BUILD a versatile probe set

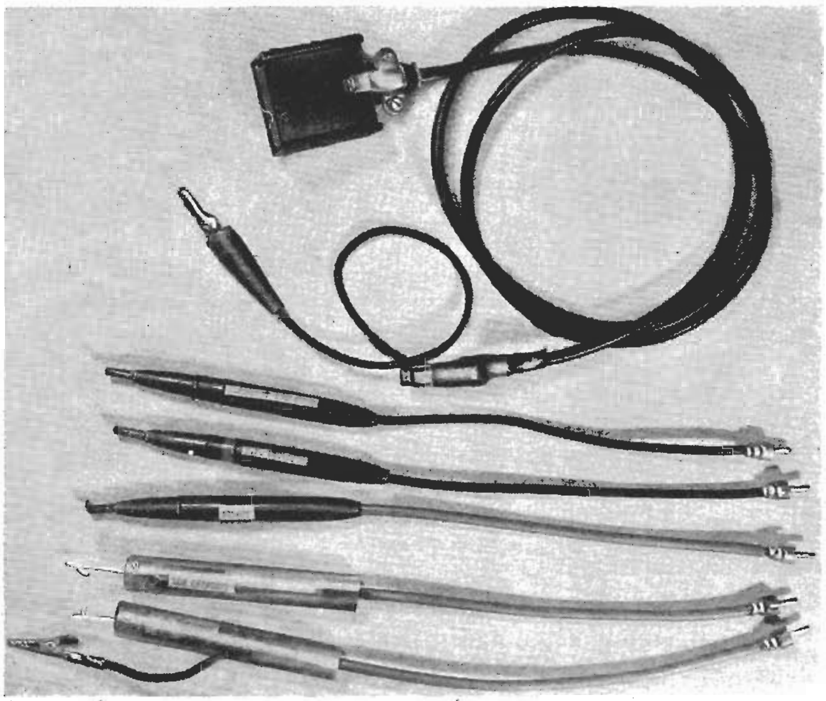

Fig. 2—The scope cable and the five probes described in article.

Part I: Construction and application of direct, alignment, isolation and high-frequency probes

By **EARL T. HANSEN**

MANY service technicians who have a fine scope have never bothered to obtain the set of probes necessary for its proper and complete use. Others have probes but are often uncertain as to which one to use for the particular circuit to be analyzed. This article describes the construction and use of five oscilloscope probes which meet practically all requirements for servicing modern electronic equipment. The cost of materials for the set is $7–14 depending on whether the probe blanks are purchased or assembled by the builder.

The original probe set used E-Z-Hook probe blanks; however, two types were duplicated using readily available materials to prove the feasibility of home construction of the entire set. Fig. 1 shows construction details. Polystyrene, bakelite or similar plastic may be used for the barrel and end plugs. A ¾-inch length of ½-inch plastic rod is drilled for a snug fit of the shielded cable and cemented flush in one end of a 4-inch length of ⅝-inch od tubing. A 7/16-inch length of ½-inch rod is drilled to clear a 6-32 machine screw. It will be easier if the rod is drilled before it is cut to size. This piece is held in the probe with two small self-tapping sheet-metal screws. The holes for these should be drilled at this time. The tip is made of steel wire. A medium-sized paper clip seems ideal; the wire is stiff and solders easily. The exact dimensions of the tip are not critical. The hooked portion is extremely useful when the probe is to be left connected to a circuit under test for any length of time. The slot in the 6-32 screw must be cleaned out with a hacksaw to assure easy soldering, and the wire tips soldered to the screw before placing in the plastic end.

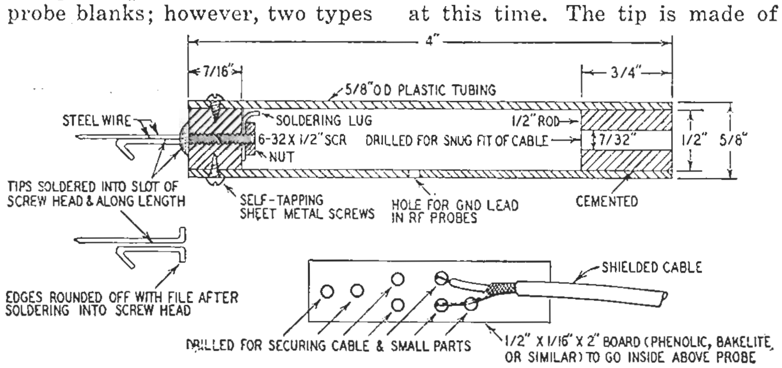

Fig. 1—Construction details for building the probe blank.

Components and the shielded cable are fastened to a 1/16 inch thick, ½ inch wide strip of phenolic insulating board, Bakelite or other material that would resist the soldering heat. A length of about 2 inches would do. A shorter strip can be used in the probes which have fewer internal parts. Holes are drilled in the strip at convenient spots to facilitate parts mounting. The shielded cable should extend as far toward the front of this probe as possible and still leave space for other parts. This minimizes the amount of unshielded wiring.

For convenience one cable is used for all five probes. The cable consists of a 3½-foot length of RG-62/U coaxial line. RG-62/U has a partial air dielectric which helps to reduce the capacitance to 13.5 $\mu\mu f$ per foot. Other types of shielded wire or cable may have several times this capacitance and therefore should not be used. In addition, this cable is very flexible and easily worked.

One end of the cable is connected to the scope vertical input terminals directly or with a shielded plug suitable for the scope to be used (Fig. 2, at head of article). The other end is soldered and taped to a female cable type phono connector into which the probes can be quickly connected. A 10-inch length of test lead wire is connected to the cable shield near the connector and is the ground connection for all the probes except for the low-frequency detector, discussed later. The ground lead has a conventional alligator clip for gripping the chassis under test. Each probe is connected with an 8- or 10-inch length of microphone cable or small-diameter coax line to a male phono plug on the end. These plugs fit the socket on the low-capacitance scope cable.

All five probes have output flat down to dc. The low-frequency limitations therefore depend on the characteristics of the scope they are used with. Capacitors which would cause the dc component to be lost have been omitted from all probes. Practically all scopes have a dc blocking capacitor at the vertical input section, to be used when the technician is interested only in the ac component of the signal, as is generally the case. Therefore the absence of blocking capacitors in the probes is an advantage under all conditions. The component layout is not critical, but it is necessary to arrange them very compactly so the barrel will slide over easily. Where E-Z-Hook probes are used, the curled lug on the end of the terminal board is used to anchor the cable shield in each case. Part of the terminal board can be filed away to fit in parts should this be necessary.

Direct probe

This is simply a direct use of the shielded cable to the scope (Fig. 3). While this probe has the highest gain (least loss), it is not often desirable to use this in TV servicing. Maximum scope gain is seldom necessary and because of scope input and cable capacitance, high-impedance circuits are loaded down and high-frequency components are attenuated, giving a distorted presentation. The use of this probe should be limited to low-level audio, checking ripple in plate supply voltages, auto radio vibrators and similar low-level or low-impedance circuits. Peak-to-peak ac currents can be observed by connecting the scope across a low-value resistance (1 ohm) with this resistance placed in series with the circuit to be checked. An example would be where the resistor is placed in series with the low side of a yoke coil and the linear sawtooth current of a properly operating deflection circuit can be observed on the scope. Capacitance loading with this type of probe will be from 55 to 125 $\mu\mu f$, depending on scope input capacitance.

Alignment isolation probe

This probe (Fig. 4) has one important use—connection to the video detector load circuit for alignment and if response curve observation. Resistor R has a multiple purpose. First, it serves as an rf filter to prevent the intermediate frequency which may pass

Fig. 3—The simple direct probe.

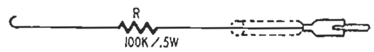

Fig. 4—The alignment isolation probe.

through the detector from reaching the cable and being radiated or fed back, resulting in curve distortion or instability. Second, R and the cable capacitance plus scope input capacitance form an R-C network which greatly attenuates frequencies above a few kilocycles. This has the effect of sharpening the markers on the response curve. Since the if response curve information has only low-frequency components, its shape is not altered by this network. Third, because of the high-frequency reduction, 15,750-cycle interference is minimized.

At this point you may wonder about the shielding of the probes. Shielding would add to the bulk, weight and input capacitance of the probe and has proven unnecessary in TV signal tracing. The unshielded leads and parts within the probe are only about 2 inches long and no unwanted signals have been picked up. However, the free-floating probe tip will pick up horizontal pulses and

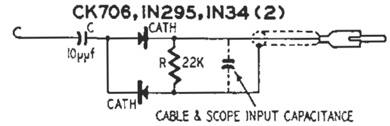

Fig. 6—The high-frequency probe.

Materials for probe set

Fig. 4
R—100,000 ohms

Fig. 6
R—22,000 ohms
C—10 $\mu\mu f$
D—CK706, 1N295, 1N34 crystal diodes or equivalent, see text

Miscellaneous (Cable and hardware listed below includes that needed for Part 2)

3½-ft RG-62U coaxial cable
4-ft microphone cable, Beldon 8401 or equivalent
1-ft test lead wire
5 male phono plugs
Cable type female phono connector
Shielded connector to fit vertical input terminal on scope
2 alligator clips
5 probe blanks, EZ-Hook or similar type, or if it is desired to construct the probe blanks:
 2 12-inch lengths ⅝-inch outside diam, ½-inch inside diam polystyrene tubing
 12-inch length ½-inch polystyrene rod
 piece phenolic board, 1/16 x ½ x 12 inches
 5 brass ½-inch oval-head machine screws, 6-32, nuts and lugs
 5 paper clips
 10 self-tapping sheet-metal screws, 3/16-inch

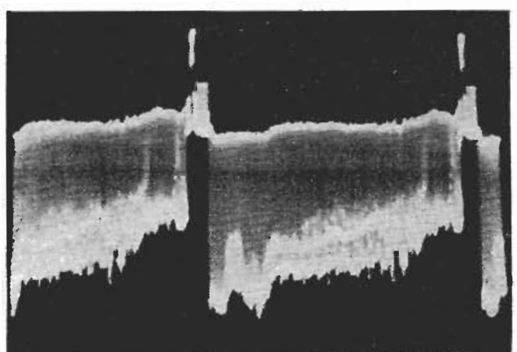

Fig. 5—Video distortion on scope when demodulator probe of insufficient band width is used for signal tracing in if section of TV receiver.

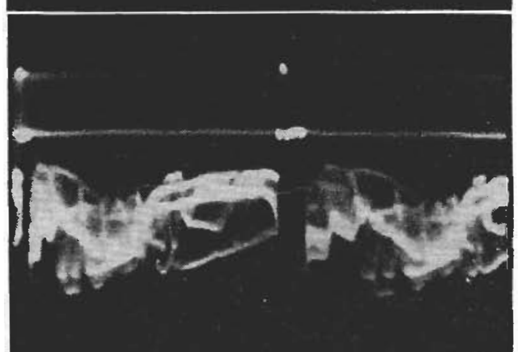

Fig. 7—Video signal as seen with high-frequency detector probe at second if stage.

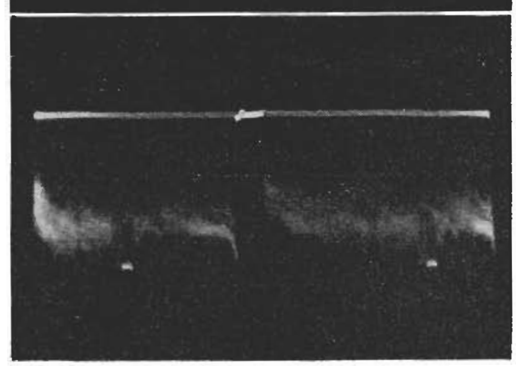

Fig. 8—Video signal with severe sync pulse clipping. High-frequency detector probe on plate of third video if stage.

a little hum but this disappears when the probe contacts the circuit under test. There would be very little sense in shielding the probe tip if the circuit under test was relatively unshielded and free to pick up stray signals. Most video amplifier, if and sync circuits are not extremely high impedance and therefore do not generally pick up unwanted signals. If unwanted signals are present in any circuit, they were there before the probe was connected.

High-frequency detector probe

The term high frequency applies to the modulated signal or audio output and not to the rf to be demodulated. This probe is designed primarily for signal tracing and analysis in the video if section of TV sets. An attempt to signal trace in an if strip with a conventional detector or demodulator probe presents a picture similar to that of Fig. 5, with the horizontal portion of the signal apparently depressed and irregular. It is difficult to determine from this presentation whether hum or sync distortion is present. The conventional probe is not designed to pass the demodulated video signal without this distortion; it is designed primarly for alignment and general signal tracing, as is the low-frequency detector probe to be described later.

The high-frequency detector probe (Fig. 6) is a voltage-doubler type, designed to give maximum output with adequate bandwidth. C is low in capacitance to reduce loading on the circuit under test. The value of R is a compromise between output amplitude and output bandwidth (modulated-signal frequency response). The output bandwidth with the component values shown in Fig. 6 is dc to approximately 100 kc, adequate to display the horizontal sync pulses at the correct amplitude. The crystals used (1N295, CK706 or 1N34) must be small enough to fit in the probe assembly; those used in the original model are about the size of a ½-watt resistor. Any crystals having similar size and electrical characteristics may be used. Somewhat larger types may be used if homemade probes are used. Electrical characteristics are not critical, those with a higher inverse voltage rating [illegible]eferable.

Fig. 7 [illegible] the video signal appears [illegible]h-frequency probe is used [illegible] signal in the 21- or 41-[illegible] th[illegible]ion of present TV re[illegible] how easily hum modula[illegible] or sync clipping (Fig. 8) could be seen if it were present. In good signal areas it is possible to get a usable signal right off the output of the tuner or the grid of the first if tube. It may be necessary to short out the tuner agc voltage to get additional signal at this point.

The probe can be connected to grids and plates progressively down the if strip to check stage-by-stage gain and signal quality. Checks in this manner are normally made with the scope horizontal sweep at 30 cycles, synchronized to the line frequency. This allows hum modulation and vertical sync troubles to be more easily identified. If the scope sweep is changed to 7,875 cycles to observe the individual sync pulses, you will note that the front and back porches are not visible and the pulse tips somewhat pointed or rounded off. The exact shape of the horizontal sync pulses could be seen more closely by decreasing the value of R. This is not recommended, however, as it would increase the loading of the circuit under test and decrease the output amplitude of the probe. It is actually not necessary since we are concerned more with the relative amplitude of the pulses, not their exact shape.

This probe has excellent 60-cycle ac rejection and therefore can be used to check for rf interference on filament and other power supply leads. If rf were present in these circuits, the modulation component would show up on the scope.

Another important use for this probe is signal tracing in the chrominance section of color receivers ahead of the synchronous demodulators. The color burst signal shows up as a pulse similar to horizontal sync pulses, with other demodulated subcarrier information interspersed. To observe this the scope should be swept at 7,867 cycles, synchronized by lightly coupling the external sync lead of the scope to the "hot" lead of the horizontal yoke coil.

To check for hum on the chroma signal the scope sweep is 30 cycles. Therefore with the aid of this probe the scope need not be a wide-band model to signal-trace in the chroma section of a modern color set. However if a wide-band scope (response to 4 mc) is used, it is far more desirable to use the low-capacitance probe (to be described later) for signal checking in the chroma circuits. Use caution in high-level demodulation circuits where the chroma voltages may exceed the ratings of the crystals in the probe. As a rule, do not go beyond the grid of the demodulator driver with this type of probe, unless the coupling to the probe tip is reduced by adding a 2-$\mu\mu$f capacitor in series with the probe tip and the circuit under test.

The high-frequency probe is not satisfactory for signal tracing in radios because of the relatively low if (455 kc). Much of this signal would be passed by this probe rather than demodulated, thus distorting the output or causing regeneration. The probe should not be used on rf above the video if range (46 mc) because the probe cable could become resonant, producing erratic indications. Because the upper-frequency limit of this probe is 46 mc, it is not necessary to use a short ground lead. However, if the builder prefers to include a separate short ground lead, it could certainly do no harm. This probe may be labeled a video rf probe, which would be more descriptive of its actual use.

TO BE CONTINUED

HANDY TESTER

Here is a versatile instrument for testing radio and TV sets. It is a substitution box containing components likely to give trouble. A multimeter is used for voltage, resistance and continuity checks. Four tube sockets provide rapid heater continuity tests.—*Alvin J. Showers.*