Simple to make—intriguing to use:

A telephone amplifier

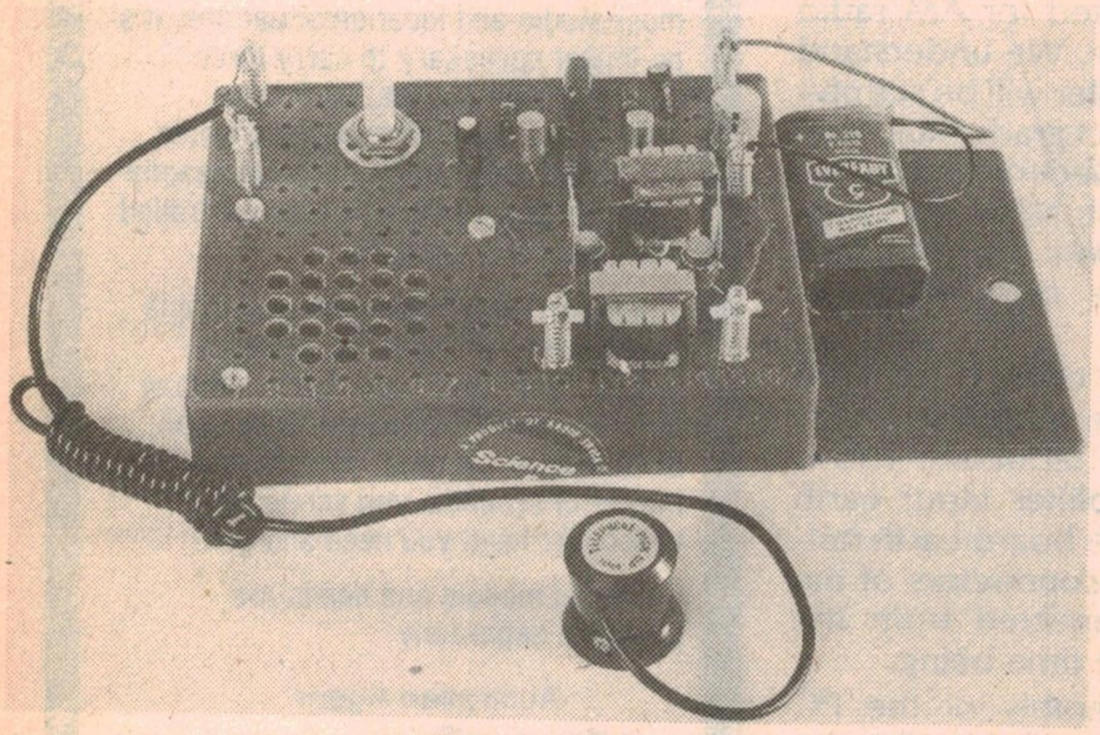
Here's a little gadget that will allow you to listen to both sides of a normal telephone conversation. While a rather primitive device in some ways, it does provide the basis for a good practical lesson and it may also open the way to the construction of something a little more ambitious.

by WALTER NEVILLE

The idea behind the gadget is simple enough: we have all had the experience of having to listen to one side of a phone conversation in which we were vitally interested; say with an old friend or a sick relative. After it's all over, the person who took the call has to try to remember what the other person said.

And there's another situation, all too familiar in the office: we call someone who is busy and are asked to wait on, which usually means sitting in enforced idleness, with one hand holding the phone. With a suitable listening aid, it may be possible to lay the handset down until a voice says: "Putting you through now, Sir".

Or that most frustrating question: "Were you waiting on somebody?"



Our version of the amplifier. At centre top is transistor Q1 with Q2 to the right of it. Q3 and Q4 are towards the front between the two transformers. Note the enlarged holes in front of the speaker.

Superficially, it would seem to be quite easy to dream up a gadget to overcome such problems: Simply make a connection to the phone line and feed the signal into an amplifier and loudspeaker, so that everything on the line is amplified to comfortable listening level.

Unfortunately, it isn't quite as easy as that, because telephone authorities have some very rigid rules about what can be connected to their lines, and who by! In any case, a suitable isolating transformer would have to be used, otherwise direct connection of an amplifier, particularly one linked to mains or earth, could cause complications.

So, if a signal is to be picked up from the phone for amplification, it has to be picked up inductively — that is, by a suitable iron-cored coil, taped to the handset or to the body of the instrument, where it will sense the tiny stray magnetic fields radiated by the telephone's own inductors.

A decade ago, it was a fairly simple operation, because the inductors in the then-current instruments had quite a strong stray field, relatively easy to intercept. With the more modern handsets, the stray field is much weaker, calling for a more efficient pick-up coil, more critical placement on the phone and more amplification.

Unfortunately, a pickup system with increased sensitivity is likely also to be more sensitive to stray fields from the 50Hz power wiring. Thus, if the signal in the phone is on the weak side, the pickup coil and amplifier will produce mainly 50Hz buzz, with very little voice. So the amplifier circuit has to be tailored to discriminate as much as possible against "hum" frequencies, while still leaving enough of the voice frequencies to preserve intelligibility.

One other point has to be watched: If the sensitivity of the loudspeaking system is too high, it may produce obvious acoustic feedback into the telephone microphone; the whole system will howl, unless the gain is turned down, or the handset is moved further away from the loudspeaker.

If one sets out, therefore, to produce a serious telephone amplifier, it tends to develop into a fairly complex piece of equipment, taking account of both electrical and functional requirements. It might typically be mains operated to save batteries; it might be built into a decorative phone stand to avoid having an awkward thing like an amplifier on the table or shelf; it would have convenient controls so that it could be adjusted or turned down as necessary; it might have a second cradle for the handset, while awaiting a call, and so on.

By the time one gets through such an exercise, there is a tendency to question whether it is warranted so that, in practice, telephone amplifiers rarely emerge either as a do-it-yourself project or as a commercial product.

That is, until one looks through the Tandy Electronics catalogue and comes across their Science Fair "learn while you build" kit 28-116. Retailing at $11.95, it makes no attempt at being decorative or functional but it has one important feature in its favour: it exists and it therefore provides the interested reader with a starting point!

At the time of writing, Tandy advise that their stocks of this kit are rather limited, so first in—first served. But if you miss out, there is no reason why the circuit cannot be built from standard bits and pieces available from most electronics suppliers. More about this later.

We imagine that some readers will build it up, learn by so doing, play with it for a while, and then strip it down to recover the components for the spare parts box. They may even use the pickup coil to feed telephone signals to a tape recorder via the mic. socket. Others may be inspired to rebuild the gadget into a decorative and functional case deserving of a more permanent place in the home or office.

This is up to you.

As with most others of these little Science Fair kits, the instructions suggest building the telephone amplifier on the red plastic box in which the parts are packaged. The box is coded with letters and numbers which form the basis for the step-by-step construction leaflet. If the uninitiated constructor reads through the leaflet, follows each step and checks it off, a complete and working telephone amplifier should result.

Rather than clip the component leads

short, we would favour keeping them to normal length, merely bending them aside and soldering as necessary. If you do want to recover the parts, or decide later to assemble them in another physical form, they can be unsoldered and the leads straightened, ready for re-use. In fact, the layout of a little amplifier like this is not at all critical and it can be built up in almost any form you like, provided the proper electrical connections are made.

And, speaking of electrical connections, make sure that you carefully identify the emitter, base and collector connections on the transistors from the literature in the kit, before actually installing them. The way the leads go in the pictorial diagram isn't quite as clear as the drawing might suggest and it is very easy to get them mixed up.

The other small point we noticed is that one of the transformers is supposed to be "painted red", to distinguish it from its companion unit. In the sample kit, the top of the transformer had indeed been hit with a red mist from a spray gun, but so fine that we completely overlooked the few tiny red droplets the first time around!

Otherwise, everything went together as intended.

We did make one deliberate modification, which will be evident from the photograph. The instructions suggest that the loudspeaker be mounted inside the red plastic box, so that it radiates only through the tiny holes already provided in the box. Guessing that the unit would not have any power or sensitivity to spare, we drilled the holes in front of the speaker to 3/16in – before the speaker was mounted of course!

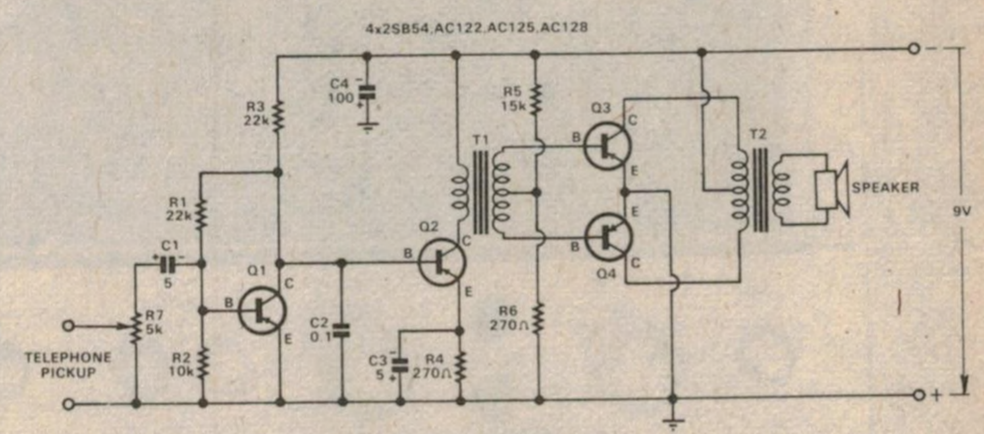
The circuit used in the 28-116 kit is conventional, and the sort of thing that was almost universal as the audio amplifier in the first generation of transistorised portable radios.

The input signal – in this case from the telephone input coil – is fed to a 5k volume control, and thence via a capacitor to the base of an ordinary general purpose PNP germanium transistor. Its emitter is connected directly to the "earthed" positive supply rail, while two series resistors from collector to emitter provide the requisite forward bias for the base. The collector itself is supplied from the –9V line through a 22k resistor, across which the amplified signal appears.

The collector of the first transistor is coupled directly to the base of the second, so that it shares the same signal and the same DC potential. It is bypassed to the earthy line by a 0.1uF capacitor which drastically reduces the response of the circuit to the higher audio frequencies, minimising the unnecessary noise and distortion components from the input signal, without detracting from voice frequencies.

Since the base of the second transistor operates at a significant negative potential, it is necessary to allow the emitter also to move towards the negative potential so that the transistor will have only a modest effective forward bias. This is accomplished by providing a fairly large value of emitter resistor, bypassed by a capacitor to obviate any loss of gain due to emitter feedback. The collector of the transistor runs to the –9V supply through the primary winding of a small interstage transformer.

The circuit of the phone amplifier is conventional, even if somewhat dated. The main points to watch during assembly are the correct identification of the transistor leads and the polarity of the electrolytic capacitors. A larger, more efficient speaker will improve results considerably.



As the collector current through the primary winding of the transformer varies with the signal, it induces signal voltage in the secondary winding, the signals at the two outer ends being of equal amplitude but opposite phase. The signals are fed to the respective bases of the two output transistors operating in what is known as push-pull class-B.

In broad concept, the "push-pull" part of the term signifies that the two output transistors complement one another in supplying drive to the output transformer and thence to the loudspeaker.

If no signal is present, a similar order of current flows from the centre-tap of the output transformer to the respective collectors; since the currents are flowing in opposite directions, they tend to cancel in their magnetising effect on the transformer core.

When out-of-phase signals are applied to the bases of the respective output transistors, the collector currents no longer balance. Thus, at a particular instant, the base of the upper transistor may receive a negative-going half cycle of signal, which will increase its collector current; at the same instant, the lower transistor will receive a positive-going signal, thereby decreasing its collector current.

On the next half-cycle of input signal, the reverse happens.

Thus the two transistors tend to complement one another in varying the normally balanced currents through the output transformer primary, and therefore in modifying the magnetic field in the transformer core. And, as the magnetic field changes, current is induced in the secondary winding and passed to the loudspeaker voice coil.

The "class-B" part of the definition implies that the transistors have only a small amount of forward bias – applied through a 15k and a 270 ohm resistor– so that they draw only a very small cur-

Try this hum-bucking trick

As mentioned in the body of this article, a problem with inductive pickup is that of 50Hz pickup from the mains. Just how serious this is depends on several factors; the location, the "tailoring" of the amplifier's low frequency response, and the strength of the incoming signal.

This latter factor can vary over a very wide range. The strongest signal will probably ride over most hum problems, but the weakest ones, which may still be adequate as a telephone signal, can easily be drowned by typical hum levels.

We considered various possible solutions. One was to provide a "notch" circuit tuned to 50Hz; something which can be provided relatively easily these days, using low cost ICs. (p 81, Electronics Australia, November 1976.)

Such an arrangement would undoubtedly provide considerable benefit, but it does have one limitation. It can only reject the fundamental 50Hz signal; it can do nothing about the harmonics (100Hz, 150Hz, etc) which, in many cases, are quite strong.

Then we had another idea. Could the hum be cancelled by picking up an equal but opposite signal containing hum only? To cut a long story short we borrowed another pickup coil from our friendly neighbourhood supplier, connected the two together appropriately — and it worked. Using a "worst case" set-up, the hum dropped from a nasty background to virtual inaudibility.

To provide the required phasing we connected the two outer shields together and took the signal from the two active leads. The two pickup coils were place side by side in the handle slot in the back of the phone, one in the best place to pick up signal, and the other as far from it as possible.

In theory this arrangement leaves the wiring unshielded against electrostatic pickup. In practice, at the relatively low impedance involved, hum from this source was negligible.

rent under quiescent (or no-signal) conditions. This being so, most of the change in the magnetic status of the core is brought about as the output transistors in turn draw more current on successive half-cycles of the input signal; in this case, where they receive a negative-going signal pulse.

While much could be said about class-B operation, it has two particular attractions in simple, inexpensive amplifiers: it minimises drain on the battery and it also minimises dissipation in the output transistors.

In fact, the kit supplies simple general purpose PNP germanium transistors for all positions. The only concession is in the provision of "flag" heat sinks for the two used in the output stage – just in case they are called on to handle a continuous loud signal, sufficient to cause some temperature rise.

Because this general type of amplifier was almost universal in the first generation of small transistor sets, it may in fact be possible to adapt the audio end of a discarded transistor receiver as a telephone amplifier, feeding a pickup coil into the volume control circuit in lieu of the original radio signal for the detector. Similar amplifiers have also been used in small intercom systems and it would be worth looking for a discarded one of these.

So much for the circuit. How does it all work out in practice?

Instructions in the kit suggest that the pickup coil, with its suction cup, be attached to the rear of the handset just behind the earpiece. This may be okay with some handsets (presumably American) but with local handsets more pickup was evident with the coil right at the end adjacent to the earphone.

Picking up the signal near the earphone has an important advantage in that the amount of energy from the local microphone and the distant voice is fairly well balanced. Unfortunately, however, the signal is quite limited and may not be enough with many handsets to drive the amplifier when the distant voice is weak.

A much larger signal is available, with local handsets, from inside the handle slot at the rear of the instrument. Lift the receiver so that the dialling tone is heard, and you will soon be able to select the point of strongest pickup. Here, dialling tone, selector clicks and local voice will all be very loud relative to the distant voice but there may be no real choice if the amplifier is to be adequately driven.

At best, however, one of the limiting factors in the 28-116 kit is the tiny speaker and the fact that the listening has to be done right near the phone. The leaflet suggests that a clearer signal will be obtained if the amplifier is used with a larger, more sensitive 8-ohm speaker– particularly if you place it where you can listen conveniently. Then you should be able to hear both sides of the conversation with less distraction.

Another possibility, which is well worth considering, is that of using the amplifier with a miniature earplug, connected in lieu of the speaker. Ordinary 8-ohm magnetic units appear to work very well.

Earlier we suggested that components should be available from sources other than the Tandy kit. Those worthy of special mention are the pickup coil, the transistors, and the transformers.

The transistors are general purpose PNP types and several alternative type numbers are given in the circuit. At least one of these types should be readily available.

Pickup coils will probably be available from Tandy as a separate item, but we found them available in at least two other Sydney stores: Radio Despatch Service and Dick Smith Pty Ltd. We imagine they would be as readily available in other states.

The same two stores should also be able to supply transformers. The output transformer should have a centre tapped primary with an impedance of around 400 to 500 ohms and an 8 ohm secondary. The driver transformer should have a primary of about 2500 to 3000 ohms, with a similar secondary, centre tapped.

Construction should not present any serious problems. As we said earlier, layout is not critical and so it may be built in almost any form. A piece of Veroboard would probably make a good substitute for the plastic box.