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Inside a Lampkin

More secrets of deviant behavior.

Test equipment is a ham's best friend! I suppose you'll ask me to justify or explain what I mean by that statement. I may not have a complete answer, but test equipment is like any tool — it has a designed use or an intended application.

In some cases, the application is very specific and when the equipment is needed, it is NEEDED NOW! The rest of the time it will sit idle on the shelf gathering dust. It's during this idle period that the owner becomes complacent and considers parting with the equipment to make room for something "new" and more in vogue with current interests.

During the years of manufacture, Lampkin offered both a deviation meter and a frequency meter as indicated in the 1957 ad shown in **Photo A**. These were both valued instruments that were required to set up FM communication radios for commercial and ham radio applications. **Photos B, C, D,** and **E** show various views of the FM modulation meter that is better known by hams as a "deev meter."

Being a deviation meter, its application is quite specific, because it was designed to measure only the carrier frequency deviation of an FM transmitter. Since most of us use commercially built ham equipment where the deviation of the carrier frequency is set by the factory, we tend to ignore the fact that we, as hams, are responsible for the signal generated by our transmitter, regardless of who made it. Unlike our cars that get serviced periodically, our ham transmitters never get serviced or checked unless there is a catastrophic failure.

My point is that we're responsible for the emissions from our transmitter, and that includes the amount of frequency deviation produced by the transmitter. When operating through a repeater, the repeater establishes a pseudo deviation requirement of 5 kHz in most cases, and distortion in the audio may occur should we exceed that amount. Listening to our signal at the output of the repeater gives us a fair idea of our transmitter's deviation — distortion vs. no distortion.

Photo A. *This a 1957 ad for Lampkin.*

Photo B. *Front-panel view of the Lampkin frequency deviation meter.*

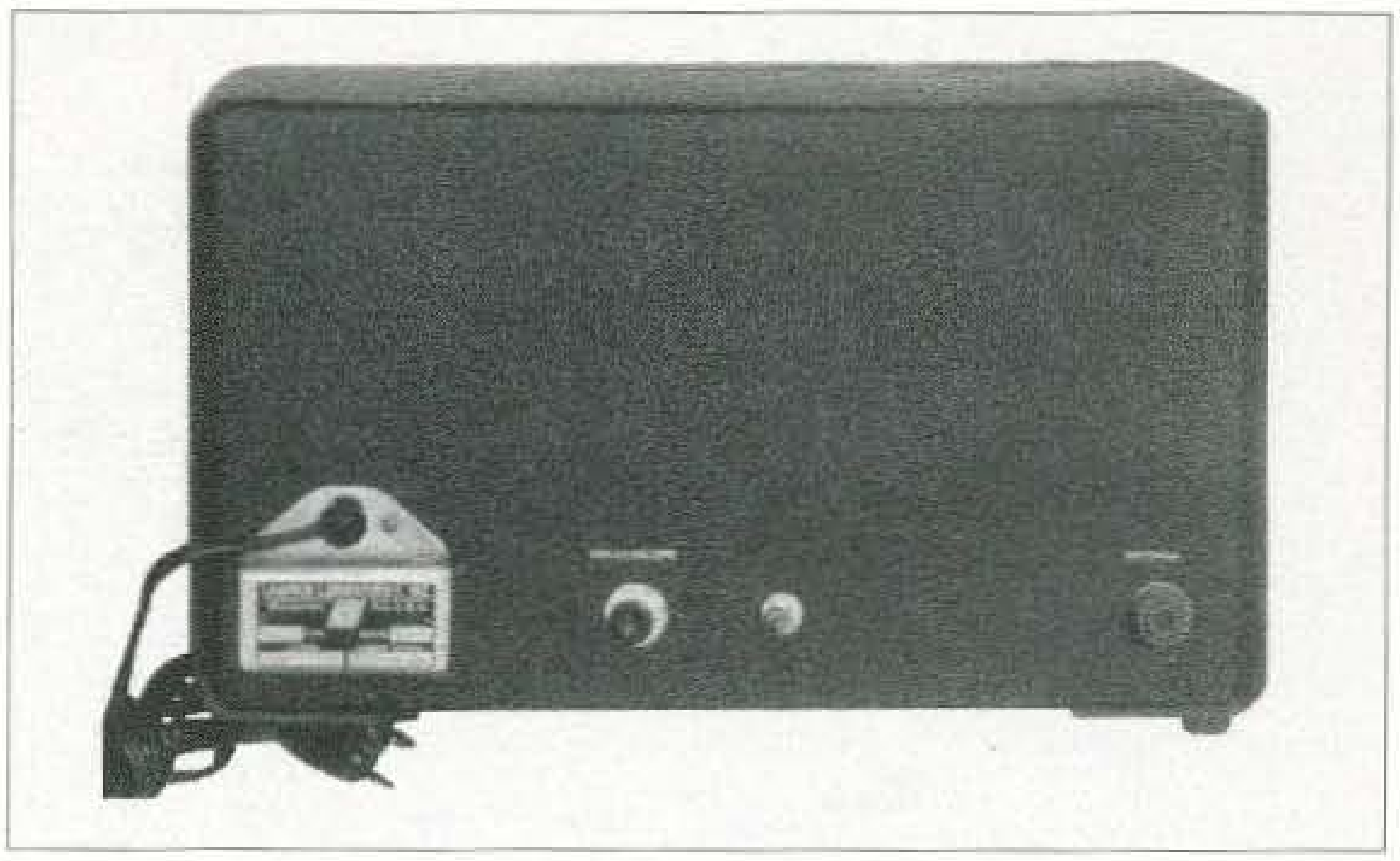

Photo C. *Rear view of the deviation meter. Provisions were made for connecting an oscilloscope.*

Those of us charged with the responsibility for setting up and maintaining a repeater system must have access to an instrument capable of measuring frequency deviation such as the Lampkin. In addition, most repeaters utilize a subaudible tone (CTCSS) to enable the repeater operation, and this tone has a specified frequency deviation. Although the FCC may not specify the CTCSS tone deviation, the tone must meet several criteria:

1. The waveform must be a sine wave.
2. Deviation must be high enough to reliably activate the repeater's decoder.
3. The deviation level must be low enough to not disrupt the normal voice channel communication.

So how do we, as hams, measure the frequency deviation emitted by our transmitter? The tool designed to perform the measurement is a deviation meter such as the Lampkin. It gives us the "eyes" to view the deviation of the emitted signal that is displayed on a meter as a deviation value. The Lampkin was designed specifically for measuring emitted signal deviation of an FM transmitter operating in the ham bands from approximately 6 meters to 70 cm. It is also capable of measuring the deviation of the CTCSS tone generator within the transmitter.

When using the Lampkin, the measurement is very simple and requires only a few moments of time. Because of the short test time it is easy to discount the importance of making the measurement that is needed to ensure that our transmitter meets the FCC requirement. Checking the deviation of our transmitter periodically is like changing the oil in our car, it's good insurance.

Deviation theory

Deviation of an FM signal is an instantaneous and a direct function of the modulating audio's amplitude measured from the carrier's resting frequency to the plus or minus peak excursion. In essence, that means the loudness of a voice introduced into the microphone controls the peak deviation of the emitted signal. However, to reduce the possibility of creating differing amounts of deviation from random operators, transmitter designs incorporate an audio peak limiter set up to prevent "overmodulation." During normal usage, voice amplitude peaks should not be quite high enough to force the limiter into action. Doing so could create audio distortion.

An important term in FM modulation theory, besides deviation, is the RATE OF DEVIATION. The rate is the speed that the carrier moves while deviating and is a function of the frequency of the audio producing the deviation. When the deviation value and the rate of deviation are combined, a

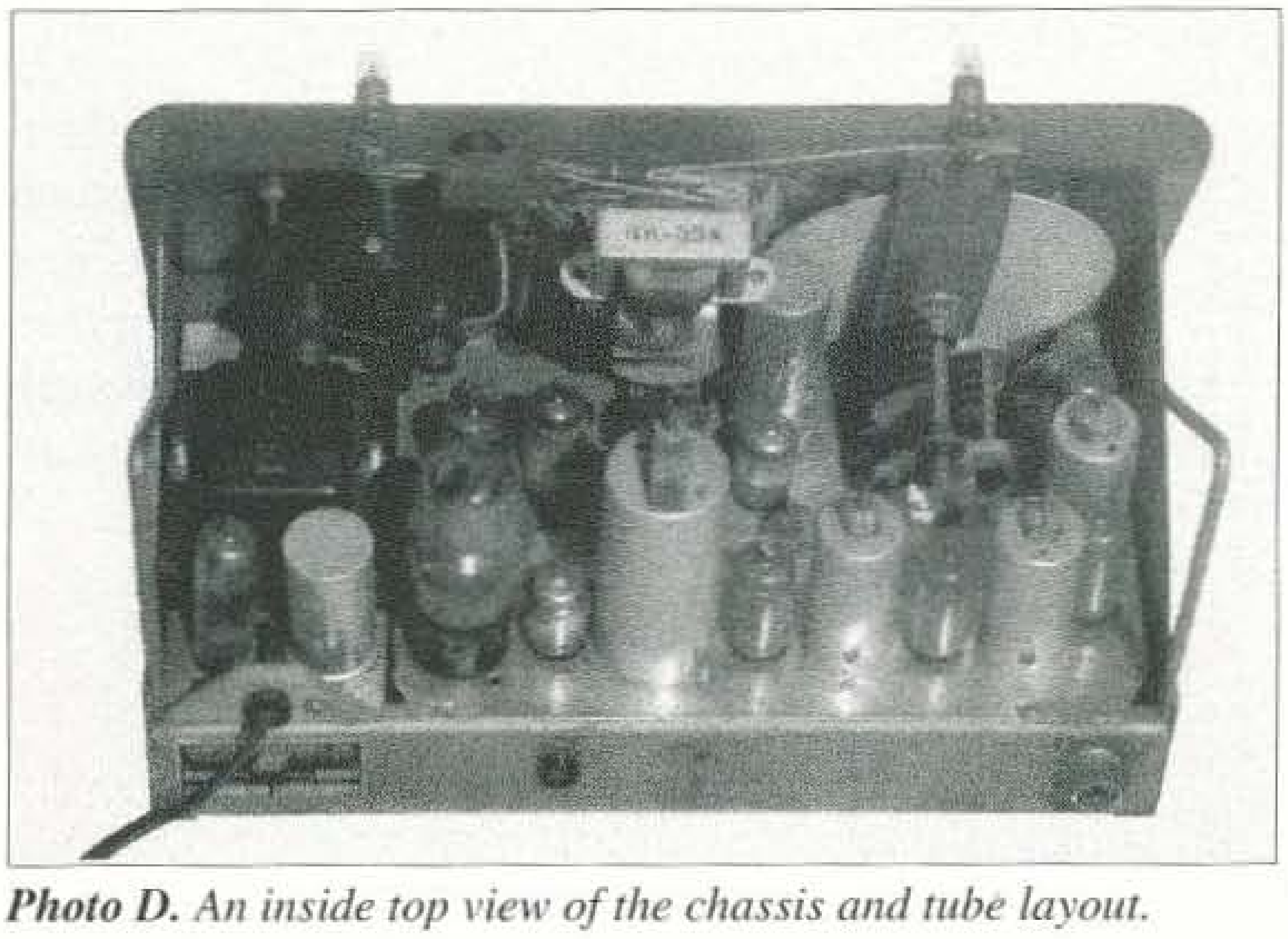

Photo D. *An inside top view of the chassis and tube layout.*

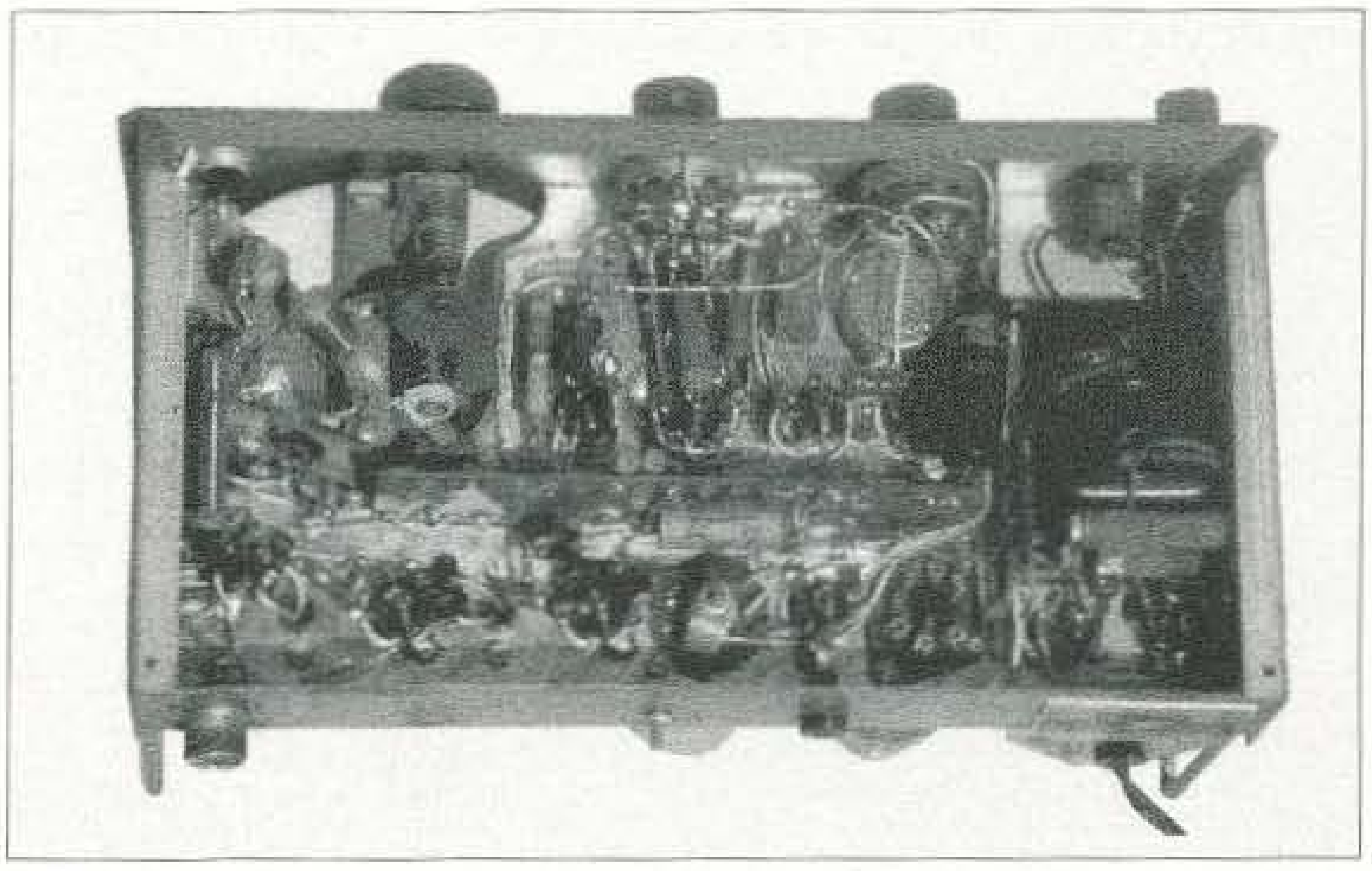

Photo E. *Inside bottom view of the Lampkin deviation meter. Note the mechanically stable design.*

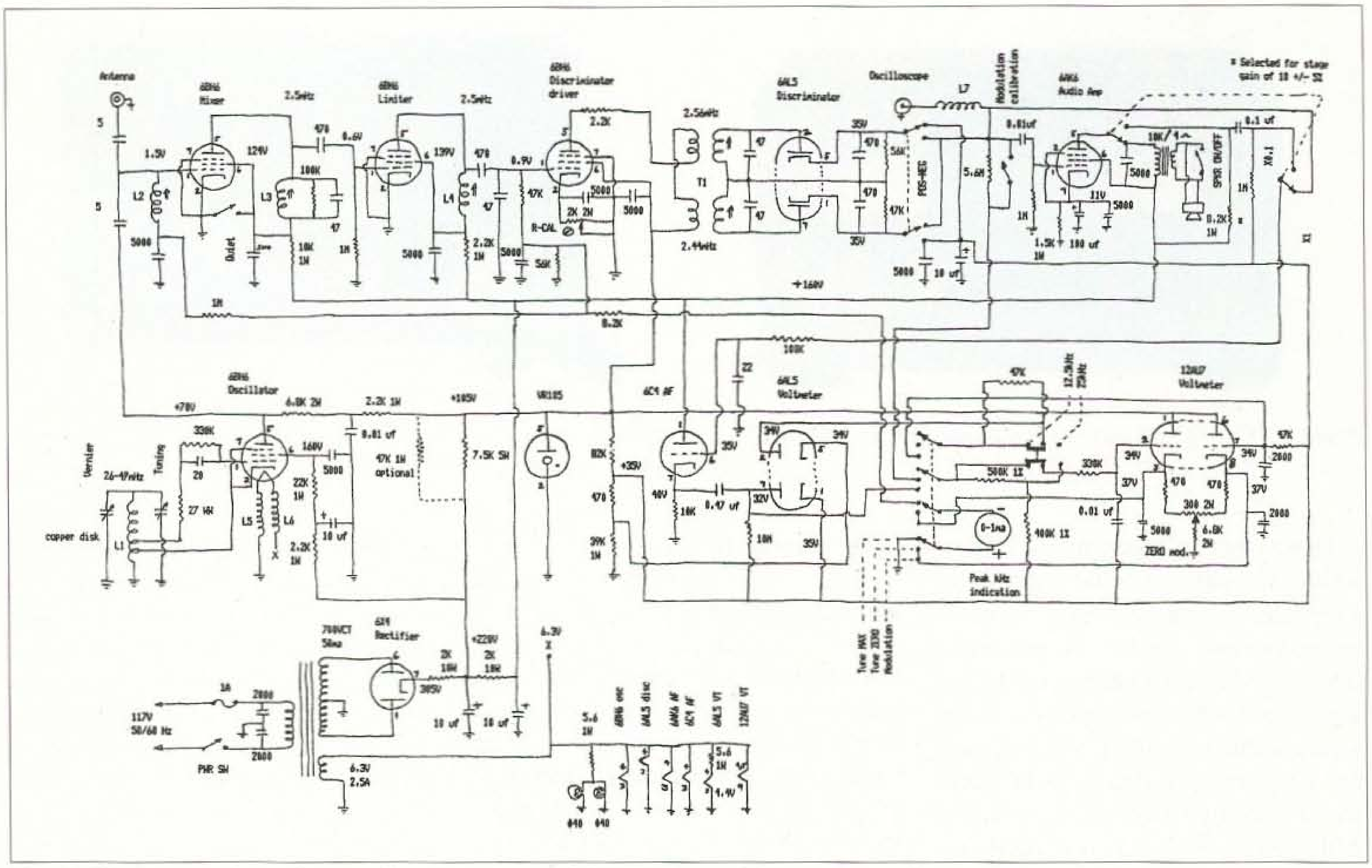

Fig. 1. This is a complete schematic for a Lampkin model 205A FM modulation meter.

modulation index value is established. Ham FM transmitters are limited to a modulation index of 1.67, where the index value establishes the maximum bandwidth to be occupied by the emitted signal. Modulation index for a signal is found by dividing the peak signal deviation by the highest audio frequency being transmitted.

Measuring deviation

There are several methods available to a ham that are suitable for measuring deviation, such as a Lampkin FM modulation meter, oscilloscopic spectral display, Bessel functions, etc.

Bessel functions are used as the basis for calibrating all deviation measurement equipment because it is accurate and repeatable. The technique utilizes a carrier null that involves the observation of when the FM carrier amplitude passes through a null or zero point. The carrier amplitude will predictably pass through a null at several modulation index points such as M = 2.405 and M = 5.52 as the first two of a series of nulls.

Calibration of deviation involves applying a single sine wave audio voltage of known frequency to the voice input of the transmitter and increasing the audio amplitude until the carrier reaches a null. The null is detected as a loss of beat note in a CW or SSB receiver or as a carrier loss as observed on a spectrum analyzer. If the modulating audio frequency were 1 kHz, then at the first null the deviation would be exactly 2.405 kHz, and would be exactly 5.52 kHz at the second null. It is usually easier to detect the first null than the second when listening to a beat note.

For calibration purposes, it is preferable to identify specific or whole number deviation values instead of using a number like 2.405 kHz. Therefore, specific audio frequencies can be calculated for a value of deviation by using the following equations:

$$F_{dev} = AF \times M(\text{at null})$$

or

$$AF = F_{dev}/M(\text{at null})$$

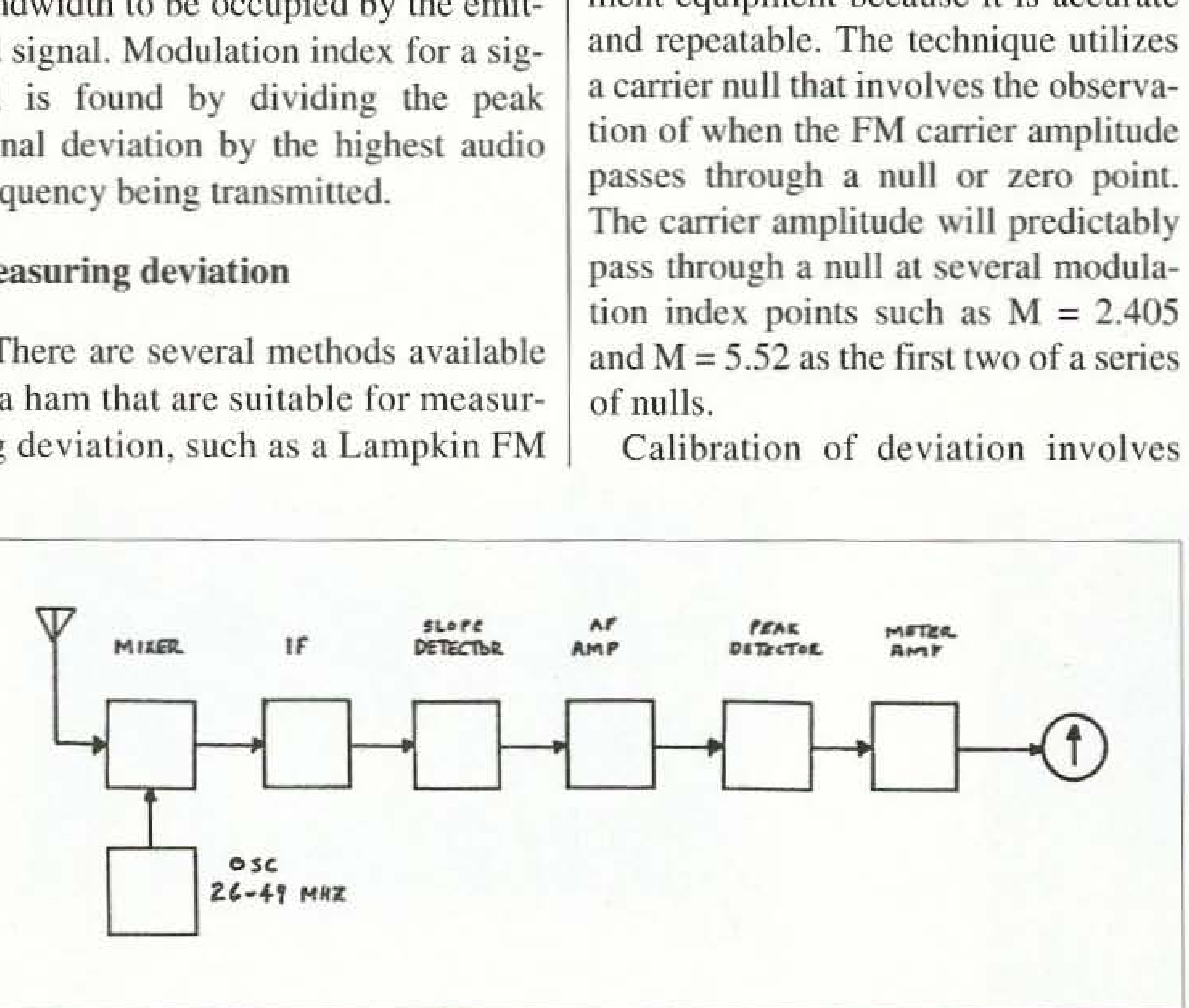

Fig. 2. Block diagram of the Lampkin 205A FM modulation meter. The design uses a single conversion superhet receiver utilizing a dual-slope FM detector.

Audio Frequency Values		
Deviation (in kHz)	1st Null (in Hz)	2nd Null (in Hz)
1	415.8	181.2
2	831.6	362.3
3	1247.4	543.5
4	1663.2	724.6
5	2079.0	905.8
6	2494.8	1086.9
7	2910.6	1268.1

Table 1. *Audio frequency values required to create a specific deviation using either the first or second null.*

Table 1 provides a listing of audio frequencies that will produce specific values of deviation that were derived from the equations. The table indicates values for both the first and second null. Setting up calibration at a single null is generally all that's required, but sometimes the second null provides confidence in the measurement at the first null.

Inside a deviation meter

To measure deviation with an instrument such as the Lampkin, the emitted signal must be detected and the peak carrier shift must be determined using a calibrated reference. The Lampkin uses a linear "S" curve produced by a dual-diode slope detector to convert carrier deviation to an instantaneous (peak) AC voltage that is displayed on a calibrated meter. When setting up the deviation meter, the "S" curve must be evaluated or calibrated against a Bessel function measurement.

Fig. 1 shows a complete schematic for the Lampkin FM modulation meter, with a block diagram shown in **Fig. 2**. It's generally easier to follow an overall device function with a block diagram. The Lampkin utilizes a conventional superhet receiver design that has an untuned input and mixer. Without tuning, the input will accommodate any signal creating a strong mix with the local oscillator, including any of the oscillator's harmonics. In essence, the input of the Lampkin will accept for deviation measurement any signal operating from about 24 MHz up to 500 MHz. The local oscillator is

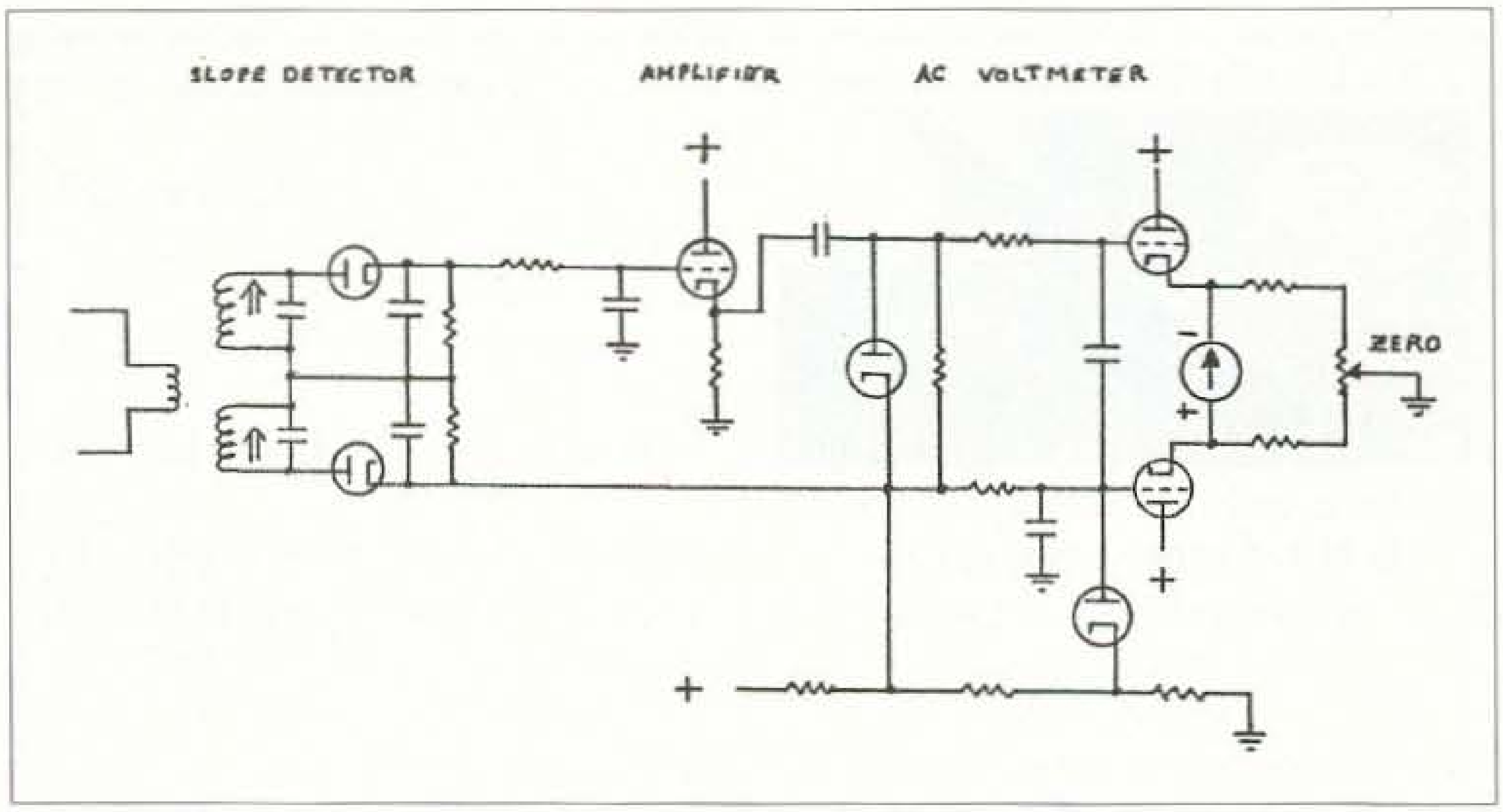

Fig. 3. A detailed layout of the dual-slope detector, amplifier, and AC voltmeter used for making a frequency deviation measurement.

designed to operate on a fundamental frequency from about 26 to 49 MHz to provide a signal mix into an IF of 2 MHz.

To ward off inadvertent signal mixes with weaker signals found on the various bands, the receiver's gain factor is intentionally low. A fairly strong signal is required at the Lampkin's antenna, and one of the benefits is noise reduction that improves the reliability of the measurement. If you've ever opened the squelch of an FM receiver you've obviously heard the white noise that emanates from the speaker. White noise is reduced as a function of signal amplitude and that reduction is important when making a deviation measurement using an FM detector. The objective being to measure the carrier deviation, not display the noise as a factor of deviation.

Referring to **Fig. 3**, the FM detector used in the Lampkin is a dual-diode slope FM detector. In reality, it is two AM detectors offset in frequency such that the combined outputs will produce a linear "S" curve over the desired deviation measurement range. To obtain a linear "S" curve, only a portion of the curve is suitably linear for measurement applications. As shown in **Fig. 4**, the total frequency offset in the two detectors is 120 kHz, and the maximum measurement portion used is 50 kHz (±25 kHz). However, most ham FM systems utilize only the ±5 kHz portion of the curve.

Apparently there were several models of the Lampkin deviation meter made, with each having the same model number but slight differences in the circuit. Although the schematic shown in **Fig. 1** and the hardware pictured in **Photo B** carry the same model number, the hardware has some slight differences in internal wiring. The schematic matches the ad hardware shown in **Photo A**. The basic model differences are in the measurement scales, where some models are single range while others are multiple range. Otherwise, the operation and capability are essentially the same for all models.

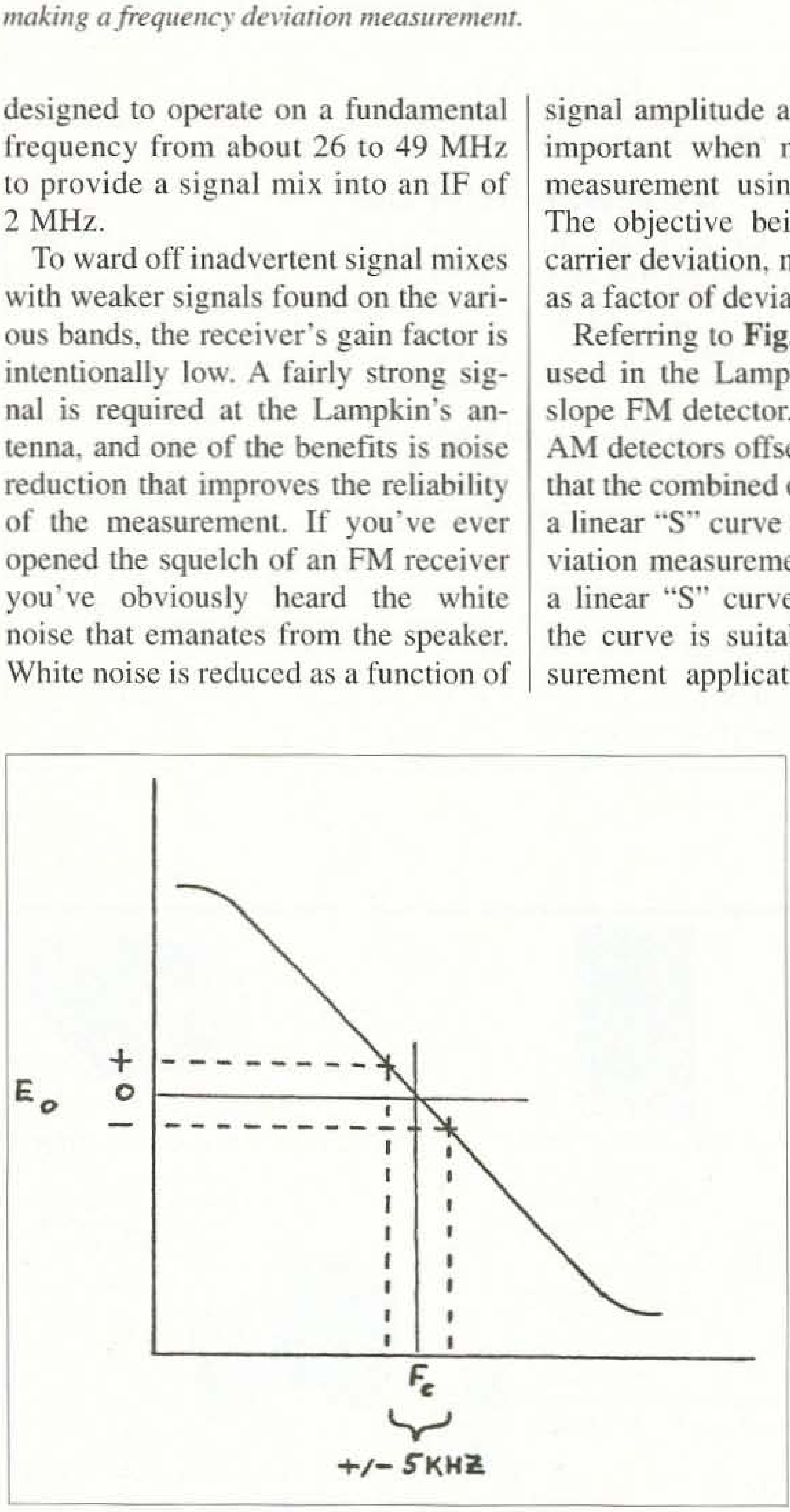

Fig. 4. This is the general shape of the "S" curve produced by the dual-slope FM detector. The curved ends are set at ±60 kHz. A linear deviation measurement may be made at values below 25 kHz.

For the age of the instrument, it has a very stable design that was well thought out for the application. As a result, the instrument is well suited for ham radio measurement applications.

Using the Lampkin

Making frequency deviation measurements with the Lampkin is very easy and requires only a few moments of one's time. The important thing to remember is that ample signal must be coupled into the instrument. Coupling is accomplished by close proximity of the Lampkin's antenna to that of the transmitter. With the instrument's selector switched to TUNE MAX, the signal amplitude coupled into the Lampkin should cause the meter pointer to rise to a value of 5–8 kHz, but not exceeding 12–15 kHz, where saturation could occur.

The steps for setting up the instrument and making the measurement are as follows:

1. Warm up the Lampkin for a minimum of 15 minutes to minimize oscillator drift.
2. Press the "quiet" button and adjust the meter ZERO adjustment to achieve a ZERO reading on the meter.
3. In the TUNE MAX position, couple the input signal to achieve a meter indication of 5–8 kHz while adjusting the main tuning dial — any dial setting that achieves the desired signal level is correct.
4. Select TUNE ZERO and adjust the fine tuning knob for a ZERO meter indication. Verify the zero setting by toggling the POS-NEG switch to average the indication.
5. Select MODULATION and speak into the microphone using a reasonably

Local Oscillator frequency – mHz	Multiplier x2	x3	x4	x5	x6	x7	x8	x9	x10	x11
26	52	78	104	130	156	182	208	234	260	286
TUNING										
49	98	147	196	245	294	343	393	441	490	539

Fig. 5. *This chart shows the local oscillator's tuning range with the usable frequency coverage via harmonic mixes. The typical measurement range is from 24–500 MHz.*

steady voice note. Observe the meter reading for the indicated peak deviation value.

6. Test complete.

To elaborate on step 3 above, some confusion may occur when using the Lampkin for the first time. Due to the low local oscillator frequency, harmonics of the oscillator will create a number of tuning dial settings that indicate the desired tuning level. **Fig. 5** shows the basic local oscillator frequency and the tuning range covered by the instrument as a function of the oscillator's harmonic. With an IF of 2 MHz, the indicated tuning range will be ±2 MHz of each harmonic frequency indicated. The typical tuning range of the Lampkin is from 24 MHz to 500 MHz. Therefore, when tuning in a transmitter's carrier for step 3 above, it is only necessary to select one of the many possible tuning points on the dial in order to make the deviation measurement.

Setting up and measuring the frequency deviation of a CTCSS tone is fairly difficult with some of the older model Lampkin deviation meters. The later models manufactured accommodated deviation measurements more easily and were capable of displaying a value in the range of 0.5–5 kHz. CTCSS tone deviation is typically within the range of 500–1,000 Hz.

Conclusion

Test equipment by default is desirable only when it's needed to make a measurement. With a piece of equipment such as the Lampkin, it is rarely used unless the operator is involved with frequent equipment maintenance activities. But as a ham, we're responsible for the emissions from our transmitter regardless of who made and/or maintains our equipment. Therefore, it's wise to pay attention and measure the emissions from our gear on a periodic basis. Lampkin FM modulation meters are usually available for a low price, making them a valuable piece of equipment to have included in one's test equipment stable.

The following references are provided for those interested in further study of FM modulation theory and measurement techniques.

References

Wells, Hugh, "FM Revisited," *73 Amateur Radio Today*, p. 21, July 1998.

Wells, Hugh, "Secrets of Deviant Behavior," *73 Amateur Radio Today*, p. 18, August 1998.