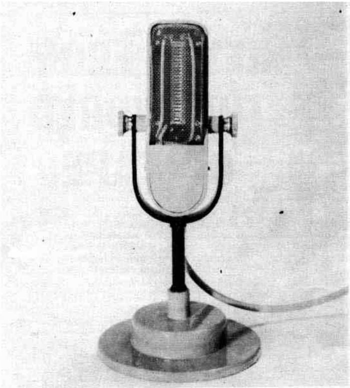


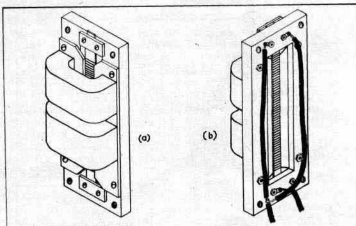


FIG. 1. THE COMPLETE UNIT

THERE must be many owners of a tape recorder who, like myself, find that it has to fit into a tight household budget. Ribbon microphones, mixers, extra speakers, pre-amplifiers, etc., are but dreams to many of us. However the absence of a goldmine in the back garden does nothing to subdue the desire for "*Hi-Fi*" or the urge to capture for future generations that earnest and private conversation over the ludo board between very young sons and daughters. Before very long the brazen head of Do-it-Yourself appears in all its over-optimistic glory and the seeds of an idea are sown.

My entry into this field of tape recording was initiated by the realisation that good quality recordings of live functions, particularly music, could only be obtained by possessing a ribbon microphone. At an average price of £10 for the cheaper types, however, these instruments are most costly items, especially when one remembers that they are essentially for studio use only, and are not suitable for outdoors. After seeing one "in the flesh", I felt that here, surely, was an item well within the scope of the home mechanic. So, after a visit to the local Public Library to obtain all the facts, I plunged into the job and eventually produced the instrument described in this article.

Structurally Simple

Although apparently a formidable thing to make, the ribbon microphone is structurally very simple; in fact probably the simplest of the three types in common use. It consists of a very light and thin aluminium ribbon held between the poles of a permanent magnet. The sound vibrations move the ribbon in sympathy and a minute electric current is generated. This current is collected at each end of the ribbon and passed on to the amplifier. The real secret of success lies in the accuracy of the construction, the care with which it is carried out, and the overall design. It is thus particularly well suited to home construction, the material cost being low and the accuracy required obtainable by time—at no cost at all!

The tools required are the barest minimum found in the mechanic's workshop. A hacksaw, vice, hand-drill, files and assorted B.A. screws are the essential items. Perhaps only the 10 B.A. tap for threading may be missing but this is easily obtainable at the ironmonger.

The complete unit, without its protective gauze case, is shown in **fig. 1**. The shape and dimensions of this design are dependant on the only commercially made items in it—the magnets, of which full details are given at the end of the article. From this drawing the layout is clearly shown, and I would advise the constructor first to study it and get the overall idea of a ribbon microphone clearly fixed in his head before proceeding with the job. When this has been done a reference to the list of raw materials should be made to ensure that everything is available.

The frame

Commence work on the $\frac{1}{8}$ in. thick paxolin frame, cutting it to the dimensions shown in **fig. 2**, and marking off the central slot. Also mark out the centre line of the frame and expand it to $\frac{1}{16}$ in. wide. The use of this guide mark will be obvious later (dotted lines **fig. 2**). The cutting of the slot may present a little difficulty to some so I will describe a simple way (See **fig. 3**).

List of Materials Wanted and Possible Suppliers

Paxolin Sheet, $\frac{1}{8}$ in. thick
Price: About 6/-d. per square foot. Obtainable at radio or electrical suppliers.

Mild Steel Sheet, $\frac{1}{32}$ in. thick
Price: For small amounts negligible. Obtainable at ironmongers or scrap merchants.

Brass Sheet, $\frac{1}{32}$ in. and $\frac{1}{64}$ in. thick
Price: For small amounts about 1/-d. Obtainable at ironmongers or sheet metal workshops.

Perforated Sheet (Meat Safe Type)
Price and source as for the brass.

Brass Wire Gauze
20 holes per inch (wire 0.015 in.) for outer grille.
100 holes per inch (wire 0.004 in.) for inner lining.
Source: Messrs. Greening Ltd., Britannia Works, Warrington, Cheshire. Price: approx. 10/-d. per sq. ft.

Screws
10 B.A.—$\frac{1}{4}$ in. round headed } Ironmonger or model shop.
8 B.A.—$\frac{1}{4}$ in. round headed }
(these are to be brass)

Matching Transformer
Price: 10/-d. "W.G." bell type, 200–250 V. in, 3–5–8 V. out. Ref. E/1095. Made by Ward and Goldstone, Manchester 6.

Magnets
"Eclipse" Power Magnets type No. 812B. Price: 8/-d. Obtainable through ironmongers.

Brass Sheet for the Case, $\frac{1}{8}$ in. thick
Price: 30/-d. per square foot. About $\frac{1}{4}$ square foot wanted for the case and is obtainable from A. J. Reeves, 416 Moseley Road, Birmingham 12.

Brass Sheet for the back and front plates of case
Price: 16/-d. per square foot. About 8 square inches wanted. Also obtainable from A. J. Reeves.

Perspex as an alternative
Obtainable from handicraft shops.

By M. H. O. HODDINOTT

MAKE THIS RIBBON MICROPHONE

THE FIRST OF TWO PARTS — DESCRIPTION AND PREPARATION

Drill out a series of small (1/8 in.) holes close to one another inside the marked out area of the slot. When a complete rectangle of holes has been made, gently chisel out the material between each hole and prise out the central portion. This will leave the slot with an irregular outline which can be filed out level until the edges correspond with the marked outline. Mark out the twelve holes in the frame as shown in **fig. 2** and drill and tap them according to the diagram.

The polepieces

Obtain a piece of mild steel about 1/32 in. thick, ensuring that it is reasonably flat and not badly rusted. Mark off the two pieces and cut them slightly oversize. Clamp the two together in a vice and finish off to the correct size with a fine file. A point of importance here is the actual pole edge that will eventually be parallel to the ribbon (R in **fig. 4**). It is essential to get this as near perfectly straight as possible and great care must be taken in the final filing. Check the edge frequently with a steel rule.

For those whose filing is not all it might be there is a way to cheat a little here. Take the original piece of mild steel, before working on it, to a local tinsmith or model engineer and ask him to trim up one edge accurately on a shearing machine. Reserve this edge then, which will require little or no filing up, for the vital pole. Whilst the two pole-pieces are still clamped together mark off and drill the two 8 B.A. clearance holes and, with a needle file, file them out slightly oval in the direction shown in **fig. 4**. This is to allow for fine adjustment over about 1/32 in. when positioning the poles on the paxolin frame. Finally, rub them down on all surfaces with an abrasive paper, clean thoroughly and paint them with either cellulose or epoxy resin paint to prevent corrosion.

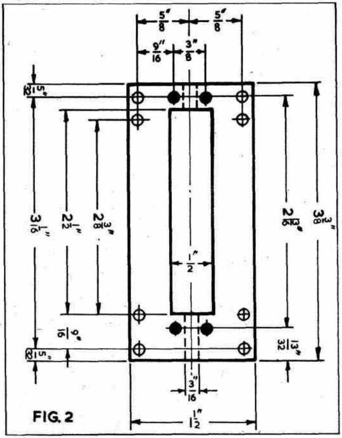


Fig. 2. The frame, 1/8 Paxolin. Holes marked solid are 10 BA tapped. Holes in outline are 8 BA clearance

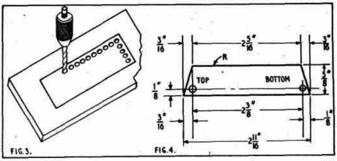
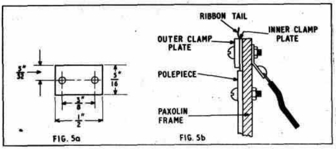


Fig. 3. *A method of cutting out the central slot in the frame, using a drill*
Fig. 4. *Pole-piece dimensions. Note that the 8 BA clearance fixing holes are filed oval*

Fig. 5a. *Ribbon clamping plates. Make two at 1/32" thick and two at 1/64" thick. Holes are 10 BA clearance.* **Fig. 5b** *is an enlarged edge-on view of one end of frame showing part of poles, ribbon and ribbon clamp*



The ribbon

Making the ribbon is undoubtedly the most difficult part of the job, not only requiring great precision but a high standard of cleanliness not usual in a home workshop. It is advisable, therefore, to take certain precautions before starting. All filing and swarf from the previous work must be cleared away completely, and the bench top covered with a piece of clean card. This action is not only important at this stage but at any time later when the microphone is open and unprotected by its gauze. It should be clearly understood that, once made, the ribbon cannot be touched without damaging it, except at the extreme ends, otherwise it will be distorted and spoilt.

Ideally, the ribbon should be made of 0.0002 in. thick aluminium foil. If you remember that cigarette packet foil is roughly 0.001 in. thick the extreme fragility of the correct ribbon will be obvious. However, foil of 0.0002 in. thick is not readily available on the retail market and I had to do some searching before I found that the foil in the common waxed capacitor would do. It is rather thicker than the correct type, being about 0.0004 in. but nevertheless works quite well. The capacitors in the 0.001 microfarad range seem to be the most fruitful, though it may be necessary to open up a few before finding the right one.

Aids to Cutting

The capacitor case should be cleaned of its wax by allowing it to melt off on to a newspaper by a stove, and the cardboard stripped with a pair of pliers. Unwind the foil and paper core right out and separate the foil. Cut it into 4 in. lengths and drop them into a tin of degreaser (carbon tetrachloride is ideal). Leave them to soak for several hours to remove any oil or grease and then swill in a tin of clean degreaser. Dry immediately between blotting paper and store between the pages of a book until wanted.

The following items of equipment should now be prepared for the cutting operation. A small (6 in. square) sheet of glass, a hardwood

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block of about the same size and any handy thickness ($\frac{1}{4}$ in.), and a couple of new stainless steel razor blades.

Place one of the 4 in. lengths of foil on the glass and smooth it by gently rubbing it with the forefinger in one direction until all the creases have gone. If it curls up turn it over and repeat the smoothing. Transfer the foil to the hardwood block and lay over it a 6 in. steel rule near one edge as a guide. With the razor blade held at an angle of about 30 degrees to the horizontal, make a steady *continuous* cut from top to bottom of the foil along the rule. To ensure a perfect edge it is imperative that this cut is made in one sweep, and care should be taken to place the fingers holding down the steel rule in a position that will not interfere with the cut.

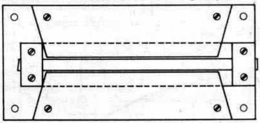
After making sure that a clean edge has been obtained, measure off $\frac{3}{16}$ in. from it and repeat the cutting operation using a *new* edge of the razor blade. If all has gone well a strip of foil 4 in. long by $\frac{3}{16}$ in. wide will result. If necessary the strip can again be smoothed on the glass at this stage, but with great care, so as not to distort or twist it.

The ribbon, which should now only be handled at its end with tweezers, must be carefully examined with an eyeglass before going any further to ensure that there are no tears, etc. I have noticed that some capacitors seem to be prone to pinholing, and this should be carefully watched out for.

The final job on the ribbon itself is to provide it with transverse ribbing to improve its stability (**fig. 7**). This can easily be done by very gently pressing it against a coarse comb. Ideally a grill of $\frac{1}{16}$ in. bars, spaced with about $\frac{1}{32}$ in. between them, should be used. If you have a cat which owns a steel comb, this will be found to be almost exactly to specification.

Place the ribbon on the comb at right angles to the teeth and put on top of it a piece of about $\frac{1}{8}$ in. foam plastic sheet, and a metal plate also about $\frac{1}{8}$ in. thick. None of these sizes are critical but are solely to ensure that the ribbon will be evenly ribbed along its length. The foam/plate combination should cover the ribbon for about $2\frac{3}{8}$ in. of its length and leave about $\frac{3}{4}$ in. at each end uncovered. Very gently apply a light pressure on the plate over its whole length. If this is done carefully the ribbon will take on a series of slight indentations across it and evenly impressed (See **fig. 7**). Here again, practice is essential, though failure far less final as the ribbon can be smoothed out on the glass plate

FIG.6 POLES AND RIBBON CLAMPS



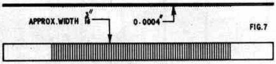


FIG.7 THE RIBBON

The ribbon clamps

There are two of these ribbon clamps made of brass, one at each end of the frame. Each one is itself a pair, made up of an outer $\frac{1}{32}$ in. plate on top of an identical inner one of a thickness as near as possible half that of the thickness of the polepiece metal. Thus if the poles are made of $\frac{1}{32}$ in. steel, this underside piece of the clamp should be $\frac{1}{64}$ in. thick. The reason for this is that each end of the ribbon which is sandwiched between these two clamping plates must be held about the centre of the thickness of the pole pieces to ensure that they are in the area of maximum field strength. A reference to **fig. 5(b)** will show clearly how this idea is applied.

Mark off on one of the $\frac{1}{32}$ in. pieces of brass the clamp dimensions as shown in **fig. 5(a)** and the two 10 B.A. clearance holes. Hold all four roughly cut parts of the two clamps together in the vice and finish off the filing to size as shown on the marked off piece. Drill the 10 B.A. holes and clean up all edges with fine abrasive paper.

The polepieces and ribbon clamping plates can now be fitted for test to the paxolin frame as shown in **fig. 6**. At this stage the alignment and adjustment of the poles, using the oval 8 B.A. holes, should be checked and the ability to parallel up the two poles accurately noted. The gap between them should be $\frac{1}{4}$ in. adjustable to $\frac{3}{16}$ in. This can be checked by fitting a strip of tinfoil, $\frac{3}{16}$ in. wide in the central slot to act as a dummy ribbon.

By M. H. O. HODDINOTT

MAKE THIS RIBBON

PART TWO — ASSEMBLY AND TESTING

MOVE the pole-pieces out of the way by taking out the top end 8 B.A. fixing screws and swinging them clear of the slot by pivoting on the bottom screws. When well clear, finger-tighten them temporarily. Remove one screw from each of the clamping plates at the top and bottom and slacken off the other. Swing the outer ($\frac{1}{32}$ in. thick) plate at either end clear of the inner one (which should remain in position) and lay the ribbon on to it. Carefully return the outer plate back over the ribbon and inner plate and replace the 10 B.A. screw, thus lightly holding the ribbon in place. It should be left quite slack, however, and the ribbon free to slide in the clamp.

Repeat the procedure with the clamping plates at the other end. The ribbon must now be lined up very accurately, so that it is central down the slot, and this can be done by referring to the $\frac{3}{16}$ in. wide guide marks made on the frame when it was under construction.

When it is straight and level tighten up the clamp screws at one end without disturbing the ribbon position. Before tightening up the other clamp the ribbon must be given a slight tension, and this can be done by

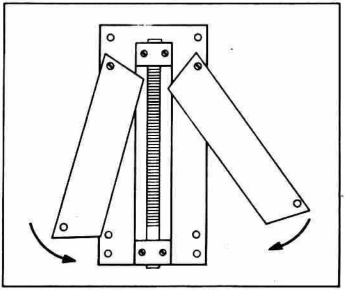


Fig. 8. *Swinging the poles back into position after fitting the ribbon.*

placing the forefinger over the tail protruding from the slack clamp. Very gently slide it away from the clamp until the ribbon has no slack in it and tighten the clamp screws.

This tensioning technique is impossible to describe satisfactorily and it is necessary to use a certain amount of trial and error to find the correct tension. As a rough guide the ribbon should just bow slightly when *very lightly* blown on. Now elsewhere in this article I have emphasised the danger of wind on the ribbon so the care with which this puff must be made should be obvious.

When the tensioning has been done satisfactorily the polepieces can be returned to their working position. This must be done one at a time, taking care that they do not accidentally touch the ribbon. Whilst swinging them back keep an eye on the closing gap as they approach the ribbon, especially at the end nearest the pivoting screws. When back parallel to the frame the 8 B.A. holding screws should be replaced and finger tightened as soon as the holes line up.

There should be a gap roughly about $\frac{1}{64}$ in. between the poles and the ribbon at this stage. Now, whilst watching the gap through an eye glass, and holding it up to the light, very carefully tap the outer edge of each pole. The gap will slowly close up until it is about the thickness of a piece of paper. The holding screws should now all be tightened up. The setting of this gap is not critical, but a close fine one will improve sensitivity; if there is any danger of fouling the ribbon the constructor is advised to leave it on the open side. Check now that there are no contact spots between the ribbon and poles with the eyeglass, and if all is clear the constructor may relax, knowing that he has completed the difficult part of the job. I found the fitting of the ribbon and aligning of the poles rather heavy on ribbons and did several dummy runs (using the spoilt ones first) until the technique was mastered.

The final job is the placing of the magnets, a simple matter, requiring only a few precautions. The two magnets used are very powerful for their size and attract iron particles in a disconcerting fashion. It is therefore advisable again to dust down the bench top, or to transfer the job to the dining room table before taking them out of their boxes. They should be applied slowly to the polepieces holding each item firmly to ensure that there is none of the usual flying together associated with magnets.

Each magnet should be placed as near to the end of the polepieces as possible, allowing a gap of about $\frac{1}{16}$ in. in the centre between them. Remember that these magnets are working in parallel and that the same poles of each must go on the same polepiece, *i.e.*, the two *Norths* together on one side and the two *Souths* on the other.

Although two magnets are shown on this microphone it will work with one, though with less sensitivity. In fact the design would be improved acoustically as there would be less shielding of the rear face of the ribbon. However, as the magnet layout was designed specifically for a high output, suitable for domestic recorders without pre-amplification, I felt that loss of rear sensitivity was less important. It still maintains a figure of eight response—if a little one-sided.

All that now needs to be done to the unit is the fitting of the leads to each end of the ribbon. The 10 B.A. screws on the clamping plates are long enough to protrude through the paxolin frame and still leave enough thread to accept a solder tag and nut.

If the unit is to be used upright, which is usual, then the indicated top and bottom shown in **fig. 6** should be noted. This will mean that one of the leads will pass down parallel to the ribbon and this should be duplicated and brought down each side of the frame. This is a minor precaution against induced interference and need not be done with the bottom lead which will leave the frame directly (see **fig. 1b** for details).

Testing

It will probably be realised by now that the ribbon microphone is essentially a low impedance instrument, and if the recorder only has a high impedance input then a transformer will be necessary to balance the circuit. Indeed, a transformer will be necessary anyway, as even low impedance inputs are around 20–30 ohms, whereas the ribbon is only a fraction of an ohm. There are several very compact microphone transformers on the market—at a price—but I decided that here again, to keep the cost down, something easily obtainable and cheap must be found. After some experiments, the common bell transformer revealed itself as apparently ideal in ratio and size. Using the 3 volt output terminals to link to the ribbon and the 230 volt input terminals to link to the tape recorder, a good, well balanced output was obtained with negligible hum. Details of the one I used are given at the end of this article though I don't doubt that any miniature type would do as well. As the output of the transformer is at high impedance, low loss co-axial cable should be used between it and the tape recorder.

Checking

To check the microphone it is helpful to be able to go up and down the musical scale, and a piano is very useful. Not only will it give a good idea of the frequency response and any excessive resonant spots, but it is a very critical test of tone quality. However, the constructor should not be too worried if the test recordings do not sound perfect, for a piano is a very difficult instrument to record domestically, even with a

MICROPHONE

commercially made microphone. I have been quite disappointed with the results of recordings made with one well known make until I discovered how damning room acoustics can be. Nevertheless this microphone has shown itself quite capable of passable piano recordings, far better than those made with the commonly used crystal types.

Some interesting tests can be made using typical domestic noises. Crockery rattling, newspaper crackles, hand-clapping, a sewing machine, or even the coke spitting in the stove all serve to demonstrate the microphone's ability to handle evenly a wide range of sound well and a remarkable realism is imparted to the recordings.

I cannot quote any test figures for its sensitivity, but I can give some results, if a trifle unscientific, on its actual performance. With my recorder (which is a Wyndsor "*Victor*") with its input control set almost at ¾ to full, I can obtain conversation recordings 2 ft. from the microphone at a perfectly adequate level on the tape. This setting will, of course, vary with individual recorders but it is at least equivalent to the test made with a commercial ribbon microphone and suggest that it would be satisfactory with most of the popular makes without pre-amplification.

If all the directions given have been followed correctly there should be little wrong, but variations in performance, due to incorrect ribbon tensioning are likely, and only trial and error can overcome this. A common fault is to overtension it. This tightens up, and nullifies the effect of the corrugations, lowers the output, and produces an unpleasant boxiness in the recorded sound. The ribbon must be slack enough to vibrate, almost like a concertina, without deforming or losing its exact position between the poles.

A persistent, complete failure of output, with everything apparently correct, may be due to the magnets being in opposition—*i.e.* a *North* on the same side as a *South*. A weak, distorted output may be due to the ribbon fouling the polepieces.

If any of these symptoms appear *don't* on any account use a test meter to check the microphone's circuitry. Even the tiny currents used to operate the meter would cause immediate and irrepairable damage to the ribbon by twisting it.

Excessive hum may be due to pickup by the transformer, which should be screened, or directly by the microphone. This is a point which must be borne in mind when using this type, as they are notoriously sensitive to electromagnetic hum. This one cannot be used within 4 or 5 feet of the radio or TV set, and it even detects the electric clock at a distance of a foot.

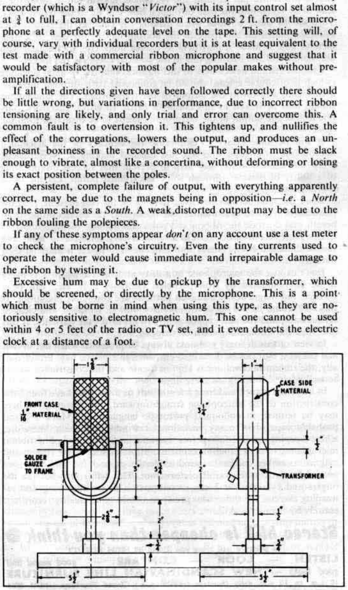
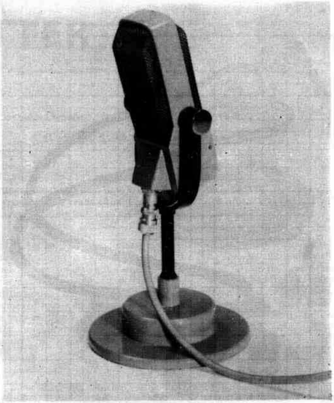


Fig. 9. *A suggested design for the case. Note that the box may be round or square.*



The case

Having decided that the microphone is working satisfactorily, some thought should be given to the case to house it in. Before this is done, however, it must be decided where to place the transformer. In the design shown in the photograph I have incorporated it in the microphone case, and the lead to the tape recorder is high impedance, using a co-axial cable. This makes for a neat compact setup for home use. An alternative setup is to have the transformer at the recorder end and to use a low impedance line to the microphone. This would consist of screened twin lead specially made for the job.

For indoor use in the average sized room there is little to choose between the two arrangements, but if one is going to be more ambitious and want long lengths (over 18 ft.), then it is usual to stick to low impedance lines.

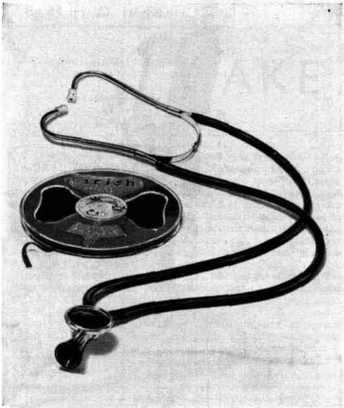
A more professional solution to the problem would be to use a small transformer to bring the ribbon impedance up to about 30 ohms, thus avoiding the losses due to cable resistance in conjunction with the very low ribbon impedance, while retaining the advantages of relatively low impedance lines. If this is done it is possible to make direct connection to a recorder with a low impedance input (20–30 ohms), or to connect a further transformer *at the recorder* to take the impedance up to about 100 K. Having made that clear I will assume that the constructor will continue with the built-in version as shown in the photograph.

There are only two important points to be kept in mind when making the case. The first concerns the position of the openings. This type of ribbon microphone, to work well, requires both sides of the ribbon to have free access to the air. Although this point is partly nullified by the magnet design, it is, nevertheless, still worth keeping to in the case construction. The best method of mounting is, therefore, vertical, and having each side protected by a wire gauze or perforated grill.

The second point concerns the materials used for the case. They must be non-ferrous throughout, indeed the only permitted iron parts in its entire construction are the polepieces. Ideally, brass should be used, but as this material requires some metalworking skill, plastics, wood or even cardboard can be used as alternatives. Perspex springs to mind immediately as a very easily worked plastic, using it ⅛ in. thick and with chloroform as the gluing agent. It can easily be bent when hot and it threads well if required. Wood and cardboard are rather less precise materials though will still make a workable case.

It is not proposed to give detailed drawings for the case as this will depend so much on the personal taste, handicraft ability, and the junk box of the constructor. I have, however, outlined the design shown in

(*Continued on page* 280)



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the photograph in **fig. 9** for anyone open to ideas. The dimensions given in the diagrams, by the way, are the minimum internal sizes necessary to house this microphone and its transformer.

The original case and stand were made of brass, the sides from a $\frac{1}{8}$ in. thick strip, 15 in. by $1\frac{5}{8}$ in. and the stand from a casting. In Perspex this thickness would still apply, though the base would have to be made of laminated pieces to build it up. The front and back are plates cut to fit the curve of the sides and the protective gauze is soldered to the tops of the plates. The edges of the gauze are strengthened by the addition of thin strips of brass soldered on to it, and this enables these edges to be a good, tight push-fit into the upper part of the case.

The aperture of the gauze is not critical, but a strong type capable of withstanding some pressure is advised. As additional dust protection a finer type can be fitted inside. Details of the gauzes are given in the notes at the end. It is worth noting that this gauze will virtually mould into corners and allow quite a measure of freedom in design. If perforated sheet is used (e.g. zinc sheet) then some allowance for cutting and soldering corners must be made.

The outlets for the cable should, if possible, be sockets fitted to the back plate (magnet side). This is a much better idea than having one of those irritating permanent leads so often seen fitted to microphones. In the diagram it will be seen that the socket is fitted at an angle. This is to enable the centre pin to clear the backplate, and to allow room for a lead to be taken into the case through a hole and on to the transformer. This will be more obvious when making the case, as the transformer occupies almost all the space in the bottom half of the case. If a non-metallic case is made it may help to reduce hum, etc., by lining it with aluminium foil and earthing this to the co-axial cable via the socket.

I should remind newcomers to this business that the co-axial shielding (which is of course a lead) should be connected right through the case, if of metal, and on to the output of the transformer. The laminations should also be linked to this common earth. In effect, therefore, only one lead of the output of the transformer needs to be insulated from the case.

It will be unnecessary to emphasise the delicacy of the assembled microphone to anyone who has just finished making it. Nevertheless, a few well chosen words may help to prevent that success disappearing in a welter of disaster through some unexpected pitfall. Let me list a few important *dont's*:

Don't use the microphone closer than 18 in. for two reasons, (1) Low frequencies become accentuated and boom and (2) condensation from breath may corrode the ribbon and poles and damage them.

Don't use it out-of-doors. The ribbon is very sensitive to wind and can be damaged by it. Heavy muffling can stop this if it *must* be used outside.

Don't expose the microphone in a dirty atmosphere where it is likely to be contaminated by iron particles. Ordinary fluff, etc., can be a menace, but magnetically attracted particles are absolutely disastrous. If this misfortune should occur the magnets must be removed, and cleaned if necessary, and the unit tapped gently to shake off the particles. If this fails then the whole thing must be stripped.

In view of this delicacy it should always be protected when not in use, and the least that can be done is to enclose it in a plastic bag. Professionally, the ribbon microphone is kept in a case and the constructor would be well advised to think on these lines.

In closing, I want to address a few words to those who have found the construction of the microphone straightforward. The design given here may be termed, in colloquial prototype language, a "Mark 2", and probably capable of many variations. I would urge them, therefore, whilst keeping to the few points essential in the design of a ribbon microphone, to try further experiments. Miniaturising of the ribbon and magnet assembly comes to mind as fertile ground for this and may possibly improve the overall performance. This will somewhat tax the fingers and eyesight but I can recommend it as an absorbing and rewarding exercise for those who prefer to obtain good quality recordings entirely by their own skill.

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