Need a UHF Dipper?

Part 1: Old TV tuners to the rescue!

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There are periods of time in the life of a ham experimenter when he needs a dipper to identify the resonant frequency of an RF circuit. Dippers, both tubed and solid state, have been around for many years to assist in the identification, but most cover the frequency bands from about 2 MHz to 250 MHz. There are dipper designs available for frequencies above 250 MHz, but they tend to be difficult to build with any reliability. Another problem involved is that the external sense loop for most dippers is too short when operated in the UHF region. The loop is the resonant circuit for the oscillator and is also used for probing an unknown resonator. Being short, it fails to reach very far, making the dipper very awkward to use.

I was in need of a 450 MHz dipper and began a search for a suitable device. It occurred to me that most any stable oscillator would work if it was operating at the desired frequency. One solution that was available to me was an old solid state UHF TV tuner. The one that I chose as a candidate for the dipper project was one of the mechanically variable variety as shown in **Fig. 1**. The frequency range of the oscillator is typically 470–900 MHz, which means that some modification would be required to shift the lower frequency into the 450 MHz ham band. But the first objective was to prove or disprove the theory that the tuner would be a suitable candidate for a dipper project. At this point, a number of tuners have been modified to function as dippers, with each being an interesting adventure. The one objection with most typical dipper designs has been the short external sense loop when used at UHF. Using the TV tuner as a dipper, the sense loop can be extended for probing an unknown circuit.

Varactor-tuned UHF tuners were examined as dipper candidates, but were abandoned temporarily in favor of the old mechanical versions. However, the

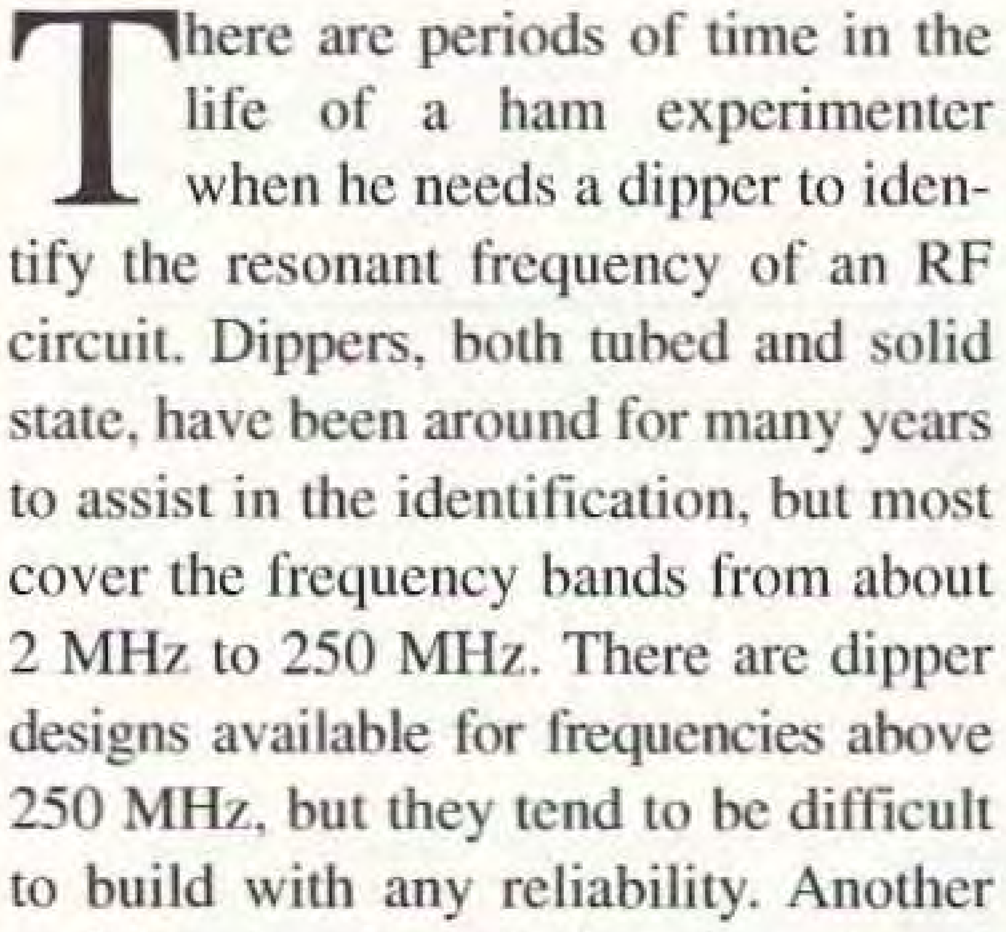

Fig. 1. Typical mechanical UHF TV tuner.

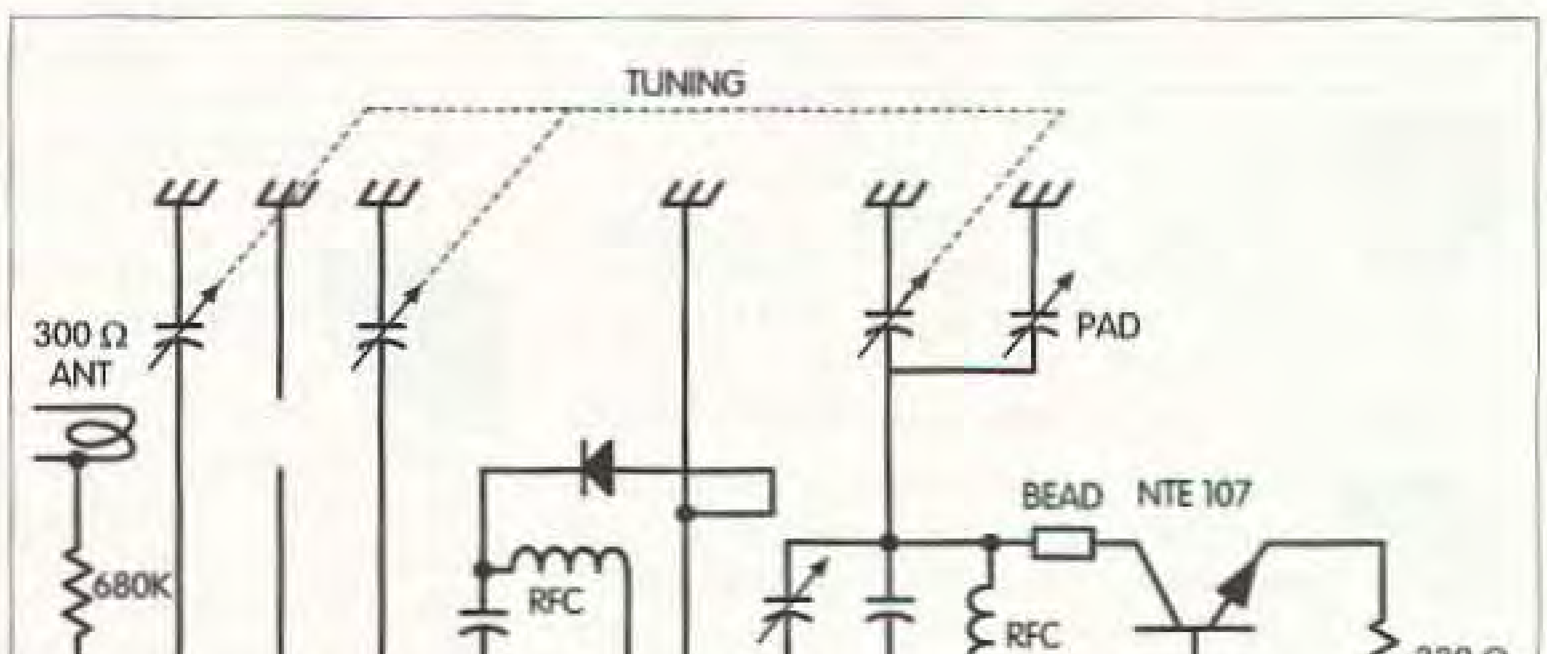

Fig. 2. Typical schematic for a mechanical UHF tuner. A varactor, if used in the tuner, is connected in parallel with the "trim" capacitor.

varactor versions appear to show some promise and will require some further investigation of feasibility.

The simple electronic circuit of the mechanical tuner, as shown in **Fig. 2**, makes the tuner very adaptable for dipper projects. Only minor modifications along with some experimentation are required to use the tuner as a dipper covering the stock frequency range of approximately 670–900 MHz. From my experiments, I know that some tuners can be coaxed to operate up into the lower portion of the 902 MHz band. I managed to get one to move up to about 928 MHz. However, my effort has been to lower the operating band for the tuner to function within the 450 MHz band. After modifying several tuners, I've found that some tuners move easily into the band while others are very stubborn and require "surgery." It is my suggestion that a tuner be made to operate in the stock configuration as a dipper, to evaluate its characteristics, before any surgery is considered or performed. The modifications can be performed progressively, with surgery only as the very last resort.

The local oscillator and diode mixer are really the only components of interest in the tuner, when used as a dipper, so the rest of the assembly can simply be ignored. When using the tuner as a dipper, the mixer diode is used as the RF activity sensor and is capable of driving a microammeter.

Testing a tuner involves measuring the operating frequency of the local oscillator. In the absence of a sensitive counter, spectrum analyzer, or calibrated receiver covering the frequency band, alternative and less exacting measurement methods must be employed.

During my early experiments in the UHF spectrum, specialized test equipment was unavailable to me; I'll assume that you are in the same predicament. To get over the hurdle of frequency measurements, some relatively simple techniques may be employed. But the methods require some ingenuity, patience, and project construction.

The two handiest pieces of equipment that got me started were the construction of a set of Lecher wires and

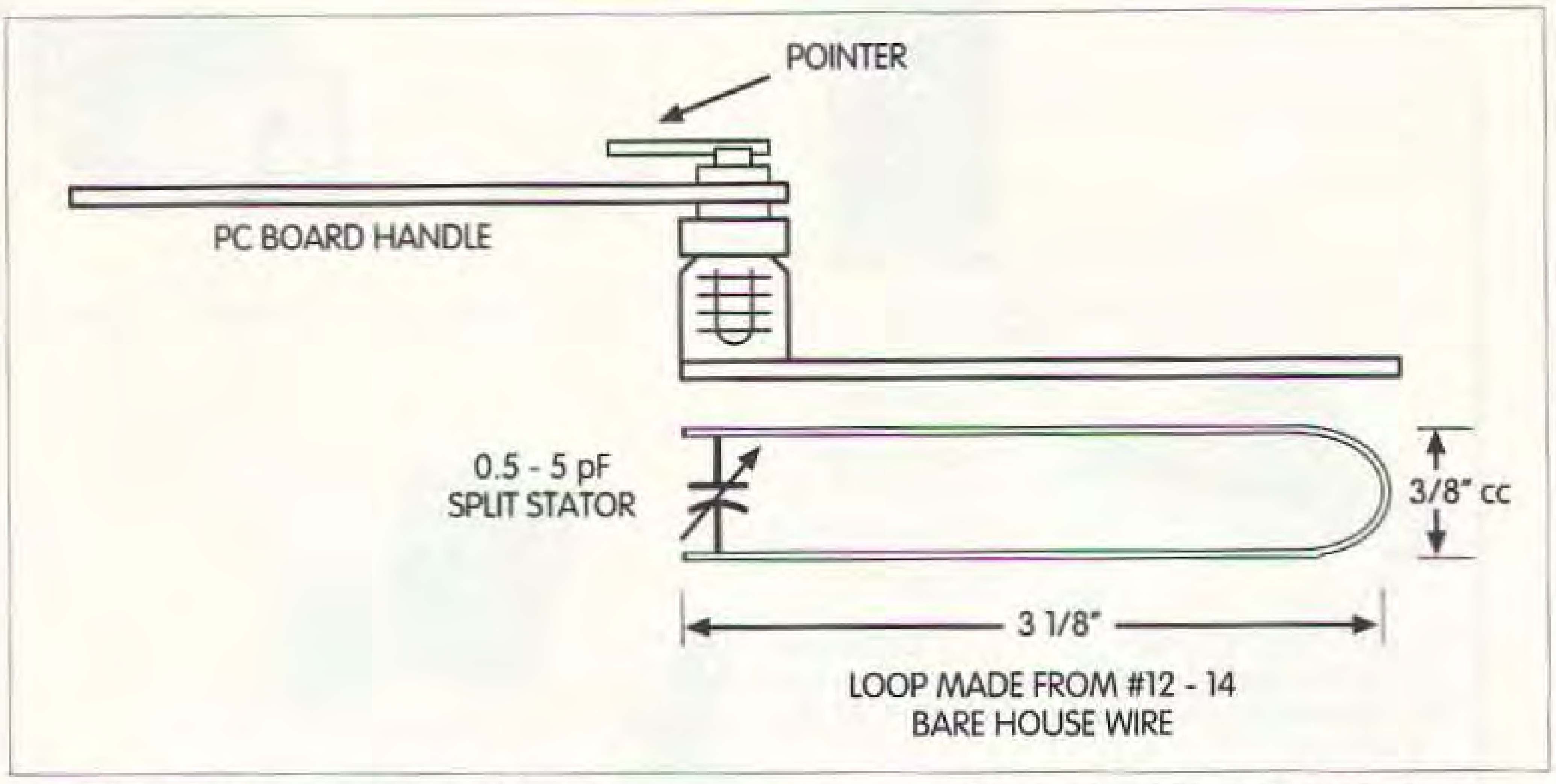

Fig. 3. Construction of an absorption wave meter tunable in the 400–500 MHz band.

an absorption wave meter. Both are resonant circuits that can be calibrated during the tuner's testing process. In use, the Lecher wires are used to determine the frequency of the oscillator; then the oscillator, as a dipper, is used to calibrate the wave meter. The reason for having two pieces of equipment is to end up with a single measurement device — a calibrated absorption wave meter. Successive frequency measurements will allow the wave meter shown in **Fig. 3** to be calibrated, and from that point on, the wave meter may be used for checking the dipper's response.

Lecher wire system

To get started in the absence of other frequency measurement equipment, it is necessary to construct a set of Lecher wires as shown in **Fig. 4(a)**, where there is a lot of freedom in the construction. This means that available material from the "junk box" is suitable. When constructing the Lecher wire system, there are only three important factors: (1) keep the wires taut; (2) have the wires close to the measurement scale; and (3) have a readable scale. The objective of keeping the wires taut is to enhance measurement repeatability. Wires do tend to stretch, so copper wire is OK, but may not be your first choice. As an alternate, iron or steel wire may also be used. Wire diameter and insulation are immaterial. In other words, enameled wire may be used without removal of the enamel. When using the Lecher wires, a narrow metal edge, such as a screwdriver shaft, is laid across the wires and then moved fore and aft, locating two points one half-wave wavelength apart. The operating frequency can be determined by placing the measured distance between the points into an appropriate equation. A block of insulating material, as shown in **Fig. 4(b)**, is rubber banded to the screwdriver shaft. The purpose of the block is to help maintain the wire spacing. Actually, the use of the block is optional when only light pressure is applied against the wires.

Perhaps the measurement scale is the easiest to make. Photocopies of a yardstick or meterstick will yield paper scales that may be glued to the board. The resulting measurements will be reasonably accurate, and that's the bottom line. **Figs. 5** and **6** show the method used and the appropriate equations as they apply to making a frequency measurement with Lecher wires.

Theory of resonator operation

Before making any modifications to a TV tuner, the theory regarding the internal resonator needs to be discussed so that the modification process will make more sense. Resonators used at lower frequencies are made up of a coil and capacitor, but as the operating frequency rises, the lumped inductance and capacitance of the coil and capacitor becomes distributed and less definable. In the case of the older UHF TV tuners, a quarter-wave wire having distributed inductance and capacitance is used within a channel as the basis for a resonator. The resonator may be likened to that of a quarter-wave antenna element as shown in **Fig. 7**. It is important to observe the E (voltage) and I (current) fields that exist around the element, as these fields are affected by the surrounding environment, and specifically by the variable capacitor at the top of the element. The resonator element may be identified as a metal strip or wire enclosed in the channel. The resonator is at RF ground on one end, with a variable capacitor on the other end. The capacitor operates as capacitive top loading on the open end of the resonator, as shown in **Fig. 8**.

Not shown in a figure is the effect of capacitive bottom loading on the resonating element. Some tuners utilize a varactor diode on the bottom of the element to trim the frequency as a result

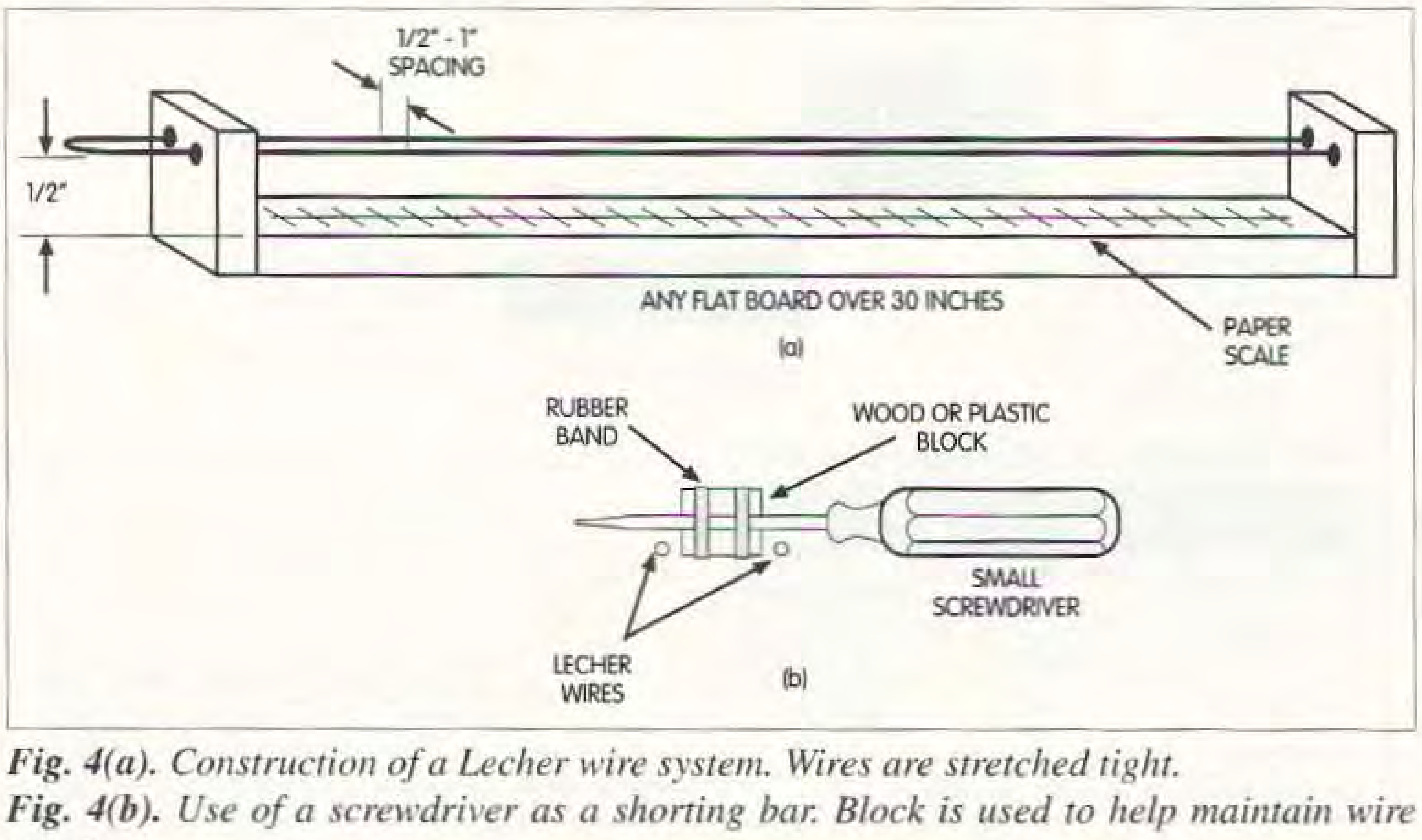

Fig. 4(a). Construction of a Lecher wire system. Wires are stretched tight.
Fig. 4(b). Use of a screwdriver as a shorting bar. Block is used to help maintain wire spacing.

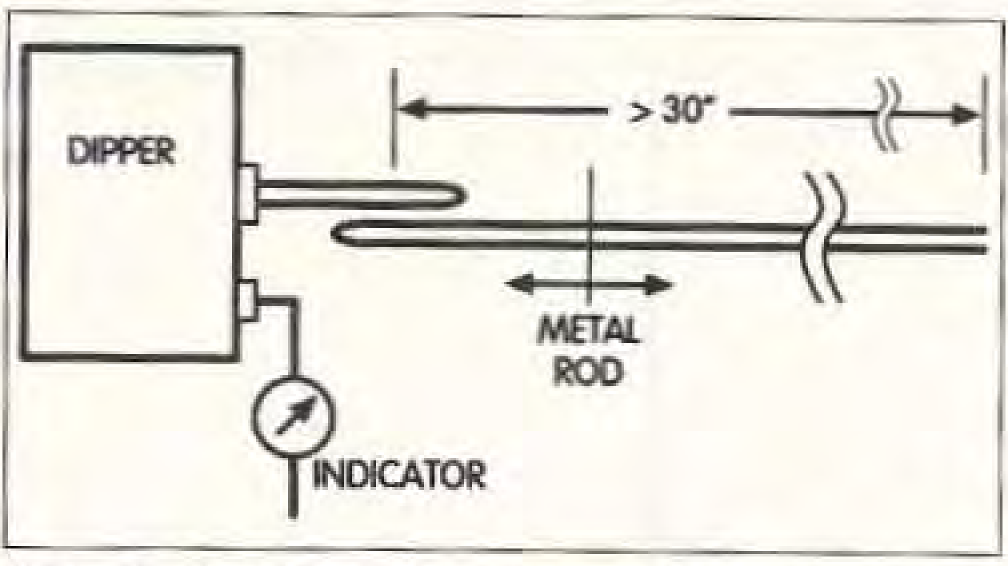

Fig. 5. Lecher wire system for measuring the frequency of a dipper.

of an applied variable voltage. Also, some tuners have a trimmer capacitor in parallel with the varactor for the initial setting of the operating band. Decreasing the bottom loading capacitance raises the operating frequency and, likewise, increasing the capacitance lowers the frequency.

Of concern is the effect that the capacitance loading, both top and bottom, has on the E-field of the resonator, because the results will guide us during the consideration for modifying the resonator. The worst case scenario is shown in **Fig. 9**, where the capacitive top loading has been increased to the point where the resonator changes mode from a quarter-wave to a half-wave element. When that happens, the resonator is essentially operating at twice the original frequency. Although this might be a desirable condition for some tuner applications, it isn't likely to happen. Also, the electronic circuit attached to the resonator may not support the mode change because of the drastic shift in transistor feedpoint impedance.

Oscillator

A transistor is connected to the RF ground end of the resonator and functions as a Colpitts oscillator driving

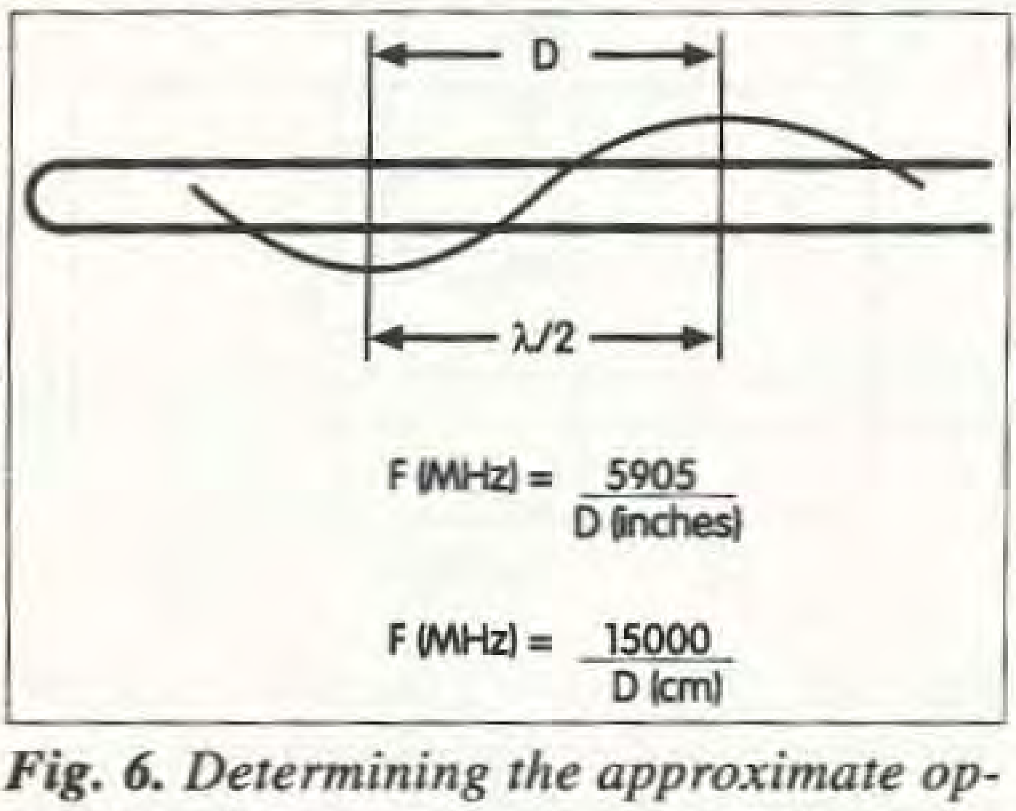

Fig. 6. Determining the approximate operating frequency using a Lecher wire system.

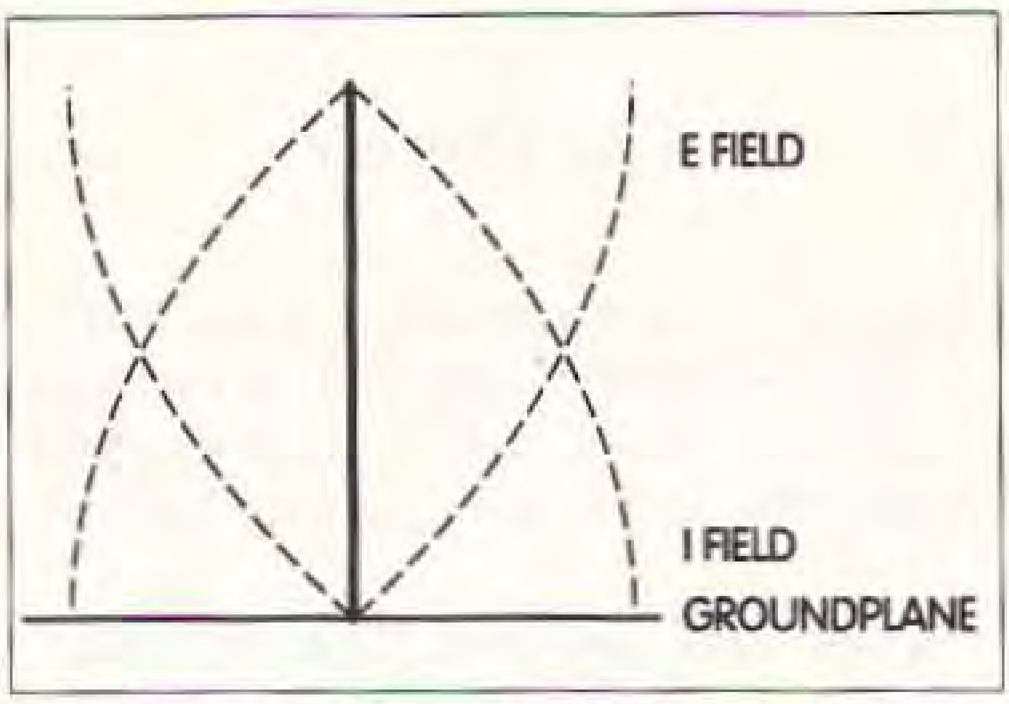

Fig. 7. Quarter-wave resonator with voltage and current fields shown.

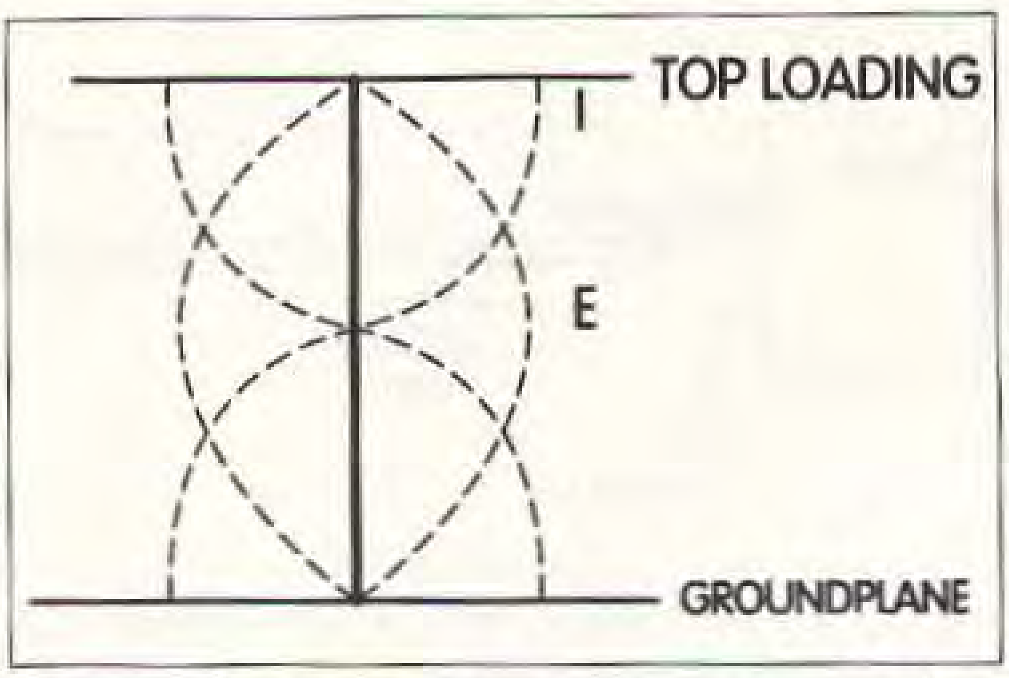

Fig. 9. Excessive capacitive top loading forces a quarter-wave element to operate as a half-wave element.

the resonator. With the transistor connected as used in the TV tuner, it is matched to the bottom of a quarter-wave element. But when the element is excessively loaded, the transistor will fail to oscillate because of a loss of feedback. In most cases, the oscillator will stop oscillating when too much capacitive loading, top or bottom, is applied. A simple explanation for the loss is the drastic imbalance of "feedback capacitance" vs. "loading" capacitance. Decreasing the loading capacitance will usually allow the oscillator to restart. The stopping and starting action of the oscillator may be monitored by observing the meter attached to the mixer diode. Sometimes an increase in oscillator feedback will assist in sustaining oscillation even with a heavy element load.

Metering circuit

Most of the tuners that I've modified for use as dippers have provided about 2 mA of current when the oscillator is operating. At that current level, most any analog panel meter having a full-scale current value less than 2 mA will work well in the dipper application. But to keep the oscillator loading to a minimum, I'd suggest keeping the actual meter current as low as possible, perhaps in the 50–200 μA range. A suitable pot may be included in series with the meter to provide a meter level adjustment as shown in **Fig. 10**.

Another thing that I've observed with tuners is that the polarity of the mixer diode varies from tuner to tuner. Of course, the reason is obvious because when used as a mixer, diode polarity is immaterial. Should the diode's polarity need to be reversed, then care must be taken during the modification process because excessive heat can damage the diode. Regardless, the tuner-dipper project is not dependent upon the diode polarity. Just select the meter's polarity to match the diode.

Some tuners have an RF choke from the mixer jack to ground. One end of the choke must be opened to allow the diode current to pass through the meter.

Part 2 of this series will continue with a discussion of the sense loop schemes and testing. Part 3 will describe the modifications that can be used to permit using the tuner as a dipper.

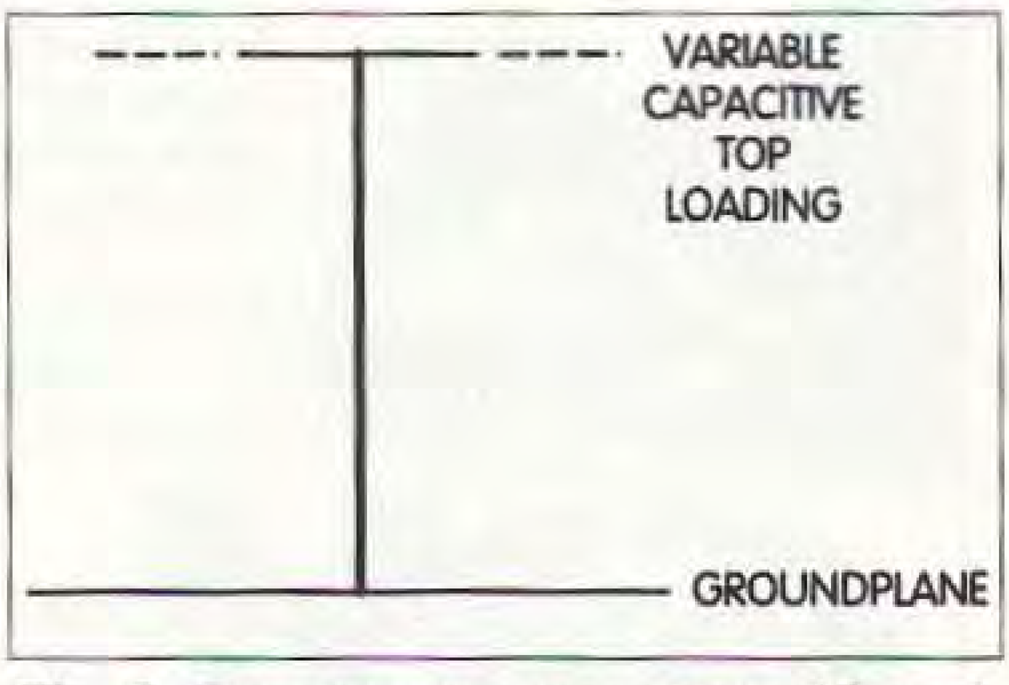

Fig. 8. Quarter-wave resonator with variable capacitive top loading.

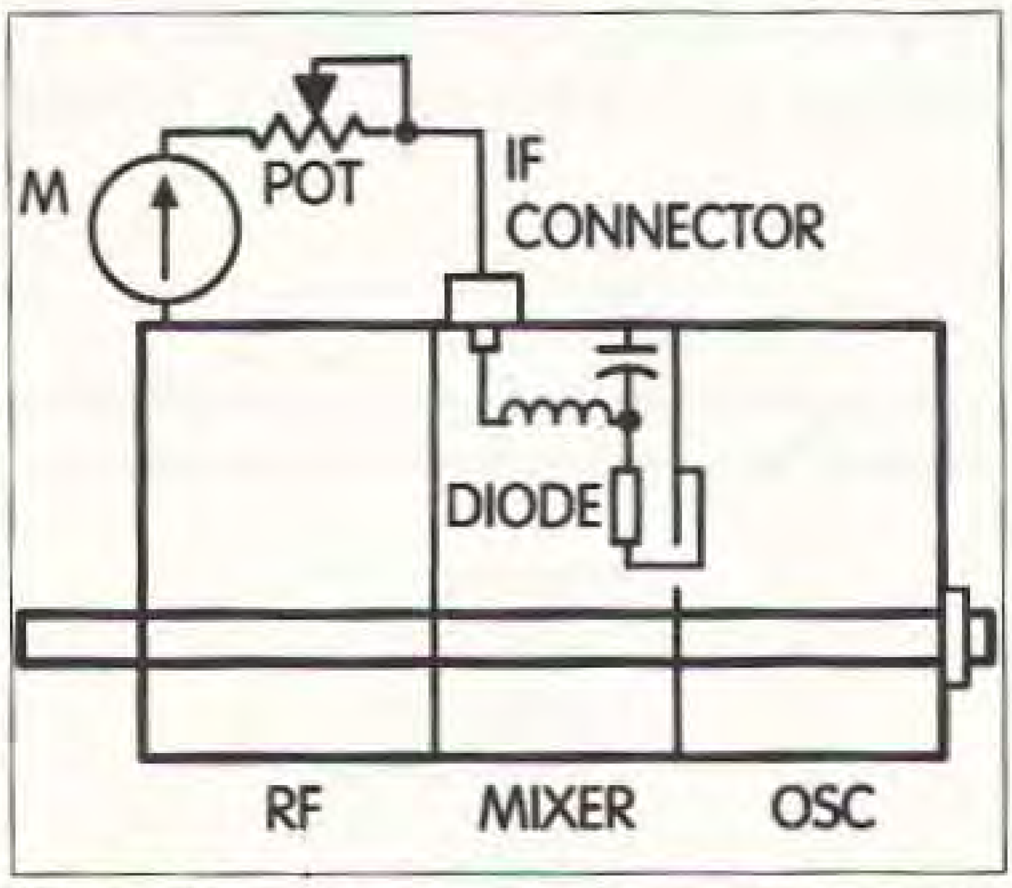

Fig. 10. Using a microammeter as the oscillator's activity monitor/dip indicator. A pot is used for adjusting the indication level.