PRACTICAL WIRELESS

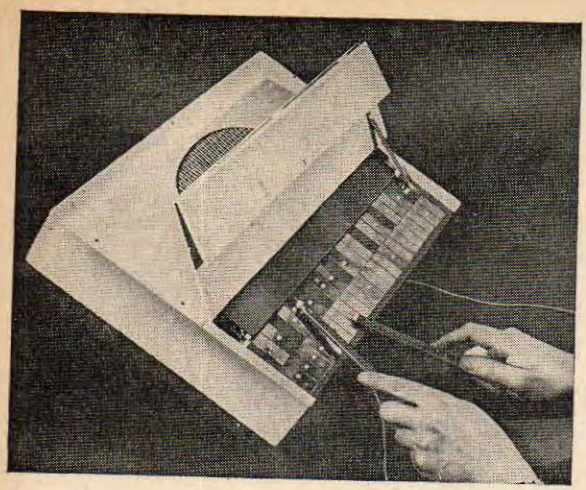
JULY 1968

2/6

Build this PORTABLE KEYLESS ORGAN

also inside

the STEPTRON
electronic stop watch
for the photographer



COVER SUBJECT

G.W. HARDY'S

portable KEYLESS ORGAN

TRANSISTORS are used throughout this instrument, which is complete with power amplifier and loudspeaker. Despite its simplicity and low cost, the tone obtained is of great appeal, and compares with the solo voice of an expensive commercial electronic organ. Keys are not always easy to obtain, and then will need altering and adapting to the new instrument. The method used by the author in this instrument, is a series of small metal plates, arranged in the usual layout of standard keys, so that it is easy to recognise and select any required note.

Two wands terminating with a contact stud are needed, one for each hand. When the contact makes with any plate, the note generator starts oscillating at the previously tuned pitch of that note. Having two wands makes for smooth or legato playing. The switch on wand No. 2 disconnects the preamplifier, but a sound is still produced provided contact is still made with that plate, but slowly decays while capacitor C13 Fig. 2 discharges. For normal playing the switch is kept closed with the forefinger. The metal plates are kept very close to each other, so that the wand contact can freely glide from one to another.

Solo Organ Prototype

The system of tuning used in the new instrument was experimentally tried out in the author's prototype of the organ described in an article which appeared in the February, March and April 1965 issues* of P.W. Readers who have built this instrument will be interested to know that the new tuning method has proved very satisfactory while in constant use for a period of over 12 months. Constructors will only need to remove the tagstrip containing the tuning resistors, and subsitute the tuning device to be explained later in this article. The vibrato used in this new instrument is a true vibrato, which means that the frequency of the sound is modulated, and is obtained from a one transistor phase shift oscillator. Another toggle switch was fitted alongside the original vibrato switch, and room found inside the case to accommodate a PP3 9 volt battery. The battery positive is taken to the common positive, negative through the new on/off switch, and then to the oscillator panel. Output from the capacitor C5 (Fig. 1) is taken direct to base of Tr3 Fig. 1 (Feb 1965 issue).

The Note Generator

A multivibrator circuit (Fig. 1) has been used again, as it is very accommodating and easy to set up. What other oscillator will give over three octaves of musical notes while only changing one resistance! With the components' values given a range of three octaves will be comfortably covered, that is from C one octave above middle C and down three octaves to C in the bass, a most useful range. A limiting resistance, R7 should be altered if necessary so that top C will be in tune when the moving arm of the tuning control VR3 is at half travel. Do not use lower value than 10kΩ or Tr3 will pass excessive current, 15kΩ should be about right, a lower value will raise the pitch, and a higher one lower the pitch. Provision has been made in the layout of panel Fig. 2 for R7 to be experimentally tried out before finally soldering to the two tags provided.

Unless the constructor has another keyed instrument to give the pitch C (C above middle C on the piano), a tuning fork or pitch pipe becomes necessary. One can be purchased from any good music store and must be marked "C international or Standard Pitch". The vibrations are 523·25c/s.

Vibrato

In Fig. 1 will be seen the circuit for the phase shift oscillator. It is important to use a high gain transistor, in order to maintain oscillation. The OC72 used was to hand and works very well. An OC45 and white spot germanium transistor have been satisfactory. VR1 alters frequency slightly, and should it not cover the requisite range of 5 to 7c/s, R3, 6·8kΩ, can be varied slightly in value. In the layout two tags have been left for an experimental try-out. VR2 slightly alters depth of modulation, and should be placed about half-way when setting up. Both controls should be midget or skeleton preset types.

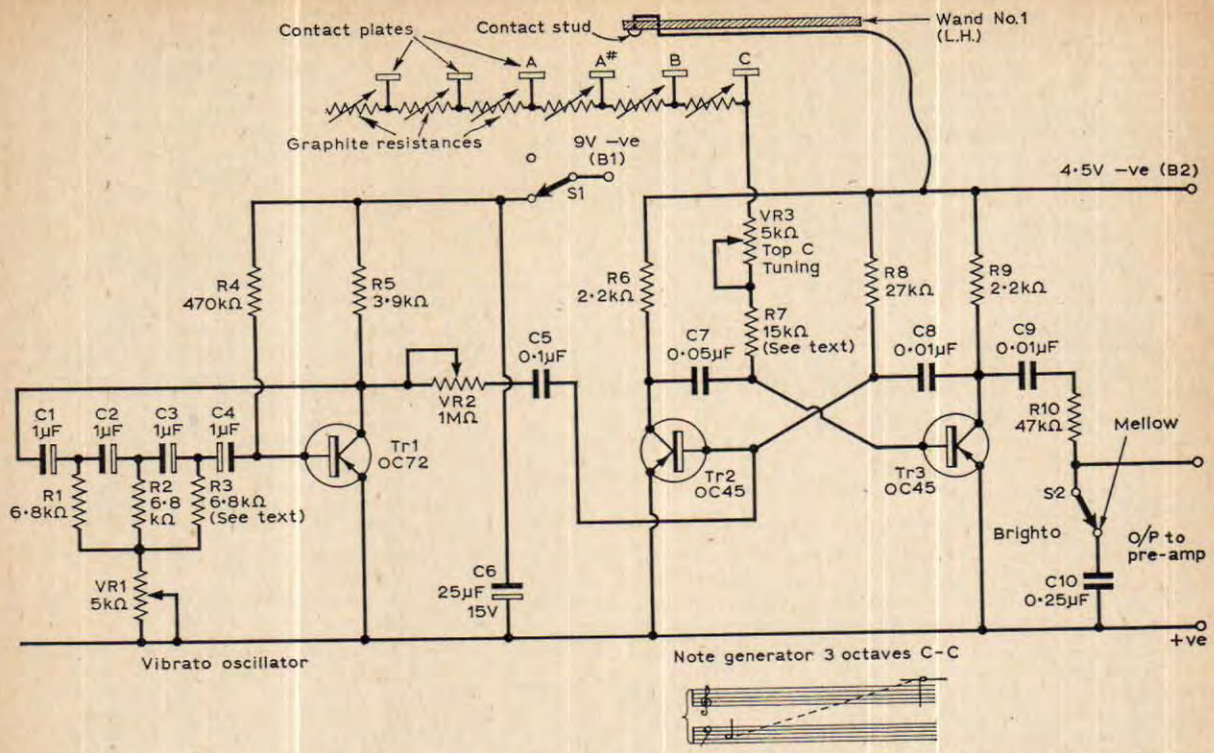


Fig. 1: Circuit of the vibrato (phase shift) oscillator with variable speed and depth control, and the three octave note generator.

The preamp Fig. 2 is a common emitter amplifier. The purpose of the 25Ω resistance R11, in series with the expression control VR4, is to prevent the sound being completely turned off, leaving it possible to play very softly. The sustain switch, S3, enables the sound to slowly decay, the duration being fixed by the capacity of C13. The 50μF specified is quite satisfactory, and gives some useful effects. R17 is to absorb make and break clicks.

The output stage has been designed around an AD140 transistor (cost about 10s.) instead of using the more conventional Class B push-pull amplifier, which has many more components and more complicated wiring. The main advantage of the latter is of course in the battery current economy. However, this is more of a consideration when used in a radio set, which might be on for long periods, in our case, the instrument would normally be used for shorter periods, and it is up to the player to make a habit of switching off at every opportunity after and between the intervals of playing. There is no warming up period to wait for when switching on again. The consumption is 40mA, and a 4½ volt flat torch battery will give good long service with care.

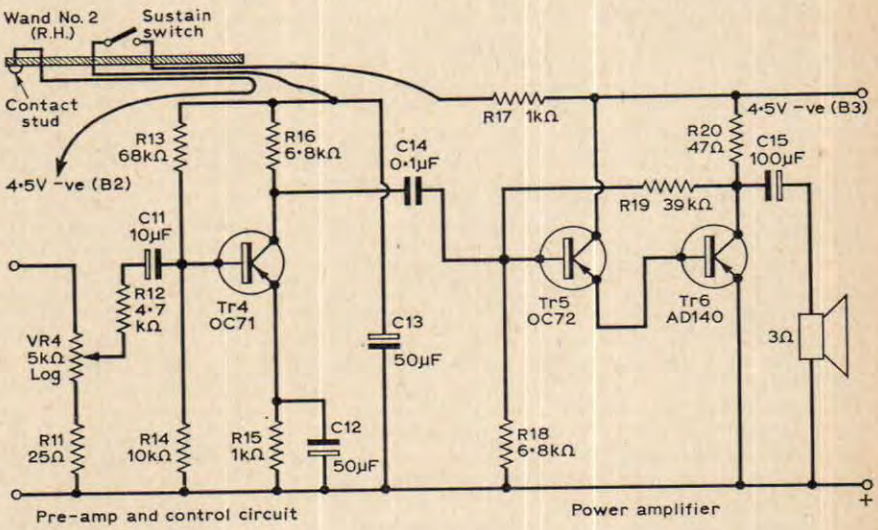


Fig. 2: Pre-amplifier and control circuit plus power output stage. VR4 is the expression (volume) control.

In the rather unusual output stage, the bias for the AD140 is derived from the driver emitter direct connection. The driver being a p-n-p transistor ensures correct polarity. Negative feedback is taken via R19 to the base of Tr5. This simple amplifier gives good quality musical output.

The contact plate board is made from a piece of exterior quality hardboard, which is oil hardened during

manufacture and much harder than ordinary hardboard, but very little dearer. A suitable off-cut may be obtained from a shopfitter or builder. The size is 18 × 5½in. and is fitted with metal plates which form the "keys". At the rear of the board is a ⅜in. wide strip of the same hardboard, divided into 36 equal spaces. Each one, after treatment, will provide a variable resistance to tune each note, the soldering tags on the resistance strip are connected and wired through a small hole in the hardboard to the tag fixed by a screw to its respective plate. On the extreme right is a simple made up on/off switch, the arm of which, when moved to the left, makes contact with the countersunk head of a screw connected underneath with the top C screw. In the on position, top C will sound continuously, while the preset tuning control is adjusted into tune with a tuning fork or other reference.

Panel Wiring

Knowledgeable constructors will have their own ideas about wiring, but the method used by the author has proved straightforward, alterations are easily made, and components can be salvaged with useful lengths of lead-out wires intact. Assemble all the components and straighten out the wires, which are then cleaned bright. With a small tapering pair of pliers, place against the body of the component, so that a 1in. of wire is in the grip of the pliers, now with the component values shown uppermost, the wires are bent down at right angles. Cut a piece of cardboard same size as the panel and mark position of tags. With a pair of dividers measure off the distance apart of the right angle bends, and using the lay-out drawing as a guide, impress on the cardboard where the component will be fixed. When finished the cardboard can be laid upon the panel and the impressions marked through with a sharp awl, these holes are then drilled with a $\frac{1}{16}$in. drill.

After this, the wires are pushed through the holes and bent over towards each other, with the component held tightly on the panel. Wires are snipped off leaving a ¼in. stub, under which connecting wire is placed, and stub pressed down hard to grip ready for soldering. In some cases leads will be long enough to orientate and place under the wire of the component to which it is to be connected. Sleeving should be used as necessary, and transistors wired in last with their full length of lead-out wires. A ½-in length of tight fitting sleeving should be put on transistor base leads and pushed up as far as possible. This will assist in identification and prevent possible shorting of leads. The tip of each transistor wire is cleaned and tinned while being held in a pair of pliers.

The AD140 transistor is bolted down flat on to the panel, after making holes to take the stout base and emitter pins. The metal body is the collector, and when wiring up, terminate the lead to the collector with a soldering tag to fit on the bolt and tighten up with a nut. Observe the usual precautions when soldering transistor leads, and those of small electrolytic capacitors. Preparatory cleaning and tinning is a great help to good soldering. To assist in the external wiring to panels, it is recommended that they be marked with a sharp-pointed awl the legends as marked on Figs. 3 and 4. Correct battery markings are important.

★ components list

Resistors:

R1	6·8kΩ	R13	68kΩ
R2	6·8kΩ	R14	10kΩ
R3	6·8kΩ	R15	1kΩ
R4	470kΩ	R16	6·8kΩ
R5	3·9kΩ	R17	1kΩ
R6	2·2kΩ	R18	6·8kΩ
R7	15kΩ see text	R19	39kΩ
R8	27kΩ	R20	47Ω 1W
R9	2·2kΩ	VR1	5kΩ preset
R10	47kΩ	VR2	1MΩ preset
R11	25Ω	VR3	5kΩ preset
R12	4·7kΩ	VR4	5kΩ Log.

All ½ Watt except R20

Capacitors:

C1	1μF electrolytic
C2	1μF electrolytic
C3	1μF electrolytic
C4	1μF electrolytic
C5	0·1μF paper
C6	25μF electrolytic
C7	0·05μF paper
C8	0·01μF paper
C9	0·01μF paper
C10	0·25μF paper
C11	10μF electrolytic
C12	50μF electrolytic
C13	50μF electrolytic
C14	0·1μF paper
C15	100μF electrolytic

Electrolytics all 15 or 25V wkg.

Transistors:

Tr1	OC72
Tr2	OC45
Tr3	OC45
Tr4	OC71
Tr5	OC72
Tr6	AD140

Miscellaneous:

One double pole on/off switch; two toggle on/off switches; four 4½ Volt flat flash lamp batteries; hardboard (exterior) 1ft. 6in. × 6in.; phosphor bronze draught excluder strip; 6ft. length stainless steel ¾in. wide (polished on one side); thirty-seven double ended tags; forty single ended tags; six ½in. wood screws for top fixing; forty ½in. 6BA round head bolts and nuts; thirty-seven ½in. 6BA cheese head bolts and nuts; ¾in. and 1in. panel pins; Bostic No. 1 adhesive; L.S. covering material; carrying handle; plastic off-cut 1ft. 6in. × 3in.; 6ft. 6in. of ½in. square (ramin wood); 5ft. of ¼in. square (ramin wood); 4ft. of 3in. × ½in. wood; paxolin $\frac{1}{16}$in. thick for panels; sheet aluminium; 6in. of thin leather strap; thick felt 6in. × 1½in.; thin coloured felt 1ft. 6in. × 6in.; solder; connecting wire.

At this stage it may be as well to explain the type of soldering tags used by the author. Phosphor bronze draught excluder strip (Woolworths) is cut off into 6in. lengths—old scissors will do for this—then cut into strips $\frac{3}{16}$in. wide. Try out with a scrap piece of paxolin. Drill a $\frac{13}{64}$in. hole and thread one of the strips through until it jams tight. Bend each end down flat outwards. Place a small straight edge on

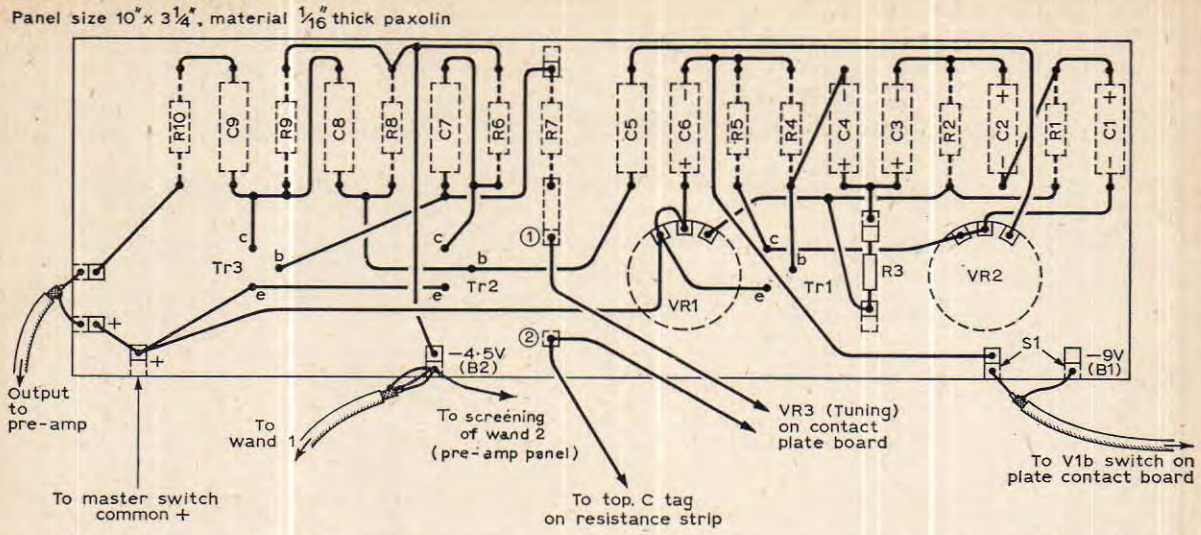


Fig. 3: Circuit board layout for the vibrato oscillator and note generator. All components are mounted on the reverse side, to the wiring.

the strip over the hole ¼in. from the bend, and with a sharp penknife score across the metal, still holding the straight edge firmly down, bend the strip up and down a few times until the metal breaks, leaving a ¼in. tag. The same is done at the back of the panel. Tags will be mostly used on the edges of panels, in this case drill the hole so that there is a space ⅛in. left between the hole and the edge, bend outwards as before, this time using the panel as a straight edge, score and bend until the metal breaks clean in line with the panel edge. Deal with the other side as before. To use up strips which are slightly narrow, drill with a size smaller drill. With wider strip these are helped through the hole by using a wire file removed from its frame, broken pieces are ideal for this. File slightly each side where the strip will be inserted. These tags take solder delightfully easy, and with practice can be fixed quicker than ordinary tags. If desired the constructor can use the latter where indicated.

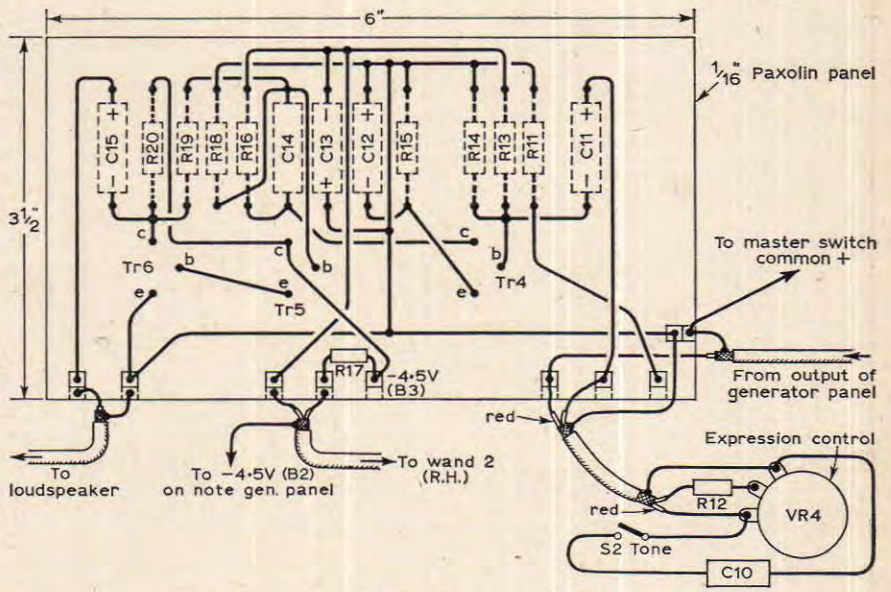


Fig. 4: Circuit board details of the pre-amplifier and output stage.

The contact plates are ¾ × 1½in. each and we require 37. First experiments were made with aluminium, but proved too soft. Bright polished copper was an improvement, but stainless steel was finally chosen, because it can be conveniently obtained in 6 foot lengths at the required ¾in. width (cost about 12s.) one length being sufficient. We only need to take care in cutting off 1½in. lengths, dead square. With a fine file clean off sawcuts, slightly radius the four corners, and slightly round the edges on the polished side. When finished, stack together and with the edges on the flat surface of a board see that they are reasonably square, none unduly proud. Remember that with 37 saw cuts something like 2½in. will be wasted, however there should still be several inches left if needed. Contrary to expectations the metal is not unduly hard to work. With the polished sides down, the plates should be laid down on a flat surface and protected with some newspaper. On the back of each plate mark two pencil lines diagonally from opposite corners, at the intersection, make a punch mark for drilling the centre hole to take the 6BA screws. After drilling, to cleanly finish the holes on the polished side use a countersunk bit or larger

—continued on page 192

—continued from page 173

drill, apply to the hole giving a twist with the fingers. When finished each plate is like a small mirror, and an attractive feature when laying on the coloured felt in the completed instrument. Now place plates polished side up and in a row with long sides adjoining. With a black *wax* pencil number from left to right from 1 to 37, above the screw holes. Below the holes write C, C sharp, D, D sharp, E, F, F sharp, G, G sharp, A, A sharp, B. (This should be numbered 12), repeat this sequence twice more and mark No 37, C. The wax pencil will plainly mark the polished surface, will not scratch, and can be easily rubbed off later.

Resistance Tuning Strip

We require the $\frac{3}{8}$in. wide strip of hardboard for the resistance strip. Make a pencil line right down the centre, on the smooth side. With a pair of dividers set to $\frac{7}{16}$in. starting $\frac{3}{8}$in. from one end, mark off 37—$\frac{7}{16}$in. spaces along this line, prepare for drilling with a punch mark on the centre line at each division. Drill the holes, to take the 6BA screws, with a clearance drill, and avoid making the holes too large. With a medium file laid flat on the underside, rub along the strip to remove any extrusion left by the drilling. The strip is now trimmed off $\frac{3}{8}$in. from the last hole.

Lay the strip down on a flat firm surface, smooth surface uppermost, with a piece of medium glasspaper placed around a small block of wood, rub from end to end along the top smooth side of the strip. Keep the block flat and avoid any rounding towards the edges. This is to remove the smooth surface and leave it slightly scored. A short worn down piece of HB pencil is now required. Remove the wood, half-way from an inch of the pencil leaving the lead exposed and half embedded in the wood. Rub the exposed lead flatwise on the roughened side of the strip, and rub well all over from end to end. The resistance strip should now be placed on one side, until the plate contact board is prepared.

** Back issues containing details of the author's prototype organ that appeared in this magazine during 1965, are out of print, and therefore we regret, are no longer available from this magazine.*

TO BE CONTINUED