



THE PRAYING MANTIS (as the editor christened it) came about after a long struggle with a combination of warped records the manufacturers keep trying to sell us, transmission-line speakers with woofs that are relatively undamped at subsonic frequencies, amps and preamps with nearly flat response way down to *there*, very high compliance floppy cartridges in the normally massive arms of the day, and after seeing a Transcriptors Vestigal arm.

Having failed to solve the problem by buying only flat records (the local stores are friendly, but I try their patience too often), by passively rolling off subsonics with capacitors between preamp and amp (1mF and .4mF are relatively ineffective and smaller values roll off the audible bass along with the warps), by using the low filter on the preamp (who wants to lose those bottom notes along with the record warps?), and by using lower listening levels (ugh, I am too addicted to live levels--100-106dB peaks at the couch): I ordered a Vestigal ("Vegetable") as a further attempt to solve the problem.

Upon trying a friend's "Vegetable," however, I discovered this solution had its own problems: relatively unfree vertical movement of the head shell due to the stiffness of the wires and the shortness

Text and photos by
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The Praying Mantis

of the lever arm, stylus force extremely variable with head shell height due to the design of the rear counterweight, high tracking angle error due to the shortness of the overall arm length, high skating force due to the shortness of the arm and the consequent large offset angle of the cartridge, lack of adequate antiskate adjustment (the recommended method of tilting the arm worsens the problem of the stylus force being height sensitive), lack of a cueing device, presence of an audible bass resonance due to the reduced overall mass and inertia of the arm and the consequent raising of the cartridge arm resonance into the audible region.

Well, it finally dawned on me (having cancelled my order for the Vegetable and replaced it with an order for an S.M.E.) that, for the investment of a very few dollars an

and a bit of time, I could design and build my own arm which might have fewer faults; and even if it was a total flop, little would be lost and some knowledge and experience gained. (About this time I saw and was encouraged by the article by Roger Sanders in the April '74 issue of *The Audio Amateur*--Issue 2, 1973 series, p.11.) So I began to work with small balsa and paper models, tape and coins (nickel = 5 grams; penny = 3 grams; dime = 2 grams), pulleys, razor blades, thread, and needles--making inertia and bearing models.

I wound up deciding on the split arm idea of the Vegetable, and on some very simple bearings that I think are better than most commercial ones. Since the forces at the three bearings required are almost entirely applied in single directions, and since the arm bearings do not need to withstand the omni-

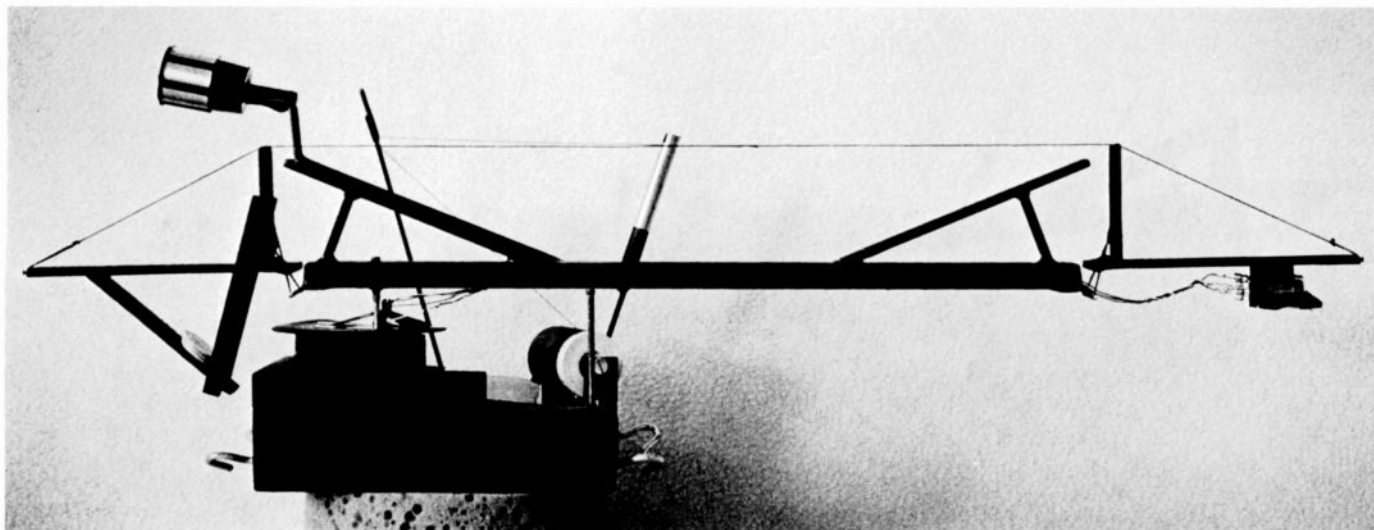


Fig. 1A, above, is a panoramic side view of the arm (mechanically dimensioned in Fig. 1B, opposite page). Fig. 2 below, shows the author's rubber cemented cartridge and Fig. 3, bottom, is a closeup of the front pivot.

directional forces which would occur during shipping, a simple bearing consisting of a needle point resting in a metal dimple (the direction of applied force determining the approximate direction of the needle) is used for the vertical moving parts of the arm (Fig. 4) and a balanced nail being guided by lubricated holes in thin metal (tin can covers) and resting on a smooth lubricated metal surface is used for the horizontal moving part (Fig. 5).

Well, you say, fine and good, but that's a lot of bearings for one arm--what about simply using a unipivot arrangement--only one needle point in a dimple? One reason for not using a unipivot is that the whole point [ahem.--Ed.] of my design is to reduce inertia in the vertical movements of the arm and the unipivot design requires the arm to be offset vertically on its own lever arm so that it, with gravity, can give it stability--thus increasing the inertia for a given arm length and weight. Also, it would be difficult to build a unipivot arm as short as the arm I built. The disadvantage of the relatively large number of bearings in my arm would be considerable if the bearings had significant friction for the lever arms being used, but they do not.

I decided to use longer arms than the Vegetable to overcome potential problems in bearings, wire bending, and stylus height force variations. A "long" $3\frac{1}{4}$ " stylus-to-bearing distance was used, which also resulted in having lower warp-wow than the Vegetable. In the horizontal arm, a whopping $13\frac{3}{4}$ " stylus-to-bearing distance was used (Fig. 1). The length has the advantages of reducing tracking angle error and reducing skating force to the point where an antiskate device is not

needed (although it is easily added).

It also makes it possible to mount the arm on a separate base and operate it off the side of the turntable so that the original arm need not be removed (Fig. 2). In fact, the two arms can play the same record at the same time, if you have two phono inputs! Cartridge comparers would be in heaven if it weren't for the different electrical and mechanical characteristics of this and any other arm.

But, you say, it's long and heavy! (in horizontal motion). Yes, but except for lead-out grooves it doesn't have to move very fast, and its relatively great horizontal inertia gives something that the stylus can work against--high horizontal inertial damping, but low vertical inertial damping, so that it can handle any pinch warp. Actually, the horizontal inertia is low enough so that it doesn't cause problems, and 'scope measurements using CBS STR 100 record sweeping from 40 through 20,000 cps. indicate about a $4\frac{1}{2}$ dB resonance at approximately 45 cycles--considerably better than the approximately 180 cycle resonance of the Transcriptors arm with the XLM cartridge.

And it has a cueing device, the design of which is determined by available parts. Mine (Figs. 6, 7) was made from parts from a defunct Fisher changer arm and center-spindle (obtained from a local audio repair shop), but anything using an arm with two positions to pull a thread could work--and could be added to the original Vegetable.

Construction

Assemble the pieces with fast-dry airplane cement, then puddle 15-minute epoxy neatly around the

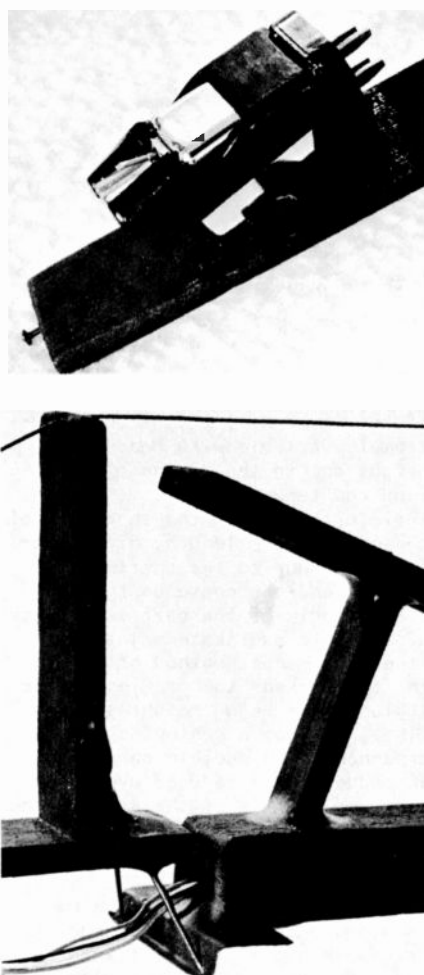
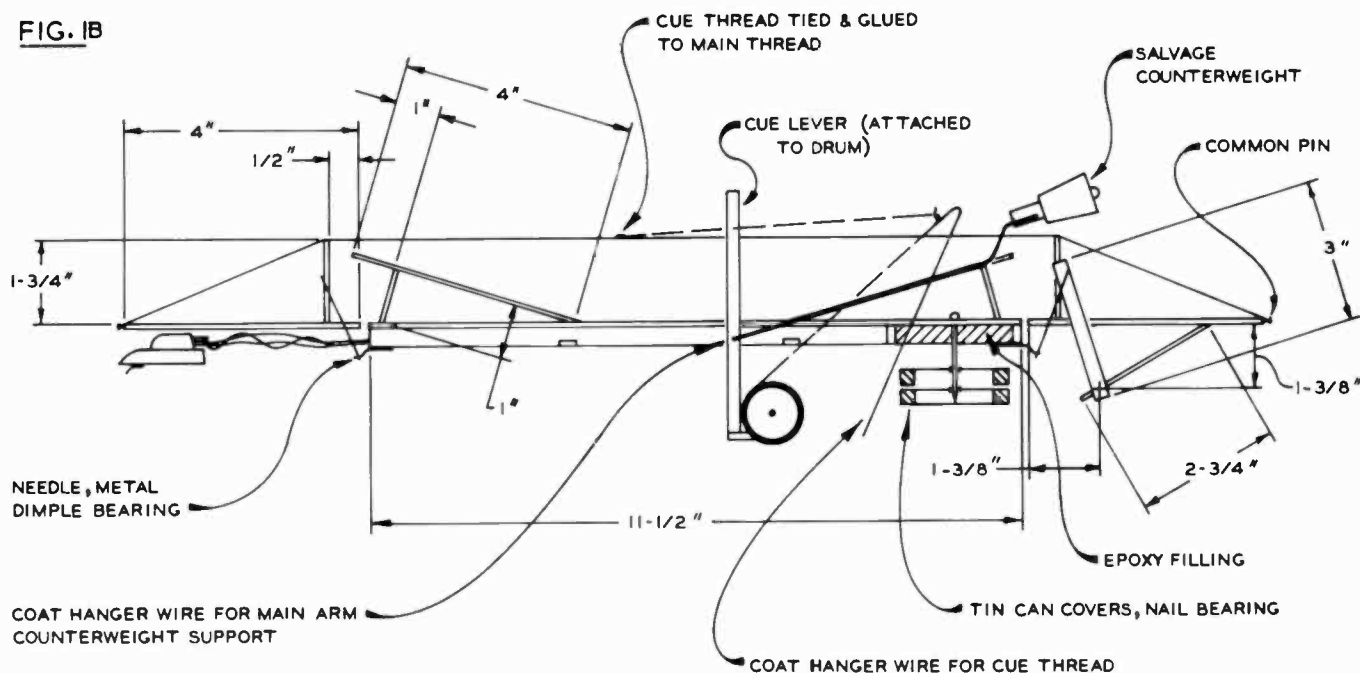


FIG. 1B



joints. Five-minute epoxy is a bit too fast, and the 15-minute variety can be speeded by heating, when desired. A nail works well for picking up epoxy and placing it in the joint.

The main arm section is made of a strip of 1/2" x 1/8" balsa with a strip of 1/4" x 1/8" balsa glued on each edge to form a piece with a "U"-shaped cross section 3/8" x 1/2". A couple of short 1/4" x 1/8" pieces were fitted in along the arm (Fig. 8) to hold the wiring inside the arm. The two short arms are basically identical and are made of 1/2" x 1/8" balsa. Common pins are punched into the ends to make hooks for the thread. The counterweight support structure of 1/2" x 1/8" and 1/4" x 1/8" balsa is made after most of the arm is complete (Figs. 9, 10).

The vertical bearings are made by cutting small rectangles, approximately 1" x 3/4", out of tin can stock. Large household scissors work well--generally cut pieces larger than desired, then trim. Bend the metal pieces carefully with pliers into the shape shown in Figs. 4 and 8, then make small dimples by placing the metal pieces on a wood surface and tapping 40 finishing nails carefully and lightly with a hammer while rotating the nails.

Be prepared to make several pieces before you have two that look alike and have dimples of the right size. These are placed on the ends of the main arm. Two 1 1/2" sewing needles are pushed through the rear of the short arms so that they are spaced properly apart and fit into the dimples so that the three parts of the arm are straight

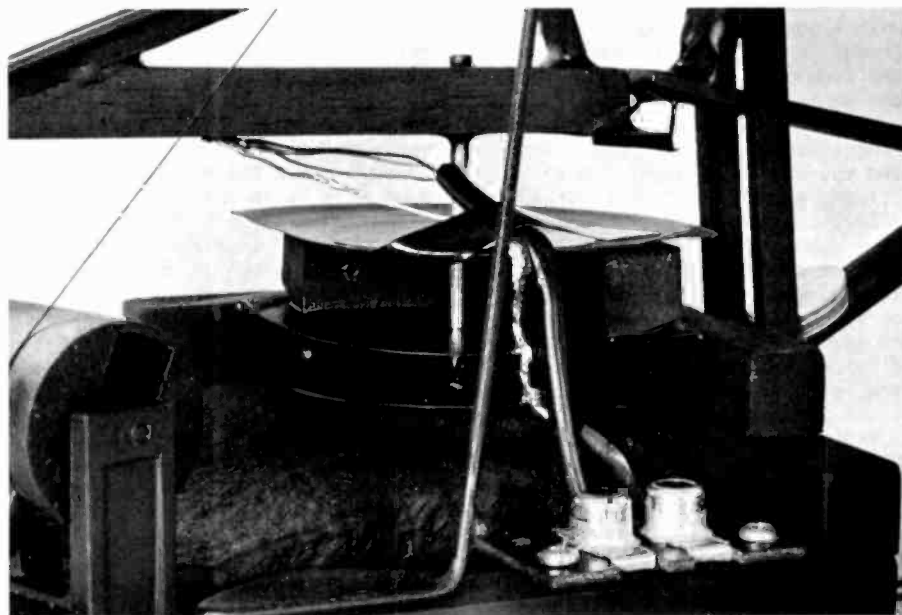
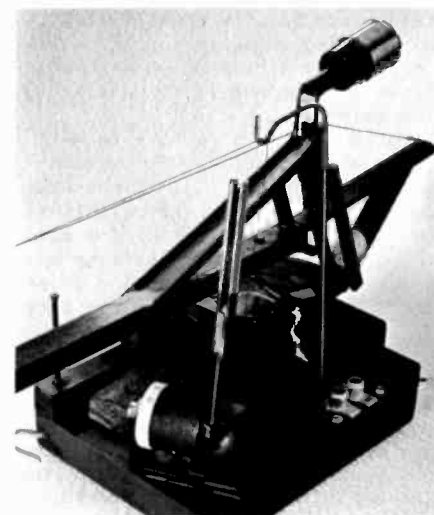


Fig. 5, above. Fig. 6, at right.

(Figs. 1, 4, 9, 10).

The horizontal bearing is a nail imbedded in epoxy in the main section of the arm, one inch from the end (Figs. 5, 11). Place a balsa end on the arm and a balsa dam in the channel four inches from the end of the arm. A 6D finishing nail is forced through the center of the top of the arm, one inch from the end, with the head resting on top of the arm. Position the nail as near to 90° perpendicular as possible. Fill the end of the arm with epoxy and allow it to set. Later, when adjusting and leveling the arm, the nail is easily bent slightly by hand to the proper position.



The nail fits into a structure of three layers of tin can tops, with $\frac{1}{2}$ " spacers between--the bottom one is unpunched, the others are carefully punched by driving a 6D nail through them, flattening the burr with a hammer, and then manually placing the nail until it just fits in a smooth hole (Figs.5, 11).

The base is made to taste--mine is made of $\frac{1}{2}$ " square balsa and sheet balsa $\frac{3}{16}$ " x 2". I have a flat rock in it to add mass (Figs. 1, 2, 5, 6, 7).

The arm is strung with thread so that both short arms are level at the same time (Fig.1). Adding a length of elastic material to the thread might improve the bass resonance characteristics, but mine does not have any.

The rear section of the arm has the counterweight position approximately right for an XLM (Figs.1, 9, 10, 11). Negligible change in stylus force occurs as the arm moves over even very large record lumps. Exact placement for your cartridge may take some experimenting. Tape a weight equal to that of the cartridge in the place it would be on the front arm (both along and below the arm) to represent the cartridge.

The actual stylus-bearing distances depend on what spot on the arm you choose to mount the cartridge, at an offset angle of 13° (Fig.3). Since you will mount it with rubber cement (easy to use, easy to clean off, sufficiently strong, and low in mass--no steel screws here!), where you mount it is your choice, unless bearing-wire difficulties dictate a longer lever arm, or short wires a shorter lever arm.

Next tape sufficient weight on the rear arm at various positions along and below the arm so that as the arms move up and down, approximately one gram is maintained on a balance scale under the front arm weight. Move the balance scale up and down to move the arm--if it remains balanced, you have found the right spot for the counterweight. While doing this, do not allow the rear weight to swing, unless the final arrangement is to be a swinging weight.

Build a balsa structure to hold the counterweight in the correct position (Figs.9, 10). (Dimes make good, obtainable counterweights--I use three.) Final trim of the counterweight for correct position and weight can be made by laying or attaching a small weight to any part of the rear arm section.

The two T-shaped bridge structures on top of the arm (Figs.1, 4, 6, 7) are there to prevent vertical arm movements and are placed by experiment. They are needed for proper operation of the cueing device and to prevent

prying of needles from dimples as a result of too much movement of the arms. I used nails for horizontal arm stops.

The large rear counterweight on top of the main arm section (Figs. 1, 6, 7) is also placed by experiment when the arm is nearly complete and the cartridge or an equivalent weight and the cartridge counterweights are installed. The large counterweight is needed to balance the entire arm structure over the nail bearing for minimum friction. Bend a wire coat hanger structure and glue it to the arm, then, with the arm on a level surface, attach the counterweight so the nail bearing is balanced--reducing side forces between metal and nail to a minimum. My counterweight, also from the Fisher, screws in and out for fine adjustment, though anything of sufficient weight can be permanently attached and will work adequately with a variety of cartridges.

To make the cueing device, attach a very fine thread to the thread going from the front to the back halves of the arm and bring it over a smooth coat hanger wire loop (to preserve it I taped the original enamel finish of the wire while spray painting the rest of the arm) exactly above the horizontal pivot down to a lever which will stay in either of two positions (if it isn't exactly over the pivot, the arm will be drawn in one or another direction when cued).

A spring holds my cueing lever in one place, the weight of the metal handle holds it in the other (Figs. 1, 6, 7). Even though the cueing is not damped, the "gear-ratio" is such that it is impossible to cue too quickly and the low mass of the arm makes damage to the stylus impossible. As fast as I can cue it, the stylus just stops at the record surface--no squashing effect.

With the string removed and parts masked, and before the arm is wired, the arm can be given thin coats of spray paint (mine is matte black). Be sure to clean the paint from needle ends and dimples before reassembling the arm--fingernails for cleaning the needles, a finishing nail end rotated in dimples for cleaning the dimples.

Wiring the arm presents some problems. Since the arm is unusually long, it requires the least possible bending resistance across the front bearing, and is not made of easily grounded (but heavy) metal. I solved the problems by using the wiring from an old table that had extra long arm cables. (Long arm wiring is commercially available, however.) These I twisted everywhere except at the bearings, where they must not bind on each other.



Figures above are, from top to bottom, 7, 9, 10, and 8.

They must also be as near as possible to the bearing axis (Figs.4, 5). Cartridge terminal clips (available at stereo shops with repair departments) were soldered on at one end of the wire, and the other ends ran to a pair of phono jacks on the arm base.

Upon first playing, a slight amount of hum was evident. I took some lamp cord, removed the insulation from one wire, and twisted it around the arm wiring inside the main arm section only (Fig.8). I soldered one end to the front metal bearing, and the back, through a short length of phono wire, to the top of the tin can cover (Figs.5, 8). I soldered a strap to all of the metal parts of the horizontal bearing and then to the ground side of one of the phono jacks (Fig.5).

Hum is now very low. (In a later arm project, I used two-conductor-plus-shield "phono wire," which

worked very well, though it is necessary to bridge the bearings with three very flexible unshielded phono wires.)

I have used two methods of suspension. Alas, feedback is a problem--if you think you don't have it, assuming you have speakers with some bass and you listen above background music levels and your turntable isn't placed on the ground, try placing your tonearm

down on a record you don't care a about with the turntable not rotating, and turn bass and volume carefully up to normal. With hand at the ready on volume control, assuming runaway feedback hasn't already occurred, lightly tap the surface on which the turntable sits. If you hear a tapping sound in the speakers, o.k.--if you hear a "booiinnngggg," you have problems. Maybe not bad ones, but enough to

kill bass detail or make you think you have a rumby turntable.

It's worth it to solve the problem--you may have less "bass," but it should sound better. Try thoroughly bracing the top of whatever the turntable is sitting on and try placing a typewriter pad, and maybe some foam blocks, under the turntable. Be careful of the resonant frequency of the turntable springs--after once putting an AR on foam, I was surprised to find the whole works rocking back and forth. Do everything cautiously!

I first placed this arm on a sponge which, on my thin, wobbly, "unfinished furniture" type stereo cabinet top and in my shaky house, worked only moderately well. Next I put four hooks at the corners of the base and hung it in a cake tin (2½" x 6" x 10") with some number ten springs (all parts from a hardware store). With some padding under it, it worked quite well, but cueing was difficult with the arm bobbing up and down, so I am showing it on the sponge, assuming your house is less shaky than mine.

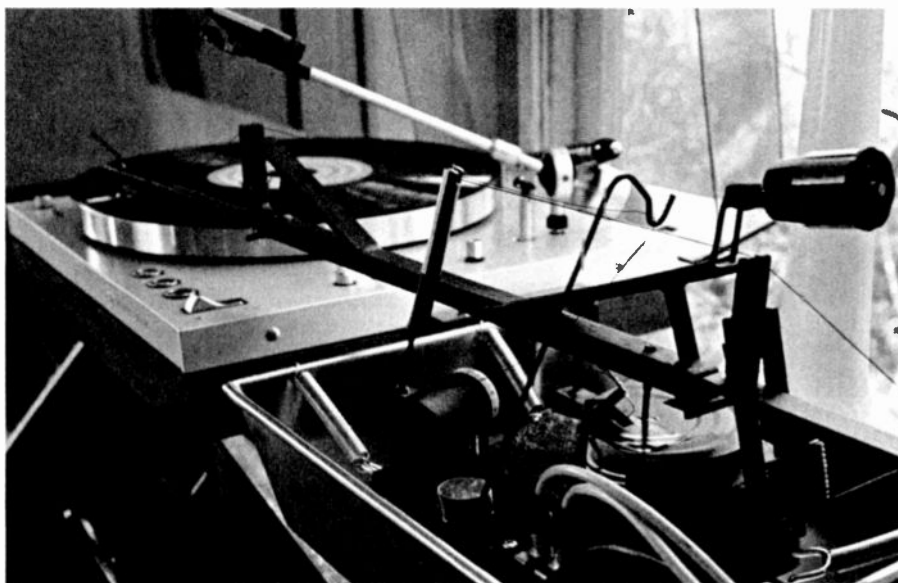
Setting up the arm is not difficult. Place the arm at a height sufficient for the front bearing to clear the record surface and so that the cartridge arm, when the stylus is on the record, is horizontal. Before doing this, it would be a good idea to set the proper (or lower) stylus force for the cartridge.

To set the overhang, place a file card on a record with a pencil line aimed at the center of the turntable spindle. Tape a cardboard strip across the arm or onto the stylus guard so that the edge of the cardboard is lined up with the axis and position of the elliptical stylus tip. Place the arm over the record, and move the arm base around until the cartridge is aligned with the pencil line when the cartridge is at the inner grooves of the record. When aligned there should be just about zero error on the inner half of the record, rising to a maximum of about 2° at the outside edge of the record.

Vertical angle is best set by ear. Choose a record with quiet surfaces and large slow undulating warps (RCA Dynaflex records work well for this) and listen for "swishing" sounds as the cartridge goes over the warps. The vertical angle of the cartridge is properly adjusted (easiest to do by raising or lowering the arm base rather than by remounting the cartridge) when the swishing and overall hiss level is minimized.

Since the antiskate force for an arm of this length is minimal--about half what is needed for a 9"

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The author commends the above variation on the P.M. arm. The front section has been lengthened to 8", the offset angle reduced to 10°, and the wiring changed to five-lead, a shield plus two-hots ("flexible" phono wire) wrapped with two light magnet wires for signal grounds. These are bridged at the bearings by very fine tone arm wire, available in 18" length sets of wire at stereo supply stores. The fifth lead would be useful for cartridge (body ground) and/or wire loop static drainer (photo of one on an S.M.E. on page 26). The finger lift is useful, and the spring suspension combined with what must be an ideal arm resonance frequency seems to have removed all feedback and footstep problems. The woofers now move a bit on record warps, but there are no resonances in the audible range, and even with the arm bobbing up and down on its suspension after having been shaken, the stylus stays in the record groove. The cueing device still works well for picking up the arm, but because of the movement of the whole arm during its operation, is impractical for set-down. (The finger lift works easily for set-down.)

The instructions are clear, and although a fair amount of work is involved, the unit goes together cleanly. Heath are entitled to a tribute for their ability not only to engineer an amplifier of this performance class, but also to make it reproducible. Further, they accomplished this without any setup adjustments or special instrumentation, and with a performance that easily exceeds its ratings.

No specification attached to the AA-1640 was unverifiable, and it exceeded almost all of them by some fair margin. The awesome amount of clean power it can deliver is far beyond that implied by the simple "200 Watts per channel into 8 Ohms."

Finally, its sound will take a back seat to very few power amplifiers, and it will best quite a

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few. In listening for extended periods the AA-1640 does not fatigue the ear or call attention to itself. In fact, only when it is compared directly with a competitive amplifier in its class can its sound be further characterized. When I have completed tests of the triumvirate of super-power kits I hope to compare the sound qualities of the three, which should be interesting.

The AA-1640 is an exceptional value for the money and should be considered by those in the market for a super-power amplifier.

Manufacturer's Comment: First, thanks for the exceptionally thorough review. It's nice to know that there are people out there who have the technical sophistication--and the aural acuity--to appreciate our design philosophy. We design conservatively and every performance specification we publish for every piece of Heath equipment is guaranteed. That's why your measurements were considerably better than our

specifications. We've got a complete line of audio equipment designed the same way and we'll be happy to send a free catalog to anyone who writes: Heath Company, Dept. 95-18, Benton Harbor, Michigan 49022.

THE PRAYING MANTIS TONE ARM

Concluded from page 9
arm with 23° offset--and is actually determined by the frictional force between the stylus and the record, which is variable between brands and at different recording levels, I think it advisable to ignore it.

The arm looks weird in use (Fig. 2)--let's face it. Maybe you can make it more esthetically pleasing--the base, especially, needs it (maybe something like what they do to Christmas tree bases)--though maybe it's not too bad. But for a paltry sum (less than \$10, or far less if you already have glues, paint, balsa, etc. lying around the house) and a bit of work, you, too, can have a super-low-mass, very-low tracking-angle-error Vegetable substitute: the Praying Mantis Arm.

If it doesn't work, you haven't spent much. If it does work, however, you can ignore all those record warps, and your woofers will no longer find them a "moving experience."

PARTS AND SUPPLIES

Balsa strips (36"), one each:

1/4" x 1/8"

1/2" x 1/8"

1/2" x 1/2"

3/16" x 2"

6D finishing nails

4 1½" sewing needles

2 common pins

1 coat hanger

1 flat sponge (or bread tin with 4 springs and hooks)

Thread, medium and very fine

Several tin can tops

Dimes

Counter-balance and other odds and

ends salvaged from old table, or

substitutes such as lead sinkers,

thread spools, coat hanger wire

levers, etc.

A rock

Tube of quick-dry airplane cement

Tube of 15-minute epoxy

Rubber cement

Matte black spray paint

Unshielded phono wire

Short length of lamp cord for

shielding wire, or shielded phono wire

4 cartridge terminal clips

Stereo phono jacks

3' stereo shielded audio cable with phono plugs at both ends

Indexes

Indexes by subject, author, and title for the first and the second three years of The Audio Amateur are now available in four-page format. Index 1 covers 1970-71-72; Index 2 covers 1973-74-75. To receive a free copy of either index, send a stamped #10, self-addressed envelope to TAA Index, Circulation Department, P.O. Box 176, Peterborough, NH 03458. Please specify Index 1 or Index 2. For one index affix postage for 1 oz.; for both indexes, 2 oz. In England send request with s.a.e. to TAA Index, Yellow Oak Cottage, Tillington, Nr. Hereford HR4 8LQ.

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