

# the Audio Amateur

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# ATTENUATORS



# TAPE DECK



# CROSSOVERS



# Building a 10½" reel Tape Deck

After reading Mr. Williamson's article on building a tape playback pre-amplifier the thought occurred to me, this might be the way to get that second tape machine I badly needed to dub tapes, to use for general listening and avoid wear on my expensive recording rig. The problem: where to find that necessary tape transport? My case was particularly difficult since I need a 10½" reel capacity machine because most of my tapes are mastered on this size reel. I do quite a bit of live recording.

In addition, I have become quite spoiled by the ruggedness, quality, and high speed winding capabilities of these machines. No tape transport on the market short of about two thousand dollars does what I want, and I doubt I would ever find a deal again like I got on the Crown tape deck I am using now. A radio station in desperate need of money sold it to me for an excellent price.

One idea kept popping into my head: Build just what you want. But I kept telling myself I couldn't get the parts and I didn't have enough tools to do the job. At length, after borrowing my neighbor's deck for dubbing for the 'umpteenth time, I sat down to seriously figure out how I might build such a unit.

I determined that the deck's specifications would have to include as low wow

and flutter figures as I could attain at reasonable cost, extreme ruggedness and durability, very high winding speed, 10½" reel capacity, tape lifters, fast brakes, gentle tape handling, and it would have to be mechanically quiet.

How could I do all that with a minimum of cash and tools? The answer is simplicity itself...keep everything as basic and as simple as possible. This led to a couple of design features that got around two of the most persistent and difficult design problems; how to build brakes and tape lifters? I accomplished the first by using electrical brakes that work as follows.

In the play mode, one feeds about 50% voltage to both spooling motors. This gives adequate tension for tape-to-head contact (no pressure pads are used), and when the deck is stopped the tension across the guides keeps the tape at a standstill. I use three switches to control the deck. One turns on the power, which starts the capstan motor, electronics, and spooling motor tension. The second switch will, when thrown to the "fast wind" position feed full voltage to one spooling motor, and cut that to the other motor to zero. Which motor gets the power in fast wind is determined by the last switch which I have turned on its side so the tape will go in the direction the switch is pointing.

For brakes from fast wind all I do

*Continued overleaf*





**FIG. 1**

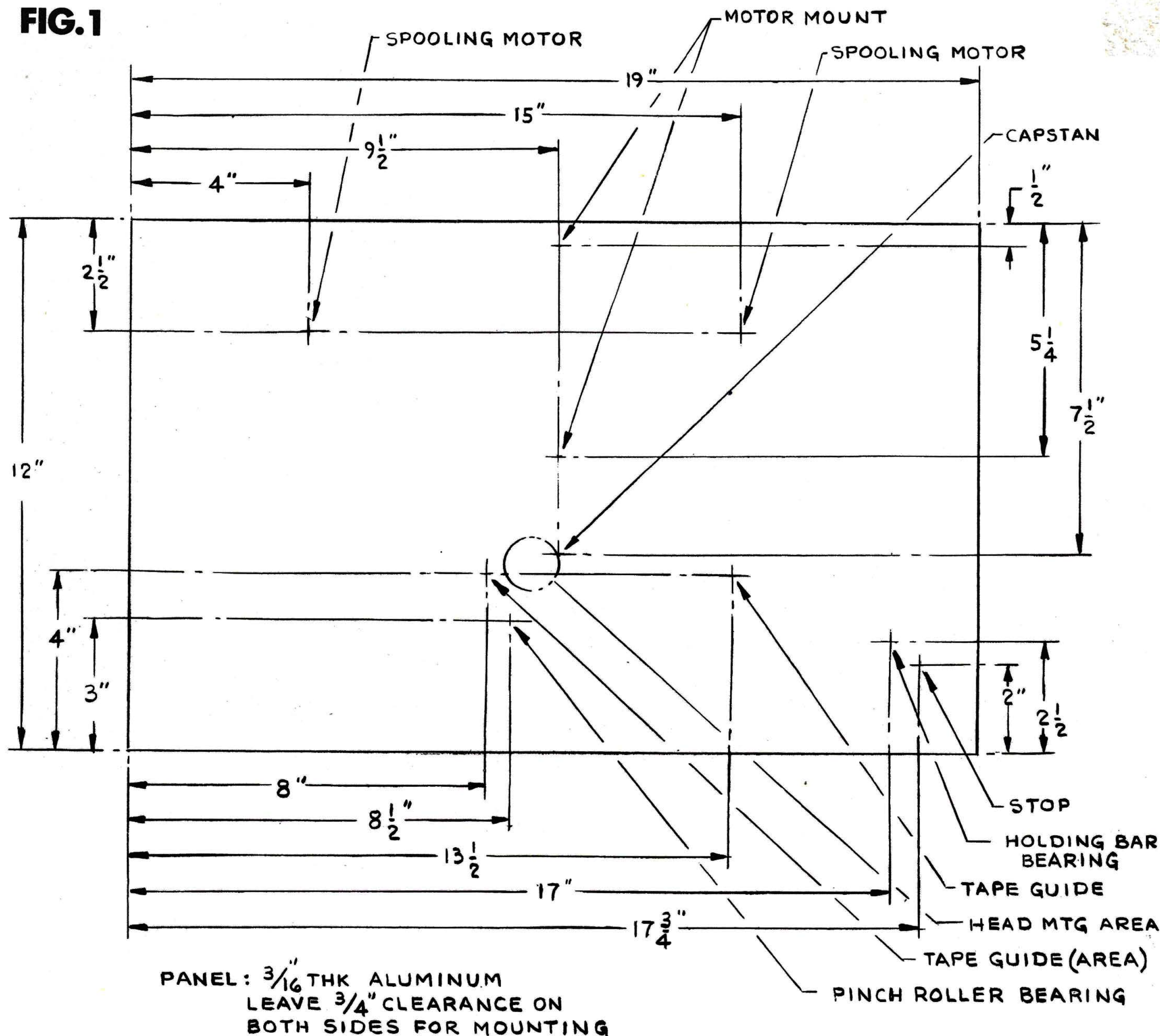


Fig. 1, above, gives the approximate locations of the elements of the author's deck. These will serve as a rough guide to other builders who reproduce the author's unit.

is throw the direction switch to the other direction and the tape rapidly comes to a stop. It will reverse direction unless you flip the fast wind switch to "normal" at or about the time the tape comes to a stop. The system is safe since about the only thing you can do in fast wind is throw the wrong switch. If you throw the fast wind switch to "normal" while the tape is at high speed, the tape will just stop very slowly, no tape will spill. The only way to spill tape is to turn the power off at high speed or engage the pinch roller at high speed.

If the deck is in play mode and you throw the tape to fast wind without disengaging the pinch roller, tape will spill (depending on direction) at a rate of only  $7\frac{1}{2}$  inches per second. This gives all kinds of time to stop the tape and spool up the spill. But none of these things are at all likely to happen.

I solved the second problem of tape-lifters by having the tape in contact with the head only when the pinch roller lifts it up to the head: Note the pictures. This also allows one to do high speed editing since you can lift the pinch roller partway at any time and still hear the signal. Wow and flutter can be reduced to a minimum by using well machined tape drive parts and by having the capstan as close to the head as possible.

Hum can be reduced to nothing if the play head is positioned exactly right. There will usually be a point where rotating the head slightly cancels out the magnetic fields and the head will pick up no hum. If this is not completely successful, rotate one motor body  $90^\circ$  and try again. I had no trouble finding a spot with no hum and therefore I have not even shielded the head. Make certain the hum is not in your electronics by



shorting the inputs and listening, then connecting the head and listening for the difference, if any.

Heads and all the head mounting hardware can be obtained from the Nortronics Co., Inc., 8101 Tenth Avenue North, Minneapolis, Minnesota 55427. They sell heads, tape guides, and the complete adjustable head mount, as well as a convenient head plug-in cable assembly. Each of these parts only cost a dollar or two apiece except for the head. Their premium quality record/playback head is available for around \$20 and their playback only head is about \$30.

Head alignment is not difficult, but does require a reproduce alignment tape (also available from Nortronics) and an accurate meter. The one in your present deck may do. Test it with an Audio Oscillator first to see whether it has a flat response. Ampex makes the best alignment tape, but price tags it at almost \$30. While playing the tone for height adjustment, move the head up and down until you get maximum meter output.

Adjust azimuth by playing the highest test tone frequency and adjusting the head azimuth screw (the one that tips the head from side to side) for maximum output on the meter. Make sure the head face is perpendicular to the deck plate. The other test tones help you adjust your playback electronics for flat response. The tape should wrap around the head almost to the edges. Center the gap in the tape wrap as shown in this top view.



Note on the construction sheet that I do not show absolute placement of head and guides, only areas. This allows you to find the area of minimum hum for your head and then place the guides for the correct wrap. Make sure both tape guides are the same height or you will not be able to get stable output since the tape will skew badly.

Allow adequate height from the deck so the spooling motor turntables can be thick enough for strength and rigid mounting. This also allows the tape to ride well up on the pinch roller. You will probably need a couple of large washers under the head mounting plate, and long studs for mounting the tape guides. Tap the deck plate to mount the head since the capstan bearing assembly is directly under it, making it impossible to mount a nut under the bolt. So just tap it and cut off the bolt flush with the underside of the deck plate.

The capstan assembly is the most critical part of the deck. I had originally intended to make the motor shaft the capstan which would be simple and reliable. It didn't take me long to discover, however, that it is just almost impossible to machine a motor shaft precisely enough to have acceptably low flutter.

I found some surplus Ampex capstan motors but all of these had bent capstans. Often I couldn't see any irregularity, but wow could I hear it! I couldn't afford a new Ampex motor

(\$210), and that left only the ReVox motor which I didn't look into. So I decided to go the pulley and flywheel route, and I can see why so many manufacturers do it this way, also.

After a lot of searching I determined the best set-up was to buy the Teac #6010 capstan, bearing assembly, belt, flywheel and pinch roller. (These cost around \$30 and are available through any Teac dealer.) Note that the mounting flange on the capstan bearing assembly does not fit flush on the deck plate, but stands above it about one inch. To mount it just use long bolts to cover the distance to the deck plate. I filed away some of the lip you will notice on the front of the bearing assembly where it rests against the deck plate. I did this so the capstan would just reach out and cover the entire pinch roller.

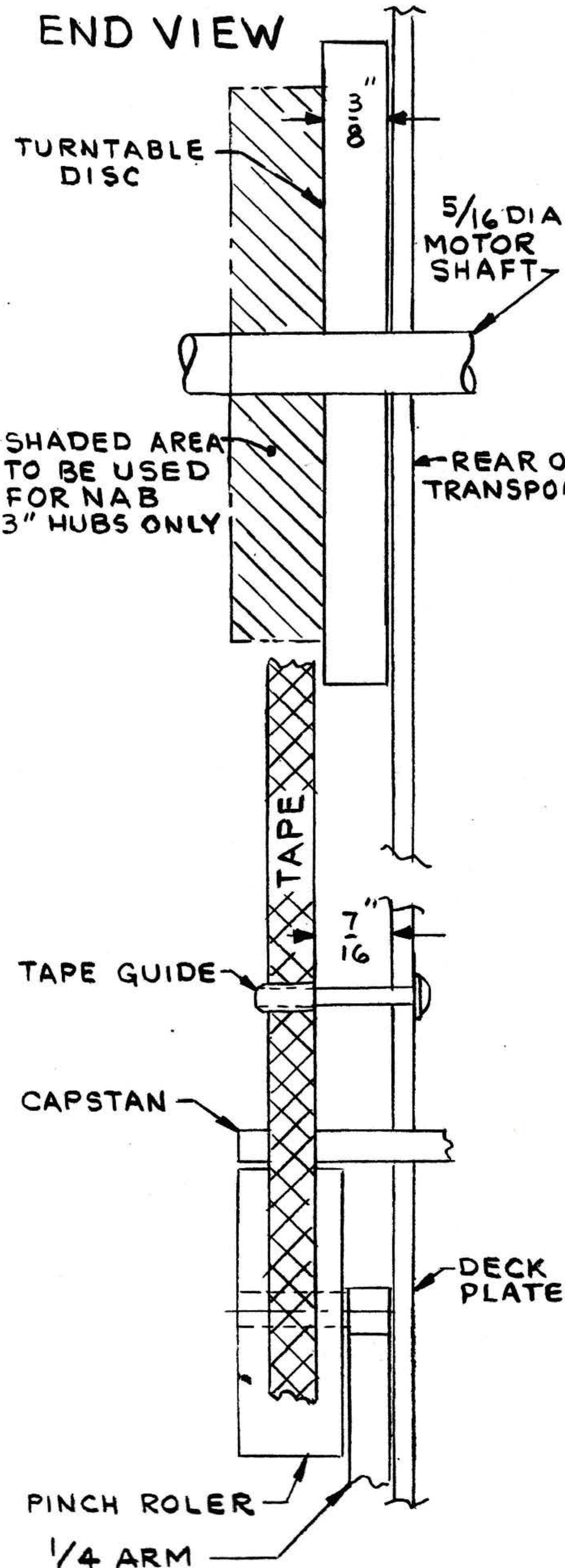
Mount the motor for the capstan drive by going to a hardware store and getting some  $\frac{1}{4}$ " threaded rod, eight nuts for it, and six lock washers. Cut this rod to suitable lengths for the two standoffs for the motor mount and bolt it solidly to the deck plate and to the rear plate on which the motor is bolted. I cut the rear plate from  $\frac{1}{8}$ " aluminum and cut slots in it so I could slide the motor to adjust belt tension. Exactly how you mount your motor will depend on the motor and your own ideas.

In fact, a great deal must be left up to you since you won't be able to get exactly the same parts I got. In addition, you may want to customize the unit to your needs. You may want only 7" reel capacity, and you must build your electronics and mount them. In short it will require a good deal of mechanical ability to build the unit from my outline. All wiring, switching, and mounting of various components will be up to you. The pictures of my deck include power supply and electronics.

Finding motors was the hardest part of the job for me. Several kinds are available, and the ideal ones are capacitor run torque motors for spooling and a hysteresis synchronous motor for the capstan drive. The spooling motor should be large enough to cause you difficulty in stalling them at full power by grabbing its smooth shaft with your fingers. The spooling motors should be identical and must not "cog" when almost stalled. To test them hold the motor shaft tight, turn it on, and slowly rotate against motor tension. If you cannot feel any change in motor tension as you turn it, then it is probably OK. If it cogs get another type.

I was surprised to find that some very cheap, four pole (not cap driven) motors did not cog and would work well except I couldn't find any with enough power for  $10\frac{1}{2}$ " reels. They would make a superb 7" unit. I finally ended up with synchronous motors for all functions. They are not the best for fast wind because their torque varies with rpm. Prices ranged from \$2 to \$5 in surplus stores. Motors of this size usually have a shaft

FIG. 2 TAPE PATH DETAIL





**FIG.3 CAPSTAN ASSY (NOT TO SCALE)**

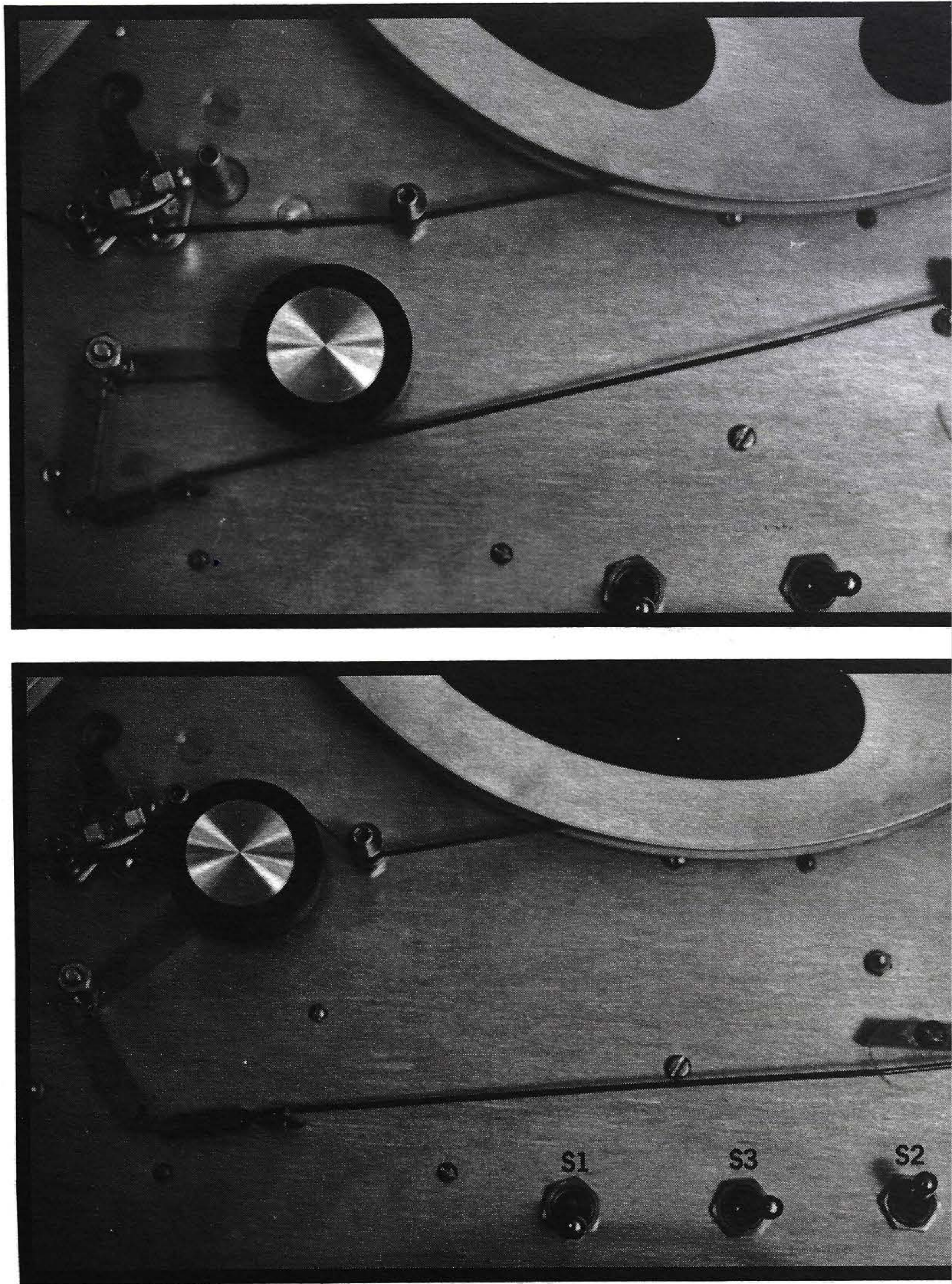
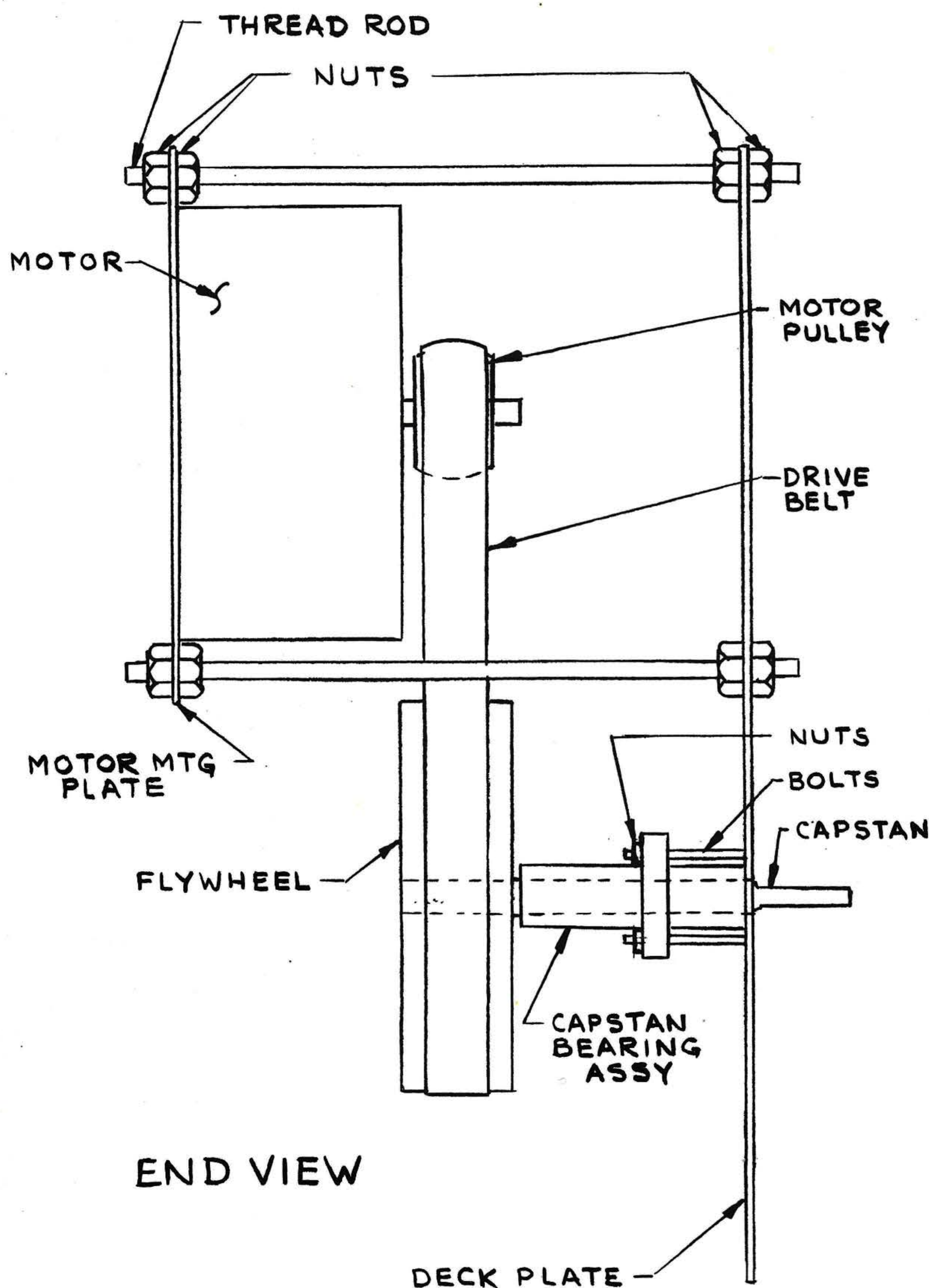


Fig. 3, above, is the motor and capstan mounting arrangement; Fig. 8 above, right, is a close-up of the pinch roller and head, guides, and capstan relationship. Fig. 9, below it, shows the pinch roller in its operational position.

that is the perfect diameter to fit a 7" tape reel.

My deck runs at only one speed:  $7\frac{1}{2}$  ips. If you want more speeds you will need either a motor with multiple windings with switching between speeds (the Teac motor sells for about \$50.) or some sort of pulley switching arrangement.

Motors must also be made to turn in the right direction. For shaded pole motors (no capacitor) you must turn the field coil around the other way to reverse direction. You can usually accomplish this easily by disassembling the motor and inserting the armature through in the other direction. For capacitor, driven motors you must play around with the wires and switch one wire from the motor side of the capacitor and one from the common side of AC. It won't blow up if you have them wrong, it just won't go around. Note the general wiring diagram for capacitor start motors on the transport schematic.

Three of the parts on my deck I could find no way to avoid having machined: The capstan motor pulley and the spooling motor turntables. Actually, I turned the motor pulley myself by mounting a chunk of aluminum on the motor shaft

and, with the motor running, cut it down to size with a drill bit braced against the motor frame. It was slow, but it works.

Note that the motor pulley must be slightly crowned in the middle. The belt will then run true as it will ride toward the highest part of the pulley. Standard sync motors turn at 1800 rpm.

The teac capstan must turn at 600 rpm for  $7\frac{1}{2}$  ips, therefore the 1800 rpm motor pulley must turn 3 times for one turn of the capstan. Tape strobes are available for about \$5 if you want to check speed. I just cut the pulley a bit, then turned it three times and checked the flywheel until I got my 3-to-1 ratio.

A machinist would just measure the flywheel and cut a pulley  $\frac{1}{3}$  as large. A shaded pole motor will run about 1750 rpm and a pulley for it will have to be cut accordingly. Don't be afraid to use a shaded pole motor. I've built a couple of turntables with shaded pole and synchronous motors and can't hear any speed variation in them. Of course if you have "brownouts" where you live a synchronous motor is a must.

You can cut the turntables for your spooling motors easiest from aluminum.



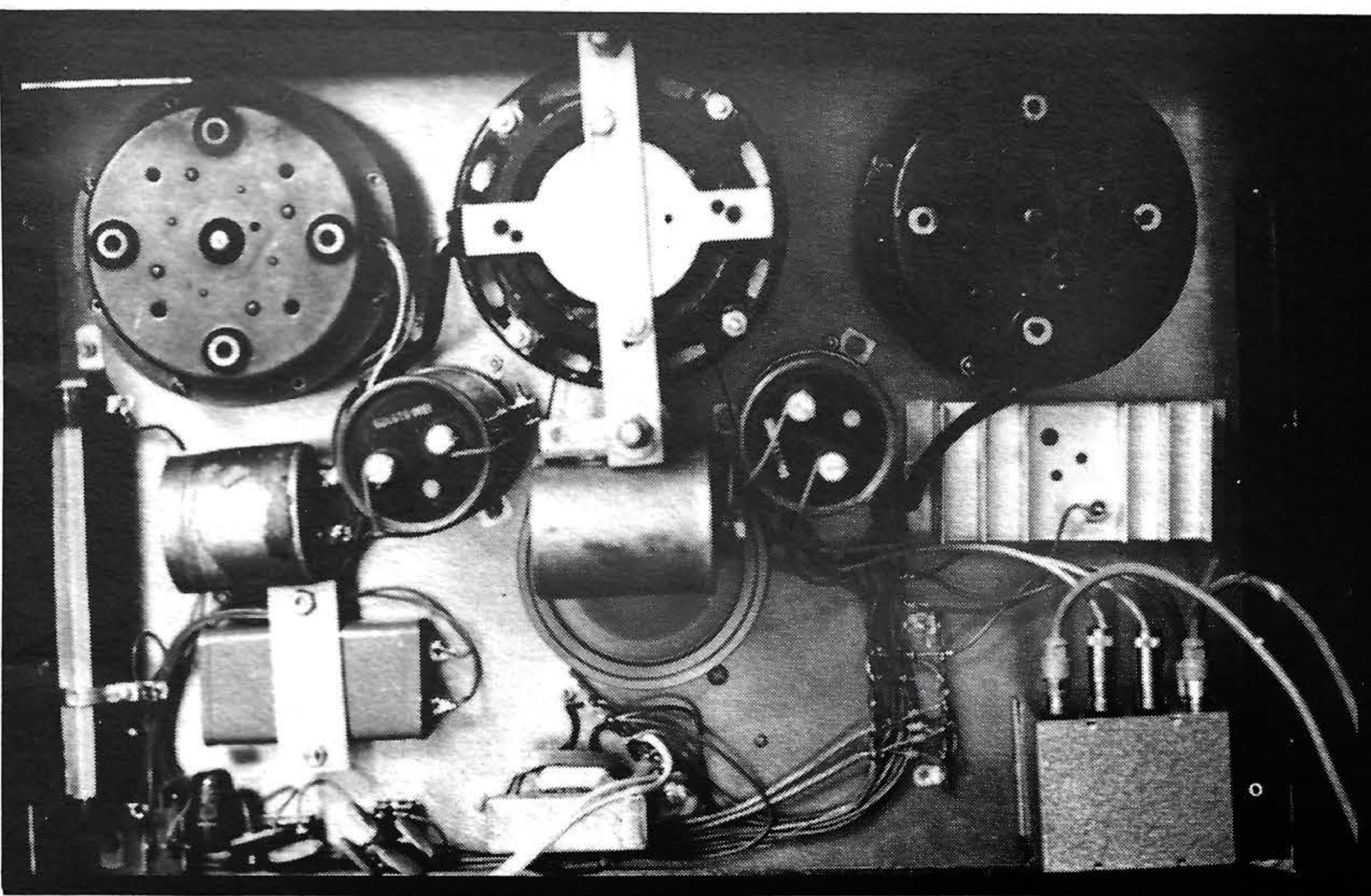
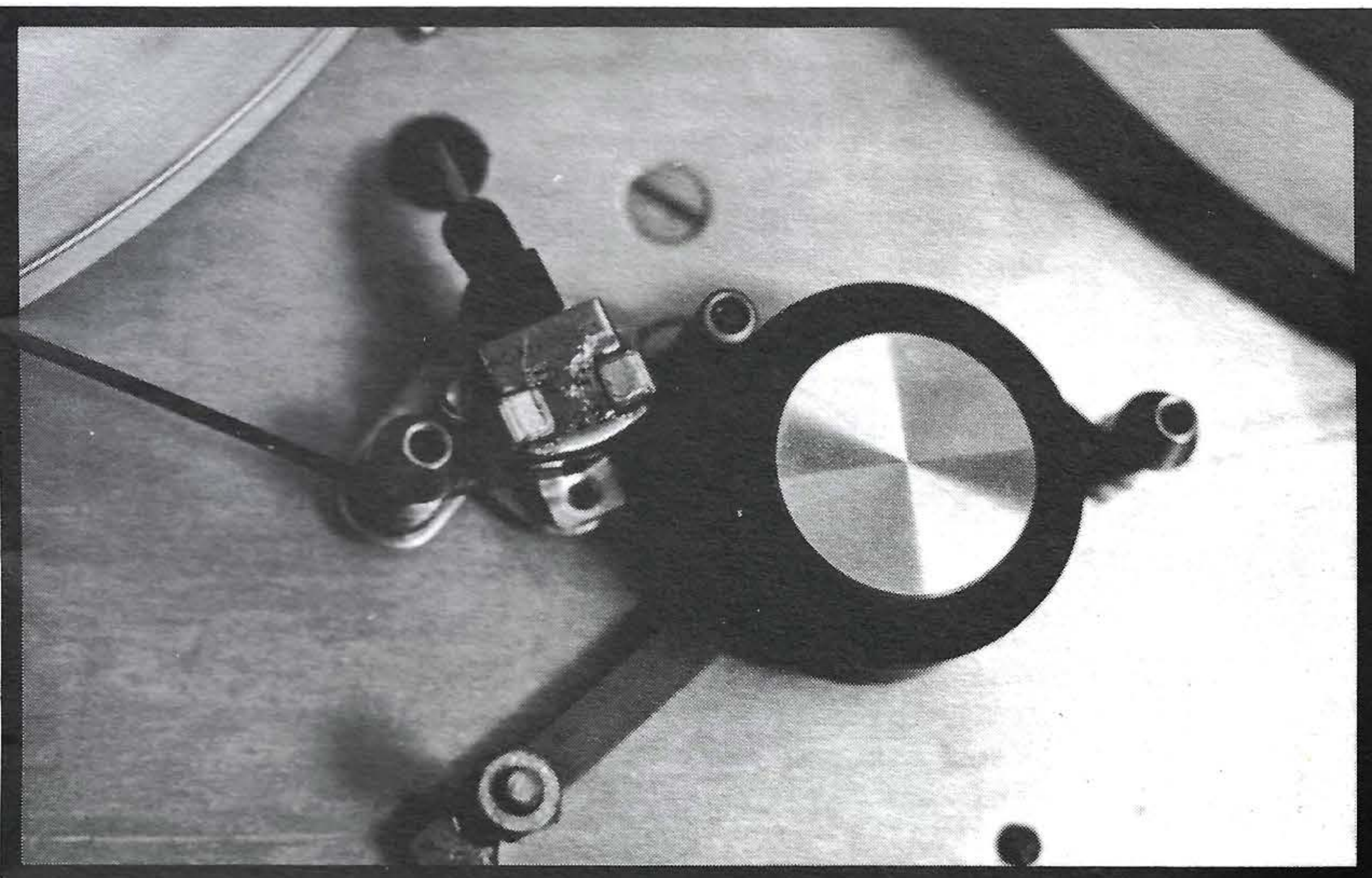


Fig. 7, top, left, is the capstan and pinch roller engaged with the resulting tape wrap around the head. Fig. 10, below it, is the back of the deck. The three motors each have a starting capacitor. R1 is visible in the lower left of the photo. The transformer at the bottom, center, is the playback amp power supply, along with diodes and a regulator on the heat sink. Playback electronics are in the box at the lower right. The two large electrolytics filter the D.C. supply. Fig. 4a and 4b are the pinch roller pivot detail while Fig. 5 is a cross section of the pinch roller assembly.

My tables were cut to take 10½" reels only, and I used spring steel wire retainers to hold them down. (The wire is available from hobby shops). If you want 7" reels just have a flat disc cut about ½" thick. Make sure it clears the deck and doesn't raise the tape too high for your guides. Put a set screw in it or use a press fit (as I did) to attach it to the motor, and insert a vertical pin in it which matches one of the holes in a plastic 7" reel. The pin could be a small bolt with the head sawed off after threading the hole for it with a tap and screwing it in firmly. You can also use the rubber holdowns commonly available to keep the reels on.

The pinch roller assembly is made up from square and round brass tubing available from your local hobby shop. The bearing is made of one piece of tubing inside another, and the tubing doesn't rotate on the bolt. It is desirable to have the end of the arms just clear the deck. This may be accomplished by either using a small washer under the assembly, or as I did, rotating the bolt.

Rotating the bolt works because my accuracy isn't perfect and as the bolt is rotated the arm ends will lift or

fall slightly which allows for very precise adjustment of their height. They must just barely clear, otherwise the pinch roller will ride too high to be completely covered by the capstan shaft. To make the angle on the square brass, notch it with a razor saw like this:

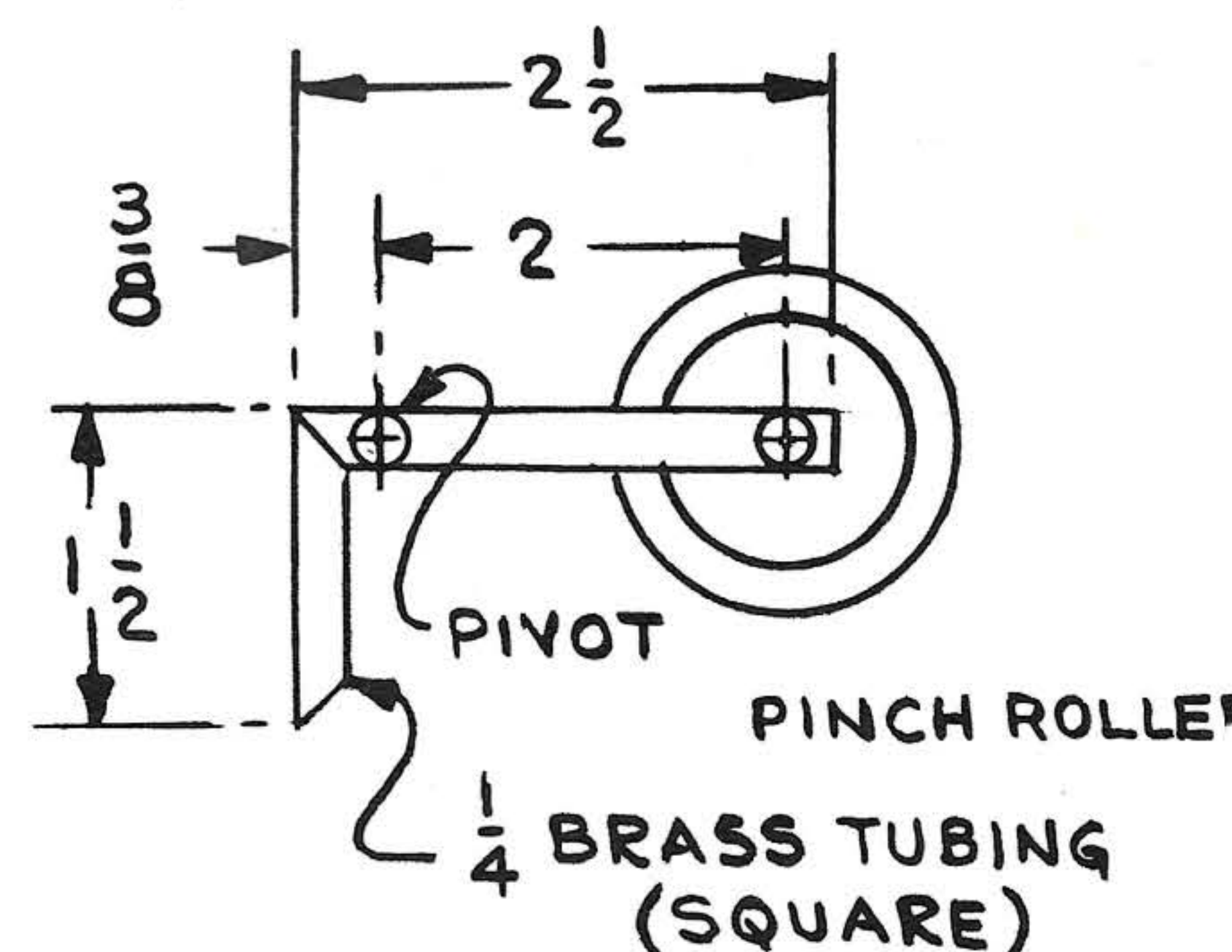


Don't cut all the way through, then bend the parts together and solder. Drill the hole and solder in the bearing. The bearing must be at least an inch long because you need great rigidity and a shorter bearing is not rigid enough.

The pinch roller itself must be modified so it is low enough to cover the capstan. Unscrew the pretty aluminum disc from the unit you bought, then take off the pinchroller by taking off the two snap washers. You should now have just the bare shaft. Take a hack saw and cut off the lower slotted part of the shaft. Cut it short enough so the groove the lower snap washer occupied will be just out of sight when sunk into the end of the pinch roller arm. The lower snap washer is not used.

Solder a piece of bearing tubing into the hole you drilled to accept the pinch

FIG 4a. PINCH ROLLER ASSY



FRONT VIEW

FIG.4 b PIVOT DETAIL, ENLARGED

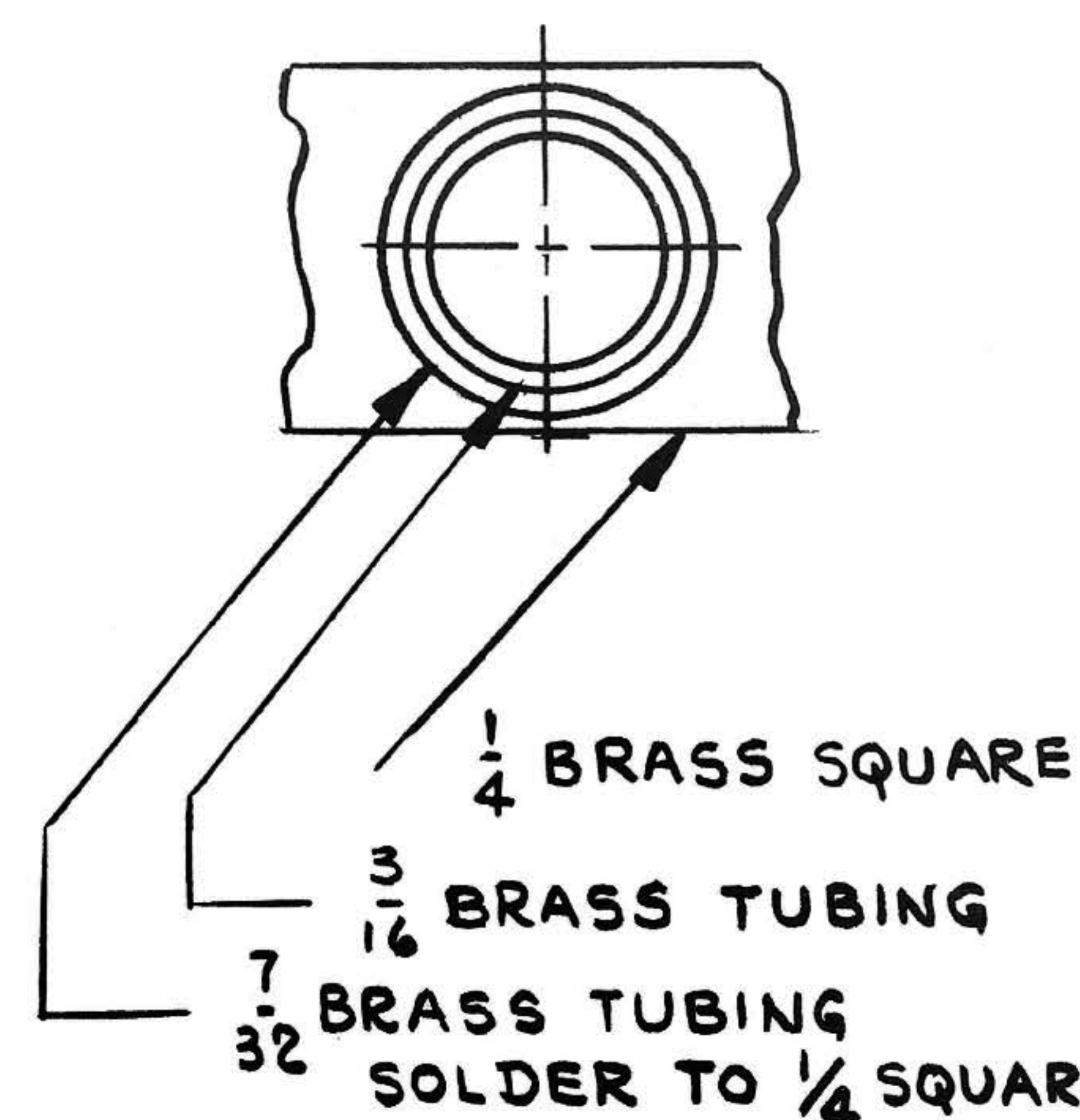


FIG.5 PINCH ROLLER ASSY CROSS SECTION

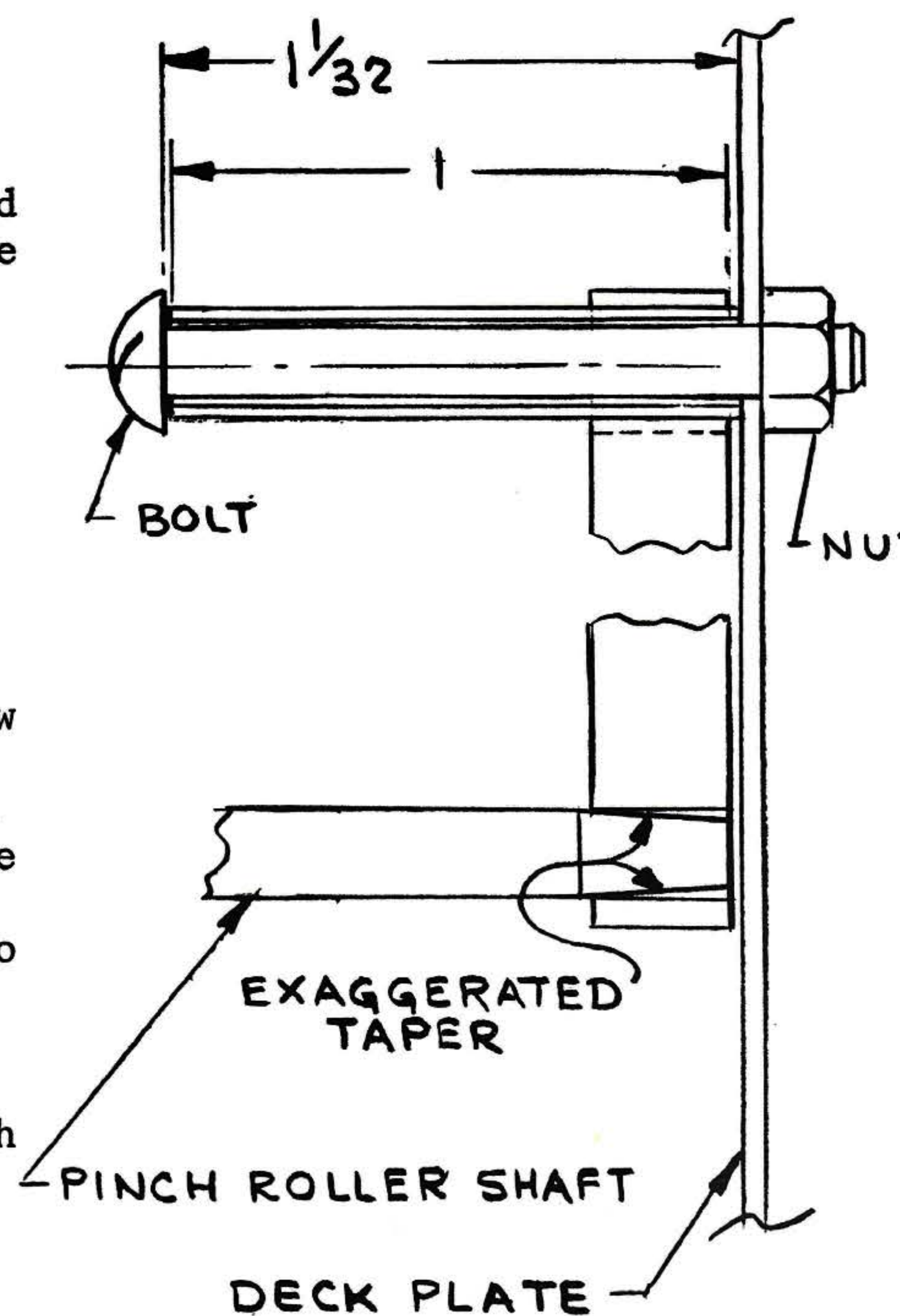
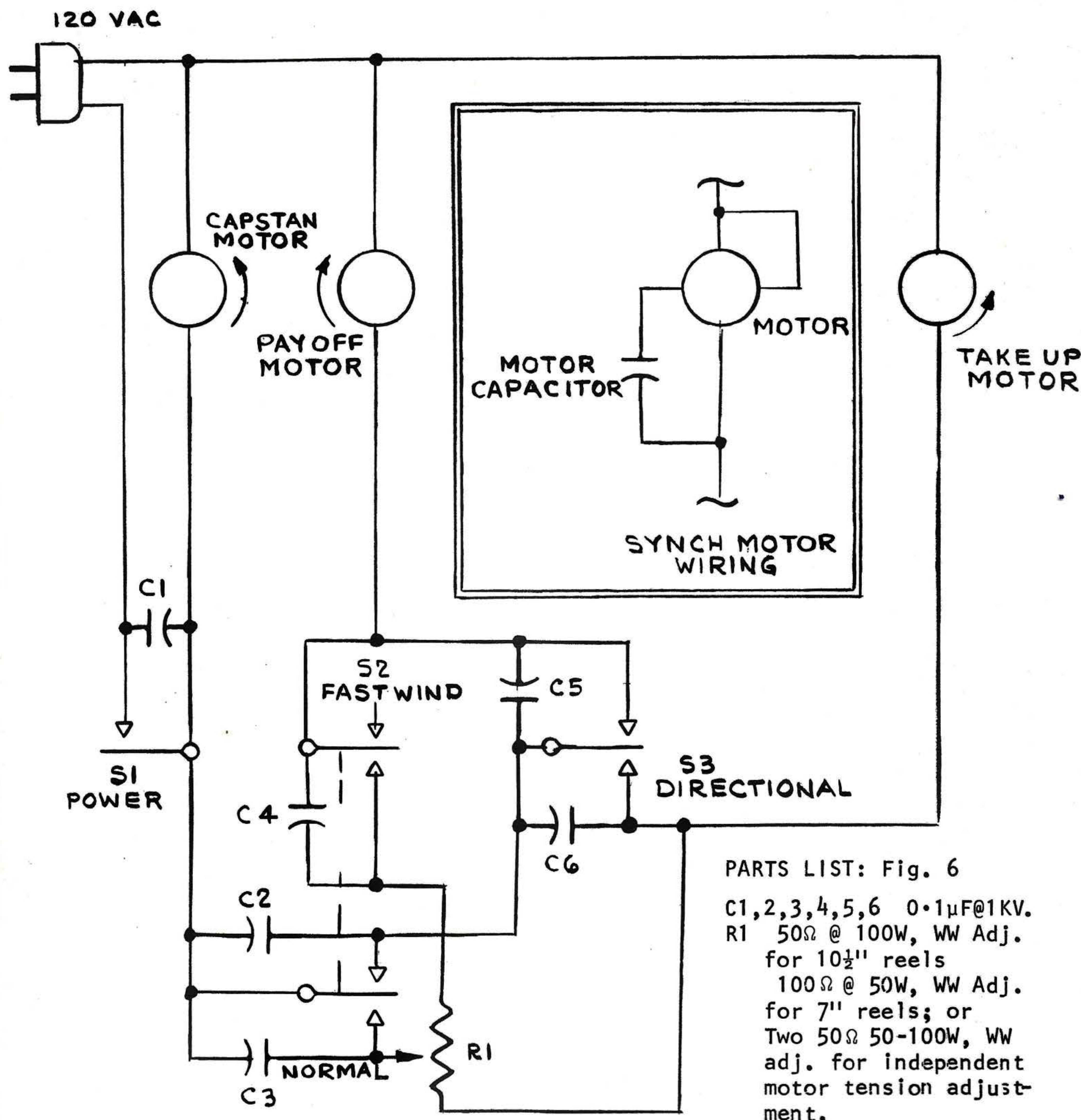




FIG. 6



## TRANSPORT SCHEMATIC DIAGRAM

roller shaft and file it off flush with the bottom and top of the arm. Now file the pinch roller shaft to a very slight taper, place it in the hole, and press it into place with a vise. Note that you must take great care when doing this work to avoid marring the actual bearing surface of the pinch roller shaft. Also, since metal has very little "give" the tapered shaft will have to be close to resting in its proper position before you try to press it in the rest of the way, otherwise, you won't make it and you will have a rough time getting it back out to cut it down more for another try.

In addition, be sure you have the shaft aligned properly in the vise before you sink it home. Now install the pinchroller itself, separated from the arm by only one very thin washer which you removed earlier when the shaft was disassembled. Now, reinstall the top snap washer and aluminum disc.

I had a difficult time figuring out a really simple way of holding tension on the pinch roller, but finally worked out the assembly shown in Fig. 4. The arm that actuates the pinch roller assembly

stays in the engaged position by resting against a stop that is positioned slightly beyond center.

You must bend the heavy spring steel connecting wire enough to clear the head of the bearing bolt. Make the bearing in the same way you constructed the one in the pinch roller assembly, only shorter. I used a washer under it since height is not critical.

The spring tension between the two assemblies determines the pressure of the pinch roller on the capstan, and the exact pressure is dependent to some degree on the spooling motor tensions. The reason: the higher the spooling motor tensions, the more differential the pinch roller must make up. This problem becomes acute when the tape is almost finished. At this point, the pay off tension is the highest and the take up tension the lowest, and the pinch roller must be tight enough to allow the tape to continue to move without a lot of wow and flutter.

My rule of thumb is to use the lowest pinch roller pressure that will move the tape at the end-of-reel condition with no audible wow and flutter. Instead of using a coil spring as I did, you may wish to bend the connecting wire in an accordion shape for an inch or so. This will allow adjustment by bending the accordion section tighter or looser until you get what you want (spring steel wire is available from hobby shops).

This brings me to the large adjustable dropping resistor I used to control motor tensions. My single unit feeds both motors; one motor on each side of the adjustable contact. This not only affords me the economy of only one resistor, it also makes it possible to adjust the tension *differential* between the two motors. I like having the take up motor tension higher than the payoff motor tension.

I can't give a specific value for this resistor since the value will depend on what motors you are using and whether you are using 7" or 10½" reels. 7" reels require much less tension, and if you intend to use both sizes you will have to have resistors for each size and a switch to adjust for correct tension. If you wish you could use separate resistors for complete tension control for both motors. 100 ohms at 100 watts should cover all conditions.

Tension should be adjusted so that at the *beginning* of the tape (when the payoff tension is weakest) the output from the tape--particularly the high frequencies--is stable. When I say stable I mean it does not change more than ±1 dB or so as you play your test tape. In addition, when you drag your finger on the reel, the output shouldn't increase more than a dB or so.

Wiring the deck is not difficult, but you should take care to keep the wiring clear of the spooling motors and the dropping resistor as they will operate at very high temperatures. Install the suppression capacitors indicated across the switch contacts to avoid loud "pops"



when operating. These should be rated at at least 1000 volts, as lesser rated ones will fail.

Cooling is not critical in this deck. I have mine rack mounted, but if you mount yours in a box, the back should be left open and a small metal grille installed above the spooling motors. I used mine in a box for awhile without grilles and had no problem. I also have a small fan mounted on the lower end of the capstan motor shaft to circulate air, but I don't believe this to be vitally necessary. The deck will operate in any position. The deck plate will get quite warm during extended running since it acts as a heat sink for the spooling motors and the dropping resistor.

The present size of my deck allows plenty of room for power supply and electronics on the lower section. I show only one stop for the pinchroller holding arm in the drawings and even this is only approximate. You will need to place the necessary stops where they move the pinch roller out of the tape path in one position and are locked up tight in the other.

I used only three basic bolt sizes.

Small 4/40x $\frac{1}{2}$ " bolts are used for mounting all the little parts such as capacitors, and for the "stops." Bolts for the pinch roller and holding bar bearing are 8/32x1 $\frac{1}{2}$ ". Bolts to mount the capstan bearing assembly must be

countersunk and have flat heads so they are flush with the deck plate. The same is true for the bolts with which you mount your spooling motors. This makes it possible to mount the head, for the pinch roller arm to pass over the area of the capstan, and allows the turntable platters to be very close to the deck plate.

Deck operation is simple. Fast wind function has been previously explained. I usually thread a tape with the power off, then turn on the power which starts the electronics and tension. Engaging the pinch roller at this time starts tape movement across the head. Disengaging the pinch roller drops the tape from the head and tape travel stops. In this mode fast wind may be used. I would suggest having the power switch located away from the fast wind functions. This will greatly decrease the possibility of turning off the power during fast wind. I've done this once--but fortunately I turned it back on before I spilled any tape.

The deck is rugged, and mine has been trouble free. Worn parts can be easily obtained. The enterprising and ingenious amateur may develop solenoid and relay operated functions, and other improvements. I would be most interested in hearing about these modifications, as well as about anyone's experience who builds the deck from this outline.

#### WHERE TO FIND PARTS

**MOTORS:** B&F Enterprises has some good looking Pabst Hysteresis Synchronous types weighing in at 7 lbs each under the number PHSM (p. 12 of their new catalog) at \$8 each. They have other types scattered through the book too. Address: Box 44, Hathorne, MA 01937.

EDI (Electronic Distributors, Inc.) 4900 No. Elston Ave. Chicago IL 60630 has a good selection of motors listed on page 135 of their catalog for 1973. None is hysteresis synchronous for this deck's speeds however. EDI has stocked surplus units of this sort before and will bear watching, however.

HERBACH & RADEMAN, 401 E. Erie Ave., Philadelphia, PA 19134 has some real beauties listed on pages 5 and 7 of their May-June 1972 "This Month" publication. Their TM17K935 is an 1800RPM job which they are selling for 3 for \$18. They have some large IMC units taken from computer decks at about \$20 each that are cadillac jobs. Their TM18K452 an IMC unit has two speed windings which turn it, at the flick of a switch, at either 3600 or 1800 RPM. It's hysteresis synchronous, of course. Price \$29.50, 3 for \$75. If building mechanical stuff is your thing you must get on H&R's list.

These three suppliers are also good bets for that large variable resistor (or two) for R1. The capacitors for the motors are usually supplied by the vendor and if not they can specify and/or sell you the proper one.

**PLAYBACK HEAD:** NORTRONICS are very nice about supplying information about all sorts of tape deck heads and mounting gear that they sell. They will not sell you anything, however. The best dealer we have found for Nortronics stuff is SAXITONE TAPE SALES, 1776 Columbia Rd., N.W. Washington DC 20009. Check over the Nortronics specs, make your list and ask Saxitone what they'll charge you for it. Even if they have to order for you the service will be prompt and accurate.

**ELECTRONICS:** With the correction note in this issue and some judicious shielding, the Williamson Tape Amplifier (Summer, 1970 issue) should work admirably.

The Meyer super op amp should work extremely well. Mr Sanders Crown tape recorder has six preamps, SS-2, four for microphones and two for playback. Their equalization is external to the plug-in board for each of them. Author Sanders bought two new sockets for his boards, built equalization networks for 7 $\frac{1}{2}$ " tape playback and a 30V power supply. When he goes out on a recording session, he just takes the two boards out of his deck and re-inserts them in the Crown.

Crown's professional dealers will usually be willing to order spare boards for those who want to do the same trick. The new version is the CX series, and they are expensive, CX-2 playback boards are fair-trade priced at \$45 each.

*Author Sanders is 23, a registered nurse by profession, and lives in Atwater, California. He enjoys fine music but soon discovered that even after buying some of the best equipment available, the music still didn't have the "you are there" qualities of transparency, dynamic range, frequency response, quietness, and "hall sound." He says he solved the problem partially by using the best condenser mikes, a Dolby noise reduction system, and making his own live recordings. He still finds locating good material a tough and persistent problem. He would welcome trading copies of live recordings with other audio amateurs. Write to him in care of Audio Amateur, Box 4.*