(54) **Electrical signal generation**

(57) For digitally generating a chirp signal, a ROM 5 stores digital numbers representing successive values of the chirp, and a counter 8 is driven by pulses derived from a timing and clock unit 6 so as to cause the ROM 5 to output the digital numbers in turn. A digital to analogue converter 12 converts the signals into an analogue output which is mixed with a carrier signal derived from a local oscillator 18. A band pass filter 20 selects the upper or lower sideband to produce the required chirp output on line 22. Also disclosed is a modification to the arrangement to enable the bandwidth of the chirp to be increased.
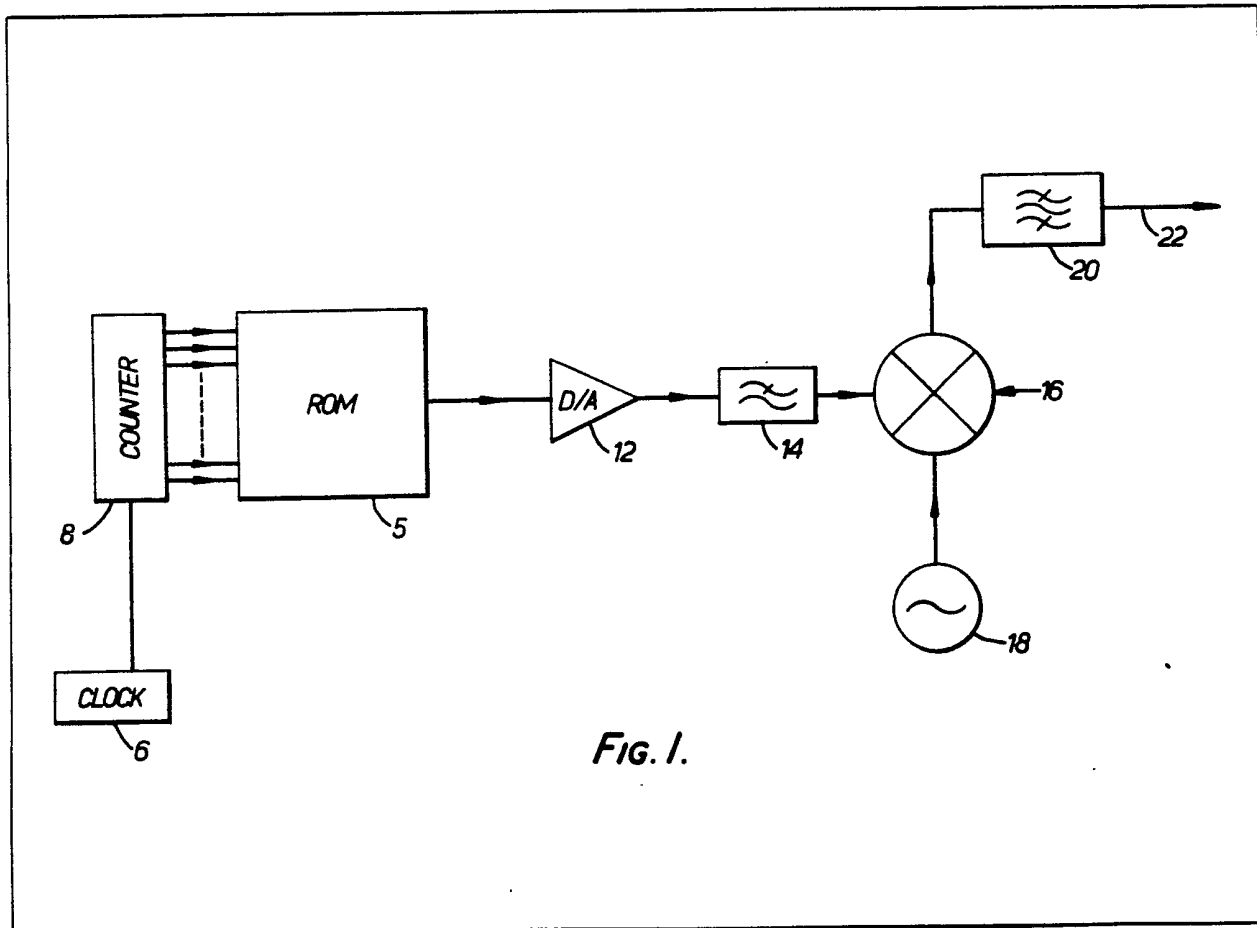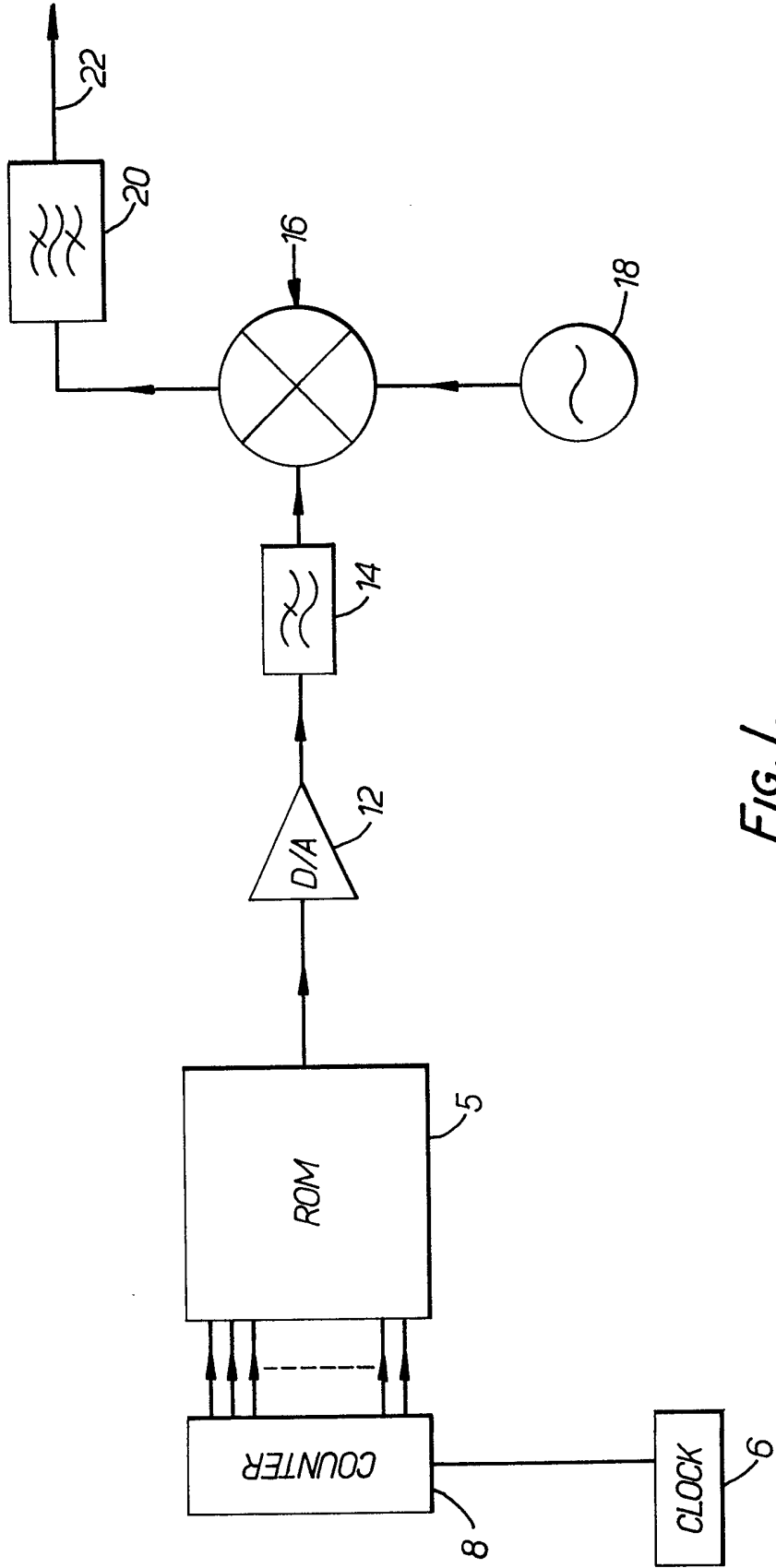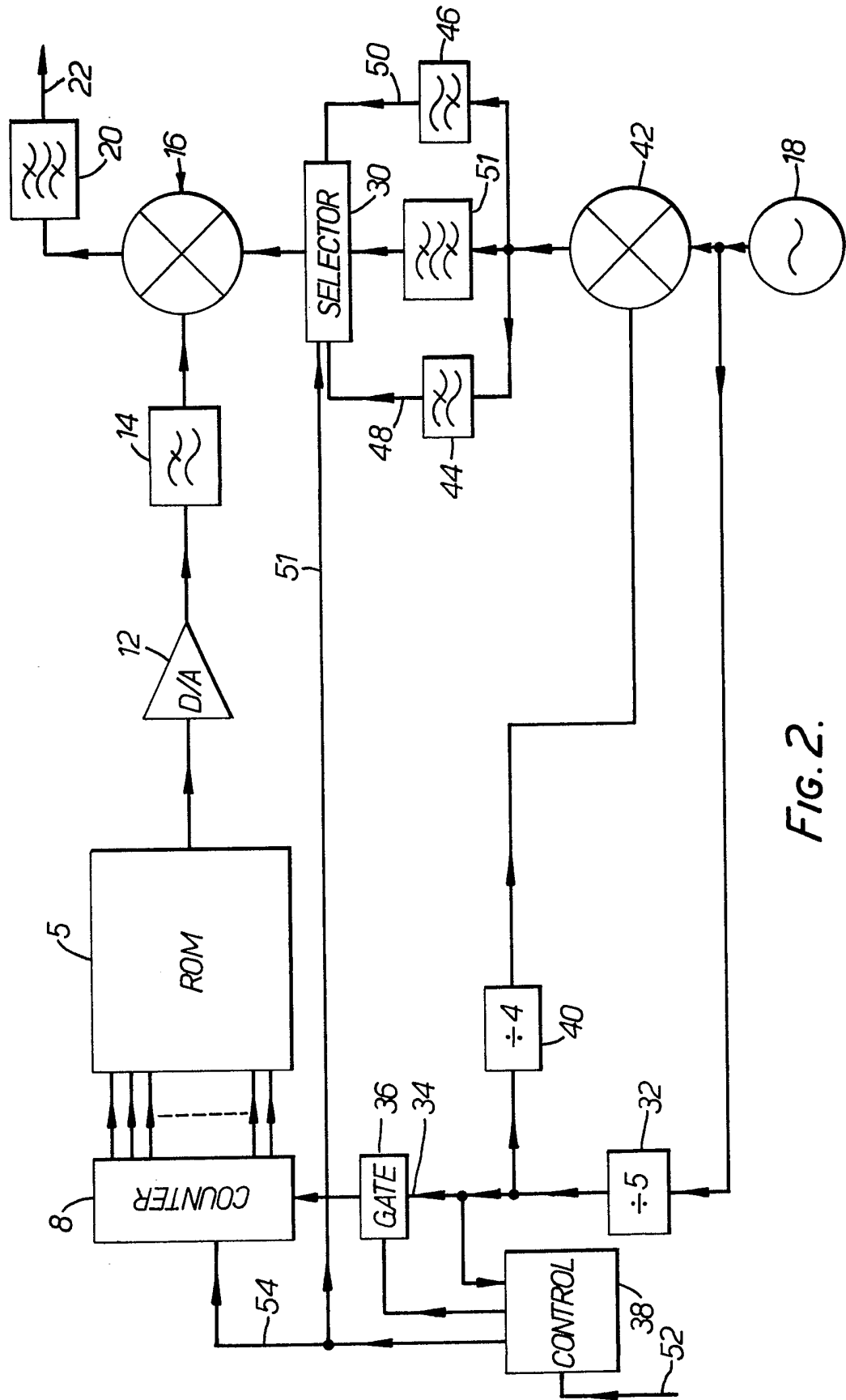

FIG. I.

GB 2 116 795 A
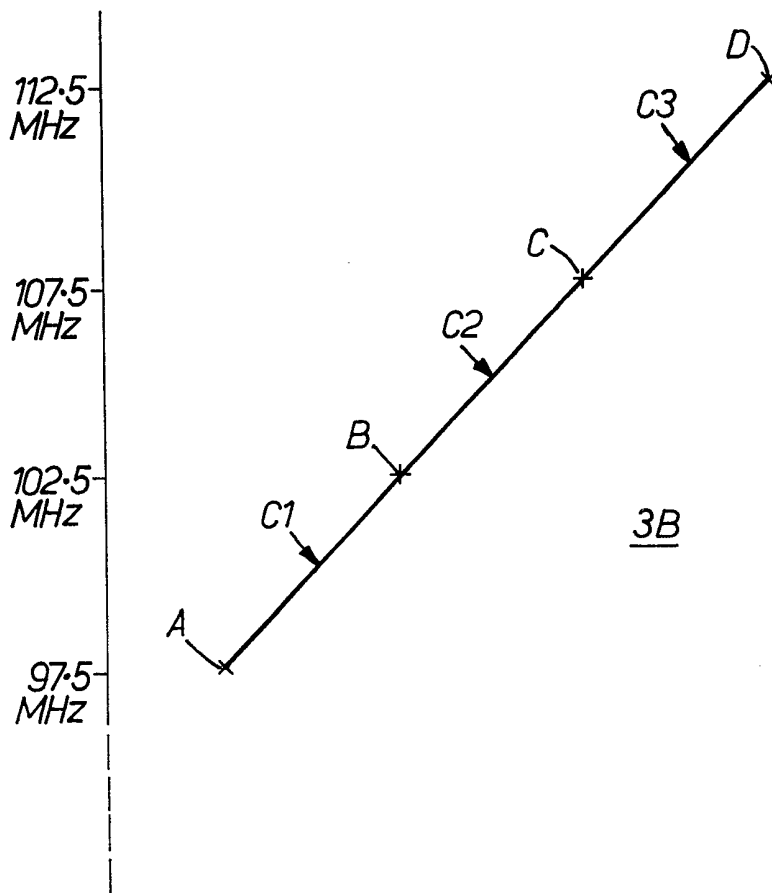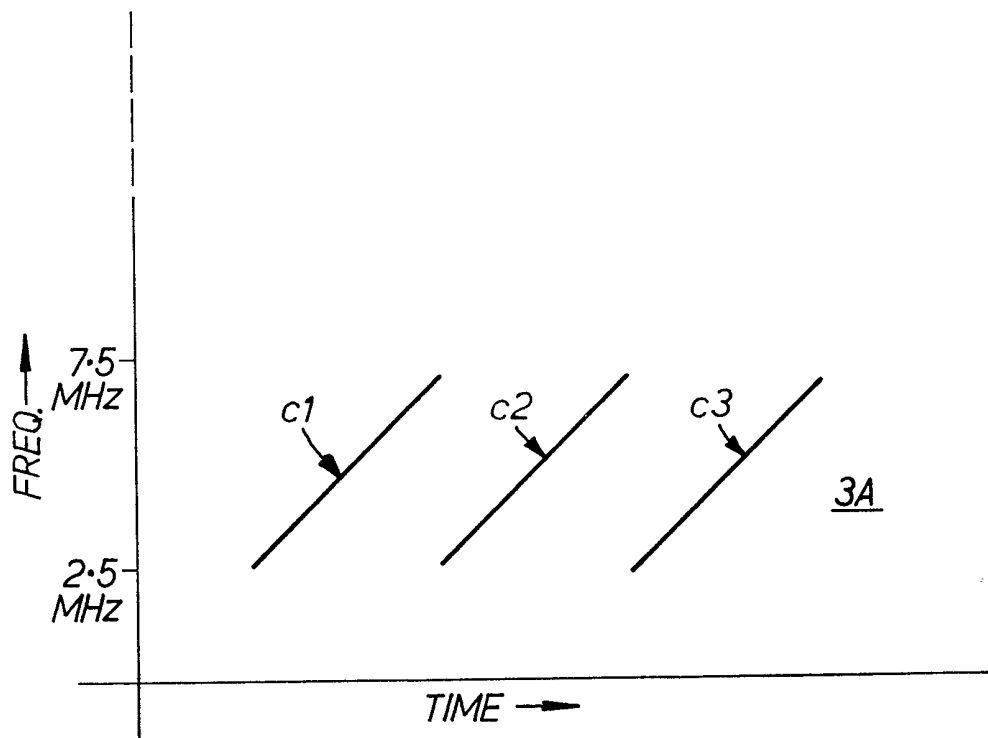
FIG. I.

FIG. 2.

FIG. 3.

3B

3A

SPECIFICATION

Improvements in and relating to electrical signal generation

5   The invention relates to electrical signal gener-
ation. More specifically, the invention relates
to arrangements for generating signals having
a frequency modulated wave form such that
10   the frequency at any point on the wave form
is predetermined. Such signals are referred to
as "chirps" and are so-called in this Specifica-
tion. They may comprise waveforms whose
frequency is swept progressively from one
15   limit to another.
     Various novel features of the invention will
be apparent from the following description,
given by example only, of an electrical circuit
arrangement embodying the invention for
20   generating chirp signals, reference being
made to the accompanying diagrammatic
drawings, in which:
     Figure 1 is a block diagram of one of the
arrangements;
25   Figure 2 shows a modified form of the
arrangement of Fig. 1 for generating chirp
signals of increased bandwidth; and
     Figure 3 is a diagram for explaining the
operation of Fig. 2.
30   More specifically to be described is the
generation of a frequency modulated electrical
signal of pre-determined time duration and
whose frequency at any time instant is predet-
ermined in which a plurality of predetermined
35   values are stored each representing the value
of the said electrical signal at a respective said
time instant, and in which the stored values
are output successively whereby to generate
the said electrical signal.
40   Advantageously, the stored values are
stored as respective digital numbers and are
output through a digital to analogue conver-
ter.
     In a more specific sense, there will be
45   disclosed below an arrangement for generat-
ing a chirp of predetermined time duration
and whose frequency sweeps in a predeter-
mined manner from one end of a predeter-
mined frequency range to the other end
50   thereof, comprising storage means for storing
a plurality of digital numbers each represent-
ing the value of the electrical signal at a
predetermined time instant within its duration,
control means operative to activate the sto-
55   rage means to output the digital numbers in
succession, digital to analogue converting
means operative to convert the digital num-
bers into respective analogue values constitut-
ing an analogue signal, signal generating
60   means operative to generate a predetermined
carrier signal, mixing means operative to mix
the analogue signal with the carrier signal,
and bandpass filter means for selecting one or
other of the side band outputs of the mixing
65   means as the desired chirp.

     Advantageously, the control means com-
prises a counter and timing means for regu-
larly stepping the counter through its count
sequence whereby to address the storage lo-
70   cations of the storage means in turn. Drive
pulses for the counter may be derived from
the said carrier signal.
     Advantageously, the signal generating
means comprises means for producing a plu-
75   rality of reference signals each having a pre-
determined and different frequency, and the
control means may comprise selecting means
operable to select any one of these signals
and to feed it to the mixing means as the
80   carrier signal, and a control unit operative to
control the feeding of the drive pulses to the
counter so that the said analogue signal is
successively repeated and to control the se-
lecting means so as to select each of the said
85   reference signals as the carrier signal in turn,
the control unit being so operative and the
frequencies of the reference signals having
such values that the sideband outputs of the
mixing means selected by the bandpass filter
90   means together constitute a chirp which
changes progressively in frequency.
     The signal generating means may produce
the reference signals and the drive pulses by
division from the output of a master oscillator.
95   Instead it may produce the reference signals
and the drive pulses by means of a respective
oscillators all of which are phase-locked to a
master oscillator.
     The foregoing are exemplary of and not
100 exhaustive of the various features of the cir-
cuit arrangement now to be more specifically
described.
     The chirp to be produced by the circuit
arrangement may have band width of, say,
105 5MHz and a duration of, say, 25 microse-
conds. The parameters of the chirp, that is,
the phase and frequency at specified time
instants during its duration, are defined by
respective samples such as respective eight-bit
110 binary numbers, for example in a suitable
non-volatile store 5. When a chirp is to be
generated, a clock generator 6, operating at
20MHz for example, feeds clock signals to a
counter 8 which produces a sequence of
115 output address signals on lines 10 which
cause the eight bit numbers to be output by
the store 5 in turn and fed to a digital to
analogue converter 12. If the frequency of the
clock 6 is 20 MHz, this produces 500 clock
120 pulses within the 25 micro second duration,
and the store 5 is therefore arranged to store
500 digital numbers to define the chirp, each
specifying an instantaneous amplitude for the
chirp. The digital to analogue converter 12
125 thus produces corresponding analogue out-
puts which are passed through a low pass
filter 14 to one input of a mixer 16.
     The stored digitial numbers are arranged
such that the centre frequency of the signal
130 produced by the digital to analogue converter

12 is at 5 MHz (in this example), and it therefore sweeps in frequency between 2.5 and 7.5 MHz. The mixer 16 mixes this signal with an input from a local oscillator 18 at,
5 say, 100 MHz, and a bandpass filter 20 selects one or other of the two sidebands produced, the lower sideband extending from 97.5 down to 92.5 MHz and the upper sideband extending from 102.5 to 107.5
10 MHz. The selected sideband is the desired chirp. If the lower sideband is selected it will be a down-sweeping chirp, that is, sweeping from 7.5 to 2.5 MHz, while if the upper sideband is selected, it will be an up-sweeping
15 chirp.

The lower frequency of the digitally generated signal should be sufficiently high to ensure that the two sidebands produced after up-conversion in the mixer 16 are separated
20 by an amount large enough to prevent interference. In the present example, they are separated by 5 MHz which has been found to be sufficient.

The 20MHz sampling frequency produced
25 by the clock 6 may be increased, to reduce distortion in the chirp, if the operating parameters of the digital components permit.

The up-conversion by the mixer 16, in order to produce the chirp at the desired IF, is
30 carried out, because speed restraints of the digital devices may prevent direct generation of the chirp at the desired IF. However, if such speed restraints do not apply, the chirp may be directly generated, that is, without the
35 need for the mixer and the local oscillator.

In a modification which may have advantages in circumstances where the speed requirements imposed on the ROM 5 are too high, the ROM may be replaced by a high
40 speed random access memory (RAM) which is connected to the ROM so as to receive the required digital signals from the ROM at a relatively low speed immediately prior to the generation of the chirp. The RAM is then
45 addressed at high speed by the counter 8 to generate the chirp.

The chirp produced can have a linear or a non-linear frequency sweep as required. Non-linear sweeps provide a wider range of design
50 options and significant operational advantages.

Figure 2 shows a modified form of the arrangement of Fig. 1, providing an output chirp of increased bandwith, and items in Fig.
55 2 corresponding to items in Fig. 1 are similarly referenced.

In the arrangement of Fig. 2, the output of the local oscillator 18 is not fed directly to mixer 16 but via a selector switch 30. In
60 addition, it is fed through a divide-by-five divider 32 to produce an output at 20 MHz which is supplied to counter 8 on a line 43 via a control gate 36 and thus produces the clock signals corresponding to those produced
65 by the clock generator 6 in Fig. 1. In the Fig.

2 arrangement, the gate 36 is controlled by a control unit 38.

The 20 MHz output from the divider 32 is also fed through a divide-by-four divider 40 to
70 produce a 5 MHz output supplied to one input of a mixer 42 which also receives the 100 MHz output oscillator 18. Filters 44 and 46 respectively select the lower and upper sidebands (at 95 and 105 MHz) which are fed
75 to the selector switch 30 on lines 48 and 50 while a bandpass filter 51 feeds the 100 MHz output to the selector switch.

The selector switch 30 is controlled by the control unit 38.
80 The operation of the Fig. 2 arrangement will be described with reference to Fig. 3.

When a start signal is received on a line 52, the control unit 38 opens the gate 36 and sets selector switch 30 so as to pass to
85 the mixer 16 the 95 MHz signal on line 48.

As already explained in conjunction with Fig. 1, the counter 8 is now stepped through at 20 MHz, in response to the sampling signals on line 34, and the digital to analogue
90 converter 12 thus produces a signal output centred at 5 MHz and with a 5 MHz bandwidth, as shown at C1 in Fig. 3A. This waveform is mixed with the 95 MHz output supplied to mixer 16 through switch 30 and
95 therefore produces a chirp C1 on line 22 which sweeps from a lower frequency of 97.5 MHz to an upper frequency of 102.5 MHz as shown between A and B in Fig. 3B, (assuming that the bandpass filter 20 is selecting the
100 upper sideband).

When the control unit 38 determines that the chirp output has been completed, it resets the counter 8 by means of a re-set line 54 and sets selector switch 30 so as to feed
105 the 100 MHz output from oscillator 18 to the mixer 16. The counter 8 is then stepped through its counts again, by the 20 MHz signal on line 34, and the digital to analogue convertor 12 therefore produces a second
110 signal output, shown at c2 in Fig. 3A this of course being identical with the signal with a carrier of 100 MHz, and the result is an output chirp C2 on line 22 at a centre frequency of 100 MHz, sweeping from 102.5
115 MHz to 107.5 MHz, that is, between points B and C in Fig. 3B.

This process is repeated again, so that the digital to analogue convertor 12 produces a third signal output c3, identical with the sig-
120 nals C1 and C2 previously produced, but during production of the third signal c3, the control unit 38 sets the selector switch 30 to select the 105 MHz output on line 50. Therefore, output line 19 carries a chirp C3 sweep-
125 ing from 107.5 MHz to 112.5 MHz, that is, between points C and D in Fig. 3B.

In this way, therefore, a composite chirp output is produced on line 19 having a bandwidth three times the bandwidth of the
130 basic chirp produced by the digital to ana-

logue converter 12, but only using a single
set of stored digital numbers, the composite
chirp sweeping from a lower frequency of
97.5 MHz to an upper frequency of 112.5
5 MHz.
It is important that there should be little or
no discontinuity in output, or phase change,
at the change-over points (B and C in Fig. 3)
where chirp generation is re-started and the
10 carrier frequency is changed. This is mainly
ensured by the fact that a single master
oscillator, oscillator 18, is used, to generate
the three carrier frequencies required as well
as the sampling frequency driving the counter
15 8. Instead, however, the three carrier frequen-
cies and the sampling frequency could all be
generated from individual oscillators all phase-
locked to a master oscillator.
In the Fig. 2 embodiment, the mixer 16
20 should be a mixer producing a single side-
band output. This is necessary because the
width of the passband which the filter 20 is
required to have, in order to pass the compo-
site chirp, is such that it would be sufficient to
25 pass part of the other sideband as well.
It will be appreciated that technique illus-
trated in Fig. 2 can be modified to produce an
output chirp of stil greater bandwith.
In the system described with reference to
30 Figs. 2 and 3, the same chirp is produced
several times, each time at a different centre
frequency, so as to produce a final, compo-
site, chirp of increased bandwidth. This ar-
rangement is therefore suited to the pro-
35 duction of a linear composite chirp. However,
it is not essential that each individual chirp
making up the composite chirp be the same.
The arrangement shown in Fig. 2 could be
modified so that the individual chirps were not
40 all identical but were mutually arranged to
produce a composite chirp giving a required
non-linear frequency sweep. The data stored
for each chirp would thus be stored in a
different part of the store. In fact, in many
45 applications, it is likely that the composite
chirp would have a non-linear frequency
sweep that was nevertheless symmetrical
about the centre frequency of the composite
chirp and some sharing of the storage space
50 might therefore be possible. Even in such
cases, however, it may be preferably still to
use separate storage space for each individual
chirp because this enables local variations to
compensate for distortion effects in other
55 parts of the system. It is believed that the
modifications necessary to the circuitry of Fig.
2, in order to enable individual chirp data to
be accessed from different parts of the ROM
5, would be clear to those skilled in the art.
60 For example, the counter 8 could be con-
nected to the ROM 5 through a suitable
selector switch which would be switched each
time the counter was reset, so as to address
different parts of the ROM.
65

CLAIMS
1. A method for the generation of a fre-
quency modulated electrical signal of predet-
ermined time duration and whose frequency
70 at any time instant is predetermined, in which
a plurality of predetermined values are stored
each representing the value of the said electri-
cal signal at a respective said time instant,
and in which the stored values are output
75 successively whereby to generate the said
electrical signal.
2. A method according to Claim 1, in
which the stored values are stored as respec-
tive digital numbers and including the step of
80 converting them into analogue from when
they are output.
3. Apparatus for generating a frequency
modulated electrical signal of predetermined
time duration and whose frequency at any
85 time instant is predetermined, comprising
means for storing a plurality of predetermined
values each representing the value of the said
electrical signal at a respective said time in-
stant, and output means for outputting the
90 stored values successively whereby to gener-
ate the said electrical signal.
4. Apparatus according to Claim 3, in
which the stored values are stored as respec-
tive digital numbers and in which the output
95 means includes a digital to analogue conver-
ter.
5. An arrangement for generating a chirp
of predetermined time duration and whose
frequency sweeps in a predetermined manner
100 from one end of a predetermined frequency
range to the other end thereof, comprising
storage means for storing a plurality of digital
numbers each representing the value of the
electrical signal at a predetermined time in-
105 stant within its duration, control means opera-
tive to activate the storage means to output
the digital numbers in succession, digital to
analogue converting means operative to con-
vert the digital numbers into respective ana-
110 logue values constituting an analogue signal,
signal generating means operative to generate
a predetermined carrier signal, mixing means
operative to mix the analogue signal with the
carrier signal, and bandpass filter means for
115 selecting one or other of the side band out-
puts of the mixing means as the desired chirp.
6. An arrangement according to Claim 5,
in which the control means comprises a coun-
ter and timing means for regularly stepping
120 the counter through its count sequence
whereby to address the storage locations of
the storage means in turn.
7. An arrangement according to Claim 6,
in which drive pulses for the counter are
125 derived from the said carrier signal.
8. An arrangement according to any one
of Claims 5 to 7, in which the signal generat-
ing means comprises means for producing a
plurality of reference signals each having a
130 predetermined and different frequency, and

the control means comprises selecting means
operable to select any one of these signals
and to feed it to the mixing means as the
carrier signal, and a control unit operative to
5 control the feeding of the drive pulses to the
counter so that the said analogue signal is
successively repeated and to control the se-
lecting means so as to select each of the said
reference signals as the carrier signal in turn,
10 the control unit being so operative and the
frequencies of the reference signals having
such values that the sideband outputs of the
mixing means selected by the bandpass filter
means together constitute a chirp which
15 changes progressively in frequency
    9.   An arrangement according to Claim 8,
in which the signal generating means pro-
duces the reference signals and the drive
pulses by division from the output of a master
20 oscillator.
    10.   An arrangement according to Claim 8,
in which the signal generating means pro-
duces the reference signals and the drive
pulses by means of respective oscillators all of
25 which are phase-locked to a master oscillator.
    11.   A method of chirp generation, sub-
stantially as described with reference to Fig. 1
of the accompanying drawings.
    12.   A method of chirp generation, sub-
30 stantially as described with reference to Figs.
2 and 3 of the accompanying drawings.
    13.   An arrangement for chirp generation,
substantially as described with reference to
Fig. 1 of the accompanying drawings.
35   14.   An arrangement of chirp generation,
substantially as described with reference to
Figs 2 and 3 of the accompanying drawings.