THE P.E. Minisonic is a synthesiser in miniature and contains the necessary circuitry to produce all the basic forms of modulation which have come to be associated with its larger brethren. Thus a ring modulator is incorporated together with the means for producing frequency, amplitude and harmonic modulation.

Being battery operated the P.E. Minisonic is safe for the younger enthusiast to build and operate and can expect to give up to 50 hours of entertainment from one pair of PP9 batteries.

Although an entirely self-contained instrument which includes two 250mW monitoring channels and loudspeakers, the P.E. Minisonic may be connected to a range of external apparatus including power amplifiers, tape recorders, signal generators, etc.

The overall cost to build the P.E. Minisonic is under £50.

SPECIFICATION

Two Voltage Controlled Oscillators (VCOs)
Sawtooth waveform. Ten octave range, logarithmic law control

Two Envelope Shapers with Voltage Controlled Amplifiers (VCAs)
Envelope shapers have variable attack and decay. VCA has up to 54dB attenuation

Keyboard Controller
Incorporates "hold" or analogue memory

White Noise Generator

Ring Modulator

Voltage Controlled Filter (VCF)
Passband variable over 5Hz to 15kHz with a 54dB dynamic range

Two 250mW output amplifiers with input mixer stages

The VCOs and Envelope Shapers are controlled from the keyboard by means of a stylus, but provision is made for plugging in an external keyboard for the benefit of those constructors more musically inclined

(Patent applied for in respect of certain aspects of this design)

PE MINISONIC

A MINIATURE BATTERY OPERATED SOUND SYNTHESISER

By G. D. SHAW

PART ONE

THE popularity of the synthesiser is not in any doubt—the phenomenal growth rate of some of the synthesiser manufacturers, particularly during the 1972-73 period and the great interest shown in various "do-it-yourself" designs which have appeared in the meantime, only go to underline the wide, general appeal of the instrument.

Although the synthesiser may be employed in an enormously diverse range of applications under the general heading of sound manipulation, specifically within the field of music it may be rightly said that the instrument has provided the greatest dynamic to have occurred for centuries. In fact, we, as the listening public, have scarcely begun to feel the impact in terms of new compositions and effects which may be achieved.

As far as the individual is concerned, probably the greatest bar to synthesiser ownership has been the relatively high cost of the commercially available instruments and even the "do-it-yourself" designs which have so far appeared, although significantly lower in cost than their commercial brothers, are by no means cheap to construct. There can be few electronics enthusiasts who would willingly set aside a hundred pounds or so to finance a complex project on which there was no firm guarantee of performance.

Since the *P.E. Sound Synthesiser* first appeared the author has received many requests to design a simpler, low-cost instrument which could possibly be considered suitable for a schools project and which would serve to introduce to the younger members of our society the fascination inherent in the electronic manipulation of sound.

The P.E. Minisonic is therefore presented with the view of complying with the requests received although it is by no means suggested that it is the complete answer.

DESIGN CRITERIA

Most synthesisers rely on a duplication of circuits in order that the most exotic effects may be achieved but such duplication can only be accommodated in terms of additional expense. Consequently there were two principal criteria which governed the design of the P.E. Minisonic.

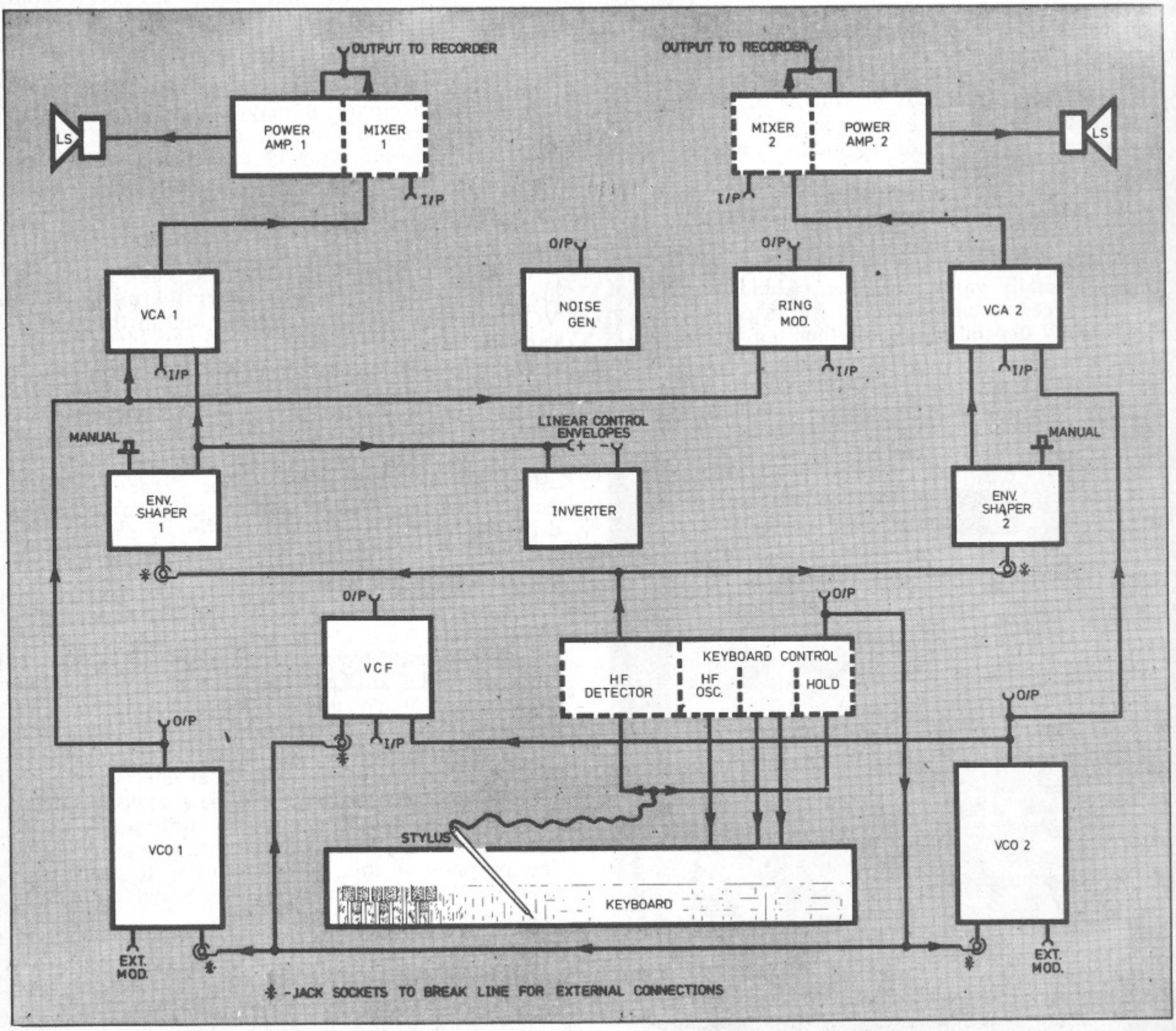


Fig. 1.1. Block diagram of the P.E. Minisonic showing the internal connections between modules

Firstly, the instrument should be able to produce the four forms of modulation, under controlled conditions, which are generally associated with the synthesiser. Thus there are facilities for amplitude, frequency and harmonic modulation, and a ring modulator is included in the scheme. Secondly, to comply with the possible requirement for duplication of circuits, each circuit within the basic instrument to be described can operate quite independently of the remainder.

The second criterion means that the constructor is offered the option of either tackling the project in accordance with the details to be published or of selecting individual circuits and building these separately for experimental purposes.

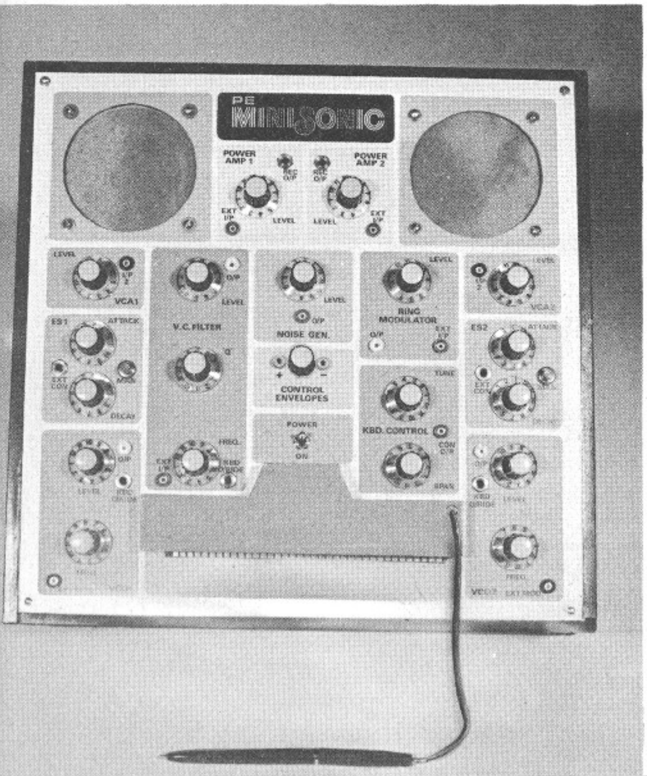
As with most synthesiser designs the possible permutations of circuits are legion and there are no hard and fast rules governing the numbers of circuits of a particular type which are to be included within a particular scheme.

THE SYNTHESISER EXPLAINED

For the benefit of those readers who may, as yet, be unsure of what a synthesiser actually does, the following brief explanations are included.

In general, all sounds may be defined in terms of three parameters: the first being pitch or frequency; the second the amplitude or volume of the sound in relation to the period over which it is audible; and the third the timbre or harmonic content of the sound.

Most naturally occurring sounds and many of those produced by acoustic instruments tend to have fairly complex structures. In the case of acoustic instruments the harmonic content, for any defined pitch, generally varies over the audible duration of the produced sound and can be made to change deliberately depending on whether the instrument is played loudly or softly.



These characteristics are not usually built in to electronic musical instruments and consequently the unchanging pitch and harmonic relationship of any particular sound produces a rather bland effect.

In the synthesiser all parameters governing the produced sound are continuously variable and, indeed, may be varied throughout the duration of a sound. This means that the instrument may be used to imitate conventional acoustic instruments with great exactitude or, on the other hand, it may be used to create totally unique sounds which can range from the amusing to the horrendous.

VOLTAGE CONTROL

The circuits in the synthesiser are operated by means of voltage control, a system which has been utilised by electronics designers for quite a number of years.

Robert A. Moog is generally credited with being one of the first designers to bring voltage control into the realms of electronic music and since the inception of his first voltage-controlled oscillators (VCO) and voltage-controlled amplifiers (VCA) the overall principle has been adopted for an ever widening circle of applications.

The great advantage of the system is that, although the controlling voltage may be derived from within the controlled circuit, it may also be derived from an external source. This, in turn, offers the advantages that differing types of circuit can control one another in various ways and also that, since control and signal paths are quite separate from one another, remote control operation becomes a practical possibility.

In the case of the P.E. Minisonic, control voltages are used in the oscillators to vary the pitch, in the VCA's to vary the sound volume and in the filter to vary the harmonic content.

These examples, of course, relate to the use of voltages of varying levels but there is another form of application in which pulses of fixed polarity voltage can be employed to command the initiation of an event. Again in the P.E. Minisonic this application is utilised in the envelope shaper to signal the start of the envelope which is, in turn, used to drive the VCA.

MINISONIC DESIGN

The overall scheme of the P.E. Minisonic is shown in Fig. 1.1.

Two independent channels are provided each comprising a VCO, an Envelope Shaper/VCA, a mixer stage and a 250mW power amplifier. A white noise generator gives an alternative sound source, whilst a ring modulator and voltage controlled filter (VCF) may be incorporated for additional effects.

To satisfy musical requirements a stylus operated "keyboard" is provided together with a keyboard controller which incorporates an analogue memory. The purpose of this latter circuit is to provide a series of voltages which define the VCO frequencies in terms of musically related tones.

As with the *P.E. Sound Synthesiser* a variable "Tune" and "Span" facility is available and this means, in practical terms, that the upper and lower frequency limits of the three octave, printed-circuit keyboard can be varied at will either in tune or with a range of semitonal frequency increments.

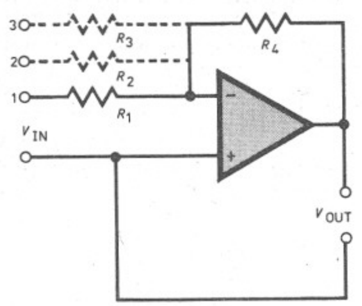


Fig. 1.2. An operational amplifier used in the inverting mode

It is appreciated that a stylus operated "keyboard" is far from ideal in the sense that it requires a great deal of skill to play it satisfactorily and also from the point of view that problems of contact oxidisation can present themselves after a period of use.

Provision is thus made for the connection of a keyboard of conventional design and it is worth pointing out that, with a little ingenuity, a discarded doll's piano can have contacts fitted and be made to perform quite creditably.

There is also an output point for connection to external amplifier or tape recorder. A tape recorder having "sound-with-sound" facilities is particularly useful in that it facilitates the whole potential of the synthesiser being realised.

Within limits imposed by the specific recorder a number of successive recordings can be made and overlaid in such a way as to result in the production of quite complex sound structures.

OPERATIONAL AMPLIFIERS

With the exception of three different types of special purpose integrated circuit which will be described in detail in the appropriate articles, the overall functions of the synthesiser are based on a combination of discrete semiconductors with the ubiquitous 741 operational amplifier.

Where these latter devices are used as part of an input stage for either control or audio signal applications, they are employed in the inverting mode as shown in Fig. 1.2.

In this type of circuit the junction of R_1 and R_4 is known as the virtual earth point. This is because current into the inverting input via R_1 is balanced by an equal and opposite current through the feedback resistor R_4.

The implication is that, when R_1 and R_4 are equal, the gain is unity and, in fact, the gain of such a stage may be expressed as R_4/R_1. The impedance seen by the input signal is effectively the resistance of R_1 and this will not change if additional inputs are provided as shown dotted in Fig. 1.2.

Where more than one input is required the gain of the individual stages is determined in terms of the ratios of the input resistors with the feedback resistor as shown above and the output signal of the operational amplifier, at any instant, is equal to the sum of the signals times the gain.

This point is made in some detail because, in the P.E. Minisonic, the minimum numbers of inputs are provided in order to comply with the requirements of simplicity.

PROGRAMMING

In the case of the VCO, four separate inputs are routed to the control stage. One of these provides a fixed voltage bias which sets the minimum operating frequency of the oscillator; another gives a manually variable voltage which will set the oscillator frequency at any point within its working range; a third routes in a voltage derived from the "keyboard" memory circuit; whilst the fourth is used for external modulation.

All four inputs may be driven at the same time and, in combination, "programme" the oscillator to give a specific frequency or effect. When all the inputs are d.c. the output frequency of the oscillator is unvarying but if, say, a sine wave signal is applied to the external modulation input then the output frequency of the VCO will rise and fall in time with the frequency of the modulating signal and in proportion to its amplitude. This particular scheme is illustrated in Fig. 1.3.

The term used to describe the programming of one oscillator by another is "frequency modulation" and in the specific case where the frequency of the programming oscillator lies between 6 and 8Hz, the overall effect is known as "vibrato".

Where additional modulating inputs are included in the scheme and each is coupled to external oscillators having differing frequencies and output waveforms, then it is possible to create some very complex effects. Careful manipulation of the programming frequencies such that each are multiples of the other, or fractionally related, will give rise to repetitive rhythm patterns covering a wide frequency range.

Whereas programming the VCO results in the production of a fixed frequency or frequency pattern, somewhat similar effects may be achieved by programming the VCF, although, in this case, the effect is based on changing harmonic relationships rather than the creation of discrete frequencies.

As with the VCO, the filter is provided with three control inputs, two of them for bias and manual

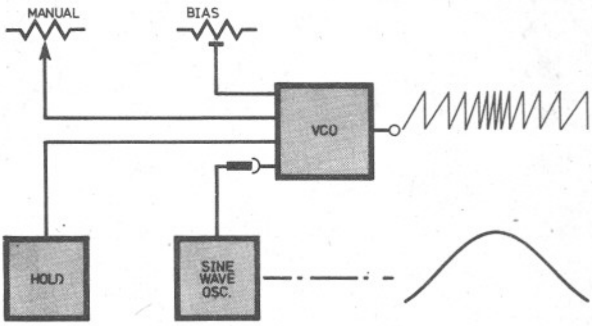


Fig. 1.3. By connecting a sine wave oscillator to the VCO, frequency modulation is obtained. The other inputs are permanently wired. The manual control sets the centre frequency and the preset bias control sets the minimum operating frequency; the remaining connection is from the "hold" circuit via the stylus

HOUSING — CUTTING DETAILS

Hardwood Strip

A 4ft × 3in × 3/16in

B 5ft × 1½in × ¼in

C 1ft × ⅝in × ⅝in

Cut A into two pieces 1ft in length and two pieces 11⅝in length.

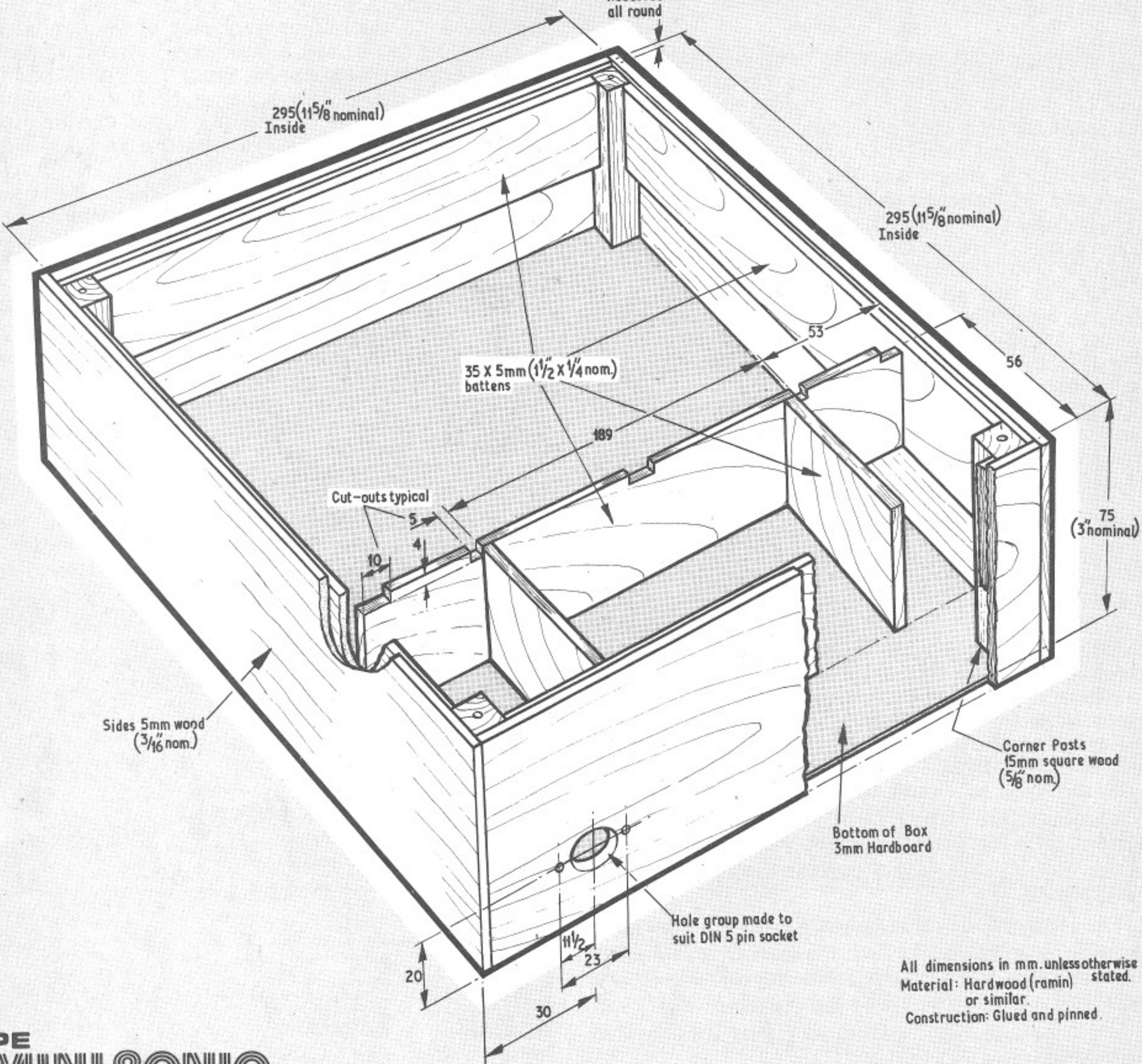
Cut B into four pieces 10⅜in, one piece 11⅛in and two pieces 2in length.

Cut C into four pieces 2¾in length.

Hardboard

Two pieces measuring 11⅝in × 11⅝in will be required. The hardboard should be ⅛in (3mm) thickness and should ideally be faced with white plastic on one or both sides.

The type which is faced on both sides is slightly more expensive but shows less tendency to warp.



PE MINISONIC

Fig. 1.4. Details of the case assembly. Major dimensions are shown in inches (1in = 25·4mm)

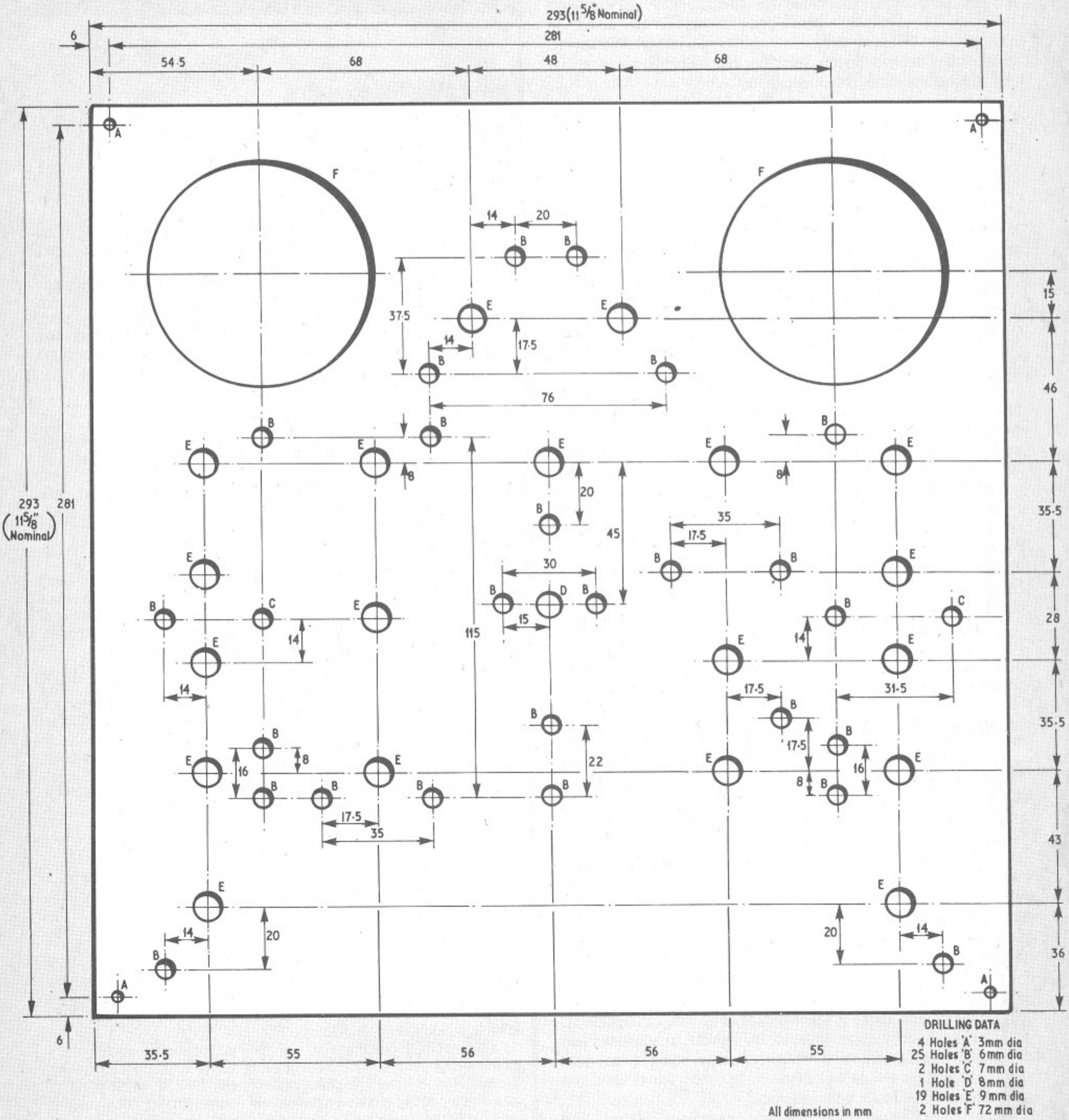


Fig. 1.5. Details of the front panel drilling required for use with scheme shown in block form in Fig. 1.1

control, whilst the third is from the "keyboard" memory circuit so that the filter pass-band range may be "played".

The VCF is a ladder network filter based on the design originally devised by Moog but very much simpler in circuitry and operation. Even so it is extremely efficient and it is quite an easy matter to "lose" the audio signal within the filter unless some care is taken with its operation.

ENVELOPE SHAPER

The envelope shaper is a circuit which produces a voltage which varies with time in a manner prescribed by two controls.

The "attack" control adjusts the period over which the output voltage of the envelope shaper rises to its peak whilst the "decay" control adjusts the period taken by the output to return to zero again.

This so-called "envelope" when applied to the input of a VCA ensures that the audio signal follows, in terms of volume, the prescribed pattern, i.e. with the envelope at its peak; so too is the volume of the audio signal.

Programming of the envelope shaper is not quite as simple as with the VCO and VCF since its operation is dependent upon the application of a pulse of at least −1V which has a duration at least as long as that set by the attack control.

In the P.E. Minisonic two control inputs are provided on the envelope shaper, one coming direct from the keyboard stylus and the other from a manual push button. However, the same basic principles governing the use of additional inputs may be followed although the result is never quite so predictable.

Further details on the programming of the various P.E. Minisonic circuits will be given in the appropriate articles together with instructions for obtaining specific effects.

CONSTRUCTING THE MINISONIC HOUSING

In the interests of simplicity the case of the P.E. Minisonic is constructed from a framework made up of standard hardwood strips which are normally available from most "do-it-yourself" stores or timber yards. Fig. 1.4 gives details of the case assembly.

The top and bottom panels of the case are made from white faced hardboard or similar material and are secured into the case by four corner screws as shown. Fig. 1.5 gives details of the front panel drillings which are required for use with the scheme shown in block form in Fig. 1.1.

The case should be assembled with panel pins and adhesive (Araldite is probably the best type to use) and can be sprayed a suitable colour on completion. During assembly care should be taken to ensure that the case is assembled with absolutely square corners and it is a good idea to use the top and bottom panels as a guide in this respect.

Both front and rear panels are secured to the housing by means of four corner screws.

The front panel, once assembled with components, is normally a permanent fixture whilst the rear panel has to be removable to allow for changing the batteries.

Next month: The VCO, Envelope Shaper/VCA, and Voltage Controlled Filter

NEWS BRIEFS

ON CALL

With the opening last month of a further Carphone centre for the Midlands, motorists whose cars are equipped with car radiophones are now able to make calls over a much extended area.

Now they can call from a new 3,000 square mile area which includes Wolverhampton, Coventry, Birmingham, Rugby, Northampton and Banbury. This is the first of five new centres to be completed and the station, located in Birmingham, is able to handle 300 users.

The other four areas will be opened up over the next two years but what is perhaps more important to users is the fact that now any user from one area can also operate in another area. Up to the present this has not been possible but the Post Office have now modified the system suitably.

LICENCE FOR SAFETY

The car licence plate could well perform a somewhat more complex role in the future if scientists at RCA Corporation have their way.

Using a complex antenna capable of receiving at one frequency and retransmitting at another, twice the first, they propose that an electronic "number plate" can be created which will be capable of interrogation at will on instruction transmitted to it.

Apart from this "big brother" aspect, the system can, of course, also be used for much more apparently useful purposes such as simple radio communication to and from a vehicle or perhaps operation as a transponder in collision-avoidance radar.

With suitable devices buried in the road at intervals, traffic could be examined not only as to quantity but also as to quality, with identification of such items as ambulances and fire engines being used to control traffic lights.

This basic idea is not new but the means for doing it cheaply is, and here RCA scientists reckon the cost could be in the "few dollars" region when manufactured in quantity.

HIGH FLYER

Air traffic control systems were well in the news last month with the announcement of two large orders, one to Plessey and the other to Marconi.

The first is an export order from Mexico and involves an automated radar air traffic control system at Monterrey Airport and instrument landing systems for Puerto Vallarta and Tijuana airports. The equipments form part of the first stage in a multi-million pound programme for the complete modernisation of air traffic operations in Mexico.

The second contract is for the supply of a radar data processing system for Scotland. This is a major contract, worth something in the region of £1·25 million, and involves equipment capable of monitoring both civil and military aircraft in the 2 million cubic miles of airspace above Scotland, Northern England and the North Sea.

Based on the new Marconi Radar Systems Locus 16 processor, one of the first systems in the world to use synthetic "clutter free" radar presentation exclusively, the system will provide an automated radar presentation, simplifying the control of aircraft in the Scottish terminal area which includes the areas round the rapidly expanding Glasgow and Edinburgh airports.