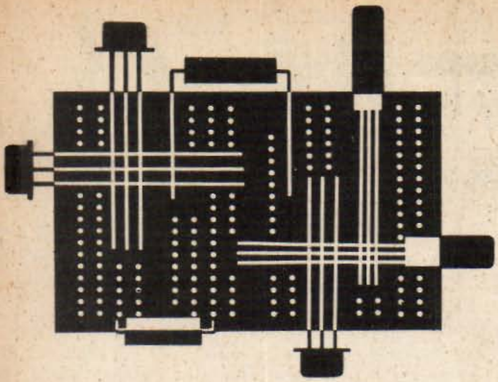


PROJECT

THE new series of practical subjects for beginners to build commences in this issue. Subsequent articles in the series will be easily identified under the "Beginners" heading in the Contents and by the symbol which will appear at the beginning of each article.

THE projects are shown built up on a "breadboard" system for four main reasons.

1. Whilst the initial cost of the systems may be high, this could be more than offset by the fact that components can be easily removed, re-positioned or used again in a more permanent construction.
2. The circuit can be assembled very quickly or expanded by adding extra functions later.
3. The actual layout of the components can follow a similar layout to that in the circuit diagram.
4. Soldering is only needed for connecting wires to large components, such as switches and potentiometers; inter-component wiring is already provided.

USING T-DEC

The "breadboard" system used is called T-Dec. It is a manufactured plastics base plate with a matrix of numbered holes. Certain combinations of interconnection are provided by spring strips underneath the holes. These are snown in Fig. 1a corresponding to the raised lines moulded on to the surface of the board itself.

T-Dec is divided into two sections which are electrically isolated, enabling two or more separate circuits to be built on to the same board. If required any part of one circuit can be connected to any part of the other circuit by using single strand copper link wires.

Some components have very thin connecting wires; these should be helped into the holes by holding the wire with a pair of long-nose pliers.

Transistor and diode wires can be inserted directly into the holes if spacing permits. It may be necessary to open up the spacing of these wires; in which case, careful bending with pliers at least $\frac{1}{8}$in from the encapsulation can do this without damaging the transistor or diode seal. Alternatively, special adaptor plugs supplied by the T-Dec manufacturers can be used to mount these components.

The component wires should be at least $\frac{3}{8}$in and preferably $\frac{5}{8}$in long to ensure satisfactory connection. Longer wires will of course, make the components more versatile in their use. It is never good practice to trim these wires short if they are to be used again.

Whole systems of breadboarding can be built by fitting two or more boards together by the dovetail tongues and grooves around the sides. Small panels for switches, potentiometers, lamps and so on are provided and are easily fitted into the slots on the edge of the boards.

HOLE IDENTIFICATION

Coming now to the numbering of holes for identification you will notice that the T-Dec has two blocks side by side with letter references A to H on both.

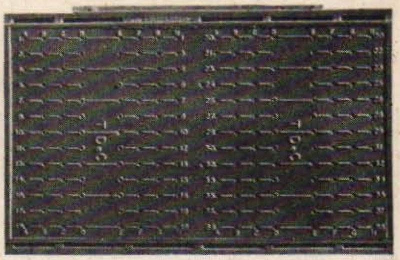


Fig. 1a. The T-Dec breadboard. Notice the connections between holes are shown as raised lines

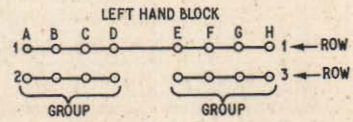


Fig. 1b. How the T-Dec holes are identified. Only the first two rows are shown here

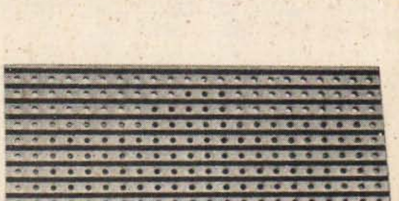


Fig. 2a. Underside view of Veroboard showing the copper strips

BUILDING—
for BEGINNERS

The numbers run in sequence for each row or group of holes in a row (see Fig. 1b). It is important not to be confused with these since, in each alternate row per block, there are two groups of four holes which are numbered separately.

In the other rows connection is already indicated between the two groups; these cannot be separated. If insufficient holes are available for a particular junction of components, a link wire can be carried to another vacant group elsewhere on the board.

ALTERNATIVE CONSTRUCTION

Some readers may prefer to use alternative construction systems, perhaps in a more permanent form. These will probably require the use of a soldering iron and, although component recovery is possible, it is not as easy as with T-Dec.

Suggestions for some construction systems are given here, using mainly some form of s.r.b.p. sheet machined or treated by proprietary manufacturers.

In order to simplify translation from T-Dec to these other forms, the same basic layout is assumed and connection code numbers correspond. If the board is too large, it can be trimmed before commencement to the size required, but the basic layout remains the same.

COPPER STRIP WIRING BOARD

Veroboard is the first of the alternative examples here because translation is very straightforward. Fig. 2a shows this board with the copper strips on the underside. To keep the same layout appearance the holes are numbered in sequence so that the top surface is that without the copper.

If the copper strips are cut to conform with the T-Dec

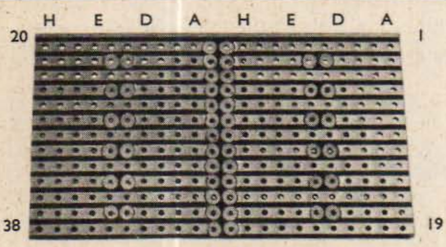


Fig. 2b. Veroboard with the strips cut to show the T-Dec wiring pattern

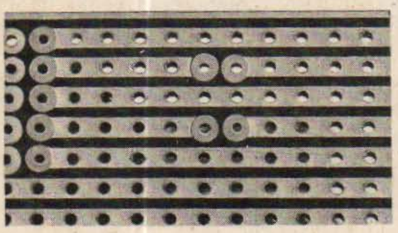


Fig. 3a. Veroboard strips prepared for the first project

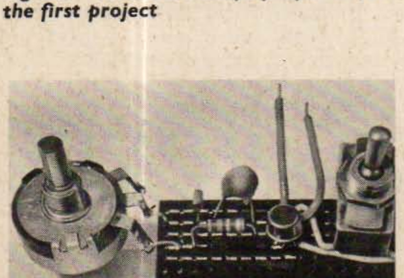


Fig. 3b. The finished metronome project

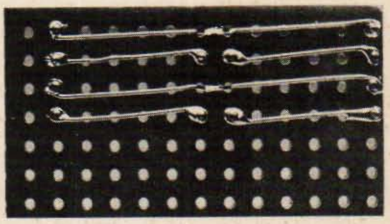


Fig. 4a. Plain perforated s.r.b.p. sheet with copper wire connections and soldering pins

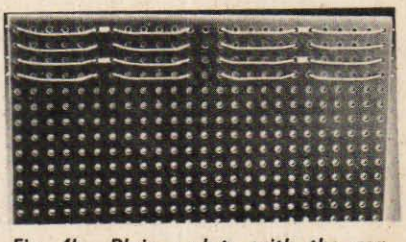


Fig. 4b. Plain s.r.b.p. with the connecting wire hooked through the end holes in the rows

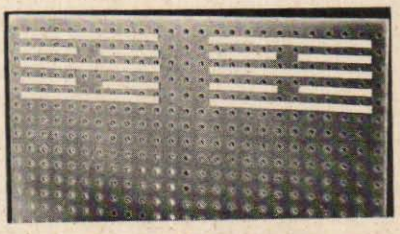


Fig. 5. Cir-kit adhesive copper strips fixed between rows of holes on plain perforated board

layout the appearance would be as shown in Fig. 2b.

The strips can be cut with a special spot-face cutter, a ⅛in drill, or a sharp knife.

Before cutting any strips, study the project circuit layout in the practical article to see how many breaks are really necessary. If only one half of the T-Dec is used none of the centre breaks will be necessary. However, if at a later stage you decide to assemble another circuit on the same board, the copper around the centre columns of holes, between column H on the left and A on the right, will need to be cut. Before doing so, check to see if any links are needed between left and right, in which case leave the appropriate strips uncut.

Next look at the project layout to see if any connections are needed between column D and column E. Having established those required cut all the other copper strips between D and E to form the groups of four holes (Fig. 3a).

Now the columns and rows of holes can be numbered exactly as for T-Dec. You can do this by laying the board on a sheet of paper and marking through each required hole in the board with a pencil. Remember that the T-Dec numbering follows that for Veroboard that has the copper side face down.

Carry out the assembly and soldering making sure that no solder bridges two or more adjacent strips. Good clean soldering is the keynote to success; dry joints will not do. Fig. 3b shows the finished project.

PERFORATED S.R.B.P. AND WIRE

The next system is simple and follows the same lines as with Veroboard, except that plain perforated board has no copper face. All connections are carried out using soldering pins and tinned copper wire; see Fig. 4a. However, do not fit wires that are unlikely to be used; this is a waste of materials and effort.

The pins can be dispensed with if the copper wire is hooked through the end holes of each row and secured with solder. An example of a typical layout is shown in Fig. 4b.

STICK ON WIRING

The third system is a development of the previous one except that the wires are replaced by self-adhesive copper strips called "Cir-kit". The method is otherwise exactly the same (Fig. 5). The narrow strip will just fit between adjacent rows of holes on plain perforated board.

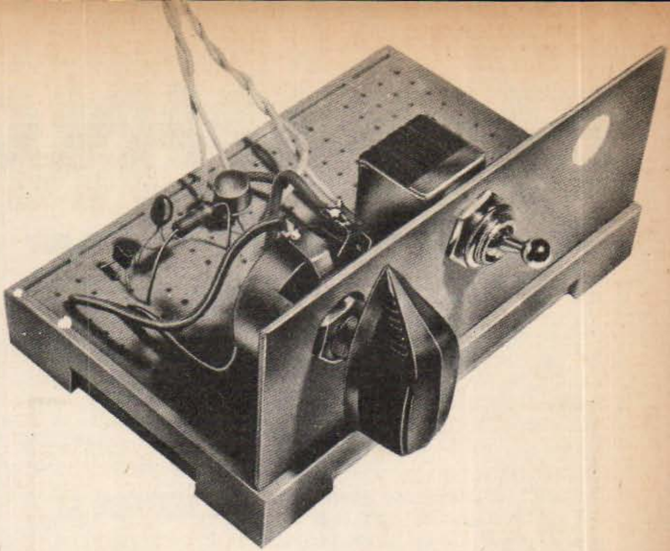
PRINTED CIRCUIT

There is no reason why printed circuit board should not be used. This will require more patience by following the instructions given with the printed circuit kit. Not all kits carry instructions, so if you are unfamiliar with printed circuit techniques try and obtain a kit that has.

It will probably be necessary to sketch out a layout of the copper pattern corresponding to the project actually being built. It is recommended that an experienced friend helps you with this as mistakes can be expensive.

This short introductory article is not intended to provide comprehensive details of using these alternative methods. Full details and instructions can be obtained from manufacturers of these and other proprietary items which are advertised in this magazine.

The project which follows can be built very easily using one of the methods described here. Future projects in the same series are to be dealt with in a similar manner.



To study a musical instrument, one of the most important requirements is strict attention to playing speed. To assist in the correct interpretation of the music's tempo the composer conveniently heads his composition with a rough guide to the rate at which it should be played like *Andante* or *Allegro*, this usually being followed by the number of crotchets, quavers, etc. that should be played per minute.

Whilst the accomplished musician has little difficulty in interpreting these tempo marks, the beginner does need some sort of aid to assist in establishing a sense of time.

More than a hundred years ago Maelzel provided such an aid in his invention of the mechanical metronome which produced loud ticks with the movement of a weighted pendulum. With the simple electronic metronome to be described, we can reproduce these ticks just as effectively without the labour of winding up springs.

RELAXATION OSCILLATOR

To simulate the sound of its mechanical counterpart the circuit of Fig. 1 was designed to produce asymmetric pulses of short width and rapid rise and fall times. The pulse generated across the loudspeaker LS1 is shown in this diagram, and it ensures a very rapid cone movement.

The frequency range extends from 40 to 220 beats per minute, which is adequate.

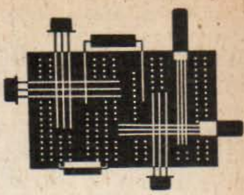
As this little device is very precise in its counting, it can also be used as an audible "darkroom" timer when set to 60 beats/minute.

The circuit itself is a simple relaxation oscillator where two complementary *npn* and *pnp* transistors are made to switch on and off at a rate determined by the resistance chain VR1, R1 and capacitor C1. With S1 closed, C1 charges until it reaches about 650mV when TR1 is switched on and immediately discharges the capacitor.

The current pulse produced by TR1 in turn switches on TR2 with the result that almost the whole of the supply voltage is made to appear across the loudspeaker.

The actual discharge time of the capacitor depends on the base-emitter impedance of TR1, the loudspeaker impedance and the output impedance of TR2 which collectively account for the exponential hump on the output pulse waveform.

With the completion of the pulse the capacitor again charges to the conduction potential of TR1, when the pulse cycle starts again.

METRONOME 

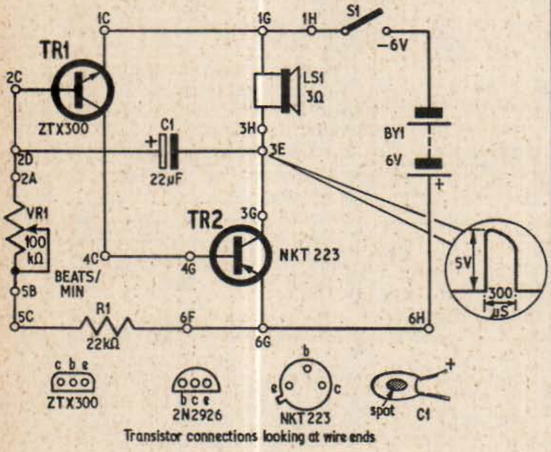


Fig. 1. Circuit diagram of the metronome showing the T-Dec hole connections, transistor wire identification and output waveform

COMPONENTS . . .

Resistors
R1 22kΩ 10% ½ watt carbon

Potentiometers
VR1 100kΩ linear carbon

Capacitor
C1 22μF tantalum elect. 16V

Transistors
TR1 ZTX300 (Ferranti) or 2N2926 orange spot
TR2 NKT223 (Newmarket) or GET102 (Mullard)

Switch
S1 on/off toggle switch

Loudspeaker
LS1 3Ω 5in permanent magnet moving coil unit

Battery
BY1 6V type 996

Miscellaneous
T-Dec.
Single strand connecting wire
Battery connectors or clips

LOW LEAKAGE

In the application of this unit timing precision is important. The simple factor most likely to give trouble in this aspect is leakage current. The choice of a silicon transistor for TR1 and a tantalum electrolytic capacitor for C1 virtually eliminates the problem.

In the choice of speaker it will be found that sound output is a function of cone diameter. In practice, a 5in speaker proved very satisfactory.

CONSTRUCTION

Construction of the unit merely involves plugging the components into the T-Dec as shown in the photograph. For the holes employed refer to Fig. 1, which shows the hole numbers for each junction.

If it is intended to make a permanent unit of this, the wiring configuration will readily translate to any of the board constructional methods outlined in the introductory article.

If such construction is undertaken the potentiometer setting must be calibrated in terms of the number of beats produced per minute. Using a wrist watch with seconds sweep or preferably, a stop watch, the potentiometer should be advanced at 20 beat intervals. These positions can be recorded on a piece of white card. A pointer knob attached to the potentiometer shaft will simplify this operation.

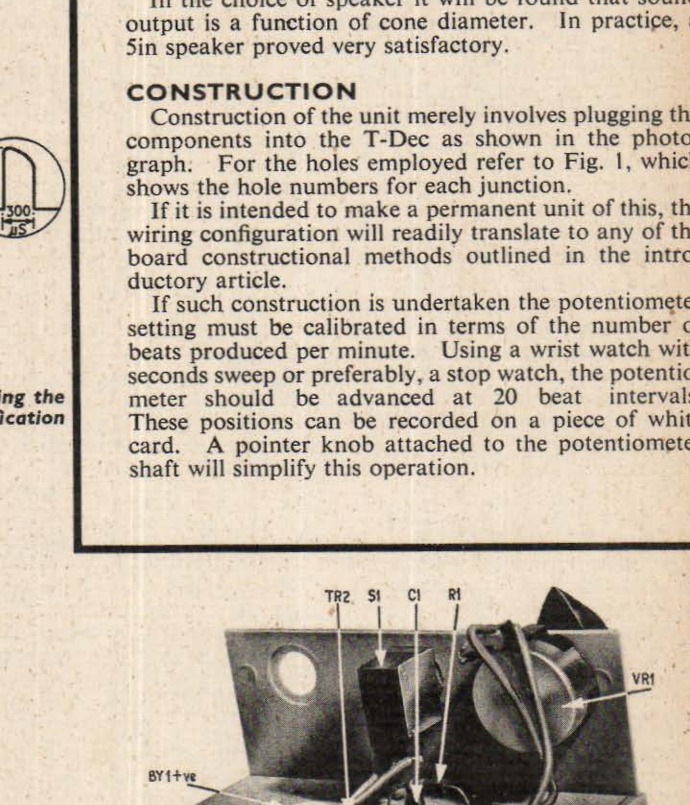


Fig. 2. The layout of components on T-Dec. Make sure the battery is correctly connected