an evening with RCA
an evening with RCA
FOREWORD

One of America’s most important industries today is servicing electronic equipment.

Radio Corporation of America has long been at the forefront in harnessing the electron to provide better goods, better services, and in the aggregate, better living for everyone.

In acquiring that leadership and "The Most Trusted Name in Electronics" RCA acknowledges the independent service organization as a major force and an ally in providing the consumer, business and industry with reliable services for electronic equipment.

In recognition of the importance of independent electronic service organizations, RCA Electronic Components and Devices, and local RCA distributors jointly sponsor "An Evening with RCA", a presentation to familiarize independent electronic servicing organizations and their service technicians with up-to-date developments in the electronic servicing industry.

This booklet, given to all who attend "An Evening with RCA", is a condensation of the information presented during the seminar. The booklet is intended to be an aid to independent service organizations in continuing their efficient, reliable and economical services for electronic equipment.

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This Shop Equipped With

PROFESSIONAL

RCA TEST INSTRUMENTS

To Serve You Better
SERVICING FOR PROFIT

Servicing electronic equipment is a big business. Statistics from the United States Department of Commerce show that during 1963 (the latest information available) sales by radio and television repair organizations totalled more than $628,000,000. There is good reason to assume that today, two years later, the total sales figure for the current year will be much higher. And it is pretty generally realized that the trend in employment is growing in the service industry and decreasing in the so-called blue-collar areas such as manufacturing and farming. This means, of course, that more and more people are needed now, and in the foreseeable future, to take care of the wonderfully convenient household time and work savers, entertainment instruments, and other devices our burgeoning economy is providing for all of us.

We in the service industry are indeed fortunate because we do have a future. By the same token, our American philosophy holds us to the tradition that we more fortunate ones have responsibilities commensurate with our good fortune. In the service business our biggest responsibility can be summed up in a single word — integrity. What this really means to each of us in the service industry is this: our customer has paid out hard earned money for the devices he calls on us to service. In calling us he is placing his trust in us. It behooves us then, to protect his investment by restoring his equipment to proper operating condition, as quickly and efficiently as possible. In short, those of us who haven’t already done so, must become professionals.

In the not-too-distant past, one of the most highly regarded professions — medicine — was held in rather low regard by the populace. Purely by insisting on adherence to the most rigid standards, technically, ethically and morally, the medical profession advanced from relative obscurity to its revered position in today’s society. If we give the same devotion to our business, our customers will eventually come to regard us as professionals. But there is a big “if” here — only if we perform as professionals! A professional uses every opportunity available to learn, and apply his knowledge in his chosen field. The service industry is a broad area. It encompasses the need for technical knowledge and proficiency, business acumen, and among other things some insight into psychology. A good businessman in the service industry must always think of his customers, because they provide his livelihood. The most successful people in any business have this thought uppermost — “What do my customers want or need?” and he then proceeds to fill the wants or needs.

In dealing with us in the service industry, a customer wants much more than what we commonly call “service.” He wants to be assured of competence; he wants low cost; he wants you to look at his problems from his own viewpoint. Those of us who recognize these points, and extend ourselves to satisfy these wants or needs, are going to be the successful, professional service technicians.

How do we go about getting to this point? In many ways it is quite simple. First of all, neatness counts. A neat, well groomed technician who speaks well has already mastered one of the attributes of competence. A neat tool kit and tube caddy, and the manner in which you attack the service problem again speak for you. When you arrive at your customer’s home or place of business, the mere fact that you carry an oscilloscope or a color picture tube tester gives the customer confidence that you are prepared and equipped to fix the trouble in his color TV, Hi-Fi or radio.

Summing up, the technician who pays attention to seemingly small details, and who has taken the time and trouble to prepare himself, and provide himself with the necessary tools and equipment, and who keeps himself informed, can be expected to be the one to whom customers turn when they need service — he’s the professional! And he’s the technician who makes a profit!

The following pages of this booklet tell briefly how service problems are solved professionally. Information is included for those technicians who have just come into the business; for those who are already professionals; and for those who have not come in contact with some of the newer products now coming into the market.

The booklet is not intended to be a complete “service course” but rather to set forth some basic electronic servicing principles, and in addition, to provide a glimpse into the future.

Radio Corporation of America, Electronic Components and Devices, is pleased to provide this booklet as another aid in helping independent service technicians keep abreast of the latest developments in the electronic servicing industry.
FIND TROUBLES FAST

NO SOUND—PICTURE OK
A "no sound" condition with a normal picture usually limits trouble to the circuits shown in the block diagram. If new tubes do not correct the condition, use an RCA WV-98C Senior VoltOhmyst® and a WR-50B RF Signal Generator connected to the points shown to quickly isolate the trouble.
Set the WR-50B for output at 4.5 Mc with 400-cycle modulation and trace the signal as shown in the block diagram, using the VoltOhmyst® as an output indicator. After the defective circuit has been isolated, voltage and resistance checks will normally locate the component requiring replacement. The VoltOhmyst® can then be used to check the audio output level.

NO PICTURE—SOUND AND BRIGHTNESS OK
Normal sound output usually rules out trouble in the AGC circuit as the cause of a "no picture" condition. The trouble will usually be found in the circuits shown here.
If tube replacement doesn’t clear up the trouble, use an oscilloscope such as the RCA WO-91B to trace the video signal from the output of the picture detector to the point in the circuitry where the signal drops out. This quickly pin-points the trouble area and limits final diagnosis to checking one or two components or voltages with a VTVM (RCA WV-98C Senior VoltOhmyst®). The scope is used because it gives positive identification of the composite video signal waveform. Checking with a meter only, may take considerable time, and, because you’re looking for video voltages, meter indications may be misleading.
**B & W TV SERVICE**

**FIND TROUBLES FAST**

**NO BRIGHTNESS—SOUND OK**

This condition usually results from trouble in the horizontal oscillator, horizontal sweep output or high voltage sections of the receiver. An RCA WV-98C Senior VoltOhmyst® using a WG-289 High Voltage Probe will measure high voltage quickly and accurately at the high voltage rectifier. If the voltage is normal, check the high voltage connection and the socket pins for the cathode and grid of the picture tube.

If the trouble doesn’t show up at these points, and is not caused by a defective tube in the horizontal circuits, check the waveforms in the horizontal circuits with an oscilloscope. Waveforms should conform to the receiver manufacturer’s service data. An oscilloscope is used because it gives you a true picture of the waveforms in the circuits and also provides a quick check of horizontal oscillator frequency. High voltage drops off sharply as horizontal oscillator frequency departs from normal. For this reason it is important to check this point.

**NO PICTURE OR SOUND—BRIGHTNESS OK**

With this condition the trouble is usually limited to the RF unit, picture IF, picture detector or AGC circuits. To find the source of the trouble quickly use the RCA WR-69A Television/FM Sweep Generator and WO-91B Oscilloscope. Connect the RF Output cable of the WR-69A to the VHF antenna terminals of the receiver. Set the receiver and the sweep generator to the same television channel and adjust the sweep bandwidth and RF output levels to the usual settings for RF unit alignment.

Using the slip-on WG-302A RF/IF/YF Signal Tracing Probe with the WG-300B scope probe, check for a sweep signal at the points indicated in the block diagram. When the sweep signal changes or disappears, use a WV-98C Senior VoltOhmyst® to locate the defective component or incorrect voltage in the specific circuit under test.
INTERMITTENT OR POOR PICTURE (SOUND AND BRIGHTNESS OK)

The cause of an intermittent picture or poor picture condition can be isolated quickly with a WR-69A Television/FM Sweep Generator and a WO-91B Oscilloscope connected as shown. The sweep generator provides the stable reference signal required to signal-trace an intermittent condition.

Using the WG-302A RF/IF/VF Signal-Tracing Probe check the points indicated. Flex the chassis and/or component leads while observing the pattern on the oscilloscope. A change in the scope pattern indicates that the intermittent condition is located in the circuit being tested. Continue moving the probe, circuit by circuit, toward the antenna, until the intermittent condition is no longer noted. The intermittent circuitry is between this point and the previous test point. Isolate the defective component, solder joint, etc., with a WV-98C VoltOhmyst®.

A similar procedure can also be used to locate the cause of a poor picture; in this case the waveform is the key to locating the trouble.

INOPERATIVE RECEIVER

If the instrument is “dead”—no sound and no picture with the set plugged in, a WV-38A Volt-Ohm-Miliameter can be used to quickly locate the initial cause of the trouble. Check the fuse, using the Rx1 scale on the meter (set unplugged). Use the AC scales on the meter to check for proper AC voltage at the input to the power transformer and the DC rectifier circuit. Using the proper DC voltage scale of the WV-38A, check the DC voltages at the filter capacitors and the supply voltage divider networks. Absence of DC voltage to the filter circuits may result from an open interlock link in the deflection yoke plug, or the plug not being plugged in, or making poor contact. A shorted filter capacitor or open filter choke may be the cause of the trouble.
HOW TO SERVICE CIRCUIT BOARDS

TOOLS
Small, low wattage soldering irons (25 to 35 watts) should be used for soldering on printed circuit boards. Repairs to the printed circuit wiring and components are simplified by using special tips for soldering and unsoldering.

Diagonal cutters are used for clipping components and trimming leads. Long-nose and curved needle-nose pliers make it easy to loop leads and also serve as "heat sinks" when soldering transistors and small component leads.

A small, stiff bristle brush is ideal for cleaning excess solder from leads and printed circuit wiring. A soldering aid is helpful in removing and inserting components on the board. A thin bladed knife aids in separation of sockets and connection devices from printed circuit wiring.

Place a flashlight or trouble lamp behind the board to find cracks in the printed circuit wiring, and to help in tracing the wiring on the component side of the board.

REMOVING AND REPLACING COMPONENTS
Components can be replaced on printed circuit boards quickly and easily if you use the proper techniques. Often, components such as resistors, capacitors and coils which are usually mounted parallel to the board can be replaced without removing the chassis from the cabinet.

Double-ended components can be replaced easily as shown in the drawing. Avoid prolonged application of heat when soldering. Always use a hot iron, because the solder melts quickly and there is less danger of damaging components or transistors.

Single-ended components should be removed and installed using the soldering iron on the printed wiring side of the board. If you must use the soldering iron near a wired-in transistor, hold the leads of the transistor firmly with needle-nose pliers to prevent heat from being transferred to the transistor.
PERSONAL QUALITY PERFORMANCE PROGRAM

In our continual search to find ways to improve our products and services, we at RCA Electronic Components and Devices have called upon every one of our co-workers to pledge his personal participation in what we call our “Personal Quality Performance” program.

Our PQP program means that when you use an RCA tube for replacement your chances of having a callback for that tube are mighty slim.

DARK HEATER

Because a dark surface gives off more heat than a comparable light-colored surface, a dark surface heater in a receiving tube radiates heat more efficiently than a conventional heater and provides better transfer of heat to the cathode. Lower temperature also means the tube heater changes its shape less during heating and cooling off, reducing the possibility of heater damage and heater shorts.

To the service technician, it means much less chance of having a call back when you’ve used an RCA dark heater tube for replacement.

BONDED CATHODE

This new development improves overall tube performance and reliability, with a resultant extension of tube life because: peeling of the emissive oxide coating on the cathode has been virtually eliminated; the bonded cathode transmits heat more efficiently and uniformly. This means improved receiving tubes, and fewer possibilities for call backs for tubes you’ve replaced with RCA Bonded Cathode types.
CONTINUOUS IMPROVEMENT IN RECEIVING TUBES

The 6BK4, used as a shunt regulator in color TV receivers, has been improved for uniform heat dissipation over the plate area. The improved version, 6BK4B, is less prone to crack at the plate cap seal. The type 6JE6 has been improved to minimize "snivets" in UHF color reception. The 6MD8 incorporates three color-matrixing amplifiers within one envelope. This means improved overall performance because the common cathode for the amplifiers increases the uniformity and consistency of the color matrix signals over the life of the tube, while maintaining proper relative gain of the color signals.

These are only a few of the developments, improvements and innovations which RCA Electronic Components and Devices constantly carries on.

PREMIUM TYPES VS. PROTOTYPE TYPES

**RCA Quick Selection Guide**

**PREMIUM TUBES**

For Military Specifications and Critical Industrial Applications

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<th>Class</th>
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*Types manufactured to conform to a particular military specification.

**RCA Quick Selection Guide**

**PREMIUM TUBES**

For Military Specifications and Critical Industrial Applications

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*Types manufactured to conform to a particular military specification.

**Premium** types may differ from their prototypes in electrical and/or mechanical characteristics, physical structure, or type of tests to which they are subjected. Tube data should, therefore, be checked before replacing a type in the prototype column with the listed "Premium" type.
PICTURE TUBES

CAPSULE CHRONOLOGY OF RCA LEADERSHIP IN COLOR-TV

1930 — RCA initiates its research in Color TV, examining the problems of transmitting and receiving acceptable color.

1940 — First to demonstrate electronic and optical Color TV receivers before the Federal Communications Commission.

1941 — RCA scientists and NBC engineers achieve first successful colorcast with experimental transmission from the Empire State Building in New York City.

1946 — Public demonstration of an all-electronic projection-type color TV receiver with a 15-in. 20-inch screen.

1947 — RCA publicly demonstrates an all-electronic color-TV camera.

1950 (April 6) — RCA demonstrates three-gun direct view Color TV picture tube and a compatible color TV system to the FCC.

1952 — NBC conducts compatible color TV tests during regular broadcasting hours.

1953 (June 25) — RCA and NBC petition the FCC to adopt the compatible television signal specifications used by the RCA color TV system as standards for commercial color TV.

1953 (Oct. 15) — RCA and NBC joined with other members of the industry in a final demonstration held by the NCTC at the request of the FCC. This provided overwhelming evidence that all-electronic compatible color television, pioneered and developed by RCA, was ready for the American public.

1953 (Dec. 17) — FCC adopts all-electronic compatible color TV standards recommended by RCA and NBC and NTSC.

1954 (Jan. 1) — NBC makes first national network colorcast. The Tournament of Roses Parade in Pasadena, California, is viewed by audiences throughout the nation on the screens of RCA color receivers.

1954 (March 17) — RCA's Bloomington, Indiana, plant starts a limited commercial production of a color TV receiver.

1955 (Dec.) — RCA offers first complete line of Color TV receivers. NBC reports a total of 215 hours of colorcasts for 1955.

1960 (May 6) — RCA introduces RCA 4401 color camera tube which requires no greater lighting than a black-and-white camera.

1960 (Dec. 15) — RCA introduces all-selenium color picture tube that produces color pictures up to 50 per cent brighter.

1961 (Aug. 4) — RCA introduces band color picture tube with safety-plate glass bonded to face of tube to cut down reflections from light sources in front of receiver. RCA color camera sets using bonded picture tubes were introduced immediately.

1962 (Feb. 7) — RCA reports the color TV industry has reached an annual going rate of $200 million and that consumer demand for color TV receivers has exceeded supply since November. All the other 11 manufacturers marketing color TV sets use the RCA 21-inch picture tube.

1962 (April 1) — RCA publicly demonstrates an experimental color TV camera which, for the first time produces four signals, three in color and one in black-and-white.

1962 (April) — RCA samples 90° round color picture tubes.

1963 — Beginning of rapid growth in color TV sales.

1964 (Sept. 24) — RCA announces the industry's first 25° 90° rectangular color picture tubes.

1964 (Oct. 22) — RCA announces the industry's first 19° 90° rectangular color picture tubes.

1965 (March 24) — RCA announces Hi-Lite color picture tubes featuring a phosphor-dot screen utilizing a rare-earth red phosphor and improved blue and green phosphors.

1965 (June) — Largest single expansion in RCA's history—a $50 million outlay with $35 million to be spent on doubling color tube production within three years.

COLOR PICTURE TUBE CODING SYSTEM

RCA and your authorized RCA Picture Tube Distributor now offer you the unprecedented support of Hi-Lite—a complete line of all new rare-earth phosphor color television picture tubes. These tubes utilize advanced green and blue rare-earth phosphors in a rare-earth red phosphor which are applied by a unique cathode coating process developed by RCA. The result is a line of all-new picture tubes that offer vivid, intense colors and picture brightness unsurpassed in the industry.

To help you quickly identify RCA Hi-Lite Color picture tubes, a new coding system has been adopted. Prefix Hi- in conjunction with the type designation indicates an all new Hi-Lite color picture tube which incorporates the rare-earth red-emitting phosphor. Prefix C- in conjunction with the type designation indicates a color picture tube which has an all-selenium or one of the earlier types of phosphor screens.

A table of RCA color picture tubes, available from your RCA Distributor, with their new prefixes is given below:

<table>
<thead>
<tr>
<th>Prefix Type</th>
<th>Prefix Color</th>
<th>Prefix Type</th>
<th>Prefix Color</th>
<th>Prefix Type</th>
<th>Prefix Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hi-1</td>
<td>Red</td>
<td>Hi-2</td>
<td>Green</td>
<td>Hi-3</td>
<td>Blue</td>
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</tbody>
</table>

COLOR PICTURE TUBES

<table>
<thead>
<tr>
<th>Type to be Replaced</th>
<th>Replacement by RCA Type</th>
<th>Replacement Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>1SGP2</td>
<td>1SGP2</td>
<td>Direct</td>
</tr>
<tr>
<td>1HPY22</td>
<td>1HPY22</td>
<td>Direct</td>
</tr>
<tr>
<td>21AXP22</td>
<td>21AXP22</td>
<td>Direct</td>
</tr>
<tr>
<td>21AXP22A/21AXP22</td>
<td>21AXP22A/21AXP22</td>
<td>Direct</td>
</tr>
<tr>
<td>21CPY22</td>
<td>21CPY22</td>
<td>Direct</td>
</tr>
<tr>
<td>21FP2</td>
<td>21FP2</td>
<td>Direct</td>
</tr>
<tr>
<td>21FP2</td>
<td>21FP2</td>
<td>Direct</td>
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<td>21FP22</td>
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<td>25FP22</td>
<td>Direct</td>
</tr>
</tbody>
</table>

* Industry Replacement and Interchangeability.
The major service market today is for instruments equipped with electron tubes. It is expected to be that way for some years to come. Increasingly though, radios, TV and Hi-Fi sets are being produced with transistors and other semiconductor devices used in place of electron tubes. Modern technology has progressed to the point where these devices approach and in some instances exceed, the reliability offered by electron tubes used for the same function. In addition, because semiconductors are in some cases relatively inexpensive and lend themselves to new or simplified equipment configurations, many manufacturers prefer to use them.

For the consumer, your customer, solid-state equipment offers some advantages, too. Radios, TV and Hi-Fi sets are smaller, use less power and turn on almost instantly without the need for warmup. Portable units can be easily carried about the home and taken on trips.

To some service technicians the advent of transistorized equipment may seem to present service problems. Indeed there are some very real problems. However, there are also many opportunities for increasing business.

Look at it this way: From the time radios first came on the market about forty-five years ago, almost anyone could change a tube or have one tested, buy a new one if the old one was defective, and many times repair his own radio. This was true with television also.

Transistorized sets are different! If something does go wrong it usually takes a knowledgeable technician — you — to get it back in working order. Except for changing batteries (and you can sell these too!) the average consumer has no way of finding out what’s wrong. Where you formerly lost a service call because the consumer went to the neighborhood drug store or super market and used the tube tester there, he now comes to you to get his transistorized TV, radio or Hi-Fi repaired.

The problems you will be concerned with are mainly in getting to understand transistors and transistor circuits. Having spent many years learning how electron tubes and circuits work — all based on the flow of electrons in a vacuum, it may seem difficult to become familiar with transistors which are based mainly on solid-state technology. But — you already have most of the knowledge you need. You know what is accomplished with oscillators, amplifiers, and rectifiers, as well as resistors, capacitors and inductances. With the many good publications available today, learning the differences between electron tube and transistor operation and equipment service is only a matter of taking the time to do so. You can be assured that the time you spend learning about transistors will repay itself many times over from the new capabilities you develop and will be able to sell.

The following pages tell how you can learn about transistors, what’s involved in servicing transistorized equipment, and show some practical methods to make it easier for you to profit from this new phase of the electronics business.
WHAT ARE TRANSISTORS?

Unlike electron tubes which depend on the flow of electrons in a vacuum, transistors and other semiconductors operate from a flow of electrons in a solid. Thus, they are called “solid state” devices. In general, solids are classified into three major categories—conductors, semiconductors and insulators—in accordance with their abilities to conduct electrons. Semiconductors are materials which have poorer conductivity than conductors, but better conductivity than insulators. Semiconductor materials used in transistors have a crystal structure. Very tiny amounts of other elements are added to the crystals, causing them to assume a desired positive (P-type) or negative (N-type) characteristic.

Diodes are formed by junctions of P-type and N-type material. An applied voltage of the polarity for which the crystal structure is designed, develops a high current in the diode. An applied voltage of opposite polarity produces negligible current flow.

When a second junction is added to the two element diode, amplification becomes possible. With the three elements, the device is called a transistor. The three elements of the transistor are called the emitter, the base and the collector.

BASIC TRANSISTOR TYPES

The two most common types of transistors are the P-N-P type and the N-P-N type. The P-N-P transistor’s emitter and collector are composed of positive type material (P-type) and the base is composed of negative type material (N-type). The N-P-N transistor’s collector and emitter are composed of N-type material and the base is composed of P-type material. The major path of electron flow in the transistor is from the emitter to the collector in N-P-N types, and from the collector to the emitter in P-N-P types. Electron flow in the transistor is always opposite to the direction of the identification arrow on the emitter symbol. In order to identify a transistor as NPN or PNP, remember that the arrow always points to the N material (just as the arrow in a compass points North).
GENERAL DESCRIPTION

OTHER SOLID STATE DEVICES

Germanium Diodes are used as detectors in TV and radio receivers.
Silicon Diode Rectifiers are widely used as DC rectifiers in power supplies for radios and TV.
The Silicon-Controlled Rectifier has a control electrode called the "gate." Silicon-Controlled rectifiers are used mainly in commercial and industrial power applications.
Varactor Diodes are semiconductor devices having variable reactance characteristics, enabling them to perform frequency-multiplication, oscillation, and switching functions with inherently low circuit noise. Voltage-Reference Diodes (or Zener Diodes) are silicon rectifiers used as stabilizing devices and as reference sources to supply constant current loads. Tunnel Diodes are small semiconductors used as amplifiers, pulse generators and R-F generators.
Thermistors are resistors made out of semiconductor materials, and have negative temperature coefficients of resistance. They are used for bias stabilization in transistor circuits.

INTEGRATED CIRCUITS

RCA semiconductor research has combined the ancient art of making and molding ceramics with the "micro-concept", using photography and modern printing to perfect the manufacture of integrated electronic circuits.
Scarce only larger than the point of a common lead pencil, integrated circuits contain a large number of transistors and diodes as well as other circuit components, and all internal and terminal wiring.
Integrated electronic circuits are available for DC, A-F, video, I-F and R-F amplification, as well as AGC, Limiter, Squelch, Phase splitter, Detector and Mixer functions. These circuits are also available for logic switching purposes in computers and data processing equipment.
In the not-too-distant future RCA's Monolithic Silicon Integrated Circuits will be used in radios, TV's and other consumer equipment just as they are now being used in military, aerospace and electronic data processing equipment requiring highest reliability with very low power requirements.
LEARN ABOUT TRANSISTORS

LITERATURE

As the use of transistors in electronic equipment becomes more common, servicing transistorized equipment will become additional profitable business for the technician who has learned about transistors and has the proper test equipment.

For those technicians who have had no experience or have shied away from transistorized equipment, now is the time to get started in learning about these very simple devices. You can learn about transistors from books, pamphlets, trade magazines, resident evening school courses, and home study courses.


LEARNING AIDS

RCA's WE-93A(K) Transistor Radio Dynamic Demonstrator Kit is a good way to learn about transistor circuits. It demonstrates operation of oscillators, mixers, I-F amplifiers, diode detectors, AF driver amplifiers and AF power amplifiers. The kit comes complete with all parts and transistors, and an easy-to-understand instruction book. Components plug into a circuit printed on the panel of the kit. This makes it very simple and easy to work with. Defective components can be substituted for good components on the board and you can see what effects these have on operation. And, when you're finished you have a working transistor radio.

Another kit, the RCA Silicon Controlled Rectifier Experimenter's Kit KD2105 permits you to build several electronic control devices using semiconductors. This kit includes a silicon-controlled rectifier, five silicon rectifiers, and two transistors.

If you want specialized knowledge and experience in control circuits, the RCA Experimenter's Manual KM-70 gives construction and operation information on 14 complete circuits for dozens of control applications as well as basic theory about solid state devices.
COMMON BASE AMPLIFIER

The simplified circuit diagram of the Common Base amplifier shows that the base of the transistor is common to both the input and output circuits. Input impedance in this type of circuit is generally low (0.5 ohm to 50 ohms), and the output impedance is high (5,000 ohms to 1 megohm). Voltage gain of 1500 is possible and power gain is in the order of 10. Phase reversal does not occur. In other words, the polarity of output is the same as the input.

COMMON-emitter AMPLIFIER

The common emitter circuit is the one most often found in television and radio receivers. The simplified circuit diagram of the Common Emitter amplifier shows that the input signal is applied to the base-emitter circuit and the output is taken from the collector-emitter circuit. Input impedance is generally from 20 ohms to 5,000 ohms, and output impedances range between 50 ohms and 50,000 ohms. Power gain of 10,000 and voltage gain of 200 is possible. A phase reversal of 180° occurs between the input and output circuits. Thus, in this circuit output polarity is reversed from input polarity.

COMMON COLLECTOR AMPLIFIER

The common collector, or emitter follower circuit shown simplified at the left, with its high input impedance and low output impedance is usually used as an impedance matching device; however, with this circuit current and power amplification is possible. Voltage gain is slightly less than 1, but a power gain up to 250 is possible. This circuit is often used to match the high impedance of an electron tube circuit or a phonograph pickup to the low impedance input of a transistor driver stage. Phase reversal of the voltage does not occur in this amplifier.
WHAT'S INVOLVED

Although the methods used in servicing transistorized equipment are similar to those now used for servicing electron tube equipment, transistors function differently from tubes. Here are some of the major differences you will find, when comparing tube circuits to transistor circuits.

Voltages used in transistor circuits are lower than those used in electron tube circuits. Therefore, capacitors will have lower voltage ratings and will be physically much smaller.

In contrast to your experience with electron tubes which are voltage-controlled devices, transistors are current-controlled devices.

Transistorized electronic equipment is smaller than electron tube equipment, uses lower voltages, generally uses printed circuit wiring, and because of its smaller size and lower voltage and current requirements is often portable, and operated from batteries.

TOOLS AND SERVICING CONSIDERATIONS

Transistors are used almost exclusively with printed circuit wiring. The tools required for servicing transistorized circuits will be the same as those required for servicing other printed circuit wiring. Also, a low-wattage soldering iron should be used, and the iron should be hot to avoid prolonged application of heat. Don’t forget to use a pair of long-nose pliers as a heat sink, when soldering in the vicinity of transistor leads.

Always use genuine replacement parts. These will fit properly into the space provided for the original part on the printed circuit board.

Capacitors and resistors used for replacement should be of the proper rating. Components having higher ratings will work satisfactorily; however, they usually are larger and may cause crowding of components on the board.
WHY USE AN OSCILLOSCOPE?

The versatile oscilloscope is the only test instrument which gives an instant picture of both the amplitude and the waveform of the signal at the point in the circuit being checked.

A "graphic voltmeter", the oscilloscope makes voltage calibration and measurement a simple, almost automatic procedure. Low level signals not easily measured by other test instruments can be quickly and accurately measured with an oscilloscope. Peak-to-peak voltages, as well as the waveforms of all signal voltages, are indicated directly.

The scope lends itself to the signal-tracing method of servicing. It offers negligible loading to the circuit, and by simple adjustment of the vertical input control, wide voltage ranges can be accommodated.

WHEN TO USE THE V-O-M

When servicing transistorized sets check the power supply and the current drain of the set first. The RCA WV-38A with its wide selection of voltage and current ranges is ideal for these purposes.

For transistorized TV sets with AC power supply, if the set is completely inoperative, check the AC input, fuse, rectifier and filter circuits. Low DC voltage output from the power supply can cause equipment to be inoperative or not function properly. When checking batteries, measure the voltage with the set turned "off" and then with the set turned "on". An appreciable drop in battery voltage when the set is turned on usually indicates weak batteries or possibly a leaky electrolytic capacitor. Checking voltage directly at the battery terminals and at the busses on the board will generally show up any poor or corroded battery contacts.

Use the Rx 100 range on the meter for resistance measurements. Use of this range minimizes the possibility of applying excessive voltage to the transistor.
GENERAL TECHNIQUES

Use diagnostic procedures which will avoid even momentary “moderate” overloads to transistors. Signal tracing, using an oscilloscope as the indicator, is preferable. The scope offers minimum loading to circuits and does not inject DC or RF reference voltage into the circuits under test.

For faster signal tracing mark frequently-used test points in colored ink on the schematic diagram and printed-circuit wiring diagrams or phantom views in the manufacturer's service data.

Use test probes with care. The case of a power transistor is frequently the collector terminal as well as being a means of transferring heat to the heat sink. Do not short the case of such a transistor to the mounting plate or the main chassis. When replacing power transistors, make certain there are no metal shavings on heat sinks or mica insulators which can cause shorts or prevent proper heat dissipation. For best heat conduction, use manufacturer's recommended silicone grease between heat sinks and transistors, also on both sides of mica insulators.

Never repair transistor equipment with the power on. Use only test equipment or devices which are isolated from the AC line. Momentary AC voltage across two transistor terminals can cause breakdown.

PRINTED CIRCUITS

Servicing procedures and the test equipment required for servicing miniature transistorized equipment are the same as those required for servicing larger versions. Service procedures are determined by the functions the equipment is designed to perform, not by the size of the equipment. Time can be saved by using servicing techniques applicable to this type of equipment.

A magnifying glass is helpful for inspecting small printed circuit wiring and for locating points in the wiring selected for observing signal waveforms and taking voltage and resistance measurements.

Test points indicated on the schematic diagram are sometimes printed on the component side of printed circuit boards. The test points may be different in appearance from those customarily used on larger equipment. For instance, the test point may be a loop in the lead of a resistor or other wiring.
SIGNAL TRACING

The fastest way to isolate trouble in transistorized equipment, as in electron tube equipment, is by signal-tracing.

The RCA WR-50B RF Signal Generator is an ideal signal source for signal tracing in a transistor radio, because it supplies 400 cycles AF as well as RF, and IF frequencies. Also, at the turn of a switch 455 kc/s or 10.7 Mc/s sweep is available.

Connect the output of the signal generator to the receiver antenna, either directly or by looping an insulated wire near the antenna. Adjust the signal generator for approximately 30% modulation at 400 cycles-per-second, and tune the generator and the receiver to the same frequency. Using the WG-350A Demodulator Probe and cable on the WO-33A oscilloscope, check for the presence of signal through the IF stages and the detector. The signal will drop out, or be sharply reduced, at the defective stage.

The same procedure may be used in the audio-frequency amplifiers, using the 400 cycle output of the WR-50B as the signal source.

VISUAL CHECKS

Transistors give no visual indication of whether they are operating or not, and except for power transistors, give off little heat. It would seem then that visual checks are of little use in diagnosing troubles in transistorized hi-fi equipment; however, this is not the case.

Some transistors are mounted in sockets and can come loose or even fall out of their sockets if the equipment is handled roughly.

Hi-fi equipment is often "sectionalized", and in the process of moving the equipment for house cleaning, interconnecting cables for the units or speakers can be damaged or pulled loose.

The condition of controls, selector switches, tape deck, turntable, etc. can be quickly determined by a visual inspection, and furnish valuable clues.

Excessive current may flow in transistor circuits and damage or burn out resistors, if the stabilization device fails. Fuses serve a dual purpose in some power amplifiers. In addition to protecting the circuit components from overloads, their internal resistance of a fraction of an ohm is used to develop a bias for the transistor. It is important to replace these "fuses" with identical types.
HOW TO USE THE AUDIO SIGNAL GENERATOR

The RCA WA-44C Audio Signal Generator with its selection of sine wave or square wave signals is useful for signal tracing in AF circuits and establishing the quality of performance.

A defect can be isolated quickly by using the sine wave output of the Audio Signal Generator and the WO-33A oscilloscope. Assuming that the speaker is OK, we could use it as an indication of performance; but using a scope provides a picture of the quality of the signal in addition to the presence of signal. Inject the audio signal at the input of the power amplifier stage, then progressively move the point of injection back to the inputs to the amplifier section. It will be necessary to reduce the output level of the signal generator as the injection point is moved back. Voltage and resistance measurements will pin-point the defective component, after the general area has been located.

The square wave audio signal is used to determine the quality of performance of the amplifier. Refer to the service data on the hi-fi equipment and the WA-44C Signal Generator instruction book for prescribed hookups and interpretation of waveforms.

HOW TO USE THE STEREO SIGNAL SIMULATOR

The RCA WR-52A Stereo Signal Simulator provides all the signals required for servicing and aligning stereo FM radio receivers.

The overall alignment procedure specified by various manufacturers may vary slightly; however, the signal generator is usually connected to the receiver FM antenna terminals and the oscilloscope is connected to the ratio detector or discriminator, as specified in the service data.

Basically, the stereo alignment procedure for any FM stereo circuit consists of adjusting the amplitude and phase of the 19 kc/s pilot signal and the 38 kc/s switching signal, adjusting the SCA ("subsidiary carrier assignment" information) trap for minimum response, and setting the internal stereo balance control. The WR-52A Signal Simulator provides all the signals necessary for making these adjustments. For step-by-step details, follow the instructions given in the service data for the FM radio.

In cases where only the stereo multiplex circuit needs service or for alignment of stereo adapters or converters, use the composite stereo output of the Signal Simulator and connect the scope as directed in the equipment manufacturer's service data.
SERVICING - HI-FI EQUIPMENT

SIGNAL TRACING IN AM, FM, AND FM-STEROE HI-FI EQUIPMENT

It is unlikely that all functions of a hi-fi equipment will be inoperative, except when the power supply is defective or both audio amplifiers are defective. Usually, the trouble will be limited to a particular function, or the right or left channel sound amplifier. The general area of the trouble can usually be determined by a visual inspection, and the trouble can then be isolated by signal tracing.

"No AM or FM radio reception" suggests trouble in the I-F amplifiers. Separate RF/Mixer stages are generally used for AM and FM reception; however both the AM and FM I-F circuits use the same transistors. Using either the WR-50B Signal Generator tuned to the frequency of the AM RF stage or the WR-52A Stereo FM Signal Simulator with the radio tuned to 100 Mc, trace the I-F signal for the radio band selected, from the converter toward the detector, until the trouble is located. Refer to the service data for the hi-fi equipment for the manufacturer's recommendations on service procedure.

"No FM-Stereo reception" suggests trouble in the multiplex or detector circuits. Connect the WR-52A Stereo FM Signal Simulator to the antenna terminals of the FM tuner, and adjust the tuner to receive the 100 Mc/s signal. Using the WO-91B Oscilloscope, check for the presence of signals progressively from the FM detector to the stereo detector. The 19 kc/s subcarrier and the 38 kc/s switching signal waveforms can be observed on the oscilloscope. Refer to the schematic diagram for recommended test points, and alignment instructions in the equipment service manual.

The cause of "No sound" in the left or right audio channel can be checked by connecting the WA-44C Audio Signal Generator to the input capacitor of the channel involved and tracing the signal through the amplifier with the WO-91B Oscilloscope until the cause of the trouble has been isolated.

The performance characteristics of the amplifier can be checked by injecting a square wave signal from the WA-44C into the amplifier channels and observing the overall response on the oscilloscope. Refer to the hi-fi service data and the WA-44C instruction book for suggested tests and typical response waveforms.

Proper speaker and system phasing can be checked by using the RCA WG-360A phase checker. This check is important when a stereo phonograph cartridge or a loudspeaker has been replaced.
SERVICING - SOLID-STATE TV

TUBE VS. TRANSISTOR TV SETS

The major function requirements in the circuits of both electron-tube and transistor TV sets are identical. They both have tuner circuits, picture and sound IF, audio, sync, deflection and high voltage circuits. The signals in transistor sets follow the same paths as they do in electron tube sets. The major difference is in the manner in which tubes and transistors operate. Because transistors are current-controlled devices, the circuits used are somewhat different than those used in the familiar voltage controlled electron tube circuits. For example, the vertical deflection signal in an electron tube equipped set is provided by an oscillator and an output tube. In solid state TV, the example shown here (RCA Victor KC5153 chassis) uses an oscillator, a pre-driver, a driver and an output stage. However, using the proper service techniques, this difference presents no particular difficulty as far as trouble shooting is concerned.

USING THE V-O-M

Voltages in solid state TV sets are generally much lower than in similar circuits in electron tube sets. But, just as in electron tube sets, significant variations from normal voltage readings pinpoint defective components.

If a transistorized TV set is completely inoperative, check the power supply first. Transistors are reliable and experience shows that they are seldom the cause of a totally inoperative receiver.

A transistor RF tuner can be checked by measuring oscillator injection voltage, comparing it with the manufacturer's service data.

Most supply voltages can be easily checked with the WV-38A Volt-Ohm-Milliammeter. For signal circuits, either a VoltOhmyst® or an oscilloscope should be used to prevent circuit loading.

Be careful when making resistance measurements in transistor circuits. Transistors can be damaged by even relatively low voltages applied to base-emitter circuits. The R x 100 range of the WV-38A can be used safely in most circuits.
OSCILLOSCOPE NEEDED FOR QUICK DIAGNOSIS

Servicing transistORIZED printed circuits in television receivers is easy, if you learn to recognize chassis "landmarks" and use appropriate service procedures. Although the familiar "string of tubes" is not there to guide you through the chassis, other landmarks such as components and groupings of components serve this purpose. When used with the wiring and schematic diagrams in the service data, these landmarks enable you to quickly locate the signal paths. The best way to isolate trouble in transistor TV sets is by signal tracing using the RCA WO-33A scope. The scope does not appreciably load the circuits and does not inject into the circuitry, voltages which might damage the transistors. To find the trouble even quicker, mark the test points on the schematic diagram and the printed wiring diagrams with a colored pencil. By referring to these notes, you'll be able to check through the circuits very quickly; and you'll find that in many cases, the trouble can be isolated without pulling the chassis.

HOW TO CHECK THE PICTURE IF SECTION

Loss of both picture and sound can be due to troubles in the IF circuits just as in electron tube TV receivers. The trouble can generally be isolated quickly, by signal tracing. Using the WG-350A Demodulator Probe and Cable connected to the WO-33A portable oscilloscope, check for the presence of signal at the input to the 1st IF stage and the other indicated points. Refer to the schematic diagram and wiring diagrams in the service data for details.

Signal from a TV station or the RCA WR-69A Television/FM Sweep Generator may be used as the signal source for signal tracing. If alignment of the circuits is required, follow the instructions given in the service data for step-by-step details.
HOW TO CHECK THE VIDEO SECTION

A no-picture with raster condition can be the result of trouble in the video section, as in electron tube receivers. Signal tracing is the fastest way to isolate the trouble. Using the low-capacitance probe of the WO-33A oscilloscope to minimize circuit loading, check for the presence of video signal at the input to the 1st video amplifier and progressively check through the video amplifiers until the trouble has been isolated. Refer to the service data for recommended test points, typical waveforms, schematic diagram and printed circuit wiring diagrams.

Signal from a TV station or the signal from the RCA WR-69A Television/FM Sweep Generator may be used for signal tracing.

The WO-33A scope is also useful for checking the video signal level, if the picture is lacking in contrast level. Consult the TV service data for typical signal levels at the specified test points.

HOW TO CHECK THE SOUND SECTION

No sound can result from trouble in the sound IF, FM detector, audio driver or audio output stages. The quickest way to isolate the trouble is by signal tracing. Either the signal from a TV station or the WR-50B RF Signal Generator may be used. If the WR-50B is used, connect the RF output to the input of the sound IF section, and set the generator at 4.5 Mc/s with 400 cycle modulation. Trace the signal as shown in the block diagram, using the WG-350A probe and the WO-33A oscilloscope.

If the signal is present through the IF stages and the FM detector, install the WG-349A Direct/Low Capacitance Probe on the scope lead and check the signal through the audio stages. Refer to the schematic diagram in the service data for the signal path and the wiring diagram for the location of components and test points on the printed wiring board. Turn the volume control to maximum while checking in the audio section.
HOW TO CHECK HORIZONTAL AND HIGH VOLTAGE SECTIONS

Loss of raster, or inadequate brightness will usually result if trouble develops in the horizontal deflection or horizontal output sections, as in an electron tube receiver. Signal tracing provides the fastest method of locating a trouble in these circuits, and an oscilloscope such as the RCA WO-33A is the test instrument to use. Waveforms are extremely important, and the oscilloscope provides an accurate indication of the form and amplitude of these signals. Using the low-capacitance probe, trace through the circuits as shown. For step-by-step details on horizontal circuit adjustments, refer to the service data.

To measure the high voltage output to the picture tube 2nd anode, use the WG-289 High-Voltage Probe with the VoltOhmyst® or the WG-297 High-Voltage Probe with the WV-38A Volt-Ohm-Milliammeter.

HOW TO CHECK THE VERTICAL SECTION

No vertical deflection, insufficient height, poor vertical linearity or unstable vertical sync can result from trouble in the vertical circuits. Signal tracing with the W0-33A portable oscilloscope is the fastest way to locate a trouble in the vertical circuits. Using the low-capacitance probe on the scope cable, trace the signal through the vertical circuits, as shown in the block diagram.

It is important that the proper waveforms are developed and amplified in these circuits. Refer to the typical waveforms given in the service data for comparison with those observed on the oscilloscope.
HOW TO CHECK THE SYNC CIRCUIT

A "floating" picture or unstable picture is usually the result of trouble in the synchronizing circuits. A trouble in these circuits can be located quickly by tracing the signal through the circuits with the WO-33A portable oscilloscope. Using the low-capacitance probe, check the signal at the input to the sync separator. The vertical sync pulse can be observed using the 15–150 c/s range on the sweep selector; and using the 1500–15 kc/s range, the horizontal sync pulse can be observed.

Using the service data as a guide, trace these signals to the vertical pre-driver and the horizontal phase control circuits. Also, the noise cancellation circuit should be checked, as indicated in the block diagram. Compare the observed waveforms with the typical waveforms in the service data.

HOW TO CHECK THE AGC CIRCUIT

AGC trouble in a transistor TV receiver can be isolated quickly by signal tracing just as in other circuits. Keyed or "gated" AGC is used in the RCA Victor KCS153 chassis used here as an example. In circuits like these it is important that you use test equipment to determine that both the horizontal sync pulses and the "gating" pulses from the horizontal output transformer are being applied to the gating transistor. These waveforms can easily be traced using a low-capacitance probe (RCA WG-349A) with the WO-33A portable oscilloscope. Compare the observed waveforms with the typical waveforms shown in the service data for the TV set.

Voltage readings are also helpful in isolating trouble in AGC circuits.
SERVICING - SOLID-STATE TV

HOW AND WHEN TO USE THE V-O-M OR VTVM

Isolating a faulty stage in transistorized TV receivers is accomplished easily and quickly using the oscilloscope. However, voltage and resistance measurements are usually required to further isolate the trouble to a specific component.

Although the voltages used in transistor circuits are lower than those you have been accustomed to measuring in electron tube circuits, voltage readings are important and help to isolate trouble to a specific component. Quick, accurate voltage measurements can be made with a VoltOhmyst® such as RCA’s WV-98C or WV-38A Volt-Ohm-Milliammeter.

Resistance readings are also important in isolating trouble to a specific component. Be sure that the test voltage of your ohmmeter does not exceed the emitter-base breakdown voltage of a transistor in the circuit to be tested, or the transistor may be damaged. A VOM having a sensitivity of 20,000 ohms per volt or greater, such as the RCA WV-38A, (R x 100 scale) can in most cases be safely used for these measurements.

RCA TOP-OF-THE-LINE—SK SERIES REPLACEMENT TRANSISTORS

One of the surest ways for you to prevent delays in servicing solid-state devices is to have a transistor or rectifier replacement on hand when you need it. You can replace more than 3900 types of transistors currently used in entertainment-type equipment, from the 16 transistor types in the RCA “SK Series”, with only a small inventory investment. Also included in the SK Series are 2 silicon rectifiers which replace more than 1300 selenium and silicon rectifiers used in color TV, black-and-white TV, hi-fi sets and radios.

The RCA “Top-of-the Line” Semiconductor Replacement Guide (SPG-202A) places at your fingertips comprehensive up-to-date information on more than 5200 transistor and rectifier types (including many of foreign manufacture) which can be replaced by “Top-of-the-Line” types in the SK Series. The Semiconductor Replacement Guide helps you to select the right replacement type, quickly and accurately.
COLOR TELEVISION

Color television has come of age. The new popularity of color wedded to the modern miracle of television has created an enormous demand for ownership of color television receivers. More than 2,000,000 new sets were purchased last year alone. This increase in color television receiver ownership in turn has created a demand for rapid, efficient service for these instruments. This demand will be met by the progressive service technician who has taken the trouble to observe, at special training meetings, or during the course of his daily business, the differences between the servicing techniques required for black-and-white television receivers, and those required for color television receivers.

The demand for service will continue to increase. Eventually, more and more technicians will be required to become familiar with color television receivers. Many service technicians are today studying, and experimenting when possible, with actual receivers.

Texts concerning theory, and service data for the instruments are available from many sources to further this training.

At this point we will review briefly some of the basic points in servicing any television receiver because color television receivers do have more circuits, and some adjustments do require extra care.

The many conflicting arguments heard about complexities and the degree of precision required when servicing color TV may cause some zealous technicians to go overboard in their efforts to do the best job possible. To set the record straight, here are some points to remember.

It should be kept in mind that voltages, resistance readings, and waveforms are indicators. Usually, where DC voltages are measured, a small variation is not significant and does not indicate trouble but rather, an excursion within the permissible tolerances. DC voltage tolerances are generally plus or minus 20% with 117 volts AC supply to the power transformer.

As an example, when measuring B-plus voltages, plate voltage for a 1st Video Amplifier may be listed on the schematic diagram as 132 volts. As measured from a receiver, the voltage may read 118 volts—a variation of a little more than 10%.

From this it can be seen that a slight voltage variation will not affect operation of the circuit to a great degree. However, where very low voltages are being measured, variations should be particularly noted since a small voltage variation in this case may mean a large percentage variation. Tolerances for voltages and individual components should be checked in the manufacturer’s service data.

The oscilloscope is one of the most useful tools we have for checking circuit operation. If the correct waveform at a particular point in the circuit is known, it is necessary only to compare the waveform under observation with the known waveform. Distortion, changes in polarity and differences in amplitude generally will show clearly on the oscilloscope while other measuring methods may not provide easily recognizable discrepancies.

Most of the common troubles found in color television receivers are the same as in black-and-white receivers. These include: defective tubes, changes in value of small components and the like.

After replacing tubes, especially in the R-F, I-F and chrominance circuits, it is a good idea to check performance in both black-and-white and color. A defective tube in these circuits may have caused a small resistor to draw excessive current, overheat and change value to such a degree that optimum performance is not obtainable even with a new tube in place.

All adjustments should be made carefully, and only after the need for adjustment has been established. It is pointless to make adjustments in a haphazard manner without a definite goal in mind.

It is also pointless to replace partsunless the need for doing so is evident.

In servicing color television receivers, it is wise to develop a logical procedure which includes: first, circuit-by-circuit elimination of the sections of the receiver which are operating correctly, and secondly, the use of proper test instruments to isolate the source of trouble.

The following pages describe the tools required for efficient color receiver servicing; tell how to use these tools; discuss procedures for determining specific needs for service; show how to use an oscilloscope at various points in the receiver; and give practical information useful in the home, or at the service bench, for localizing the source of improper operation of the receiver.
GENERAL

WHAT YOU NEED TO KNOW

With a good background in servicing black and white TV you can become an expert in servicing color TV receivers. Basically a color TV set is a black-and-white set with a few additional circuits. Three separate colors are used to get either a black-and-white picture, or a color picture having all the colors of the rainbow, so you will have to learn about color itself. Some color TV service problems are different than black-and-white TV because not only must you get a good picture and sound, but the picture must show the proper colors.

Fortunately plenty of good, inexpensive books are available, from many sources, to help you understand color TV. And there's RCA Institutes' Home Study Course in color TV. To help you on the job, RCA's Color Pict-O-Guide is as handy and useful as your volt-ohm-milliammeter. In addition, RCA — and most other manufacturers — publish service data for their instruments. These can be a big help in learning.

For color TV service you do have to know more than for black and white TV servicing, but it pays off. Just as in any other business, the people who have taken the time to learn more are the experts. And with color TV at its present stage, you can get in on the ground floor.

COMPARISON WITH BLACK AND WHITE TV

The RF, IF, horizontal and vertical sync, and audio circuits perform essentially the same functions as they do in black-and-white TV sets. However, the RF and IF sections must provide a wider bandwidth with flatter response to handle the full bandwidth required for color signals. Most color receivers use a separate sound detector with the sound IF signal being removed ahead of the video detector. This prevents a 920 kc beat signal, which is produced between the 4.5 Mc sound IF signal and the 3.58 Mc color subcarrier signal, from getting to the video section. The video section is a little different because the 1st video amplifier is usually the point from which luminance, sync, burst and chrominance signals are fed into their processing sections. A delay line in the video section holds back the luminance (black-and-white) signal so it can arrive at the picture tube at the same time as the color signals. Horizontal output circuits produce higher voltages with better regulation than in black-and-white TV sets. Picture tube circuits are more complicated because they process much more signal information than in black-and-white TV sets.

All in all, the major differences are in the precise manner in which the signals are processed rather than in complexity of circuits.
GENERAL

COLOR CIRCUITS

The color section of the receiver recovers the color signal information in a circuit called the Bandpass Amplifier from where it is passed on to the Demodulators along with a 3.58 Mc crystal-controlled signal generated by an oscillator in the chroma section of the receiver. The phase of the 3.58 Mc signal relative to the color signal is established by the color sync signal (called “burst”) which is recovered in a Burst Amplifier circuit. The burst signal also turns “on” the color circuits when a color picture is being transmitted. The combination of the color signal and the 3.58 Mc signal in the Demodulators results in two output voltages whose amplitudes depend on the amplitude and phase relationship of the two input voltages. These two voltages are added (or mixed) in the Matrix section where they are converted to voltages representing red, green and blue. These three voltages are applied to the individual electron guns in the color picture tube along with the normal brightness (black-and-white) signal to produce a picture in its original colors.

COLOR PICTURE TUBES

All color television receivers currently being produced by America’s major manufacturers use the three-gun shadow-mask tri-color picture tube. Although different circuits may be used to process the color signals in the receivers, the end result is to apply proper voltages at the proper times to produce either a black-and-white or a color picture on the face of the color picture tube.

Although many different sizes, and both round and rectangular envelopes are used for color picture tubes, the basic principles of the tri-color, shadow-mask tube, using three separate phosphors to produce shades of red, green and blue and black-and-white should be thoroughly understood by the technician who expects to service color sets profitably. The RCA Color TV “Pict-O-Guide” tells you everything you need to know to fully understand how the color picture tube works, and why more adjustments are required than you are used to with black-and-white picture tubes.
COLOR TV

GENERAL

ALL MAKES ARE BASICALLY ALIKE
The recent enormous increase in production of color television receivers, with an ever expanding field of manufacturers, may lead to some apprehension about the wide variety of makes, sizes and models coming on the market. Basically, all color receivers are the same. They all have the same tasks to perform, and although approaches may vary somewhat, or the nomenclature used by one manufacturer may differ from another, or slight variations in set-up and adjustment may be involved, if you are familiar with one manufacturer's sets, you have a good basis for understanding the others.

To make it even easier for you, RCA Electronic Components and Devices has put into one handy volume, "The RCA Color TV Service Handbook", a compilation of the methods of adjustment recommended, chassis layouts, and other service aids, for sets produced by color TV manufacturers.

TEST EQUIPMENT FOR HOME SERVICE
In addition to the normal hand tools and completely stocked tube caddy carried by all TV service technicians, the following items ought to be considered musts. The trusty Volt-Ohm-Milliammeter (RCA WV-38A) or VTVM (RCA WV-77E or WV-98C) takes care of the most obvious troubles and pinpoints defective components after diagnosis has located the general area of trouble. A high voltage probe (WG-289 or WG-297) to go with the VoltOhmyst® or V-O-M, saves time in checking high voltage quickly and accurately.

To set-up a new receiver, or check the results of your service job, and for providing a stable, known color signal, the RCA WR-64B Color Bar/Dot/Crosshatch Generator is an indispensable tool in color TV service work. Although many service technicians have not considered the oscilloscope as portable test equipment, the new super portable RCA WO-33A can be the one most useful test instrument the technician can carry. It is particularly desirable and in many cases necessary for servicing transistorized circuits — both in color and black-and-white sets.

Another professional time-saver is the WT-115A Color Picture Tube tester. This unit can pay for itself many times over in saving trips back to the shop to check the picture tube.
COLOR TV

GENERAL

TEST EQUIPMENT FOR SHOP SERVICE

A neat, clean shop equipped with the proper tools and test equipment to do a fast, efficient servicing job not only results in savings in time and money, but also tells your customers that you are a professional. Generally, the minimum requirement to do a thoroughly professional job includes the following:

- Color Bar/Dot/Crosshatch Generator (RCA WR-64B) for color circuit servicing
- Wide Band Oscilloscope (RCA WQ-91B) for fast diagnosis and alignment
- VTVM (RCA WV-98C Senior VoltOhmyst®) for precision voltage and resistance measurement
- Sweep Generator (RCA WR-69A) for alignment and circuit tracing
- Marker Generator (RCA WR-70A or WR-99A for precision alignment)

It may be surprising to some technicians, but the WR-64B Color Bar/Dot/Crosshatch Generator is also an excellent tool for servicing black-and-white TV sets, because it has stable RF output, with a modulated signal if desired.

V-O-M OR VTVM USED FOR BASIC CHECKS

Either a Volt-Ohm-Milliammeter or a Vacuum-Tube Voltmeter is the basic service instrument used by all technicians. It is used in the field to pinpoint defective components, to check supply and operating voltages, to check for shorts or open circuits, and for current measurements where necessary. Analysis and diagnosis of a condition will localize the trouble to a specific stage. An oscilloscope will track down a difficulty to a particular circuit. The V-O-M or VTVM, however, is the instrument that will tell the exact component that lies at the root of the problem.

RCA’s WV-38A Volt-Ohm-Milliammeter, the WV-77E VoltOhmyst® and WV-98C Senior VoltOhmyst® are rugged, reliable instruments which exactly fit the requirements for this most basic service tool.
HOME SERVICE - GENERAL

HOW TO CHECK HIGH VOLTAGE

In a color receiver any wide variations in high voltage will result in changes in picture size, blooming of the picture, changes in brightness levels and improper gray-scale tracking from lowlights to highlights. For this reason color receivers incorporate a regulator tube to maintain the high voltage at a constant level. Occasionally it is necessary to check the high voltage. This is done with either a V-O-M or VTVM using the appropriate HV probe. On most receivers high voltage can be adjusted with a control in the shunt regulator circuit. In most cases high voltage may be measured at the cap of the HV regulator tube.

CURRENT MEASUREMENTS IN HV CIRCUITS

In color receivers, the horizontal output and high voltage circuits are somewhat more critical than in black-and-white receivers. To maintain HV at a constant level a shunt regulator tube is connected in parallel with the picture tube HV anode across the HV supply. The regulator maintains a constant load on the HV source, thus insuring a constant HV level at the 2nd anode of the picture tube. Correct current in both the regulator and the horizontal output tube is essential for proper regulation of the HV output voltage. Most receivers incorporate a jumper in the cathode circuit, at the socket of the horizontal output tube, for measurement of horizontal output tube current. Shunt regulator current can be checked by measuring the voltage drop across a resistor in the regulator tube cathode circuit and calculating the current. Most color sets have provisions for adjusting regulator current to the proper level. In some earlier receivers, the WV-38A V-O-M ("1MA" scale) may be used in the cathode circuit of the shunt regulator for measuring the cathode current (meter in series with cathode resistor).
HOW TO USE THE SCOPE—IF SECTION

Advantages of using the oscilloscope for TV servicing have been overlooked by many technicians. A few hours spent in brushing up on how to use the scope can prove invaluable. New lightweight portable models such as RCA’s WO-33A, make this instrument practical for use in servicing in the home, and with greater usage of solid state devices, it is becoming just about a must. For instance, using the oscilloscope for checking gain, stage by stage, in the IF section of a transistorized TV set will enable the technician to quickly pinpoint a source of trouble in this section of the receiver. The effect of open components, faulty capacitors and intermittent conditions, not usually detectable with a meter are easily seen with an oscilloscope, and you don’t have to analyze waveforms, just use the scope to measure levels at inputs and outputs.

HOW TO USE THE SCOPE—VIDEO SECTION

The operation of the video amplifiers may be checked quickly and easily with the WO-33A scope. By comparing the schematic diagram and the circuit board assembly many convenient points will be found where you can look at the video waveform. By comparing the grid waveform (input) of a video amplifier stage with the plate waveform (output) the amplification of a particular stage can be determined. Any stage that shows little or no amplification should be suspected and investigated closely. Measure voltages at the tube socket and compare with normal voltages in the service data. Be sure the conditions of signal input, line voltage, etc. are as specified. Check resistors and other components in the circuit with a V-O-M.

When signal tracing the video amplifiers be sure to take note of any controls in the circuit which will affect the gain of the amplifiers.
HOW TO USE THE SCOPE—
SOUND CIRCUITS

One of the best ways to check the sound circuits is by signal tracing using a portable scope (RCA WO-33A). First check the sound IF, sound demodulator, and audio output tubes as the most probable cause of trouble. Connect a WR-50B RF generator to the input of the 1st sound IF. Set the generator for 4.5 Mc/s output with 400 c/s modulation. Then check for an audio waveform at the audio output transformer, volume control, sound demodulator output, and 1st I-F output. After localizing the trouble with the scope, use the WV-38A V-O-M to measure voltages or check components. All of this trouble shooting can be done without pulling the chassis!

HOW TO USE THE SCOPE—SYNC CIRCUITS

Synchroizing pulses appear in the composite video signal and can be observed with an oscilloscope connected to the output of the 1st video amplifier. The oscilloscope indicates the peak-to-peak voltage of the signal. Refer to the manufacturer’s service data for correct peak-to-peak voltage or typical waveform amplitude. If the sync pulse does not have sufficient amplitude at this point (see waveform at left), the trouble may be in the 1st video amplifier or preceding. If the waveform shows good sync amplitude, and the picture does not sync, check the sync separator. The waveform at the plate of the sync separator should be relatively free from video. From that point the sync pulses are applied to the vertical and horizontal oscillators. Set the scope to a low sweep rate (30 or 60 c/s) for checking vertical sync and a high rate (7.5 kc or 15 kc/s) for horizontal.
HOW TO USE THE SCOPE—AGC and HORIZONTAL CIRCUITS

The oscilloscope is very useful for servicing the AGC and horizontal deflection circuits. Pulse type waveforms (AGC and high voltage) and complex waveforms (horizontal oscillator) can best be measured with a scope. The horizontal sine wave adjustment, for example, is almost impossible to make without seeing the waveform. When checking this waveform, always use the low-capacitance probe on the scope because the horizontal oscillator is a high-impedance circuit.

A quick way to check the horizontal output circuit is to clip the scope lead lightly to the insulation of the lead to the plate cap of the horizontal output tube. Set the scope sweep selector to the horizontal rate. If the horizontal oscillator and output circuits are functioning, a large pulse will be seen on the scope. The horizontal pulse is also used in the chroma section and can be checked in the same manner as the horizontal oscillator and output.

HOW TO USE THE COLOR BAR GENERATOR—SET-UP

The WR-64B Color Bar/Dot/Crosshatch Generator combines in a single unit the test facilities needed for adjusting the color-phasing, matrixing, linearity, and convergence circuits. It is the one most important test instrument needed for checking for proper operation of color TV receivers. Using the CROSSHATCH function of the generator the fixed numbers of vertical and horizontal lines in the pattern quickly show linearity of both black-and-white and color TV receivers. The vertical and horizontal scan (size) can also be checked.

The DOT function produces a stable dot pattern for convergence adjustments. The CROSSHATCH function may also be used for convergence adjustments.

When a new color TV receiver is installed, the picture should be observed for good black-and-white reproduction over the entire screen area. No objectionable color shading or fringing should be seen. If set-up adjustments are required, proceed with purity and other preliminary adjustments as outlined in the manufacturer's service data. Then, remove the outside antenna leads, connect the leads of the color bar generator to the antenna terminals of the receiver, connect the ground lead to the chassis, and you're ready for the convergence adjustments.
HOME SERVICE - GENERAL

HOW TO USE THE COLOR BAR GENERATOR — CHROMA CIRCUITS

One of the main functions of the WR-64B generator is the color bar display. Even if a color program is available the color bar pattern is indispensable for checking and adjusting color TV receivers. For example, the "hue" or "tint" control range is checked by noting the color of the eighth color bar from the left. Accurate adjustment of the control produces cyan (blue and green); a slight adjustment of the "tint" control on the receiver produces green or blue on the eighth bar.

The WR-64B also checks color sync lock. If the color bars fall out of sync, with a slight decrease in the chroma control on the WR-64B, the color sync section of the receiver may require service.

Another important feature of the WR-64B is its use in aligning the chroma section of the receiver. Using the color bar pattern, the frequency of the 3.58 Mc oscillator and the phase of the color demodulator may be adjusted.

SHOP SERVICE - GENERAL

TYPICAL SHOP ARRANGEMENTS

Ideally, a separate section of the shop should be reserved for servicing color TV receivers. A test fixture such as the RCA Color Test Jig (11A1015) eliminates the need for removing the picture tube from the cabinet and of reconverging when the chassis is returned.

It is recommended that the following test equipment be installed in this area for color TV alignment and shop service:

- Wide Band Oscilloscope (WO-91B)
- Color Bar/Dot/Crosshatch Generator (WR-64B)
- VHF Sweep Generator (WR-69A)
- Crystal Calibrated Marker Generator (WR-99A)
- Vacuum Tube Voltmeter (VoltOhmyst®)
- Volt-Ohm-Milliammeter (WV-38A)

Alignment Accessories:
- Video Marker Box (WG-295C) — Used with Sweep Generator (WR-69A)
- Bias Supply (WG-307B) — A variable source of DC voltage

As an alternate the units (sweep, scope, marker generator, etc.) may be installed on a dolly.
SHOP SERVICE - GENERAL

HOW TO PERFORM AFPC (Automatic Frequency and Phase Control) ALIGNMENT

Aligning the chroma section of a color receiver is easier to do than sweep alignment of a black-and-white set. There are three parts to chroma circuit alignment:

1. **Bandpass (color I-F) alignment.** This is a video amplifier stage requiring sweep alignment. Requires sweep and signal generators and RF modulator.

2. **Frequency adjustment.** The 3.58 Mc/s oscillator must be adjusted accurately. The color bar generator is required for this adjustment.

3. **Phase adjustment.** The color bar generator and oscilloscope are used to adjust the phase of the color demodulator. If this adjustment is incorrect the tint (hue) control will have poor range.

When the proper equipment is used and the service data procedure is followed, the AFPC alignment becomes routine.

OVERALL ALIGNMENT

Alignment equipment requirements:

**Oscilloscope.** For alignment work, high gain and narrow bandwidth is required. The RCA WO-91B oscilloscope has a selector for narrow-band operation (1.5 Mc/s) and also wide-band (4.5 Mc/s). The wide-band position is useful for troubleshooting the chroma section of the receiver.

**Sweep Generator.** The primary requirement of a sweep generator is that its output voltage remain constant at all frequencies in the sweep range. For color TV alignment the sweep generator should have a continuously variable sweep width of 0 to 12 Mc/s. (RCA WR-69A.)

**Marker Generator.** A crystal-controlled generator is required for accurate frequencies in the I-F and VHF ranges. The RCA WR-99A has 1 Mc/s and 10 Mc/s crystal check points and can be used as a heterodyne frequency meter.

**Vacuum Tube Voltmeter.** Similar to RCA WV-98C VoltOhmyst® or equivalent.

**Accessories.** Video Marker RCA WG-295B or equivalent. Bias supply (RCA WG-307B). A complete analysis of alignment can be found in the RCA Color Television Pict-O-Guide. For experienced technicians, the manufacturer's service data gives the alignment procedure for specific color TV receivers.
LOCALIZING THE TROUBLE

The symptoms displayed by the color receiver must be analyzed to determine the section, then the stage and finally the particular component at fault. In color receivers, three categories of troubles are usually considered: set-up, black-and-white or color troubles. By tuning in a black-and-white picture, a quick check should show whether black-and-white reception is normal and whether improper set-up is causing poor purity, improper convergence or improper black-to-white tracking. Abnormal operation in these areas will give a poor color picture, although the difficulty is not in the color circuits. Make sure that black-and-white operation is completely normal before attributing the trouble to the color circuits. Generally speaking, symptoms which are present on both black-and-white and color reception can be attributed to R-F, I-F, video, sync or picture tube functions. Symptoms evident on color reception only are usually attributable to difficulty in the color circuits.

CHECKING BLACK-AND-WHITE PERFORMANCE

Since the most of the circuits in a color TV receiver affect black-and-white reception, it can be assumed that the majority of troubles will be the same type of troubles experienced with black-and-white TV receivers. Therefore the servicing procedure will be the same. Check the operation and decide which major section is at fault — R-F, I-F, video, sound, AGC, deflection or high voltage. Check the tubes in the suspected section by substitution. If tube substitution does not correct the trouble, use the oscilloscope to isolate the stage. Then, use the V-O-M to measure tube voltages and resistances and to check components in the isolated area.
COLOR TV

SERVICE PROCEDURE - HOME

CHROMA PROCEDURE

Problems in the chrominance (chroma) section generally show up as one of the following defects:

1. No color or weak color. Check bandpass amplifier, color killer, and 3.58 Mc/s oscillator. Use color bar generator and oscilloscope.

2. Incorrect color. Check color bar display. If 8th bar cannot be made cyan with "tint" control in center of range, check phase circuits of 3.58 Mc/s oscillator. Also check color demodulators. Refer to color bar waveforms in the manufacturer's service data.

3. Diagonal color bars (no color sync). Check AFPC alignment. The color bar generator is used not only for frequency and phase adjustments but can be used to indicate how well the receiver holds color sync.

DEFLECTION AND HIGH VOLTAGE MEASUREMENTS

The deflection circuits of a color TV receiver are very similar to deflection circuits of a black-and-white receiver. Service procedures, therefore, will be the same as for black-and-white. High voltage, in some color sets however, is not only higher (25 KV) but is also regulated. When servicing the horizontal and high voltage circuits, the high voltage and the cathode current of the horizontal output tube should be measured. To check HV, use a V-O-M (WV-38A) and a high voltage probe (WG-297). When current measurements are made in the cathode circuit, adjust the meter for a range of 0-500 ma, and insert the meter in series with the cathode lead. Some service procedures require a measurement of the current in the shunt regulator tube. This may be done by connecting a low range voltmeter across the 1000-ohm resistor in the cathode circuit. The voltage measured will then equal the current in milliamperes.
SERVICE PROCEDURES - SHOP

SET-UP AND ANALYSIS

Ideal shop set-up for servicing color TV receivers includes a test picture tube with deflection yoke, convergence assembly, and extension leads for the picture tube socket, yoke, and high voltage lead. Since deflection yoke connections may differ from one model to another, yoke adapters will be required to accommodate a wide range of chassis. An adapter for RCA chassis is described in the RCA Color TV Pict-O-Guide. The technician should realize the limitations of a test jig when dealing with problems concerning deflection size, linearity, or yoke ringing. In extreme cases it may be necessary to use the customer's yoke and convergence assembly to find troubles of this nature.

RF, IF, AND SOUND ALIGNMENT

Modern television receivers today, including color TV sets, do not generally require alignment of R-F and IF circuits during their life span. Experienced technicians have learned not to disturb alignment adjustments unless necessary and then only with the proper test equipment. However, when coils, transformers or other components in the RF or IF stages are replaced, alignment may be necessary. Before alignment is attempted, check for missing tube shields, improper lead dress and other conditions that might affect alignment. Check for weak tubes and improper bias. Experienced technicians will find that alignment of the RF and IF section of color TV sets is very similar to black-and-white TV. The chroma bandpass alignment is different (see next page). Although some alignment procedures are involved, it is not difficult when the proper equipment is used and you have an understanding of what you are doing—and why.
COLOR CIRCUIT ALIGNMENT (CHROMA BANDPASS)

The bandpass amplifier is a special video amplifier for the chroma frequencies centered on 3.58 Mc/s. Since the chroma frequencies are not amplified equally in the picture IF amplifier, the response curve of the bandpass amplifier must complement the IF response to produce equal response of the chroma signals.

The method used to sweep the combined I-F and bandpass circuits is called Video Sweep Modulation (VSM). The output of a marker generator and a sweep generator are combined in an R-F modulator (RCA WG-304-A) to produce a video-modulated (0-5 Mc/s) picture carrier (45.75 Mc/s). The IF and bandpass circuits shape the signal to give equal amplification to the chroma frequencies centered on 3.58 Mc/s. A scope with a demodulator probe (RCA WG-350-A) is used to view the response at the bandpass amplifier.

USING COLOR BAR WAVEFORMS

The bar pattern at the left describes the colors seen on a color TV set with a normal color bar display, using the RCA WR-64B Color Bar/Dot/Crosshatch generator as the color signal source, and an RCA WO-91B oscilloscope to observe the waveform. The waveform shown at the left is a typical waveform of the color bar signal observed at the signal input point to the red gun of the picture tube. It shows the greatest amplitude occurring at the third peak from the left. This causes the red gun to produce maximum output at that point in the horizontal sweep, and produces maximum red on the third bar (from the left) of the color bar display.

A similar relationship exists between the color bar display on the picture tube and the color bar waveforms observed at the blue gun and the green gun. That is, the maximum peak observed will produce maximum color for the gun being checked.

Analysis of the color bar patterns and waveforms is extremely helpful in diagnosing troubles in the chrominance section of the color TV receiver.
A "NO COLOR" SERVICE CALL

PRELIMINARY CHECKS

Before servicing the receiver a few preliminary checks should be made. Many adjustments and controls can cause "no color".

Fine Tuning Control. Incorrect setting of the fine tuning can cause no color, weak color, smear and a sound beat in the picture. To set the fine tuning correctly, turn the control in the direction that causes a sound beat in the picture. Now, reverse direction slightly to remove the sound beat. This is the correct position.

Color (chroma) Control. Turn control fully clockwise when servicing.

Color Killer Control. This control prevents color by blocking the bandpass (chroma) amplifier. Turn the control to see if color is produced.

As a further check and preparation for signal tracing, connect a color bar generator to the antenna terminals. If color bars are seen the antenna system must be at fault. If color bars are not seen, trace the signal with a wideband oscilloscope.

HOW TO CHECK THE BANDPASS AMPLIFIER

Before attempting to service the bandpass amplifier, checks should be made to isolate the trouble to the chroma section of the receiver. Connect the color bar generator to the antenna terminals and using a wideband oscilloscope look at the output from picture detector. If color bar waveforms are seen here, check the grid (input) and the plate (output) of the bandpass amplifier. If bar waveforms are seen at the grid but not the plate, the amplifier is inoperative. Having previously determined that the color killer is not the cause, check the voltages and components in the bandpass amplifier. If color bar waveforms are seen at the plate as well as the grid, check the grids of the demodulators. Color bar waveforms may be seen here, too, without producing color because of another condition, an inoperative 3.58 Mc/s oscillator. "No color" troubles, therefore, are localized to the bandpass amplifier (including the color killer) and the 3.58 Mc/s oscillator.
A "NO COLOR" SERVICE CALL

HOW TO CHECK THE COLOR KILLER

The function of the color killer is to "kill" the color circuits during black-and-white programs. The plate circuit of the color killer develops a negative voltage with the help of a horizontal sweep pulse, a charging capacitor, filter, and discharging resistor. The negative voltage prevents conduction of (cuts off) the bandpass amplifier and effectively blocks color signals to the color circuits.

To receive color, the color circuits must be unblocked. This is done by the color burst signal transmitted during all color programs. The burst signal generates a negative voltage in a killer detector circuit. This voltage stops conduction in the color killer; the negative voltage on the bandpass amplifier is removed; and the color circuits are activated.

To service these circuits, measure the blocking bias voltages with a V-O-M and check the horizontal pulse with a portable scope (RCA WO-33A).

HOW TO CHECK THE 3.58 Mc/s OSCILLATOR

The color demodulators in a color set require a 3.58 Mc/s crystal-controlled signal to remove the color information. Without the 3.58 Mc/s signal most color receivers will not produce color of any kind—even if color signals are present at the color demodulators. Checking the 3.58 Mc/s oscillator is no different from checking any other oscillator. Simply measure the grid voltage. This can usually be done without removing the chassis.

Another method of checking the 3.58 Mc/s oscillator is to use a portable oscilloscope (RCA WO-33A). The wideband position of the selector on the scope is used for this measurement and can provide full scale deflection from the output of the 3.58 Mc/s oscillator. A check of the reactance control circuit (which is used to keep the 3.58 Mc/s oscillator on frequency) can best be made by using a color bar generator. Usually, troubles in this circuit can be resolved when an AFPC alignment is made. Refer to the AFPC alignment procedure.
A "WRONG COLOR" SERVICE CALL

HOW TO LOCALIZE TROUBLE TO CHROMA OR PICTURE TUBE

A "wrong color" complaint may be described as colors that cannot be corrected by the tint (hue) control. This trouble can be caused by either the chroma circuits or the picture tube. To determine which section is at fault, connect a color bar generator to verify complaint of incorrect color. Turn off color, using chroma control. If a normal black-and-white picture is seen, the faulty colors on the color display are the result of trouble in the chroma circuits in the receiver. If the entire screen area is shaded with a particular color, check the circuits of the picture tube guns that could produce such a color. For example, a defective blue gun (or circuitry) produces a yellow (red and green) color. Also, remember, yellow at a low brightness level produces brown!

Troubles associated with the picture tube can best be analyzed by reviewing the set-up adjustments — purity, color temperature, and gray-scale tracking.

HOW TO USE COLOR BAR GENERATOR TO CHECK PHASE ERRORS

When a diagnosis has been made that the chroma section is causing "wrong colors", the phase of the color bars should be checked. To do this, connect the color bar generator to the antenna terminals of the receiver. Adjust the fine tuning to produce sound in the color bars, then reverse direction of the fine tuning until the sound beat pattern just disappears. The tint (hue) control changes the phase of the 3.58 Mc/s oscillator which changes the colors of the bars. If the tint control cannot make cyan at the 8th bar (from the left) of a normal color bar display, a phase adjustment is required. This adjustment is easily made by setting the tint control to the center of its range and adjusting the burst phase transformer for a cyan color on the 8th bar. This transformer may not be identified on the service data but is generally located between the phase detector (a dual diode) and the burst amplifier.

If a phase transformer adjustment does not produce a normal color bar pattern, the color demodulators and adders (matrix) sections should be checked.
A "WRONG COLOR" SERVICE CALL

HOW TO USE COLOR BAR GENERATOR TO CHECK AFPC

The automatic frequency and phase control (AFPC) section of the receiver produces the 3.58 Mc/s signal and automatically controls its phase for color demodulation. Usually, small changes in frequency of the 3.58 Mc/s oscillator can be corrected with the tint control. However, if a large frequency change occurs, diagonal color bars will be seen and the tint control merely changes the number of bars. This condition is called loss of color sync. The WR-64B color bar generator can be used to adjust the 3.58 Mc/s oscillator very accurately. When the frequency is properly adjusted, the bars will be straight and locked in place. If the bars drift to the right or left, check the reactance tube and associated components.

A check of the sensitivity of the AFPC system can be made by reducing the strength of the color bar test signal by using the chroma control of the Color Bar Generator. When the chroma control is turned down to the point where color is fading out, the bars should remain locked in sync.

HOW TO USE COLOR BAR GENERATOR TO CHECK DEMODULATORS AND ADDERS

The color demodulators and adders (and the picture tube) usually produce a "missing" color that cannot be corrected with the tint control. Diagnosis of this trouble using a color program is difficult; a color bar generator makes it easy. Signal tracing, using a signal generator and an oscilloscope is the best way to find troubles in the chroma section. Although all receivers do not have the same system of color demodulation, the service data usually shows the oscilloscope pattern seen at the two demodulators. Be sure to adjust the tint (hue) control to obtain the correct pattern. The correct patterns should also be given in the service data for the R-Y, B-Y, and G-Y signals in the adder (matrix) section. A fault in this section resulting in a "wrong color" or missing color can be easily isolated by circuit tracing using the characteristic color bar pattern found in this section.
A "POOR COLOR" SERVICE CALL

ISOLATING TROUBLE

A "poor color" complaint may mean the colors are correct in all respects except that they are weak—even with the color control at maximum. Any circuit of the receiver that processes the picture signal can be a possible cause of weak color. To quickly pinpoint or eliminate the antenna as a source of trouble connect a color bar generator to the antenna terminals. If the antenna is not the cause of the trouble, connect an oscilloscope to the video detector and look at the amplitude of the color bar waveform as compared to the amplitude of the sync pulse. If the color bar amplitude is less than one-half the sync amplitude, the color subcarrier is being attenuated in the picture IF or the tuner.

A weak amplifier in the video or bandpass stages can also produce "poor color". After making these checks with the color bar generator and oscilloscope, the trouble should be isolated. A voltage check should be made in the suspected area.

HOW TO CHECK CHROMA CIRCUITS AS A CAUSE OF POOR COLOR

Connect a color bar generator and isolate the trouble as described in the section above. Partial loss of color in the chroma section can usually be localized to the bandpass amplifier because other circuits of the chroma section usually cause "wrong color" or loss of color sync.

The first check of the bandpass amplifier should be a voltage measurement of the grid bias. The color killer may be creating an excessive bias voltage on the bandpass amplifier, causing weak amplification of the color signals. During color reception the killer should be cut off. Check the killer threshold adjustment and the killer detector. If a negative voltage is not produced by the killer detector during color reception, check the burst amplifier and burst amplifier adjustment.
A "POOR COLOR" SERVICE CALL

HOW TO CHECK VIDEO AS A CAUSE FOR POOR COLOR

After isolating the trouble to the video circuits using a color bar generator and oscilloscope, the individual stages may be checked with the oscilloscope if tube replacement does not correct the trouble. To do this, compare the grid waveform with the plate waveform. If the gain of an amplifier appears low, check the voltages at the tube connections and compare with the voltages in the service data. Be sure to take note of any controls in the circuit that could affect the gain of the amplifiers.

HOW TO CHECK R-F AND I-F SECTIONS FOR POOR COLOR

A condition of "poor color" can be localized to the R-F and I-F sections of the receiver by using a color bar generator and an oscilloscope. If the color bar pattern on the oscilloscope shows the amplitude of the color bars to be less than 50 percent of the sync amplitude, the R-F and I-F sections should be suspected. Look for weak tubes in the tuner or I-F amplifiers or a defective circuit component that might result in low gain. Poor alignment of the R-F and I-F amplifiers can also be a cause of "poor color" since the color sub-carrier may be too low on the response curve. However, alignment should not be attempted until the tubes have been checked and you are certain the only trouble is alignment.
HOW TO CHECK A COLOR PICTURE TUBE

LIMITED CHECKS

Troubles in color picture tubes may not produce the same symptoms as troubles in black-and-white picture tubes because color picture tubes have three independent electron guns. By shorting out two guns and observing the third gun we can analyze the performance of the tube. The symptoms usually observed when the color picture tube is defective are as follows:

**Symptom**

**Probable Cause**

- Silvery metallic sheen in highlights — poor definition in picture
  - Low emission in gun being checked
- Screen control has no effect
  - Short or leakage in gun being checked

Before assuming the picture tube is at fault, the picture tube circuits should be checked using a VTVM such as RCA Type WV-77E or WV-98C “Volt-Ohmyst®”, because all the effects caused by a faulty picture tube may also be caused by the associated circuits.

When checking the picture tube, shorts between gun elements can be detected with the VTVM. Grid-cathode leakage can be detected by measuring the bias with the picture tube socket connected, then disconnected. An increase in meter reading when the socket is removed will indicate leakage. These checks will indicate difficulty but are limited and not necessarily conclusive. The best method to check the color picture tube is with a good color picture tube tester such as RCA’s WT-115A.

QUICK SURE CHECK

The ideal method for checking a color picture tube is with a picture tube tester such as the RCA’s WT-115A. When there is any suspicion that the picture tube is the source of a service difficulty, the tester will give a fast, accurate and sure check. The WT-115A checks color picture tubes for emission, shorts and interelectrode leakage. It may be used with the picture tube, either in or out of the cabinet merely by connection of the tester socket to the base of the picture tube. The procedure consists of five simple steps which take less than ten minutes to perform, as follows:

1. Plug in tester to power line and connect to tube socket.
2. Make line voltage adjustment.
3. Perform test for LEAKAGE.
4. Perform a 2 MINUTE QUALITY TEST.
5. Perform a 4 MINUTE QUALITY TEST.

You have now made a fast and accurate test of the picture tube.
WA-44C
Designed for use in testing electronic equipment and other applications requiring sine-wave or square-wave signals in the range from 20 cps to 200,000 cps. Weighs only 10 1/2 lbs. • Switch selection of sine-wave or square-wave output • Simple one-scale dial • Separate 60 cps output for intermodulation distortion measurements • Wide frequency range, 20 cps to 200,000 cps • Less than 1/4 of 1% distortion over the audio-frequency range.

WG-295C
Provides seven simultaneous absorption-type markers at accurately preset frequencies for marking video response curves in color receivers. Markers 0.5 Mc, 1.5 Mc, 2.5 Mc, 3 Mc, 3.5 Mc, 4.1 Mc, and 4.5 Mc. Each marker is identified simply by touching a corresponding contact on the WG-295C case. This reduces the amplitude of that particular marker. Connects between the IF/VF output on the sweep generator and the video output cable.

WG-307B (K)
The RCA WG-307B(K) TV bias supply kit provides three output voltages, and is designed for use in servicing and aligning color and black-and-white TV receivers. Three separate output voltages, adjustable from 0 to -15 volts minimum are provided for application in rf, if, and ac bias circuits. The WG-307B(K) utilizes a power transformer and operates from 105-125 volts, 60 cps.

WG-360A
Used for a dynamic check of phasing in any audio system from input to the output of the speakers. Features: sound powered; requires no external voltage source, any VOM, VTVM, or oscilloscope may be used as the indicator.

WO-33A (Kit or Wired)
Available as kit or wired instrument. Weighs only 14 lbs. Its compact size plus high gain and wide band width offers wide versatility in classroom or laboratory use. Voltage-calibrated, frequency compensated, 3-to-1 step attenuator • Sealed graph screen and calibrating voltage source allow direct reading of peak-to-peak voltages • "Plus-minus" internal sync • Includes shielded input cable with direct/low capacitance probe.
**RCA ELECTRONIC INSTRUMENTS**
**TEST AND MEASURING EQUIPMENT**

**RCA 5-INCH OSCILLOSCOPE**  
**WO-91B**

High-performance, wide-band oscilloscope for color TV, black-and-white TV, and other electronic applications. Used to measure color burst signals and for trouble-shooting wideband color circuits. Multi-scale graph screen makes peak-to-peak voltage measurements as simple as with a VTVM. Provision for connecting signals directly to the vertical deflection plates of the CRT.

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**RCA RF SIGNAL GENERATOR**  
**WR-50B**

**WR-50B (Kit or Wired)**

Designed for maintenance, troubleshooting and instructional purposes, this versatile RF Signal Generator provides an accurate source of CW or amplitude-modulated signals in the fundamental range of 85 Kc to 40 MC. It is particularly well suited for aligning and signal tracing AM, FM, Hi-Fi and Citizens' Band receivers. New features include sweep output at 455 Kc and 10.7 MC with return trace blanking.

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**RCA STEREO FM SIGNAL SIMULATOR**  
**WR-52A**

A compact, lightweight instrument designed to generate the signals necessary for service, alignment and maintenance of Mono and Stereo FM receivers and multiplex adaptors. In addition to its value as a service instrument, the three low-distortion sine-wave frequencies, the crystal controlled 19 Kc and 38 Kc frequencies, and the adjustable 100 Mc carrier make the WR-52A an extremely useful test instrument for FM broadcasters and manufacturers of stereo FM equipment.

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**RCA COLOR BAR/DOT/ CROSS HATCH GENERATOR**  
**WR-64B**

For checking overall operation of Color TV receivers. A "must" for adjusting and trouble-shooting color phasing and matrixing circuits. Generates signals for producing ten bars of different colors simultaneously. Also provides extremely stable fine-line crosshatch and dot patterns free from "jitter" and "crawl."

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**RCA TELEVISION/ FM SWEEP GENERATOR**  
**WR-69A**

For visual alignment and troubleshooting of TV RF/IF/VF circuits and other electronic equipment. IF/video frequency ranges 50 kc to 50 Mc, TV channels 2 to 13, plus FM range 88 to 108 Mc. Sweep width continuously adjustable to 12 Mc.

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**FOR SERVICING • PRODUCTION • RESEARCH • TRAINING**
## WR-70A
For rf, if and video sweep alignment of both color and black-and-white TV receivers. Eliminates or reduces distortion of sweep curve by the marker. Permits trap alignment without marker “sinkout”. Hi-Q markers—high in amplitude, narrow in width. Four marker choices: positive peak, negative peak, positive and negative peaks (wide band), positive and negative peaks (narrow band). Voltage stabilized for rock-steady trace display.

## WR-99A
Supplies a fundamental frequency rf carrier of crystal accuracy for aligning and trouble-shooting color TV, black-and-white TV, FM receivers and other electronic equipment operating in the 19 Mc to 260 Mc range.

## WT-115A
Designed specifically for the testing of color picture tubes. Offers a quick, reliable means of checking each gun for emission quality (including warm-up performance), inter-electrode leakage, and shunted elements. Tests color picture tube in-set or out-of-set. Built-in cable and socket assembly.

## WV-38A (Kit or Wired)
The V-O-M with extra value, 0.25 volt and 1.0 volt dc ranges. Response is flat to 800,000 cps on 2.5 and 10 volt ranges. Easy to read 5½” meter. Color coded panel markings. Meter movement protected against burnout. Non-breakable sealed plastic case. Jacks located below switches to keep leads out of way. Spring clips on handle to hold leads.

## WV-76A
A high sensitivity AC VTVM for Hi-Fi and other audio applications. Designed for measuring ac voltages from 0.0001 volt to 500 volts over the frequency range of 10 to 1,500,000 cycles. Offers nine overlapping ac voltage ranges from 10 millivolts to 100 volts full scale. Comes with Direct/Low Capacitance Probe and Cable.
RCA ELECTRONIC INSTRUMENTS
TEST AND MEASURING EQUIPMENT

RCA
VOLTOHMYST®
WV-77E

WV-77E (Kit or Wired)
Available as a kit or wired instrument. Measures ac and dc voltage to 1500 volts; resistance from 0.2 ohm to 1000 megohms
- Features 1.5 volts rms and 4 volts peak-to-peak ranges for low ac voltage measurements
- ±3% accuracy on dc; ±5% accuracy on ac
- Meter electronically protected against burnout
- Aluminum panel with permanent etched lettering.

RCA
ULTRA-SENSITIVE DC MICROAMMETER
WV-84C

WV-84C
This ultra-sensitive, battery-operated vacuum tube microammeter is designed for measuring minute direct currents. When used as a voltmeter it is especially suited to measurements in circuits where loading is a critical factor. Can also be used as an Ohmmeter to measure extremely high resistances such as leakage and insulation resistance. Six dc ranges permit current measurements from 0.0002 to 1000 microamperes. Measures resistance in the order of billions of ohms.

RCA
SENIOR VOLTOHMYST®
WV-98C

WV-98C (Kit or Wired)
Permits direct reading of peak-to-peak voltages of complex wave forms found in video sync, and deflection circuits of black-and-white and color TV receivers; rms values of sine-waves; dc voltages; and resistance
- ±0.5-volt dc range for checking transistor circuits
- Provides accuracy of ±3% full scale on BOTH ac and dc measurements with less than 1% tracking error
- Separate color-coded peak-to-peak and rms voltage scales
- Meter electronically protected against burnout.

RCA
POWER LINE MONITOR
WV-120A

WV-120A
For constant indication of power line voltage. Features an expanded scale readable from 10 feet or more. The expanded scale 100 to 140 volts indicates true rms. Connects directly to power line outlet. Wide frequency range of 25 to 400 cps.

RCA
COLOR TEST JIG
11A1015

11A1015
For any serviceman now servicing or planning to service Color TV receivers, the RCA Color Test Jig makes a one man service call to costly two man cabinet pulling jobs. Eliminates necessity of removing picture tube from cabinet and of reconverging tube when chassis is returned. Convergence control panel provides dynamic as well as static convergence.

FOR SERVICING • PRODUCTION • RESEARCH • TRAINING
WG-289

The WG-289 extends the dc-voltage range of the WV-77A, WV-77B, WV-77C, WV-87A, WV-87B, WV-97A, WV-98A, WV-98B and WV-98C VoltOhmysts® to 50,000 volts. It is provided with a microphone type connector. A choice of three multiplier resistors is available enabling the probe to be used with many volt-ohm meters.

WG-297

The WG-297 extends the range of the WV-77E VoltOhmyst® and the WV-38A Volt-Ohm-Milliammeter to 50,000 volts dc. It is provided with banana plugs for use with appropriate VoltOhmysts® and VTVM’s and VOM’s. Three multiplier resistors are available which provide for the probe to be used with many volt-ohm meters.

WG-299D

The WG-299D is a single-unit probe for use with VoltOhmysts® except WV-77E, Switch provides instant selection of de or ac/ohms operation. The WG-299D replaces the WG-299A, WG-299B and WG-299C.

WG-300B

Designed for use with the RCA Scopes. Cable is 48” long, completely shielded from microphone connector to probe tip to minimize hum and stray field pick-up. Built-in switch provides instant selection of direct or low-capacitance operation. Input characteristics: 10 megohms resistance, less than 12.5 µfd capacitance in low capacitance position. Includes ground lead and clip.

WG-301A

“Slip-on” type for use with the WG-229A, B or C DC/AC Ohms Probe and Cable extending the frequency range of VoltOhmyst® to 250 Mc.
RF/IF/VF PROBE SIGNAL TRACING 

WG-302A

“Slip-on” type high-frequency probe designed for use with the WG-300A and B probe and cable to permit visual signal tracing for rapid isolation of trouble in radio receivers and in television IF and video stages.

DIRECT/LOW-CAPACITANCE PROBE 

WG-349A

A 48 inch, small diameter, extremely flexible shielded cable designed for use with the WO-33A Oscilloscope. The probe consists of three short leads with alligator clips for ground, direct, and low-capacitance connections. For convenient use, the WG-349A eliminates the need for switching, increases input impedance to 10 megohms, 12 μF capacitance.

DEMODULATOR PROBE 

WG-350A

For use with the WO-33A Super-Portable Oscilloscope for demodulation and signal tracing of radio/TV rf and if signals.

CRYSTAL DIODE PROBE 

WG-351A

For extending the rf measuring capability of the WV-77C, WV-77E VoltOhmyst® and WV-77E(K) Volt-Ohmyst® Kit, to over 100 Mc.

CAPACITANCE-TYPE VOLTAGE-DIVIDER PROBE 

WG-354A

The RCA WG-354A Capacitance-Type Voltage Divider Probe is a slip-on accessory for use with the WG-300B Direct/Low Capacitance Oscilloscope Probe. The WG-354A used with the WG-300B Probe and Cable extends the range of oscilloscopes such as the RCA WO-33A and WO-91B so that signal pulse amplitudes up to 5000 volts can be observed.
RCA RECEIVING TUBE MANUAL (RC-24)
This publication describes over 1200 receiving tubes. A tabular section of 50 pages contains data for over 500 discontinued and renewal tubes. Also included is data on picture tubes for black-and-white and color TV, tube theory, application data, selection charts and typical circuits.

RCA RADIO & TELEVISION SERVICE NEWS
This publication is designed to keep the dealer and service technician informed on the latest television and radio sales and servicing techniques. Read it regularly for interesting articles as well as for helpful hints on new merchandising procedures, new products, and new promotions. Published quarterly.

RCA TRANSISTOR MANUAL (SC-12)
This publication contains definitive data on over 600 semiconductor devices including tunnel diodes, silicon controlled rectifiers, varactor diodes, conventional rectifiers, and many classes of transistors. Features easy-to-understand text and over 40 practical circuits, complete with parts lists, highlighting semiconductor-device applications.

RCA EXPERIMENTER'S MANUAL (KM-70)
This publication contains complete construction and operating information on 14 circuits for dozens of control applications that can be built using RCA basic EXPERIMENTER'S KIT (KD2105). Kit contains one silicon controlled rectifier, two transistors and five rectifiers.

RCA "TOP-OF-THE-LINE" SEMICONDUCTOR REPLACEMENT GUIDE (SPG-202A)
This publication places at your fingertips the information on more than 3,900 transistor types, including many of foreign manufacture, which the RCA "Top-of-the-Line" types replace.
RCA COLOR TV TROUBLESHOOTING PICT-O-GUIDE (1A1389)

The latest available information is presented to simplify and speed up the installation, adjustment, and servicing of color TV receivers. Step-by-step instructions are given, supplemented by hundreds of charts, tables, circuit diagrams, and general illustrations—many of which are shown in true-to-life color.

RCA COLOR TV SERVICE HANDBOOK (1A1553)

Specific service information for routine service adjustments and preliminary troubleshooting on many makes of color TV sets is given. Most of the data usually needed on a house call is provided; however, when more-detailed information is required, the manufacturer's service notes should be consulted.

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