

An Experimental FM "Wireless" Record Player

This do-it-yourself project will provide a well-deserved sense of accomplishment, followed by many hours of rewarding listening to high-quality reproduction.

by Art Trauffer

An AM "wireless" record player, amplitude-modulated by a crystal or ceramic phono pickup, and reproduced through an AM superhet radio, cannot give you the best from modern hi-fi records because of the limitations of the phono pickup and the radio. On the other hand, an FM "wireless" record player, frequency-modulated by a crystal or ceramic phono pickup through a reactance stage to the oscillator, is again limited by the phono pickup.

This article describes the construction of an FM "wireless" record player which is directly frequency-modulated by a capacitance-type phono pickup. If the capacitance pickup is well designed, the quality of reproduction will be limited only by the records and the amplifier and speakers following the FM tuner.

As shown in the illustrations, a small low-power transistor oscillator, working in the 88-108 MHz FM band, is mounted on top of a wood tone arm. A capacitance-type phono pickup, consisting of a phono stylus having a small metal angle plate

mounted beside it, is connected across the tank circuit (coil & capacitor circuit) of the oscillator. As the stylus rides in the record grooves, the capacity between the stylus and metal plate varies according to the wave forms in the record grooves, and the frequency of the oscillator is shifted by this varying capacitance. This is frequency modulation in its simplest and purest form, and the highest possible quality is within reach.

However, if you want a record player that you can put together in a hurry and sit back and enjoy your favorite discs, this project is not for you. This project is a challenge to the experimenter, and it will give you electronic engineer and mechanical engineer fellows a good chance to show what you can do. This is a fine project for Science Fairs, and electronics classes, to demonstrate the fundamental principles of FM.

Brief History: The capacitance-type phono pickup is an invention of Ben F. Miessner, of Miessner Inventions, Inc., Morristown, N. J. It was used in a phono system by

RCA Victor in the late 1920s. In the 1950s Paul Weathers, of Weathers Industries, Barrington, N. J., produced a high-quality record player using a capacitance phono pickup to frequency-modulate an oscillator which was then detected and passed into the audio amplifier and speaker. The Weathers system was considered by some experts to be the finest record-playing system in the world, but, due to complications, it was given up when stereo records came in. Also in the 1950s, Motorola produced a radio & phono combination using a capacitance phono pickup to modulate the RF circuit in the receiver before detection, but this was also given up when stereo came in.

Constructional Details

Motor, Turntable, and Cabinet:

As shown in figures 1 & 2, the writer used a common low-priced three-speed phono motor and turntable, but a high-quality motor and turntable is recommended for minimum rumble and "wow." The wood cabinet was put together with one-by-twos and a 1/2" plywood top, and measures 12" by 10" by 2 1/2". The



Figure 1



Figure 2

cabinet was covered with "Contact" adhesive plastic material.

Wood Tone Arm: Figure 3 is the plan for jigsawing the hardwood

tone arm. Metal must not be used because the leads cemented along the sides from the pickup to the oscillator are not shielded. The

writer used birch wood. Sand the arm smooth, and stain it to match the cabinet if desired.

Universal Joint for Wood Tone

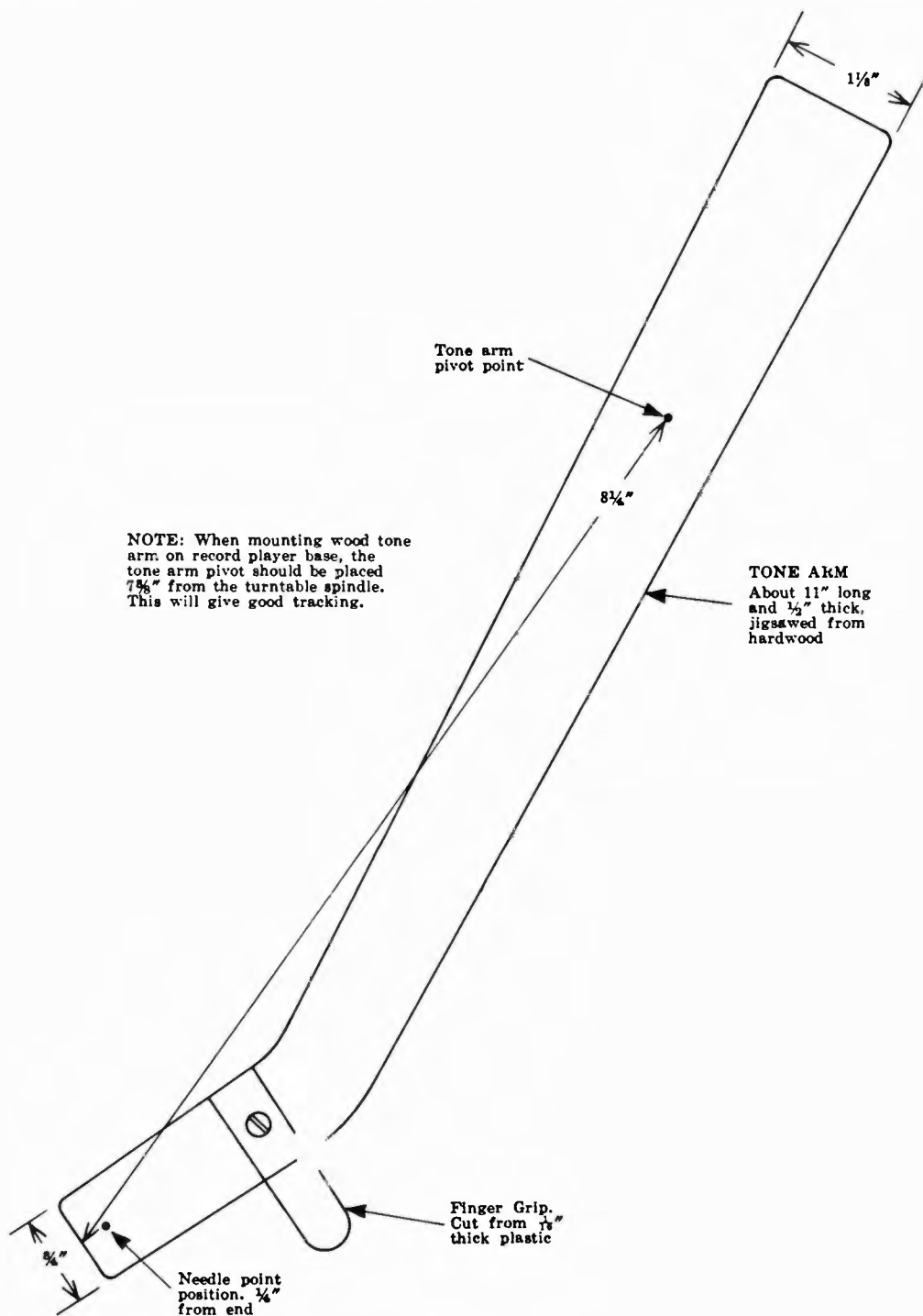


Figure 3
SIZE AND SHAPE OF
HARDWOOD TONE ARM FOR CA-
PACITANCE PHONO PICKUP
(Copy this closely for
good tracking)

Arm: Figures 4 and 5 give all details for making the brass universal joint for the tone arm. The main objective here is to strive for low friction, giving the arm very free lateral and vertical movement, which is very important when using a capacitance-type phono pickup having a highly compliant stylus, especially when playing records that are warped or have off-center holes. Note that the two side strips connected to the tone arm are made from insulating material (not metal)—this prevents metal-to-metal contacts which are picked up by the oscillator and heard in the speaker.

Oscillator and Battery Clips: Figure 6 is the schematic diagram for the low-power high-frequency transistor oscillator, showing how the capacitance pickup is connected across the tuned circuit (tank) of the oscillator. Figure 7 shows how the oscillator parts are mounted and wired on top of the wood arm, and how the battery clips are mounted and wired to the oscillator. The variable-trimmer capacitor is mounted with two wood screws, and the ends of the coil are soldered into the lugs on the capacitor. All wire leads should be soldered, be short and direct, and as rigid as possible to reduce microphonic effects. Parts and wire leads can be cemented securely to the tone arm with Duco cement. The correct polarity for the two batteries should be marked on the wood arm so you don't forget. The writer doesn't use a battery on-off switch (the batteries are removed when finished playing) but there is room on the tone arm for two miniature SPST toggle switches.

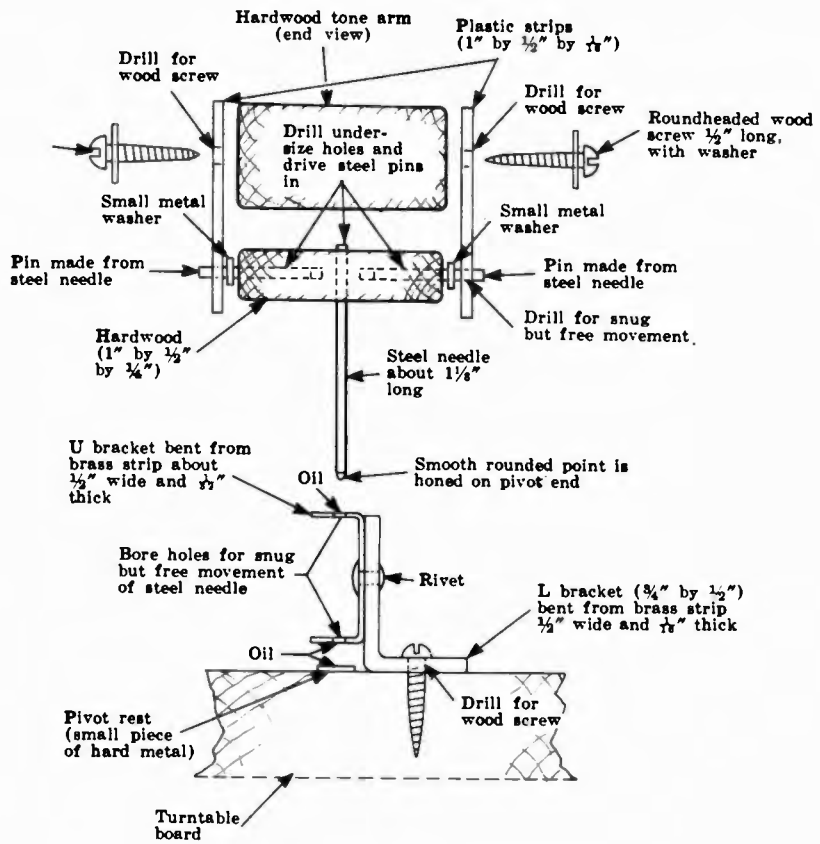
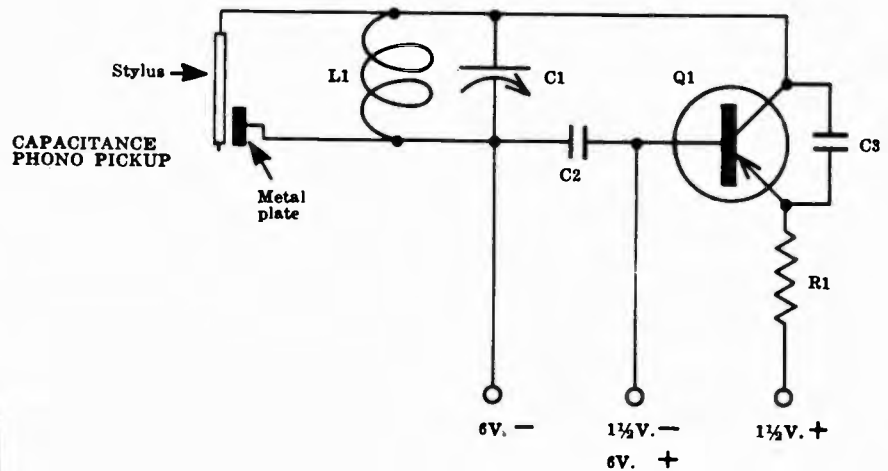


Figure 4
UNIVERSAL JOINT FOR WOOD TONE ARM
(Strive for free vertical and lateral movement of tone arm)



- Capacitance phono pickup (see text).
- L1 Oscillator coil (3-turns solid copper, #16, 1/2" dia).
- C1 30 pF variable capacitor (Centralab trimmer capacitor, 4-30 pF Allied Radio Shack Cat. No. 748B7050).
- C2 .001 mF disc capacitor (smallest size).
- C3 7 pF disc capacitor (smallest size).
- R1 500-ohm, 1/4-watt, fixed resistor.
- Q1 UHF pnp transistor (Motorola HEP 57, or equiv).

Figure 6
SCHEMATIC DIAGRAM FOR FM "WIRELESS" RECORD PLAYER

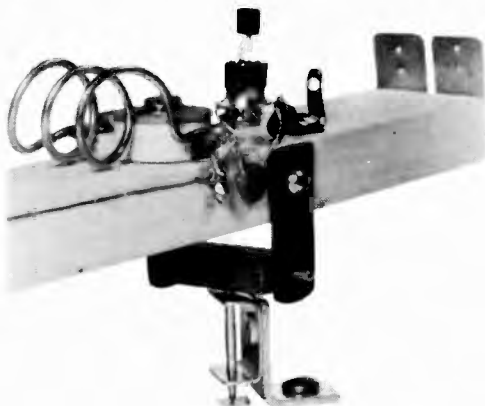


Figure 5

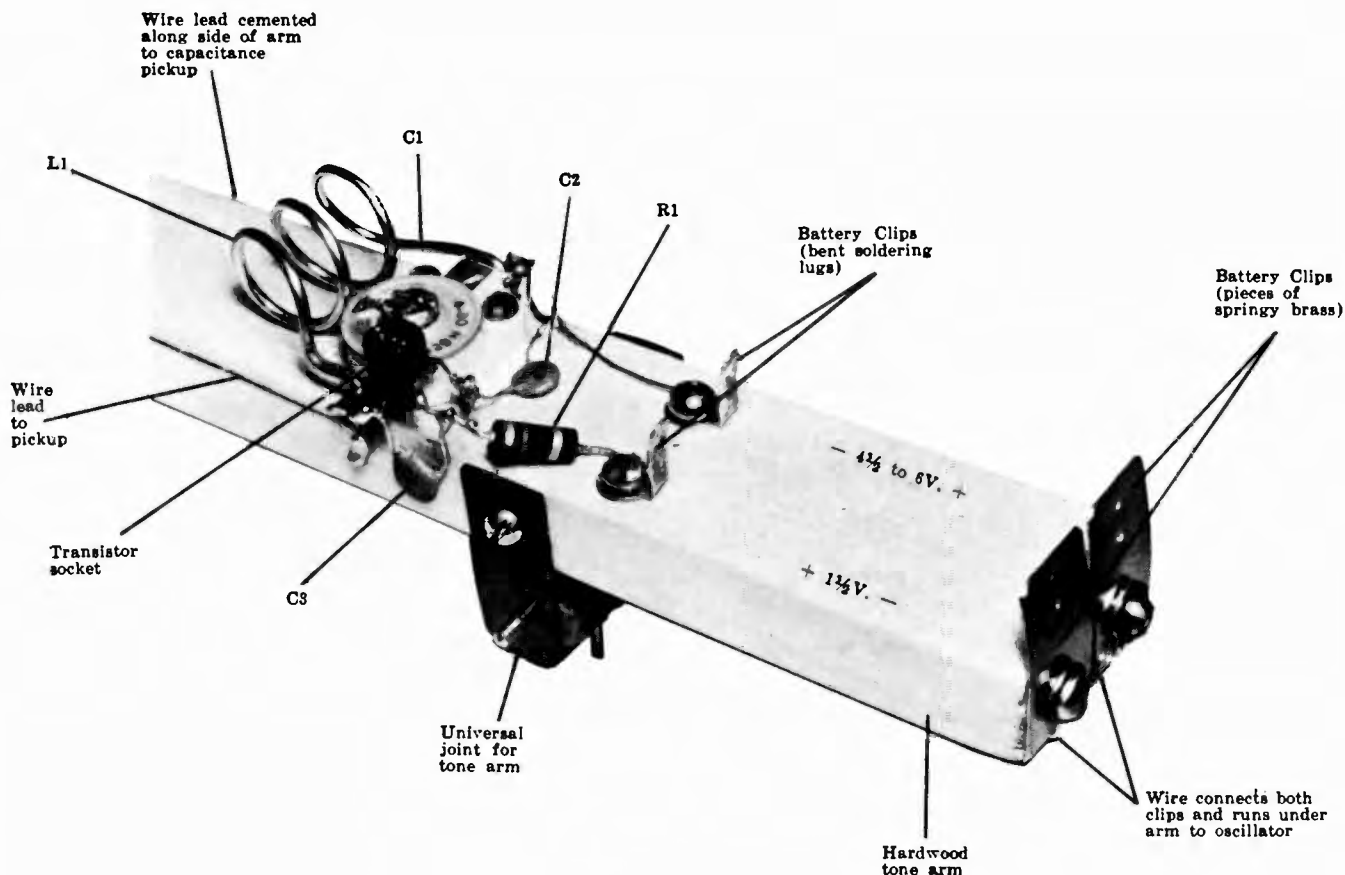


Figure 7
 DETAILS OF OSCILLATOR, BATTERY CLIPS, AND
 UNIVERSAL JOINT FOR WOOD TONE ARM

The Capacitance Phono Pickup: Now we come to the most important part of the whole project. The quality of reproduction from a capacitance pickup depends on how well you design it. The stylus must have a very low mechanical resonance in the audio range. Stylus resonances that might not amount to much in a cheap crystal or ceramic cartridge, will stand out like a house on fire when used with a capacitance phono pickup.

The finest stylus ever used by the writer was made for the FM record player produced by Weathers Industries in the 1950s. This stylus had low mass, high compliance, and very low mechanical resonance in the audio range. Reproduction when using this stylus was beautiful. You may still be able to obtain one of these styluses from the Weathers Industries (if still in business), or from a well-stocked dealer selling replacement

phono needles. Replacement styluses for the Weathers FM Record Player were also made by Jensen Industries, Forest Park, Illinois, and by Astatic Corporation, Connecticut, Ohio. If you can obtain a Weathers FM pickup stylus, mount it on the tone arm as shown in figures 8 and 9.

In the 1950s Motorola made a capacitance phono pickup cartridge for their Models 53F2 and 21F5 hi-fi radio & phono combinations. This cartridge number was 1C630821, and is shown in figure 10. If you can still get one of these cartridges from Motorola, or one of their replacement parts distributors, mount it as shown in figure 11. The cartridge is cemented in a slot sawed in the nose of the arm, and the wire leads are cemented to the two lugs in the rear of the cartridge, as shown. This Motorola capacitance cartridge has some stylus resonances and will not sound as

good as the Weathers. It also has a .002" stylus tip for use with records of all three speeds, and this is not the best for playing LP micro-groove discs.

A home-made capacitance phono pickup tried out by the writer is shown in figure 12. Needless to say, this is not the best way to do it, but it works well and costs practically nothing. If the stylus has low mechanical resonance, and if the trunnion bearing in the old cartridge has free movement, very good results can be obtained.

Another home-made capacitance phono pickup is shown in figures 13 and 14. Here, the top end of the stylus is seated in a plug punched out of a soft pencil eraser and pushed into a hole drilled in the nose of the tone arm, as shown. Fine results can be had with this simple pickup if the stylus has low mechanical resonance in the audio range.

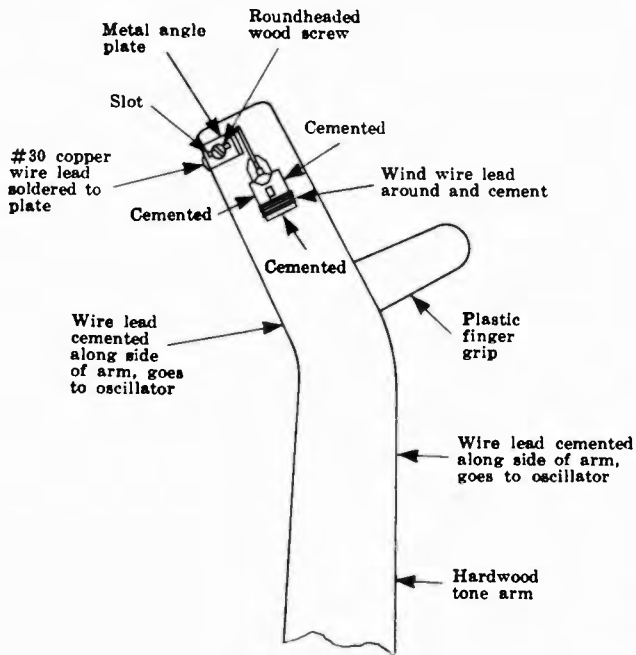


Figure 8

HOW THE WEATHERS INDUSTRIES CAPACITANCE PHONO PICKUP STYLUS IS MOUNTED ON ARM

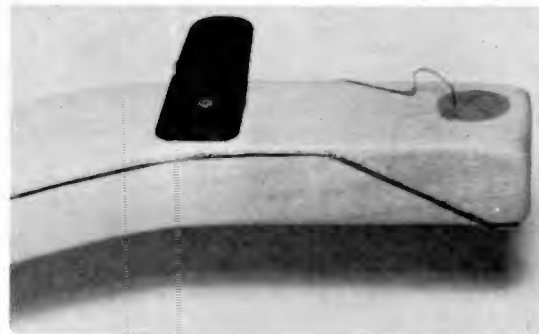


Figure 9

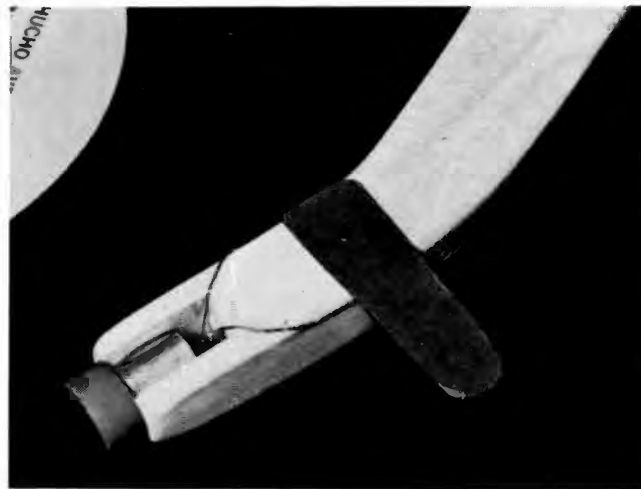


Figure 11



Figure 10

A Few Tips: When this capacitance pickup travels across the record towards the inner grooves, there will be some frequency drift of the oscillator due to the effect of the metal turntable on the pickup and its leads, but this shouldn't bother you if your FM tuner has AFC, or if your phono motor has a plastic turntable as some do.

As the pickup travels towards the inner grooves of the records you may notice a scratching noise in the speaker. This is due to the metal turntable center shaft turning in its socket (any metal-to-metal friction close to the pickup or oscillator will be transmitted to the FM receiver). The writer solved this problem by turning out a plastic turntable shaft on a lathe to replace the metal one.

All FM broadcast stations purposely boost the high musical frequencies (preemphasis), and all FM tuners contain a de-emphasis network to bring the frequency balance back to normal — this is done

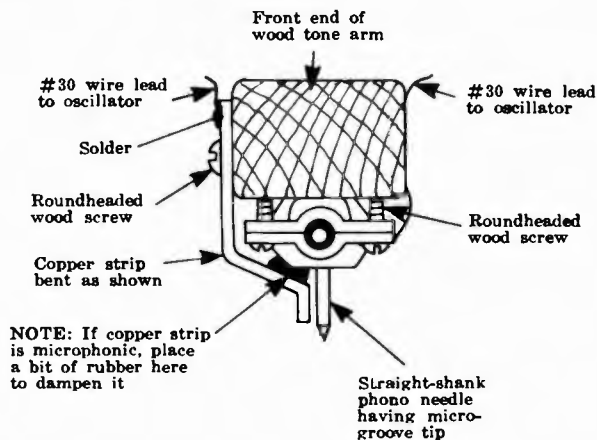
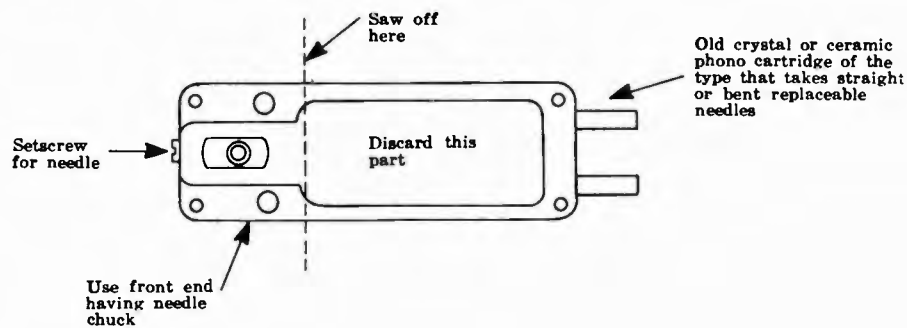


Figure 12

FRONT END OF DISCARDED CRYSTAL CARTRIDGE CAN BE USED TO HOLD NEEDLE FOR CAPACITANCE PHONO PICKUP

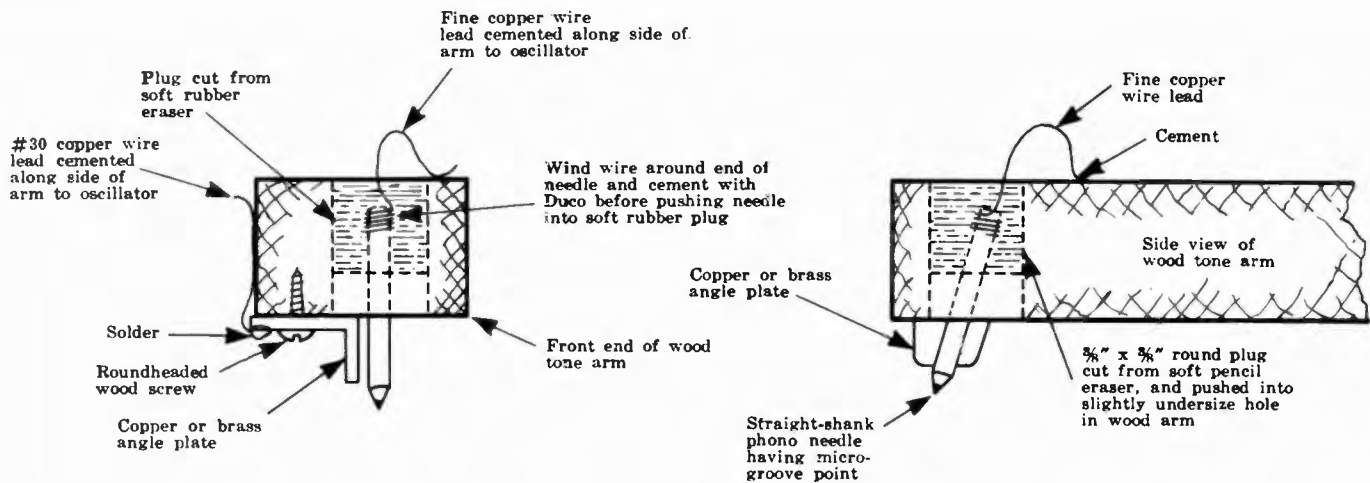


Figure 13
HOME-MADE CAPACITANCE PHONO PICKUP

(Hole in metal angle plate can be slotted to permit adjustable spacing between plate and phono needle.)

to reduce static and other high-frequency noises in the receiver. Since our FM record player has no high-frequency preemphasis, you can either disconnect the resistor and capacitor de-emphasis network in your FM tuner, or boost the highs in your audio amplifier.

Now that we have given you the main idea, put your electrical and mechanical engineering talents to work and produce one of the finest phono pickups ever conceived. Remember that the pickup stylus must have low mass, high compliance, and very low mechanical resonance in the audio range. Since the stylus has nothing to do but ride in the records grooves it will respond to a wider range of frequencies than anybody can put on a record!

To quote from a letter to the writer from the inventor of the

capacitance phono pickup, Ben F. Miessner: "The mass, and therefore the motional reactance of the needle, should be reduced to the lowest possible minimum consistent with stiffness and a very high natural vibration frequency. Obviously a tubular form, without such appendages as a needle chuck, a vibratory axis, or extra electrode section will accomplish this object and at the same time provide ample surface area for the capacitance pickup function. Duraluminum or magnesium is the best material. The jewel tip may be cemented into one end of this tubular needle with shellac or other thermoplastic material. This is a fascinating and fertile field for experimentation with rich rewards in very closely approaching, if not actually realizing, the dream of perfect fidelity of reproduction. Dynamically, the response of such a pickup is absolutely linear through much wider ranges of vibration amplitude than are encountered in phonograph recordings. The frequency response curve cannot be other than linear down to zero cps because this is an amplitude- and not a velocity-type of device when used with an FM or AM capacitive translator."

Materials List — FM "Wireless" Record Player

Oscillator:

- 1 foot #16 solid copper wire (for making L1).
- (C1) small 30 pF variable trimmer capacitor (Centralab Trimmer Capacitor, 4-30 pF, Allied Radio Shack Cat. No. 748B7050).

- (C2) .001 mF, small size disc capacitor (Allied Radio Shack).
- (C3) 7 pF, small size disc capacitor (Allied Radio Shack).
- (R1) 500-ohm, ¼-watt, fixed resistor (Allied Radio Shack).
- (Q1) UHF npn transistor (Motorola HEP 57, or equiv).
- Transistor socket for above transistor.
- One ¼-volt transistor battery (Eveready No. 333).
- One size AA 1½-volt flashlight battery (Allied Radio Shack).
- 2 long soldering lugs (for battery clips).
- 2" length ½" by ½" springy brass (for battery clips).
- 6 roundheaded wood screws ½" long, and 4 washers to fit.
- Two-foot length #30 bare copper wire (for pickup-to-oscillator leads).

Capacitance Phono Pickup: (see text).

- 1 piece hardwood 12" by 3" by ½" (for jigsawing tone arm).

Universal Joint for Tone Arm:

- 1 piece brass band 1½" long, ½" wide, ⅛" thick (for L bracket).
- 1 piece brass band 1½" long, ½" wide, ⅛" thick (for U bracket).
- 1 rivet, and 1 roundheaded wood screw (for L-U bracket).
- 1 piece insulating material (plastic) 2½" long, ½" wide, ⅛" thick, (for making tone arm side brackets).
- 1 small piece hardwood 1½" by ½" by ¼" (for making block to hold pivots).
- Few steel darning needles of various sizes (for universal joint pivots).
- 2 roundheaded wood screws ½" long with washers to fit (for holding plastic brackets to wood tone arm).
- 1 piece plastic about ⅛" thick (for making finger grip for tone arm).

Baseboard for Motor and

Turntable:

- 4-foot length hardwood 2" wide, ¾" thick (for making sides of box).
- 1 piece plywood 10" by 12" by ½" (top of wood box).

Phono Motor and Turntable: (see text).



Figure 14