World's Most Expensive FM Tuner

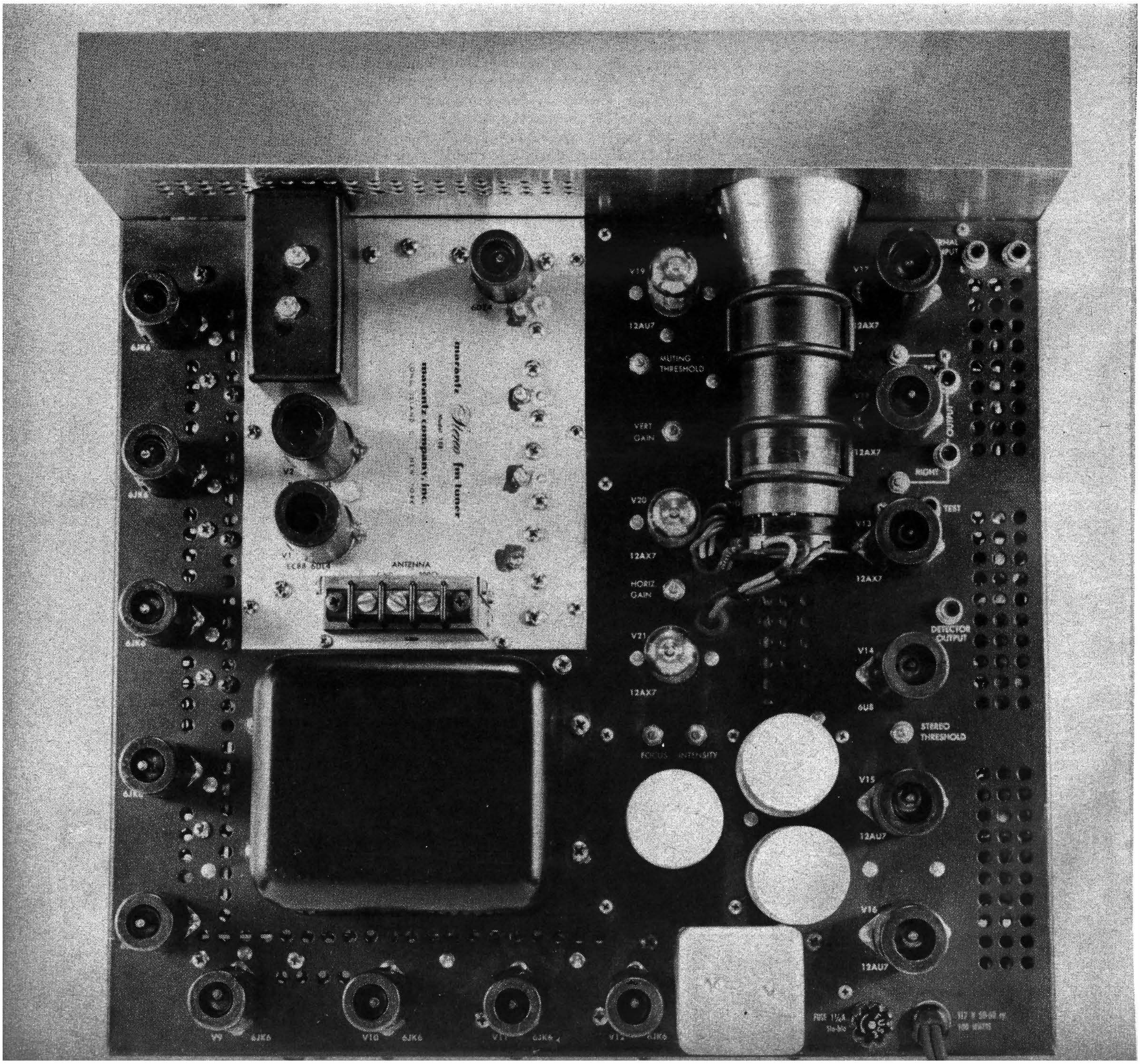
Marantz 10-B, Rolls-Royce of FM tuners, combines superb engineering and unusual circuit features

By PETER SUTHEIM

ON OUR COVER THIS MONTH ARE TWO views of the world's most expensive FM tuner: the Marantz 10-B. It costs $750, and there are no discounts. At this writing, the Marantz Co. can see the 5,000th model 10-B not too far ahead. Knowing the company's reputation—which is unusually spotless in an industry as fast-moving and often cut-throat as hi-fi is—it seemed unlikely that the high price was a product of cynical steel nerve. The 10-B just *had* to be a significantly better tuner than any other.

It costs twice as much as any other hi-fi/stereo FM tuner on the market!

My question—shared with several thousand other people: why?



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STEREO FM

From its beginning, in January 1954, the Marantz Co. has always been associated with the better—and usually the more expensive—hi-fi equipment generally available. Until 1965, the output of the company was strictly and literally audio: just a preamp and some power amplifiers.

When the company decided at last to produce an FM tuner, it was determined at the outset that it would have to be better than anything else on the market, in keeping with the company's reputation.

The coming of multiplexed FM stereo in 1961 and 1962 brought a snarl of FM reception problems, plus accusations, claims, counterclaims and a good deal of ill will. Stereo FM quality was often atrocious. Audiophiles charged broadcast stations with incompetence, and the broadcast stations retorted with accusations of poor antenna and receiver design, and unavoidable multipath reception.

Whoever was at fault, it was clear that somebody was doing something wrong. Stereo FM reception was a far more critical and delicate matter than anyone had guessed. One of the worst difficulties, as the broadcasters claimed, is multipath reception. Signals from the same station arrive at the receiving antenna by several paths, separated from each other by a few microseconds because of reflection from buildings, airplanes or a rippling ionosphere. Channel separation in FM stereo depends critically on the phase relationship among the amplitude-modulated subcarrier sidebands (which carry the stereo information), the main carrier and the 19-kHz pilot signal. Anything that disrupts these relationships causes poor (or—worse—varying) channel separation. It may cause reversal of channels and a good deal of high-frequency distortion and flutter.

For the same reason, the *phase linearity* of the receiver is a vital consideration. Ideally, there must be no *nonlinear* phase shift in the signal being processed through the receiver as it swings from zero deviation (center frequency) to ± 75 kHz, defined by the FCC as 100% modulation. While any nonlinear phase shift might not be noticeable in monaural FM, it is in stereo, because of the need to keep the 19-kHz pilot and sidebands firmly phase-locked.

If the FM receiving circuits are not to alter the phase relationships of the signal, they must process the selected signal in a phase-linear way. At the same time, they must select one station and reject all others. It isn't hard to design a filter to do one of these jobs, but to make one that does both is tremendously difficult.

The conventional double-tuned i.f. transformer most commonly used in FM tuners can be linearized over a bandwidth of some 200 kHz, but its

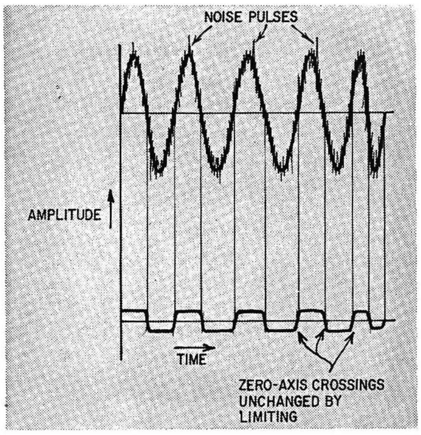


Fig. 1—FM information is recovered from zero-axis crossings so waveform may be clipped without detracting from fidelity.

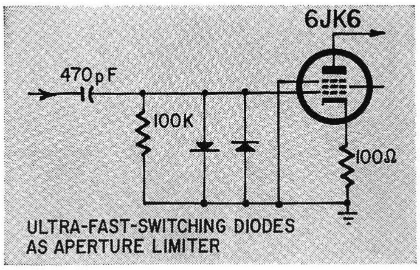
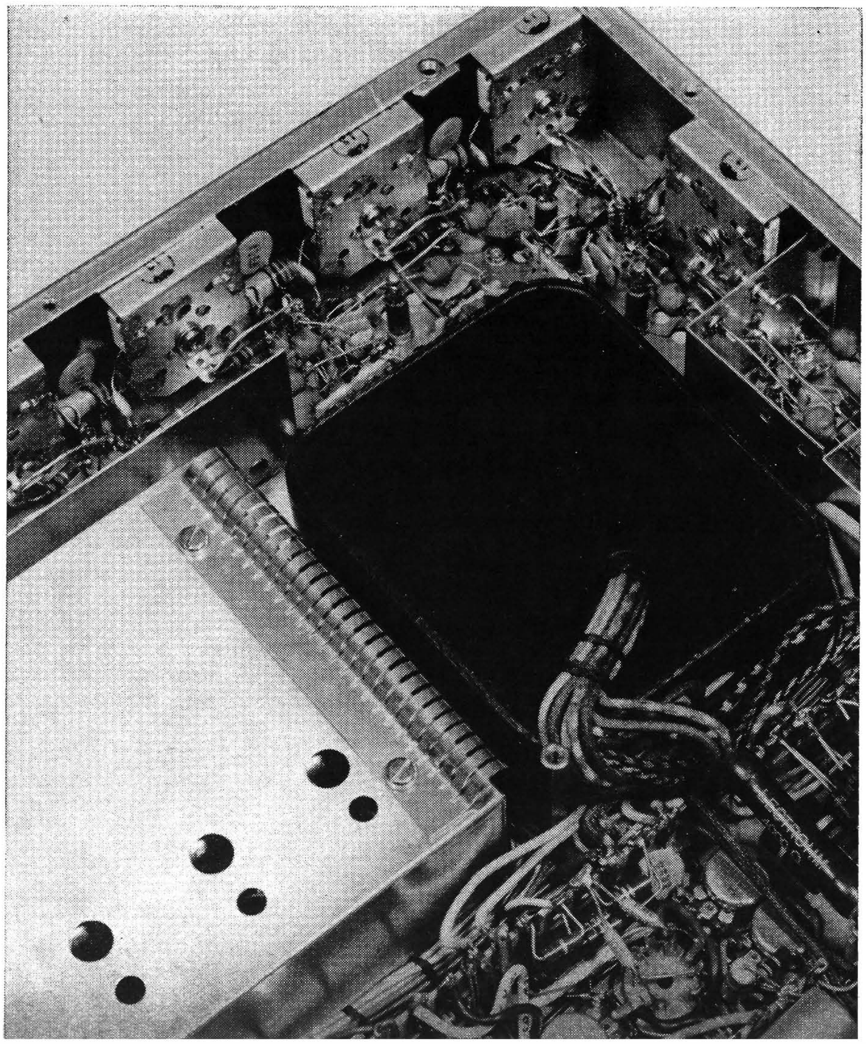


Fig. 2—Diode aperture limiter operates without bias and clips signal close to zero.

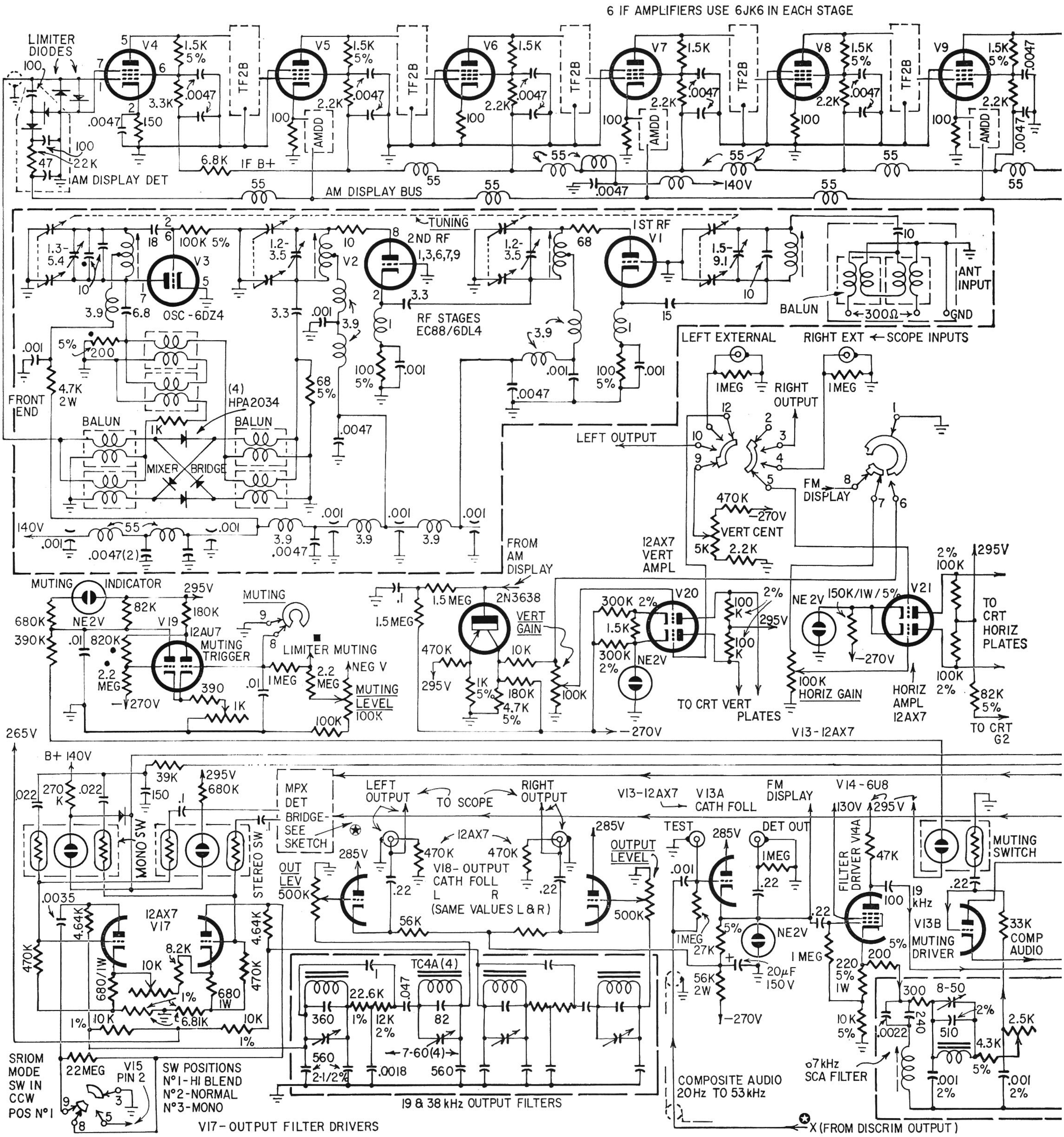


Notice i.f. filters around skirts of chassis. Holes at lower left are front-end alignment access.

selectivity is limited—a maximum skirt rejection of 12 dB per octave per stage. But a *three-pole Butterworth filter* can be made to satisfy three conditions: amplitude linearity, phase linearity, and a selectivity of 18 dB per octave per stage. That filter design is the one used in the Marantz 10-B. To illustrate the difference in selectivity alone, a conventional tuner with four i.f. stages coupled by double-tuned transformers has a 48-dB/octave attenuation slope; the Marantz 10-B, with six stages coupled through the filters, has a 108-dB/octave slope. The difference is clearly apparent in the 10-B's ability to separate stations.

The result, as you can see in the schematic, is a system of six i.f. amplifier stages, cascaded, with a Butterworth filter at the input of each. The gain of the six cascaded stages is 72 dB, and that of the limiter and detector drivers which follow the i.f.'s brings the total system gain to some 140 dB—a voltage gain of 10 million. The reason for that most uncommon amount of gain will be explained later. The filters, by the way, unlike conventional transformers, never need alignment once the factory is finished with them, even when an i.f. tube is changed.

But linear filters are not the whole



answer to the problem of leaving the signal's phase relationships untouched. Another serious flaw in the design of many tuners, says Dick Sequerra, chief engineer at Marantz, is the effect agc (automatic gain control) has on phase. Agc, when applied with a short time constant, is one way of limiting impulse noise. The shorter the time constant, the more effective the agc in that job. But a really short time constant (a few microseconds) means that the agc bias will follow almost every instantaneous "glitch" of noise in the incoming signal. Each time the bias applied to a tube changes, the tube's input capacitance changes. (This is "Miller effect.")

But this is exactly the wrong sort of thing to have when you want a phase-linear amplifier. As the tube's input capacitance changes, it looks like a variable reactive element across the output of each interstage filter, altering the bandpass of the filter. The result: undesired phase shifting in the signal, in effect transforming the amplitude noise pulse into a phase-shift pulse, which is detected as audio content. Therefore, no agc at all is used in the tuner. Naturally the dynamic range of the Marantz 10-B must be greater than that of any other tuner, since the signal cannot be compressed by changing the gain of the system.

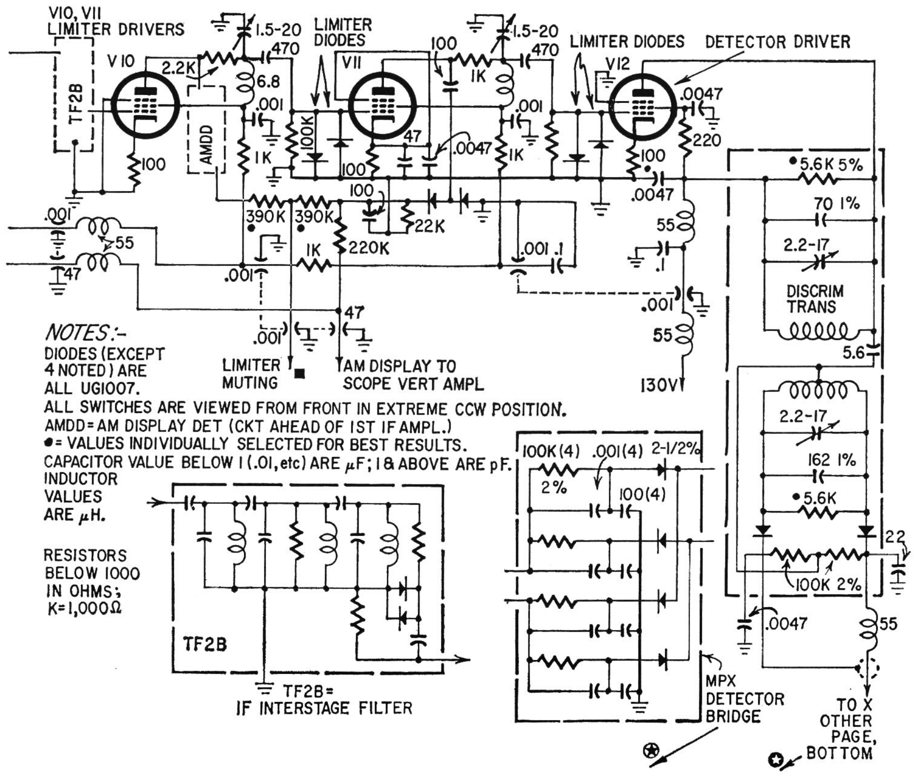
The same sticky Miller-effect problem occurs with amplitude limiting. One of the great charms of FM is that all the information it carries depends on the time (or frequency) relations in the signal; amplitude variations play no part at all. All useful information is contained in *zero-axis crossings* of the sidebands. Because of that, it's possible to lop off the top and bottom of the signal waveform at any point at all as long as the time relationships aren't changed (Fig. 1). Noise, which rides the signal almost entirely as amplitude changes, can therefore be limited in the receiver, leaving a clean signal.

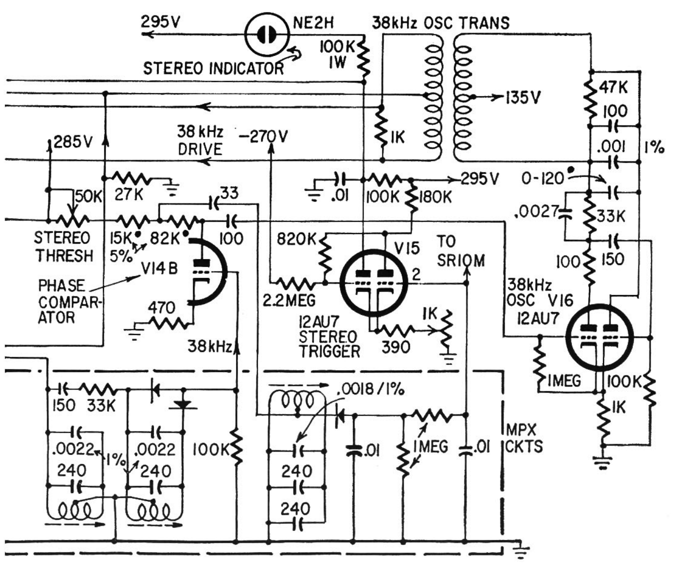
The most common limiter is the *saturation limiter,* usually a sharp-cutoff pentode operating with zero or nearly zero bias and a low plate and screen voltage. Above a certain low control-grid signal level the output (plate) signal is independent of changes in the input level. The tube is said to *saturate* at low signal strengths, washing out amplitude variations in the signal. But Miller effect is at work again here, making this kind of limiter undesirable for phase-linear systems. The gated-beam limiter, used in some high-priced tuners, is better, but still ruled out for much the same reason.

The most suitable kind of limiter is an ultra-simple *diode aperture* type, shown in Fig. 2. Because of the barrier potential of the diodes (about 0.6 volt), they do not conduct immediately, but only above that potential. As soon as they do conduct, they shunt the rest of the signal to ground. In effect, they discard all but a tiny portion of the signal, right around the zero axis.

Again, the cost of this is high. In terms of utilization of signal, it's very wasteful. And to insure proper limiting even on very weak signals, on the order of 2 μV, a tremendous amount of gain is needed in the i.f. strip. Hence the six i.f. stages, two limiter drivers and one detector driver (V4–V9, V10–V11, V12).

A phase-discriminator circuit is used as the detector, instead of the much more common ratio detector. Though the ratio detector has much to recommend it for less expensive systems (it discriminates by a good 20 dB or so against amplitude noise without any





This schematic of the Marantz 10-B is complete except for the power supply, cathode ray tube and heater circuits, which were omitted to save space. Position of elements in diagram approximates actual placement on chassis. Heater circuit is extensively decoupled to prevent unwanted feedback between stages. Because of the large number of special coils, diodes and other components, and the equipment required to adjust the tuner, any attempt to duplicate it at home is not likely to be successful.

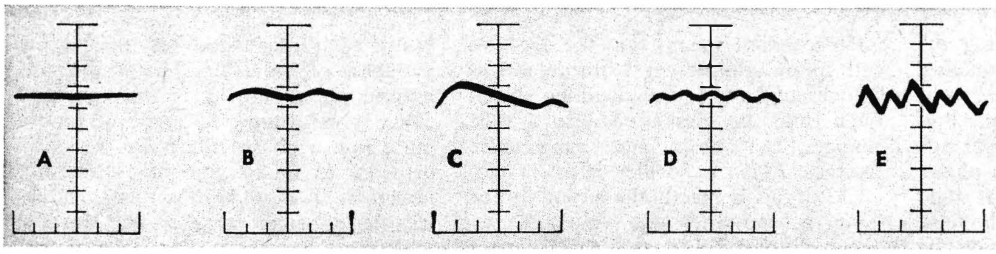


Fig. 3—CRT patterns show presence or absence of multipath interference. Pattern A is ideal. Patterns B through E show increasingly severe cases of multipath interference. The reception can be improved considerably with a sharp antenna with rotor for pin-point aiming.

separate limiters), it is not as linear or as perfectly balanced at high modulation frequencies as a phase discriminator can be.

Response to Marantz's most conspicuous innovation—a built-in cathode-ray oscilloscope tuning indicator—has been a mixture of skepticism and loud approval. If your idea of a tuning indicator pictures a device that helps you only to find the center of the FM channel or the point of strongest signal, a scope seems an extravagance. But the scope provides additional information that no other type of indicator can. Because it actually shows the dynamic passband of the tuner, it reveals problems like standing waves on the antenna lead-in, multipath reception, overmodulation at the station, and mistuning.

The oscilloscope is a simple affair—a compact 3-inch Amperex CRT driven by push-pull dc amplifiers for both vertical and horizontal plates. When the panel switch is set to TUNING, the vertical deflection is proportional to instantaneous carrier amplitude, and the horizontal deflection to the instantaneous frequency deviation (of the carrier from nominal station frequency). The pattern, with rapid, fairly high modulation and no reception problems, looks like a nearly straight horizontal line (Fig. 3-a). It is, except that it is really part of a flat-topped passband curve familiar to anyone who has ever sweep-aligned an FM or TV set. Because the passband of the 10-B is greater than the maximum deviation of any carrier (limited to ± 75 kHz), the scope beam should never crawl down onto the steep sides of the curve. If it does, the station is overmodulating.

Because the scope displays instantaneous carrier amplitude on the vertical axis, anything that affects the carrier amplitude will show up on the trace. Slow, long-term changes, such as might result from fading, simply shift the vertical position of the trace as a whole. Any amplitude change that depends on frequency—such as cancellation at some frequencies due to standing waves or multipath reflected signals—turns the trace from a straight line into a wavy one (Fig. 3b–3e). Because of that feature, any changes you make in the antenna system, from rotating your antenna to grasping the lead-in with your hand, show on the scope trace. Therefore, the scope is a valuable device for discovering multipath reception and eliminating it by adjusting the antenna. The difference in sound can be very noticeable. Persistent high-frequency distortion on some stereo programs disappears when the receiving antenna is properly oriented. And the only way to be sure the antenna is properly oriented, without listening for 15 minutes, is to watch the scope on the 10-B. Naturally, the scope is most useful with a directional antenna system on a rotator.

Ever think you're hearing monaural sound even though your tuner's stereo indicator is lit? With the 10-B you don't have to wonder. You throw the scope's DISPLAY switch to LEFT/RIGHT OUTPUT and see. The display will be like one of the drawings in Fig. 4. And your question is answered. The oscilloscope now shows instantaneous left-channel amplitude (vertical) against instantaneous right-channel amplitude (horizontal). Stereo indicators (including the one on the Marantz tuner) show only the presence or asbsence of the 19-kHz pilot signal or the locally generated 38-kHz carrier. Both can exist without stereo program material; for example, a station may continue transmitting its pilot signal even while the program material is monaural. With the Marantz scope, there need be no confusion.

It's a pity there isn't room to detail some of the other features of the Marantz 10-B, like the multiplex demodulation circuitry which guarantees 30-dB separation at 15 kHz, or the complex and tremendously effective filters for removing any 67-kHz SCA subcarriers from multiplexed FM stereo signals and for killing virtually every trace of 19- and 38-kHz noise in the audio outputs. Another unique feature is the use of noiseless, quick-acting, maintenance-less light-dependent resistors for muting between stations and for stereo/mono switching.

Marantz says, "We'll probably never do anything quite like this again. It cost us around a quarter of a million dollars to develop the 10-B, and we were losing money on it at the original price of $600."

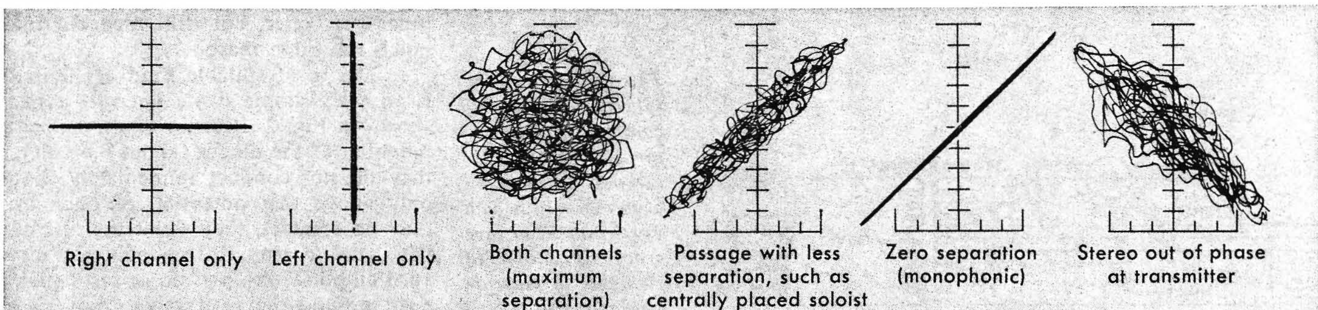


Fig. 4—The CRT also provides for program analysis, indicating strength of left- and right-channel signals, separation, phase.

The Marantz 10-B is, like the Rolls Royce or the Leica, the product of an approach that to some might seem fanatical. From the basic choice of certain circuits over others that would do the job *almost* as well, to the inclusion of an extra resistor here, and an extra stage there, the Marantz 10-B was designed to do everything it does better and longer, with less maintenance, than any other tuner. All this, of course, comes at a price, and only you can decide whether it's worth the money. END