measuring circuits can be eliminated as possible trouble suspects; conversely, if the voltage readings are inconsistent, the resistance and current measuring circuits can be eliminated. In the same manner, the resistance and voltage circuits are eliminated when erroneous readings prevail only during current measurements.

Further localization of the defect results when the erroneous readings are confined to a particular scale (this is usually the case). At this point, reference to the manufacturer's schematic of the instrument under test should localize the defective component to a particular leg of the circuit; for instance, if erroneous readings are present only on the R × 100K range, the defect has to be in that particular circuit—i.e., the switch contact(s) or resistors related to that particular setting of the function switch. This will hold true for any scale. An analysis of the schematic shown in Fig. 4 will illustrate this fact.

Meter Sensitivity

Most VOM's used for servicing electronic apparatus have a sensitivity of 20,000 ohms-per-volts. This is about the maximum sensitivity available in ruggedly constructed VOM's —and they have to be rugged to stand the pounding they get in the course of duty. Most 20,000 ohms-per-volt instruments utilize a 50-microampere meter with an internal resistance of 20,000 ohms. Of course, due to excessive circuit loading, even the best VOM's leave something to be desired when grid voltages are to be measured.

Meter Shunts

Occasionally, it may be necessary to compute the value of a shunt and/or multiplier resistor; the value of a resistor might be unreadable, making identification impossible, and the schematics for the VOM or VTVM under repair may not be available

Ammeter Shunt

The formula for determining the value of an ammeter shunt is:

$$R_S = \frac{I_M \times R_M}{I_S}$$

where,

R_S is the resistance of the shunt resistor

I_M is the full-scale current rating of the meter

R_M is the meter resistance

I_S is the current that will flow through the shunt at full scale.

The current flow through the shunt (I_S) is the difference between the meter current (usually 50 microamperes) and the current to be measured; for example, to calculate the shunt resistance requirements for a 100-microampere scale using a 50-microampere meter:

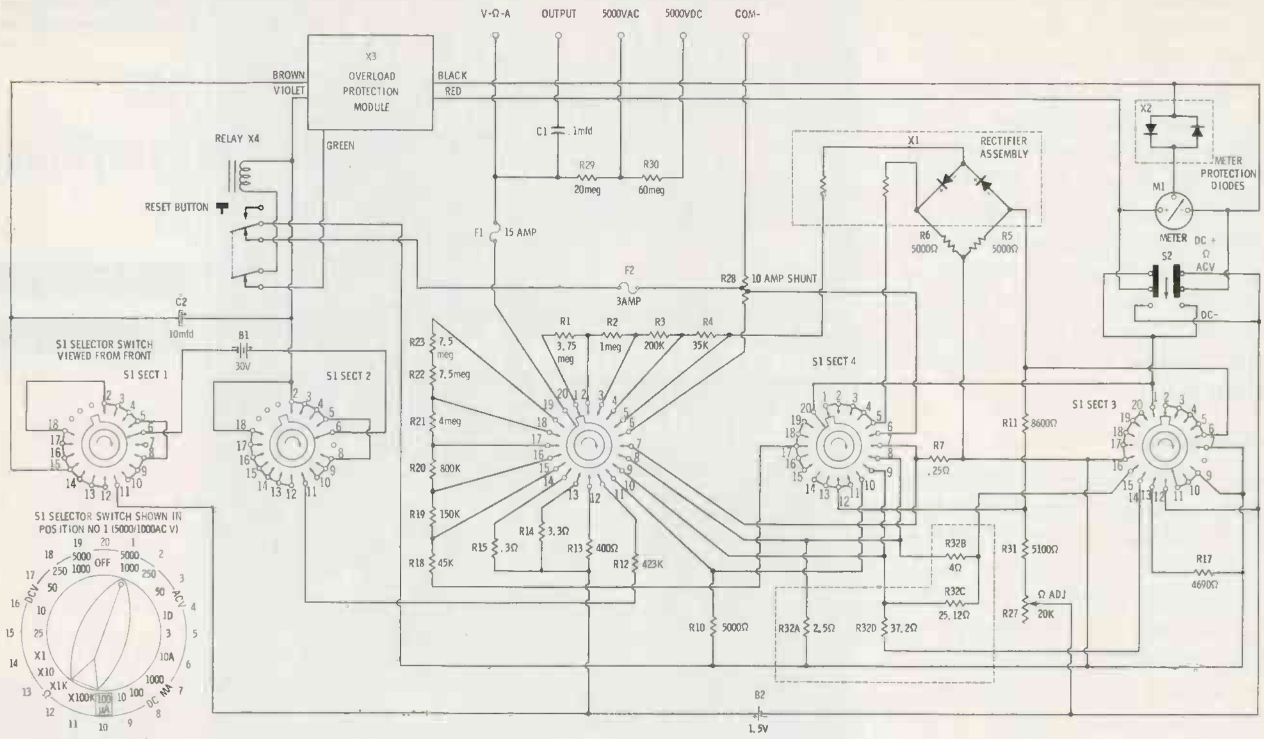


Fig. 4. Complete schematic diagram of typical volt-ohm-milliammeter.

$R_S = 20{,}000$ ohms

$I_S = .0001 - .00005$

$I_S = .00005$ amp

Consequently,

$$R_S = \frac{.00005 \times 20{,}000}{.00005}$$

Voltage Range Multipliers

Multiplier resistors in a VOM are simply resistors of selected values that extend the voltage measuring range of the meter. These resistors are switched in by the range selector switch. To find the actual value of any specific multiplier, the meter resistance and desired full-scale voltage range must be known. The multiplier value may then be computed as follows:

$$R_{MULT} = \frac{E_{VR}}{I_S} - R_{METER}$$

where,

E_{VR} is the full-scale voltage range

I_S is the full-scale meter current

For example, if the resistance associated with 250-volt DC range cannot be determined from the markings on the resistor, it can be calculated as follows:

$$R_{MULT} = \frac{250}{.00005} - 20{,}000$$

$R_{MULT} = 4.98$ megohms

AC Voltage Reading Circuit

The majority of VOM's in use today employ the d'Arsonval meter movement, which requires a rectifier circuit to rectify AC voltages before a reading can be obtained. Since the rectifier circuit functions only during AC measurements, it is logical to suspect this circuit when trouble symptoms occur only during AC measurements. A typical circuit configuration for AC voltage measurement is shown in Fig. 5.

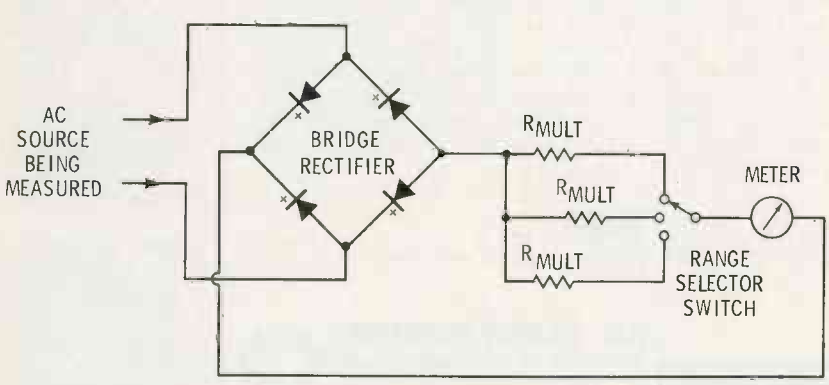


Fig. 5. Bridge-type rectifier circuit for measuring AC voltage.

General Service Procedures

1. Check the defective instrument on all scales and functions; make a list of trouble symptoms. A careful analysis of the instrument's overall performance is essential.
2. Refer to the schematic and study the circuits; determine in what area you can expect trouble. The

list made up in Step 1, used in conjunction with the schematic, should help you pinpoint the trouble area.

3. Check out the suspected circuit leg using another VOM. Remember, most resistors used as shunts, multipliers, etc., have at least 1% tolerance, and sometimes less.

Calibration

Due to the variation in circuitry from manufacturer to manufacturer, a detailed calibration procedure that would apply to all instruments is impossible. In general, an instrument can be checked in several different ways:

1. Its performance can be checked against that of another instrument of its type. The meter being used as a standard must have a known performance rating.
2. The ohmmeter portion can be quickly checked by measuring resistors of known value; a decade box is useful for this purpose.
3. The voltage portion can be checked by measuring various outputs of a variable power supply, battery outputs, etc.
4. The ammeter portion can be evaluated in the same manner as the voltage portion except, of course, current is used in place of voltage.

Do not overlook the possibility of trouble external to the meter. Most meter failures occur when probes, test leads, adapters, etc., become worn. A loose test lead can give such a wide range of indications that it will be almost impossible to evaluate a meter's performance. Always suspect leads and probes first, then the meter itself.

Servicing VTVM's

The VTVM utilizes the same basic operating theory associated with the VOM; that is, current flowing through a meter movement produces deflection of the pointer. The major difference between the two instrument types is that at least one vacuum tube circuit is employed in the VTVM (Fig. 6). The use of the vacuum tube(s) gives the VTVM several advantages over the VOM, but as is true in nearly all phases of electronic design, "when you gain something, you lose something"; so, there are also disadvantages.

VTVM Advantages

1. A much higher input impedance. This is due to the inherently high input impedance of the vacuum-tube grid circuit. This higher input impedance results in greatly reduced circuit loading, and increases the use of the meter.
2. Another inherent feature of the vacuum tube circuit is the low input capacitance. This allows measurement of AC voltages at much higher frequencies than the VOM.
3. The amplification of the input signal by the vacuum tube amplifier increases the sensitivity of the meter, allowing measurement of much smaller voltages and greatly extending the range of resistance measurement.

VTVM Disadvantages

1. More frequent calibration required (compared to VOM) due to aging of vacuum tube.
2. The very nature of a vacuum tube circuit is indicative of less stable operation.
3. An external power source (usually 110 VAC, 60 cycle) is required.
4. The VTVM must reach operating temperature and correct voltages before stable operation is possible.
5. The circuit is somewhat more trouble prone than the VOM because of the more complex circuitry.

VTVM Maintenance and Repair

Since specific circuits are used for specific measurements, the overall circuit can be broken down into sections to facilitate troubleshooting procedures:

1. DC voltage measurement circuit.
2. AC voltage measurement circuit.
3. Ohms or resistance measurement circuits.
4. Power supply.

A careful analysis of the trouble symptom(s) permits quicker isolation of the circuit defect to a particular stage. The circuits associated with one function are fairly well isolated from those of another; for instance:

1. Amplifier circuit—DC (negative and positive) voltage readings.
2. Rectifier stage — AC voltage measurements.
3. Battery and multiplier resistors —Resistance Measurements.
4. Power supply—Both AC and DC voltage measurements.
5. Probe—All measurements.
6. Function selector switch—All measurements.
7. Range selector switch—All measurements.

Tube Failure

As in any electronic apparatus, the amplifier or rectifier tubes can and do fail. This condition is immediately discernible and can be evidenced by any of the following indications:

1. No response whatever.
2. Response only on AC readings.
3. Response only on DC reading.
4. Erroneous or erratic readings on AC and DC measurements.
5. Readings lower than expected.
6. Will not balance, or inability to perform calibration procedures.

Following replacement of defective tubes in a VTVM, the instrument must be recalibrated. Calibration should be carried out in accordance with the manufacturer's instructions.

It will be necessary to "age" replacement tubes before installation. This is necessary due to changes in tube characteristics during their first 100 hours of operation. One method of "aging" is accomplished by installing the tubes in the VTVM, turning the VTVM on and applying operating voltage to the tubes for approximately 100 hours before calibrating.

Component Replacement

Tolerance is the main factor to be considered when replacing a component in a VTVM, or any meter circuit. Replacement parts must be within the tolerance stated in the manufacturers information. Extreme care should be exercised during the replacement operation. Avoid overheating terminals, excessive solder on joints and unnecessary heating of adjacent components.

The battery employed in the ohmmeter circuit (B1, Fig. 6) should never be allowed to reach a badly discharged condition, nor should a discharged battery be allowed to remain in the case. To check the level of charge, proceed as follows:

1. Set the function selector to "ohms."
2. Turn the range selector to "RX1" position.
3. Rotate the ohms-adjust control to attain full-scale deflection.
4. Short the probe and ground leads together.
5. Remove the short between probe and ground leads.
6. The meter should read full-scale; if not, the batteries are probably weak.

External Troubles

When troubleshooting any device, the most logical trouble source is usually the part that is handled the most; consequently, the probes and ground leads of the VTVM require special attention. Frequent inspection of probes and leads can save time and prevent the frustration of erroneous meter indications.

Servicing Transistor VOM's

Electronic meters utilizing transistors rather than vacuum tubes are able to combine most of the advantages of the VOM and the VTVM. Such meters have an extremely high

Circle 20 on literature card

Circle 21 on literature card

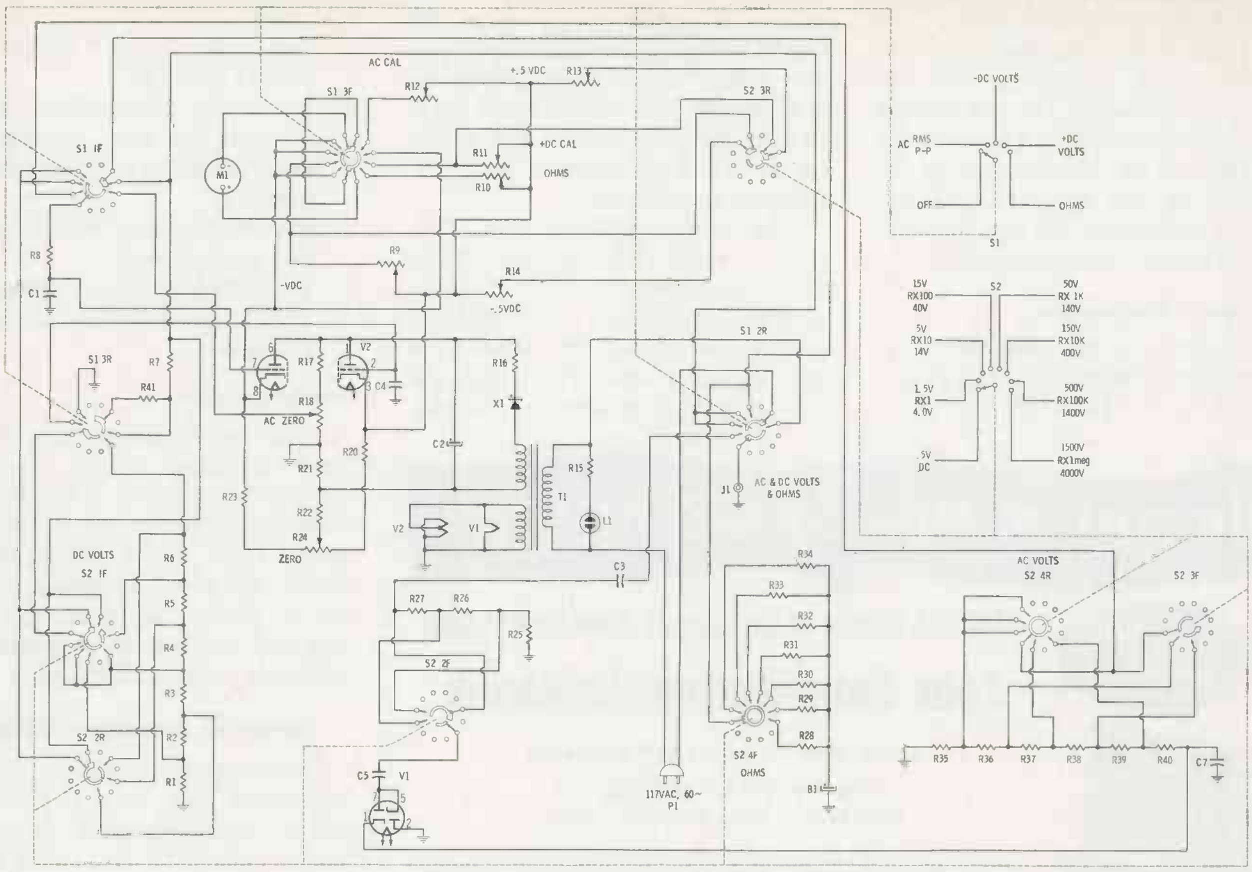


Fig. 6. Complete schematic diagram of vacuum-tube voltmeter.

Fig. 7. Multimeter employing field-effect transistors.

input resistance (10-22 Megohms), require no warm-up time, and are portable since no external power source is needed.

One such instrument (Fig. 7) employs field-effect transistors (FET) in the circuitry (Fig. 8). The operation of a field-effect transistor is very similar to that of a vacuum tube; one suitable (but over-simplified) description of it is: "a transistor that thinks it's a tube."

The FET and vacuum-tube circuits illustrated in Fig. 9 point up the similarities of the two configurations; terminology is about the only significant difference. Bias is obtained for the FET circuit in the same manner used in the vacuum tube (current flowing through the bias resistor develops a voltage across it). The operation of these two devices is so similar that like terms can be applied when describing their operation: The gate (grid) controls the current flow between the source (cathode) and the drain (plate) by regulating or governing the effect of the existing electrostatic field between the gate (grid) and the source (cathode). However, there are differences: The FET doesn't have a "treated" cathode that becomes depleted of electrons, and the circuit is far more stable and resistant to operational changes than the vacuum tube circuit.

FET Meter Circuit Analysis

Transistors Q1 and Q2 (Fig. 8) make up the differential amplifier required for use in DC voltage and ohmmeter measurements. When there is no voltage applied to the input of Q1, the zero adjust control is adjusted so that the voltages developed across source resistors R14 and R22 are equal in amplitude; consequently, no current will flow through the meter. The DC balance control (R29) works the same as the zero adjust control; however, it is an internal adjustment and is used to compensate for internal component tolerances. When a DC voltage is applied to the input circuit of Q1, the balance existing between Q1 and Q2 is upset, current flows through the meter, and the pointer indicates the value of the applied voltage. Input divider resistors R1 through R8 permit a total of seven AC and DC ranges. Capacitors C2 through C8 compensate the divider resistors for the different AC ranges. The DC calibrate control functions as the name implies: It calibrates the meter for accuracy when a known value of DC voltage is applied. If a voltage higher than the limit indicated by the range selector switch is applied to the input of Q1, the neon bulb (NE2) will light (fire) and hold the voltage applied to Q1 at a safe level, protecting Q1 from damage.

Resistance measurements are accomplished by a voltage divider consisting of a known and unknown value of resistance; the value of the voltage developed across the unknown resistance is translated to resistance on a meter scale calibrated in ohms.

With the value of the unknown resistance at "zero" (leads shorted together), the ohms-adjust control (R23) is adjusted so that the pointer deflects full-scale when the full potential from B1 is applied to Q1; as increasing amounts of resistance are applied between the leads, the pointer deflects less due to smaller amounts of current applied to the meter.

With the function selector set for AC measurements, the AC voltage is applied to a divider resistor (R2-R8), as was done for DC measurements. The output of transistor Q1 is then fed to a p-p detector made up of C10, C11, X1 and X2. This DC output is then applied to transistor Q2 through the divider network made up of R25, R26, R27, and CR6. The meter is located in the source circuit of transistor Q2. The DC voltage developed in the source circuit of Q2 (proportional to the p-p voltage applied to Q1) is fed to the meter. Diodes X5 and X6 are for temperature compensation and make the meter independent of temperature changes occurring between 32° and 122°F.

DC current measurements utilize meter and shunt resistors R16 through R19. The transistors and their associated circuitry are not required during current measurements. The meter is rated at 100 microamperes; consequently, the meter is connected directly into the circuit when using the 100-microampere scale. To troubleshoot field-effect

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The new Super 50 chassis is designed for better performance and greater reliability. Installation in the home and adjustment of alignment is easier. And if the necessity for service ever arises, you'll find the Super 50 chassis has been specially planned in many ways for fast, easy and efficient servicing.

Circuitry is simplified, clutter has been eliminated. Heat critical components are isolated in the coolest area of the chassis, for longer life. Important servicing test points are clearly identified by chassis stampings or by "flags." All parts are more accessible. And all separated assemblies (tuner, convergence assembly, deflection yoke, speakers, etc.) have a "plug in" connection.

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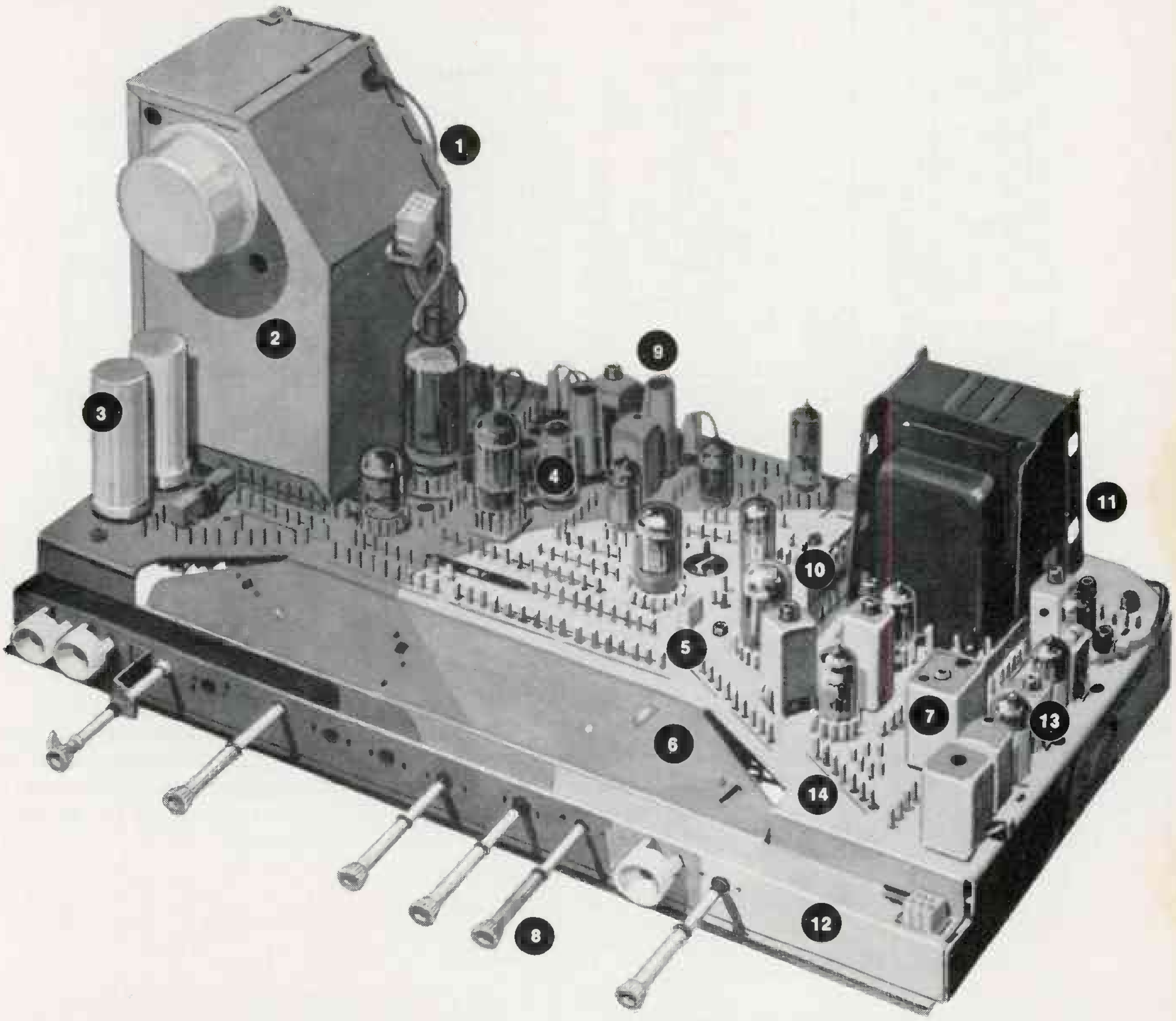

1. Exclusive Zenith High Voltage Regulator Circuitry
Zenith's regulator tube keeps a constant 25,000 volts of picture power while itself operating at 5,000 volts or less — one-fifth the operating voltage of a conventional shunt regulator tube when maintaining the same picture power.
2. High Voltage Sweep Transformer
Zenith's new sweep transformer is shielded within a metal cage. And it's sealed in polyester resin virtually impervious to moisture and protected against corona discharge.
3. Heat Critical Components Isolated
The electrolytics, relocated to the chassis's coolest corner, are isolated from heat producing components for longer life.
4. Automatic Color Level
Keeps colors constant—station to station, channel to channel. Helps compensate for variations in signal transmission.
5. Plug-In Assemblies
All assemblies not mounted on the rugged metal chassis have "plug-in" electrical connectors for easy removal without breaking soldered connections.
6. Automatic Degaussing Circuit
Automatically demagnetizes the color tube each time the set is turned on from a cold start.
7. Zenith AFC (Automatic Fine-tuning Control)
Electronically fine-tunes Zenith Color TV at the flick of a finger. Assures the sharpest color picture. Most of the 23" diagonal models are equipped with this feature.
8. Pull-Out Secondary Control Knobs
Now all secondary control knobs pull out one full inch for easier access and adjustment.
9. Advanced Color Demodulator Circuit
Zenith patented circuit extracts color from the incoming signal and sends it to the picture-tube with peak precision for natural, life-like colors.
10. Solid-State Video Amplifier
This transistor amplifies the picture information and assures excellent highlight brightness and picture detail.
11. Fin-Cooled Power Transformer
With excellent heat-dissipating characteristics, it assures constant, full voltage.
12. Exclusive Horizontal Handcrafted Chassis
No printed circuits. No production shortcuts. Rugged 16-gauge steel base provides up to 200% greater heat conduction ability than phenolic material used in ordinary plastic printed boards.
13. 3 Stage I.F. Amplifier
All three stages—each with its own frame grid tube and interstage transformer—have been relocated to reduce possible interaction with other circuits for greater stability.
14. Metal Cone Check Points
Easy-to-read numbers and "flags" identify the metal cone check points, help to make diagnosis easy and accurate.

NOT SHOWN ABOVE

Easy Access Front Convergence
In most 20" and 23" (diag.) models simply remove the grille and speaker assembly for easy access to the entire convergence panel assembly, saving you time and trouble.
Removable "Easy-Service" Plate
The bottom of the cabinet is cut out and covered with a perforated metal plate. Alignment tools may be inserted through slots in this plate. Or the plate can be removed for easy access to up to 90 per cent of the circuitry.

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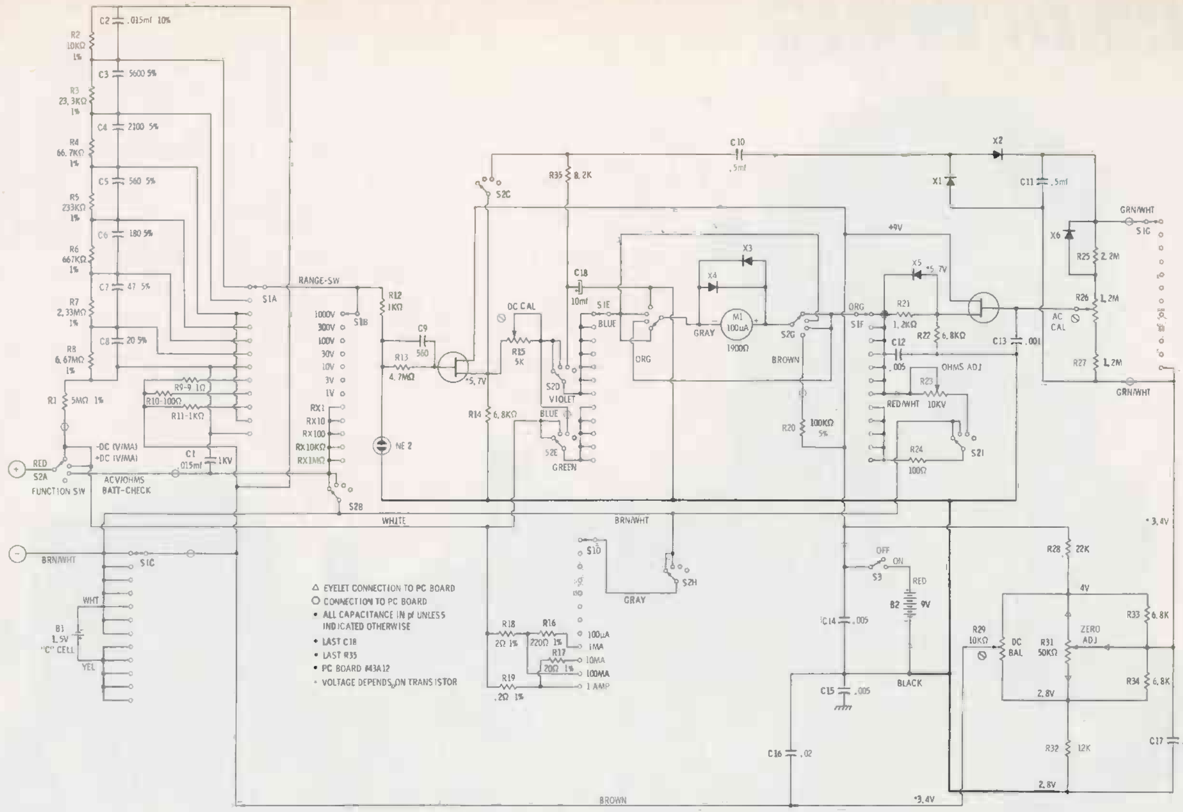

Fig. 8. Schematic diagram of multimeter employing FET's in place of vacuum tubes.

or conventional transistor volt-ohmmeters, use the same procedures that were outlined for VOM'S and VTVM's:

1. Carefully analyze the trouble symptoms.
2. Be sure you are checking in the right circuit.
3. Make a careful visual inspection.
4. Check components carefully; make replacements only with components rated well within the tolerances stated by the manufacturer. ▲

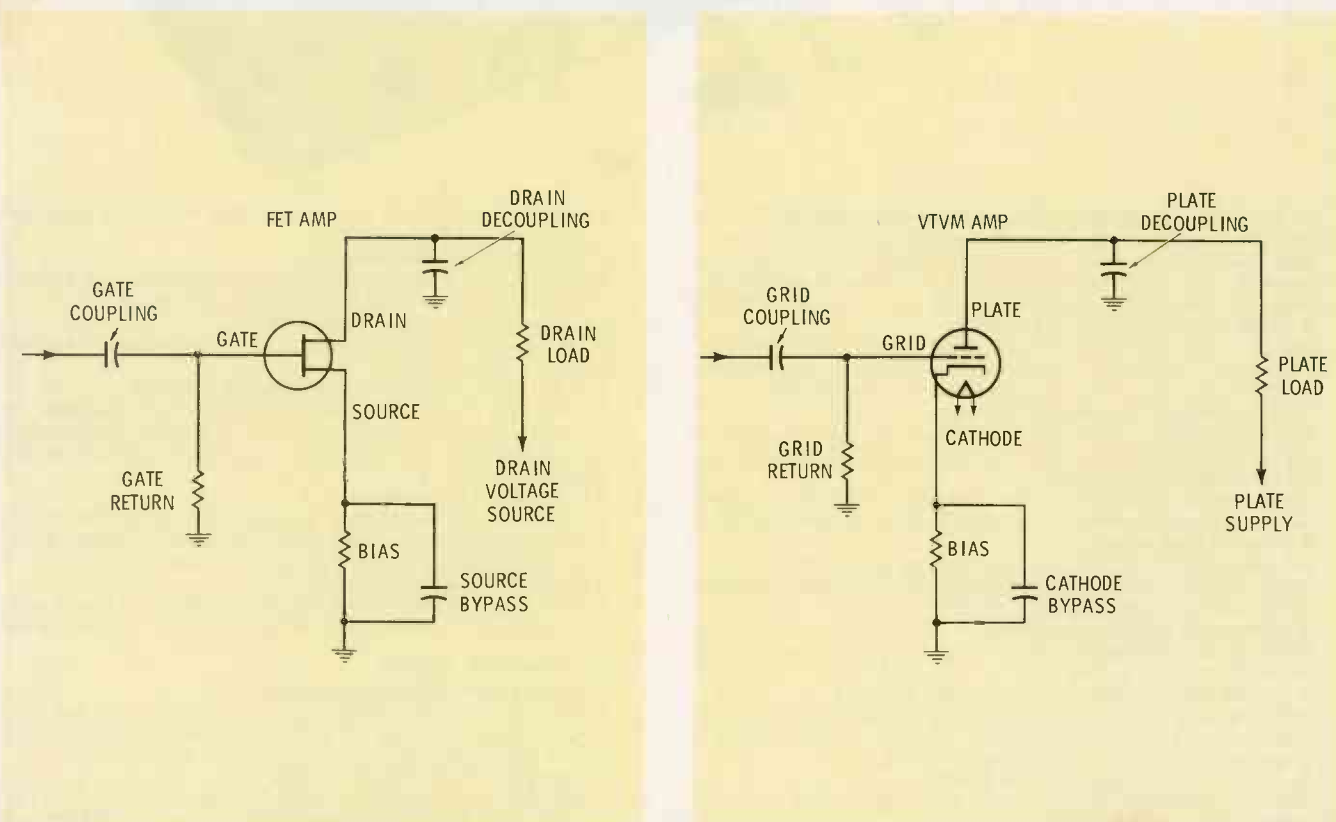

Fig. 9. Comparison of amplifiers employing field-effect transistor and vacuum tube.

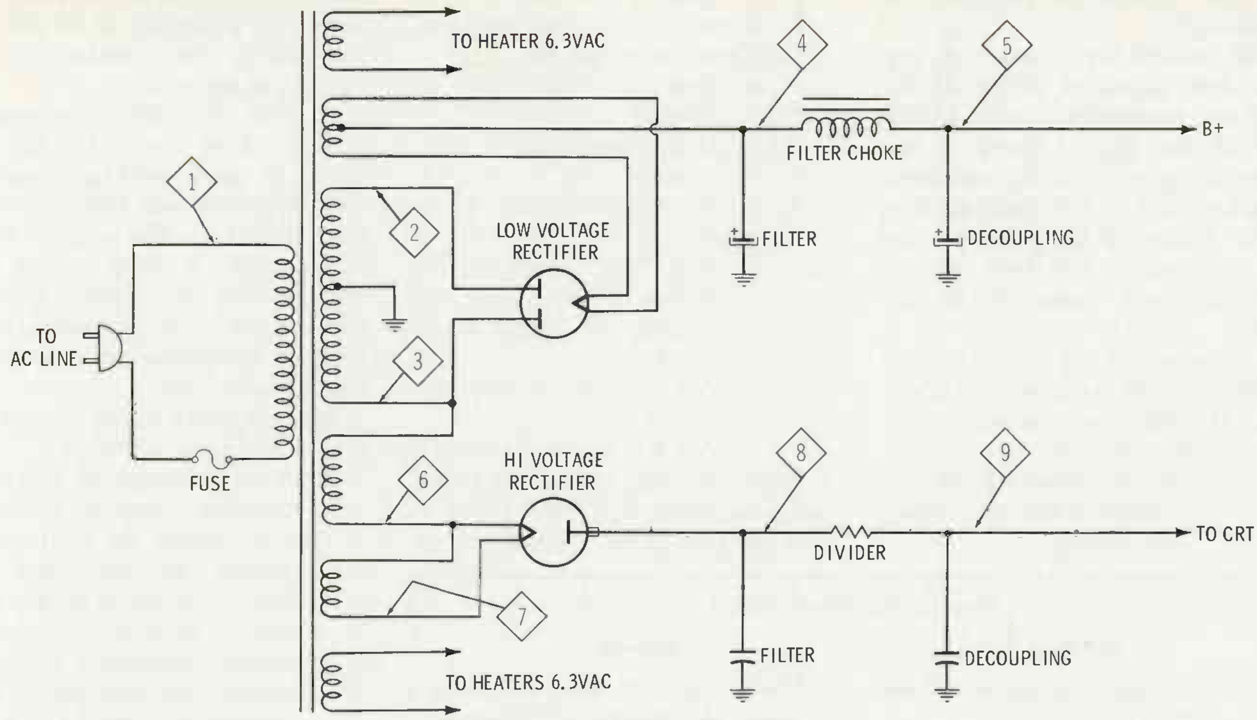

Fig. 5. Typical scope power supply.

Fix That Scope

(Continued from page 19)

same. Two controls are normally provided for control of the horizontal sweep oscillator. One of these is usually a rotary switch and it will probably be termed "Coarse Frequency"; the other will be a potentiometer and in all probability will be named "Fine Frequency."

There must be some method of synchronizing the vertical input signal with the internal horizontal sweep oscillator. This is accomplished by picking off a portion of the vertical input and applying it to the horizontal sweep oscillator stage (Fig. 3). This signal (the portion picked off the vertical section) is used to trigger the horizontal sweep oscillator. When you adjust the horizontal controls to view the desired number of vertical pulses or cycles, you are locking the horizontal oscillator "ON" at a specific multiple or submultiple of the input vertical signal. Practically all scopes on the market today also provide facilities for application of an external horizontal sync signal.

Scope power supplies must be capable of providing both low voltages (in the order of 300 volts) and high voltages (ranging from 450 to 1200 volts). These power supplies can be incorporated into one section, or they may be separated. Nothing goes wrong in a scope power supply that doesn't go wrong in a radio, television, amplifier, or any other power supply. Filters short or open up, bleeder and divider resistors change value, and transformers break down. These troubles are comparatively easy to isolate, and should cause you very little concern in troubleshooting. Fig. 5 shows a typical scope power supply.

The cathode ray tube (CRT) must be considered the heart of an oscilloscope. The size and type of the CRT to a large extent determines the power supply requirements. Operation of a CRT is as follows (Refer to Fig. 6):

1. The heater current is supplied by a winding of the power transformer.
2. As the heater warms up, the cathode is heated and starts emitting electrons.
3. Electrons emitted from the cathode are attracted by the nearest positive CRT element, which will be grid No. 2.
4. These electrons will pass through the aperture in grid No. 2 and continue through anodes No. 1 and No. 2.
5. Anodes No. 1 and No. 2 shape the electrons into a tight beam.
6. The deflection plates (vertical and horizontal) will then attract the electron beam, causing it to bend on its path to the phosphorous CRT coating in accordance with applied signal volts.
7. The electrons are then collected by the interior coating (internally connected to anode No. 2), and the circuit is completed.

Servicing Procedure

As is the case in any servicing problem, the initial analysis of the trouble symptom is of utmost im-

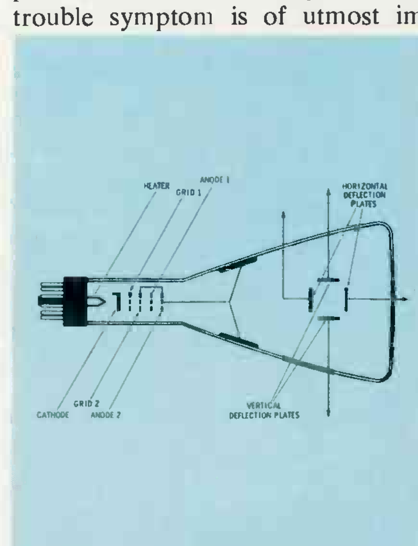

Fig. 6. Important elements of a CRT.

portance. The time spent learning how the instrument functions is never wasted.

The vertical input circuit, amplifiers, and deflection plates of the CRT are responsible for the amplitude of the signal. Sweep is the responsibility of the sweep oscillator, amplifier and horizontal-deflection plates. Failure of the power supply will, of course, affect both vertical and horizontal operation of the scope.

An analysis of the trouble should contain the following information:

1. If trouble is occuring in the vertical section:
   a. Is it occurring on all ranges of the input selector switch?
   b. Is it intermittent or continuous in nature?
2. If the trouble affects the horizontal sweep circuits:
   a. Does it occur on all ranges?
   b. Is it intermittent or continuous?
3. If the trouble consists of no sweep:
   a. Is a "dot" visible in the center of the screen, indicating no sweep whatever?
   b. Are external connections okay?
   c. Are B + voltages normal?

Before actually attempting to repair your scope, it is a good idea to have answers to these questions. Be sure you are not having trouble with external equipment. Probes and leads take a beating, so be sure you are making good connection to the equipment under test.

A little preventive maintenance can go a long way in keeping your scope in good working condition. One thing that will help immeasurably is to keep the controls of the scope clean. A dirty control (and if one is dirty, it is a pretty good bet they all are) can provide a multitude of symptoms such as erratic trace, bounce, etc.

A quick check of the controls can be accomplished as follows:

1. Turn the scope on, and adjust controls to provide horizontal trace across the CRT screen.
2. Adjust the horizontal gain control slowly in such a manner as to cause the trace to spread completely across the screen, then decrease the trace (adjust the control) to a minimum. The trace should move smoothly across the screen. Any jerky movement of the trace is indicative of a dirty horizontal control, or improperly operating horizontal section.
3. Apply a 60-Hz sine-wave signal to the vertical input terminal. Adjust the controls to provide a visual indication of the input voltage. Run the vertical input selector switch through its various positions, adjusting the vertical gain potentiometer to keep the trace (as much as possible) within the confines of the CRT screen; if it does not move smoothly, cleaning of both switch and control is in order.
4. Other controls (horizontal frequency, etc.) can be checked in the same manner by applying an appropriate, known signal to the inputs. Adjust controls for a normal visual indication. Any jerky or abnormal indication should be checked out.

NOTE: A properly operating piece of equipment should be left alone, but any deviation from normal operation should be checked out at once. A little cleaning here and there can prevent a lot of trouble and insure that the equipment is ready when you need it. ▲

Troubleshooting Chart

Symptom	Remedy
1. No trace, screen not illuminated, pilot light on.	1. Check fuses. If fuse is blown, make all checks to eliminate possibility of direct short to ground. Never clip or jump across fuse terminals. 2. Don't overlook the possibility of a bad tube. 3. Make voltage and/or resistance checks from test points 1 through 9 to ground (Fig. 5).
2. Trace moves from left to right across CRT screen, but no vertical sweep.	1. Check the probe. 2. If another scope is available, monitor waveforms at test points 1 through 8 in Fig. 3. With a VTVM, check voltages at test points 1A through 6A. 3. Be sure wafer contacts on vertical attenuator switch are clean and making good contact. Check compensation networks for value changes, although value changes in these circuits should show up as poor frequency reresponse.
3. Vertical trace in center of screen, trace changes in amplitude, but no horizontal sweep.	1. Check waveforms at test points 1 thru 6, make voltage checks at test points 1A thru 8A (See Fig. 4). 2. Check compensating networks at input circuit. Be sure input selector switch wafer contacts are clean and making good contact. 3. If external horizontal sync is applied, check probe for good contact at circuit point under test and for good contact with scope connector. Probe ground straps are frequent offenders.

VOLTS ARE WHERE THEY FIND YOU

He who understands electricity and its potential, usually respects it. However, familiarity does breed contempt, and most of us are guilty at one time or another.

by A. J. Dilles

You probably haven't done much service work if you haven't been "zapped" a few times. Maybe they were pretty mild or possibly they were the real teethgrating, body-quivering, quick-jerk-to-escape type —the kind that keep you honest for a long time. The sources are many and varied, ranging from 110 volts AC to B+ to Boost B+ to the snapping 25 kv in the color sets. Unpleasantly sometimes, volts are prone to turn up in some of the least expected places, which means that most of us, at one time or another, absently touch a wire or a component or a cabinet, and then —Zap!

Take one person I know, an experienced serviceman who really should have known better. He kept an AC/DC radio on the kitchen sink of his home, and the knob was missing from the tuning shaft. But Al was no fool. He simply moved the radio to the far end of the drainboard, nicely out of reach of the faucet, a perfect ground. We all know what a nuisance finding just the right knob can be and, after all, Al's was such an easy solution.

And so one night Al stood idly tuning the radio as his wife busily washed the dinner dishes. An affectionate mood came over him and, still holding the unprotected shaft, he stretched over toward his wife to kiss her. She in turn leaned responsively toward him, one hand resting on the faucet. Their lips met and —Zappo! Talk about kisses!

I recall a real jolt I once caught while repairing an antenna. Who would have stopped to consider the probability of a shorted capacitor in the receiver? I subsequently found out—the hard way—that the culprit was one of the two RF bypass tubulars that shunt each side of the AC input. The set played fine, but unfortunately for me, the chassis was now hot, and the AC, obeying the laws of electricity, ran a devious, crazy path from the chassis through the balun, through the twin-lead, through the antenna and through me to the vent which I was touching. Needless to say, I now unplug the set before I climb on the roof.

This experience was, of course, with a transformer-equipped set. On series-string models, the manufacturer will generally isolate the antenna terminals from the tuner by inserting a small capacitor in series with each side. Whenever you have the back off such a set, it's a good idea not to bypass these capacitors by connecting the lead-in directly to the tuner. Remember that cable systems are almost always grounded, while a conventional antenna system may very well be. Thus, you could end up with a burned-out balun or—if you got between the lead-in and the chassis—a healthy jolt. If the tuner input lead must be removed, the problem can be solved very nicely by carrying in your tube caddy a short length of twin-lead with alligator clips at each end and an isolating capacitor in series with each side.

Along the same line, I once made a service call where the owner complained of having been shocked by the rabbit ears. Even after the set was unplugged, he refused to touch them. I noticed that a wall heater was mounted directly beside the set. A voltage check confirmed that 110 volts AC existed between it and the rabbit ears. Undoubtedly, the customer had touched them both simultaneously. A brief inspection and subsequent questioning disclosed that he had thriftily replaced a defective line cord himself, bypassing the interlock and soldering the ends directly under the chassis. He had allowed the sharp edge of the chassis to rest on the cord and, predictably, the metal had cut through the insulation and made contact with one of the wires. It was the same story: A hot chassis with current flow through balun, lead-in, and antenna to the most convenient ground—in this case, the wall heater. The customer's person had acted as the switch that closed the circuit.

Other potential trouble spots are to be found in the metal cabinets that enclose the many transformerless portables and table models, including some color sets. Standard manufacturing procedures call for insulating the chassis from the cabinet by the use of nylon spacers. Here again the error factor sometimes occurs, and the two may contact each other. Thus, if the plug is not polarized, a potentially lethal situation exists. You can help avoid this possibility by not using screws that are too long and that might extend beyond the nylon and touch the chassis. Also, inspect for loose wires, misplaced ground braids or missing spacers. And finally, before you button it up, make an ohmmeter check between the cabinet and the chassis, flexing the cabinet as you do so.

Another, less serious, problem exists in residual voltages. Many a technician (not to mention customer) has felt a sharp jolt and rubbed a suddenly numb hand, suppressing what he would have said if the lady of the house had not been watching curiously. Capacitors will hold a charge—often a substantial one. Here the serviceman's best friend comes in handy—the common, ordinary, inexpensive clip lead. Before making any static checks, ground out the fuse holder and any exposed electrolytics. When changing high-voltage tubes, attach the clip to the high-voltage lead and leave it there till the tube has been substituted. Remember, even though the shock may only sting, it could cause you to tear open your hand as you jerk away.

And so, the next time you troubleshoot a set, take that extra minute to be sure. If there's any question, use your meter to eliminate doubt. And be skeptical—don't take anything for granted. Don't just assume the set is unplugged. Think in terms of safety. Precautions pay off —especially when they become a habit. ▲

PHOTOFACT™ BULLETIN

PHOTOFACT BULLETIN lists new PHOTOFACT coverage issued during the last month for new TV chassis. This is another way PF REPORTER brings you the very latest facts you need to keep fully informed between regular issues of PHOTOFACT Index Supplements issued in March, June, and September.

Aiwa		
	11T-05	940-1
Bradford	CWGE-55301A, CWGE-59576A	938-1
Coronado	TV2-6611A, TV2-6612A, TV2-6810A	941-1
	TV2-6613A, TV2-6615A, TV2-6616A, TV2-6811A	939-1
	TV2-7112A	938-2
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	Chassis M4	937-1
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	Chassis 8Y4B36	936-3
Production Change Bulletins		
Admiral		
	Chassis G308-3, G310-1/-2, G334-2, G344-1/-3, G346-1/-2/-3, G347-1/-3, G1255-4/-5, G1256-2, G1257-2, G1295-1	941-3
	Chassis 20B6CB, 20B6TB, 20UB6CB, 20UB6TB, 25E6, 25F6, 25UE6	937-3
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	Chassis AA, AY, MW (19"), MW (23"), SA	937-3
	Chassis SY, TA	939-3
Silvertone		
	Chassis 456/528.61227/236/239	939-3
Zenith		
	Chassis 29JC20, 29JC20Q	939-3

NOTES ON TEST EQUIPMENT

analysis of test instruments ...operation...applications

by T. T. Jones

Transistor Tester

One of the most attractively styled instruments to be marketed in recent months is Jackson's Model 810 Dynamic Transistor Tester. It has a sloping edge on the front of the case, coupled with just the right touch of color present in the push-button switches. It's a real eye-catcher. Jackson is the first manufacturer we've noticed using the new Centralab switches, but the latter are so versatile that we expect to see more of them in the future.

Circuit-wise, the Model 810 uses an AC-beta test which is becoming somewhat of an industry standard. Fig. 2 is a simplified schematic of the beta test, with the tester set to read NPN transistors on the "HI" scale. The meter is reading collector current. The internal resistance of the meter is 220 ohms, so the actual value of the collector load is about 22 ohms (R8 and the meter in parallel). Note that the base resistor is 220 ohms. The meter is set to fullscale by adjusting the power transformer primary voltage. The capacitors are in the circuit for bypassing and stability.

When the "Beta Test" switch is depressed, the meter and R7 are transposed. The collector load remains the same since R7 and the meter have the same resistance. The base bias remains the same, for the same reasons, but now the meter is reading base current, and since the meter is no longer shunted, the sensitivity is 10 times greater. If the deflection of the meter is the same in both positions of the "Beta Test" switch, the transistor under test would have a beta of 10.

Fig. 1. Jackson Model 810 transistor analyst is eye-catcher.

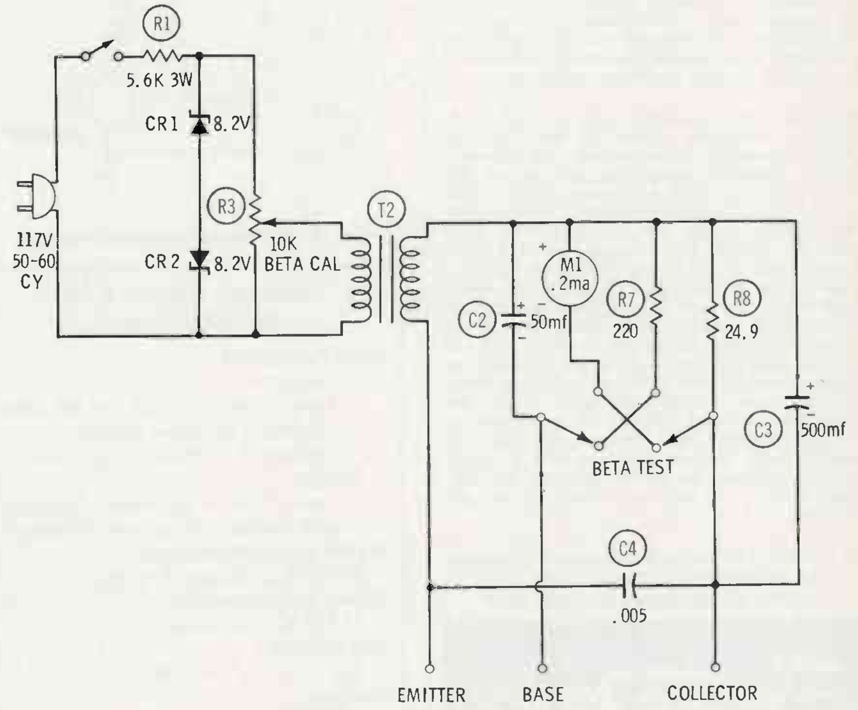


Fig. 2. Beta testNPN HI range.

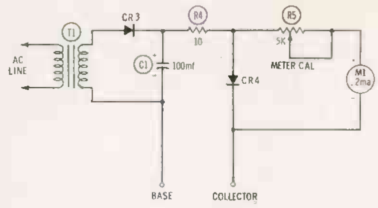


Fig. 3. Leakage test—NPN range.

The leakage test is shown in Fig. 3. This circuit is also quite simple since it is nothing more than a continuity test of the Base-Collector junction. Note though, in the photo (Fig. 1), that the leakage scale is linear to a midscale reading of 100 microamps, and then becomes semi-logarithmic in the second half, to a fullscale reading of 5 milliamps. This is accomplished by CR4 and R5. Remember that most diodes do not conduct until a certain amount of forward bias is applied—usually about 0.5 volt. They then conduct in a semi-logarithmic fashion. If CR4 is chosen so that it just begins to conduct when the meter is at midscale, it will take an increasing share of the current as the current is increased.

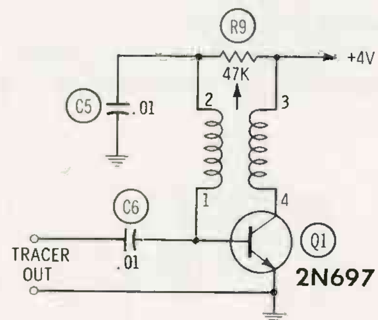


Fig. 4. The signal generator stage.

Jackson Model 810 Specifications

Tests Performed

Transistors:
Beta 2-100, 10-500 in- or out-of-circuit, signal or power.
Leakage 0-5000 μa (V_{CB} = 4V).

Diodes:
Open or short in-circuit. Forward and reverse current out-of-circuit.

Signal generator output:
8.5 VPP semi-square wave.

Power Requirements:
117 VAC 2½ watts.

Size (HWD):
7½" × 7½" × 4⅝".

Weight:
4½ pounds.

Price:
$89.95.

The Model 810 also has a built-in signal generator which can be used in a variety of troubleshooting applications. The output signal is a semisquare wave with a considerable amount of frequency modulation. Since the shape of the output is quite complex, it can be heard on the speaker even when injected into an AM RF stage. The manufacturer claims the fundamental frequency is about 3500 Hz, but we synced it on a scope at about 20 kHz. To further confuse matters, when we injected the output in an audio amplifier we got a zero beat at about 600 Hz, so we can't really say what the fundamental frequency is. Regardless, the generator does the job for which it was intended—it feeds through most any amplifier stage and you can hear a signal in the speaker if the stages are good.

New VTVM

A recent addition to the Precision Apparatus test equipment line is the Model V-95 VTVM, shown in Fig. 5. This VTVM is the first of a new generation of instruments carrying the Precision Apparatus name, and it's quite different from their earlier equipment.

It's immediately apparent that the engineers were as much style-conscious as they were concerned with producing an instrument which is functional. The case is a very heavy gauge vinyl-clad steel, and the vinyl carries a walnut-grain pattern. It appears as though the whole instrument was designed around the meter movement, as about ⅔ of the front panel is occupied by the meter. The Model V-95 should make a very

Fig. 5. Precision Apparatus Model V-95 VTVM is first to carry name.

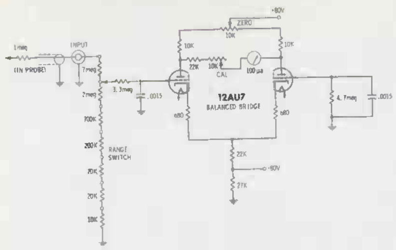


Fig. 6. Simplified overall schematic.

good bench instrument, because of the very large meter, and because it weight over 6 pounds. Since it's quite heavy, it should stay where you put it, and not slide all over the bench (or onto the floor) the first time you stretch the leads.

The circuit (Fig. 6) is the standard balanced bridge. Not shown in the simplified schematic are the ohmeter and AC circuits; the latter is a 6AL5 in a peak-to-peak detector. The Model V-95 has a 0.5-volt DC scale which should be quite useful for transistor servicing, and at the other end of the range is a 1500-volt DC scale, useful on color receivers. An accessory probe is available to extend the DC ranges to 60 kV; also available is an RF detector probe which is useful to 250 MHz. The normal AC response is ± 1 dB from 40 Hz to 4MHz. ▲

Precision Apparatus Model V-95 Specifications

DC Voltmeter
- Ranges:
  - 0-.5-1500 in a 5-15 sequence.
- Input resistance:
  - 11 megohms.
- Accuracy:
  - ±3% fullscale.

AC Voltmeter
- RMS ranges:
  - 0-1.5-1500 in a 5-15 sequence.
- P-P ranges:
  - 0-4-4000 in a 4-14 sequence.
- Accuracy:
  - ±5% fullscale.
- Response:
  - ±1 dB, 40 Hz-4 MHz
- dB scales:
  - −6 to +66 dBm.

Ohmmeter: 0-1000-1000 Meg (10 center). No battery required.

Power Requirements: 105-125 VAC.

Size (HWD): 7½" × 8" × 4".

Weight: 6¼ pounds.

Price: $79.95.

Circle 27 on literature card

SEE PHOTOFACT Set 798, Folder 2

Mfr: Motorola

Chassis No: STS-914YA, B

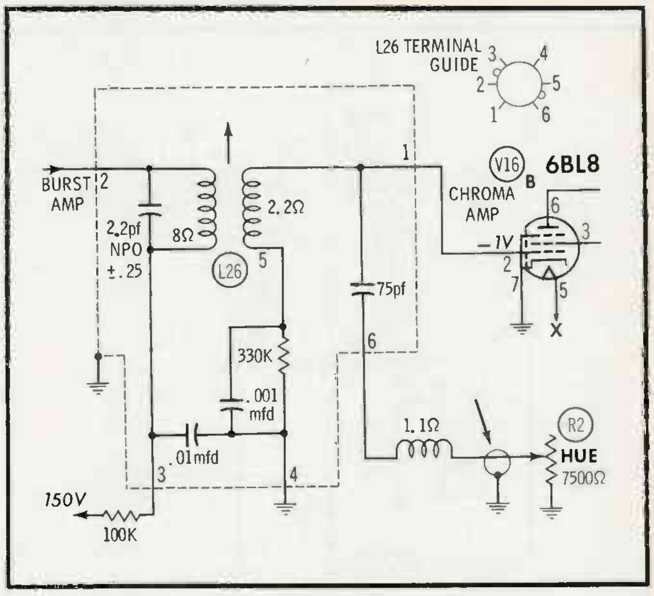
Card No: MO 914Y-1

Section Affected: Color pix.

Symptoms: No control of hue on color pix, hue remains unchanged. Black-and-white pix normal.

Cause: Shielded cable connected to hue control defective. Also, check 3.58-MHz crystal.

What To Do: Replace shielded cable connected to R2.



Mfr: Motorola

Chassis No: STS-914YA, B

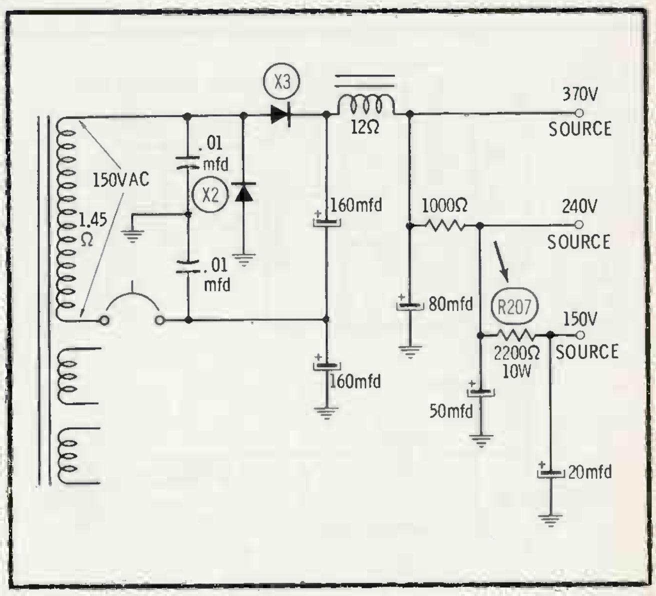
Card No: MO 914Y-2

Section Affected: Raster.

Symptoms: No high voltage. No 150-volt output from low-voltage supply.

Cause: Open resistor in 150-volt line of low-voltage supply.

What To Do: Replace R207 (2.2K ohm, 10 watt).



Mfr: Motorola

Chassis No: STS-914YA, B

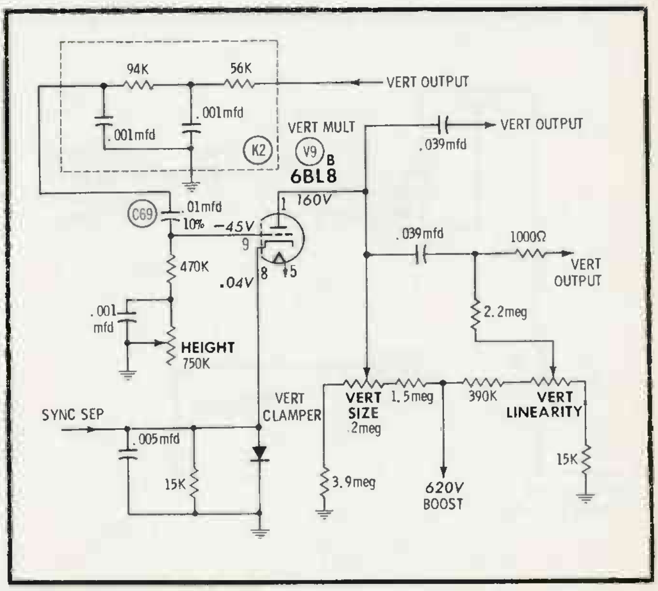
Card No: MO 914Y-3

Section Affected: Sync.

Symptoms: Vertical sync drifts after set warms up.

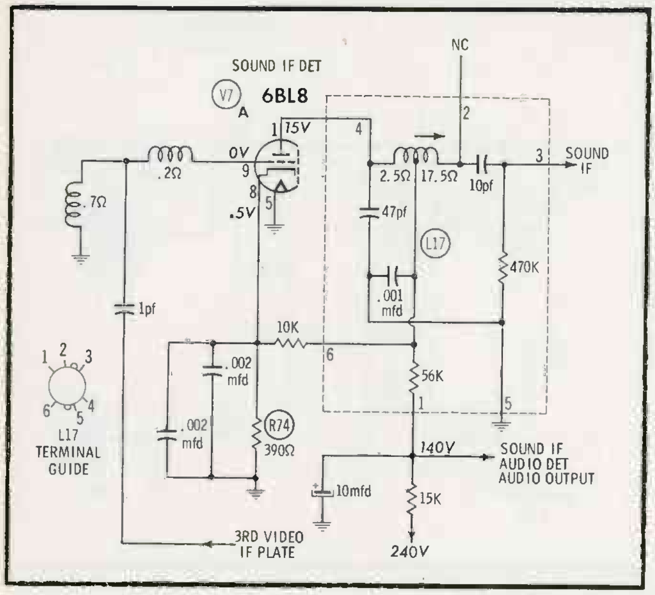
Cause: Leaky feedback capacitor in grid circuit of vertical multivibrator.

What To Do: Replace C69 (.01 mfd).



SEE PHOTOFACT Set 798, Folder 2

SEE PHOTOFACT Set 798, Folder 2



SEE PHOTOFACT Set 798, Folder 2

Mfr: Motorola

Chassis No: STS-914YA, B

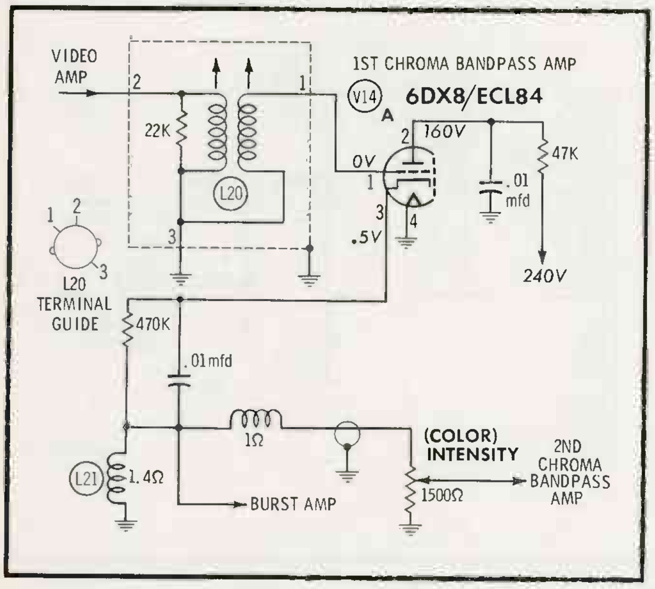
Card No: MO 914Y-4

Section Affected: Sound.

Symptoms: Intermittent, crackling sound. Voltage fluctuates on cathode (pin 8) of sound IF detector.

Cause: Overheated resistor in cathode circuit of V7A, sound IF detector—may even burn open.

What To Do: Replace R74 (390 ohms) and check V7 for shorts.



Mfr: Motorola

Chassis No: STS-914YA, B

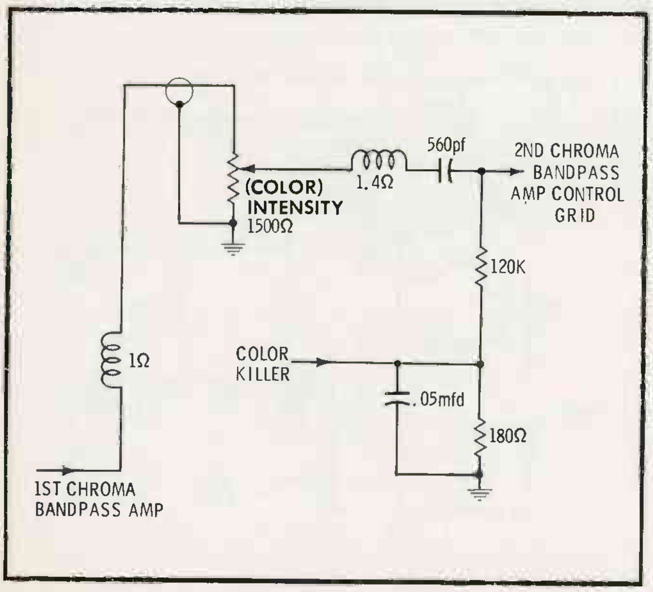
Card No: MO 914Y-5

Section Affected: Color pix.

Symptoms: Color unstable in pix. Black-and-white pix normal. Voltage at cathode (pin 3) of 1st chroma bandpass amplifier normal.

Cause: Choke in cathode circuit of V14A opens intermittently.

What To Do: Resolder connections to L21, or replace coil if defective.



Mfr: Motorola

Chassis No. STS-914 YA, B

Card No: MO 914Y-6

Section Affected: Color pix.

Symptoms: No color pix. Black-and-white pix normal.

Cause: Defective shielded cable leading to intensity control.

What To Do: Replace shielded cable.

VIDEO SPEED SERVICING

ZENITH

SEE PHOTOFACT Set 869, Folder 3

Mfr: Zenith

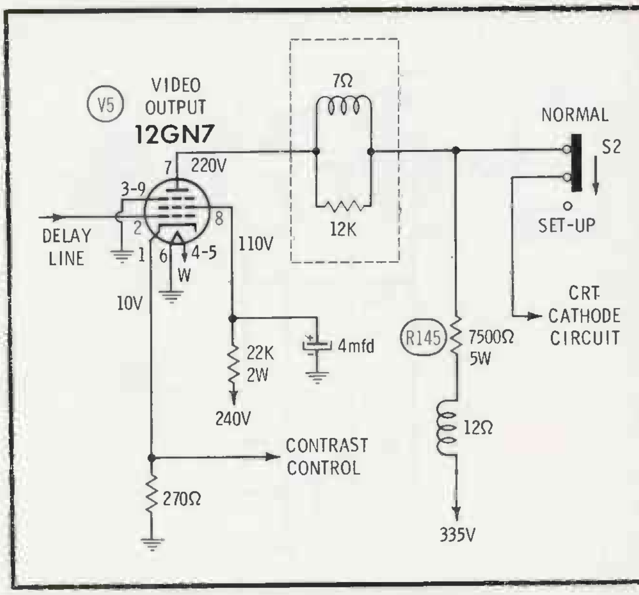
Chassis No: 25NC37

Card No: ZE 25NC37-7
Section Affected: Raster.

Symptoms: Bright screen; no control of brightness level.

Cause: Open video output plate load resistor.

What To Do: Replace R145, (7.5K ohms, 5W).



Mfr: Zenith

Chassis No: 25NC37

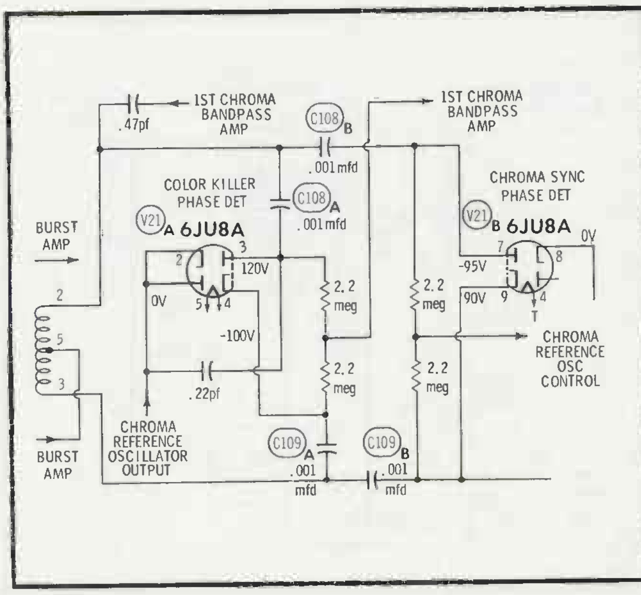
Card No: ZE 25NC37-8

Section Affected: Color.

Symptoms: Color far out of phase.

Cause: Defective capacitor in color killer phase detector.

What To Do: Replace C108 or C109 (dual section, .001 mfd).



Mfr: Zenith

Chassis No: 25NC37

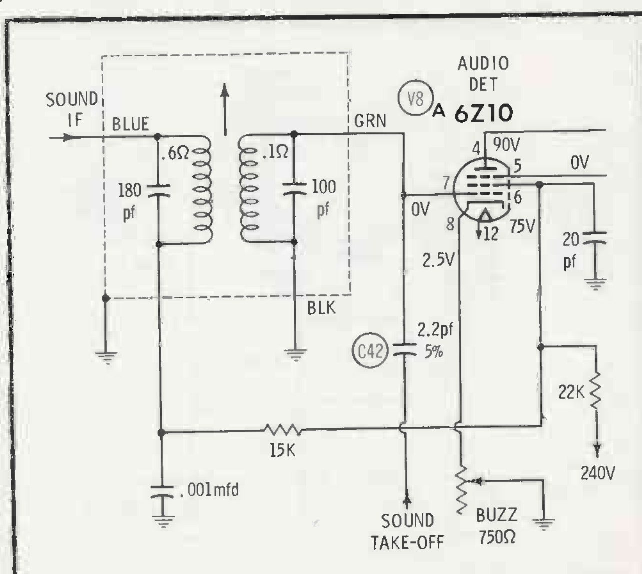
Card No: ZE 25NC37-9

Section Affected: Sound.

Symptoms: Buzz in sound.

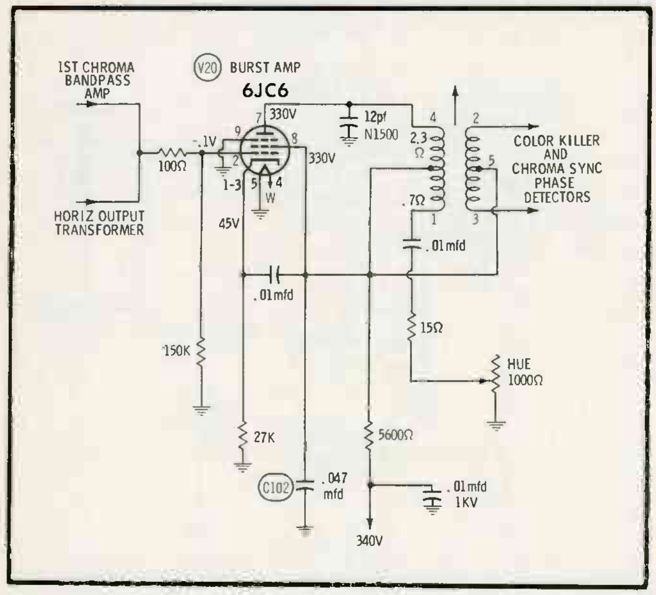
Cause: Open feedback coupling capacitor in sound detector circuit.

What To Do: Replace C42 (2.2pf, 5%).



SEE PHOTOFACT Set 869, Folder 3

SEE PHOTOFACT Set 869, Folder 3



SEE PHOTOFACT Set 869, Folder 3

Mfr: Zenith

Chassis No: 25NC37

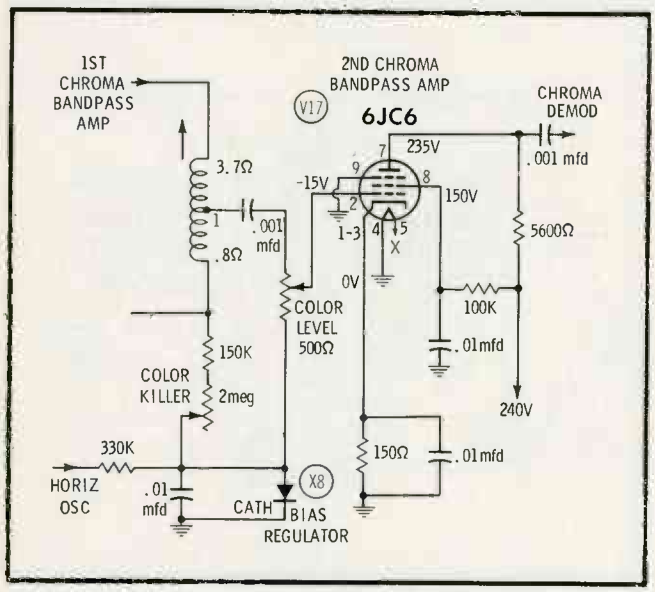
Card No: ZE 25NC37-10

Section Affected: Color.

Symptoms: Poor color sync; raster tinted green when receiver properly fine-tuned.

Cause: Open grid bypass capacitor in burst amplifier circuit.

What To Do: Replace C 102 (.047 mfd).



Mfr: Zenith

Chassis No: 25NC37

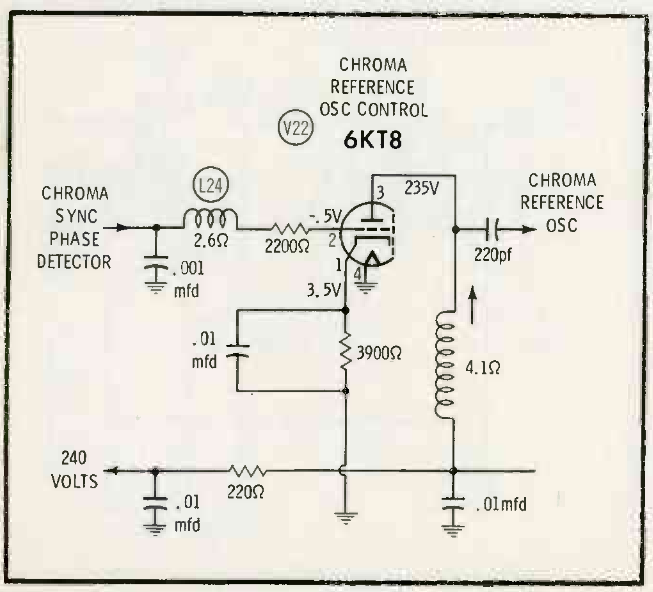
Card No: ZE 25NC37-11

Section Affected: Pix.

Symptoms: Color killer inoperative

Cause: Shorted bias regulator diode in grid circuit of 2nd chroma bandpass amplifier.

What To Do: Replace X8, bias regulator.



Mfr: Zenith

Chassis No: 25NC37

Card No: ZE 25NC37-12

Section Affected: Color.

Symptoms: No color, or intermittent color.

Cause: Open coil in grid circuit of chroma reference oscillator control.

What To Do: Replace L24.

BRIDGE CIRCUITS

A REVIEW/PART 2

A continuing need for exceptionally accurate measurement of such electrical quantities as resistance, capacitance and inductance has sustained the use of this relatively old circuit. This two-part article will refresh your knowledge of the various designs and applications of the bridge.

BY RUFUS P. TURNER

Part 1 of this article began with an analysis of the evolution and operation of the basic AC and DC bridges, then focused attention on the resistance measuring bridge. Part 2 continues our review of bridge circuits with a discussion of capacitance- and inductance-measuring bridges.

Capacitance Bridges

The capacitance bridge is similar to the resistance bridge in configuration and operating principle, the chief difference being the presence of capacitors in two or more of the bridge arms. Unlike the resistance bridge, the capacitance bridge is always an AC device.

For a long time, the capacitance bridge was the only means of measuring capacitance accurately and quickly without calculations. As a group, capacitance bridges cover a range extending from a few tenths of a picofarad to several thousand microfarads.

The descriptions in this article progress from the simple slide-wire type of bridge through the more complex types which are in common use. Similarities between these bridges and their resistance-measuring counterparts will be apparent.

Basic Slide-Wire

Fig. 10 shows the most rudimentary type of capacitance bridge, the basic slide-wire type. This circuit is seen to be similar to the basic slide-wire resistance bridge described in Part 1 of this article. Here, C_X is the unknown capacitance, C_S the standard capacitance; the balancing device is the slide-wire — a single strand of resistance wire of uniform cross section, stretched taut between terminals A and B or wound around a form having a circular cross section, and provided with a sliding contact. An AC generator (e.g., an audio oscillator) and an AC detector (e.g., VTVM or oscilloscope) are connected to the GEN and DET terminals, respectively. Transformer coupling is advisable.

The circuit is balanced by moving the slider between A and B to locate the null. At null: $C_X = C_S\,(R2/R1)$. Thus, the unknown capacitance is found by multiplying the standard capacitance by the resistance ratio established by the position of the slider along the wire. Note that the resistance fraction in the equation is inverted with respect to its counterpart in the slide-wire resistance-bridge equation given in Part 1. This results from the fact that in reality the reactance, not the capacitance, of C_X is balanced against the reactance of C_S (i.e., $X_{CX}/X_{CS} = R1/R2$). It also accounts for the fact that null points for the higher capacitances occur near point A, and those for the lower capacitances near point B (the reverse of the situation in the resistance bridge).

Neither the total resistance (R1 + R2) of the slide wire nor the individual values R1 and R2 need be known in order to make a C_X measurement. The calculation may be made in terms of distances D1 and D2 measured along the slide wire in centimeters, inches, or arbitrary linear units. Thus: $C_X = C_S(D2/D1)$. From the balance equations, it is seen that null occurs halfway between A and B when the unknown capacitance equals the standard capacitance, to the left of this center point when C_X is greater than C_S, and to the right of center when C_X is less than C_S. To change the capacitance range, one needs only to change the value of the standard capacitance C_S.

Like the slide-wire resistance bridge, this type of capacitance bridge has the advantages of simplicity and relative economy. It requires few components and needs no capacitance or resistance calibration if the aforementioned equation is used. And it is convenient for emergency measurements, as it requires only a standard capacitor, a length of resistance wire (stretched over a meter stick, yardstick, or other linear scale), and a generator and detector—all usually available in the laboratory or shop. A disadvantage is the failure of the circuit to give a complete null (absolute zero balance) unless the losses in the unknown capacitor equal those in the standard capacitor.

Slide-Wire with potentiometer

A more compact version of the slide-wire capacitance bridge, like the similar version of the resistance bridge, substitutes a wirewound potentiometer for the slide wire. Fig. 11 shows this arrangement.

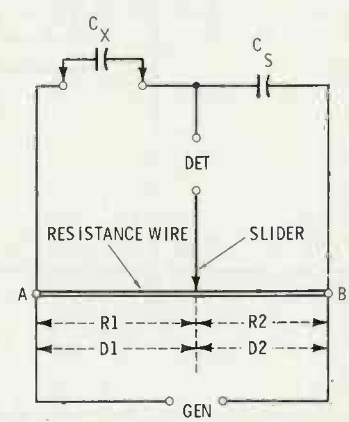


Fig. 10. Basic slide-wire bridge used for measuring capacitance.

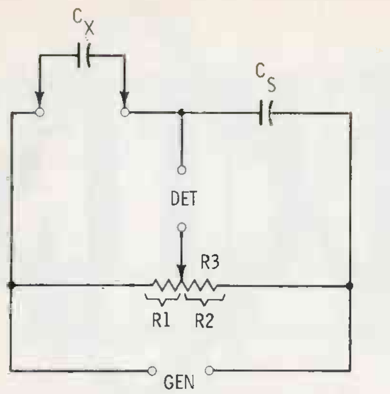


Fig. 11. Slide-wire capacitance bridge employing wirewound potentiometer.

In this circuit, the balancing potentiometer has a total resistance R3. At any setting, $R3 = R1 + R2$, the resistance between the contact blade and the low end, and the contact blade and the high end, respectively, of the resistance element. Resistances R1 and R2 determine the bridge ratio.

At null, the unknown capacitance (C_X) is determined from the standard capacitance (C_s) and the resistance ratio: $C_X = C_s(R2/R1)$. The potentiometer dial may be calibrated to read directly in picofarads or microfarads by locating the null points for a number of known capacitances connected successively at C_X. It may also be calibrated with the aid of the equation, in terms of measured R1 and R2 values. If the potentiometer dial reads directly in resistance setting (as the dial of a multiturn potentiometer often does), the unknown capacitance may be calculated with reference to that setting by using the formula $C_X = C_s [(R3-R1)/R1]$
where,

R1 is the resistance setting indicated by the dial,

R3 is the total resistance of the potentiometer.

Like the basic slide-wire bridge, the potentiometer-type circuit is simple and economical. However, it has three disadvantages: (1) because of stray capacitances in the circuit, C_X values lower than 100 pf cannot be measured accurately; (2) unless the potentiometer has a special taper, such as logarithmic, the graduations will crowd at the ends of the dial, seriously impairing accuracy, and for that reason the capacitance range with any one standard capacitor C_s should not exceed 0.1 to 10 times C_s, even though the potentiometer can afford a wider range; and (3) a complete null occurs only if losses in the unknown capacitor equal those in the standard capacitor.

The degrading effect of stray capacitances in the useful ranges of the bridge may be reduced somewhat by keeping the potentiometer resistance, R3, reasonably low — say 5000 ohms. Also, the wasted ends of the potentiometer in the simple circuit may be resolved by means of extension arms (such as R1 and R3 in Fig. 12) which allows the useful 100:1 capacitance range to be spread over the entire resistance range of the potentiometer.

Practical Slide-Wire Bridge

Fig. 12 shows the circuit of a practical bridge using a 5000-ohm wirewound potentiometer (R2) as the balance control. This bridge covers the range 100 pf to 100 mfd in three steps: 100 pf-0.01 mfd, 0.01-1 mfd, and 1-100 mfd. The capacitance ranges are selected by switching in standard capacitors (C1, C2, C3). The 100-ohm noninductive resistors R1 and R3 provide the extension arms explained in the analysis of the basic potentiometer-type slide-wire bridge.

Any convenient test frequency may be employed, up to about 5kHz. Best stability is obtained when the generator is coupled to the bridge through a shielded transformer. It is advisable also to insert a transformer between the bridge and the detector; however, this second transformer may be omitted if the first one is used, especially if the lower DET terminal is grounded.

This bridge may be calibrated by balancing it with a number of accurately known capacitors connected successively to terminals X-X, and inscribing the potentiometer dial accordingly. Only one range need be calibrated in this manner; the others will track if accurate values are used at C1, C2, and C3. Thus, the lowest range (0.0001-0.01 mfd) may be calibrated, and the A, B, and C settings of switch S1 used to multiply this basic range by 1, 100, and 10,000, respectively.

The null balance is sharp if losses in the capacitor under test equal those in the standard capacitor (C1, C2, C3). Since high-quality capacitors customarily are used as standards, this usually means that a sharp null is obtained with low-loss test of significant losses in the capacitor under test.

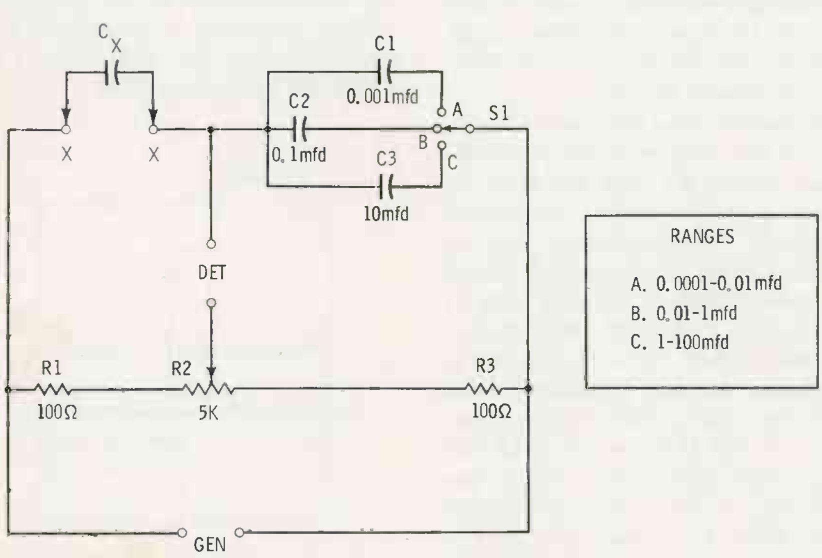


Fig. 12. Practical slide-wire bridge for measuring capacitance.

Power-Factor Balance

The preceding sections explained that a complete null is impossible with a simple slide-wire bridge unless the losses in the unknown and standard capacitors are equal. The reason for this is the complex nature of the capacitor as an impedance network (resistance and capacitance in combination, the resistance component representing the losses). When the unknown and standard capacitors are of the same kind and magnitude, and when their equivalent impedances are the same in all respects, then a complete null may be obtained. Separate balances are required for the resistive and reactive components.

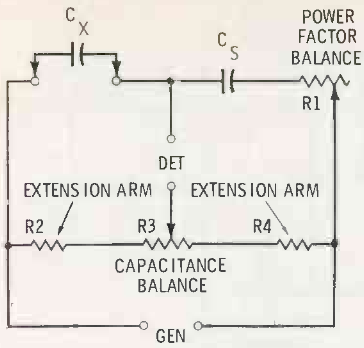


Fig. 13. R1 in series with C_S balances power factor of capacitors.

It is convenient to express the relation between losses (resistive component) and capacitance (reactive component) as the power factor of the capacitor. Numerically, power factor pf = R/Z = cosine of the phase angle of the equivalent RC network. The highest value which power factor can reach is 1 (also expressed as 100%). A low-loss capacitor therefore has a very low power factor. Capacitor quality may be expressed also as the quality factor $Q = X_C/R$ = tangent of the phase angle, or as the dissipation factor $D = R/X_C$ = cotangent of the phase angle. A low-loss capacitor has a high Q and low D.

In somewhat more specific terms, the original statement may be expressed in the following way: A complete null is obtained only when the power factor, Q, or D of the unknown capacitor equals that of the standard capacitor. When these factors are unequal, as they almost always are in practice, enough resistance can be added in series(or sometimes in parallel) with the low-loss capacitor and thus make it equivalent to the higher-loss capacitor(usually the standard) to increase its power factor (reduce its Q) and thus make it equivalent to the higher-loss capacitor. Fig. 13 shows this arrangement. Here, rheostat R1 is adjusted to improve the null. Additional adjustments of R1 and R3, alternately, will give complete null (dip to zero). The resistance of R1 does not enter into the calculation of unknown capacitance. Nor does the resistance of R3 enter into the calculation of power factor.

For complete null, the resistance of R1 must be adjustable to the equivalent series resistance of the unknown capacitance, C_X. A dial attached to this rheostat may be calibrated to read directly the power factor (shown either as a decimal or as a percentage;) however, this dial will read correctly only at the calibration frequency. All complete capacitance bridges are equipped with such a power, Q, or D balance.

Under some circumstances, resistive balance may be obtained also by means of a rheostat in parallel with the standard capacitor. This method works best when the dissipation factors of the unknown capacitor is higher than 1, particularly when the unknown capacitor has a significant equivalent parallel resistance (as in electrolytic capacitors). It tends sometimes to broaden the capacitance null.

Fig. 14 shows how a power-factor balance rheostat is included in a universal bridge so that it may be switched in series with either the unknown or standard capacitor, whichever has the lower power factor—i.e., the lesser resistance as related to capacity. (A universal bridge is a skeleton-type instrument to which unknown and standard resistors, capacitors, or inductors may be connected.) Such a bridge is convenient for checking an unknown (C_X) against any available capacitor (C_S) whose capacitance is known, but not necessarily its power factor. When switch S1 is in position A, the power-factor rheostat (R3) is in a series with standard capacitor C_S; when S1 is in position B, rheostat R3 is in series with unknown capacitor C_X.

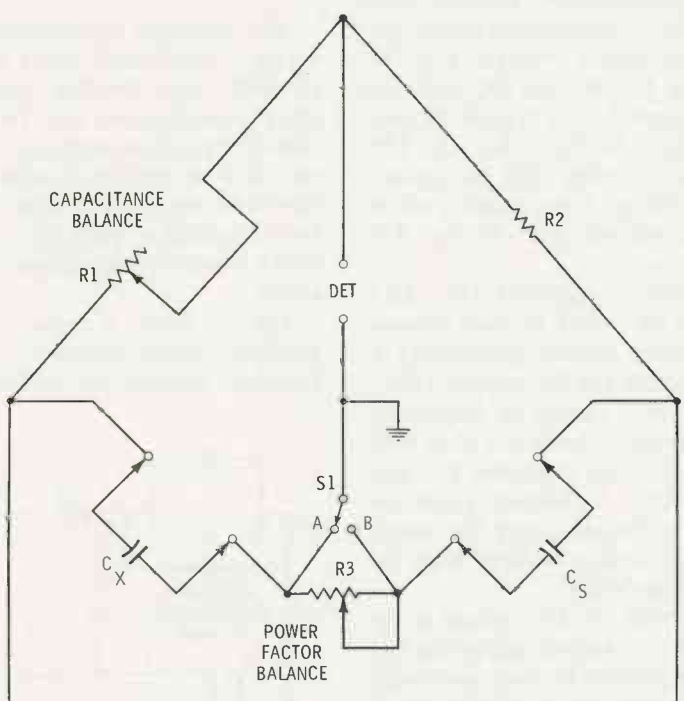


Fig. 14. Universal bridge employing power factor balance control.

Capacitance Comparison Bridge

The simplest and perhaps most common capacitance bridge merely substitutes capacitance arms for two of the resistance arms in the Wheatstone bridge, retains the other two resistance arms to complete the basic circuit, and adds a power-factor balance. Because of the similarity of the two bridges, the capacitance type is sometimes familiarly called a

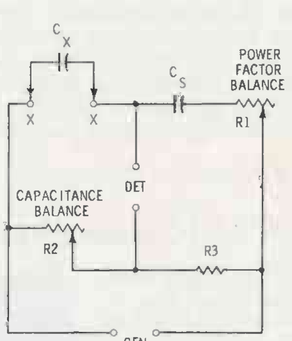
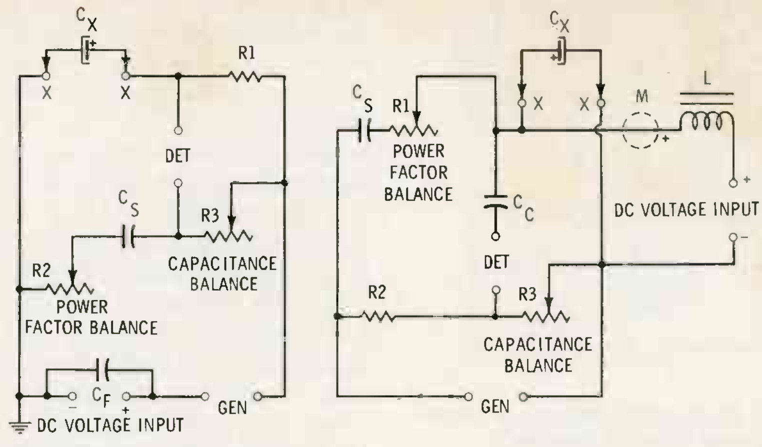


Fig. 15. Capacitance comparison bridge is similar to Wheatstone design.

"Wheatstone capacitance bridge," but the term "capacitance comparison bridge" appears most often in technical literature.

The comparison bridge overcomes many of the shortcomings of the slide-wire bridge, principally the dial crowding and lower-capacitance limit of the latter instrument. Fig. 15 shows the basic circuit of the comparison bridge. Here the bridge ratio (R3/R2) is established by fixed resistor R3 and the capacitance-balance rheostat, R2. A second rheostat, R1, provides the power-factor balance. At null: $C_X = C_S(R3/R2)$.



(A) DC in series with AC

(B) DC applied across C_X

Fig. 16. Both AC and DC voltages must be used when measuring some capacitors.

DC Polarizing Voltage

The capacitance of an electrolytic capacitor is not the same with and without a DC polarizing voltage. The direct application of an AC signal to an unpolarized electrolytic capacitor, besides giving false readings, is also damaging because of polarity reversal. Moreover, the capacitance varies with the magnitude of the DC voltage. The same is true of a capacitor having a nonlinear ceramic dielectric.

Such capacitors must be measured with their normal DC working voltage applied simultaneously with the AC bridge signal voltage. Fig. 16 shows how the AC and DC voltages may be applied to a typical capacitance bridge. In Fig. 16A, the DC voltage is in series with the generator AC voltage. Capacitor C_F offers a low-impedance path to the AC signal.

Note that a capacitor (C_X, C_S) sets up a DC block in each branch of the bridge circuit, preventing a short circuit of the DC supply. However, the DC voltage is impressed upon standard capacitor C_S, as well as upon unknown capacitor C_X, and the standard capacitors must be rated to withstand safely the maximum DC voltage which may be applied to the bridge.

In Fig. 16B, the DC voltage is applied across unknown capacitor C_X. This arrangement is often used with bridges having no provision for a polarizing voltage, since an external DC supply may easily be connected to the X-X terminals. Choke coil L (30 henrys or higher) prevents the DC supply from short-circuiting the AC bridge signal. A DC milliammeter, M, may be inserted to indicate leakage current of the unknown capacitor. Capacitor C_C provides DC blocking to protect the null detector. In this arrangement, the output capacitance of the DC power supply must be negligible with respect to the capacitance being measured; otherwise, it must be subtracted from each measured C_X value. The DC voltage must be free from ripple, or the ripple frequency will interfere with the AC signal and obscure the bridge balance.

Substitution Method

The difficulty of accurately measuring capacitances lower than 100 pf with some bridges, because of stray capacitances, has been mentioned in previous sections. Low values may be measured satisfactorily, however, with any bridge by using the substitution method, a process which automatically compensates for strays.

Fig. 17 shows a conventional capacitance bridge adapted to the substitution method by addition of a

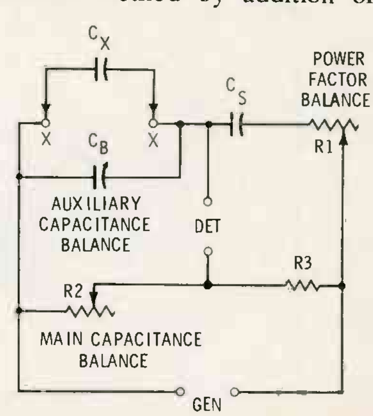


Fig. 17. Substitution method permits measurement of low values.

calibrated variable capacitor, C_B, connected to the unknown terminals, X-X. This capacitor is usually a 100- or 1100-pf air type having a dial reading directly in picofarads. In all other respects, this bridge is identical to the one shown in Fig. 15.

A four-step procedure is employed:

1. With no unknown capacitor (C_X) connected to terminals X-X, variable capacitor C_B is set to its maximum capacitance (C_M), and the bridge then balanced in the regular manner by adjustment of R2 and R1. Hence, R2 is not disturbed.
2. The unknown capacitor next is connected to terminals X-X by the shortest possible leads. This adds capacitance and accordingly unbalances the bridge.
3. The bridge is rebalanced by setting variable capacitor C_B to a lower capacitance (C_L) and readjusting power-factor balance R1.

Finally, the unknown capacitance is calculated from the two settings of the variable capacitor: $C_X = C_m - C_L$. In this way, capacitances of less than 0.1 pf are measured with good accuracy. If long connecting leads are unavoidable, the bridge may be initially balanced in Step 1 with the leads connected to X-X and in the same position they will have when connected to the capacitor C_X. Then the capacitor is connected for the remaining steps.

A practical advantage of the substitution method is the ease with which it may be used with any capacitance bridge Thus, a dial-calibrated variable air capacitor may be connected externally to the unknown terminals of any bridge, provided that short rigid leads are used and that the four-step procedure described previously is employed.

In commercial substitution bridges, the variable capacitor dial sometimes is graduated with zero at the maximum-capacitance setting of this capacitor, and with maximum capacitance at the zero-capacitance setting. The initial balance with R2 (see Step 1 above) then becomes a zero adjustment, and after rebalance (Step 3) the dial reads C_X directly in pf, no calculation being required.

Inductance Bridges

Inductance bridges may be regarded as forming the second large class of AC bridges. In general configuration, the inductance bridge resembles the capcitance bridge and the resistance bridge. It differs from thet capacitance bridge, however, in the presence of inductors in one or more of its arms and also in the respect that it can, in some versions, compare unlike impedances, i.e., inductance with capacitance.

As a class, inductance bridges cover the range from 0.1 nanohenry to 10,000 henrys with accuracies reaching ±0.1% or better. Like the resistance bridge and capacitance bridge, the inductance bridge may be either simple or complex to suit individual demands.

Basic Slide-Wire

Fig. 18 shows the most basic inductance bridge. In this arrangement, the variable balancing resistor is a single strand of resistance wire (the slide wire) tautly stretched between points A and B (or wound around a form having a circular cross section) and provided with a sliding contact (the slider). The wire has a uniform cross section and is of constant composition, so its resistance is directly proportional to its length.

As the slider is moved along the wire, it divides the latter into two parts: D1, the length from point A to the slider, which has a resistance of R1, and R2, the length from point B to the slider, which has a resistance of R2. Thus, the resistance increases on one side of the moving slider and decreases on the other side.

The bridge is composed of unknown inductor L_X (connected to terminals X-X), standard inductor L_S, and the two sections (R1 and R2) of the slide-wire variable resistor, which provide the ratio arms.

The bridge is balanced by moving the slider along the wire until the detector response is minimum. At this null point, $L_X/L_S = R1/R2$, and from this relationship the unknown inductance may be determined in terms of the standard: $L_X = L_S (R1/R2)$.

The total resistance of the slide wire is unimportant to the calculation. So also are the actual resistance values on each side of the slider. In fact, distances D1 and D2 may be measured in inches, centimeters, or arbitary linear units and used in the preceding calculation in place of resistances R1 and R2; thus, $L_X = L_S (D1/D2)$. For this reason, the basic slide-wire bridge is convenient for emergency measurements of inductance, since it requires only a standard inductor and a length of bare resistance wire stretched along a meter stick or yardstick, in addition to a generator (e.g., an audio oscillator) and a detector (e.g., AC VTVM, oscilloscope, or high-resistance headphones)

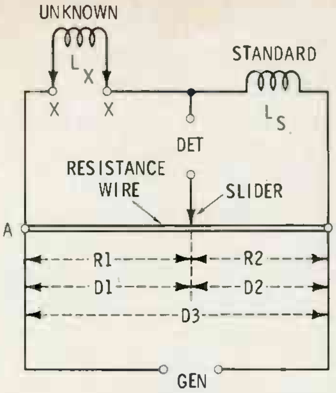


Fig. 18. Basic inductance bridge.

Sometimes it is more convenient to read the position of the slider with respect to the total length (D3) of the wire than to measure D1 and D2 separately. In such an instance: $L_X = L_S [D1/(D3 - D1)]$.

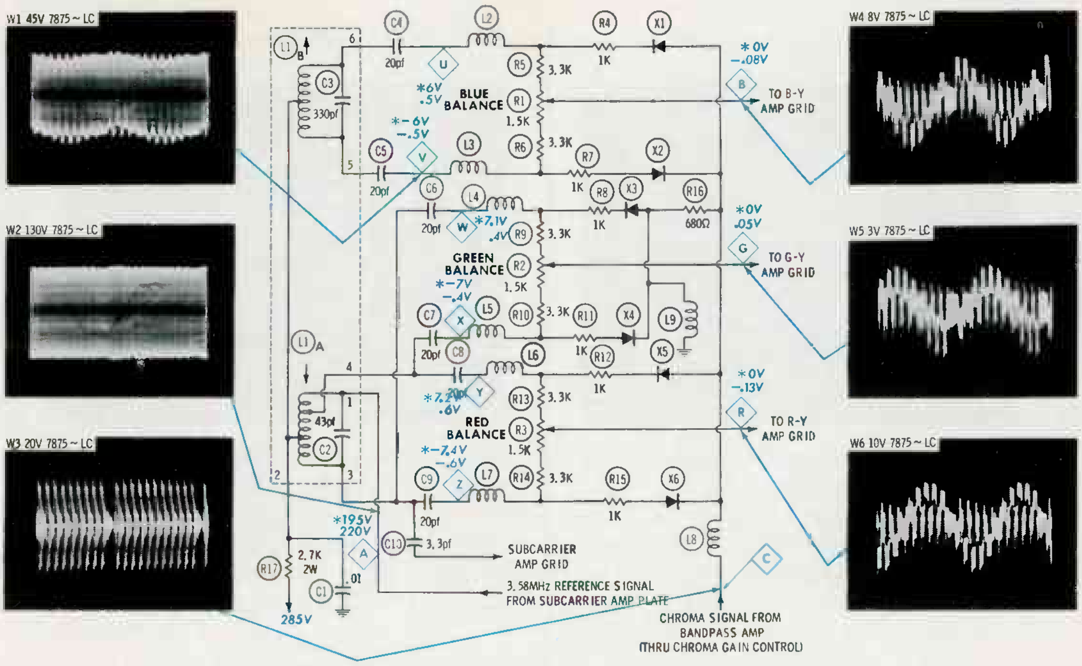
It is apparent from either of the latter two equations that the unknown (L_X) is equal to the standard (L_S) when null occurs with the slider halfway between A and B (i.e., when D1 = D2, making D1/D2 = 1.) Also, the slider must move to the right of center when L_X is greater than L_S, and to the left of center when L_X is less than L_S.

If the wire is long (say, 1 meter or more), little difficulty is experienced in measuring inductances over the range $0.01L_S$ to $100L_S$, provided a sensitive detector is used. Unless the wire has reasonably high resistance (large ratio of length to thickness), however, the current may heat it enough to impair the accuracy of measurement.

Part 3 of this article will continue our analysis of inductance-measuring bridges and will conclude this series. ▲

Chroma Demodulator

Balanced Diode



DC VOLTAGES taken with VTVM—color bar generator not operating. *Indicates voltage taken with generator operating—see "Operating Variations."

WAVEFORMS taken with wide-band scope TV controls set to produce normal color-bar pattern on screen. LC (low-cap) probe used to obtain all waveforms.

Normal Operation

Circuit shown is balanced-diode color demodulator used in General Electric chassis. Balancing out 3.58-MHz reference signal at detectors maintains zero potential at difference amplifier grids, even if amplitude of reference signal varies—thus preventing color shading. L1 between terminals 1 and 2 is plate boost for subcarrier amplifier. Reference signal of proper phase for red modulation is tapped off at terminals 3 and 4. 3.58-MHz signal is also coupled to L1B where correct phase for blue demodulation is tapped off at terminals 5 and 6. Green demodulator uses same phase of 3.58-MHz signal as red, but composite chroma signal is delayed by R16 and L9 so that green is detected at proper phase. Configuration of L1 may vary between different chassis but basic operation is same. Since each demodulator functions similarly (component values are same) only blue (B-Y) demodulator will be analyzed. 3.58-MHz signal is coupled to diodes X1 and X2 thru C4 and C5. Diodes function as peak detectors after initial full charge of C4 and C5. Composite chroma signal is connected to anode and cathode of X1 and X2, respectively. When diodes are conducting, chroma signal is detected by each diode. X1 develops positive voltage which is proportional to sum of chroma and in-phase reference signal. X2 develops negative voltage proportional to sum of chroma and the 180° out-of-phase reference signal. Equal but opposite reference signals produce zero DC output, but detected chroma information adds across R5, R1, and R6. Chroma output at point B is negative-going signal with amplitude equal to half the total across resistors R5, R1, and R6.

Operating Variations

A — With color signal present, burst excites reference oscillator into conduction; plate voltage drops from no-signal potential of 220 volts to 195 volts.

U thru Z — Dc voltages are direct result of rectified reference signal (near zero with no signal) and vary somewhat according to amplitude of burst signal. Voltages indicated are typical with good signal input from keyed rainbow generator. Voltages at two test points in each demodulator section should be equal in amplitude but of opposite polarity.

C, B, G, R — These test points remain at zero volts with or without color signal.

Waveforms — W2 amplitude varies according to level of burst—measures about 50 volts p-p on fringe station, 110 volts p-p on local station. Tint control varies W2 p-p reading from 50 volts to 150 volts. W1 changes in direct proportion with W2 since it is same signal, only coupled through L1 for proper phase—tint control varies amplitude of reference signal portion, chroma gain control changes content (jagged peaks). W3 varies from zero (no color) to about 40 volts p-p (severe color "bleeding") according to chroma gain control (good color if about 10 volts p-p). W4, W5, and W6 vary with signal strength and setting of chroma level control (0 to 150% of values shown). Color bar pattern good with 75% of values shown.

SYMPTOM 1

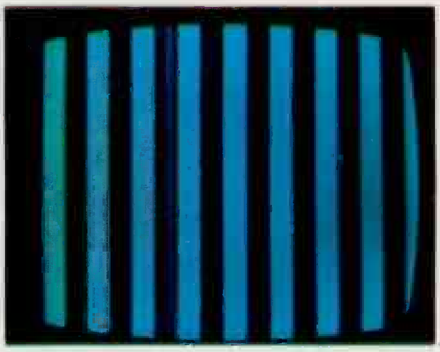
Weak or No Color

Color Bars Correct

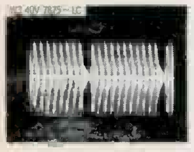
R17 Increased In Value

(Voltage Divider—2.7K, 2W)

Symptom Analysis



Almost normal color with chroma gain at maximum on local station; little or no color on fringe station. Generator signal color bars in correct order but weak. Tint control operates when color present. B-W picture normal. Symptom indicates chroma signal loss.



Waveform Analysis

W3 eliminates chroma circuitry trouble since amplitude is at least 200% of required level and content is good. Although not shown, W4, W5, and W6 isolate defect to demodulator circuitry—all are 25 to 30% of normal amplitude. W1 is good clue—amplitude reduced (normally about 45 volts p-p) and content lacks 3.58-MHz signal. W2 amplitude localizes trouble to L1—only about 10 volts p-p (normally about 130 volts p-p).

Voltage and Component Analysis

A: *27V, 19V

U: *3.4V, .5V

B+: *285V, 270V

V: *−3.2V, −.5V

Voltages at points U thru Z are about 50% of normal but are balanced—readings of each section are equal but opposite—confirms demodulators are operating but at reduced level. 27-volt reading at point A isolates trouble to R17, C1, or L1A since B+ checks near normal. Increased resistance of R17 (voltage divider supplying subcarrier amplifier) results in loss of 3.58-MHz signal supplied to demodulators. R17 completely open or open between terminals 1 and 2 of L1, or shorted C1, would cause complete loss of color.

Best Bet: Scope then VTVM.

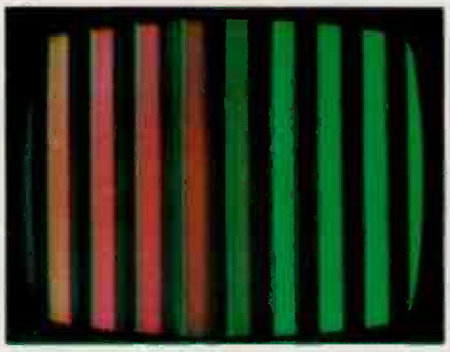
SYMPTOM 2

No Blue

B-W Picture Normal

Open X2

(Blue Demodulator Diode)

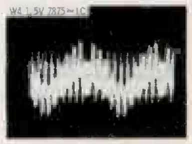


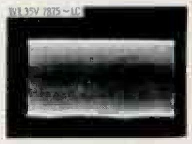
Symptom Analysis

Loss of blue evident on station color programs—whites have yellow tint, other colors using blue are wrong. Tint and chroma gain controls operate. Bar pattern shows only green and red—blue missing and background yellow with chroma gain at minimum. B-W normal.

Waveform Analysis

Amplitude of W4 explains loss of blue—normally about 8 volts p-p, now only 1.5 volts p-p. Content shows excess 3.58-MHz signal. Although not shown, W5 and W6 are normal. W2 (3.58-MHz input to B − Y demodulator) shows sufficient reference signal but content lacks rectified chroma signal riding on subcarrier. Thick waveform at point U is near normal in content and amplitude. Comparison of waveforms at U and V gives clue to trouble.





U: *9V, .1V

B: *3.2V, .05V

V: *3.2V, .05V

Voltage and Component Analysis

Volytage at U and V 3.2 and 9 volts, respectively (normally near equal but opposite). This unbalance is reflected at points B; reading is 3.2 volts, should be zero. DC voltage at these points is result of diodes rectifying reference signal, thus no-signal readings (b-w) are near normal (zero). CRT B − Y grid is cut off as result of demodulator unbalance (positive voltage at B − Y amplifier grid)—blue is lost, whites are tinted yellow, and other colors using blue are incorrect. Good b-w picture helps isolate trouble.

Best Bet: VTVM for voltage and resistance measurements.

SYMPTOM 3

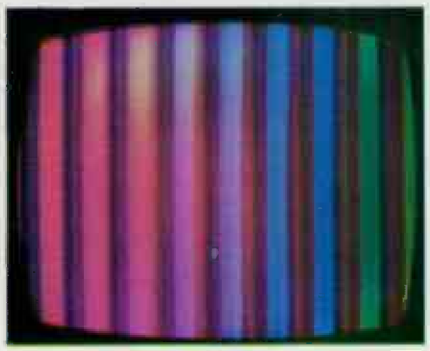
Red Predominant

B-W Picture Normal

Leaky X5

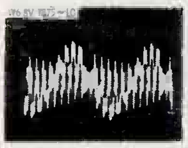
(Red Demodulator Diode)

Symptom Analysis



Color programs show excesive red—also, areas that should be white are red. Near normal color picture obtained by misadjusting tint and color controls. Screen is tinted red with color signal; but with chroma gain control at minimum b-w picture has proper gray scale.

Waveform Analysis



W6 (shown), as well as W4 and W5 (not shown), have sufficient amplitude and proper content to produce good color bars. Second and third waveforms shown here, from points Y and Z (3.58-MHz reference signal input to red demodulator), although slightly higher in amplitude, are similar to W1. W1 is representative of waveforms at points U thru Z—all similar in amplitude; content is 3.58-MHz signal with detected chroma signal riding on carrier.

Voltage and Component Analysis

Y: *3.5V / 0V

R: *−2.2V / −.04V

Z: *−9.2V / 0V

Defective X5 measures approximately 3K either direction; causes unbalance in red demodulator section—voltage at point Y is 3.5 volts, point Z is −9.2 volts—produces negative voltage (−2.2V) at point R. This results in continuous R−Y amplifier conduction which causes red shading with color signal input. B-W picture normal since unbalance caused by rectified 3.58-MHz signal. Leaky X6 would cause loss of reds. Any component value change in balanced demodulator causes too much color or loss of color.

Best Bet: VTVM and circuit analysis.

SYMPTOM 4

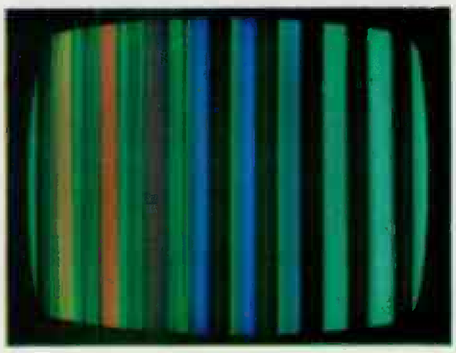
Green Screen

On Color Only

Open C1

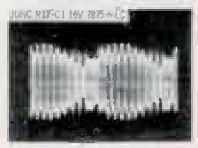
(Bypass Capacitor—.01 mfd.)

Symptom Analysis



Station program with chroma gain at normal setting is predominately green—flesh tones green and tint control inoperative—white areas are green—other colors weak. Other colors wrong with chroma gain at maximum. Color bar pattern mostly green. B-W normal.

Waveform Analysis



Amplitude of W5 is satisfactory but content shows reason for excessive green: negative portion which causes G−Y amplifier conduction is relatively straight—conducts constantly. W4 and W6 content mostly 3.58-MHz reference signal. Although not shown, W5 with chroma gain at minimum contains 4-volt p-p 3.58-MHz signal—normally less than .5 volts p-p. W1 amplitude low but acceptable. R17-C1 indicates trouble, normally only DC here.

Voltage and Component Analysis

B: *1.1V / 0V

R: *.5V / 0V

G: *−.3V / 0V

Comparative DC voltages at inputs of each demodulator section (L1 thru Z) all show unbalance which causes abnormal readings at points B, G, and R. B−Y and R−Y amplifier conduction is limited by positive potential, while G−Y is allowed to conduct heavily. Open C1 allows burst frequency to be coupled to chroma bandpass circuitry, then to point C. L1 is also detuned—3.58-MHz reference signal to demodulators is reduced and phase relationship upset. G−Y amplifier conducts constantly and heavily at burst phase.

Best Bet Careful scope and VTVM work will solve.

Symptom 5

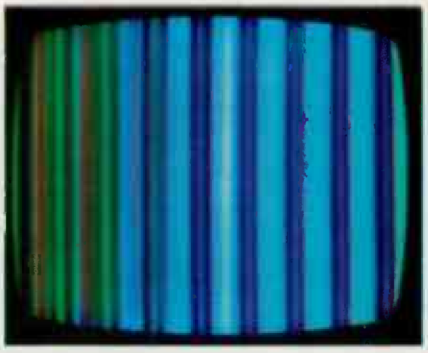
Reds Missing

Blues and Greens Near Normal

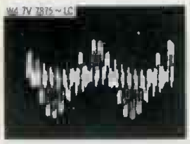
R3 Wiper Arm Open

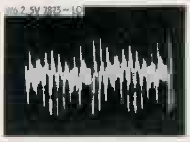
(Red Balance Control—1.5K)

Symptom Analysis



Impossible to get proper flesh tones on station color signal—tint control varies hue from purple to green but no normal flesh tones between. Red reduced in picture—color bar pattern shows little red even at maximum chroma gain setting. B-W normal.

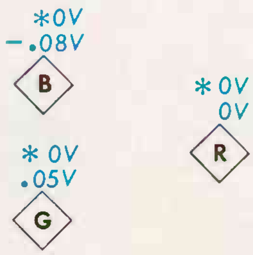




Waveform Analysis

W4 (shown) and W5 not (shown), blue and green demodulator outputs, have normal amplitude and content. W6 (input to R−Y amplifier) is very poor—amplitude only 2.5 volts p-p compared to normal 10 volts p-p, and content is all wrong—third negative-going pulse should be at maximum—instead, all pulses nearly equal. Waveform at point Z (shown) and Y (not shown) have normal amplitude and content— isolates trouble to red demodulator.

Voltage and Component Analysis



Proper DC potentials (OV) at points B, G, and R, along with sufficient 3.58-MHz input signal at points U thru Z, eliminates demodulator unbalance. To adjust DC balance: Connect color bar generator, set chroma gain control to minimum, adjust R1, R2, and R3 for zero volts at points B, G, and R, respectively. Controls normally vary DC potential about 1 volt above and below zero. With open wiper arm, R3 has intermittent or no effect on voltage at point R. Open control itself would unbalance demodulator—R3 voltage not zero.

Best Bet: Scope first; then VTVM.

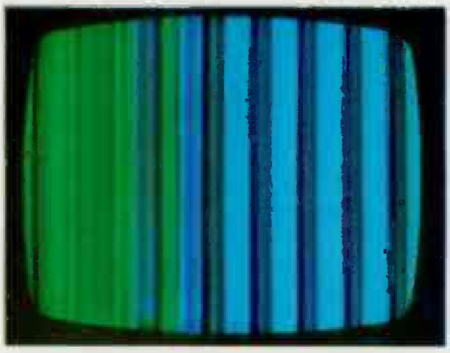
Symptom 6

Reds Lost

Greens Incorrect

Transformer Winding Open

(L1—3.58-MHz Phase Transformer)

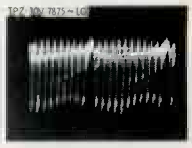


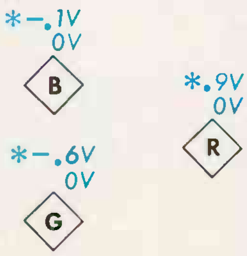
Symptom Analysis

Flesh tones are greenish, as is most everything except for some blue information. Chroma gain control operates, but tint control has no effect. Color bar pattern shows blues in approximately correct position. Most other bars green or shaded blue. B-W normal.

Waveform Analysis

Waveforms at test points R (W6, shown) and G (W5, not shown) are similar; amplitude of about 7 volts p-p is sufficient, but content is very poor—normal sine-wave effect of pulses is missing. Waveform at Z is weak — normally about 50 volts p-p, now 10 volts p-p—content all wrong—appears to be negative-going spikes of chroma signal. Waveform at point W similar but positive going. W2 (3.58-MHz input) is about 50% of normal.





Voltage and Component Analysis

DC voltages at points U and V are low but nearly balanced—voltages at points W, X, and Y, Z are unbalanced. This results in nearly correct potential (OV) at point B but negative voltage at point G and positive at point R. Open winding between terminals 2 and 3 of L1 causes loss of reference signal input to one side of red and green demodulators, resulting in unbalance, as well as detuning subcarrier amplifier plate circuit. Blue demodulator is affected to lesser extent by reduced and incorrect phase of reference signal.

Best Bet: Scope; then VTVM for voltage and resistance.

THE TROUBLESHOOTER

Picture and Sound Missing

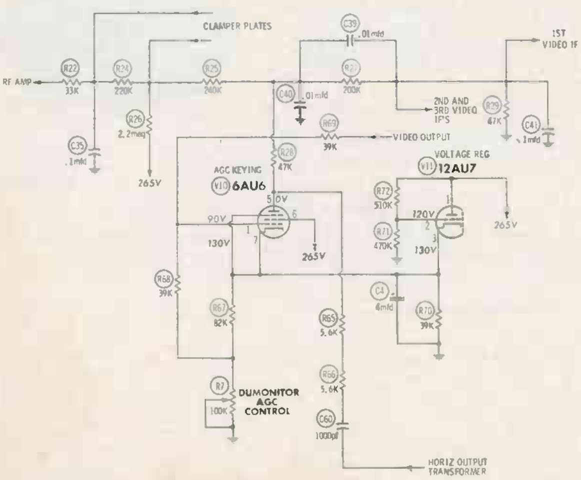
A Dumont Model RA-168 (PHOTOFACT Folder 216-2) that I am servicing will produce a beautiful picture for hours, then suddenly both the picture and sound disappear, leaving a blank but normal raster. Following are the only voltage clues I have obtained:

Tube and Element	Normal operation, no signal input	Picture and sound missing
RF amplifier grid	−1	−50
1st video IF grid	−3	−20
2nd video IF grid	0	−20
3rd video IF grid	0	−20
AGC clamper plates, pin 5	+3	−60
pin 6	−7	−60
AGC keyer plate	+1	−130

OTTO HALM

Allentown, Pa.

The foregoing symptoms indicate that you are confronted with an "excessive AGC" problem. The grid cutoff voltage for a 6CB6 with 125 volts applied to the plate (the type of tube employed in the video IF's of this particular Dumont chassis) is approximately −6.5 volts—you now measure −20 volts. The cutoff voltage for the 6BK7A employed in the RF amplifier is about −7 or −8 volts with a plate voltage of 105 volts—you measure −50 volts.



Recently we have received a number of letters requesting assistance with AGC problems; therefore, instead of merely indicating the most probable circuit defects, let's cover the operation of this particular keyed AGC system along with associated troubleshooting techniques.

The AGC keying stage (V10) is a coincidence amplifier; that is, it requires two input signals for conduction. One input signal is a horizontal pulse that is applied to the plate (pin 5) of V10 via R65, R66, and C60. The other input signal is a positive-going video signal applied to the grid (pin 1) of V10 from the plate circuit of the video output stage (via R69). The video signal contains positive-going horizontal sync pulses whose amplitude reflect the level of the received signal—i.e., the larger the received signal, the higher the amplitude of the horizontal sync pulses.

When both input signals arrive simultaneously at their respective tube elements (grid and plate), the tube conducts, with the amount of conduction depending on the level of the horizontal sync pulse at the grid and the setting of the R7, the AGC control. Both factors affect the bias of the keying tube. Note that the cathode of the keying tube is maintained at 130 volts by triode voltage regulator V11A. Adjusting R7 so that its wiper arm moves toward ground causes the DC bias at the grid of V10 to become more positive, increasing the conduction of the keying tube and, thus, developing more AGC voltage. Moving the wiper arm of R7 toward the top (as viewed on the schematic) produces an opposite effect.

When V10 conducts, a negative voltage is developed at its plate. The reason the voltage is negative instead of positive is because no positive DC potential is supplied to the plate; instead, the normal requirement of a positive plate for conduction (with respect to the cathode) is fulfilled by the highly positive horizontal pulse, which exists for only a relatively short period of time. The plate DC current path is from plate to ground via the voltage divider network of R28, R27, and R29. The AGC voltage supplied to the first three video IF stages is the negative DC potential present at the junction of R27 and R29, while the DC voltage that exists at the junction of R28, R27 and R25 is supplied to the tuner AGC line.

The function of the dual diode clamper in the tuner AGC line is to delay the application of AGC voltage to the tuner until a relatively strong input signal is received, thus preventing attenuation of weaker input signals in the tuner. Note that the tuner AGC line and clampers are tied to the 65-volt source through R26 and R24. When a relatively weak input signal is being received, the AGC voltage (negative) present at the junction of R28 and R25 is small compared to the positive potential that exists at the top of R26; consequently, with a positive potential at its plates, the clamper conducts and the tuner AGC AGC line is maintained, or clamped, at a potential somewhere between .5 and 1 volt. However, when a relatively larger input signal is received, the negative voltage at the junction of R26 and R24 increases sufficiently to overcome the positive potential at the top of R26. With the positive potential removed from its plates, the clamper ceases to conduct, and the tuner RF amplifier grid is supplied with a negative voltage to reduce its gain.

When the input signal and bias requirements of V10 are satisfied and it conducts, coupling capacitor C60 is charged so that the side connected to V10 is negative. Capacitors C40, C39, and C41 are also charged at the same time. When conduction ceases, the negative charge on C60 bleeds off to ground through R66, R65, R28, R27 and R29. The charge on the other capacitors connected to the AGC line also bleeds off through their respective resistors, filtering and smoothing the AGC voltage. This concludes our brief discussion concerning the operation of the keyed AGC system. Now let's do a bit of troubleshooting.

As stated before, the probable trouble causing the symptoms you describe is excessive AGC. The high level of negative voltage at the plate of the keyer tube (V10) and at the tuner amplifier and video IF grids is the basis for this conclusion. You could begin your troubleshooting by disabling the keyer (05-mfd, 1-kv capacitor from plate to ground will remove the horizontal pulse) and applying a clamping voltage from a negative voltage, or bias, source (variable, 0 to 45V). The picture and sound should return with the AGC (clamping) voltage at the proper level. However, the tube element voltage levels already mentioned preclude such action because they clearly localize the source of trouble. What remains is to consider the possible troubles that could upset the bias of the keyer, causing it to increase conduction and, thus, develop excessive AGC voltage. The most probable causes fall into two categories: (1) increased level of input signal at grid of V10 and (2) a defect within the keyer circuit itself that decreases the bias on the keyer tube.

Since the amount of AGC voltage developed by a normally operating AGC keyer stage is dependent on the level of the horizontal sync pulse present in the composite video signal applied to its grid, any overamplification of the video signal will cause an increase in the level of the horizontal sync pulse and, consequently, an increase in the AGC voltage. Normally, such overamplification is caused by a gassy video output tube (the keyer grid pulse is obtained from the plate circuit of the video output stage) or increased conduction of a video IF stage not controlled by AGC voltage—such as the 4th video IF in this chassis. (The increased conduction of such a stage could be caused by a circuit defect that reduces the bias of the stage or a defect that causes regenerative feedback and, consequently, oscillation). You can prove the existence of any one of the foregoing possibilities by checking the output of the video detector, or the amplitude of the waveform at the grid of the keyer—excessive signal amplitude will be found at either or both points. Further voltage checks within the suspected circuit or stage will isolate the specific cause.

Next, let's consider possibility No. 2—a defect within the keyer circuit itself that decreases the bias and, thus, causes increased conduction. If C4 is leaky or shorted, the voltage at the top of R70 will be reduced (to ground potential if C4 is shorted), causing the cathode of V10 to become more negative with relation to the grid, thereby reducing the bias of V10 and causing it to conduct more. A substantial decrease in the value of R71 will increase the bias on V11, reducing its conduction and the potential at the top of R70 and, in turn, will decrease the bias on the keyer tube. Other possible defects include a gassy keyer tube and an increase in the value of R68.

It is highly unlikely that a defective component on the AGC line itself is causing the trouble. Normally, a defect on the AGC line will dissipate the AGC voltage instead of increasing it; exceptions include a substantial increase in the value of R27 or R29. Also, an increase in the value (or complete opening) of R26 will kill the AGC delay or clamping action to the tuner, placing excessive AGC on the tuner RF amplifier and, thus, reducing the receiver sensitivity. Such a defect is characterized by a weak picture or washed out picture with excessive snow.

It is doubtful that a defective R7, R29 or R26 is the trouble in this particular case, because a defect in any one of these components would increase the AGC voltage of only the video IF's or the tuner—not both, as has happened in the situation under consideration.

From the preceding, it can be seen that an understanding of the basic operation of a circuit is essential to successful trouble analysis—anything less is simply guessing. ▲

TEST EQUIPMENT

MANUFACTURERS' *addresses*

The following is a list of manufacturers who are active in the service equipment industry. We have purposely left out the names of those manufacturers who deal exclusively with the laboratory and production markets. In compiling this list, every effort has been made to insure completeness and accuracy. Nevertheless, because of changes of address, corporate names, etc., this listing is not as complete as we would like it to be. PF REPORTER will welcome any corrections to this list.

Amphenol Distributor Division
2875 South 25th Avenue
Broadview, Illinois 60153
B & K division of
Dynascan Corporation
1801 W. Belle Plaine Ave.
Chicago, Illinois 60613
Blonder-Tongue Laboratories, Inc.
9 Alling Street
Newark, New Jersey 07102
Channel Master Corporation
Ellenville, New York 12428
Components Specialties, Inc.
101 Buffalo Avenue
Freeport, L. I., N. Y. 11520
Eico Electronic Instrument Co., Inc.
Malta Street & Wortman Ave.
Brooklyn, New York 11207
Electronic Measurements Corp.
625 Broadway
New York, New York 10012
Hallmark Instruments
6612 Denton Dr.
Dallas, Texas 75235
Heath Company
Benton Harbor, Mich. 49022
The Hickok Electrical Instrument Co.
10514 DuPont Avenue
Cleveland, Ohio 44108
Jackson Electrical Instrument Co.
35 Windsor Avenue
Mineola, New York 11501
Jerrold Electronics Corporation
401 Walnut Street
Philadelphia, Pennsylvania 19105
Karg Laboratories, Inc.
162 Ely Avenue
South Norwalk, Conn. 06854
Lampkin Laboratories, Inc.
Bradenton, Florida 33505
Leader Electronics Corp.
101-103 Rome Street
Farmingdale, L. I., N. Y. 11735
Lectrotech, Inc.
1221 W. Devon Ave.
Chicago, Ill. 60626
Mercury Electronics Corp.
315 Roslyn Road
Mineola, New York 11501
Pace Communications Corp.
24049 Frampton Ave.
Harbor City, California 90701
Precise Electronics division of
Designatronics Inc.
Mineola, L. I., N. Y. 11501
Precision Apparatus division of
Dynascan Corporation
1801 W. Belle Plaine Ave.
Chicago, Ill. 60613
Precision Electronics, Inc.
9101 King Street
Franklin Park, Illinois 60131
Radio Corporation of America
Electronic Components and Devices
Harrison, New Jersey 07029
Seco Mfg. Co.
1001 S. 2nd St.
Hopkins, Minn. 44343
Sencore, Inc.
426 South Westgate Drive
Addison, Illinois 60101
Simpson Electric Company
5200 West Kinzie Street
Chicago, Illinois 60644
Sprague Products Company
North Adams, Massachusetts 01247
The Triplett Electrical Instrument Co.
Bluffton, Ohio 45817
Waterman Instrument Corporation
400 South Warminster Road
Hatboro, Pa. 19040
Workman Electronic Products, Inc.
Box 3828
Sarasota, Fla. 33578 ▲

Circle 32 on literature card

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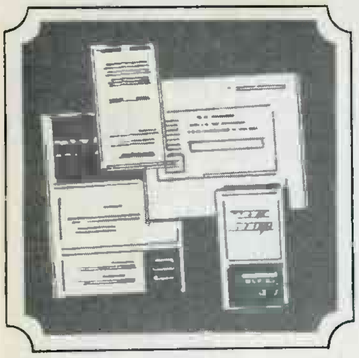
Circle 39 on literature card

Circle 40 on literature card



$ FREE $ CATALOG AND LITERATURE SERVICES

*CHECK "INDEX TO ADVERTISERS" FOR FURTHER INFORMATION FROM THESE COMPANIES

ANTENNAS

100. *ALLIANCE*—Colorful 4-page brochure describing in detail all the features of Tenna-Rotors.

101. *BLONDER-TONGUE*—Flyer sheet on new Colortap outlet plates and plugs for 300-ohm lead-in.

102. *DELHI*—Twelve-page catalog introducing a complete new line of home TV towers, ham towers, citizens'-band towers, masts, and telescoping masts.

103. *FINNEY*—4-color brochure with description and technical details on new Finco Color Spectrum, frequency-dependent antennas for UHF-VHF-FM, VHF-FM, and UHF. Form 20-413.

104. *JERROLD*—New 4-page, full-color catalog describes the new Paralog Plus antennas.

105. *JFD*—Color Laser and LPV antenna brochures. New, 1968 dealer catalog covering complete line of log-periodic, outdoor antennas, rotators, and accessories.

107. *WINEGARD*—Data sheet on Color-Tracker UHF antenna; folders on complete antenna line and MATV products.*

108. *G. F. WRIGHT STEEL AND WIRE CO.* Flyer gives specifications and packaging data for steel and aluminum guy wire.

AUDIO

109. *ACTION SYSTEMS CO.* — Brochure 715A, "SOUND BUSINESS," tells how to enter paging and intercom business.

110. *ATLAS SOUND*—Form #PP-2537 describes the Banshee voice speaker for music groups.

111. *BELL P/A*—Complete specifications, operating instructions, and schematics on the new Carillon series amplifiers.

112. *ELECTRO-VOICE* — Pocket-size guidebooks for microphones, hi-fi loudspeakers, and hi-fi systems.*

113. *NUTONE*—24-page booklet describes built-in stereo, intercom, and radio systems.

114. *OAKTRON*—Brochure #673 describes the PVS-800 acoustic-lens speaker.

115. *OXFORD TRANSDUCER*—Bulletin A-109 features speaker installation in automobiles, hospitals, and recreation rooms.*

116. *RACON*—Catalog C665T on horns, drivers, sound columns, and accessories.

117. *RECOTON*—42-page catalog and reference guide gives information on phonograph needles, tape and accessories, and record accessories.

118. *UTC*—Brochure describes Maximus line of hi-fi speakers.

COMMUNICATIONS

119. *AMPHENOL*—2-color spec sheets on new Model 650 CB transceivers and Model C-75 hand-held transceiver.

120. *COMCO*—Brochure on marine radiotelephone models 626 and 802.

121. *CUSH CRAFT*—Full-line catalog, CB-68, of CB base-station antennas and accessories.

122. *DOBBS/STANFORD* — 1968 catalog of microphones, headphones, and wireless headphones.

123. *MOSLEY*—Catalogs on antennas for TV/FM, CB, and ham use.

COMPONENTS

124. *BELDEN*—Catalog 867, a 56-page catalog of the complete Belden line.

125. *BUSSMAN*—12-page bulletin, SFUS, listing the complete line of BUSS and FUSETRON small-dimension fuses by size and type also indicates proper fuseholder and shows list prices.*

126. *CENTRALAB*—24-page replacement parts catalog 33GI.

127. *CORNELL-DUBILIER* — New 4-page Color-lytic list.*

128. *MALLORY*—Bulletin 4-82 describes radial- and axial-lead tantalum capacitors.

129. *MILLER*—Catalog 167, a 156-page general catalog with complete cross-reference guide.

130. *LITTELFUSE* — Pocket-sized TV circuit-breaker cross reference, CBCRP, gives the following information at a glance: manufacturer's part number, price, color or b-w designation, and trip ratings.*

131. *QUAM-NICHOLS*—Catalog No. 67 has information on the entire line.*

132. *SPRAGUE*—C618, the 1968 general-line catalog, is offered.*

133. *TEXAS CRYSTALS*—12-page catalog of crystals including engineering data, specifications, and prices.*

134. *WORKMAN*—46-page catalog #100 of resistors, fuses, circuit breakers, brighteners, adaptors, and test accessories. Cross-reference charts are included.

SERVICE AIDS

135. *CASTLE TUNER*—Fast overhaul service on all makes and models of television tuners. Shipping instructions, labels, and tags are also included.

136. *GC*—FR-67, the full-line catalog.*

137. *MID-STATE TUNER SERVICE*—Flyer describes 24-hour tuner service.

138. *PERMA-POWER* — Technical Bulletin LCC-502 describes brighteners for color CRT's.

139. *T.V. TUNER SERVICE*—Brochure lists cost and mailing instructions for 24-hour service on any make tuner. Repair tags and shipping labels included.

SPECIAL EQUIPMENT

140. *ATR*—Literature about DC-AC inverters up to 600 watts load.

141. *COMPONENTS SPECIALTIES*—Flyer on SPECO Fire Guard is offered.

142. *SONIC INDUSTRIES*—Flyer describes wireless converters for intercepting police and fire calls.

143. *SOUNDOLIER*—Specifications of 2-amp and ½-amp DC power supplies.

144. *STANDARD KOLLSMAN*—Flyers describe replacement TV tuners, built-in UHF converters, external UHF-to-VHF and VHF-to-VHF converters, and contact-cleaner kits.

145. *TERADO*—Flyer describes voltage booster for portable electric tools.

TECHNICAL PUBLICATIONS

147. *CLEVELAND INSTITUTE OF ELECTRONICS*—Free illustrated brochure describing electronics slide rule, four-lesson instruction course, and grading service.*

148. *RCA INSTITUTES*—New 1968 career book describes home study programs and course in television (monochrome and color), communications, transistors, and industrial and automation electronics.*

149. *SAMS, HOWARD W.*—Literature describing popular and informative publications on radio and TV servicing, communications, audio, hi-fi, and industrial electronics, including special new 1968 catalog of technical books on every phase of electronics.*

TEST EQUIPMENT

150. *B & K*—Bulletin ST-32B describes test-equipment line.*

151. *COLETRONICS* — Flyers give specifications and prices of tube-socket adapters.

152. *EICO*—New spec sheet describes model 100A4 multimeter with DC sensitivity of 100K ohms per volt.

153. *HICKOK*—Quick-reference catalog No. 67D gives brief descriptions and prices for complete test-equipment line.

154. *LECTROTECH*—Two-color catalog sheet on new Model V6-B color bar generator gives all specs and is fully illustrated.*

155. *MERCURY*—All-new 16-page test-instrument catalog.

156. *PRECISION*—Bulletin PST-35 describes test-equipment line.

157. *SECO*—Operating manual for the HC8 in-circuit current checker for horizontal-output tubes.

159. *SENCORE*—New 12-page catalog on all SENCORE products.*

160. *SIMPSON*—Reprint, "A Guide to the Selection of Multitesters" explains how to evaluate multitesters before you buy.

161. *TRIPLETT*—New catalog 52-T describes complete line of VOM's, test equipment, and accessories. The Model 600, transistorized volt-ohmmeter is featured.

TOOLS

162. *ARROW*—Catalog sheet showing 3 staple-gun tackers designed for fastening wires and cables up to ½" diameter.

163. *ENTERPRISE DEVELOPMENT* — Brochure from Endeco demonstrates improved desoldering and resoldering methods for speeding and simplifying operations on PC boards.

164. *SWING-O-LITE*—Catalog sheet on Models BBM-9 and BB45 bench lamps.

165. *UNGER*—Information sheets and technical data for various soldering irons and equipment.

166. *VACO*—Catalog SD-119 describes Snap Driver kit featuring 30 blades that fit one handle.

167. *XCELITE*—Bulletin N867 describes hollow-shaft nutdrivers which speed lock-nut/screw adjustments.

TUBES AND TRANSISTORS

168. *GENERAL ELECTRIC* — Entertainment semiconductor almanac, ETR-4311C, and picture-tube replacement guide, ETR-702K, are offered.*

169. *INTERNATIONAL RECTIFIER* — New MRO (maintenance, repair, and operation service) catalog has 12 pages of semiconductor listings and a 4-page glossary.

170. *MOTOROLA*—HEP cross-reference guide lists approximately 12,000 semiconductor types.

171. *RCA*—PIX-300, a 12-page product guide for RCA picture tubes covering both color and black-and-white.*

172. *SEMITRONICS* — A zener-diode replacement chart is available.

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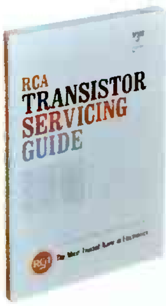
(Note: Code letters NTE and TS indicate *Notes on Test Equipment* and *The Troubleshooter*, respectively.)

Put yourself in the profit picture

All the items shown are available from your local participating RCA Tube Distributor with your purchases of RCA receiving tubes and picture tubes.

FABULOUS ELECTRIC RAZORS FROM SCHICK (1A1694M) (1A1694L)—For men, the Schick "Traveler". For ladies, the "Lady Petite".



RCA TRANSISTOR SERVICING GUIDE (1A1673)—This very important Guide will be indispensable to you in your understanding of transistor theory, amplifier principles and considerations and servicing!

A complete Subscription to RCA Service Notes for 1968 (1A1687)

THE RCA FIELD SERVICE GUIDE FOR RCA COLOR RECEIVERS FOR 1967 AND 1968 (ERT-201) — This Guide helps you perform all adjustments on 1967 and 1968 RCA Color TV Receivers that can be performed in the home.

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