synthesiser has been configured only $\overline{D0}$ to $\overline{D4}$ are of direct programming significance, each digit corresponding to one figure in the display LED readout.

Suppose you wish to receive or transmit a signal on 28.215MHz. It requires that the synthesiser produces a local oscillator signal of 37.215MHz, ie 9MHz above. The push button tuning circuitry of **Fig 8** either increments or decrements (counts up or counts down) the row 4029 up/down counters, IC8 to IC12. An upper row of buttons on the front panel causes the counter chain to count up at various rates — each button selects a different output of a 4040 ripple counter — while the lower set of buttons does exactly the same but in the downwards direction.

IF offset

The result is that the 4029 counter chain provides a five digit BCD number which corresponds exactly to the frequency that you want to receive or transmit on; in the example IC12 will have a BCD '2' on its outputs, IC11 will have an '8' and so on until IC8 which has a '5' on its output. Together the counters display the frequency 28215 which represents the program number for the HEF4751, IC2.

IC2 requires that the digits of the programming number are fed into it sequentially to the A port $\overline{A0}$ to $\overline{A3}$. A row of 4016 CMOS switches, IC13 to IC17, are turned on in succession by the digit select outputs on IC2, $\overline{D0}$ to $\overline{D4}$. Note that all programming inputs and strobe outputs are active low, inversion by the hex invertors IC4 and IC6.

You might well ask yourself 'so far, so good but what about the IF offset? I've loaded 28215 into the synthesiser but the frequency I really need is 37.215.' If you were really awake while you have been reading this you might also have noticed that IC2 has just a subtractor, not the adder that you really need. Exactly put, number B is always subtracted from number A even when you need to add them together (A=28216, B=09000, LO=37215).

It requires a little trick to get 37215 programmed into the synthesiser while displaying 28215. You simply add 100000 to number A so that the actual programming number is 128215, and subtract 9000 from 100000 and use the remainder, 91000, as the constant program number for the B input. So now: 128215 (number A) — 91000 (number B) = 37215, the LO frequency needed for reception of 28215. QED.

A 10.7MHz IF offset is obtained with B=89300, 21.4 MHz offset with B=78600, 35.4 MHz offset with B=64600 and so on. The B number is constant and programmed by diodes D11, D12 and D13 making the BCD number 91000. D9 and D10, pulled down during $\overline{D6}$, program the internal counter configuration and have nothing to do with the frequency programming. Similarly D7 and D8, also active during $\overline{D6}$, perform a similar function on the A input. Descriptions of the actual functions is beyond the scope of this article. D6, active on the A input during period D5, puts the '1' in front of the 28215 of the example to produce 128215.

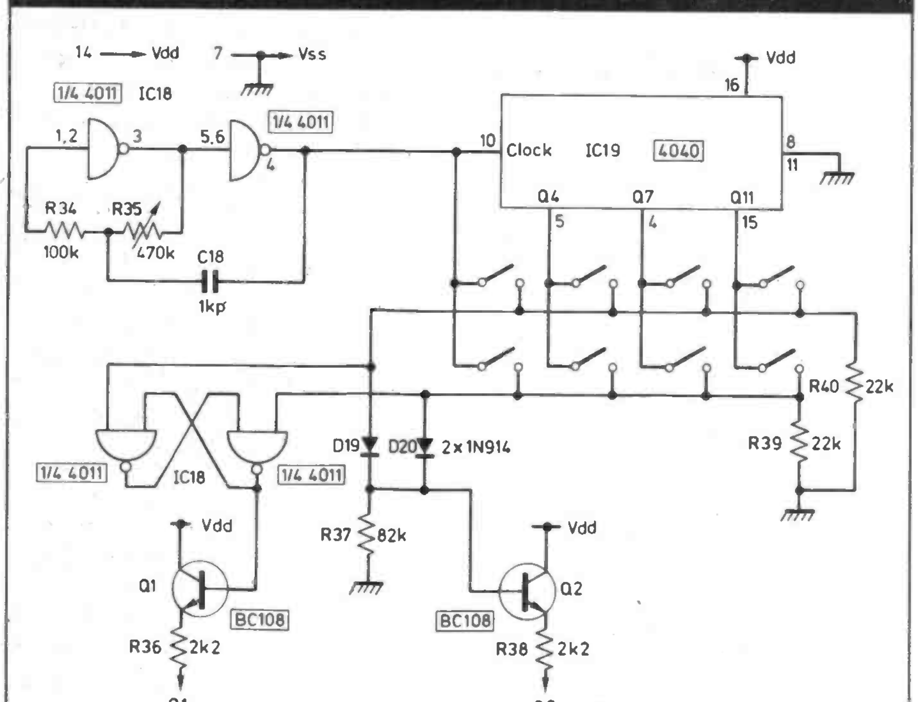

FIG.8

Step size

IC1 and IC2 (**Fig 4**) comprises a frequency synthesis system which operates in two stages. The 5MHz crystal is divided down to produce a 10kHz reference frequency. A 5MHz crystal has been suggested for the reference oscillator but any crystal frequency up to 10MHz would have done equally well. The only proviso is that the crystal frequency produces a whole number when divided by 10kHz. The required division ratio is programmed by hard witing of IC1.

Although the final synthesiser steps are arranged in 1kHz, the system does a first approximation at 10 kHz using the X10 output designed FF. When the signal and reference frequencies ae sufficiently close, the system moves to 1kHz resolution using the high accuracy analogue phase comparator circuitry mentioned earlier. In a later issue, we plan to give details of a simple addition to the basic circuit which offers synthesis in 100 or 10Hz steps. Resolution at this level only requires the addition of four cheap 4000 series CMOS circuits.

The comparator outputs are summed in an integrator circuit, Fig 5, and rescaled to provide up to 25V for the varicaps in the VCO. As an interesting aside, the 30V supply rail to the circuitry of Fig 5, essentially a 741 op-amp, is provided by a little step up inverter, Q3 driven by the crystal oscillator output on IC1. The step up transformer is nothing more than a ferrite bead wound with 12