Color TV Repair

MARTIN CLIFFORD

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To SARAH

contents

introduction

Every now and then the service technician is called on to make some kind of transition or adjustment in his thinking, his working methods and in his knowledge of electronics. Fortunately, this doesn't happen too often, but when it does, there seems to be some kind of shake-up and those technicians who cannot or will not change disappear from the servicing scene and drift into other kinds of work.

When have such events taken place? They happened when manufacturers abandoned the old trf in favor of superhets; when manufacturers moved from transformer-type receivers to ac-dc sets and when they jumped from tubes to transistors. They happened when manufacturers turned their attention to television receivers.

These were just a few of the really major changes. We've had others, perhaps not as momentous, but still enough to cause many TV service technicians to stop and take stock — both of themselves and their equipment. We're referring here to the boom in audio and hi-fi; the rapid growth of CB; the developing market in communications receivers; and finally a sort of catch-all development of electronics gadgets — electronic garage door openers; transistorized ignition systems; electronic baby minders, electronic burglar alarms, and many others in this classification.

But what has all this to do with color TV? The answer here is that this is another one of those transition periods and while color TV may have been slow in getting off the ground, there is no possible doubt about its growth potential. What does this mean to you as a service technician? It means that once again you must get busy. If you are not familiar with the theory of color TV, then it's advisable to learn it. We must assume that you know black-and-white theory and that you've had your share of

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black-and-white TV repair. If you have this kind of background, then servicing color TV isn't as tough a challenge as you might imagine it to be. Savvy service technicians look on it as a chance to bring extra business into the shop — and that it is!

And that — in a sort of roundabout way — brings us to the purpose of this book. This is a servicing book — a book that tells you what sort of trouble symptoms you can expect in a color TV set and how to get those symptoms to help you fix the set. There isn't a single book on repair that has ever been published that will help you cure every possible trouble in every receiver ever manufactured. All of us have had experience with dogs that were hard to fix and which sometimes wouldn't stay fixed. But this book will take you out of the tube-puller class (if that's been your level) and it will more than pay for itself if it helps you fix just one color TV receiver. This is a pretty low-level kind of ambition, since it certainly should do more than just that.

This book represents the combined experience of some of the top men in the field of color TV repair: — David R. Anderson, Ed Bukstein, Arthur Cunningham, Jack Darr, Homer L. Davidson, Wayne Lemons, Art Margolis, Bob Middleton and Warren Roy. Their articles, which appeared in RADIO-ELECTRONICS Magazine, were carefully selected and combined to form this book.

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chapter 1
color circuits

HERE'S A CONTROVERSIAL STATEMENT: COLOR TV IS NO HARDER to service than black-and-white! You do *not* need a Master's degree in electronic engineering and thousands of dollars worth of test equipment. You can even service color at the same service charges as black-and-white—and make money!

Are color troubles complicated?

Pause and consider this indisputable fact—each circuit in a color set uses tubes, resistors, capacitors and transformers. How many other kinds of parts are there? If you can find a leaky coupling capacitor in a black-and-white set, you can surely find one in a color set!

The really "complicated" troubles seldom occur. From your own experience, how many really rough jobs do you run into in black-and-white—percentagewise? About 5%, just like everyone else. All the rest are easy. Dead tubes, burned resistors, leaky capacitors, bad filters and so on. If you serviced nothing *but* color TV, you'd find exactly the same proportions; after all, they're *TV sets,* aren't they?

Example: one set's picture suddenly turned a bright green. Picture good, sound OK. Diagnosis? Trouble in the green amplifier tube. Heater–cathode short, no bias, tube ran wide open, and the green drowned out the other two colors. Tube replacement and cure should take less than 3 minutes. Many others are equally simple.

Symptoms

In black-and-white servicing, what do we look for in the way of symptoms? What *is* there, and what *isn't* there—sound, video,

sync, etc. From this, we make our first diagnosis and then proceed to check it out. We use the process of elimination to find out just which one of the many possible causes is responsible.

The same process will work in color. You're going to find that the great majority of troubles in color sets are *the same* as those in black-and-white—sound, sync, horizontal sweep, and so on—and you've been fixing those for years. There are only a few extra circuits, just as simple as the rest, and they will give you a very definite set of symptoms when they're not working right!

Let's clear up a few things about the color TV signal, in short words. What's a "color subcarrier," and why "3.58 mc"? How is it transmitted?

The black-and-white signal

A black-and-white TV signal is an AM picture signal and an FM sound signal, on the TV station carrier (Fig. 101). If this
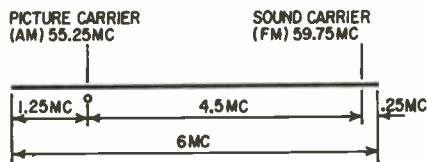
Fig. 101. *Black-and-white signal on channel 2. The picture modulation is AM; the sound is FM. Overall channel width is 6 mc.*

is channel 2, the carrier frequencies would be as shown—sound 4.5 mc higher than the picture. Actually, the sound could just as well be 4.5 mc *below* the picture. It is, when we get to the receiver's i.f. stages!

The color signal

A color signal begins as three AM signals (from the cameras). These are combined in the familiar 30% red, 59% green and 11% blue ratio to make the brightness signal (100%). Now we've got to get this onto the carrier without interfering with what's already there. So we modulate it onto a *subcarrier* to make it a higher frequency. Also, since we've already used up AM and FM, we use *phase modulation* (PM). The color information is converted into PM values of the sidebands of a 3.58-mc carrier. To save postage (and interference!), we take out (suppress) the 3.58-mc carrier and send only the sidebands.

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In-phase and quadrature signals

We send *two* signals, not three. To keep them from mixing, we leave one In-phase with the carrier (I) and throw one 90° out of phase with it, or in "Quadrature" (Q). (This is the "ideal" approach; in modern sets the signals—always at right angles to each other—may not be exactly in line with and at 90° to the carrier. So we read about R — Y and B — Y, or X and Z, instead of I and Q signals.) These are the upper and lower sidebands, centered around where the carrier would have been. Now our TV channel looks like Fig. 102, still on channel 2. The picture
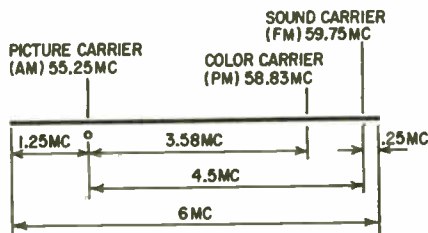
Fig. 102. *This is the same TV carrier as that shown in Fig. 101 on the facing page. However, the carrier has now had a color subcarrier added — or at least where the color subcarrier would be if it were transmitted. Actually, only the sidebands go along. Note that the overall channel width is still only 6 mc.*

carrier is still the reference point, with the color sidebands 3.58 mc above it and the sound 4.5 mc above it. This whole mess is now pumped up the transmission line and sprayed over the countryside.

Why 3.58 mc?

Why 3.58 mc? Well, we're adding a lot of extra stuff to the already crowded TV channel. Engineers discovered that the energy wasn't even distributed over the whole channel, but concentrated in small bunches. So they picked a color subcarrier that is an odd harmonic of the horizontal scanning frequency. This makes the color signals fall into holes *between* the bunches. On black-and-white receivers, the color signals cancel on alternate scans of the raster, and all we see is the video or brightness signal. The result is compatible color—it can be viewed directly as black-and-white.

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When we get to the TV receiver, all this is amplified, converted to an i.f., amplified again and fed to the video detector. There, after detection (or demodulation), we find the picture signal as AM, and the 4.5-mc sound i.f. signal, which appears for the first time (it's a beat between the picture and sound carriers). Also, we recover the color signals, as a group of frequencies centering around 3.58 mc. These go to an amplifier stage tuned to accept only these frequencies, the sidebands of the original color carrier. That is where we get the name *bandpass amplifier*.

We left the color carrier behind at the transmitter, but we tore off little samples or "bursts" and sent them, sitting on the back porch of the horizontal sync pulses. Now we take these samples, use them to synchronize the receiver's crystal oscillator at 3.58 mc, and we have our color carrier back again, in phase with the one at the station.

Matrixing

We sent only two of the three color signals. But we have the whole, or sum, in the brightness signal, which is 30% red, 59% green and 11% blue (= 100%). Since we have two of these fractions, we can add them, then subtract the result from the "whole," and we have the missing signal! Sounds complex, but it isn't. Look at the color amplifier circuits of a typical receiver. Three tubes, with their cathodes tied together, have separate inputs to the grids, while the plates go to their individual guns in the color CRT.

These tubes do the "matrixing," which simply means "adding and subtracting," and the result is the same three color signals we started out with back at the transmitter!

No matter what we do to this signal along the way—change its frequency, etc.—we'll still wind up with the same results when we get to the receiver, as long as we don't change the signal's relationship to the picture carrier, and we can't do that.

And now that we've had this thumbnail review, let's go over the color circuits in a little more detail. Remember—we're assuming that you know how black-and-white sets work and that you've had some experience in servicing them.

Color vs black-and-white

Are there any *new* circuits in a color TV receiver? Circuits that you've never seen before? Let's start at the video detector. Up to this point, the circuits are *exactly* the same as those in

black-and-white: tuner, i.f., sweeps, sync, agc, power supply, etc. Let's go down the line and examine each color circuit.

The burst amplifier

This is a standard pentode tube, with normal plate and screen voltages. See Fig. 103. The grid is keyed by a pulse from the fly-
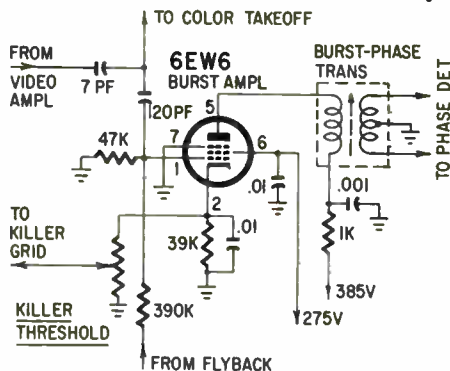
Fig. 103. *Burst circuit amplifies only because it is keyed on its control grid with a flyback pulse. The input is from the video stage.*

back transformer, so that the tube actually conducts only during horizontal blanking intervals. So, what does it do? It amplifies the burst signal which is on the back porch of the horizontal sync. How is this burst separated from the sync, video, etc. signal? How do we separate a 4.5-mc *sound* signal? Feed it through a sharply tuned transformer! You can see it in the plate circuit of the burst amplifier in Fig. 103. This transformer has a center-tapped secondary, which feeds the phase detector.

Phase detector

Sometimes called afpc and other complex names (Fig. 104).
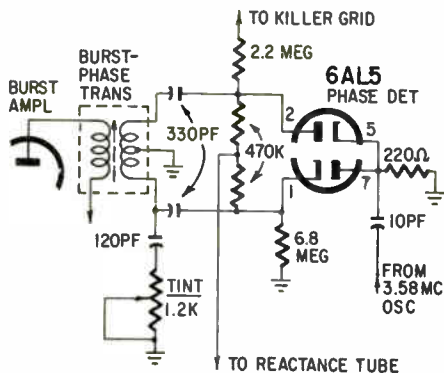
Fig. 104. *Automatic frequency-phase control detector. You've seen circuits like this in FM radio and black-and-white TV.*

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Don't let 'em fool you—it's just a plain old ratio detector, discriminator or whatever you want to call it! The phase detector compares the phase of the burst signal from the transformer with the signal being developed by the local oscillator, and develops a dc correction voltage to apply to the reactance tube.

Reactance tube

This circuit certainly should be familiar to all the old-timers. The same circuit is used in lots of older TV sets, to control the horizontal oscillator! Automatic frequency control, in other words, or, afc. See Fig. 105.
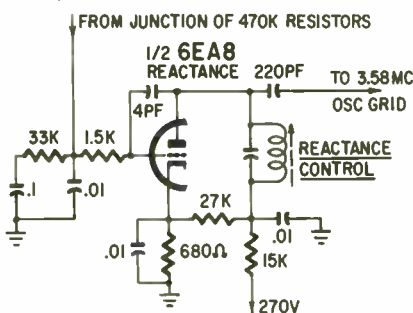
Fig. 105. *Reactance tube thinks it is a coil or capacitor! The tube controls the 3.58-mc oscillator.*

The small dc control voltage from the phase detector is applied to the control grid of the reactance tube. This controls the phase angle of the control tube's plate voltage and current, making it behave like a reactance. Thus we can make the tube control the oscillator circuit automatically, by varying the amount of reactance it appears to be. The control comes from the correction voltage, which is in turn developed by the color signal itself. So, we keep the 3.58-mc oscillator right on frequency.

Think of the 3.58-mc oscillator frequency in the same way in which you consider the vertical and horizontal sweep frequencies. They must be in exact step with the station to which the set is tuned. Same with 3.58-mc. It must be kept in step with the corresponding frequency at the station.

The 3.58-mc oscillator

This is usually a standard crystal oscillator circuit. Sometimes it's even a Pierce, which is about as simple as you can get. The circuit contains a tube, crystal, and a few oddments like plate

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voltage and stuff. Fig. 106 shows a typical oscillator circuit, which, come to think of it, *is* a Pierce, the original version. This uses the screen grid as the oscillator plate, leaving the real plate free to take off the 3.58-mc signal. Is this unusual? How about the oscillator circuit in some small radios where a pentagrid tube is used as mixer–oscillator? The screen functions as the oscillator plate, and the i.f. signal is taken from the real plate. Same thing you've been accustomed to right along, isn't it?
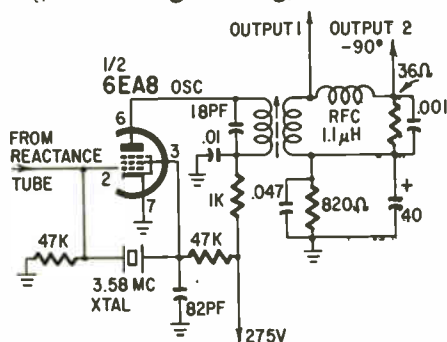
Fig. 106. *Pentode Pierce oscillator circuit generates a 3.58-mc subcarrier. The same kind of circuit is used with pentagrids in AM sets (without crystal control, though). It's really not new—just a different application.*

Control for this oscillator, which isn't needed too badly anyhow, comes from the reactance tube through the 220-pf coupling capacitor shown in the plate circuit of the reactance tube in Fig. 105. Just enough to keep it right on its correct frequency at all times.

Servicing the oscillator

Servicing? Measure the negative voltage on the control grid of the oscillator tube. If it's about 4 to 5 volts, the circuit is oscillating; if it's zero or positive, it isn't. About the only thing that can keep a Pierce circuit from oscillating is a dead tube or crystal! The coil in the plate circuit has no effect on the operating frequency; it merely provides a place to get the output signal from. Note the tiny rf choke (RFC) across the secondary. This shifts the phase of part of the 3.58-mc output so that we can have two signals to use in our color detectors (one in phase with the burst and another 90° out). These signals are fed to the cathodes of the color demodulators.

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Color demodulators

You'll find these called X and Z, I and Q, R and G, you name it—any combination of letters. See Fig. 107. They all do the
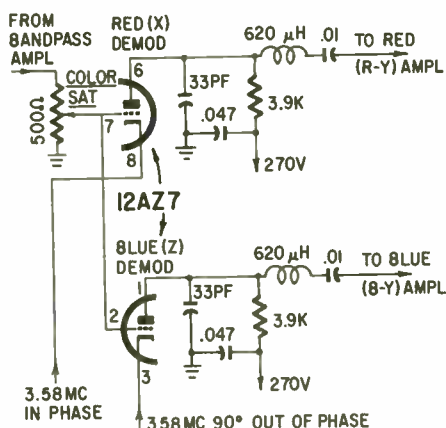
Fig. 107. *Color demodulators work in quadrature, keyed by direct and 90-degree-shifted 3.58-mc voltage.*

same thing: separate the color information from the video signal. How? Phase detection. A good simile is the quadrature-detector circuit used in sound detectors with the 6DT6 or 6BN6.

Separating the colors

How do we get the colors separated? Notice that a combination signal, with all colors in it, is applied to both grids. This signal comes from the bandpass amplifier, which we'll get to in a minute. The color signals are all in there, in the form of different *phases* of the basic 3.58-mc color *subcarrier* (which was removed at the transmitter to save postage—the 3.58-mc oscillator puts it back in at the receiver).

So, with all of the colors on the grids, we put a 3.58-mc signal from the oscillator on the cathodes. Now, each tube passes only the part of the color signal that's in phase with its cathode signal. Same principle as keyed agc. In the output, we get red in one plate circuit and blue in another. "Wait a minute!" somebody says. "Where's the *green?*" OK, we *make* it, right in the receiver, in the color amplifiers.

There's no point in transmitting anything that isn't absolutely essential.

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Color amplifiers

As you can see in Fig. 108 these are just three simple triode amplifier stages. But, you still want to know, where does the
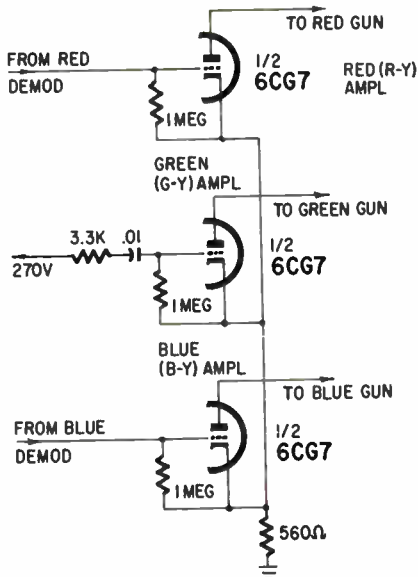
Fig. 108. Color amplifiers. The green signal is "made right in the customer's own receiver" by subtracting the red-blue signal from the total color signal.

green come from? We're putting our red and blue signals onto the grids of the top and bottom tubes. The cathodes are all tied together. So, the cathode voltage on the green amplifier is a combination of the other two colors. Now, the *whole* color signal is red + blue + green, isn't it? So, what would we have left if we *subtracted* red and blue? Green!

This is what takes place in this tube, because of the arrangement of the cathode and grid voltages. It becomes a sort of backward adding machine, and subtracts the red and blue signals, leaving the green. These are amplified and fed on to the green gun of the color picture tube.

Let's back up and get a few things we had to leave while we were following the color signal through the circuit to the picture tube. One of these is the bandpass amplifier we mentioned as feeding the color demodulator stages.

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Bandpass amplifier

Actually, this is hardly worth illustrating. See Fig. 109. If you've ever seen an i.f. stage in a radio or the sound i.f. in a TV set,
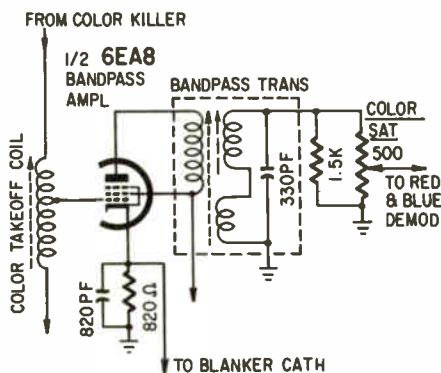
Fig. 109. *The bandpass amplifier circuit sounds mysterious, but it is no different than a typical AM, FM or TV i.f. stage.*

you've seen the same circuit. The color signal goes to the grid from the color takeoff coil, and the plate feeds the "bandpass" transformer. This is used to clean up the color signals and keep out interference from other circuits. On the secondary of the transformer is a control usually called *saturation,* but which ought to be called a "color volume control," since that's how it works. It simply regulates the amount of color signal.

Since this stage handles the whole color signal, it's a good place to put the color killer. Note that the color takeoff coil is connected to the color killer circuit.

Color killer

What's this for? Its only purpose is to cut off the bandpass amplifier during black-and-white transmissions. Some men have had trouble understanding the thing (Fig. 110) because it "works backward," in a way. During color reception, the killer is cut off, and the bandpass amplifier works. During black-and-white reception, the *killer* works (conducts, that is) and the bandpass amplifier's cut off.

This is basically a keyed stage; see the pulse being applied to the plate from the flyback? So, this tube conducts only during horizontal retrace time. Notice the "balance" circuit connected to the control grid. We get — 45 volts from the phase detector by

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connecting this to one end of the two 470,000-ohm resistors. (While a color signal is being received, a negative voltage is developed there. During black-and-white reception, this voltage disappears, because there's no color burst to make it show up.) The other end of the 10-megohm resistor goes to a source of + 45
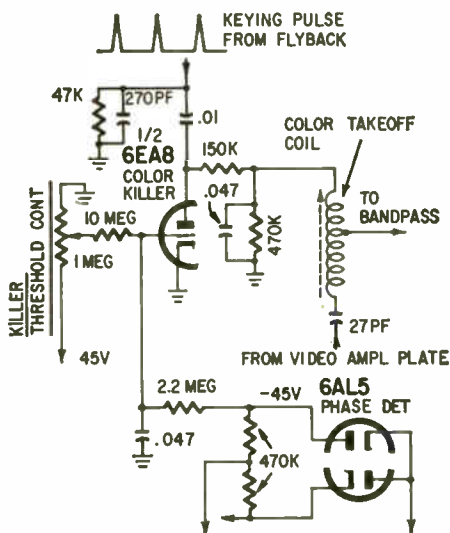
Fig. 110. *Circuit of the color killer. Like the burst amplifier, it is keyed by pulses from the flyback transformer.*

volts (the burst amplifier cathode in this case—all we need is a source of positive voltage at the right level). This is fed through the killer threshold control so that we can adjust the grid voltage on the killer stage.

If the killer tube is not conducting, we don't get any voltage drop across the 150,000-ohm resistor in the plate circuit. So, the bandpass amplifier is allowed to pass the signal, which is color. (Killer cut off, bandpass amplifier working.)

When the killer tube *is* conducting, the drop across the plate load resistor puts a negative voltage on the grid of the bandpass amplifier. (Killer working, bandpass amplifier blocked.) So, it can't pass any signal at all because it's biased to cutoff. This keeps the whole color circuit from operating, since all of the color signals have to come through the bandpass amplifier. So, during black-and-white reception, we don't have colored snow

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on the screen, or "confetti," as they used to call it. This stage is as simple to serve as any keyed stage. (You *can* fix keyed agc stages, can't you?)

The blanking tube

Because there are so many signals going in so many directions around here, we don't want any trouble with retrace of either kind. So we add the blanking amplifier stage, Fig. 111. This is
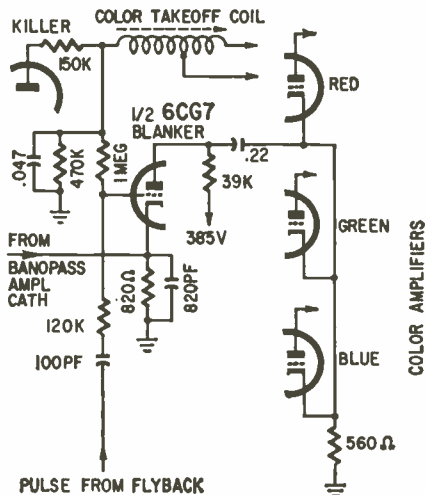
Fig. 111. *Blanking amplifier circuit. This is just a conventional vertical and horizontal retrace blanking arrangement, plus an amplifier stage.*

nothing but amplified retrace blanking. Same circuit used in uncounted jillions of black-and-white sets, except that we are using a tube to be sure that the picture tube stays cut off during horizontal and vertical retrace times.

The delay line

The *video* signal (that is, the one we use in black-and-white containing only brightness signals) goes straight to the picture tube grids. The poor little color signal, on the other hand, gets chased around through all sorts of phase-shifting networks and stuff before it is allowed to reach the picture tube. We have to give the video a little "handicap" so that everybody will reach the finish line at the same time. Actually, this isn't much—usually about 1 microsecond!

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Delay line troubles

The theory of a delay line is very complicated, but a practical delay line may be nothing more than an 8-inch piece of coaxial cable! It takes a signal slightly longer to get through the cable than it does in free space. (The velocity of propagation is lower.) If a greater delay is needed, sometimes a small coil is used inside the delay line, slowing the signal down still more. Only two possible troubles: a broken wire or a short to ground, both fairly easy to find. It isn't possible for the time constant to be changed by any defect.

So, there you have it. We've taken a black-and-white TV receiver and added the color circuits. (Up to the video detector, the circuits are exactly the same as in black-and-white, and subject to the same faults.) While we discussed nine functions, one popular receiver does them all with only seven tubes.

Are they all alike?

"But!" somebody says, "they don't all work that way!" So? How about black-and-white sets? Are they all alike? If they were, you could carry your just one circuit diagram in your shirt pocket! Naturally, there are differences. Circuits are changed and simplified all the time, just as in black-and-white. The earliest practical color set was a fat 24 inches on each side, weighed about 75 pounds and used 44 tubes. The latest is half that volume, uses 24 tubes and you can carry it in one hand.

Natural differences in approach are trivial. One manufacturer might use a three-stage video amplifier. Another uses a single high-gain tube. What's the difference? Both circuits will work, and work very well, and will be equally easy to service.

Some circuit differences

We hope we didn't leave you with the impression, based on what we said above, that TV sets are generally carbon copies of each other. Are all TV sets alike? Well, they are and they aren't. Basically, as we have mentioned, they are all the same. However, you know as well as we do that TV sets have all sorts of "refinements" thrown into them by TV set designers. We couldn't possibly list every one of them for you, but we will give you a few so that they won't come completely as a horrible surprise.

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Automatic color fidelity control

The automatic color fidelity control (Fig. 112) permits the viewer to adjust the warmth or coolness of color and black-and-

Fig. 112. *Circuit of the automatic color fidelity control.*

white pictures to suit his taste. Black-and-white pictures can be viewed in tones ranging from cool blue to warm sepia. It minimizes the need for color adjustments whenever the TV set is moved or whenever the color purity is affected by stray magnetic fields.

When the COLOR FIDELITY control is in the maximum counterclockwise position, the junction of R544 and R526 is grounded. These two resistors are proportioned so the blue grid voltage is about 8% below the green grid. Both these grids are at a lower voltage than the red, and the picture has a sepia tone.

When the control is turned fully clockwise, it places 400 volts on the junction of R544 and R526. The blue grid has less resistance (1.2 megohms) than the green (3.3 megohms), so its voltage is about 5% higher. The red grid is about 30 volts lower so the picture is predominantly blue.

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Automatic color intensity circuit

The automatic color intensity circuit is shown in Fig. 113. (Several manufacturers use versions of this circuit and call it
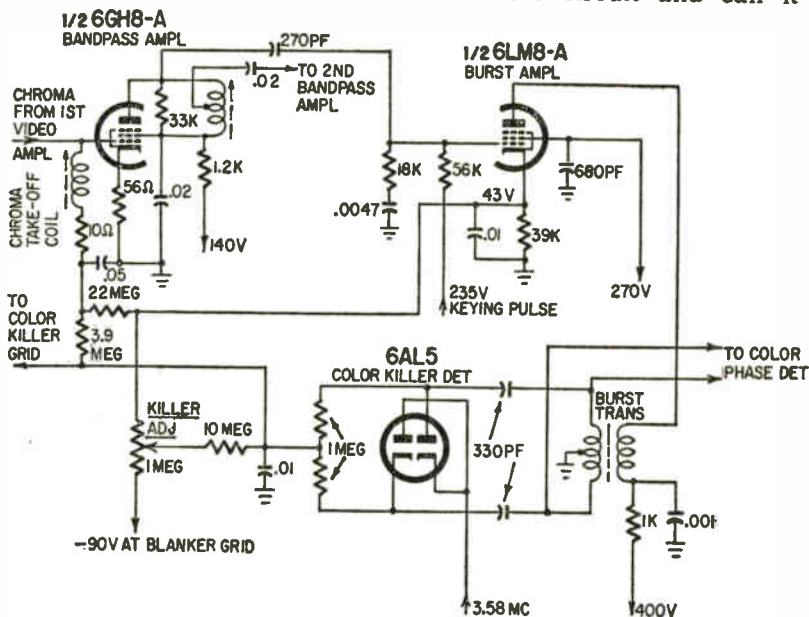

Fig. 113. *Automatic color intensity circuit (automatic chroma control or acc). Circuit supplies agc action to keep chroma and burst signals at constant levels.*

automatic chroma control or acc.) Its purpose is to adjust the gain of the bandpass circuit to keep the chroma and burst signals at relatively constant levels.

The negative control voltage used for the color killer is applied to the grid of the first bandpass amplifier. This voltage depends on the amplitude of the burst signal but is always high enough to cut off the color killer when a burst is present.

AGC action

If the burst is weak, the negative biasing voltage applied to the bandpass amplifier is low, allowing the color signal to be amplified more. If the burst is strong, the negative voltage is higher and the amplifier's gain is reduced. This circuit is a special agc that automatically holds the color signal at a constant level in the bandpass and burst amplifiers.

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Vertical blanking

Vertical blanking prevents vertical retrace lines from appearing in the picture. The circuit is shown in Fig. 114. During the vertical retrace interval a high-amplitude positive pulse appears
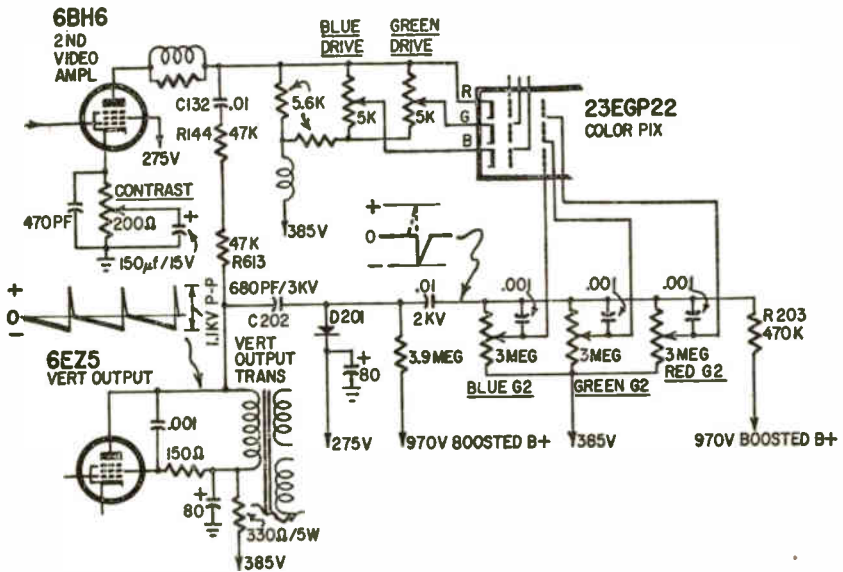

Fig. 114. *Vertical blanking circuit. The purpose of this circuit is to blank the vertical retrace lines, keeping them out of the picture.*

at the vertical output plate. This pulse is fed through R613, R144 and C132 to the cathodes of CRT and drives it to cutoff. These pulses don't last long enough to keep the picture tube cut off for the full retrace interval. Additional blanking is applied to the screens to keep the tube cut off for the balance of the retrace interval.

C202 and R203 differentiate the positive pulse into broader positive and negative pulses with the negative pulse following the positive. Diode D201 conducts and shorts the postive pulse (dashed lines) to ground. The negative pulse drives the CRT screens negative and keeps the tube cut off during the remainder of the retrace period.

Note the high-voltage rating of some of the capacitors, such as C202 and the .01 connected to it. That boosted B-plus is almost up to 1 kilovolt. Those capacitors are also under the strain of pulsed voltages. There's some possible breakdowns here.

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Anti-blooming circuit

Blooming often occurs during sudden changes in picture brightness.

The anti-blooming circuit sometimes used is shown in Fig. 115. A positive keying pulse from the flyback drives the burst amplifier
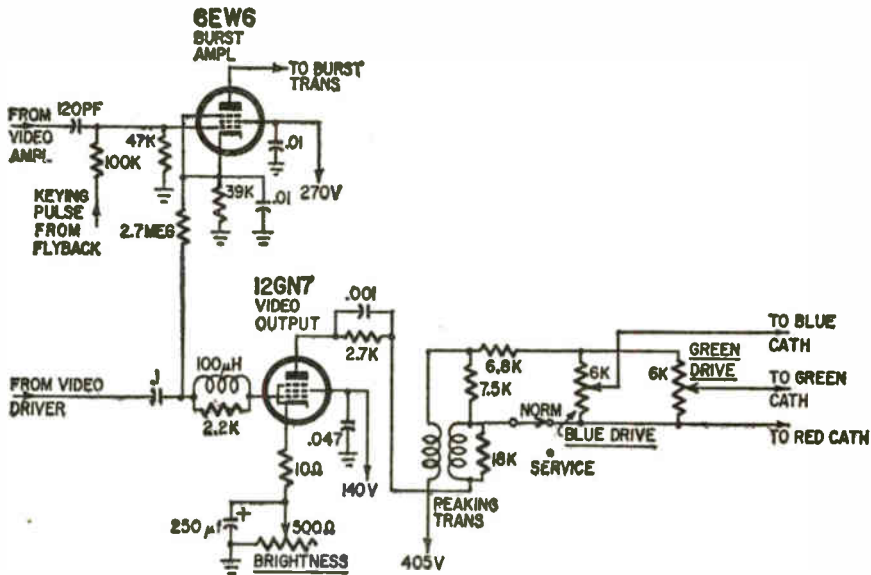

Fig. 115. *Anti-blooming circuit helps prevent blooming when picture brightness changes suddenly.*

and tends to hold its cathode at a fixed positive potential. This positive voltage biases the grid of the video output tube. On bright scenes, the high CRT current loads down the horizontal output circuit and reduces the amplitude of the keying pulse. This reduces the voltage on the burst amplifier and video output grid, biasing back the video amplifier and opposing any tendency toward abrupt changes in brightness or contrast.

This is just one way that TV set designers have worked with the problem of blooming. Another method is to modify the HV regulator circuit. This is described beginning on page 26 with the circuit modification (Fig. 119) shown on page 27. However, blooming could still be caused by a weak HV regulator tube.

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Other demodulators

One circuit, shown in Fig. 116, demodulates on the R—Y, B — Y and G — Y axes directly rather than deriving the G — Y
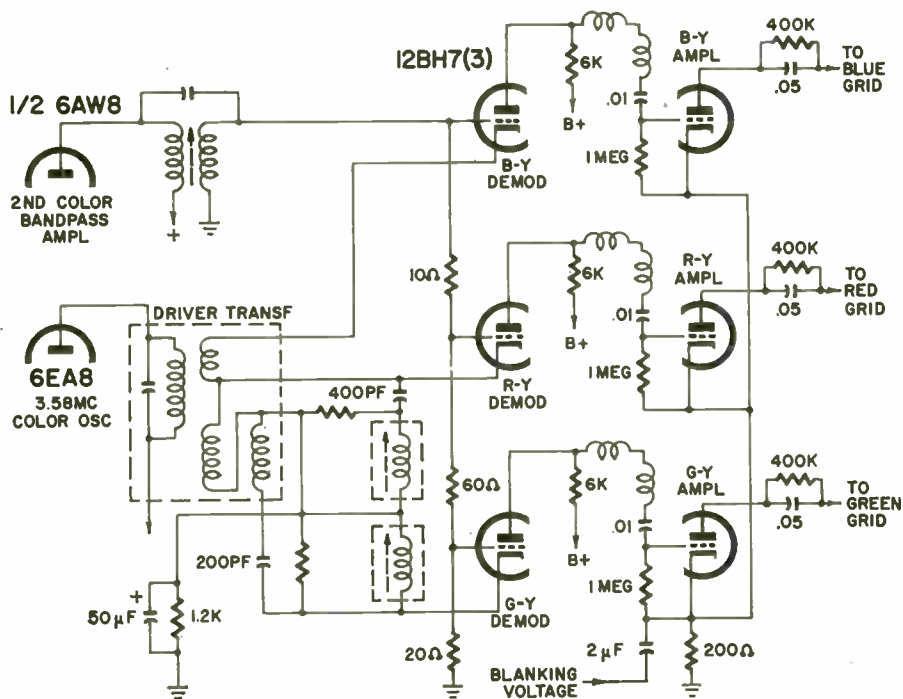

Fig. 116. *Simplified schematic of unusual color demodulator and amplifier circuits.*

in the amplifiers. This is done by taking a third phase axis from the 3.58-mc color oscillator and supplying all three of the demodulator grids with selected amounts of the color signal from the second bandpass amplifier. The cathodes of the color amplifiers which follow these demodulators use a common cathode resistor even though the G—Y signal has already been derived. This common connection is necessary so that blanking can be applied through the color amplifiers to all three color grids simultaneously.

Power supplies

Another feature found on some sets is "boosted boost." This is an added voltage obtained from the flyback and normal boost

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circuit so that several hundred volts more is available for the screens of the color tube. This is said to produce both a brighter picture and somewhat better focus. A high-voltage *selenium* rectifier tapped up on the flyback develops an additional 420 volts over the normal boost supply.

One other popular feature is a high-voltage selenium diode as a focus rectifier instead of a 1V2 tube. This has the advantage that no sweep power is used to supply the focus rectifier filament.

Setup and convergence

A setup switch that sets the bias on the picture tube and at the same time kills the vertical deflection for making gray-scale tracking adjustments is a standard feature on all American-built sets. The Toshiba color set does not use this switch but does have individual gun killer switches mounted on the convergence panel (a "why not" feature that would be a welcome addition to any color set). The killer circuit is interesting and is shown in Fig. 117.
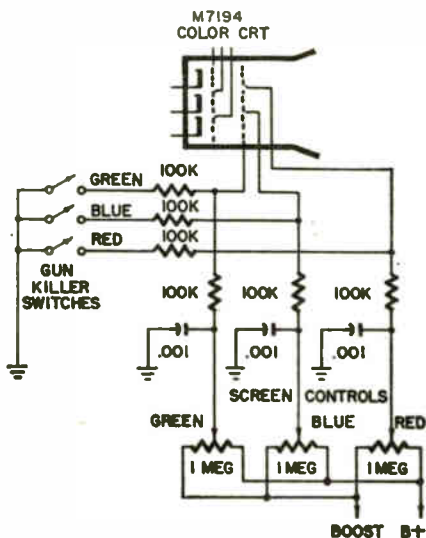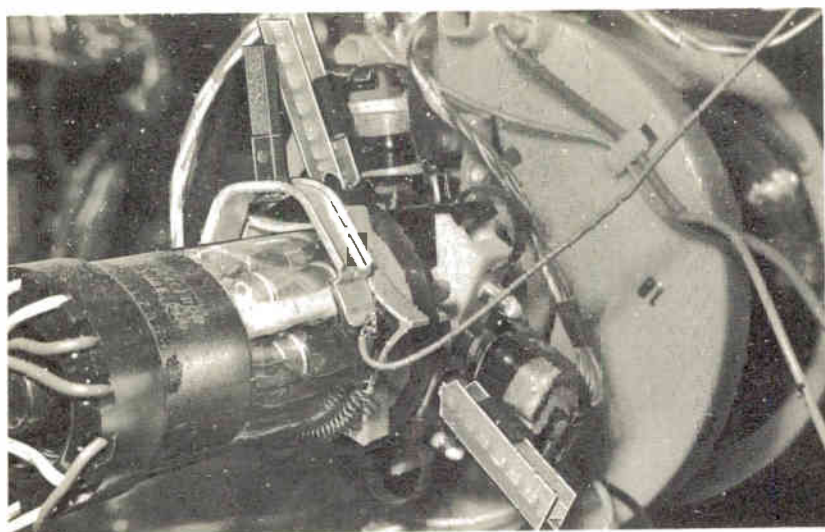

Fig. 117. *In this setup switches kill the individual color guns.*

Note that 100,000-ohm resistors are switched in but *not* in the control grid circuit. These are switched into the circuit to reduce

the voltage on the CRT screens. This permits long leads without the possibility of video deterioration.

Fig. 118. *Closeup of CRT neck shows "H"-cross-section convergence magnet holders and sliding blue lateral magnet.*

Several sets use an H-bar plastic magnet holder for the dc convergence adjustments and a slightly different design for the blue lateral magnet. These are shown in Fig. 118.

HV regulator changes

High-voltage regulator circuits are starting to feel the effects of refinement. Some sets have a "video controlled" circuit. This circuit tends to reduce blooming when there is a large amount of white in the picture. Compensation is needed because the picture tube draws more current from the high-voltage supply when the white content of the picture increases.

The circuit feeds a monitoring voltage from the plate of the video amplifier to the grid of the high-voltage regulator through a 12-megohm resistor. When white content is high, the plate voltage of the video amplifier is lower. This lower voltage lowers the regulator grid voltage slightly and the regulator tube draws less current, puts less load on the high voltage, and the high voltage rises.

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One circuit variation uses a varistor in series with the boost voltage of the grid of the 6BK4 shunt regulator (Fig. 119). This
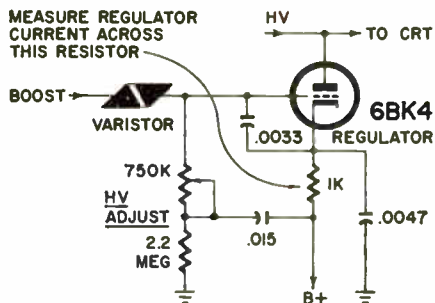

Fig. 119. *This circuit regulates high voltage with a varistor.*

voltage-dependent resistor tends to accentuate the effects of boost-voltage changes and so provides somewhat better regulation. An ordinary resistor here would pass the boost-voltage change to the grid in a 1-to-1 ratio while a varistor of this kind passes more current with an increase in voltage than you'd expect from Ohm's law. The resistor looks like less resistance in the circuit when the voltage is higher, and like more resistance when the voltage falls.

Pincushion correction

The 23-inch rectangular tubes are not without circuit problems. One major one is the more noticeable effects of pincushioning (lines bent) at the outer edges of the raster. Permanent magnets, as used with wide-angle black-and-white tubes, are not the answer in color because the magnets affect both convergence and purity. To whip this problem, Motorola developed a "Dynamic Pin Cushion Corrector" (DPCC) circuit. Fig. 120 is a simplifi-
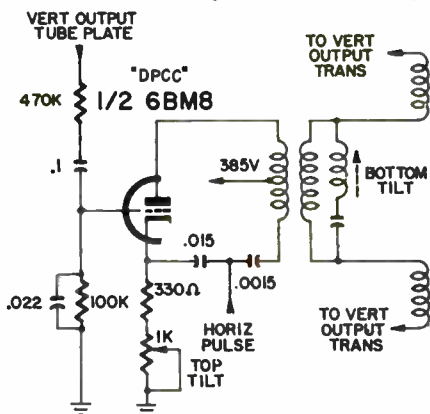

Fig. 120. *Dynamic Pin Cushion Corrector circuit.*

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cation explaining how it works. A pulse from the plate of the vertical output tube is shaped and fed to the grid of the DPCC tube. In addition, a horizontal pulse is fed into both sides of the primary of the DPCC transformer (one side by way of the cathode of the DPCC tube). The secondary of this transformer is in series with the vertical yoke windings. The combinations of these voltages provide a method of speeding or slowing the scan at the upper and lower edges of the tube.

A control in the cathode circuit is simply adjusted for most correction (straightening of the bent lines) at the top of the picture while the slug-tuned coil across the transformer secondary is adjusted for best correction at the bottom of the screen.

"Color" indicator lights

Motorola and Magnavox have lights to indicate that the set is receiving a color program. Fig. 121 shows how Magnavox modi-
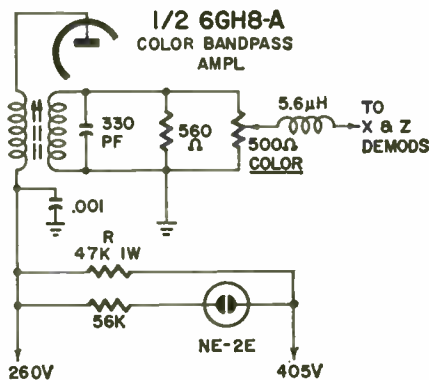

Fig. 121. *Circuit using color program indicating light.*

fied a chassis to provide an indicator. When no color program is being received, the color killer keeps the bandpass or "color i.f." stage cut off; this means there is no drop across R and the neon does not light. During a color program, the bandpass tube is on and the drop across the 47,000-ohm resistor exceeds the firing voltage of the NE-2E, which then glows.

A completely new system of color TV?

The circuits we have just described for you are new or different only in the sense that they are designed to make a color TV receiver work better. Note that they do *not* change the existing color TV

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system. Your efforts to learn more about color TV repair are not about to be tossed out the nearest window.

The plain fact is that introduction of a radically new color receiving system is unlikely in the near future. The reasons are economic as well as technical. The tremendous costs of development and tooling of completely new systems would outweigh many of the advantages. Today's receiving system of color TV is far more than adequate. Any new system would have to promise markedly better performance or much lower cost to receive serious consideration. Even a system which could be proved to be slightly better or slightly cheaper would probably be rejected — and, to the best of our knowledge, nothing of this kind is in sight.

Nevertheless, the various circuits covered in the latter part of this chapter show that you can expect many changes and improvements within the present approach to color TV reception. Color TV is competitive. "Ghost manufacturing" is a thing of the past; every manufacturer makes its own sets.

Test equipment

"But," comes the same plaintive voice from the back row, "You've got to have so much *equipment* to service color TV!" Are you in again? I thought you'd left. Well, let's see. On how many black-and-white sets do you use a scope, sweep generator, marker-adder, flyback tester, capacitor tester, pattern generator? *About 5% or less.* Most of the troubles are *simple:* dead tube, bad capacitor and the like. You're going to find color *exactly* the same.

So you can use your present test equipment to service color. Later on, you can add color bar generators, etc. You must have them if you want a completely equipped shop. However, if you *can* service 95% of the sets with your present equipment, what better percentage do you want? The most useful piece of test equipment in the shop is that mass of gray mud between your ears!

Service information

Fortunately for us, a lot of service information and help is available. Set manufacturers have spent millions printing color training courses, holding service meetings, and doing everything they could to get the basic idea of color over to us. We ought to be grateful to them, and most of us are.

Once we realize that color television is *not* as complex as it might seem, we're well over the hump. After all, and always

remember this — we're not *designing* these circuits: we're just *repairing* them! They did work once, and they can be made to work again. All we have to do is locate the defective part and replace it.

There's more to come

Now that you have this down nice and pat, we'll toss you a few crumbs of comfort by telling you that in the next chapter (and succeeding chapters) we'll continue to belabor the same circuits but in more detail and with servicing information added. After all, that's why you read the first chapter. You did read it, didn't you? You should — at least once — even if you are an old pro. You can never tell! You might correct a mistaken idea you may have about a color circuit, or even learn something new. But if none of these things do happen, you will at least reinforce what you already know. And that's good!

chapter 2
abc's of color tv servicing

A BLACK AND WHITE TV RECEIVER MAY HAVE 19 TUBES — A
color receiver may have 26. This does not mean that a color
receiver is harder to service. Here's why. A black-and-white
combo may have 28 tubes — but it is no harder to service than
a 19-tube receiver. The technician tackles only the TV section,
if there is no picture. He works on the phono section, if the
audio section won't sing out. He investigates the AM section if
the local broadcast station is silent. In orther words, he resolves
the job into a TV, radio or phono service problem. He disregards
the TV and phono sections if symptoms show that the trouble
is in the AM radio section. An AM radio is an AM radio
whether it is alone or on a combo chassis.

A color TV receiver is just another type combo. It is a black-
and-white TV receiver with a color-circuit section. You can
have a black-and-white picture with no sound. We know an FM
radio is an FM radio, whether constructed on an FM radio
chassis or inside a TV. Who's afraid of an FM radio? Every-
body *would* be afraid if informed that "Values of Bessel functions
here involved, of zero order, for integral values of the argument
from 1 through 9, and for orders through 44, corresponding to
integral values of argument 1 through 29, are as follows:"

The long-haired mathematician who polished that gem would
probably be panic-stricken if you sat him down at a service
bench. By the same token, the joker who runs off at the mouth
about R — Y, B — Y, G — Y, colorimetry, product demodula-

tion and readjusted chroma values is least likely to succeed at the service bench. The common-sense technician who looks at chroma circuits as he looks at FM-radio circuits has the basic ideas of color TV pretty well under control.

Forget the gobbledegook

It has its purposes, but not at the bench. Let's get down to brass tacks. Fig. 201 is a common-sense block diagram of a

Fig. 201. *Simplified block diagram of color TV receiver. (Refer also to Fig. 501 on page 68 and Fig. 601 on page 79.)*

color TV receiver. The sections to the left of the picture tube are those we find in an ordinary black-and-white receiver. The sections to the right are what makes a color receiver a combo. *These left-and-right sections can work independently of each other, and often do.* For example, if you tune to a black-and-white program, the right-hand sections are "killed" by an electronic switch, part of the chroma amplifier. (Refer also to the more detailed block diagrams, Fig. 501, on page 68 and Fig. 601 on page 79.)

If a circuit defect stops the black-and-white signal in the video output stage, and you tune to a color program, you see a color picture with no black-and-white reproduction. Again, if the 3.58-mc oscillator is dead, and you tune to a color program, you see a black-and-white picture with no color reproduction. *A color receiver is a combo, and your troubleshooting approach can be profitably based on this viewpoint.*

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Black-and-white-vs-color signals

The difference between a black-and-white and a color signal is shown in Fig. 202. The black-and-white signal is seen in b;
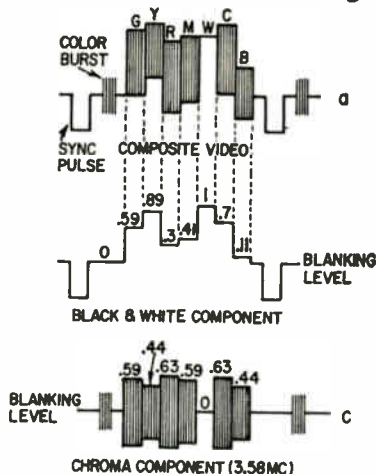

Fig. 202. *How color signals compare with black-and-white. The complete composite video signal is shown at the top (a), the black-and-white component (b) and the chroma component at the bottom (c).*

the chroma signal in c. Add b and c and you get the complete or composite video signal a. This is the output from the video detector, when you apply a color-bar signal to the receiver. After the video detector, the complete color signal is separated into its black-and-white and chroma components. Both end up at the picture tube. The black-and-white signal is applied to the cathodes of the color picture tube; the chroma signal to the picture-tube grids.

Note that if the receiver is working properly, you will see a normal color-bar pattern on the screen. If the chroma signal is "killed" in the chroma amplifier, you will see gray bars (with no color). Again, if the signal is "killed" in the video amplifier, you will see dim color bars. This is a basic example of color picture analysis. Remember that if the chroma sections fails, the color TV receiver becomes the exact equivalent of a black-and-white set.

The signals are separated by tuned transformers and traps. Note that the chroma signal component (Fig. 202-c) has a

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frequency of 3.579545 mc which we easily approximate as 3.58 mc. When the complete color signal passes through the video amplifier, the 3.58 mc trap stops the chroma signal component, as in Fig. 203. On the other hand, the chroma amplifier is
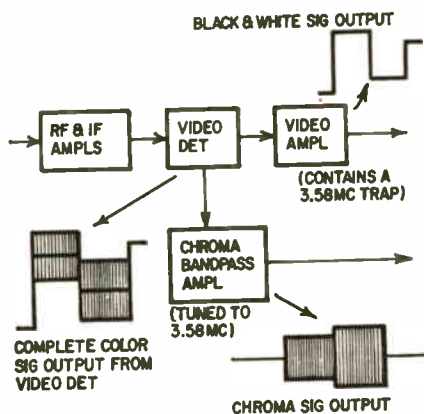

Fig. 203. *Separation of the black-and-white and the chroma signals.*

tuned for a bandpass response centered on 3.58 mc. Hence the black-and-white signal component is stopped, while the chroma signal passes through.

Need for alignment

This separation depends on the fact that a black-and-white signal is built up chiefly from frequencies below 3.58 mc. A chroma signal is built up from frequencies in the vicinity of 3.58 mc. Typical frequency-response curves for the video amplifier and chroma amplifier are shown in Fig. 204. Clearly, the chroma
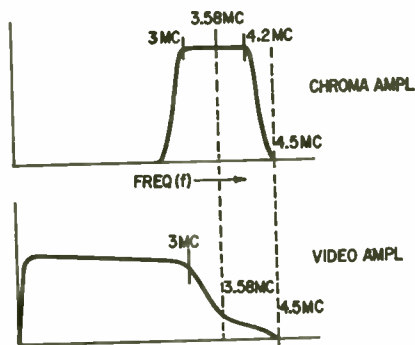
Fig. 204. *How the complete video signal and chroma component curves look.*

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amplifier must be in good alignment. Misalignment causes weak color reproduction, distorted colors, interference in the color picture or no color. The chroma signal must be picked out at full strength, and must be effectively separated from the black-and-white signal. Then it can be broken down into its red, green and blue components.

Breaking down the chroma signal

When all three cathodes of a color picture tube are driven by the black-and-white video signal, a black-and-white picture is displayed. We also know that when the red grid is driven, red appears on the screen; when the green grid is driven, green is displayed; when the blue grid is driven, the color is blue. It follows that the chroma signal must be broken down into its red, green and blue signal components.

The simplest way to do this it to use three chroma demodulators (Fig. 205). The demodulators are detectors, and each
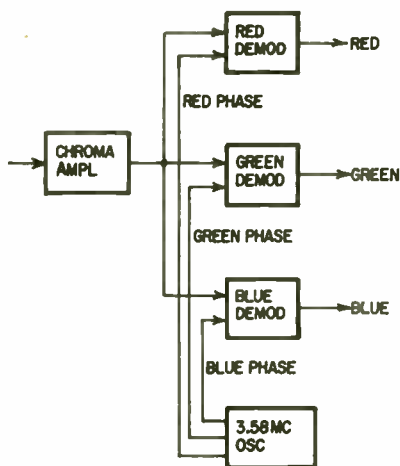
Fig. 205. *One way to detect the color signals is to use three demodulators. Fig. 209 on page 38 shows that only two chroma demodulators are really necessary.*

is like the phase detector in a horizontal afc circuit. We can say that each of the demodulators in Fig. 205 is locked in on a different chroma phase. Each demodulator picks out the signal phase to which it is locked. It rejects the other two phases, responding only to its particular phase.

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Stripped of all gobbledegook, the chroma signal is a three-phase signal, as shown in Fig. 206. All three signals have the same
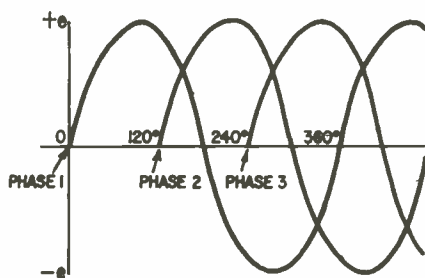
Fig. 206. *Basic three-phase color waveform.*

frequency (3.58 mc), but they are separated in time. The three chroma demodulators in Fig. 205 are operated essentially as electronic switches. Each is driven into conduction at the peak of one signal in Fig. 206. This is done as shown in Fig. 205. The 3.58-mc. subcarrier oscillator in the receiver supplies a different signal phase to each demodulator. In turn, each demodulator is driven into conduction at the required time.
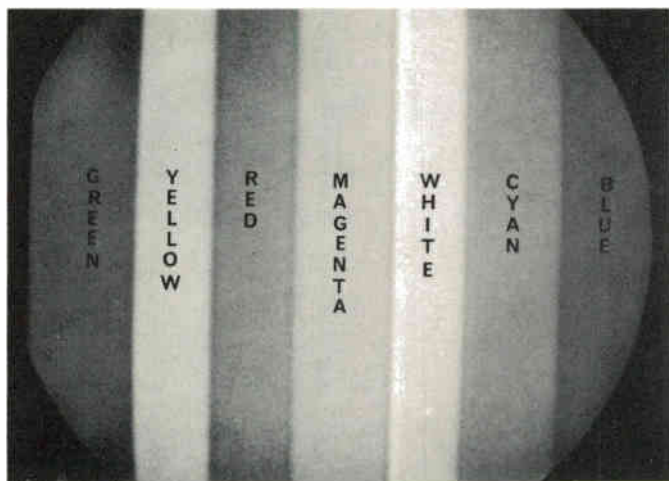
Fig. 207. *Representation in grays of color-bar pattern in sync.*

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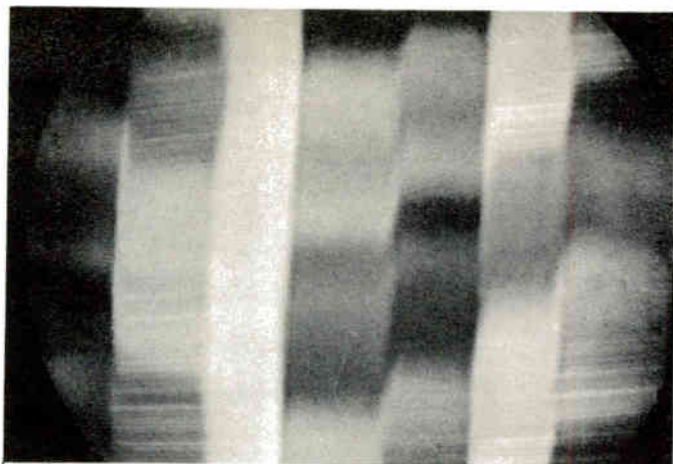
Fig. 207 (continued). *Representation in grays of color-bar pattern out of sync.*

Chroma demolulator lock-in

It is clear from Figs. 205 and 206 that the chroma demodulators must be accurately locked in (synchronized) with the transmitted three-phase signal. Otherwise the receiver loses color sync. Fig. 207 shows how a color-bar pattern breaks up into rainbows when the 3.58-mc. oscillator is not locked. We know how the horizontal sync pulse maintains horizontal sync. In the same way, the color burst (Fig. 208) maintains color sync.
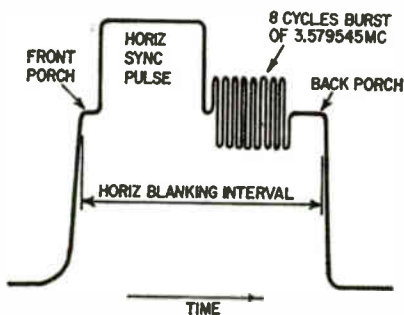
Fig. 208. *Color-burst phase reference. The color burst follows each horizontal pulse but is omitted following the equalizing pulses and during the broad vertical pulses. The burst consists of 8 cycles of color subcarrier at a frequency of 3.579545 mc gated into the back porch of the horizontal sync pulse. The average value of the burst is at black level.*

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Just as the horizontal afc phase detector holds the horizontal oscillator in sync, so the color afc phase detector holds the subcarrier oscillator in sync.

Keying the burst amplifier

The burst amplifier is keyed into conduction in step with the color burst, so that a clean reference signal is fed to the burst phase detectors. A dc bias output from the phase detectors is generated by comparing the burst phase with the 3.58-mc oscillator phase. This control bias is fed to the oscillator control stage to correct the oscillator phase as required. Hence, the chroma demodulators conduct only at the peaks of the chroma signals.

Matrixing the signals

American color TV receivers do not use three chroma demodulators as in Fig. 205. Instead, they have two demodulators and a matrix to simplify circuitry. One popular arrangement matrixes the red and blue demodulator outputs to produce a green output signal (Fig. 209). How is this possible? Note in Fig. 206
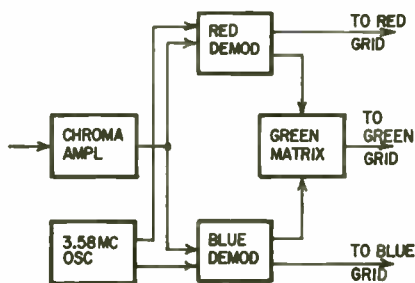
Fig. 209. *How two signals are combined to make a third signal. Compare this block diagram with the one shown earlier on page 35.*

that the red, green and blue chroma signals are 120° out of phase. This means that the green signal has red and blue signal components. In turn, the green signal can be obtained by mixing suitable proportions of the outputs from the red and blue demodulators. As we mentioned in Chapter 1 this saves us the trouble of transmitting the green signal.

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X and Z demodulators

Another popular matrixing arrangement is shown in Fig. 210. The "red" demodulator is called an X demodulator by custom; likewise, the "blue" demodulator is called a Z demodulator. (We
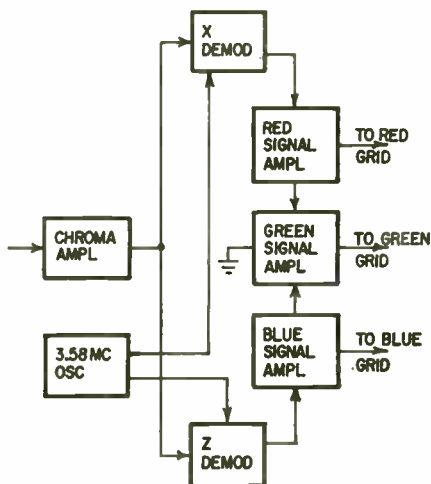

Fig. 210. *X-Z matrix demodulation.*

sometimes refer to the X and Z demodulators as red and blue demodulators.) Actually, the output from the X demodulator is not applied directly to the red grid of the picture tube; instead, it is modified somewhat in passage through the red amplifier. Similarly, the output from the Z demodulator is not applied directly to the blue grid of the picture tube; it is modified in passage through the amplifier.

(A detailed circuit arrangement using X and Z demodulators is shown on the next page and is also essentially repeated in Fig. 807, on page 115. Servicing information for X and Z demodulators is supplied beginning on page 114.) The output of the three color amplifiers is adjusted by individual potentiometers, supplying red, blue and green background control. The potentiometer connected in the cathode circuit of the X and Z demodulators is a matrix balancing control.

The green signal is obtained by matrixing the red and blue amplifier signals. This is done by having a common-cathode cir-
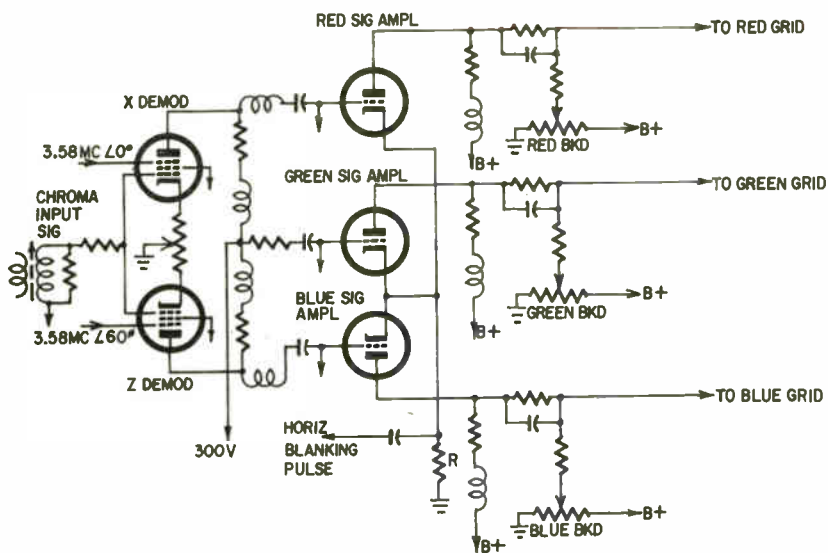
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Fig. 211. *The block diagram of Fig. 210 is shown here in schematic form.*

cuit for the red, green and blue amplifiers (Fig. 211). Note that the common-cathode resistor R, not only provides a matrixed input signal to the cathode of the green-signal amplifier, but also produces interaction between the red-signal and blue-signal amplifiers. This is the reason why the outputs from the X and Z demodulators are not the same as the output from the red-signal and the blue-signal amplifiers.

The common denominator

A comparison of Figs. 205, 209 and 210 reveals that all chroma demodulator and demodulator-matrix systems have one feature in common—their signal outputs are fed to the red, green and blue guns of the color picture tube. This fact is of basic importance to the TV technician. It means that one fundamental test method can be used to check any demodulator system for correct operation or adjustment. A signal that produces maximum drive to the red grid normally produces zero drive to the blue grid.

Demodulator test signals

Demodulator test signals are provided by color-bar generators. Let's consider the keyed-rainbow generator, one of the most

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popular instruments. A keyed-rainbow signal normally provides the pattern of Fig. 212 on the screen of the color picture tube.
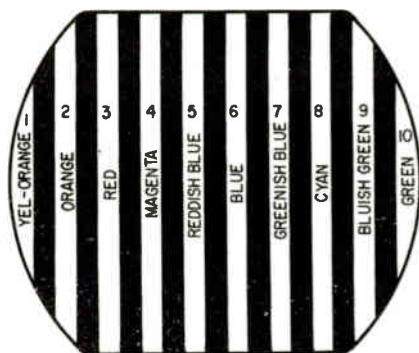

Fig. 212. *Normal keyed-rainbow pattern.*

When there is trouble in the chroma-demodulation or matrix system, colors are incorrect. Although troubleshooting can be guided by the color pattern, circuit action can be evaluated better by scope waveforms.

Waveforms

The key troubleshooting waveforms are given in Fig. 213. Connect a scope and low-capacitance probe to the red-grid
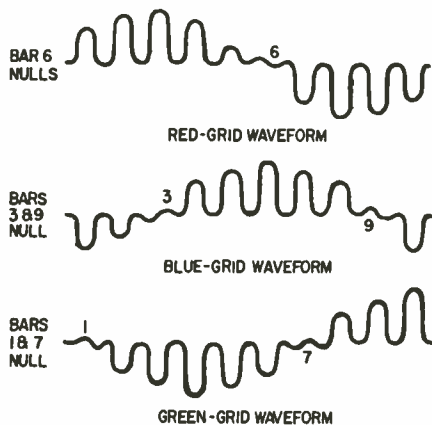
Fig. 213. *Operating waveforms common to all chroma demodulation systems.*

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terminal of the picture tube. Adjust the receiver's color-phasing control to null bar 6, as shown. Then, transfer the scope probe to the blue-grid terminal; bars 3 and 9 should null. Finally, connect the scope probe to the green-grid terminal; bars 1 and 7 should null. If one of the waveforms does not null correctly, it will guide you to the defective circuit section. It can happen that two of the waveforms may not null, due to a defective component in a common branch of two circuits.

Note also that the relative amplitudes of the three waveforms in Fig. 213 guide the technician to defective components in the chroma-demodulator or matrix circuitry. Relative amplitudes may vary from one receiver to another, depending upon the color picture tube used. Hence, check the receiver service data. Fig. 214
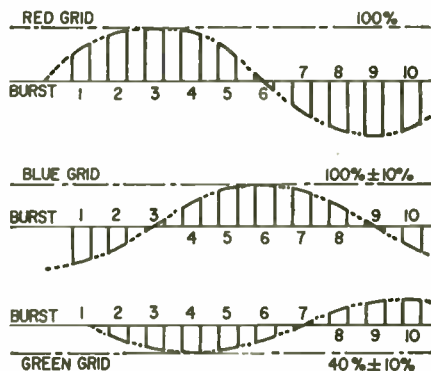
Fig. 214. *Waveform amplitudes and tolerances for a typical color receiver.*

shows the relative amplitudes and permissible tolerances for a typical set. If either the blue or green waveform is more than about 10% out of tolerance, you must check the associated circuit for a defective component.

The servicing approach

Color TV servicing is easy when we forget about the long-haired gobbledegook and approach service problems on a common-sense basis. Color receivers are just another kind of combo. After all is said and done, every circuit boils down to resistors, capacitors, coils and tubes. We need a color-bar generator and wide-band scope to check the chroma section, but a color-bar generator is

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easier to use than an AM signal generator—we do not have to tune a color-bar generator. A wide-band scope operates just like a
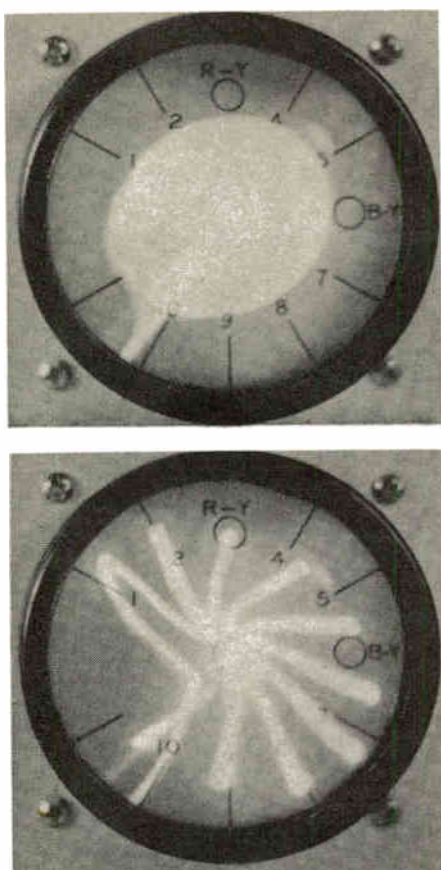
Fig. 215. *Vectorscope patterns. The upper photo is a vectorscope display that shows loss of color sync; the lower photo illustrates poor demodulator alignment.*

narrow-band one. It's also very helpful to have a vectorscope, an instrument that gives a display of color bars spaced 30° apart on a calibrated scope face. Fig. 215 shows two vectorscope patterns illustrating loss of color sync and poor demodulator alignment.

The difficulties of color TV servicing have been trumped up by the gobbledegookers—they are mostly imaginary. Let's get back to plain old common sense.

From the inside to the outside

What we have had so far, as you know by now, has been an encapsulated review of the color section of a receiver plus a few tidbits on how to approach the problem of servicing. But sometimes the trouble with a color receiver has nothing to do with the receiver itself, as some unhappy technicians have learned *after* they lugged a color receiver back to the shop. You can make it a pretty good rule-of-thumb that if a black-and-white receiver is in a location that needs a good outside antenna, then a color receiver in the same area will need one that is just as good—but preferably better.

Servicing means more than just repair. You know it means more than just the replacement of tubes and components that have suffered the onslaughts of time and temperature. It also means taking a critical and appraising look at the roof—something we are about to do in the next chapter.

chapter 3
antennas and boosters

A COLOR TV SET WITHOUT THE RIGHT ANTENNA IS USUALLY A color TV set without color. The cliche about the Cadillac that won't run without gasoline applies equally well to color TV. A thousand-dollar set can't make satisfactory color pictures without the right antenna.

Color antenna requirements

The color antenna must have three things: good gain, ample bandpass and complete freedom from parasitic resonances. This last includes the entire system: antenna, transmission line and booster, if one is used. Pattern shape and front-to-back ratio are very important, in some applications, for maximum freedom from ghosts and interference.

These requirements are not hard to fill. Any *good* antenna will. Ordinarily, if an antenna gives really good pictures on black-and-white, it will be suitable for color.

Antenna troubles

The symptoms of antenna trouble in color reception are definite.

1. Excessive snow or confetti indicates that the signal level is too low.

2. Intermittent drift or sudden shift in colors is usually caused by parasitic resonances, called "dropouts" or "suck-outs," in the antenna system. These cause standing waves on the lead-in, and cancel the color burst or shift its phase.

A good quick-check for this last condition is to disconnect one

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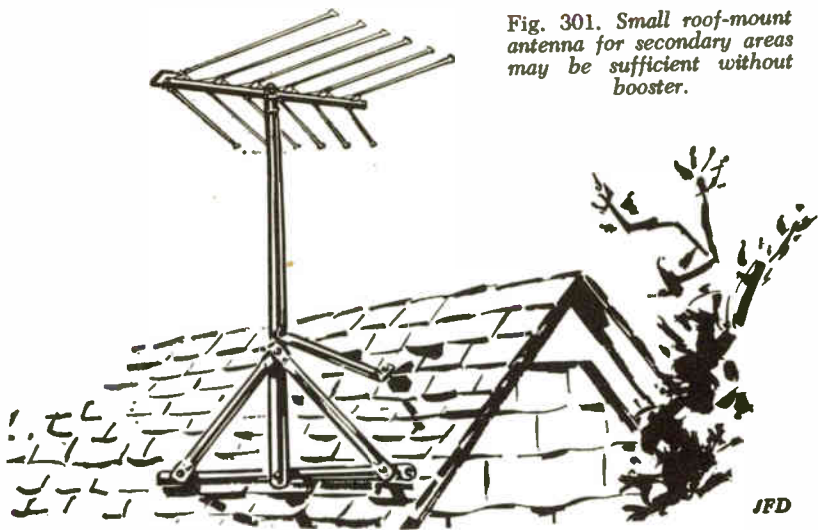
Fig. 301. *Small roof-mount antenna for secondary areas may be sufficient without booster.*

JFD

side of the lead-in as you watch a color program. If the color returns, though the picture goes down into the snow, standing waves are probably cancelling the burst. Wrap a small piece of tinfoil around the lead-in and slide it back and forth while watching the color. If you find a point where the trouble disappears, tape the foil there. This point may not be the same for all channels—you'll have to experiment.

Color ghosts

A third trouble, found mainly in fringe areas, is multipath reception from distant stations. The delayed reception of the second signal causes wavering colored ghosts and color shifts because of phase differences between the two bursts. There is no foolproof remedy for this, but it is almost always temporary, lasting 2 to 3 minutes at most.

Primary-Area troubles

Primary areas also have their share of antenna troubles. If rabbit-ears or built-in antennas are used for color reception, field interference caused by people walking between set and station, reflections from steel-framed buildings or similar objects, can cause color trouble. This is usually in the form of a sudden loss of color. If the set can be placed against the wall of the room nearest the station, the effects will not be so noticeable.

A better remedy is to relocate the antenna. Mount the rabbit-

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ears on the wall above the set, or use a window or attic antenna. The method depends on the circumstances. A simple dipole in an interference-free area up in the eaves, for example, will often help. This should be cut to channel, of course.

In suburban areas, attic antennas are very useful. They are made in several types, some quite directional, with rotators, and are fastened to the underside of roof rafters. An easier installation can be made with the small roof-mount antennas such as the one of Fig. 301. They are made in several sizes, depending on the needs of an installation. The model shown has medium gain and directivity. Others have more elements, to give you a narrower pattern if you need it. This is often necessary to eliminate ghosts caused by reflection from nearby objects. (Table 3-1 is a list of the antenna types to use for different areas.)

Table 3 — 1
ANTENNAS FOR DIFFERENT AREAS

Area (miles)	Antenna type	Booster?
Primary: 0-10	Rabbit-ears, built in, simple dipole window-mount, attic-mount.	
Secondary: 10-50	Roof-mount: dipole-reflector, small combination types, broad-band, log-periodic. Conical with reflector.	Under some circumstances. Test for improvement in picture.
Fringe: 50-100	Broad-band Yagi, log-periodic. Same, with built-in booster. Rotator probably needed also.	Yes. Built-in or added later. Top-mounted or connected behind TV set.
Deep Fringe: 100-150	"Long" broad-band Yagi; multiple elements, with built-in booster. Individual Yagis, each with built-in booster, plus matching network.	Always. Every bit of signal needed here. (For long runs of lead-in, use low-loss open wire line. Never use coaxial lead-in; loss much too high.)

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Signal levels

Too much signal can cause as much trouble as too little. Tuners in color sets are very sensitive, and very high signals can cause curve shift to the point where color will be attenuated or pop in and out. This is due to Miller effect in rf and i.f. amplifier stages. The agc is unable to deal with such great overloads. The answer is to reduce the signal.

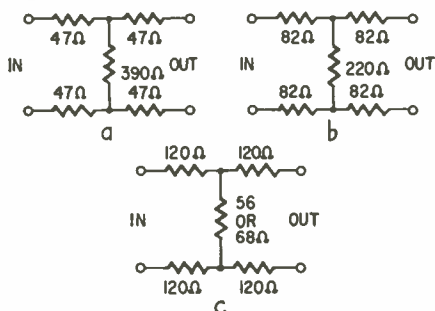The simplest way to add a resistive pad in series with the input. Fig. 302 shows resistance values for three typical pads.

Fig. 302. *Attenuator pads to prevent strong-signal overload: (a) is a 6-db pad (½ signal voltage to the receiver); (b) is a 10-db pad (⅓ signal voltage to the receiver) and (c) is a 20-db pad (1/10 signal voltage to receiver). Also refer to page 141 for further information on attenuator pads.*

These will cover most situations. A quick way to find out which one you need is to make up one of each, attached to clothespin antenna clips (Fig. 303). These can be clipped in series with the lead-in.
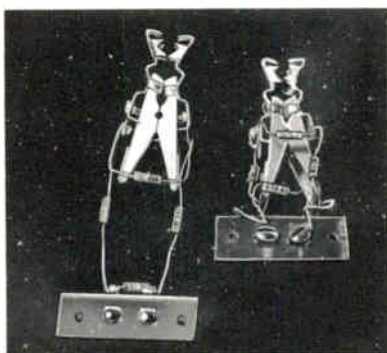
Fig. 303. *Carry a few clip-on pads with you to check out suspected overload problems.*

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After you hit on the right pad, make up a permanent one and attach it to the antenna terminals. A handy place for this is inside the cabinet. Unsolder the lead-in to the tuner, and connect the pad in series (Fig. 304).

TWIN-LEAD FROM
BACK OF SET TO
TUNER

PAD

TUNER

ANTENNA
TERMINALS
ON BACK
COVER
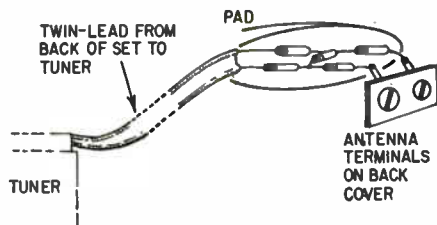
Fig. 304. Once you determine how much attenuation an overloaded set needs, wire the pad permanently inside the set, in the tuner input line.

The formula for computing other values of attenuation pads is shown in Table 3-2. However, those in Fig. 302 will cover almost every situation, since the ajc action of the receiver gives a great deal of latitude.

Table 3—2

The diagram shows a balanced H-pad which can be used to attenuate too-strong TV signals. The two formulas are used to

Balanced H-pad.

$Z_{IN} = 300\,\Omega$ R2 $Z_{OUT} = 300\,\Omega$

R1

$R1 = 150 \times \dfrac{A-1}{A+1}$ $R2 = 300 \times \dfrac{2A}{(A+1)(A-1)}$
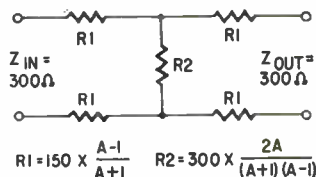
figure the two resistor values; A is the *number of times* the input signal is to be decreased—*not* the number of db. That is, to get an output equal to *half* the input, you decrease the input *two* times. Hence A = 2.

In the 20-db pad of Fig. 302, the formula works out this way:

$$R1 = 150 \times \frac{10 - 1}{10 + 1} = 150 \times \frac{9}{11} = 123 \text{ ohms}$$

$$R2 = 300 \times \frac{2 \times 10}{(10 + 1)(10 - 1)} = 300 \times \frac{20}{99} = 60 \text{ ohms}$$

The nearest EIA ½-watt, 10% values are satisfactory for these pads. In our example, these would be 120 and 56 (or 68) ohms.
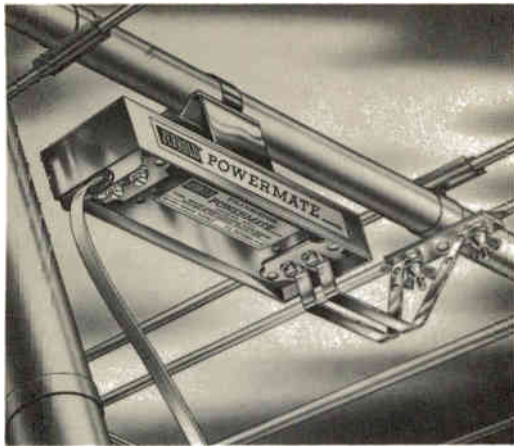
Fig. 305. *Best place for the booster is at the antenna. Most boosters draw power through signal lead-in.* (Jerrold)

Several manufacturers make printed-circuit resistor pads in several attenuation values, and some have "substitution box" devices, permitting you to switch in different amounts of attenuation before deciding on an optimum value. Check catalogs or your distributor.
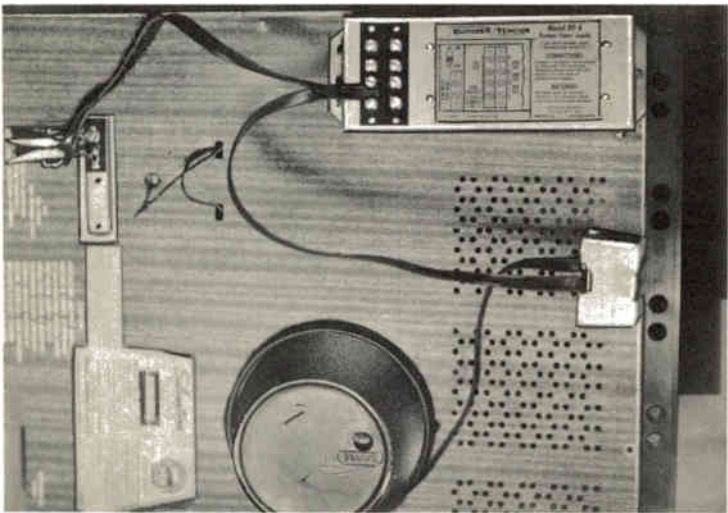
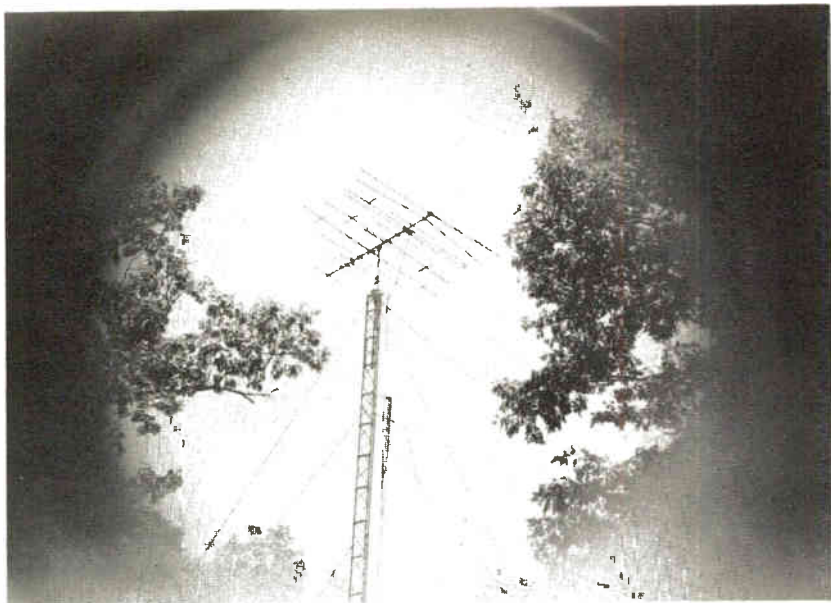Fig. 306. *Back of the receiver is a convenient place for untuned, broad-band booster.*

Fig. 307. *Fringe areas require top-notch antenna installation plus booster installed at the antenna.*

Secondary areas

In secondary area installations (within 50 miles of the station) many people try to use existing antenna installations. If they are more than 2 or 3 years old, they may not be good enough for color. Deterioration of the lead-in, corrosion at the antenna terminals, misorientation and many other troubles show up. The signal strength *must* be checked before making the color installation final.

In cases where the existing antenna is fair but signal levels are low, the remedy is a booster. Transistorized boosters can be very helpful in these cases. Many of the later antennas include "built-in" transistor boosters, with gains up to 14 or 16 db, as in the type shown in Fig. 305. The best location for these is at the antenna terminals, as shown, but they can be used at the back of the set (Fig. 306) to avoid the time and expense of lowering and raising a tall antenna.

The simplest way to find out whether a booster will help is to

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try one. Many technicians carry one of the small transistor boosters, fitted with clothespin connectors, in their service kits. It may be snapped into circuit instantly to see how much improvement results. Performance will be slightly better with the booster installed at the antenna.

Precautions: No booster can *make* a picture; this is the purpose of the antenna. Boosters can *improve* any picture, but a fair amount of signal must be there to start with. The major purpose of the booster is to clean up marginal signals, remove snow and give more positive color lock.

Fringe areas

The precautions needed in secondary areas are also necessary in fringe areas. Antennas must be the highest-gain types available, and powerful boosters are also a must. Antennas of the type in Fig. 307 may give reception over distances up to 150 to 175 miles under good conditions.

Absolute height is not the important factor that it was once thought, although it is decisive in some areas. In many fringes today, antennas are about 30 feet in height, instead of 100 feet or even more. Field testing disclosed that this was about the optimum height for good reception. Very careful installation techniques are necessary to keep these taller, heavier antennas up.

Lead-in troubles

Look to the lead-in for problems of poor color response. Not all twin-lead is 300 ohms even though it may have been purchased as such. The cheaper varieties are not manufactured to rigid specs and what their impedance may be is anybody's guess. In any event, ordinary twin-lead is certainly not the best way of getting the signal down from the roof. Twin-lead can act as an antenna in its own right and the signal it picks up is certainly going to be out of phase with the antenna signal . . . to say nothing of noise voltages it receives. And it is also affected by any stray metal it is close to, including metal gutters and drain pipes.

If you want to substitute coax you can use a balun mounted right on the mast to get a match between a 300-ohm antenna and 75-ohm coaxial cable. You will then need a matching transformer at the input to the set to get that 75 ohms up to the 300 ohm input. And if the receiver's input is 75 ohms, it shouldn't have been using 300-ohm twin lead (or its not-so-reasonable facsimile) in the first place.

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Amplified distribution systems

Color sets are often connected to amplified signal distribution systems. These may be community antenna systems in small towns, or systems in large apartment houses or hotels. The very broad-band amplifiers used with these systems give good reception, for there is no chance of clipping color bursts, as was once thought possible.

However, in high-signal areas, one peculiar trouble has been found: undesired direct pickup at the receiver. Since the signal suffers some delay in traveling through the coaxial cable of the distribution system, the direct pickup will be slightly out of phase. This phase delay results in color trouble, usually showing up as cancellation of burst and sudden dropouts of color.

To test for this condition, remove the antenna connection and connect a temporary dipole or rabbit-ears antenna to the set. If there is enough signal to make even a snowy picture, there is a possibility of interference. The remedy is to shield the antenna connection. Use shielded 300-ohm two-conductor cable between the distribution system terminal box and the set. It may be necessary to replace the short link between the terminal board and tuner with the shielded wire.

Just as in all other branches of TV work, selection and installation procedure will vary with individual technicians. There are no hard and fast rules for success. Thorough field testing, with a careful evaluation of the results, will be the most helpful single factor. There is no such thing as the *"one* right antenna" for any area: there will aways be a choice between types and makes.

Antenna pointers

1. Check the antenna connections at the receiver for corrosion and poor contact.
2. Check the antenna connections at the antenna end for corrosion and poor contact.
3. Is the antenna corroded or covered with soot?
4. Is the lead-in frayed, broken, or touching the building or antenna mast?
5. Has the antenna changed orientation?
6. Has a second receiver been attached to the antenna without the owner's knowledge?
7. Has the antenna been blown away or removed by the landlord without the owner's knowledge?

8. Is the lightning arrester causing trouble due to leakage?
9. Has the owner been sold a replacement antenna lately that might not be suitable for color . . . especially the channel used for color?
10. Have any of the antenna elements been damaged or blown off so that the antenna response could change?

(Motorola)

Back to the receiver

As you can see, taking care of the problem of the antenna for color TV is almost the same as for black-and-white—only more so. A general rule is that it takes a good antenna to supply a good signal—and no matter how perky the TV set is, it needs at least this much.

Back at the receiver one of the problems(yes—there may very well be more than one) might be the picture tube. The years have slipped by and many a color receiver has a long overdue picture tube replacement need. There are more ways of having fun than putting in a new color picture tube, but it certainly isn't nearly as bad as you might think. The next chapter gives you full details on how to tackle this job.

chapter 4
replacing the color picture tube

WHEN A DEFECTIVE COLOR PICTURE TUBE MUST BE REPLACED, don't throw up your hands in despair and wonder how you'll ever do it. This will probably be your first reaction if you have never had this experience. And if you have replaced color picture tubes, go through this chapter for useful ideas that may make the next replacement job an easier one. This chapter deals with color picture tube replacement, step by step, so that any service technician can do it. The photos show the exact settings of the units on the neck of the color tube and the text follows along the same lines.

Installing a new color picture tube is a five-step procedure:

1. Removing the chassis and picture tube.
2. Removing components from the picture tube. See Fig. 401.
3. Installing components on the new picture tube.
4. Installing the tube and replacing the chassis in the cabinet.
5. Receiver convergence.

The receiver described in this chapter is an RCA set although replacing most other color picture tubes calls for the same procedure.

Removing the chassis and the CRT

After pulling off all front knobs and removing the rear cabinet cover, disconnect the high-voltage lead going to the picture tube. In older sets, this lead must be unfastened from the metal

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YOKE ASSEMBLY

BLUE DC ADJ MAGNET

PURITY RING

BLUE LATERAL BEAM MAGNET ASSEMELY

DYNAMIC CONVERGENCE COILS

GREEN DC ADJ MAGNET
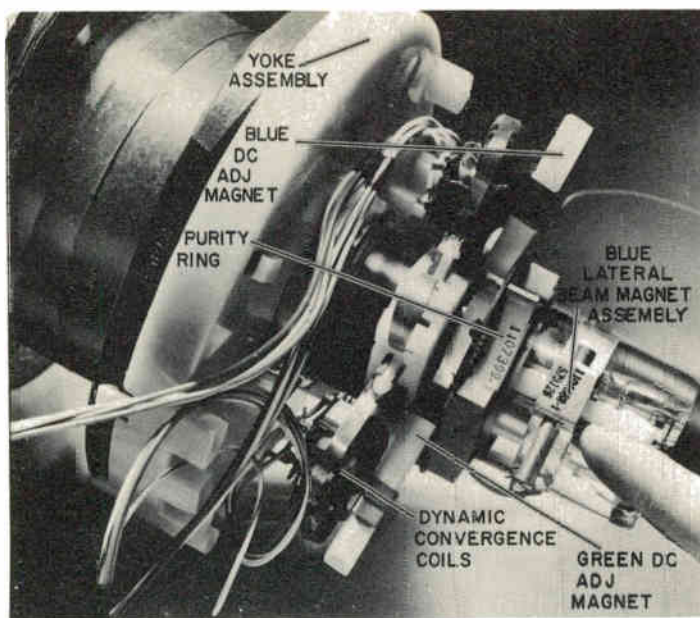
Fig. 401. *View of assemblies around the neck of the picture tube.*

box before you open the box lid. Push down against the high-voltage connection with a long insulated screwdriver to discharge the high voltage. This lead will pull straight out of a pin socket. In newer sets, the high-voltage lead unplugs from the glass picture tube.

Now remove all wires connected to components on the picture tube. Remove the picture-tube socket and the yoke leads (Fig. 402). All the colored wires going to the deflection yoke are marked on the yoke where they plug in. There is little danger of getting them wrong when replacing them. Unhook the blue lead from ground to the blue lateral magnet. Unplug the speaker cable. Unplug the convergence yoke cable from the top of the chassis and loosen the two ¼-inch bolts that hold the antenna assembly to the case. Slide the antenna assembly out and down.

One or two chassis bolts at the top of the chassis and two bolts in the bottom of the chassis must be removed. Now slide the chassis out about 3 inches and loosen the ¼-inch metal

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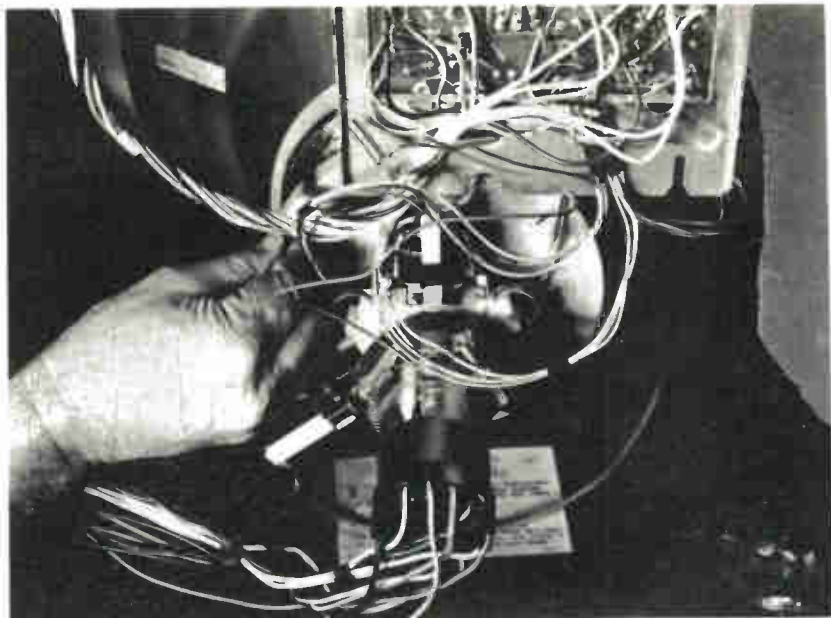
Fig. 402. Unhooking the leads from the yoke assembly so the set chassis can be removed.

Fig. 403. With the chassis removed, only the color CRT and the convergence chassis remain. (Also see Fig. 902 on page 123.)
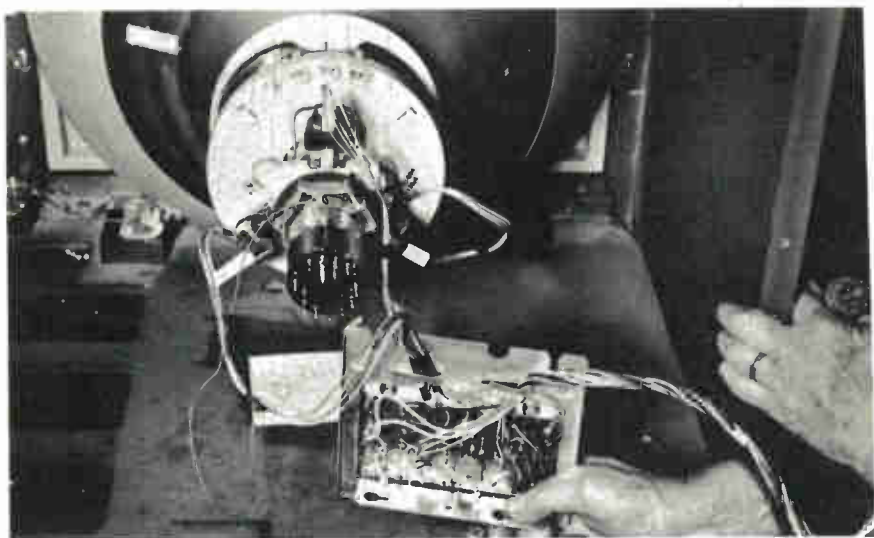
screw that holds the small-controls assembly down. Slide the unit back and then lift up. The chassis is now free and can be removed (Fig. 403). After the chassis has been removed, it may be wise to turn the cabinet over on its face before removing the CRT—especially if the top and side of the set you are working on are not removable.

Four nuts hold the picture tube in place—two at the top and two at the bottom of the assembly. Loosen the bottom nuts first, then the top two. Two men should work together to remove the picture tube from the receiver cabinet. You can use only one man, but you will find that the cabinet may start to crawl. The picture tube is heavy too.
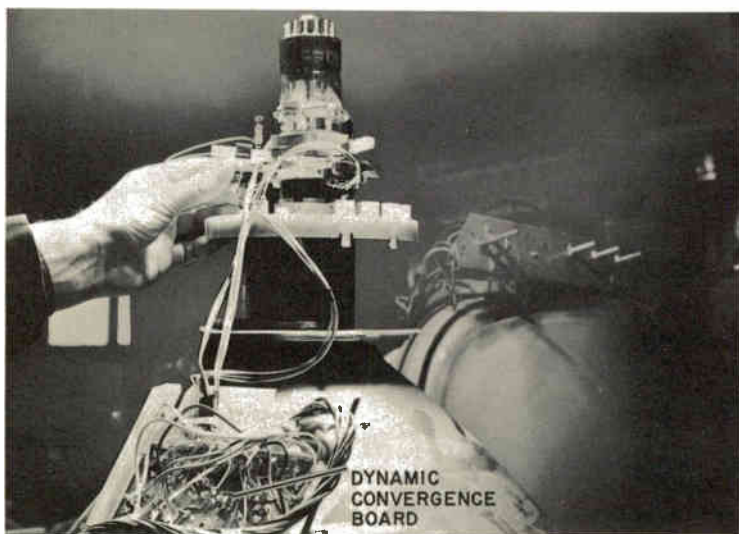
Fig. 404. *With the color tube on your bench, start removing the yoke and convergence assemblies.*

You can remove the components from the tube while it is in the cabinet or on the bench (Fig. 404). Note: Everything was left on the color tube so pictures could be taken as each was removed.

Removing components from CRT

Place the kinescope face down on a drop cloth or newspaper to protect the face from scratches. To be sure that the com-

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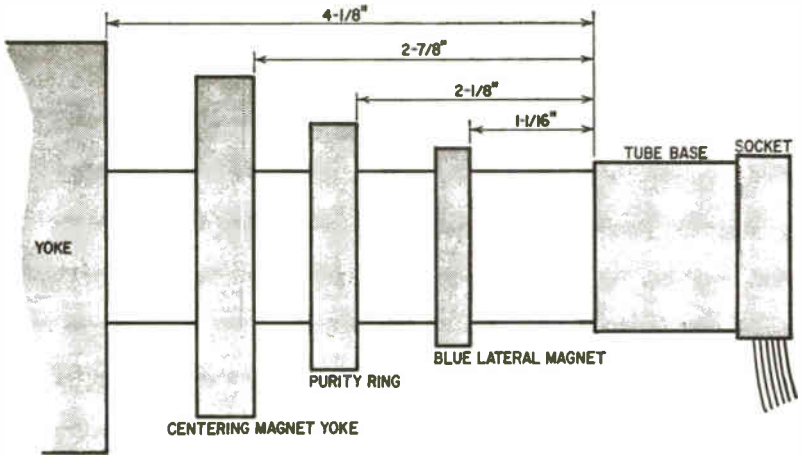
Fig. 405. *Measure the spacing between components before removing them from the CRT neck. The measurements may be only approximate, but they are very helpful when replacing parts on the neck of a new picture tube.*

Fig. 406. *Measuring position of elements around the CRT neck in relation to the base of the tube.*
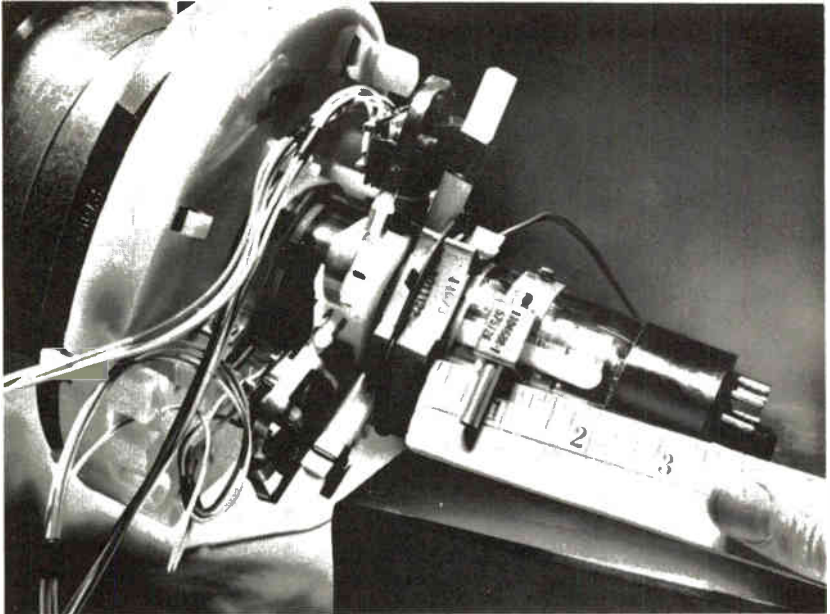
Fig. 407. Center purity ring is lined up with the red stripe on the neck of the CRT.

Fig. 408. Closeup shows greater detail of convergence elements.
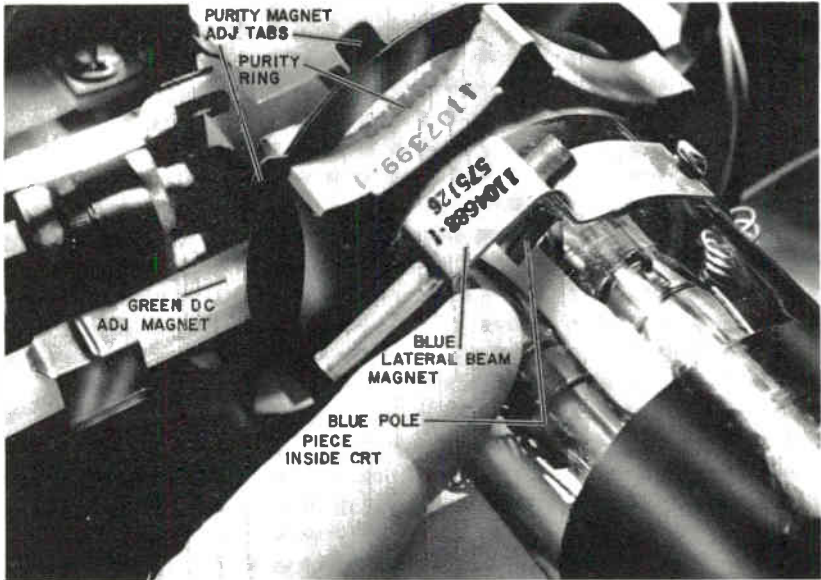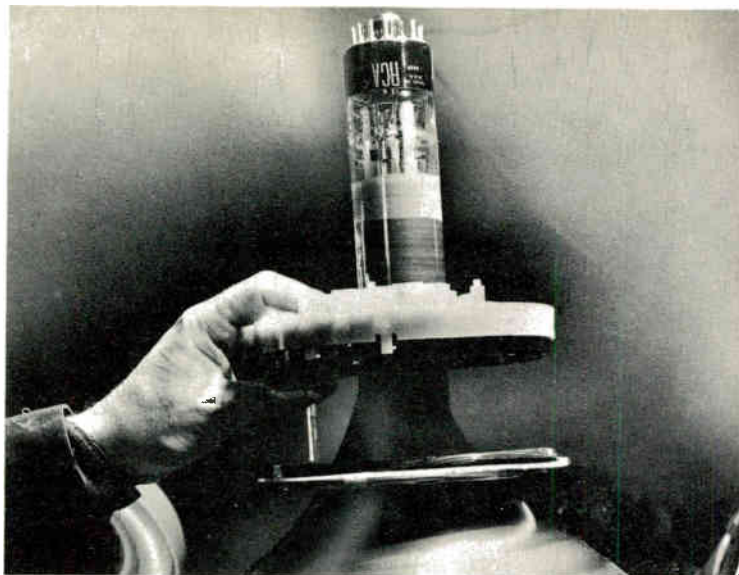
Fig. 409. *Removing the yoke from a defective color CRT. Be careful! That yoke is heavier than you may realize.*

ponents will be replaced on the new tube correctly, measure the settings, with a rule, from the base of the kinescope. Fig. 405 shows the settings in inches for a tube that was removed. Make all measurements with reference to the tube base as shown in Fig. 406. When you remove the blue lateral magnet, you will notice that it sits right over a clip inside the picture tube.

The purity ring sits over the red ring marked inside the tube (Fig. 407). Notice that the center adjustment magnet and convergence yoke are mounted at the opposite end of the red ring (The convergence elements are shown in greater detail in Fig. 408.) Note also that the blue wires from this yoke are at the top of the picture tube over the blue gun, the red wires at the right side and the green wires on the left going to the green dynamic convergence coils.

The large deflection yoke is loosened with a ¼-inch nut driver and slid off the end of the tube. It is heavy; don't be surprised into dropping it (Fig. 409).

The masking must be removed from the front edge of the picture tube. On older sets, the mask extends several inches down
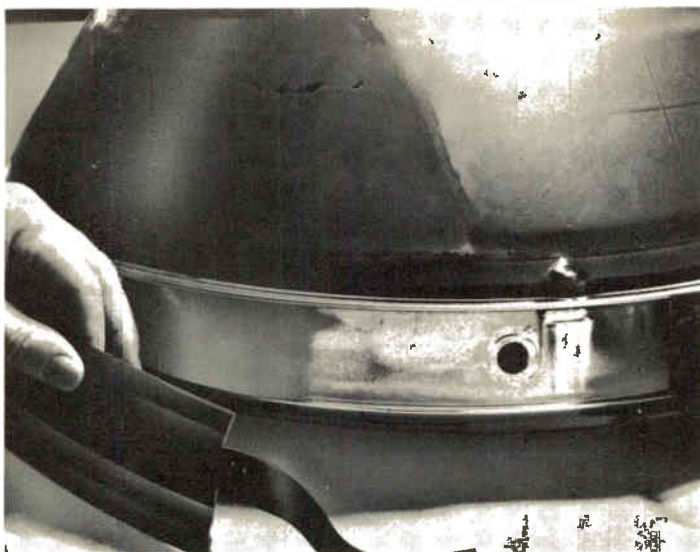
Fig. 410. *Removing front protective mask from the face of the tube.*

onto the tube. Plastic tape holds or seals the joint of the mask section (Fig. 410).

Replacing components

When placing the mask on the new picture tube, be sure that the center of the face mask (there is a mark on the new mask showing the center) is placed in line with the blue gun. The blue gun is always at the top of the screen. Use either plastic tape or masking tape to hold the mask in place. At this time, the new color CRT can be placed in the receiver cabinet.

First, be sure the safety glass has been washed and cleaned. Also, make sure there is no lint or dirt on the face of the new CRT. Then tip the picture tube and push it into the cabinet. Check to make sure that the blue gun is up and set the tube into its plastic holders. Help is needed here. At this time, check to see if any foreign matter has fallen into the front glass. If not, place the four nuts over the metal tube harness and tighten them.

Now slide the yoke into place and tighten the ¼-inch bolt

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slightly (Fig. 411). You should still be able to push the yoke back and forth on the picture tube neck. Install the other components, making sure they are in proper order and spacing them according to the measurements you made when you removed them from the defective tube. Now replace the TV chassis and reconnect
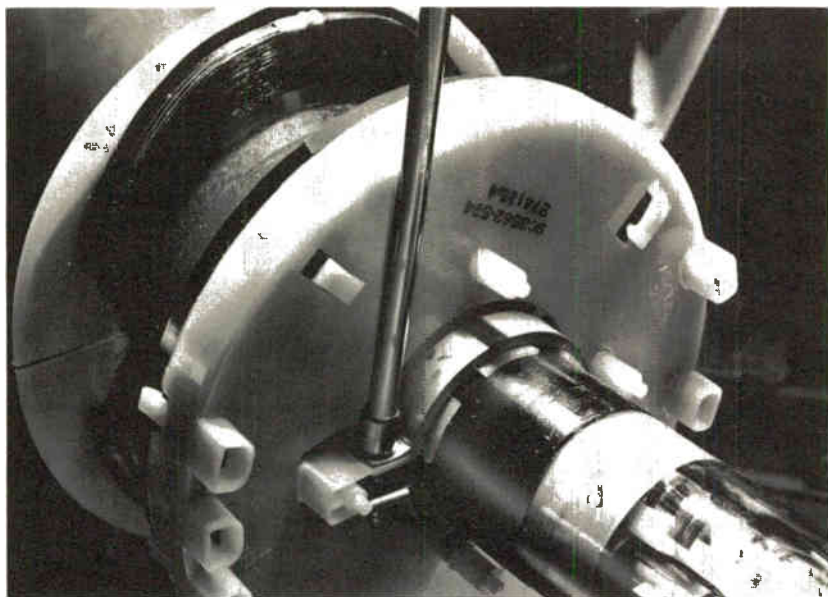
Fig. 411. *Replacing the yoke assembly. (Also see Fig. 903 on page 123.)*

all leads. Once everything is back in place, turn on the receiver and let it run for 15 or 20 minutes before converging the set.

Receiver convergence

Before starting to converge the TV screen, turn the dot-bar generator on and let it warm up thoroughly. While it is stabilizing, take your degaussing coil and demagnetize the set. After degaussing, if you see any color shading anywhere on the screen, purity must be adjusted.

To start the purity adjustment, turn off the set and unplug the i.f. cable going to the tuner. Plug the ac interlock cord back in and, after the receiver warms up, short the green and blue grids through a 100,000-ohm resistor. There are commercial kinescope grid-shorting switch boxes on the market for this purpose. Now the screen is red. Adjust the center purity ring for center red

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coloring. Then push the yoke back and forth and adjust the purity ring until the entire screen has an even red tint.

If this is done correctly, the green and blue shading will fall in line. It is always best to check each one separately by shorting the other two grids to ground through a 100,000-ohm resistor. If there is still shading or color at the edges, adjust the hairpin magnets at the outside or (on the older sets) bell of the tube to erase them. These magnets are not used on the newer sets. If a little shading persists, try degaussing the kinescope again.

At this point, check two things. Be sure the picture is level and in focus. The temperature and black-and-white adjustments generally are not too far off if these controls did not get bumped. Check receiver operation on black-and-white. If adjustment is required, follow the manufacturer's setup procedure.

On later-model receivers, convergence adjustment is comparatively easy. Connect the dot-bar generator to the antenna terminals and set the generator to the same channel as the TV receiver. Remove the convergence board assembly from the back of the set and place it on the slots at the top and back of the receiver. Tighten the two metal screws so the board is solidly in place. Watch the wires that connect to this board and the yoke assembly so that they do not get hung up.

Do the vertical convergence first. If the receiver was properly converged when the picture tube went out, the dynamic convergency controls will need only a touchup. Put the dots on the screen and check down the center for a white dot. Short the blue gun with the 100,000-ohm resistor. Bring the red and green dots together in the center of the screen, sliding the green and red beam center magnets to set the dots on top of one another. Check and readjust this setting several times to make sure it is right.

If they won't quite come together, rotate the red magnet (Fig. 412) a half turn and reinsert it, and the dots will come together. Once they are together in the center of the screen, short the green grid and line up the red and blue dots. The blue-beam center magnet moves the blue dot up and down. The blue lateral beam moves the blue dot horizontally. Place them on top of one another. Go back and check the red and green guns again. Now check all three dots, which should result in a white dot. The amplitude and the tilt controls should be adjusted unless the dots fail to drop in.

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It is best to step back and take a look at the screen with a station tuned in, to observe the colors that are bleeding through. After this observation, switch the dots back on and check vertical convergence across the screen.

Fig. 412. *Dc magnet assembly is lined up at this end of the red stripe on the color CRT.*

On later receivers, half the screen can be converged at a time. Short the blue grid to ground. Adjust R-G-1 (Fig. 413)
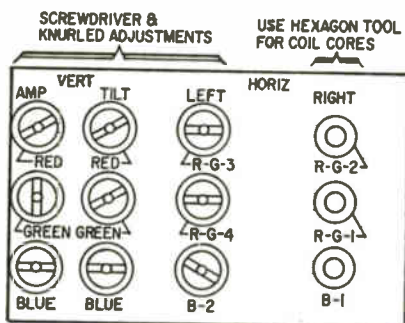

Fig. 413. *Typical convergence adjust-ment board.*

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to make the vertical dots converge on the left side. Then adjust R-G-2 to make the horizontal dots converge on the right side. Adjust R-G-4 to make the red and green horizontal dots converge on the left side of the screen. Go back and touch them up again.

Now short the green grid and converge the red and blue dots. Check to make sure the red and blue dots converge down the center of the screen. Adjust coil B-1 to make the blue dots fall on the red dots in the right side and adjust B-2 to adjust the horizontal blue dots to fall on the red dots on the left side. If the blue dots are too high, lower them with the blue beam centering magnet. If they are to the right or left, adjust with the blue lateral positioning magnet. Remove the short from the green grid and white dots should appear all over the screen. It is impossible to get a 100% converged screen, although the new color sets are much easier to converge than those of several years ago.*

Go over convergence adjustments several times. Be sure you are satisfied with the convergence. Check the focus of those dots, for changing the focus will throw the convergence off. Practice makes perfect, but be sure to fill out the warranty tag for the new color picture tube just installed.

Other tubes

You may be wondering why we have concentrated on the picture tube and neglected the other tubes, especially when tube troubles are just as prevalent in color receivers as in black-in-white. Actually, tube troubles in a color TV receiver are more common than in a black-and-white set for the simple reason that there are more tubes. However, since tube replacement is such a quick way of repairing a set or bringing up its overall level of performance, we've included tube replacement information in the next chapter. That chapter supplies general information for the rapid repair of color TV receivers. Later chapters deal with more difficult repairs—but more difficult only in the sense that they concern troubles that are not as easy to locate.

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*Many manufacturers have mounted the dynamic convergence board where it is more accessible from the front of the set. Some receivers feature some form of automatic degaussing.

chapter 5
how to pinpoint the
defective color section fast

AS WE TOLD YOU AT THE END OF THE LAST CHAPTER, TUBE troubles in a color TV set are going to be with us, so the experience you have gained with black-and-white will still be essential. There are some tubes in the color TV receiver that perform a dual purpose in the sense that they are needed whether you are tuned to a color picture or one in black-and-white. The audio output tube is an example. You need it no matter what program is being picked up. However, we must assume you know enough to check the audio output tube if the symptom is no sound. All we are concerned with here is color—what tubes do we consider with suspicion if there is no color, or weak color or if there is loss of color sync? When you get symptoms such as these, your first service step is to consider the tubes indicated in the color TV trouble chart given in Table 5-1.

Troubleshooting

Color TV troubleshooting can be greatly simplified by dividing the set's circuits into two major groups—circuits needed for both color and black-and-white pictures, and circuits needed only for color pictures. A defect in the first group is handled just as though it were in a standard monochrome receiver. A defect in the "color only" circuits calls for new techniques. Localizing the bad stage is the usual procedure. And this chapter details some quick checks to help you do just this.

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Table 5 – 1. COLOR TV TROUBLE CHART

When these symptoms appear, test the check-off tubes as first service move.

Possible Tubes	NO COLOR	WEAK COLOR	LOSS COLOR SYNC.	COLORS COME AND GO	HUM BARS	MISSING or TINTED	
						HUES	RASTER
Bandpass Amplifier	X	X			X		
Color killer	X	X		X	X		
Burst keyer			X				
Burst amplifier			X				
3.58-mc oscillator	X		X			X	X
Reactance tube	X		X				
Phase detector	X		X				
Demodulator tubes					X	X	X
Tuner, i.f. & video amps	X	X			X		

The color section

The color portion of the receiver breaks down into several sections (Fig. 501), but finding the defective one is easier said than done. (Fig. 201 in chapter 2 showed us the relationship—
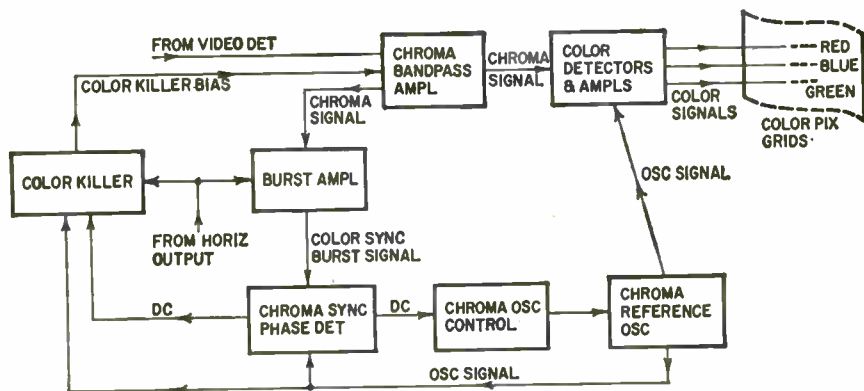
Fig. 501. *Block diagram shows division of receiver's color section and the various signal paths for the color signals. (Also refer to the block diagram shown in Fig. 601 on page 79.)*

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in block diagram form—of the color and monochrome sections, giving us an overall view. Since we are now interested in details Fig. 501 supplies us with a more thorough approach to the color section.)

No color

When the complaint is no color, any of the sections except the color detectors and amplifiers can be at fault. A defect in this section would cause a loss of one or two colors rather than a complete color loss. Fortunately, a few simple checks can quickly determine which section is defective.

The first check tells us whether the chroma bandpass amplifier is working. The schematic of such an amplifier is in Fig. 502.
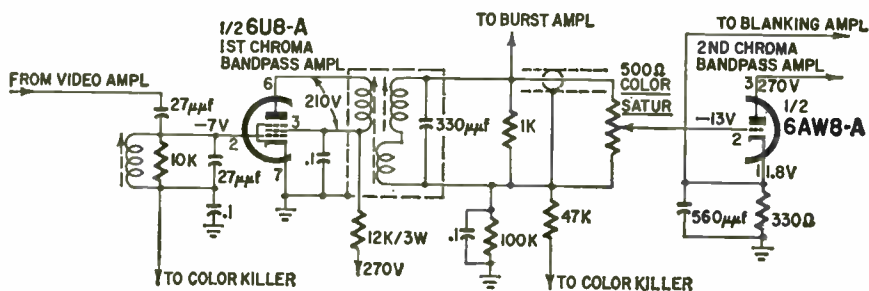
Fig. 502. *Circuit of the chroma bandpass amplifier. This circuit amplifies color information only.*

Notice that the grids of the bandpass amplifiers connect to the color-killer circuit. When a color receiver is tuned to a monochrome station, the color-killer circuits supply enough negative bias to the bandpass amplifier grids to make them inactive. This prevents the amplifier from interfering with the monochrome picture.

When a color signal is being received, the color killer is turned off, removing the negative bias from the bandpass amplifiers.

Since a defect in the color killer, or an associated circuit, might permit this bias to remain even when a color signal is being received, pull the color-killer tube to check the bandpass amplifier.

If the bandpass amplifiers are working, color will appear on

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the screen. It may be badly out of sync, but will be there if the amplifiers are working.

If no color appears when the color-killer tube is pulled, the defect is in the bandpass amplifier section and a scope can be used to locate the defective amplifier. Resistance and voltage measurements will pinpoint the defective component.

If pulling the color killer restores color to the receiver, the defect is in the chroma reference oscillator and its control circuit, the chroma sync phase detector, the burst amplifier or the color killer.

The chroma reference oscillator and its control tube are shown in Fig. 503. Check the oscillator by measuring the bias at its
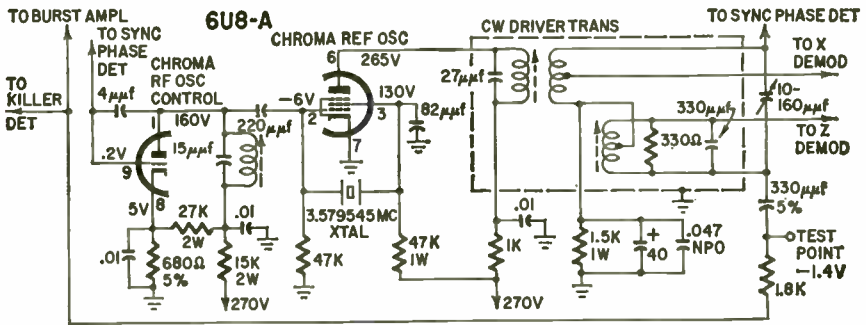
Fig. 503. *Chroma reference oscillator and the chroma rf oscillator control tube. This circuit provides the necessary reference frequency for the detection of the color signals.*

grid. If the oscillator is working, you should find about − 4.5 volts. If you read low or zero voltage, the oscillator is not working.

The first step in checking the oscillator is to substitute a new crystal. If this fails to restore operation, voltage and resistance measurements will lead you to the defective component.

If the reference oscillator is working properly, check the burst amplifier next. A diagram of a burst amplifier is in Fig. 504. It
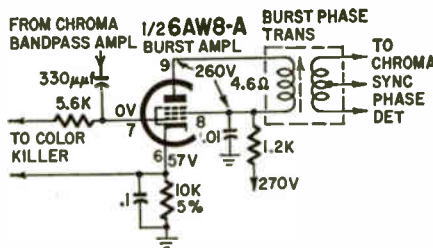
Fig. 504. *The burst amplifier circuit amplifies the color burst signal.*

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consists of a single tube and can be checked quickly with resistance and voltage measurements. If this section checks out, the only ones left are the color killer and the chroma sync phase detector.

An example of these circuits is shown in Fig. 505. Here again,
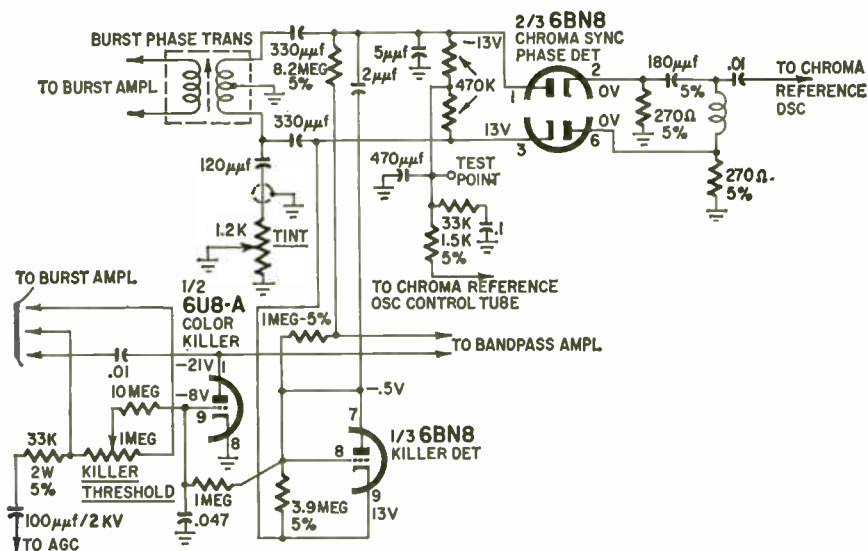
Fig. 505. *The color killer and the chroma sync phase detector circuits. The killer circuit makes the chroma bandpass amplifier inoperative when a black-and-white signal is being received.*

as with the burst amplifier, the circuits may be checked with resistance and voltage measurements.

Color signals in black-and-white

A defect in the chroma sync phase detector can produce picture tinting in the form of horizontal rainbows across the picture. The trouble results in loss of control over the reactance circuit, and thus indirectly over the chroma reference oscillator. A defect in the color killer can result in color signals appearing in black-and-white transmission.

Improper color

When the complaint is improper color, and adjusting hue and saturation controls does not remedy the situation, one of the primary colors that drive the picture-tube color grids is probably missing.

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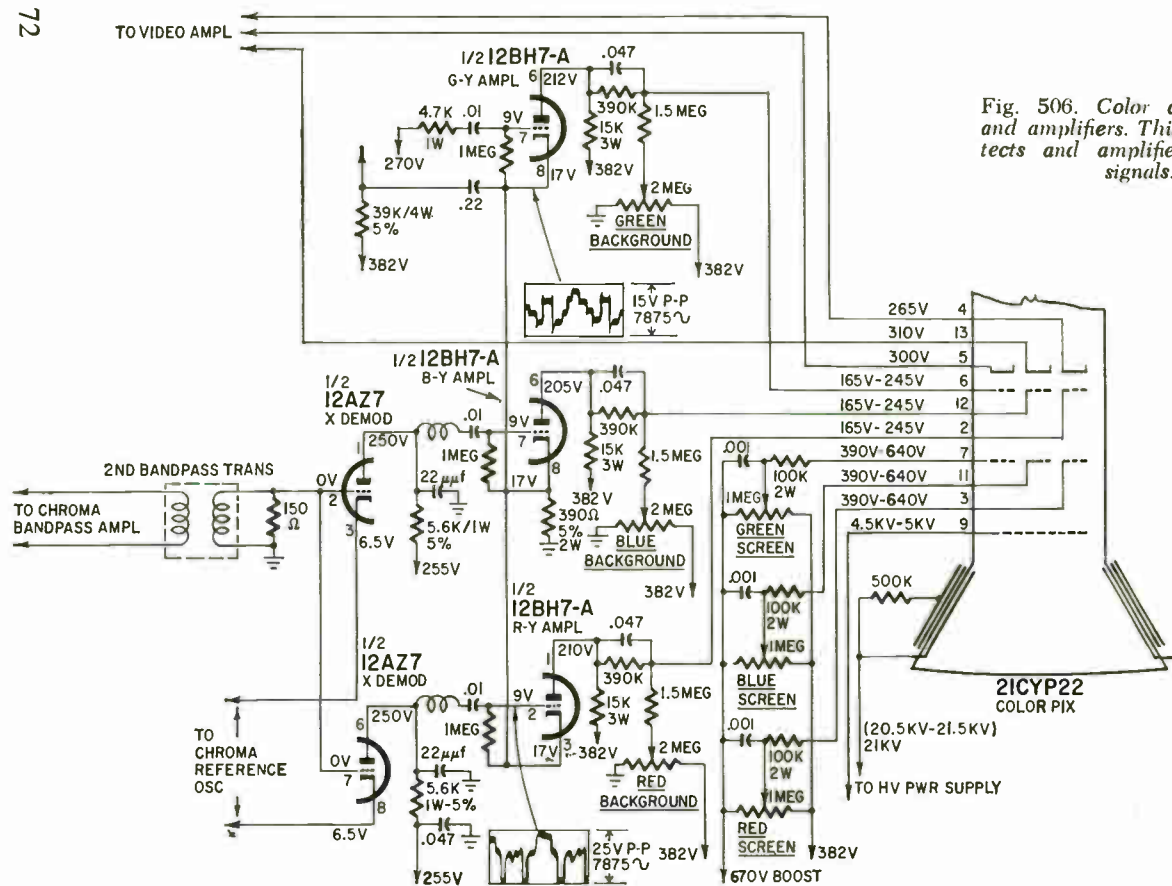
Fig. 506. *Color demodulators and amplifiers. This section detects and amplifies the color signals.*

In this case, the trouble lies in the color detectors and amplifiers. Fig. 506 is the circuit of this section.

While similar symptoms can be caused by improperly setting background and screen controls, there is a quick way to find out whether all colors are present.

Pull the G — Y amplifier and the B — Y amplifier. If the R — Y amplifier and its associated detector are working, an all-red image will appear on the screen of the picture tube.

Next, replace the B — Y amplifier and pull the R — Y amplifier. If the B — Y amplifier and detector are working, an all-blue image will appear. Use the same method to check the G — Y amplifier.

If one of the colors is missing, no image will be produced when its respective amplifier is plugged in.

No color sync

The complaint of no color sync can be caused by the chroma sync phase detector, the reference-oscillator control tube or the reference oscillator. To determine if the defect is in the phase detector or the oscillator and its control tube, ground the grid of the control tube. This removes any voltage fed to this grid by the phase detector.

If with the grid grounded, the colors roll slowly through the picture, the phase detector is the defective section. It may then be checked out with resistance and voltage measurements.

If the color remains badly out of sync with the grid of the control tube shorted, the defect is in either the control tube or oscillator section. These sections can be checked with voltage and resistance measurements.

Checking out a color TV set

There's a simple procedure for checking out a color TV set. Just follow the checklist shown in Table 5—2. It's actually the same checklist used by the expert color technician when he makes

TABLE 5 — 2. CHECKLIST FOR GOOD COLOR INSTALLATION
1. Picture: good black-and-white, no color tinting. (Color temperature)
2. No colored areas on screen. (Purity)
3. No colored fringes around objects. (Convergence)
4. Color control: Covers range from off to too bright.
5. Tint control: makes faces go from greenish to reddish.
6. Fine tuning: goes from "worms" to black-and-white picture.

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those all-important preliminary tests. These things must be right, before we *can* do anything else. Just as in black-and-white TV, the action of the controls tells us a lot about where the trouble is or, more important, where it *isn't*. So let's go through this checklist, in plain English, one thing at a time.

Some of this may sound a bit elementary, but don't let it fool you. If you plan to service color TV you'll make many a color service call to do nothing more complex than turn down the contrast control! (It was more fun before they got smart and hid the color-killer control). These are all eyeball tests: no test equipment needed. From the results, we can tell what is wrong, if anything.

Tuning-up

Do *you* know how to tune a color TV set? A lot of people don't, simply because no one has ever showed them! (This is one of the installer's main jobs: he should show the set owner how to *run it!*) It's simple, really. Tune just as in black-and-white. Then turn up the color control till you see color in the picture. (This is easier if the show is in color, of course!) Now, check people's *faces*. If they don't look people-colored, adjust the tint control till they do.

Always set the tint control on human faces — never on any other colored object in the picture. Turn the color control up or down to get a natural-looking picture. Finally, recheck the fine tuning; if it isn't exactly right, you may have trouble. That's all there is to it.

New installations

Let's see what a new set ought to do if it's properly installed and adjusted. First, it must make a *good* black-and-white picture. No blobs of color on the screen, no colored fringes around objects at normal viewing distance. (You can put your nose right up to the screen and see a little fringing in most of them, around the edges. 100% convergence is almost impossible, although some of the new sets get awfully close to it.) However, if the picture looks "clean" at normal viewing distances, fine. Remember, *all adjustments on a color set are made to get a good black-and-white picture! If these are correct, then the color will take care of itself.* Now let's run through the operating controls and see what their normal reactions ought to be.

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The operating controls

1. *Brightness.* From blackout to a "too-bright" screen. The picture should bloom very slightly and may go out of focus at "full-up." This is normal. Watch closely to be sure that the picture stays black-and-white at all usable brightness levels—no tinting.

2. *Contrast.* Just like black-and-white. Normal setting, in all but the very latest models, is full *off!* Full-on contrast will give a harsh picture and very bad *apparent* misconvergence! This is normal, too.

3. *Color.* Off, for black-and-white pictures. As you turn this control up, the colors should gradually get more vivid (go from pale pastel to bright and glaring). There must be no change in the color (hues) themselves, only in their intensity. This is a "color volume control."

4. *Tint or hue.* This one *changes* the colors. Normal range: human faces should go from a sick greenish color at one end, to a purplish-red at the other, sort of a cross between a bad sunburn

Fig. 507. *"Worms" or "wiggles" in the picture because of improper adjustment of the fine-tuning control.*
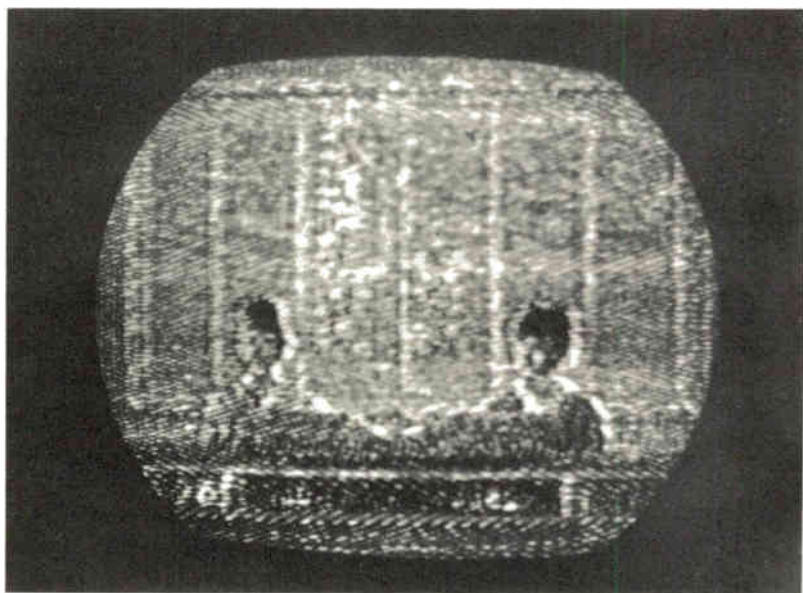
Fig. 507 (continued). *This is a blown-up view of "worms" or "wiggles" in the picture.*

and an alcoholic's nose. Somewhere in the middle, faces will be "natural-looking."

5. *Fine-tuning.* This one is important in color. Turn the fine tuning through its full range on a color show. At one side, you'll see sound in the picture and get "worms" as in the photos, Fig. 507. At the other side, you'll lose the color and get a slightly smeared black-and-white picture. Correct setting: tune into the worms, then back up until all of the "wiggles" are out of colored objects and you have nice smooth color. Leaving the fine-tuning too near one side or the other can cause color dropouts, or worms in the picture, from normal warmup drift of the tuner oscillator. Set the knob as close to the center of the color range as you can.

Troubles that aren't

Before we go any further, let's look at some troubles that aren't troubles at all. Every one of these has caused unnecessary service calls.

Temporary dropout or shift of color in the middle of a show: Most common cause, network or station trouble. If this happens

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often, say at least three times during a half-hour color show, there may be an intermittent tube in one of the color circuits. Once or twice a day isn't uncommon for this. Always check it on at least three color shows before doing anything drastic.

Differences in color between two TV stations—not at all uncommon! It's due to differences in transmitters, operators, network amplifiers and so on. One station can have "very strong color" while another can be very pale, on the same show. This is *not* in the set! As long as you *can* get good color by readjusting the color control, or even the tint, fine. If you find a station with chronic color troubles, write nasty letters to its chief engineer, but don't tear into the set!

Sudden color troubles ("It was working fine when I turned it off!"): Such troubles as no color at all, apparent misconvergence, worms in the picture, etc. First check *all* the operating controls. Children and unqualified "technicians," like your brother-in-law, may have turned some of the knobs. Don't panic.

If there is a chronic tinkerer in the family, you may even have to check the rear controls, too. Find out for sure what has happened; we'll give you the methods in a minute. If there *is* a real "sudden trouble," it is almost sure, on percentages, to be a single bad tube. *Don't* make any adjustments to the rear controls at random. There are ways to tell what has happened.

What not to do — the "mussentouchits"

Let's get one thing straight first: there are certain things on a color TV set that should *never* be adjusted without cause, and even then only when a full set of test equipment is on hand. Actually, they very seldom cause trouble, because of the way they're built.

Here they are: tuning adjustments on rf, i.f. and above all, the color circuits; and the little slugs in the transformers. (Random Experimental Adjustments on any of these means a trip to the service bench and a full realignment!) The expert never adjusts them until his tests have shown that they need it.

Tubes

Tubes can be replaced, one at a time, if they are stone cold and dead. This is the best way. Set owners should be warned about taking out all the tubes and trying to test them at the supermarket! This results in mixing up i.f. tubes and such, and could cause misalignment. Besides, those tube testers are seldom accurate

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enough to evaluate a set of tubes in such uses! The value of tube testers depends a great deal on the skilled *evaluation* of the results. Single tube replacements — watching to see if there is any improvement in the set's performance — is still the best way.

Convergence

This is one of the final Mussentouchits. Convergence adjustments must be left strictly alone, unless you have a good, stable bar-dot generator. Don't *ever* try to reconverge or to "touch up" these adjustments on program material! You must have a stable pattern of some kind, and TV program material is always moving. Another caution: when working around the back of the set, don't let your elbow hit the convergence yoke or blue lateral magnet! If you knock them out of place, you'll *have* to reconverge!

In the next chapter and those that follow, we become involved in more troubles—some simple and some not so simple.

chapter 6
servicing the chroma circuits

IT IS HELPFUL TO KEEP A CHROMA-SIGNAL FLOW CHART IN MIND. Fig. 601 is a block diagram for a color TV receiver, with the black-and-white sections eliminated. The arrows show the distribution of the 3.58-mc signal. Next, let us note the significant characteristics of the processing circuits.
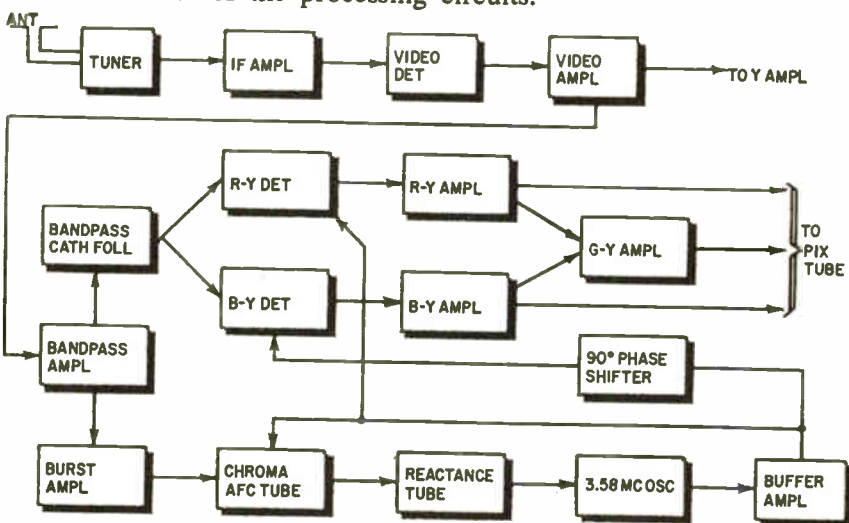
Fig. 601. The chroma signal is processed in these sections of the color receiver. (Also see Fig. 501 on page 68.)

The video modulating signal

If we are receiving a color test pattern via the antenna, or feeding a color bar generator signal into the front end, the video modulating signal appears as in Fig. 602. If we are operating on
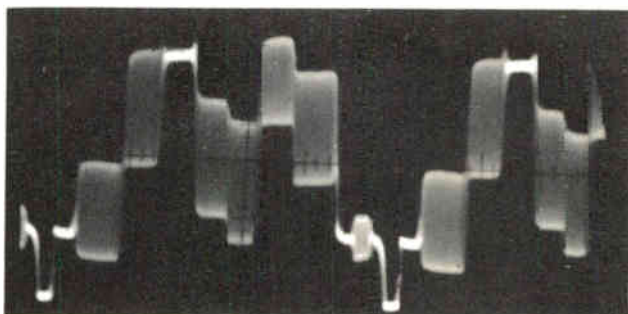
Fig. 602. *The video modulating signal from a color bar generator.*

channel 3, for example, the signal amplitude-modulates a 61.25-mc rf carrier. The "shaded" blocks in the Fig. 602 waveform contain the chroma information, and each block consists of a 3.58-mc sine wave. *The only difference between consecutive blocks is a phase difference.*

Reference phase for chroma

Reference phase for the entire chroma system is established by the burst phase. Fig. 603 shows a simple Y-signal plus burst.
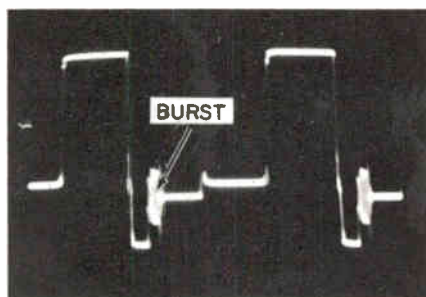
Fig. 603. *Y-signal with color burst. The burst, eight cycles of a 3.58-mc sine wave, is located on the back porch of the horizontal sync pulses.*

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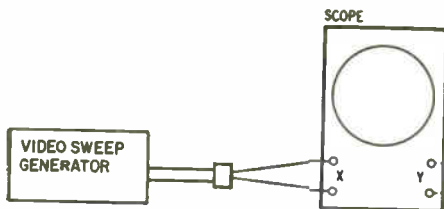
Fig. 604-a. *Setup for checking the frequency response of a scope. Set the scope on internal sweep. (No connections to the horizontal terminals of the scope.) The video sweep range should extend out beyond the frequency of the burst signal.*
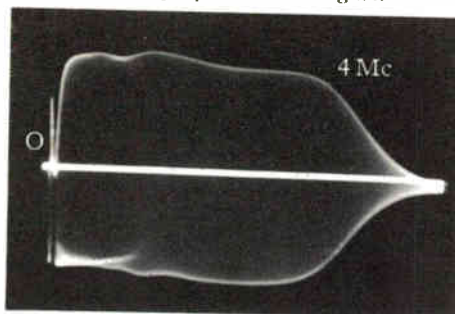
Fig. 604-b. *Pattern that may be shown on the screen of the scope when using the test setup shown in illustration a, above. In this case the frequency response indicates that the scope is suitable for servicing color TV receivers.*

This burst has a frequency of 3.579545 mc (commonly rounded off to 3.58 mc) and consists of a minimum of eight sine-wave cycles. As mentioned earlier (Fig. 208 on page 37) the burst sits on the back porch of the horizontal sync pulse. To check the burst signal, we must use a scope which has a fairly flat frequency response which extends out to at least 3.58 mc.

Which scope?

TV technicians often ask whether a particular scope is suited for chroma work. The best way to answer this question is to feed the output from a video-frequency sweep generator into the vertical input terminals of the scope, as in Fig. 604-a. An un-demodulated FM waveform appears on the screen (Fig. 604-b). The best scopes have a very flat response through the burst fre-

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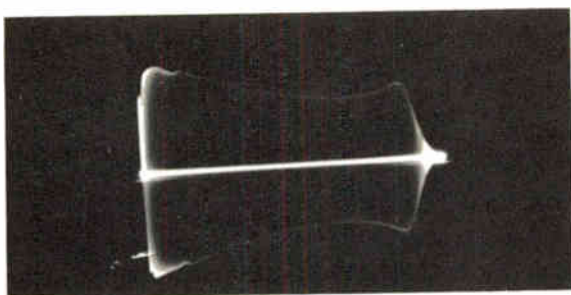
Fig. 605. *This frequency response is
also usable.*

quency. If a scope has some attenuation of high frequencies (Fig.
605), it is still usable. However, the height of the burst display
is reduced in proportion to the attenuation in the vertical ampli-
fier—experienced technicians can take this into account in
analyzing chroma waveforms.

Of course, any scope with good 60-cycle square-wave response
can be used in sweep-alignment tests. If a question arises con-
cerning the frequency response of the front end, check it with
an rf sweep test (Fig. 606). The chief consideration here is that
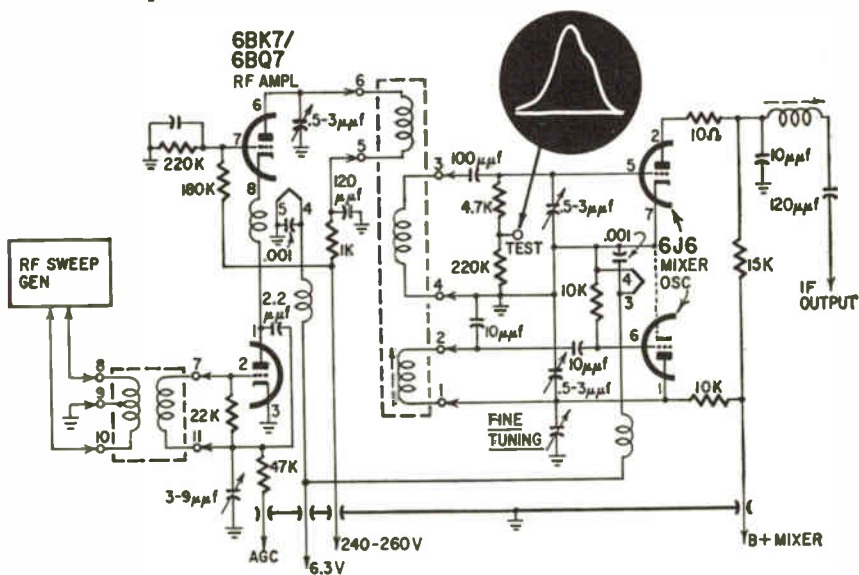
Fig. 606. *If a question arises concerning front-end response, check it with
a sweep-generator test.*

the response curve should have full response at 3.58 mc. We locate the picture-carrier and the chroma-subcarrier points on the curve with a marker generator. In the front end, we should find *both* the picture carrier and the chroma subcarrier very near the top section of the curve. Otherwise, rf alignment procedures are in order.

Is realignment needed?

Using ordinary service instruments, we will first see the video modulating signal (Fig. 602) at the output of the picture detector. The chroma information in Fig. 602 is attenuated almost 6 db. Now, this *may or may not* indicate the need for rf or i.f. realignment. It all depends upon the type of receiver on the bench. One kind of color receiver is designed to pass the chroma subcarrier at the top of the i.f. response curve (Fig. 607). In this
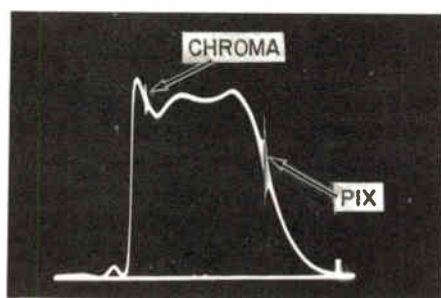
Fig. 607. *Chroma i.f. response at 100%. The positioning of the chroma subcarrier on the i.f. response curve varies with different receivers.*

case, unattenuated chroma information passes through the picture detector.

On the other hand, another type of color receiver comprises an i.f. amplifier normally aligned for vestigial-sideband chroma reception. This simply means that the chroma subcarrier does *not* fall on the top of the i.f. response curve, but instead is found 50% up the far side of the curve (sound-carrier side). Hence, the chroma signal is attenuated by half in passage through the i.f. amplifier, and the burst, with all chroma bars, has half the usual amplitude at the picture-detector output. Note that in this type of receiver the bandpass amplifier has a compensating frequency response to restore the chroma amplitude.
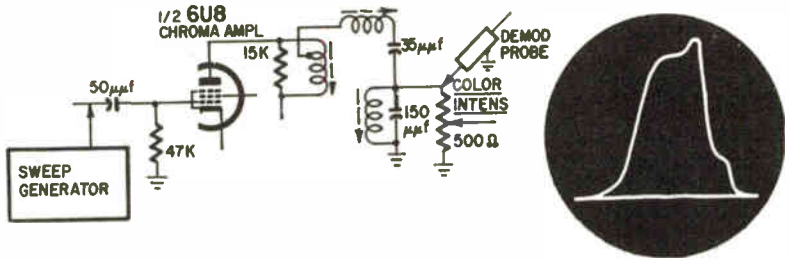
Fig. 608. *Checking the chroma bandpass amplifier. The sweep generator is connected to the input of the chroma amplifier. The output for the scope is taken off the hot end of the color intensity control with a demodulator probe.*

Checking frequency response of a chroma bandpass amplifier

We check the frequency response of a chroma bandpass amplifier as in Fig. 608. Procedure is conventional, with the exception of a demodulator probe used in series with the vertical input cable to the scope. We use this probe because, unlike an i.f. amplifier, a chroma amplifier is not followed by an AM detector. Hence, to display a conventional response pattern, we supply an AM detector in the form of a demodulator probe. Again, the scope used in this test need have only good 60-cycle square-wave response.

The bandpass response curve shown in Fig. 609 is that of an
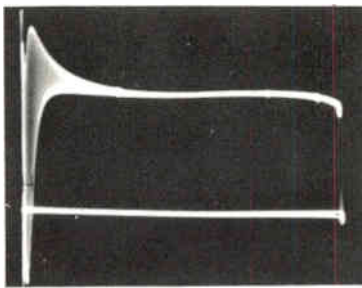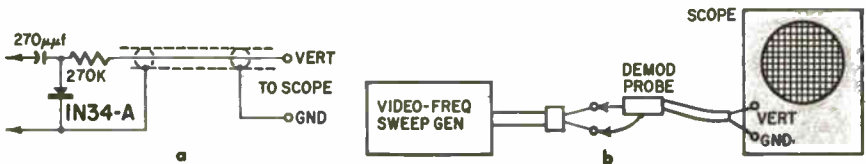
Fig. 609. *At low rf, the demodulator probe permits feedthrough of ac signal voltage. The demodulator probe is shown in a; the sweep generator setup in b and a typical scope pattern obtained in the test is illustrated in c.*

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i.f. amplifier having the color subcarrier located at the top of the i.f. curve. Hence, the bandpass curve also has an essentially flat-topped response. On the other hand, when the i.f. amplifier has vestigial chroma-sideband response, the bandpass curve will have a sloping top, with twice as much amplitude at the high end. Bandpass frequency limits are determined with the aid of a marker generator, in the usual manner.

Attenuated chroma-signal response

Returning to the picture detector, consider the problem of attenuated chroma-signal response, in the event that we suspect the scope's frequency response to be inadequate and the video sweep generator to have attenuated high-frequency output. In this situation, we need some method of checking the video sweep generator. This can be done as in Fig. 609. We eliminate the scope from the problem by connecting a demodulator probe in series with the scope's vertical input. Now, with the generator sweeping from zero to 4 mc, we should see a flat-topped pattern. Otherwise, the generator is inadequate for chroma-circuit sweeping. Note in Fig. 609 that a large "marker" apears in the vicinity of zero frequency. This is normal. It is caused by the inability of simple demodulator probes completely to demodulate and filter very low video frequencies.
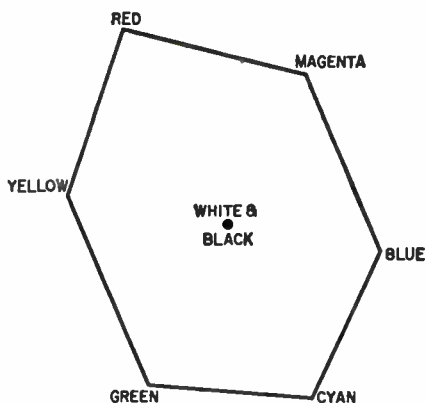
Fig. 610. *Vectorgram from chroma detectors.*

Quick check of chroma action

How can we make a quick check of chroma-detector action? A vectorgram provides the maximum information in a single pattern (Fig. 610). To display a vectorgram on the scope screen,

connect the output from the (R — Y) detector to the vertical input terminal, and the output from the (B — Y) detector to the scope's horizontal input terminal (Fig. 611). The receiver is
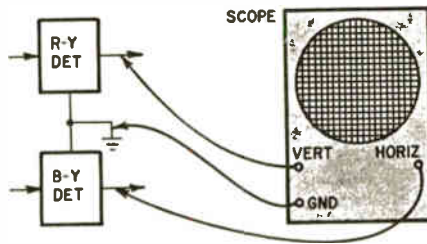
Fig. 611. *Test setup to display a vectorgram.*

driven by a color bar generator. The generator should supply the primaries and complementaries (green, yellow, red, magenta, cyan and blue). If receiver operation is normal through the color detectors, we see the vectorgram pattern of Fig. 610.

Vectorgrams

A scope used for vectorgram displays should have good 150-kc square-wave response. This requirement is imposed on *both the vertical and the horizontal amplifiers*. Otherwise, there will be distortion in the display. Note that quite a few scopes with satisfactory vertical-amplifier response may have limited horizontal-amplifier response. The busy color TV shop will find it advantageous to obtain or draw up a vectorgram graticule for the scope. They are used in all color TV broadcast stations to monitor the transmitted signal periodically. The graticule layout is similar to that shown in Fig. 612. The small squares indicate the limits of phase error for each color. Whether we will see a burst indication when testing chroma detectors depends on the receiver design. Quite a few color receivers trap out the burst ahead of chroma detection.

Preliminary troubleshooting

When a color receiver is tackled (as we mentioned earlier in chapter 5) first we make sure that the tubes are OK. In general, symptoms of defective tubes in the black-and-white section are readily recognized. On the other hand, newcomers to color servic-

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ing can be baffled by tube symptoms in the chroma section. Common symptoms caused by faulty tubes in the chroma section are in Table 6—1. (Note that this table is much more detailed than Table 5—1 given in chapter 5.)

Obviously, preliminary troubleshooting is enormously simplified by driving the receiver from a color bar generator, instead
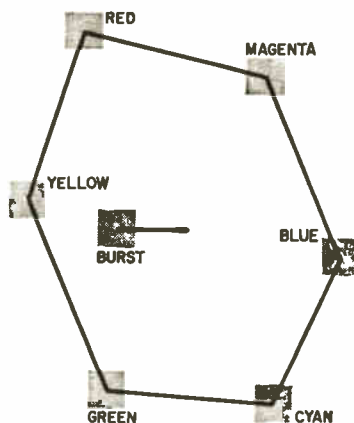
Fig. 612. *Vectorgram graticule.*

of using a color program signal. The bars displayed on the picture-tube screen and the color signals observed on a scope screen are pure and saturated when a bar generator is used. *A good color · bar generator is a must for the serious color TV technician.*

Practical servicing

Measure dc voltages and resistances in suspected chroma circuits. Standard service data provide these values for color receivers, just as for black-and-white sets. Hence, the second *must* is a schematic of the receiver. Although many operating defects can be traced to the offending component by dc voltage and resistance measurements, some faults show up clearly only in scope tests.

Within its limitations, the color picture tube is a scope, when the receiver is driven by a color bar generator. On the other hand, pattern analysis is of no avail when the color signal is killed somewhere ahead of the picture tube. In this case, we can save

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Table 6 — 1. CHROMA TROUBLESHOOTING CHART

Symptoms	Tubes to Check
Normal raster and black-and-white picture. No color.	Bandpass amplifier and cathode follower; 3.58-mc buffer; (R—Y) and (B—Y) demodulators; (R—Y) and (B—Y) amplifiers; 3.58-mc oscillator and reactance tube; rf amplifier; mixer-oscillator; first, second and third i.f. tubes.
Normal raster, normal black - and - white picture, color out of sync. Color information falls off to side, similar to out-of-horizontal sync.	Bandpass cathode follower; 3.58-mc buffer; burst amplifier; (G—Y) matrix amplifier; color afc tube; 3.58-mc oscillator and reactance tube.
Normal raster and black-and-white picture. Poor color tone and balance on color portion of picture.	Burst amplifier and (G—Y) matrix tube; (R—Y) and (B—Y) demodulators; (R—Y) and (B—Y) amplifiers; picture tube.
Tinted raster (entire raster tinted evenly).	Picture tube—make visual check first to see if all three heaters are glowing; burst amplifier and (G—Y) matrix tube; (R—Y) and (B—Y) demodulators; (R—Y) and (B—Y) amplifiers.
Excessive 920-kc beat interference in picture.	Rf amplifier; oscillator-mixer; first, second and third i.f. amplifiers; sync and video amplifiers; agc detector and amplifier; brightness amplifier.
Picture size changes excessively with adjustment of brightness control.	High-voltage regulator tube.
Tinted raster (one or more sections tinted, usually in the outer areas).	Picture tube.

Table 6–1. CHROMA TROUBLESHOOTING CHART

Symptoms	Tubes to Check
Color fringing.	Picture tube.
Sound OK; no picture. (Receivers using separate sound detector).	Last i.f. amplifier, picture detector tube.
No sound, no color; black and white picture OK. (Receivers using separate Y detector.)	Chroma-and-sound detector tube.
Picture blooms badly, with varying dynamic convergence as brightness control is advanced.	Regulator tube. (Some receivers utilize a triode regulator—others use a corona bleeder tube). If corona tube is used, weak high-voltage rectifier tubes may reduce the high voltage below the striking level of the regulator.
Color hum bars in picture.	Heater-cathode leakage in color detector tubes, or color amplifier tubes.
Blues and greens only are present in the color picture.	$(R-Y)$ detector, or amplifier.
Reds and greens only are present in color picture.	$(B-Y)$ detector, or amplifier.
Bars appear without color in various shades of gray.	Color subcarrier oscillator.
Color bars appear as red, green or blue "barber poles." Pattern may be stationary or drifts.	Phase detector.
Bars show some changes in hue, due to loss of spot convergence; horizontal width reduced.	High-voltage regulator (tube or selenium rectifier).

much wasted effort by using the scope as a *chroma signal tracer* to find out where the chroma signal stops in the circuits. If we find normal chroma output from the picture detector, we can check the output from the bandpass amplifier. With a 3.58-mc
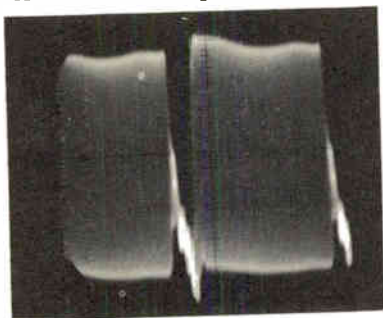
Fig. 613. *Output from a bandpass amplifier.*

signal modulating the picture carrier, we should see the typical bandpass output signal of Fig. 613. The breaks in the 3.58-mc signal are caused by the keying pulse. Many bandpass amplifiers are keyed off during the burst interval, to accommodate subsequent chroma circuitry.

Trouble in the keyer circuit

Trouble in the keyer circuit often results in the bandpass amplifier being biased off continuously, which kills the chroma output. By the same token, a fault in the color-killer circuit can render the bandpass amplifier inoperative. In either case, waveform checks in these two circuits will localize the trouble or clear the control circuits. A practical note here is to use a low-capacitance probe with the scope when making chroma-circuit tests. At 3.58 mc, instrument loading can easily lead to false conclusions. If you do not have a low-capacitance probe—get one!

Rainbows

Even when the chroma signal is getting through to the picture tube in a defective color receiver, it is often difficult or impossible to localize the trouble by picture-screen analysis. We see that the colors are distorted or weak, but we can't tell whether the distortion is in the high-frequency circuits, in the bandpass amplifier, in the chroma detectors or amplifiers, or possibly in the color-sync section. Complete loss of color sync causes rainbows

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to appear on the picture-tube screen, but drifting or pulling in the color-sync circuits can distort the colors while still holding the bars in sync.

Fig. 614. *Rainbows in a color-bar pattern.*

Chroma signal tracing, followed by analysis of vectorgram (or partial vectorgram) displays, accordingly provides the easiest practical approach. It might appear that practical procedures would require only a multimeter to run down chroma trouble. This is an oversimplification. The competent technician must be prepared to include a wide-band scope in his bench gear. Otherwise, he will find himself "hunting with a bow and arrow."

Poor color sync or no sync

Tubes have been replaced, but we still have rainbows (Fig. 614)—color sync is unstable or completely lost. The first step is a signal-tracing procedure, to locate the defective stage. With a wide-band scope and a low-capacitance probe, we check the waveform at the input of the burst amplifier—(1) in Fig. 615.
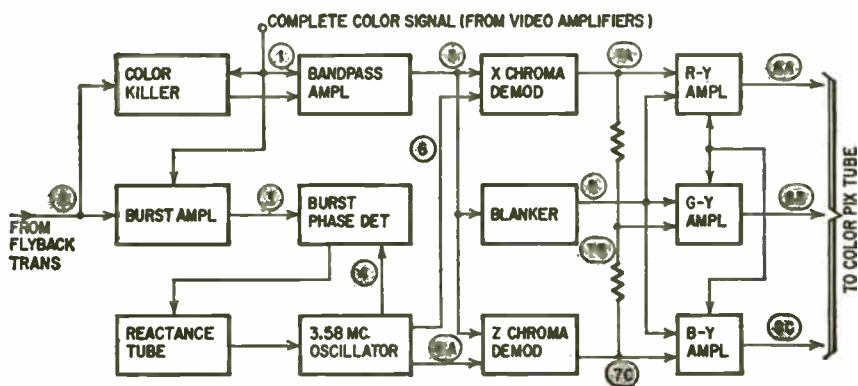
Fig. 615. *Nine of the important chroma-signal test points.*

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This tells us whether the trouble is in the chroma section or in the preceding video section. (The video section includes the video amplifier, i.f. amplifier and rf tuner).

Here we are concerned with the burst amplitude (Fig. 616).
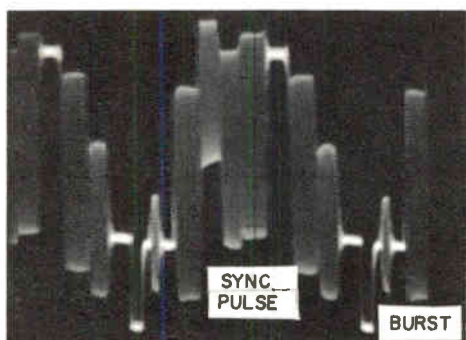
Fig. 616. *Burst and sync pulses normally have the same peak-to-peak amplitude.*

The burst normally has the same peak-to-peak amplitude as the horizontal sync pulse. Although we can use a color TV station signal in this test, a color bar generator is preferred. The advantage here is that the generator has a normal ouput signal which is not affected by characteristics of the antenna, by technical difficulties in the station network or by propagation anomalies.

Burst attenuation points to poor i.f. or rf alignment, or to inadequate high-frequency response in the video amplifier.

Weak keying pulse

Now we check the keyer pulse from the flyback transformer, (2) in Fig. 615. The burst amplifier can be compared with a
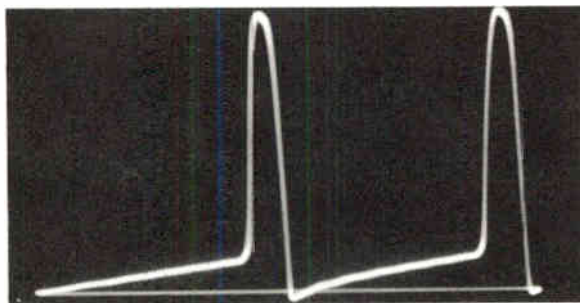
Fig. 617. *Typical keying pulses.*

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keyed-agc tube—it conducts only when the keying pulse is present. If there is no keying pulse, the burst signal cannot pass through the burst amplifier. If the keying pulse is weak, the output from the burst amplifier is weak. A typical keying pulse is shown in Fig. 617. Use a calibrated scope, and check the pulse amplitude against the value specified in the service data. If the pulse is weak or absent, stop here and trace back into the flyback section. The keyer winding may be broken down, or there may be a defective capacitor or resistor in the keyer circuit.

Burst output

When burst and keying signals to the burst amplifier are normal, we should see the output waveform shown in Fig. 618 from the
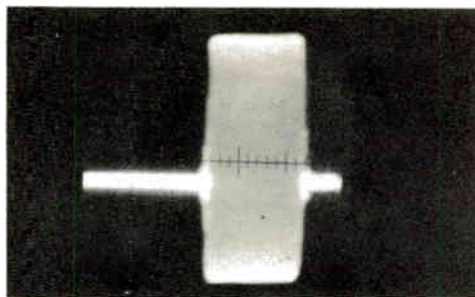
Fig. 618. *Output from a typical burst amplifier.*

burst amplifier. Check with a wide-band scope and low-capacitance probe at (3) in Fig. 615. Although the waveform in Fig. 618 is unsymmetrical, this is not a matter for concern. Many burst amplifiers are nonlinear. What we *are* interested in here is the amplitude of the output waveform—check its peak-to-peak voltage against the service data. If its amplitude is down more than 20%, the trouble will be in the burst amplifier. Use a vtvm to measure the dc voltages in the burst-amplifier circuitry, just as in black-and-white troubleshooting. Check capacitors for leakage, shorts or opens. Look for off-value resistors. Investigate alignment last, because it is least likely to be at fault. However, there is a possibility that the slug(s) in the burst-amplifier transformer may need touching up.

It is possible for the burst signal to become attenuated even though the Y signal may not be affected. The trouble may be as far back as the antenna, or may be due to misalignment in the r f , i.f. or chrominance circuits. However, color sync will often lock in on a lower-than-normal color burst.

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Burst phase detector

When the burst amplifier output is normal, we go to the burst phase detector in tracking down the loss of color sync. The burst phase detector has two signal inputs—the burst-amplifier output and the 3.58-mc oscillator signal. The latter is checked at (4) in Fig. 615. You should see the pattern of Fig. 619. Note that,
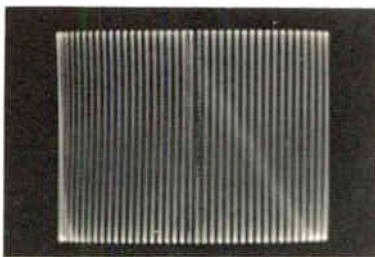
Fig. 619. *Subcarrier input to burst phase detector. (See also Fig. 702 on page 102.)*

although this is actually a sine wave, it appears very cramped on most scopes, because of its comparatively high frequency. Also, in Fig. 619, there is a jitter in the scope sync action which makes the waveform appear somewhat as a series of vertical lines—many service scopes do not lock tightly on a 3.58-mc frequency.

However, we are concerned only with the amplitude of the waveform. Compare its peak-to-peak voltage with the value specified in the service data. If low, check the coupling capacitor between the 3.58-mc oscillator and the burst phase detector. It may be leaky or open. Of course, there may be a defect in the oscillator circuit, such as low plate-supply voltage. So make dc voltage and resistance measurements in the oscillator circuitry, if necessary.

But color sync can be lost even with normal amplitude, if the oscillator *frequency* is incorrect. Modern color receivers generally have an L-C oscillator circuit, provided with a tuning slug. Do not forget to touch up the oscillator tuning slug, to try and lock in the color sync. An ideal check here is to place the input lead of a heterodyne frequency meter near the oscillator tube, and measure the operating frequency on the meter scale. Unfortunately, many shops do not have a calibrated frequency meter, and the oscillator frequency can be judged only indirectly by observing receiver circuit action.

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Note that oscillator section is associated with the reactance-tube circuit (Fig. 615). If there is a defective capacitor, off-value resistor or incorrect supply voltage to the reactance-tube circuit, it will be impossible to make the 3.58-mc oscillator zero-beat with the burst. In most receivers, the output circuit of the re-actance tube contains a tunable coil, which is also the input of the oscillator circuit. We will have tried to adjust it when checking out the oscillator. Capacitors are the most common trouble makers.

Final tests in tracking down loss of color sync are made in the burst phase-detector circuit, a comparatively simple section consisting of a duo-diode and a few resistors and capacitors. With normal inputs feeding into the phase detector, loss of color sync is necessarily due to a simple circuit defect—often an off-value resistor which unbalances the dc control voltages to the diodes. Of course, a leaky capacitor in this section will cause the same difficulty. In printed circuits, look for leakage across the board between conductors, because this is a comparatively high-impedance circuit. It doesn't take much surface leakage to impair the function of an 8.2-megohm resistor!

Poor color reproduction

In this next step, we leave the problem of tracking down loss of color sync, and investigate poor color reproduction.

Start by checking the output from the bandpass amplifier with a wide-band scope and low-capacitance probe, (5) in Fig. 615. The typical waveform is shown in Fig. 620. Note how the Y-signal is removed from the Fig 616 waveform by the bandpass ampli-fier, permitting entry of chroma information only to the X and Z demodulators. Our chief interest here is in the amplitude of the Fig. 620 waveform. If its peak-to-peak voltage is low, the colors will be weak.
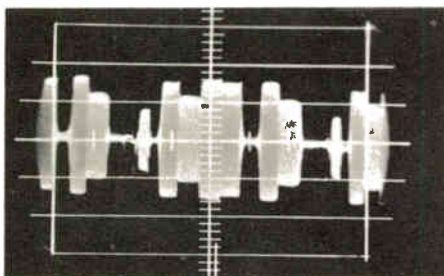
Fig. 620. *Typical output waveform from burst amplifier.*

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The bandpass amplifier is a tuned stage like an i.f. amplifier, but it processes a 3.58-mc signal like a video amplifier. It differs from both, however, in that it has a *bandpass* response, such as from 3.1 to 4.1 mc. We *check alignment last*. If the output waveform from the bandpass amplifier is weak, measure the dc control voltage from the color killer—it may be too negative and running the amplifier near cutoff. If the control voltage does not check correctly against the service data, make the necessary tests in the killer circuitry, just as if you were checking a keyed-agc stage. A defective capacitor or resistor is most likely to cause trouble.

However, with correct dc voltages supplied to the bandpass amplifier and the possibility of a defective capacitor eliminated, we will finally make an alignment check. Ideally, this should be done with a video-frequency sweep and marker generator. Since most shops may not have suitable equipment, we must often fall back upon touching up the bandpass tuning slug(s), and judge alignment indirectly on the basis of receiver response. In rare cases, there will be a broken slug, shorted or open coil, or leakage between coil turns. These possibilities are investigated only if you can't get correct alignment.

3.58-mc voltage below normal

When the chroma demodulators are fed a normal chroma signal, colors on the pitcure-tube screen can still be weak, absent or distorted, if the 3.58-mc injection voltage is subnormal. This brings us to step (6), Fig. 615. A scope check should show the same waveform as in Fig. 619, but at the amplitude specified in the service data. Check *both* injection voltages, because there is individual circuitry for the input demodulator stages. Note that (6) is repeated in Fig. 615. One injection waveform (6), might have normal amplitude, with the other (6A), weak or absent. If so, make the usual capacitor and resistor tests — and do not forget to check the small inductor often found in the common portion of the modulator inputs. A dc resistance measurement usually reveals a bad coil, but if its resistance is not specified, make a substitution test.

These injection voltages may be out of phase, even though their amplitude is normal. This sounds like a difficult matter, but it is really a very simple test procedure, provided you have a color bar generator.

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Checking phase

Apply an X/90° signal (a signal 90° from the X base line) from the color-bar generator to the receiver and connect a scope and low-capacitance probe at (7A) of Fig. 615. What should the scope show? Nothing! Only a horizontal trace should appear on the scope screen. On the other hand, if you get vertical deflection as in Fig. 621, try adjusting the receiver's COLOR-PHASING
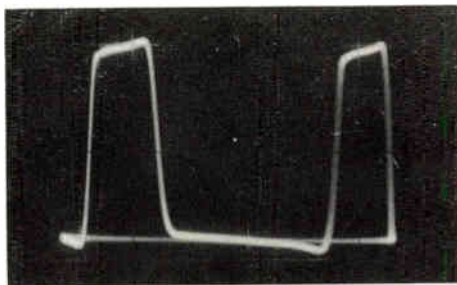
Fig. 621. *Typical demodulator output waveform.*

control (tint control). If the vertical deflection can be minimized, we are not yet finished with the burst phase detector and reactance-tube stages! Some defective component causing an abnormal phase shift has been overlooked.

Unsatisfactory null

With normal output at the X demodulator, shift the low-capacitance probe to (7B) and then to (7C), Fig. 615. You should find vertical deflection at these points, because of feed from the Z demodulator. The check at (7C) is particularly useful. Drive the receiver with a Z /90° signal from the color bar generator, and look for a null output from the Z-demodulator. If the Z-demodulator nulls at the same setting of the color-phase control as was found for the X demodulator, all is fine. But if a Z-null is unsatisfactory, check capacitors, resistors, and inductors in the demodulator stages to close in on the culprit. Note that X/90° and Z/90° signals are specified bars in a keyed-rainbow generator signal.

If your color bar generator does not have the X and Z outputs, you can check the demodulators indirectly by going to the next step.

Amplifier nulls

Connect the scope and low-capacitance probe at (8A), Fig. 615. Feed a B — Y signal into the receiver. There should be a null at the output of the R — Y amplifier when the color phase control is suitably adjusted. If you don't get a satisfactory null, follow the foregoing track-down procedures. Note that we are working through the R — Y amplifier, which is interconnected with G — Y and B — Y amplifiers. This indirect method of demodulator testing *could* show an unsatisfactory scope pattern caused by trouble in one of the amplifiers.

The amplifiers are quite straight-forward, aside from their interacting feature, and trouble localization reduces to dc voltage measurements, plus resistance and capacitance checks. Later amplifiers do not even have peaking coils to confuse the issue. Here are the normal nulls from the amplifier outputs:

1. The R — Y amplifier nulls on a B — Y signal.
2. The B — L amplifier nulls on an R — Y signal.
3. The G — Y amplifier nulls on a G — Y $\underline{/90°}$ signal.

When we use a rainbow generator, we can easily check the amplifier outputs for correct relative amplitudes. These are often specified in the receiver service data. They are just as important as correct nulls for good color reproduction. In X and Z systems, correct circuit phases usually go with correct amplitudes, because of the system interaction.

Checking blanking pulse amplitude

The blanker simply cuts off the picture-tube beam during horizontal retrace, so the burst does not contaminate the color picture. Connect the scope at point (9) in Fig. 615, and observe the blanking pulse for proper amplitude as specified in the service data. If the pulse is weak or absent, there are only a few resistors and capacitors to check in the blanker circuit.

You will find that the scope is the most useful signal-tracing instrument for localizing a faulty section in a chroma system. Without its help, a vast amount of time can be wasted in making random trial-and-error tests with a meter and by component substitution. After the faulty section is located, the vtvm is needed to check voltages and resistances. A capacitor tester is very useful, unless you have a large stock on hand, and don't mind cutting out the suspects and replacing them.

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Miscellaneous troubles

There are a number of miscellaneous troubles that might lead you to suspect difficulties in the various color circuits we've been telling you about but which are nothing more or less than voltage problems. Thus, colors may become smeared, indistinct or have that "washed out" look. Before jumping to the conclusion that the color circuits need some attention, try adjusting the focus control. This may be either a slug or pot. If no adjustment enables you to go through focus, replace the focus rectifier tube. If the set uses a selenium unit as the focus rectifier, replace it, since selenium units can get old, and when they do they can upset the focus circuit enough to make focusing impossible.

As with black-and-white, the majority of color TV troubles are with tubes. The horizontal output, damper, high-voltage rectifier and regulator all seem to have a high failure rate. The circuit breaker is another commonly encountered trouble.

In some receivers, recurring circuit-breaker tripping, while often caused by circuit or tube defects, can occasionally indicate a defective circuit breaker. Replacing it in the home is simple. Just slip the chassis back a few inches, replace the breaker and solder the leads. Your color caddy should contain several new circuit breakers.

Another part which may fail for no apparent reason is the surge resistor. It, too, is easily replaced in the home, and several should be carried. Other in-the-home repairs include replacing the 3.58-mc crystal and the .01-μf capacitors in the grid circuits of the demodulator tubes. The associated resistors in the plate and cathode circuits of the preceding stages, as well as the cathode resistor in the demodulator stages, should also be checked and replaced if necessary.

Automatic degaussing

Some of the newer color sets use automatic degaussing. Every time the receiver is turned on the automatic degaussing unit goes on, demagnetizing the picture tube. The automatic degausser remains on for a very short time. Either a thermistor-varistor combination or a thermal relay is used to cut out the degaussing coils. One receiver type uses a pushbutton switch for this purpose. Fig. 622 is the circuit of an automatic degausser.

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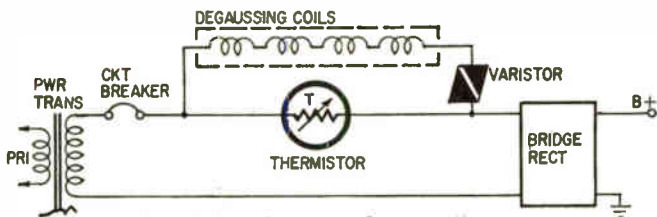
Fig. 622. *Automatic degaussing cir-cuit. Circuit remains on for about 20 seconds.*

Unexpected troubles

As you can see, servicing color TV follows fairly much the same procedure as in black-and-white. It consists of localization of trouble and constantly narrowing down the area of suspicion until the defective component is definitely pinpointed. It's about time, then, that we started examining components and learning what sort of troubles they produce. That's exactly what we are going to do in the next chapter. That chapter is based on case histories of unexpected troubles caused by capacitors.

chapter 7
unexpected causes of
tv color failure

A SURPRISINGLY LARGE NUMBER OF COLOR TV FAILURES ARE
due to capacitors. The technician expects to find these in circuits
which operate at B-plus or screen-grid voltages. Leaky or shorted
capacitors in cathode circuits are less common because working
voltages are comparatively low. The few pulsed circuits in color
receivers are another story. Capacitors in these circuits have
the poorest life expectancy. This results from the strenouous
"working" of the dielectric by pulse voltages. Capacitor failure
in a keyed-agc circuit, for example, would not be unusual. On
the other hand, a capacitor failure in a tuned signal circuit with
zero dc voltage is quite unexpected. A complaint of very weak
color (Fig. 701) is generally pinpointed by changing tubes first,
and next by measuring dc voltages and resistances in the chroma
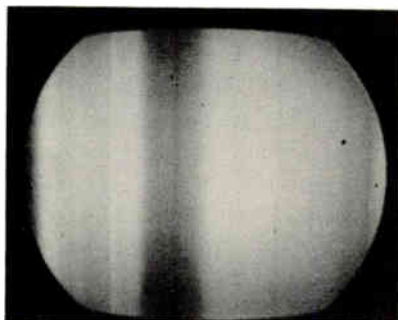
Fig. 701. Very weak color bar pattern.

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section. As a leaky or shorted capacitor usually shows up on dc voltage and resistance tests, capacitor trouble did not appear likely because all dc voltages and resistances were normal.

Open capacitor

There was a trace of color in the pattern when the intensity control was turned all the way up. Black-and-white reception was normal. As a last resort, *a wide-band scope with a low capacitance* probe was set up. An open capacitor often stops (or greatly weakens) an ac signal without causing a significant change in dc voltages. In such cases a scope will show whether the signal can be traced to one end of a coupling capacitor, only to disappear at the other end. A scope likewise shows whether the output from the subcarrier oscillator is weak or absent.

Advantages of a color bar generator

The next logical step was to check the oscillator output. This supplied the pattern of Fig. 702, which showed normal injection
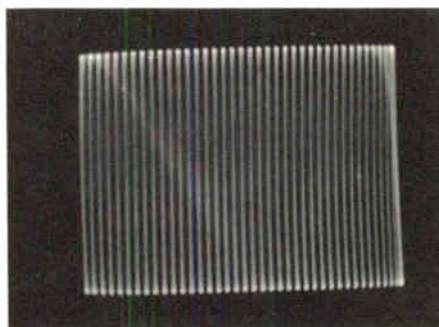
Fig. 702. *Injection voltage from subcarrier oscillator. This pattern shows normal amplitude. (See also Fig. 619 on page 94.)*

levels. With the oscillator cleared, the chroma signal was traced next. A color bar generator was used to drive the receiver, instead of an antenna signal. It has the advantage of supplying a steady and standardized signal, which can be adjusted for level or various chroma components as may appear desirable.

The color bar generator was set for I and Q output since the trouble was in the chroma section. With the low-capacitance probe at the bandpass amplifier input, a normal waveform was

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displayed (Fig. 703). The burst signal, followed by the I and Q signals, appeared normal. The burst is somewhat distorted by
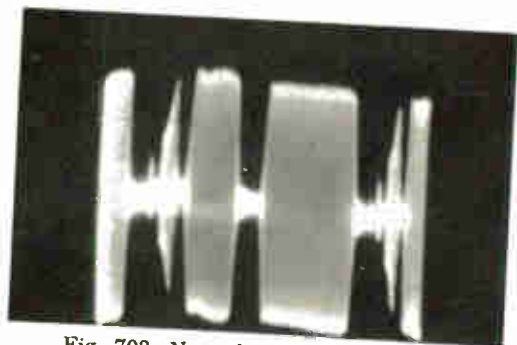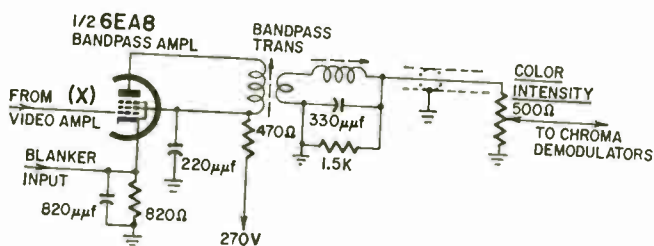
Fig. 703. *Normal waveform at point X in the bandpass amplifier circuit.*

the blanker characteristics, but this is of no significance. The horizontal sync pulse is absent, being rejected by the chroma-bandpass input circuit (not shown in Fig. 703). This also is normal.

Trouble in the bandpass output circuit

However, when the probe was applied at the color intensity control, it was an entirely different story. Here, the chroma signal appeared weak and contained integrative distortion (integration of pulses, Fig. 704-a). Now the trouble was pinpointed to the bandpass output circuit. The transformer appeared OK on a continuity test, but might have had some shorted turns. This could account for the integrative distortion as well as the weak output. However, the same symptoms would result from a de-fective 330-$\mu\mu$f (330 pf) tuning capacitor. One end of the capacitor was disconnected, and an ohmmeter test made. The meter read 40 ohms!

With a replacement capacitor wired in, receiver operation snapped back to normal (Fig. 704-b). This rather unusual color
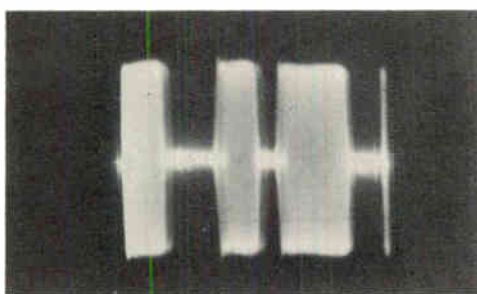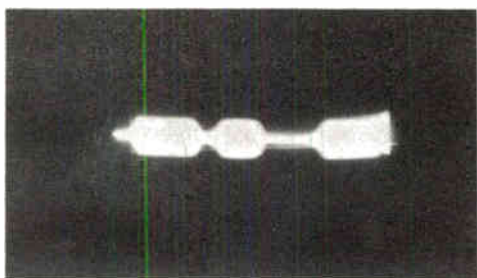
Fig. 704. *Improper waveform (a) at the color intensity control. Correct waveform is shown in the lower photo (b).*

TV service case ended up on the profit side of the ledger thanks to prompt use of a scope when meter readings offered no clues.

Distorted color — no green

This general approach brings to mind an earlier job on a somewhat similar chassis which also had an unusual capacitor trouble. The complaint was distorted color, with noticeable absence of green hues, and the defect did not show up on dc voltage and resistance tests. There was plenty of color, such as it was. Black-and-white reception was normal. The hue control was operative, but greens were not reproduced if the red and blue bars were properly phased in.

Picture analysis accordingly threw suspicion on the G — Y section. Dc voltages and resistances were well within tolerance, and a wide-band scope was brought in to conduct a cross-exam-

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ination. The input (cathode) waveform was normal, but the second test (Fig. 705) showed an abnormally large and distorted waveform at the grid bypass capacitor. The most likely cause would be an open capacitor. This was quickly confirmed by
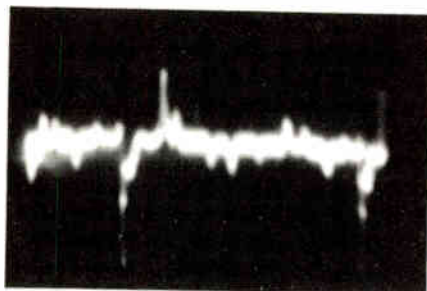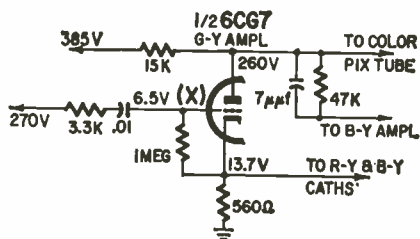
Fig. 705. *Waveform found at point X in the G — Y amplifier circuit.*

bridging the suspect (the .01-μf unit in the grid circuit) with a replacement. The green, cyan and yellow bars reappeared.

To understand why the greens disappear from the picture when the 01.-capacitor is open, note that the cathode of the G — Y amplifier is driven from the cathodes of the R — Y and B — Y amplifiers. The G — Y stage operates as a grounded-grid amplifier. Because of interelectrode capacitance between grid and cathode, the grid "follows" the cathode unless the grid is returned to ac ground. So, when the 01.-μf capacitor opens, the amplifier action substantially disappears.

Dc distribution

The dc distribution in Fig. 705 is not entirely obvious, and may appear unusual. Although the grid is returned to the 13.7-volt cathode, it measures only 6.5 volts. The reason is based on signal-developed bias. Although there is no signal as such specified while making dc voltage measurements, the noise level

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is fairly high, because the G—Y amplifier is preceded by numerous stages, and the agc line is not clamped. The noise voltages drive the cathode of the tube and, although the grid is grounded for ac, grid current is drawn on negative peaks of drive. A negative drive to cathode is the same as a positive drive to the grid.

The grid would rest at 13.7 volts were it not for grid-current flow which cancels about half of the cathode bias voltage. As would be expected, if you shunt a large capacitor across the 560-ohm cathode resistor, the dc voltages at grid and cathode become the same, except for small contact-potential shift. The ac ground return in Fig. 705 is made from grid to B-plus instead of chassis ground because the R — Y and B — Y amplifiers have their grids coupled to preceding plate circuits energized from the same B-plus line. The scope shows a small ripple on the supply line, which varies with the changing chroma signal. Thus, this method of returning the G — Y grid to ground prevents the chroma amplifiers from seesawing the B-plus ripple.

Noise on video waveforms

The noise voltages which produce the perhaps unexpected dc distribution in the G — Y amplifier also appear superimposed on video waveforms whenever i.f. bias is low. Fig. 706 shows
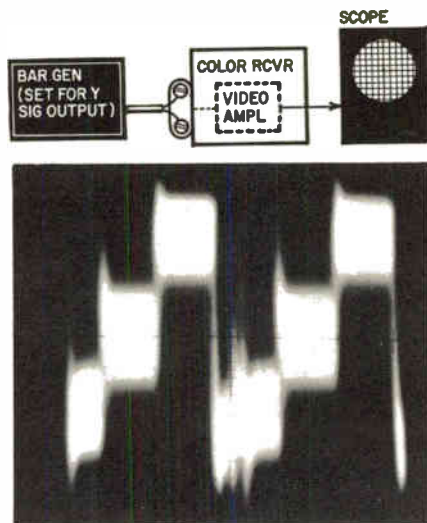
Fig. 706. *This color bar waveform shows blurring caused by noise.*

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noise on a video amplifier signal. To avoid noise disturbance in waveform checks, set the color bar generator output for a desirable signal-to-signal ratio. If there are signs of overloading, adjust the agc level control or clamp the agc lines.

Unless this is done, you may have unusual difficulty in evaluating waveforms. Most noise voltages are generated in the mixer, although the rf amplifier also make noticeable contributions. The amount of noise interference in video waveforms is determined almost entirely by the signal level at the mixer. If the generator output is increased, the signal-to-noise ratio at the mixer is also increased. The noise level itself is not significantly affected. Thus, a tenfold increase in generator output reduces the apparent noise to about one-tenth of its initial value.

Compression or clipping

Of course, this tenfold increase in signal level will overload various signal circuits following the mixer if agc bias has been set for weak-signal reception. Overload shows up as compression or clipping of the signal waveforms, and is highly misleading if it goes unrecognized. If a signal waveform appears distorted, reduce the generator output while watching the waveshape. If the waveform remains the same, but merely becomes noisier, the trouble is actually in the receiver circuits. On the other hand, if the waveform changes in shape and becomes more nearly normal, the trouble is very probably due to overloading in one or more of the stages.

To converge or not to converge

The fact that a color picture is out of convergence does not necessarily mean that it is so, even though the picture gives every symptom of needing convergence. Before you touch those controls, how is the black-and-white picture? Is it linear? Are width and height ok? If not, adjust the linearity controls. You may find it necessary to replace tubes involved in vertical and horizontal sweep. Insufficient sweep may also be due to a weak low-voltage rectifier. Then, after you are satisfied that linearity and sweep on black-and-white are what they should be, you may find your convergence problem has solved itself.

The oddball problem

As you probably know from your own experience, it is practically impossible to anticipate or to describe each and every

trouble of which a TV set is capable. There is always something new—and there is always a servicing problem which just doesn't seem to have ever happened before. You can chalk that up to the innate orneriness of TV sets in general but it doesn't alter the fact that sooner or later (and generally sooner) you, personally, are going to tangle with a tough one. Sometimes the solution (after you have found it) is so simple and so obvious that you may feel like kicking the set (and yourself). It has its bright side, though. Maybe that's what keeps TV repair from becoming a boring and routine job.

A few of these *different* servicing problems appear in the next chapter. You may think them easy—or you may be glad they didn't happen to you. One service technician's burden is another technician's boon.

chapter 8
troubleshooting with a
color bar generator

COLOR PICTURE ANALYSIS IS USEFUL UP TO A POINT. WHEN A color bar pattern is broken up into diagonal strips (which may or may not "roll" vertically) as in Fig. 801, color sync loss is clear-cut. We go to the color sync section at once. But if the color bar generator produces the pattern in Fig. 802, while the TV screen displays a sequence of distorted and mixed hues, is the trouble in the color sync section, the chroma demodulators, matrices, or in a network common to two sections?

Loss of color sync provides a somewhat different symptom than loss of black-and-white sync. When black-and-white sync disappears the effect may run all the way from "venetian blinds" to multiple pictures, depending on whether the trouble is horizontal or vertical. With loss of color sync, the picture remains in place but the colors "run."
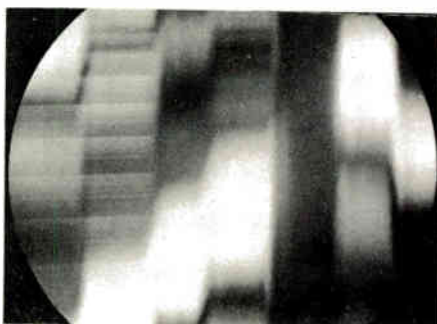
Fig. 801. *Loss of color sync produces this pattern on the screen of the color picture tube.*
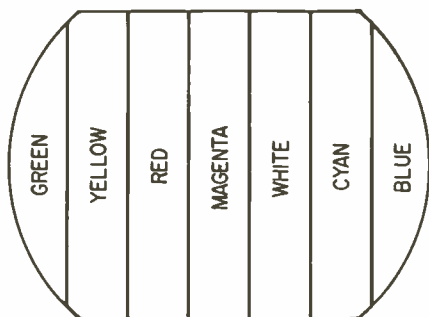
Fig. 802. *Typical normal color sequence.*

Incorrect color reproduction

In most incorrect color reproduction "across the board," the sequence of hues change when the TINT (or equivalent) CONTROL is turned, without giving any useful clues for pinpointing the trouble. We still don't know whether the subcarrier oscillator is being "pulled" short of breaking color sync lock, or whether the oscillator output is being used incorrectly. This basic question is answered by chroma signal substitution, with the color generator set to supply a complete color signal (Fig. 803).

BURST
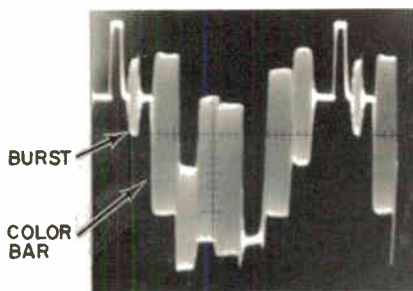
COLOR
BAR

Fig. 803. *Waveform of complete color signal.*

The video signal is injected at the video detector output. This is preferable because the rf and i.f. circuitry is bypassed in the test. So if a normal color bar pattern now appears on the picture tube screen, we'll look for trouble in the rf and i.f. sections. Or

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the other hand, if we see abnormal color bars, the chroma section must be checked out.

At this point, we substitute a synchronized subcarrier signal from the color bar generator in the color sync section, to determine whether "pulling" is taking place and causing the abnormal color reproduction. This test voltage is automatically locked with the bar signal, because both are derived from a common source in the generator. To make the test, apply the 3.58-mc output from the generator to the grid of the subcarrier oscillator tube in the receiver (Fig. 804). You don't have to unplug the oscillator crystal.
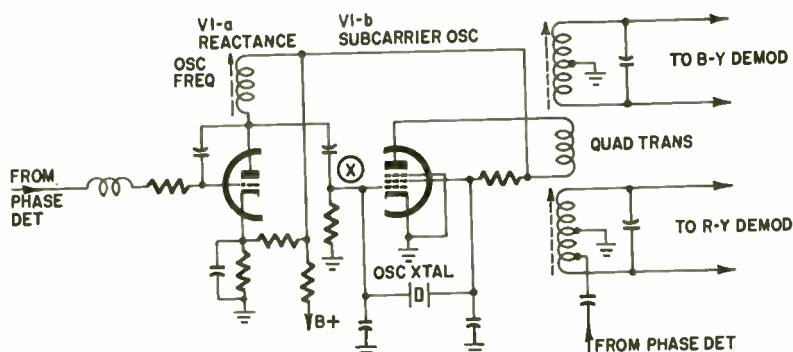
Fig. 804. *Inject subcarrier substitution signal at point X.*

Now, the output from the subcarrier oscillator tube is locked, and its phase is fixed. The subcarrier phase is independent of any defects in the reactance tube or phase detector circuitry. To put it another way, we can now make definitive checks of the chroma demodulators and matrices. First, try turning the tint (color phasing) control through its range, to see whether a normal color bar pattern can be displayed. If it can, the trouble is in the reactance tube or the phase detector section—forget about the chroma demodulators and matrices.

No normal pattern

If a normal color bar pattern cannot be displayed, there are two other possibilities. Here, we cannot *assume* that the trouble is in the chroma demodulators or matrices, because the phase of the injected subcarrier voltage is arbitrary and the COLOR-PHASING CONTROL may not have enough range to "bring it in."

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Therefore, the first job is to find out if we can display a sequence of normal hues, but a sequence *which does not start at the beginning of the horizontal scan.*

Now switch the generator to CHROMA. This eliminates the Y-signal from the otherwise complete color signal. Note that the pattern of Fig. 801 was obtained with the function control in its CHROMA position—hence the normally white bar appears dark. Eliminating the Y-signal does not change the indentifiable hues in the color bars, though they lack the brightness provided by a complete color signal. Now, turn the color phasing control through its range, and observe the chroma bar pattern.

If the chroma demodulators and matrices are functioning normally, you will see a normal chroma bar pattern at some setting of the color phasing control. However, the red bar, for example, might not start at the left-hand edge of the screen—it might start at the middle. If it starts at the middle, check hues of successive bars just as if the red bar were in its usual location. In other words, the chroma bar *sequence* is not changed in any way, but the *start* of the sequence is moved by some arbitrary distance on the horizontal scan. This indicates that the defect is in the phase detector, reactance tube or subcarrier oscillator section. The chroma demodulators and matrices are cleared of suspicion.

If you cannot get the chroma bar display, there is a defect in the chroma demodulators or matrices. Since the subcarrier oscillator and control circuits have been cleared, disconnect the 3.58-mc injection lead. Leave the video signal lead from the generator connected at the video detector output, and turn the generator function switch to its R — Y position. Observe the pattern on the picture tube while turning the color-phasing control. If you can obtain a correct R — Y chroma bar, the R — Y circuitry is OK. But if you cannot obtain the R — Y hue at any setting of the color phasing control, there is a defect in the R — Y channel or its associated circuits.

Then make a similar test, using the B — Y generator output. Note whether a correct B — Y hue appears at some setting of the color phasing control. Finally, apply a G — Y/90° signal to see whether the normal orange hue can be reproduced. These are particularly useful tests, because they show which, if any, of the three chroma channels is capable of normal operation.

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Older receivers

These preliminary findings are evaluated with respect to the chroma circuitry in the particular receiver. This is comparatively easy in older color receivers. Fig. 805 shows how the demodu-
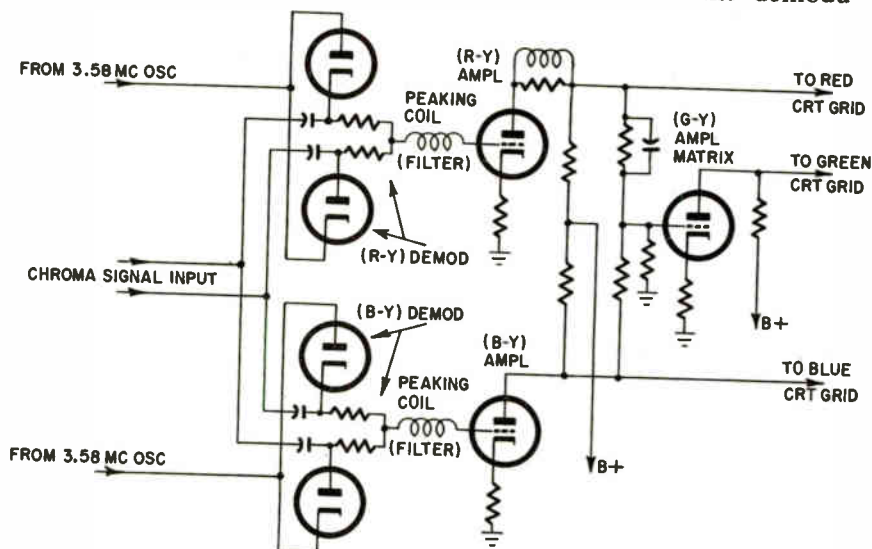
Fig. 805. *How demodulated outputs are fed through buffer amplifiers into a G — Y matrix.*

lated outputs are fed through buffer amplifiers into a G — Y matrix. In this configuration, the reproduction of correct R — Y and B — Y bars with distortion of the G — Y hue indicates that we should make voltage and resistance measurements in the G — Y section. A leaky capacitor in the matrix grid circuit is also a possibility. If an R — Y bar is correctly reproduced but B — Y and G — Y bars are distorted, check the B — Y demodulator. Note that an off-value resistor, open or leaky capacitor or open peaking coil in this stage will distort both the G — Y and B — Y outputs, because G — Y is compounded from B — Y and R — Y signals.

Again, in Fig. 805, if the B — Y hue is correctly displayed but R — Y and G — Y hues are distorted, the trouble is in the R — Y stage. Look for defects in the R — Y amplifier as well as the R — Y demodulator. If the plate peaking coil in the R — Y circuit is open, for example, circuit continuity is maintained through

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the damping resistor but the R — Y bar is weak or absent due to signal loss through the resistor. The bandpass amplifier is eliminated from suspicion in these situations, because at least one chroma bar is reproduced normally. If you are unable to obtain normal display of any one of the three basic chroma signals, the bandpass amplifier becomes suspect too.

A definitive test is advisable either to clear the bandpass amplifier or pinpoint the difficulty to this section. Disconnect the generator from the video detector output and apply the signal at the output of the bandpass amplifier (Fig. 806). Set the generator
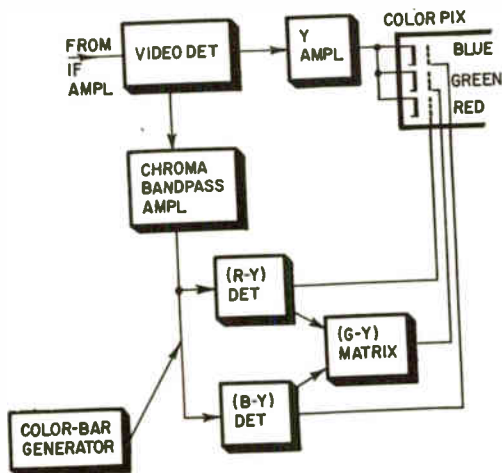
Fig. 806. *Checking the bandpass amplifier.*

on CHROMA. If there is a defect in the bandpass amplifier, a normal chroma bar display now appears on the picture-tube screen. Incorrect hues confirm trouble in the chroma demodulator or matrix sections. Look for a shorted capacitor common to both chroma demodulators, which will upset the action of both stages, as well as the following matrix.

More modern sets

Most recent color receivers use X and Z demodulators (Fig. 807). Although chroma circuitry is somewhat simplified, inter-action is extensive and must be contended with when shooting

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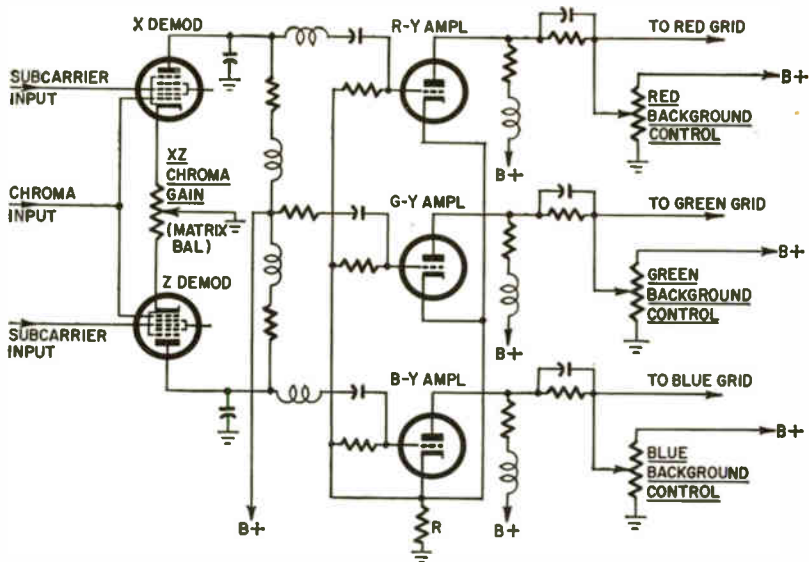
Fig. 807. *In X and Z demodulators, circuitry is somewhat simpler but circuit interaction is more extensive.*

trouble. Check for leaky or shorted capacitors *at the outset;* this fault usually disturbs the operation of the entire system. An open capacitor can be almost as troublesome. Experience has shown that if the fault has been caused by an *interelectrode short in a tube,* all resistors in the circuit must be carefully checked. The circuitry is dc-coupled throughout, and a heavy B-plus demand by one tube can be expected to overheat and change the values of several resistors. To insure against recurrence of this headache, replace the off-value resistors with wirewound types of ample power ratings.

Remember the basic principle that some video detectors have positive-going and others negative-going output. Signal polarity *must be observed* in making any video signal tests. Color generators have an output function switch, with — video and + video positions. If you make a mistake and feed + video into the output of a detector which normally develops — video, there will be no horizontal sync, the bandpass amplifier will operate incorrectly (or not at all), and the color killer will operate erratically.

Another basic consideration is the signal level. It is controlled by the attenuator setting. Do not overload the circuits under test

by using excessive signal output. Conversely, do not use a sub-normal signal level or you will get pale hues and an appearance of low gain in the chroma section.

Types of presentation

Some color bar generators have individual switch positions for R — Y, B — Y, I, Q, etc., signals and display only one chroma bar at a time, as seen from the scope pattern in Fig. 808. On the
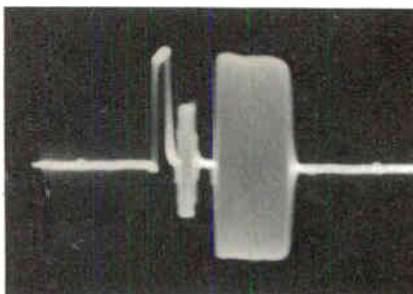
Fig. 808. R — Y *chroma signal; single-bar presentation.*

other hand, a color bar generator may provide two chroma signals simultaneously—one bar being narrower than the other (Fig. 809). This provides identification in any test where you might
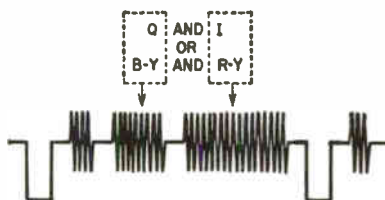
Fig. 809. *Simultaneous B — Y and R — Y bars. Note that bars are not of equal size.*

not know whether a B — Y or R — Y bar is being displayed. The B — Y (or Q) bar is only half as wide as the R — Y (or I) bar, whether viewed on the picture-tube or scope screen.

Most generators also provide a series of six chroma bars corresponding to the primary and secondary colors (Fig. 810). Note carefully that the chroma-component signal for red is *not* exactly the same as R — Y, and that the chroma-component signal for

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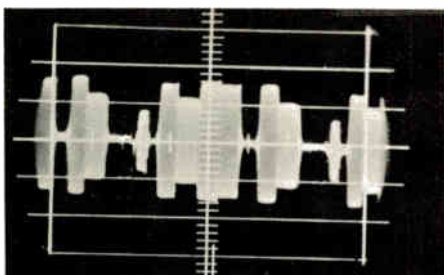
Fig. 810. *Chroma-component signals for green, yellow, red, magenta, cyan and blue.*

blue is *not* exactly the same as B — Y. There is a phase difference which, though small, is required for reproduction of true colors. Phase differences cannot be readily determined at 3.58 mc with ordinary service scopes, hence we need some method of ready identification of the various chroma signals.

Boosting chroma output

Some color generators have a comparatively high output; others have some high-level and some low-level outputs, and a few have low-level outputs on all functions. Hence, when substituting a 3.58-mc signal in a "dead" subcarrier oscillator circuit, you may have to boost the generator ouput. This can be done easily (Fig. 811). A video amplifier in or from a good black-and-white TV is a useful utility wide-band amplifier.
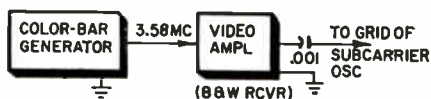
Fig. 811. *A good video amplifier in a black-and-white receiver will step up the generator signal.*

Connect the generator output to the grid of the video amplifier tube, and run a test lead from the video amplifier output (usually the picture-tube cathode) to the signal-injection point in the color receiver. Generally, the grid of the subcarrier oscillator tube is a suitable signal-injection point. We stress the use of a good black-and-white receiver, because the video amplifier should have full gain at 3.58 mc. If the signal-injection point in

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the color set is properly chosen, so that the video amplifier output circuit is not loaded excessively, the amplifier frequency response will not be seriously impaired. On the other hand, you'll be disappointed if you try injecting the 3.58-mc signal into a cathode circuit in the color receiver, because loading becomes excessive.

Rainbow generator

The output from a rainbow type generator is an offset color subcarrier with a frequency of 3.56 mc. Hence, we do not find an output suitable for oscillator signal-injection tests. Nevertheless, this is a highly useful generator and simpler to operate than the NTSC type. Viewing a scope screen, we see 11 bursts between successive horizontal sync pulses (Fig. 812). The first is

Fig. 812. *There are 11 bursts between sync pulses.*

used for color sync, leaving 10 bursts to drive the chroma circuits. Observe in Fig. 812 how consecutive bursts follow around the "color wheel," the colors normally displayed on a color picture tube.

Yellow-green is usually off screen, being lost during the burst-keying interval. Now, let us look at Fig. 813. Here, the first burst (color burst) is ignored, and the visible bars are numbered from 1 to 10. The upper diagram shows the proper sequence

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of colors. The lower diagram illustrates the normal scope patterns at the outputs of the R — Y and B — Y chroma demodulators. All bars have the same width, and we identify the various phases by "counting bars."
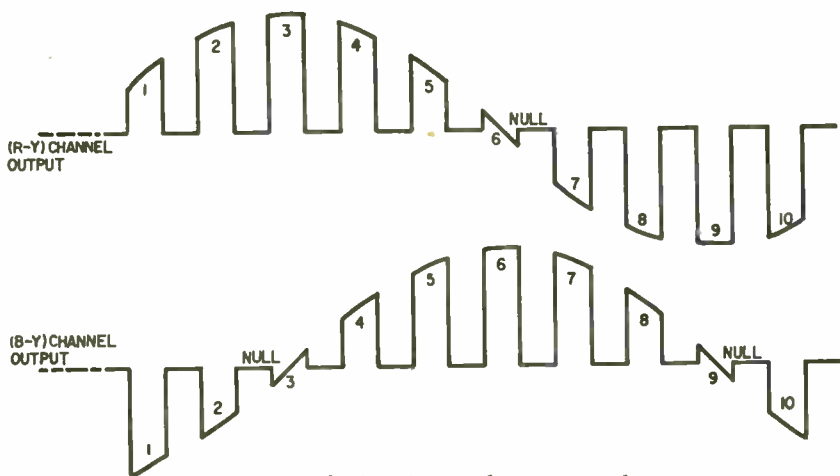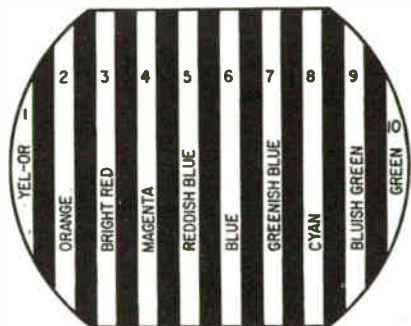
Fig. 813. *Signal identification by counting bars.*

Thus, the sixth bar should cause a null from the R — Y demodulator, and the B — Y demodulator should have two nulls; one at the third and one at the ninth. If the proper nulls do not appear, chroma troubleshooting is called for. The first and seventh bars normally null at the output of a G — Y demodulator, because they are G — Y $\underline{/90°}$ signals. Of course, if we tackle an IQ system in a vintage receiver, the I demodulator is expected to null on the Q signal, and vice versa.

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The high utility of various color bar generators can be appreciated only by practical bench experience. A color bar generator is comparable to a scope—it has a forbidding appearance but after adequate experience in its operation it is indispensable in practical troubleshooting.

Color service hints

There are two very good ways of learning how to fix color TV receivers. The first, and better way, is through direct experience. But you can also learn quite a bit, and possibly save yourself a lot of servicing time by picking up ideas from the experience of other technicians. That's why we've included a number of servicing suggestions in the next chapter.

chapter 9
color service hints

COMMERCIAL COLOR MOCKUP TEST UNITS ARE EXPENSIVE, BUT if you plan to get into color TV servicing, you'll need one. With it, you can eliminate one man on a color TV service call, if the set must come into the shop for repair. Just pull the chassis and bring it to the shop. Also, it's more convenient to hook the color chassis to a test unit right on the bench than to try to work behind it.

It is very easy to construct your own color mockup tube out of a regular color receiver. First, remove the color chassis from the set you plan to use. Do not disturb the picture tube, yoke and convergence assembly. Leave the speaker in the cabinet if you don't have a speaker test unit on the mockup bench. Clean the cabinet thoroughly. The photo in Fig. 901 shows the units that will be in the mockup. Fig. 902 shows the "stripped" cabinet, with only the CRT and convergence board left. Now you need connections to the yoke assembly, picture-tube socket, high voltage, convergence control board and speaker, and a good ground cable.

Cable construction

Five wires connect from the chassis to yoke assembly. The vertical connections are yellow-black and yellow. The horizontal winding connections are red, blue and blue-black. Most color receivers use only the red and blue wire connections.

Select a good grade of flexible hookup wire or test lead. Make

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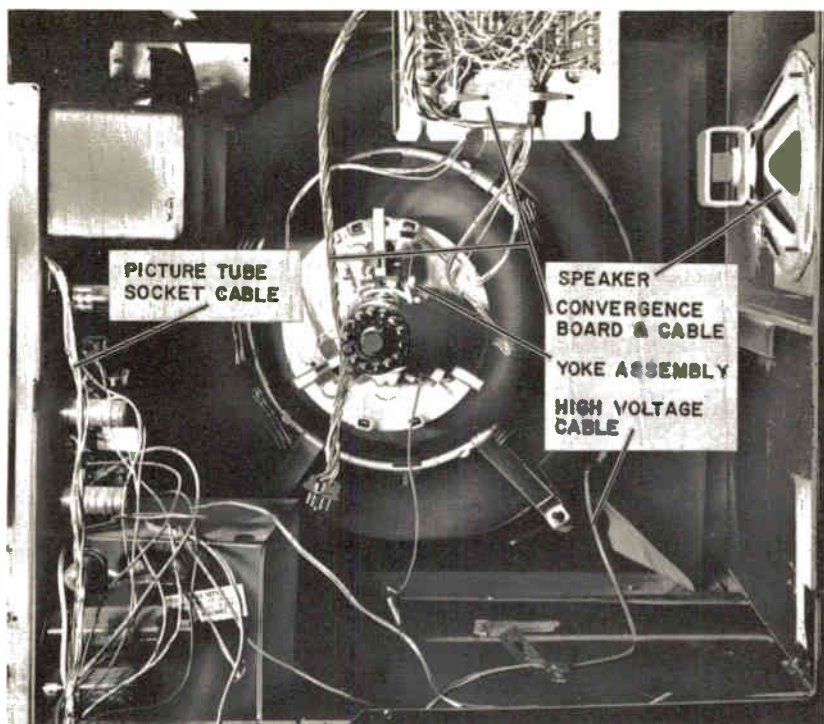
Fig. 901. *The parts of the original color set you should retain for the mockup.*

all cables 4 or 5 feet long. Remove the plug-in lugs and yoke wires from the color chassis and solder them to one end of the extension cables. Make a spade lug for each wire out of brass or copper pieces. Solder the lugs to the other ends of the extension wires.

These five wires should be color-coded as they were in the color TV receiver. If the correct insulation colors are not readily available, use paint. Brush or spray the correct color for about a foot from each end. Fig. 903 shows the yoke assembly.

The 14-lead cable for the picture tube can be made but it is much cheaper to buy one. Make a high-voltage lead from a roll of 25,000-volt cable. Remove the clip from the present high-voltage cable and attach it to the end of the cable extension. A small alligator clip will also work on the high-voltage cable end.

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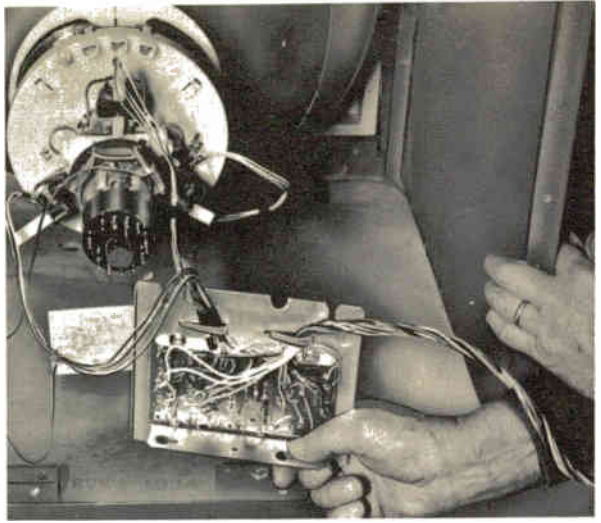
Fig. 902. A better look at the convergence board of the stripped set. (Also see Fig. 403 on page 57.)

Fig. 903. Yoke connections and assembly. (Also see Fig. 411 on page 63.)

NUT DRIVER
TIGHTENS
SHEET-METAL SCREW

COLOR
YOKE
ASSEMBLY

YELLOW-BLACK
WIRE

RED WIRE

VERTICAL
HOOK-UP

HORIZONTAL
HOOK-UP

YELLOW
WIRE

BLUE WIRE

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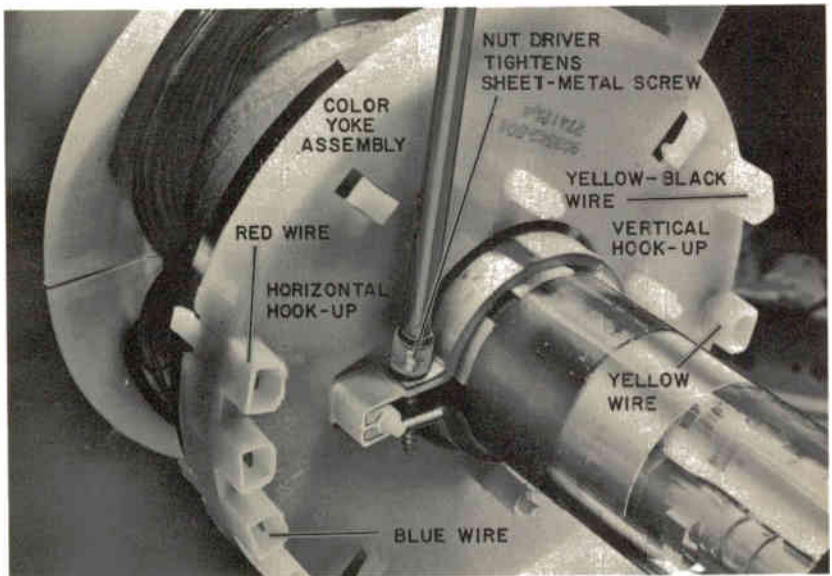
Where the two cables are connected together, use good plastic tape over the soldered joint, and saturate with corona dope or spray.

The convergence control board has an 8-prong tube socket that plugs into the TV chassis. Only seven wires are used, but an 8-wire rotator cable serves as a connecting cable. Connect as shown in the cable diagram in Fig. 904. Remove the male tube
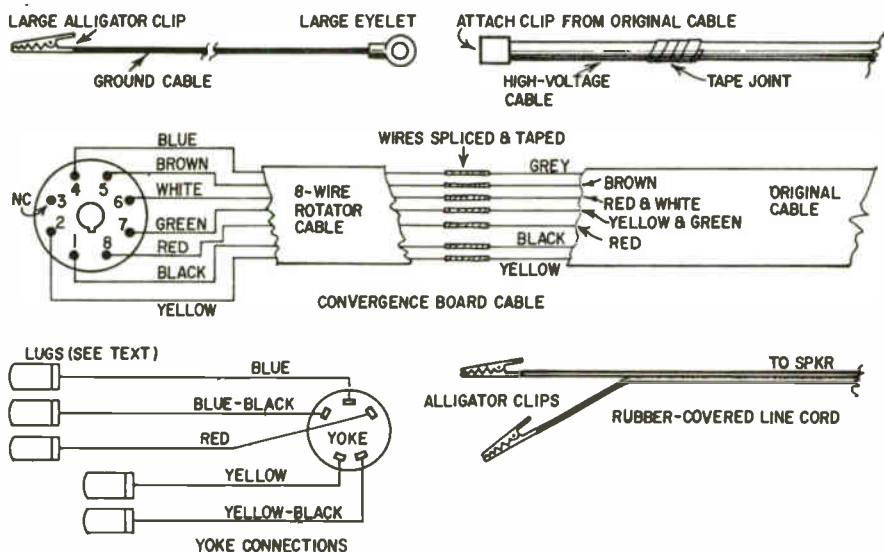
Fig. 904. *The five extension cables you will need. Your set's convergence cable may use different wire colors, so check the schematic of your model for connections between convergence board and plug.*

socket from the convergence board, and solder each connecting wire to the rotator cable. Solder the other ends to the wires that were removed from the octal plug, and tape the joints.

Regular rubber-covered line cord can be used as the speaker cable. Solder two small alligator clips to the connecting ends. Use a black test lead as a ground cable. Solder a large metal eyelet to one end and a large alligator clip to the other. Secure the large eyelet under one of the picture-tube mounting bolts. Run a short length of bonding strip from this bolt connection to the TV chassis. A good ground is a must. Tape the five yoke wires together to form one cable, taping every foot or so.

The wires protrude through holes in the side of the cabinet, as shown in Fig. 905.

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CONVERGENCE
BOARD CABLE

CRT CABLE

HIGH VOLTAGE
CABLE

GROUND CABLE

⊙ OFF - VOLUME

Fig. 905. *Extension cables protrude from control holes
in mockup set. Bushings and dial plates from junkbox
keep insulation from chafing on edges of holes. Plastic
insert nearest hand is convenient for holding cables when
mockup is not used.*

Setup and use

Before you can use the color mockup, you will have to check
purity and convergence, and possibly touch them up in the usual
way. Get a good color chassis and hook the mockup to it with
the cables.

Once the test unit has been converged, you will need to degauss
the color CRT only occasionally. With the mockup, you can check
the black-and-white picture and the chroma section with the
chassis out in the open where you can locate a defective part.

And now that we have our color mockup test unit out of the
way, let's examine some color TV trouble *symptoms* and the
recommended *service* procedure.

Symptoms: Poor purity after color tube has been replaced.

Service: When purity is a problem, start by degaussing the
receiver—even if it was already done a half-hour before. Then
adjust purity rings and yoke positioning, following the manu-
facturer's recommendations. If purity is still not good, check

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the settings of the static convergence magnets and check picture centering.

Occasionally there will be a minor impurity near the edge of the picture or raster. If rechecking the purity does not get rid of it, get a couple of pincushion magnets and fasten them to the picture-tube mounting near the location of the impurity on the screen. Then move the magnets around to find the position that clears up the impurity. Fasten in place with a drop of cement.

Symptoms: Impossible to obtain purity on the rim of the color tube. All ring adjustments have been made but there is still contamination around the rim.

Service: This sounds like rim-magnet trouble, if the set is one of the older models, or yoke adjustment on any of them. If you'll use a magnifier on the dots, you'll see that the purity ring magnets move the dots at the center of the screen around in a circle (Fig. 906) while the yoke adjustment (forward and back on the neck of the tube) causes *radial* movement.
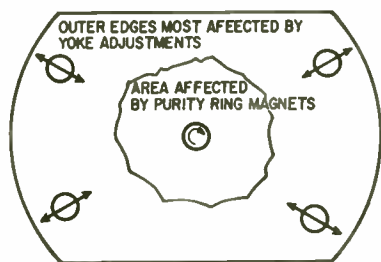
Fig. 906. *Central area of color CRT is affected by ring magnets on neck of tube. Dots move in a circular pattern. At outer edges of tube dots move toward and away from center of screen. All edges move simultaneously.*

So, follow the purity-setup adjustment procedure given in the manual for that particular set, although it's about the same for all of them. Roughly converge some white dots in the center of the screen, then set the purity rings for best *center* purity. (Red screen, blue and green screen controls turned off.) Now, slide the yoke back and forth along the neck until you get the best *edge* purity. You may have to reset the rings slightly. Keep at it until you get a pure red. Rim magnets, if any, should be fully retracted.

Symptoms: Difficult to get purity right on set using glass picture tube. Set has no rim magnets or any other means of making this adjustment. There are still tiny areas of contamination near the edge.

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Service: If you've tried everything else, try getting some small pieces of the rubber-covered PM magnet strip used to seal refrigerator doors. You can get this at appliance dealers, etc. Cut off very small pieces of this, and stick them on the bell of the tube, or near the rim, or wherever they're needed. You can adjust the magnetic field by cutting the strip to different lengths. A drop of speaker cement will hold them in place after you find the right adjustment.

Symptoms: Color fringing over entire screen.

Service: Degauss the tube and chassis thoroughly, being careful to retract the rim magnets. Keep the degaussing coil away from the neck of the tube at all times, to prevent demagnetizing the convergence magnets there. Then run purity adjustments, screen temperature, and *then* converge, using a fairly thick line in your crosshatch pattern. It may be difficult to converge these old timers on very thin-line patterns. However, if you can get reasonably good convergence on a line about ¼ inch wide, you'll find that there is no noticeable color fringing at even fairly close viewing distances. As a rule, it is not possible to attain *100%* convergence on some chassis; you'll always have a wee bit of fringing at the extreme edges. This will seldom be noticeable in the picture, so don't worry about it.

Make frequent "picture checks" during convergence, to see when the black-and-white picture has reached an "acceptable" stage, and it will be much easier.

Symptoms: Intermittent blue flashes. Sound and video are OK.

Service: Change the *blue* amplifier. What happens in a black-and-white set if the video amplifier goes out? The screen stays *lit up!* In other words, the video signal *extinguishes* a bright raster to make a picture. Same in color TV. With a white raster, we've got all three guns conducting full steam. So, to make a picture, the amplifiers (demods, etc.) have to *extinguish* the three guns.

If you have trouble in the blue and it can't pass a signal, what's going to happen? It will be unable to cut off the blue gun, and the raster will turn blue. This is due to the blue gun running wide-open all the time. In the sets using X and Y demodulation, if the X demod goes out, you get no red. If the Y demod goes, no blue.

Symptoms: Blue lines do not seem to come out right. All adjustments seem to work fine, but ends of the lines do not want to converge properly.

Service: Let's take the convergence trouble first. Since all

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adjustments seem to be working right, try a slightly different method of convergence. You see, you have all kinds of adjustments on your *blue,* while the other colors have only two major adjustments, both diagonal. So run the purity, degaussing, etc. adjustments first, then turn the blue completely out (with the blue screen control, or shunt the blue gun, etc.) then run the red–green convergence until you get a good yellow line or lines. *Now* turn your blue back up and see if it isn't easier to get the blue to move over to converge with the yellow. You'll find it probably will be. You can move the blue laterally, horizontally and vertically, or alter the shape, by setting the blue adjustments: horizontal tilt, vertical tilt, blue lateral and blue static, etc. Most technicians use this method, and you'll find it easier.

Symptoms: Poor black-and-white picture after color tube has been replaced.

Service: One common trouble in replacing a color picture tube is that no matter how carefully you adjust the video drive controls, you can't get a clean black-and-white picture. This is caused by differences in the efficiency of the phosphors of the old tube as compared to the phosphors of the newer replacement tube.

To adjust for this trouble, first find which phosphor is the weak one. Set up the set, following the manufacturer's black-and-white tracking instructions carefully. When finished, step back and look at the picture.

If the screen has taken on a cyan tint, change the connections at the drive controls to match *a* in Fig. 907. If the picture has a magenta tint, set up the circuit to match *b*. And if the picture looks yellow, set up the circuit to match *c*.

These changes will compensate for the weak phosphor and make it possible to get good black-and-white tracking once again. Changing drive-control connections should not affect the original settings of the screen controls. But it may be wise to recheck the screen controls anyway to insure the best possible tracking.

Symptoms: Intermittent color loss. Black-and-white picture not affected.

Service: Since only color is affected, this narrows our search considerably! The most likely suspect would be an intermittent heater or similar defect in the 6AU6 color amplifier tube or in the tetrode section of the color amplifier. Quick-check for presence of color if there are no color programs on the air: Detune the fine tuner until you see the "worms" show up in the picture (the

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NOTE WIRING CHANGES!
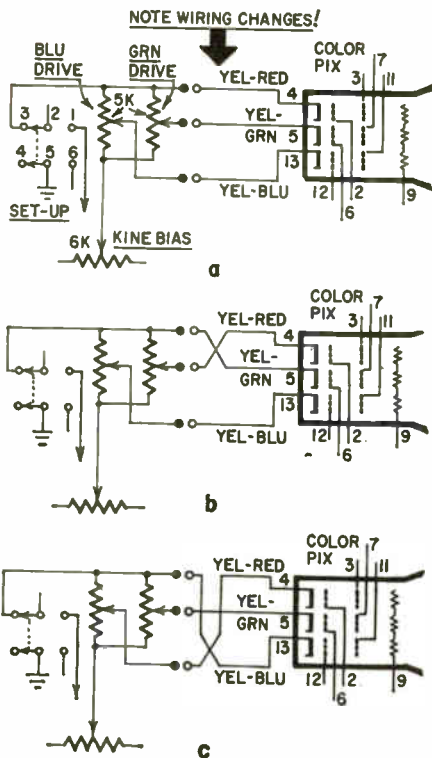
Fig. 907. *Deliberate wire crossing helps compensate for differences in phosphor efficiencies in old and new color tubes. Diagrams a, b and c show what to do for cyan-, magenta- and yellow-tinted pictures, respectively.*

wriggly outlines around objects). Be sure that the color-killer switch is turned *on*. If color is getting through, you'll see colored "fringes." No color in fringes: loss of color signal.

Explanation: beats are created when the tuner is mistuned like this. Some of them will find a way to get into the color circuitry, and create flashes and bits of color, *if* the color amplifiers, etc., are OK.

Symptoms: Worms in color picture. Color is good. Cannot tune out worms without losing the color.

Service: This is most likely a very slight misalignment. Check

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the setting of the 3.58-mc trap, and the input sound trap. If these are slightly off frequency, they will reduce the color burst amplitude. Also, be sure to check the setting of the "Fringe-Lock" control. Excess clipping here can also cause the same symptoms.

Symptoms: Poor definition in RCA CTC 12 chassis.

Service: RCA's field engineers recommend changing the i.f. alignment curve on this chassis, from that shown in the original service data (Fig. 908-a). The "haystack" curve doesn't seem to give the best picture definition.
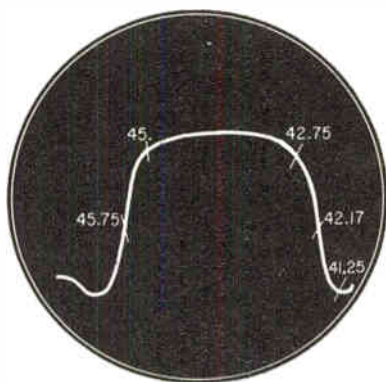
a
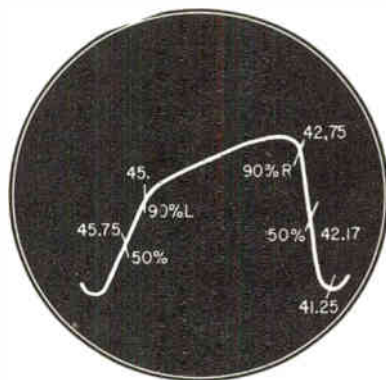
b

Fig. 908. *Original CTC 12 i.f. curve (a) can be improved for better definition as in (b). The adjustments do interact, and it may be necessary to line up each transformer a few times.*

Fig. 908-b shows the recommended curve. Set the first i.f., T302, to put the 45.75-mc marker at the 50% point on the left;

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the second i.f., T303, to get the 42.17-mc color subcarrier marker at 50% on the right side, and the third i.f., T304, to get the proper tilt to the top of the curve.

These adjustments all interact as usual, but you can get the proper curve with careful alignment. Be sure to set the 45.0-mc markers and the 42.75-mc markers at 90%, as shown on left and right shoulders of the curve.

Symptoms: Odd colors.

Service: You can see some odd colors in color TV sets. You can also hear some very odd and loud noises! Flashes of blue-white light, and perhaps smoke! The hysterical set owner is convinced the whole thing's burning up! Considering the cost, you can't blame him! So, our first task when we get there is to get him calmed down enough to tell us what's happened. After we get him down off the wall, we can usually find and fix the fireworks without too much trouble. Components in color TV high-voltage circuits are usually pretty well built, and they'll stand up to a pretty severe arcover if it's caught in time.

Fig. 909. *High-voltage regulator circuit can have some critical values. Regulation depends on voltage divider in grid circuit of 6BK4. (Also refer to Fig. 918 on page 140.)*
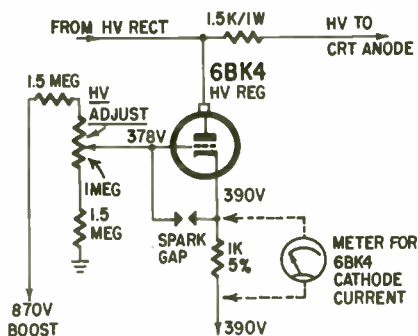
This is sometimes due to a high humidity, but more often to some trouble inside the set. With the very high voltages, color sets are more apt to flash over than black-and-white. Let's look at the circuits and see what's going on.

Clue: Color sets are about the only ones using regulated high voltage. If the regulator tube opens up, or isn't working, the high-voltage will go up, since there will be no control on it at all.

In these flashovers, it is not the high voltage that is doing the arcing; it's usually the *boost.* In color circuits, this runs about 800 volts. The 6BK4's plate is connected directly to the 25-kv line (Fig. 909). It usually draws a preset amount of plate current,

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thus shunting the high voltage. The more plate current this tube draws, the lower the high voltage, because the tube acts as a shuntload across it.

Now, we have to have a "signal" voltage on the grid, to tell the tube when to draw more current. This is the boost voltage. The total boost is fed to a voltage divider, and the regulator grid is tapped off that. B-plus goes to the cathode. If something happens (say, an increase in line voltage) the boost rises (goes more positive). This increases the positive voltage on the grid of the 6BK4, and it draws more plate current, reducing the high voltage because it makes more load across it. Simple, huh?

Now. In some sets (for instance the Zenith 25LC20 chassis), they have thoughtfully provided a spark gap in this circuit. This is just one of the regular solder-terminal boards used on these and several other makes—see Fig. 910. (This particular one is
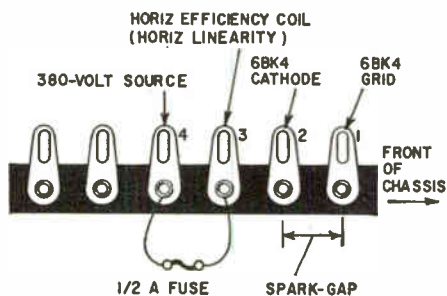
Fig. 910. *Terminals 1 and 2 on this strip are used as protective spark gap on some Zenith models.*

set close to the base of the 6BK4 tube, for obvious reasons.) Other terminals on the same board can be used to make tests; more on this in a minute.

Normally, flashovers *should* take place between 1 and 2 on this board. Most of the time, they will. However, in some cases, you'll see flashovers at the high voltage control on the back apron of the chassis. Because of the high voltage present, you'll find an arcover from the end of the resistance element to chassis. If this is allowed to go on too long, a carbon path will form, and you'll have to replace the control to avoid a callback.

Most of these troubles start with a bad 6BK4. For example, if the heater burns out, we lose all regulation. This can cause a flashover, but if the air is pretty dry, you may see loss of focus,

too much brightness, and similar symptoms in the picture. Take the lid off the high-voltage cage, turn the set on, and look at the 6BK4 heater. If you can't see it, because of the very large insulating plate cap on top, turn the set off, wait a minute or two, then feel the tube. If it's cold, it's out. Just watch where you put your hands, though!

While this tube has very wide spacing, it *can* short, just as a 1B3 can, if it wants to. Look for this; it's a common cause of arcovers. After you have replaced the shorted tube, check the set. The shorted regulator tube can overload the high-voltage rectifier, and even the horizontal output. If so, you'll get a narrow raster, loss of brightness, and possibly some tinting.

Check the cathode current of the output tube. In most sets, you can lift the high voltage fuse and connect a milliammeter across the holder. In the Zenith shown in Fig. 910, disconnect the fuse and connect the meter between terminals 3 and 4 on the same strip. The service data will tell you what the correct current is. In this set, it's 215 ma. If this current is very low, but B-plus voltages are normal, the horizontal output tube is weak and will have to be replaced. Leave the meter in place until you get the new tube in and working. Always check this cathode current whenever the output tube is replaced, just to be sure. It takes only a little while, and it's a big help in avoiding a callback!

Regulator action can be checked at this same terminal strip. In other chassis, test-points will be provided. Normal cathode current on this tube, with high voltage set at the correct value, about 24–24.5 kv, should be about 0.9 ma. In this circuit, you can read the dc voltage across the 1,000-ohm resistor in series with the cathode. In others, the meter is hooked into the cathode circuit, and the resistor opened. Follow the procedure given in the service data for whatever set you're working on.

If the high voltage has been set at the rated value, and the current's too low, reset the horizontal efficiency coil (horizontal linearity) to bring it up. The horizontal-output tube's cathode-current meter should still be in the circuit when this is done, of course, to keep the tube from getting too much current.

Check all resistors in the 6BK4 grid circuit. Since the two 1.5-megohm resistors and the high-voltage control form a voltage divider, they're pretty critical. An increase or decrease in any of

them can throw the circuit beyond the range of control. For a horrible example, if the upper resistor decreased in value, the 6BK4 grid would go highly positive. This would cause a great increase in its plate current, and the result could easily be a burned out 6BK4 and a melted-down flyback! So check 'em!

Symptoms: Vertical retrace lines show in RCA model CT-660U. The lines are intermittent and sometimes cover the whole screen.

Service: Vertical blanking in this series chassis is fed to the red cathode, and thence to the rest through the voltage divider (Fig. 911). Check for the vertical blanking spike at the red
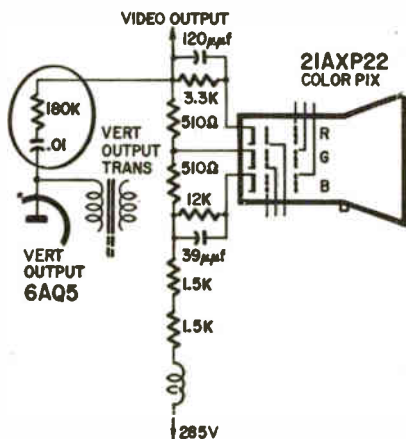
Fig. 911. *Retrace blanking circuit of RCA chassis.*

cathode with a scope. With a normal picture, you ought to get something like Fig. 912. The vertical blanking pulses here should have an amplitude of 130 volts peak to peak. The blanking is fed through the R-C network shown in Fig. 911. If blanking pulses are missing, trace back to the plate of the 6AQ5, to see where the pulse is getting lost.

This trouble could also be caused by vertical oscillator instability. If the 6AZ8 first video i.f., and vertical oscillator tube is slightly weak, this chassis has a tendency to roll. Just before it does, retrace lines show up. So, try replacing the 6AZ8 and resetting the vertical height and linearity.

Symptoms: Color set suddenly jumped out of convergence. Set degaussed and reconverged without trouble.

Service: The only possible answer for this is a thing that few

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have encountered personally, but have heard of in several cases—
lightning! A heavy lightning bolt striking within a certain dis-
tance, not striking the set, but hitting nearby, can cause partial
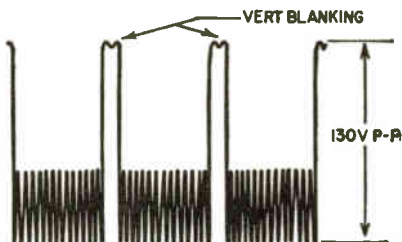
Fig. 912. *Waveform on 21AXP22
cathodes.*

demagnetization (or magnetization) of the purity magnets, face-
plate, etc. and foul up the convergence. Sort of a gaussing
operation.

Symptoms: Screen brightens, gets very reddish, and goes out
of focus. Now and then it becomes completely dark. Turning
up the brightness control sometimes restores the picture. Adjusting
the focus control does not help.

Service: This may be due to an intermittent damper tube.
Also, the reduction of boost voltage, with the decrease in load
on the flyback, apparently changes the focus by changing the
voltage applied to the focus rectifier. The red shift may have
something to do with the loss of boost voltage.

There is also the possibility of a defective red amplifier or
green amplifier. Here, the reddish tint would be due to a loss of
green, not an increase of red.

Symptoms: Off-color response.

Service: Since we have two signal paths for the video informa-
tion, one for the brightness and the other for the color, we can
have all kinds of troubles!

Look for what *is* there, and for what *isn't.* In some of the
older circuits, the color amplifiers were hooked up so that you
lost the color amplified by that particular tube. For example, if
the red amplifier went out, no reds. The picture went blue-green.
Most later models, because of the dc coupling used in color
video circuitry, seem to *increase* the color. If the red amplifier
goes out, the red gets brighter. Here's a "f'rinstance." We pulled

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tubes from an RCA CTC9 chassis to see what would happen, and this is what we found. (See Fig. 913.)
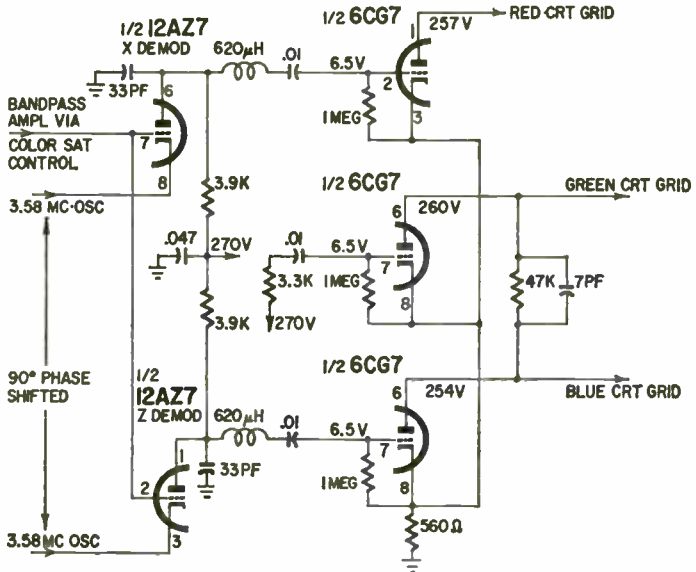
Fig. 913. *Color demodulators and amplifiers. If the demodulator tube goes out, all color disappears. Black-and-white is not affected. If color amplifier is pulled, corresponding color dominates picture, which also goes out of focus. This is handy to keep in mind for diagnosis.*

6CG7, green amplifier: Picture turned bright green and lost focus.

6CG7, red, blue amplifiers: Picture turned bright purple, lost focus.

12AZ7, X and Z demodulators: No effect at all on black and white picture, total loss of color signal on color.

You might repeat this test on the next color set you service; the results will tell you about what's going to happen if a given tube goes out. Of course, these are all twin triodes: if only one half goes out, as is common in some of these tubes, you'll lose only the color associated with the one tube. Most likely, instead of losing the color, you'll lose *control* over it. The screen will show *more* of that color.

If the dead tube has been getting weaker for quite a while, the color-temperature controls may have been adjusted to make up for that. So, when the new tube is installed, you'll have to check the color temperature, at least, and probably readjust it. Always

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keep the "Kine Gain" (RCA's name) as low as possible, for maximum life on the Big Bottle. Happy hue-hunting!

Symptoms: Brightness troubles. With both brightness and contrast controls turned down, raster remains on. Contrast control also acts like a brightness control. Picture tube checks OK.

Service: Both the brightness and contrast controls in many color TV chassis, are in an entirely different location from the standard control positions used on monochrome TV sets (Fig. 914).
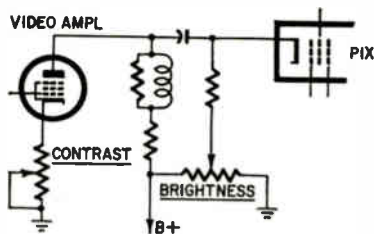
Fig. 914. *Brightness and contrast controls in a conventional black-and-white set.*

Because of the circuit connections used on the three-gun color tube, the video output stage is dc-coupled to the cathodes of the 21AXP22-A. So they regulate the beam current of the tube by controlling the bias of the video output tube (Fig. 915). You'll
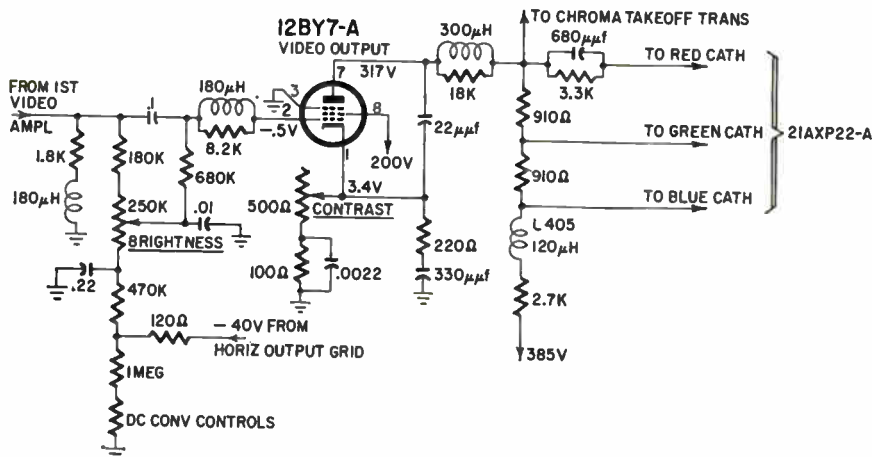
Fig. 915. *Brightness and contrast controls in a color receiver.*

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find some variation here but, in some models, it will be bright-ness control in the grid and contrast control in the cathode circuit.

So look for a gassy video output tube, a leaky coupling capacitor, open grid resistor or similar troubles in the video output stage when you have this kind of defect.

If you'll trace the circuit as we have in Fig. 915, you'll see that the video output grid circuit goes back to the horizontal output tube grid, through the R-C filter shown. This is done to get a negative voltage for biasing the video output. So, if the 470,000-ohm resistor is increased or decreased in value, or the 0.22-μf filter capacitor is open or leaky, you will have troubles showing up, not in the horizontal output, but in the video output, because
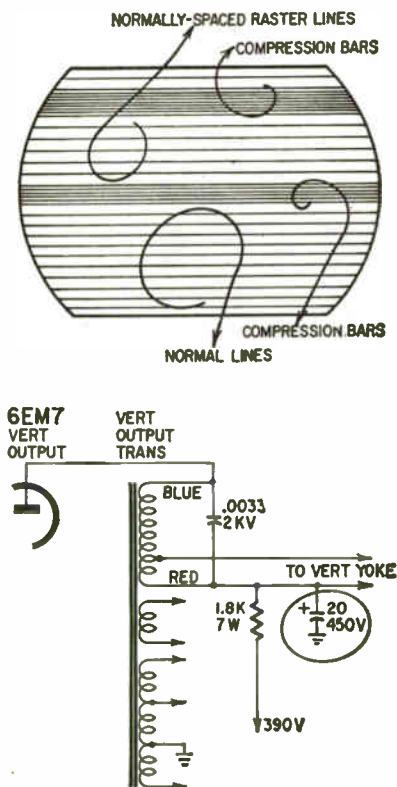
Fig. 916. *Partial circuit of vertical output stage in Zenith 29CJ20 color chassis. The drawing of the raster is that of a Zenith color set when 20-uf electrolytic is open.*

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of improper bias. Check all voltages around the 12BY7 video output and see if they are OK, and, if not, why not.

Symptoms: Black-and-white picture is perfect. Red smears.

Service: Transmitter trouble! Or, trouble in a stabilizing amplifier in the telephone company's office, where the coaxial cable or microwave link is terminated.

This is caused by a phase shift in the cable, or some similar component. It is delaying the blue and green or introducing a lead into the red.

This cannot be in your receiver! Why? Because it makes a good monochrome picture. The only thing that could cause this particular trouble in the receiver would be a severe misconvergence. But either one of these would cause the red fringing to show up on monochrome too!

Symptoms: Intermittent shrinkage. Color jitters; tearing of the color bar pattern into jagged strips. Set is a Zenith 29JC20.

Service: This is caused by an intermittent electrolytic capacitor, and the most likely suspect is the 20-μf 450-volt unit in the B-plus end of the vertical output supply (Fig. 916). Since the vertical output transformer in all color sets is the source of the waveforms used for convergence, etc., this circuit is very particular as to filtering. Any trouble at all around here can cause very peculiar effects. Check with a low-capacitance probe on your scope, to be sure.

Symptoms: Insufficient vertical tilt on CTC 10 chassis.
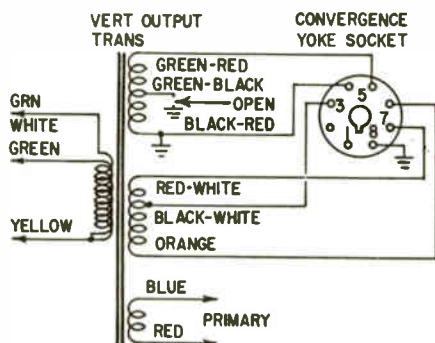
Fig. 917. *Insufficient vertical tilt range can be fixed by moving the ground on the vertical output transformer.*

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Service: This is probably due to low amplitude of the convergence waveform itself. This comes from the vertical output transformer, T104.

Look at the transformer. If the green-black wire is grounded, change this ground to the black-red wire. This will give you a higher-amplitude waveform for application to the vertical convergence circuits, and should help out. Fig. 917 shows the change.

Symptoms: Bad blooming in the highlights on RCA CTC 7 color chassis. No setting of the color temperatures adjustment will stop it. Voltages all normal. High voltage OK.

Service: This is most likely due to too much current in the 6BK4 high-voltage regulator. Try adding about 470,000 ohms to the grid resistor. This is a 1.8-megohm 1-watt resistor between the 6BK4 grid and boost voltage. See Fig. 918.
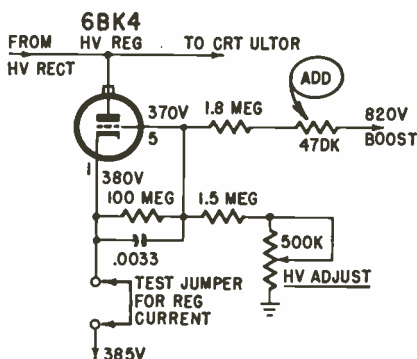
Fig. 918. *If too-high HV-regulator current causes blooming, add 470,000 ohms to the grid circuit. (Also see Fig. 909 on page 131.)*

Check the 100-megohm resistor between grid and cathode of the 6BK4, also the 1.5-meg in series with the high-voltage adjust control. Be sure that the voltages on the regular tube are OK, and check the current as specified in the instructions. This could also apply to any of several later chassis like the CTC 9, 10 and 11.

Also be sure to read the section under the heading of *odd colors* given on page 131.

Symptoms: Bad color sync in RCA CTC 5 chassis.

Service: Check the .022-µf bypass capacitor at the bottom of the grid winding on the burst keyer transformer. This is shunted across a 1-megohm resistor. If it opens, the grid impedance rises

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and seems to cut off the burst amplifier tube. At any rate, no color sync, or very badly reduced color sync, gets through to the color circuits. Fig. 919 shows where this capacitor is lócated.
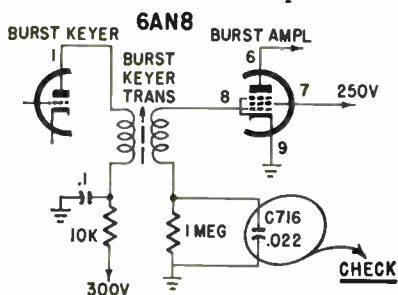
Fig. 919. *Check circled capacitor if sync is poor.*

Symptoms: Color hops in and out.

Service: This is one of two things: either agc or antenna trouble. Under most circumstances, too much signal is just as bad for color reception as too little. The sensitive tuners used in modern color sets will be beaten to their knees by too much signal. Unless, that is, you set the agc properly and, if necessary, reduce the signal level applied to the input with pads. If you try to pad, always use resistive pads (Fig. 920), never inductive, to avoid forming traps for the color signals.
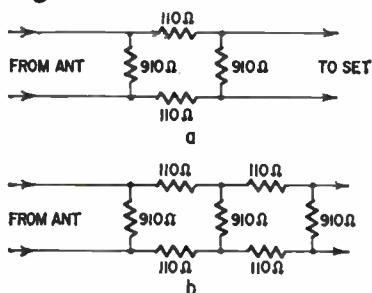
Fig. 920. *Two pads for reducing signal strength in strong-signal areas. Pad in (a) drops signal 6 db. For additional attenuation, add another section as in (b). For further information on pads, refer to Chapter 3 and also to Fig. 302 on page 48.*

In the second case, you could have a trap in the antenna. Try disconnecting one side of the lead-in. If this brings the color back

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steadily, you'll either have to cool off that lead-in with metal foil or put up a less sensitive antenna.

Be sure to read Chapter 3 (Antennas and Boosters) and see Fig. 302 for additional attenuator pads.

Too much signal can also cause distortion, color cancellation and buzz as described below.

Symptoms: Distortion. Cancellation of color. Sound buzz, both on black-and-white and color. Service area is very close to station.

Service: The main trouble here is *too much* signal. A very strong signal can cause distortion or even cancellation of color, buzz and a lot of other things. The only cure is to reduce the signal level applied to the tuner input. The easiest way to do this is with simple resistive pads. Fig. 302 in Chapter 3 and Fig. 920. show some typical values.

If the set is really close—that is, within a couple of miles of a 100-kw station, you may even have to eliminate the antenna altogether. Try a short piece of Twin-Lead or even a piece of single wire. Another suggestion that has helped in similar cases is using shielded 300-ohm Twin-Lead between the pad and the tuner input. Build the pad inside a small shield can to reduce pickup. Any kind of tin can will do, as long as it's not too small. Put an insulating liner inside the can to keep the components from shorting. Let the can hang off the antenna terminal board.

Customer relations

There is one very important adjustment in color TV installation that is often neglected. Not the convergence, the purity, the color temperature or the high voltage—the customer! Remember what a time we used to have when black-and-white TV first came in? Lots of people didn't know the difference between the vertical and horizontal holds.

We have the same problem today, with color TV, and we'd better get used to paying some attention to it. If we'll spend just 15 minutes with the new color TV user when the set is first installed, we'll save a lot of nuisance calls later, and make the user a lot better satisfied with color.

Color TV installation today has been tremendously simplified, compared to what it was some years back. Now it is possible to install a set and make all the technical adjustments within 15 minutes. So, since we have a little time left over, what better use could we make of it than training the customer in operating his set for the best reception?

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You can work out your own "routine" according to your ideas, but here's the one our shop uses: After we pick the location for the set (away from too much direct light—colors look a lot brighter!), we set up the dot generator and check the convergence, etc. The customer should always be present while this is being done; most of 'em will be anyway, out of curiosity. So here's an important point: act very nonchalant. This is just an everyday thing in your life. These adjustments are complicated, but not difficult. This attitude helps alleviate the customer's unconscious fear of not being able to operate this polychrome monster. (Customers can be scared of color, too.)

For the last adjustment, set the color temperature. *Get the owner to help you.* Never set the color temperature and tell him (or her), "That's white." *Ask* him. Say politely, "Would you mind sitting over there where you can see the screen and telling me when I get it white?" Then go ahead with your adjustment. There's a psychological point here. If she or he has chosen the screen color, they're not nearly so apt to call you back the next day and complain, "This thing looks greenish."

After it's set up, turn the color off or tune in a black-and-white picture. Now run through the operation on B/W, comparing it to the controls on the old set. Run 'em through the tuning, brightness, contrast, etc. adjustments several times. If there's a teen-ager present, let him set it up, tune it and so on. (He probably will anyhow.)

With black-and-white zeroed in, turn on a color program with the color turned *off*. (If you were smart, you delivered the set when there was a day-time color show on.) Schedule your deliveries so that you'll have plenty of time to get there and get set up before the color show starts.

With the color show ready, tune it in and *then* turn up the color. You get a better dramatic effect this way! Now, explain the operation of the two color controls. Show them what each does, and make them adjust them. Concentrate on explaining how simple color TV is to tune and operate. Change channels and show them how the set cuts the color off, then brings it back automatically. Be sure to show them the fine tuning and how it affects color.

Keep it simple

Don't give them the big scientific routine about how mistuning the mixer-oscillator affects the position of the color burst

on the response curve! Say something simple, like our pet line: "You know how you can move the fine tuning and lose the sound or the picture? Well, color's the same way. So set the fine tuning till you get the best color!"

Emphasize the *simplicity* of the whole operation. After all, they've been tuning their old black-and-white set for quite awhile now, and they *can* tune for color without any trouble if you'll tell them in simple words just how to do it.

Divide your color installation time. Figure about 15 minutes to adjust the set, and up to a ½-hour to adjust the customer! Much better results than the other way.

chapter 10
glossary

acc: Automatic color control (also automatic chrominance control). Similar to automatic gain control, except that it acts on the chrominance signal, automatically reducing the gain of the chrominance amplifier to prevent overloading on strong signals. The burst signal is rectified and applied as bias to the chrominance amplifier. An increase of burst amplitude will therefore decrease amplifier gain.

additive primaries: Primary colors are those which can be mixed to form other colors, but which cannot themselves be produced by mixing other primaries. Red, green and blue are the primaries in TV because, when added in various proportions, they produce a wide range of other colors. For this reason, red, green and blue are called *additive* primaries.

afc: Automatic frequency control. Two forms of afc are used in TV receivers: one locks the frequency of the horizontal scanning oscillator and the other maintains correct phase and frequency of the 3.58-mc local oscillator of a color receiver (see *apc*).

apc: Automatic phase control. Sometimes called automatic frequency phase control or afpc. Because the 3.58-mc chrominance subcarrier is suppressed at the transmitter (only the sidebands are retained), it must be reinserted at the receiver. The receiver therefore contains a 3.58-mc oscillator. The reinserted carrier

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must be maintained at correct phase and frequency for accurate reproduction of the colors in the televised scene. For this reason, a sample of the suppressed subcarrier is transmitted (the color burst signal) and used in the receiver to control the local 3.58-mc oscillator. A phase detector compares the burst signal to the signal from the local 3.58-mc oscillator. Any difference produces a dc output which controls a reactance tube which, in turn, controls the phase and frequency of the oscillator. See Fig. 1001.
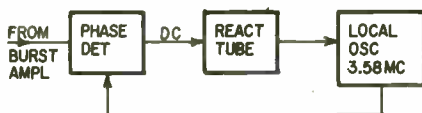
Fig. 1001. *Block diagram shows relationship of phase detector, reactance tube and 3.58-mc oscillator.*

aperture mask, (see *aperture plate.*)

aperture plate: A thin metal plate mounted slightly behind the phosphor dot screen of a three-gun picture tube. The aperture plate has many small openings so positioned that one of the three electron guns will excite only red phosphor dots, another electron beam will strike only green dots, and the third strikes only blue. The aperture plate is also known as an aperture mask or a shadow mask.

automatic phase control: (see *apc.*)

bandpass amplifier: The amplifier tuned for the 3.58-mc chrominance signal. Bandwidth of this amplifier is great enough to include the I and Q sidebands which carry the color information. This amplifier receives the total video signal but passes only the chrominance portion. The bandpass amplifier is also known as the chrominance amplifier or color amplifier.

blue gun: The electron gun whose beam, when properly adjusted, strikes only the blue phosphor dots in the color picture tube.

blue video voltage: The signal voltage that controls the grid of the blue gun in a three-gun picture tube. This signal is a reproduction of the blue output signal of the color TV camera.

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brightness signal: Signal voltage that represents the variations of brightness in the televised scene. This signal is formed at the transmitter by combining portions of the outputs of the red (30%), blue (11%) and green (59%) cameras. The brightness signal is also known as the luminance, monochrome or Y-signal.
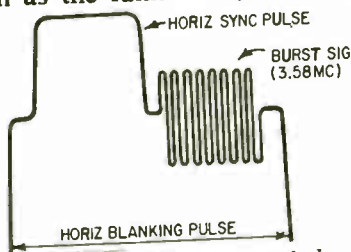
Fig. 1002. *The purpose of the 3.58-mc sine wave burst is to synchronize the phase and frequency of the chroma reference oscillator.*

burst: A 3.579545-mc (roughly 3.58) signal transmitted for several microseconds after each horizontal sync pulse. In the receiver, the burst signal synchronizes the phase and frequency of an oscillator that reinserts the suppressed carrier. The burst signal is carried on the back porch following the sync pulse. See Fig. 1002.

B—Y signal: A color-difference signal representing the difference between the brightness signal (Y) and the output of the blue camera. In the receiver, the brightness signal is added to the B—Y signal to produce B—Y+Y=B. This signal controls the blue gun of the picture tube.

chrominance amplifier: The amplifier that separates the chrominance signal from the total video signal. (See *bandpass amplifier.*)

chrominance signal: The sidebands produced when the I and Q signals modulate the 3.58-mc subcarrier. These sidebands carry color information only (brightness information is carried separately by the luminance signal).

chrominance subcarrier: The 3.579545-mc subcarrier (referred to as 3.58-mc for simplicity) which is modulated by the I and Q signals to produce the sidebands which carry the color informa-

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tion. These sidebands, along with the brightness signal, modulate the picture carrier of the channel.

color amplifier: (See *bandpass amplifier.*)

color bar generator: A test instrument used for troubleshooting and alignment. Its output, applied to a color TV receiver, produces a pattern of colored bars on the screen.

color burst: A sample of the suppressed subcarrier. (See *burst*).

color demodulators: Often called X and Z, I and Q, or R and G. Color demodulators are detectors and separate the color information from the video signal. (See *I demodulator and Q demodulator*).

color-difference signal: A waveform produced by subtracting the luminance signal (Y) from the output signal of the color cameras. Since brightness information is handled separately in the transmitter and receiver, it can be eliminated from the chrominance signals. Subtracting the brightness signal from the output of the blue camera yields the "blue minus brightness" or B—Y signal. Similarly, subtracting the brightness signal from the red camera output produces the "red minus brightness" or R—Y signal. The G—Y signal can be produced by combining portions of the B—Y and R—Y signals. (See *B—Y, G—Y, R—Y.*)

color edging: Extraneous colors at the boundaries of colored areas in the picture.

color killer: A circuit that cuts off the chrominance amplifier during black-and-white reception. If this were not done, noise voltages in the chrominance amplifier would produce colored snow (confetti) in the black-and-white picture. When color is transmitted, the burst signal deactivates the killer, allowing the chrominance amplifier to operate normally.

color subcarrier: See *chrominance subcarrier.*

composite color signal: The complete signal required to produce a color picture. This includes the luminance (brightness) signal,

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the chrominance signal, all blanking and sync pulses, and the color burst.

confetti: Flecks or streaks of color caused by tube noise in the chrominance amplifier. Because of its colors, confetti is much more noticeable than snow in a black-and-white picture. The chrominance amplifier is therefore cut off during a black-and-white program. (See *color killer.)*

convergence: The condition in a color picture tube when the three electron beams intersect in the plane of the shadow mask, so that all three beams strike their own color dots (red, blue and green) on the screen.
(See *dc convergence* and *dynamic convergence.)*

dc convergence: The condition in a color picture tube when the three electron beams intersect while passing through an opening in the center of the shadow mask. Such convergence of the un-deflected beams is also known as static convergence.

decoder: (See *matrix.)*

degaussing: The process of demagnetizing metal parts or supporting structures of the color picture tube. Degaussing is done with a large-diameter coil connected to the ac line.

delay line: Simple component, such as coil or coaxial cable, used to delay the video signal in the receiver so that it reaches the CRT at the same time as the color signal.

demodulator: See *I demodulator* and *Q demodulator.*

dynamic convergence: The condition in a color picture tube when the three beams remain properly converged even when deflected to the edges of the screen. Compensation must be made for the greater distance the beams must travel when deflected away from the center of the screen.

frequency interlacing: The frequency components corresponding to the luminance signal do not occupy a continuous spectrum but rather occur in clusters. The unused spectrum space between

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adjacent clusters can therefore be used for color information signals. In this manner, both luminance and chrominance information can be transmitted in the same channel bandwidth without interfering with each other. This technique is known as frequency interlacing or frequency interleaving.

green gun: The electron gun whose beam, when properly adjusted, strikes only the green phosphor dots in the color picture tube.

green video voltage: The signal voltage that controls the grid of the green gun in a three-gun picture tube. This signal is a reproduction of the output of the green camera at the transmitter.

G—Y signal: A signal representing the difference between the green camera output and the brightness (Y) signal. The G—Y signal can be produced by combining portions of the R—Y and B—Y signals. If the brightness signal is added to the G—Y signal, the result will be $G—Y+Y=G$. This G signal is used to control the green gun of the picture tube.

H-pad: Attenuator or network of resistors used for weakening TV signals when they are too strong.
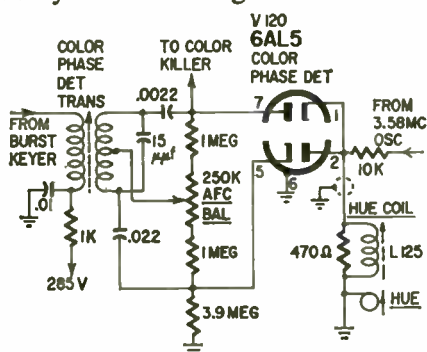
Fig. 1003. *Hue control circuit in the RCA CTC4 chassis. The hue adjustment on this set is a small metal blade which changes the inductance of the coil in the color-phase detector plate. A slug inside the coil tunes it to the proper inductance. See Fig. 1003.*

hue: The technical name for what is commonly called "color." Red, green, orange, blue, yellow, etc. are hues. See Fig. 1003 for a hue-control circuit.

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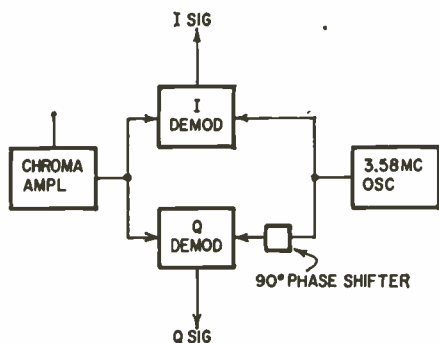
Fig. 1004. *Block diagram of the I and Q demodulators. The two demodulators are out of phase by 90 degrees.*

I demodulator: A demodulator circuit whose inputs are (1) the chrominance signal and (2) the signal from the local 3.58-mc oscillator. The output of this demodulator is a video signal representing colors in the televised scene. The Q demodulator is similar except that its input from the local oscillator is shifted 90 degrees. See Fig. 1004.

I signal: A color information signal produced at the transmitter by combining portions of the outputs of the red, green, and blue cameras. At the receiver, these sidebands (chrominance signals) are reconverted to color video signals. (See *I demodulator.*)

luminance: Pertaining to brightness, as distinguished from chrominance, which pertains to color.

luminance signals: The signal that carries brightness information only, as distinguished from the chrominance signal, which carries color information only. Luminance signal is also known as brightness signal or Y-signal. (See *brightness signal.*)

matrix: In the transmitter, the circuit that combines the red, green and blue camera signals in proper proportions to produce the I and Q signals. This matrix is sometimes referred to as a color coder or encoder. The matrix in the receiver performs the opposite operation; it combines the Y, I and Q signals in proper proportions to produce red, green and blue video voltages for the three electron guns of the picture tube. This matrix is sometimes referred to as a decoder.

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monochrome signals: See *brightness signal.*

noises: See *confetti.*

NTSC: National Television Systems Committee. This committee formulated the TV standards later approved by the FCC.

phase detector: A circuit that compares the burst signal and the signals produced by the local 3.58-mc oscillator of the receiver. If they differ in frequency or phase, the phase detector produces a correction voltage, which is applied to a reactance tube to correct the phase or frequency of the local oscillator.

phase modulation: Form of modulation used for the color carrier. The picture carrier is AM and the sound carrier is FM. Phase modulation is abbreviated as PM.

phosphor-dot screen: A glass plate containing small dotlike deposits of phosphor. The dots are deposited in groups of three, each containing a red-, a blue- and a green-light emitting dot. The three electron beams of the color picture tube are so adjusted that one strikes only red dots, another strikes only green, and the third strikes only blue.

phosphor trio: A group of three phosphor dots (red, blue and green). For each such group there is one hole in the aperture plate through which the three electron beams can pass. The intensity of the three beams can be varied independently so that any or all of the three colors can be combined in various proportions to produce other colors.

picture control: Technique for varying picture tube electrode voltages to obtain proper highlights and lowlights. See Fig. 1005.

primary colors: Colors which can be combined in various proportions to produce a wide range of other colors, but which cannot themselves be produced by mixing other primaries. Red, green, and blue are the primaries in color TV. (See *additive primaries.)*

purity: The condition in a color picture tube when the electron beam from the red gun strikes only red phosphor dots, the blue

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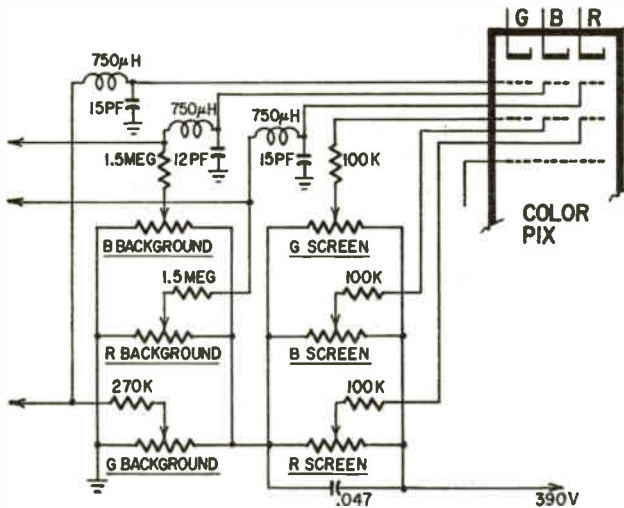
Fig. 1005. *Gray-scale tracking: the control-grid pots (background) adjust highlights; the screen-grid pots adjust lowlights.*

beam strikes only blue dots, and the green gun excites only green dots.

purity magnet: A magnet mounted on the neck of the picture tube and used to direct the electron beams for good purity. (See *purity.*)

Q demodulator: A demodulator circuit whose inputs are the chrominance signal and the signal from the local 3.58-mc oscillator after it has been shifted 90°. This phase shift is necessary so that the local signal will be an accurate representation of the Q subcarrier that was suppressed at the transmitter. Output of the Q demodulator is a color video signal representing colors in the televised scene. (See *I demodulator.*)

Q signal: A color information signal produced at the transmitter by combining portions of the outputs of the red, green and blue cameras. This Q signal is then converted to sidebands of a 3.58-mc subcarrier (the subcarrier modulated by the Q signal is 90° out of phase with the subcarrier modulated by the I signal). At the receiver, the sidebands are reconverted to color video signals. (See *I demodulator.*)

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rainbow generator: A test instrument whose output, applied to a color TV receiver, produces a continuous spectrum of colors across the screen.
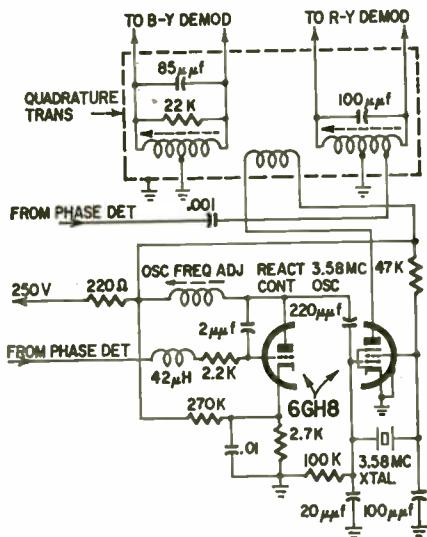
Fig. 1006. *Reactance-oscillator circuit. Phase is controlled by the afc phase-detector circuit in conjunction with the reactance tube.*

reactance tube: The tube that controls the frequency and phase of the 3.58-mc oscillator in the receiver. Responding to correction voltage supplied by a phase detector, the reactance tube adjusts the phase and frequency of the oscillator. See Fig. 1006. (See *apc*.)

red gun: The electron gun whose beam, when properly adjusted, strikes only red phosphor dots in the color picture tube.

red video voltage: The signal voltage that controls the grid of the red gun in a three-gun picture tube. This signal is a reproduction of the output from the red camera at the transmitter.

regulator circuit: Circuit used for maintaining a fairly constant high voltage for varying picture tube load changes. See Fig. 1007.

ringing circuit: In some color receivers, the 3.58-mc oscillator operates continuously. In others, the burst signal is used to shock-excite a quartz crystal. Because of its high Q, the crystal continues to vibrate (ring) until the next color burst arrives.

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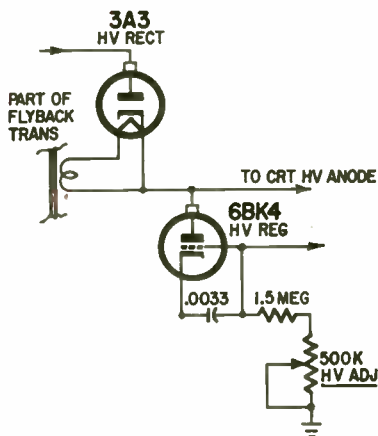
Fig. 1007. *HV regulator circuit. The regulator circuit helps minimize blooming.*

R—Y signal: A color-difference signal representing the difference between the brightness signal (Y) and the output of the red camera. In the receiver, the brightness signal can be added to the R—Y signal to produce R—Y+Y=R. This R signal controls the red gun of the picture tube.

saturation: The extent to which a color is undiluted by white. High-saturation colors are deep and brilliant; low-saturation colors are soft and pale. Red and pink, for example, are the same hue at different levels of saturation. Deep red contains very little white and is therefore highly saturated. Pink contains a considerable amount of white and is therefore low in saturation.

shadow mask: A thin metal plate mounted slightly behind the phosphor-dot screen of the color picture tube. The shadow mask contains many small openings through which the electron beams bombard the phosphor dots. (See *aperture plate.*)

static convergence: See *dc convergence.*

subcarrier: A signal that is modulated by a lower frequency and then used to modulate a higher frequency. Two subcarriers are

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employed in color TV, both of the same frequency (3.58 mc) but 90° out of phase. One subcarrier is modulated by the I signal and the other by the Q signal. The sidebands of the modulated subcarriers modulate the picture carrier of the channel.

synchronous detector: A detector circuit, one of whose inputs is a locally generated signal which represents a signal suppressed at the transmitter. (See *I demodulator.*)

trio: (See *phosphor trio.*)

white: For color TV, white is a mixture of red, green and blue. In the picture this is produced by exciting all three dots in each phosphor trio. Since the eye cannot distinguish the individual dots, the mixture appears white.

X and Z demodulation: A system of demodulation in which the two reinserted 3.58-mc subcarrier signals differ by approximately 60° rather than the usual 90°. R—Y, B—Y and G—Y voltages are derived from the demodulated signals, and these control the three guns of the picture tube. An important advantage of this system is that receiver circuitry is simpler than that required with I and Q demodulation.

Y signal: A signal containing luminance information (see *brightness signal.*)

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