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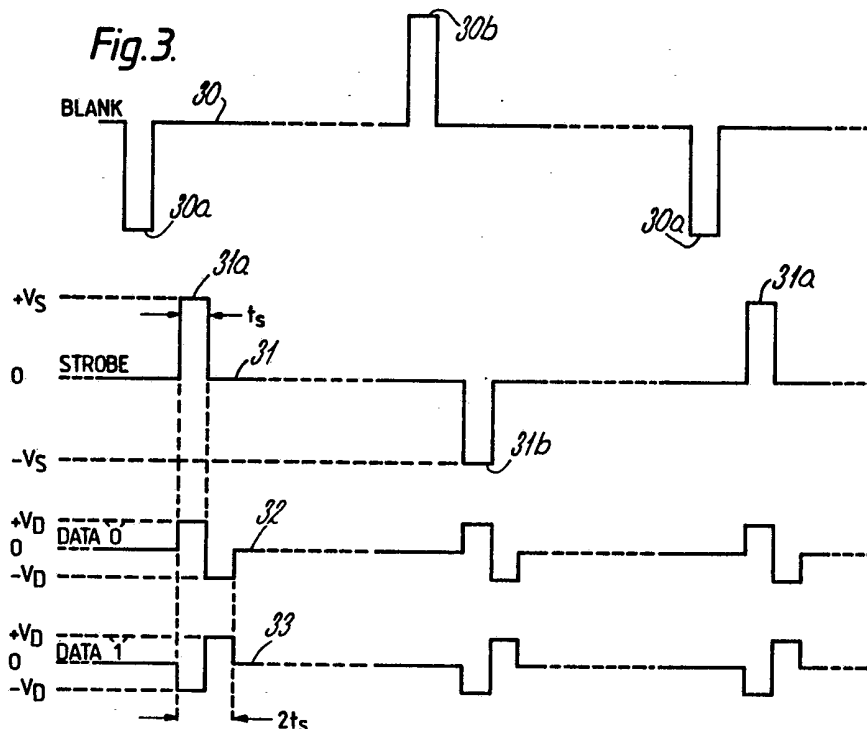
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G5C A310 A342 HB

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None

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G5C
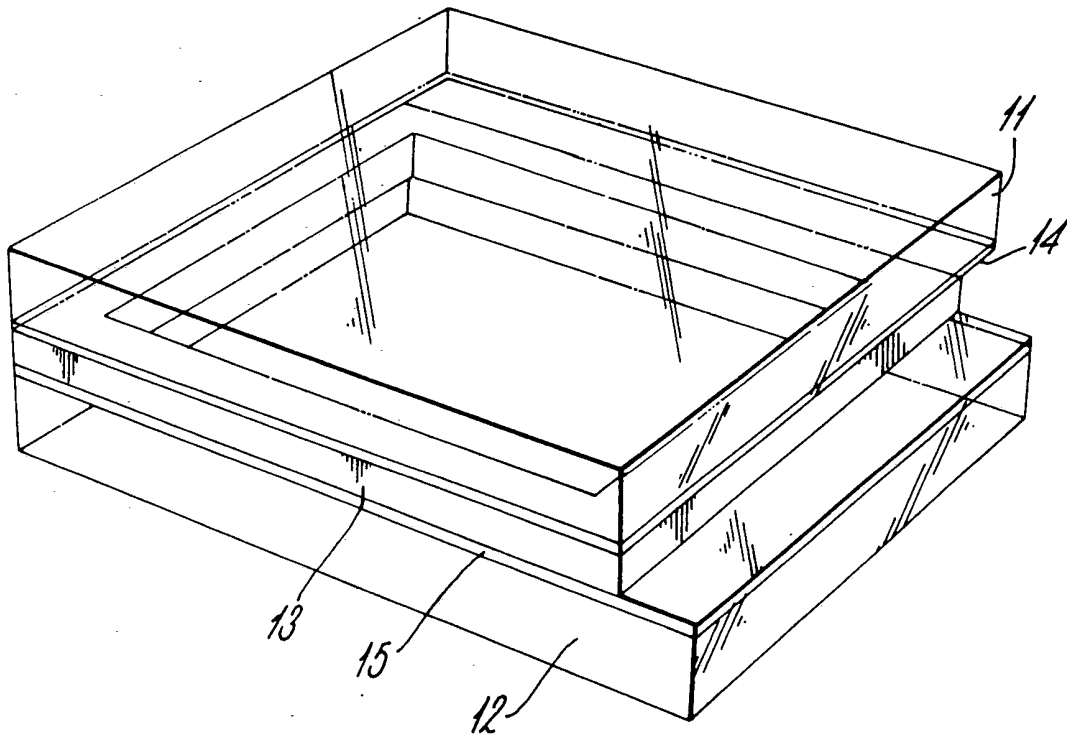**Selected US specifications from IPC sub-class G09G**

(54) **Addressing liquid crystal cells**

(57) A method of addressing a matrix addressed ferroelectric liquid crystal cell is described that uses parallel entry of balanced bipolar data pulses on one set of electrodes to co-operate with serial entry of unipolar strobe pulses on the other set of electrodes. Data entry is preceded with blanking (erasing) pulses applied to the strobe lines. The polarity of the strobing and blanking pulses is periodically reversed to maintain charge balance in the long term. Polarity reversals may be on a regular or random basis. The blanking pulses may be applied to a single, selected group or to all electrodes. The blanking pulse may be included in the strobe waveform.
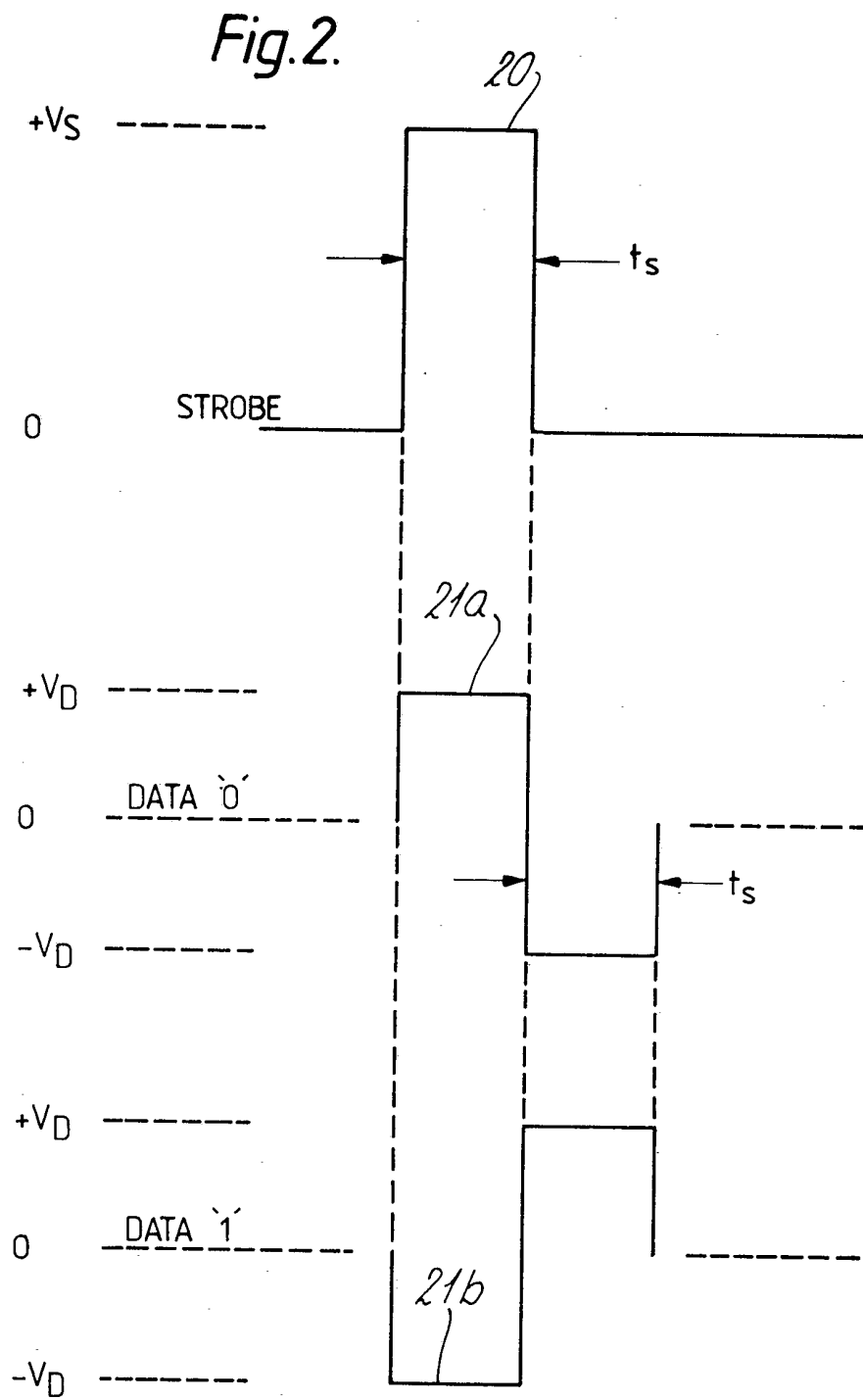
Fig.3.

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The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

Fig.1.

Fig.2.

Fig.3.

Fig.4.

2173336

Fig.5.

+V_D —— —— 52

0 DATA '0'

t_s

t_s/m

−mV_D —— ——

+mV_D —— —— 53

0 DATA '1'

−V_D —— ——

Fig.6.

+V_D —— —— 62

0 DATA '0'

t_s

t_s/m

−mV_D —— ——

t_ol

+mV_D —— —— 63

0 DATA '1'

−V_D —— ——

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Fig.7.
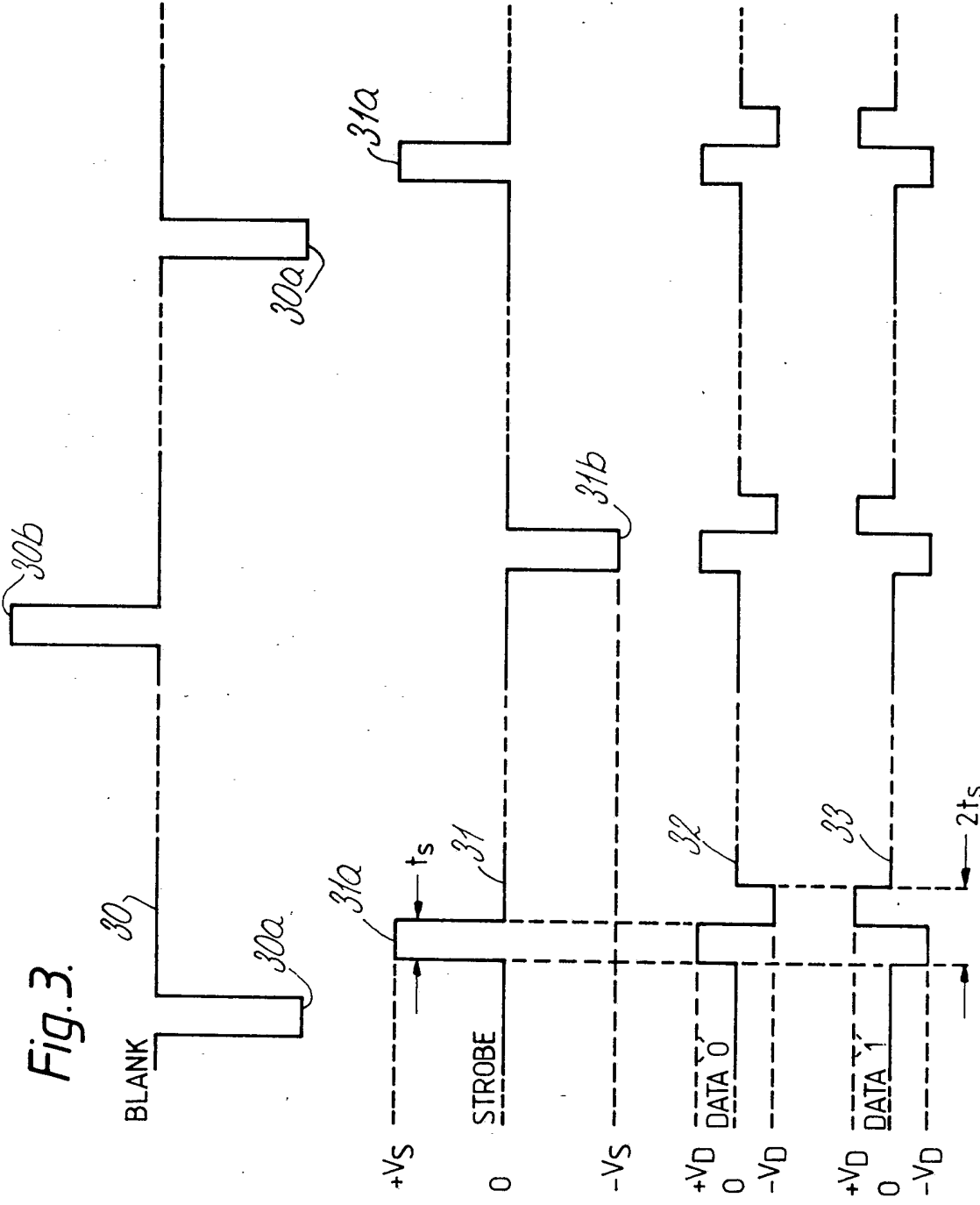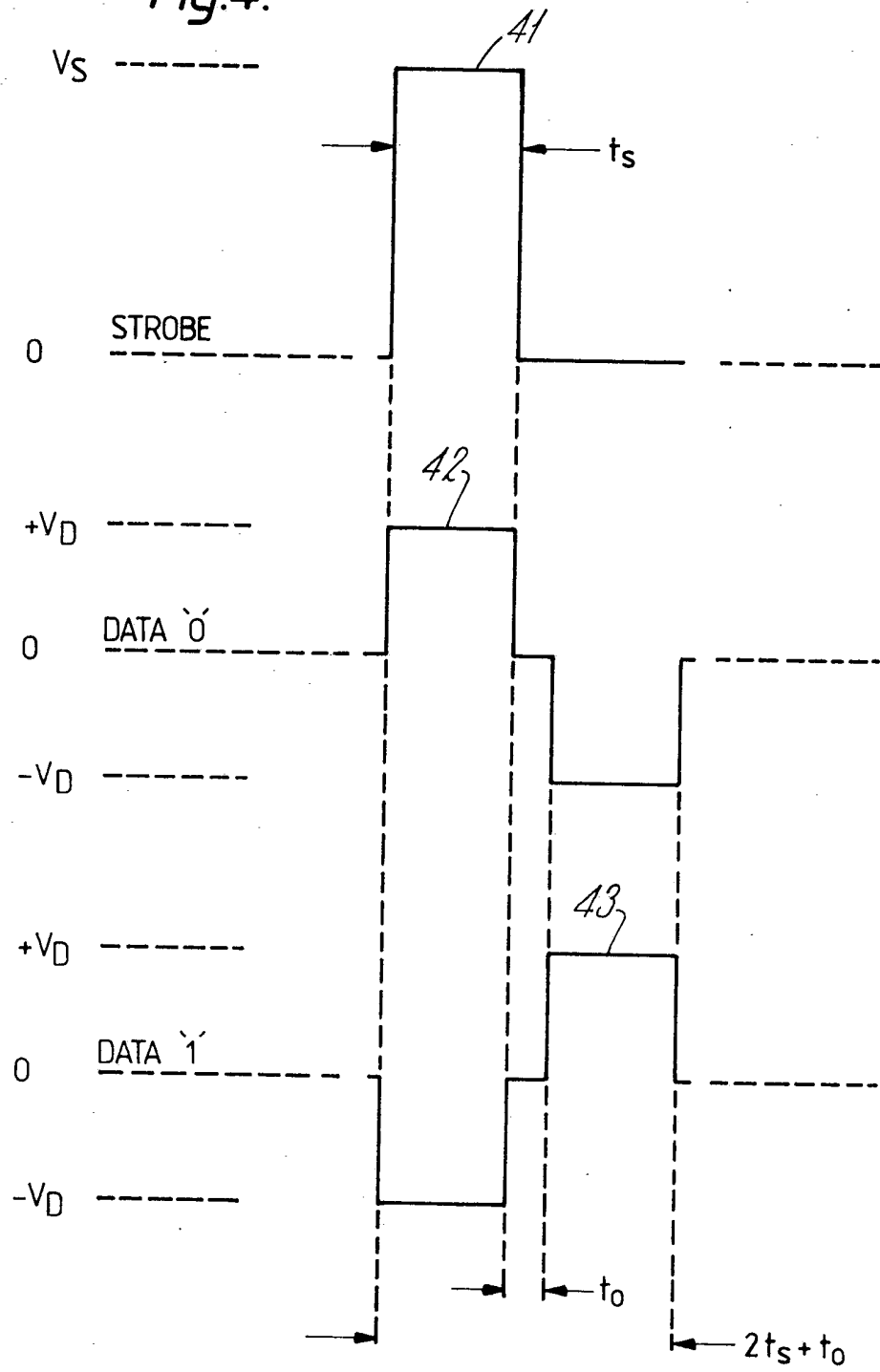
Fig.8.

Fig. 9.

SPECIFICATION

Addressing liquid crystal cells

5 This invention relates to the addressing of ma-
trix array type ferroelectric liquid crystal cells.
Hitherto dynamic scattering mode liquid
crystal cells have been operated using a d.c.
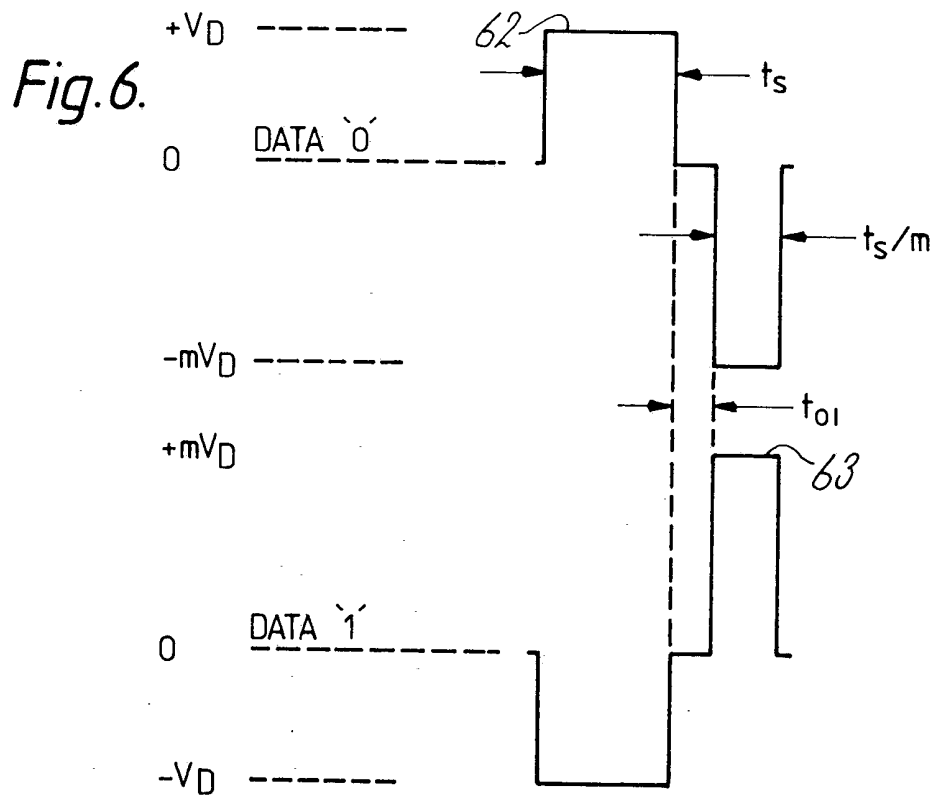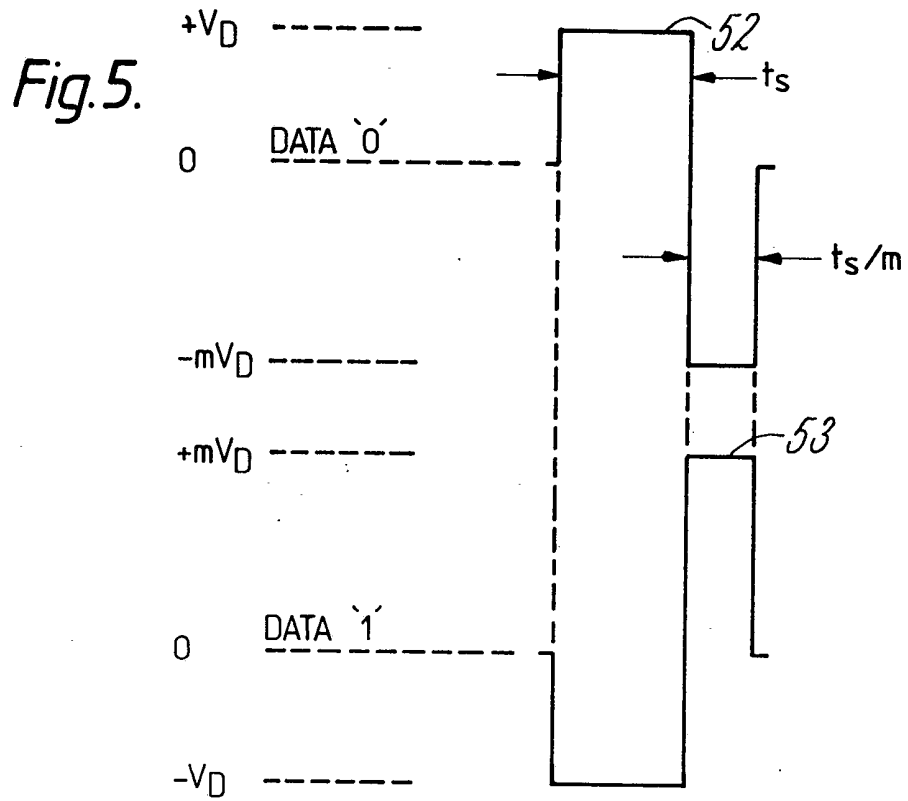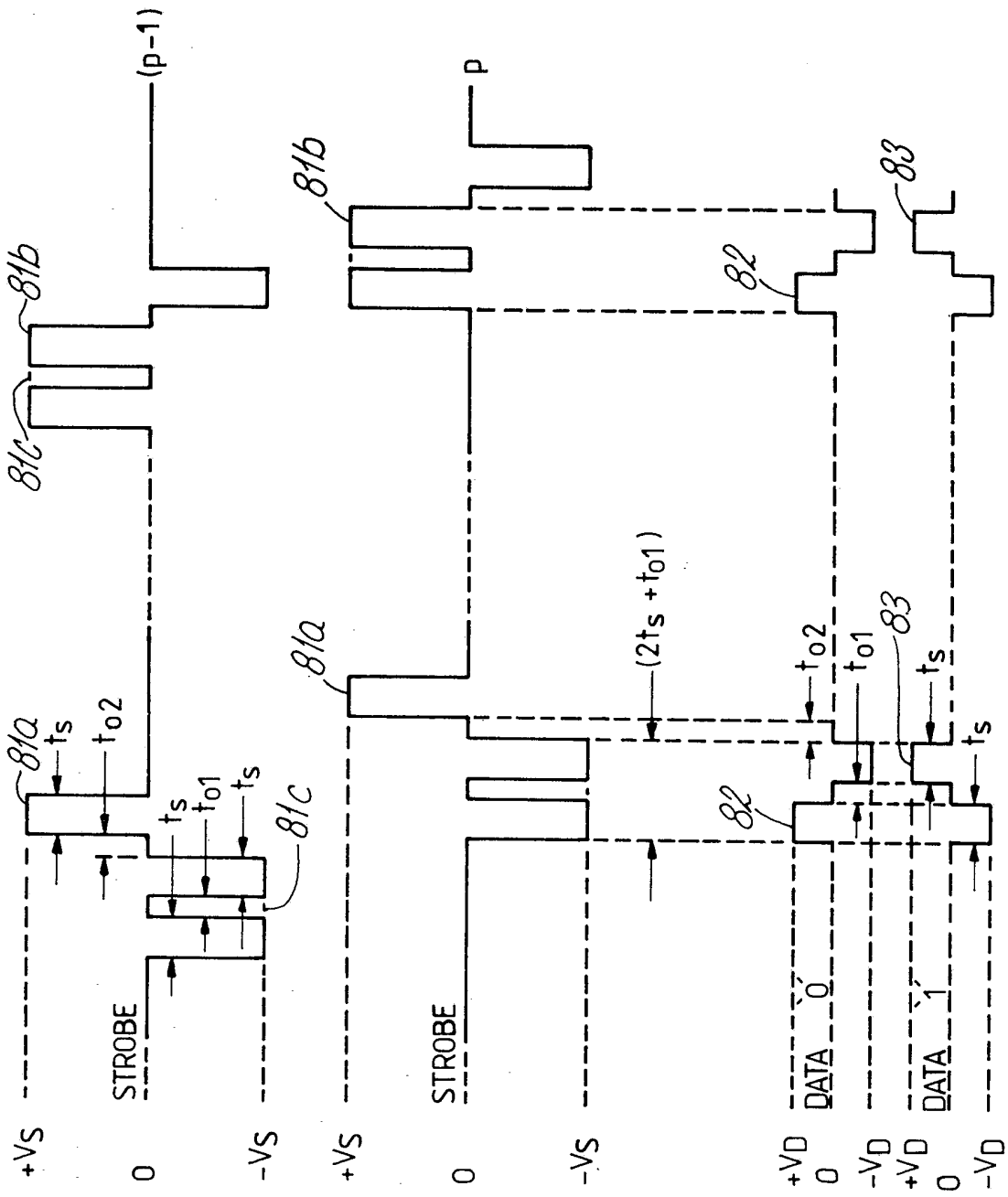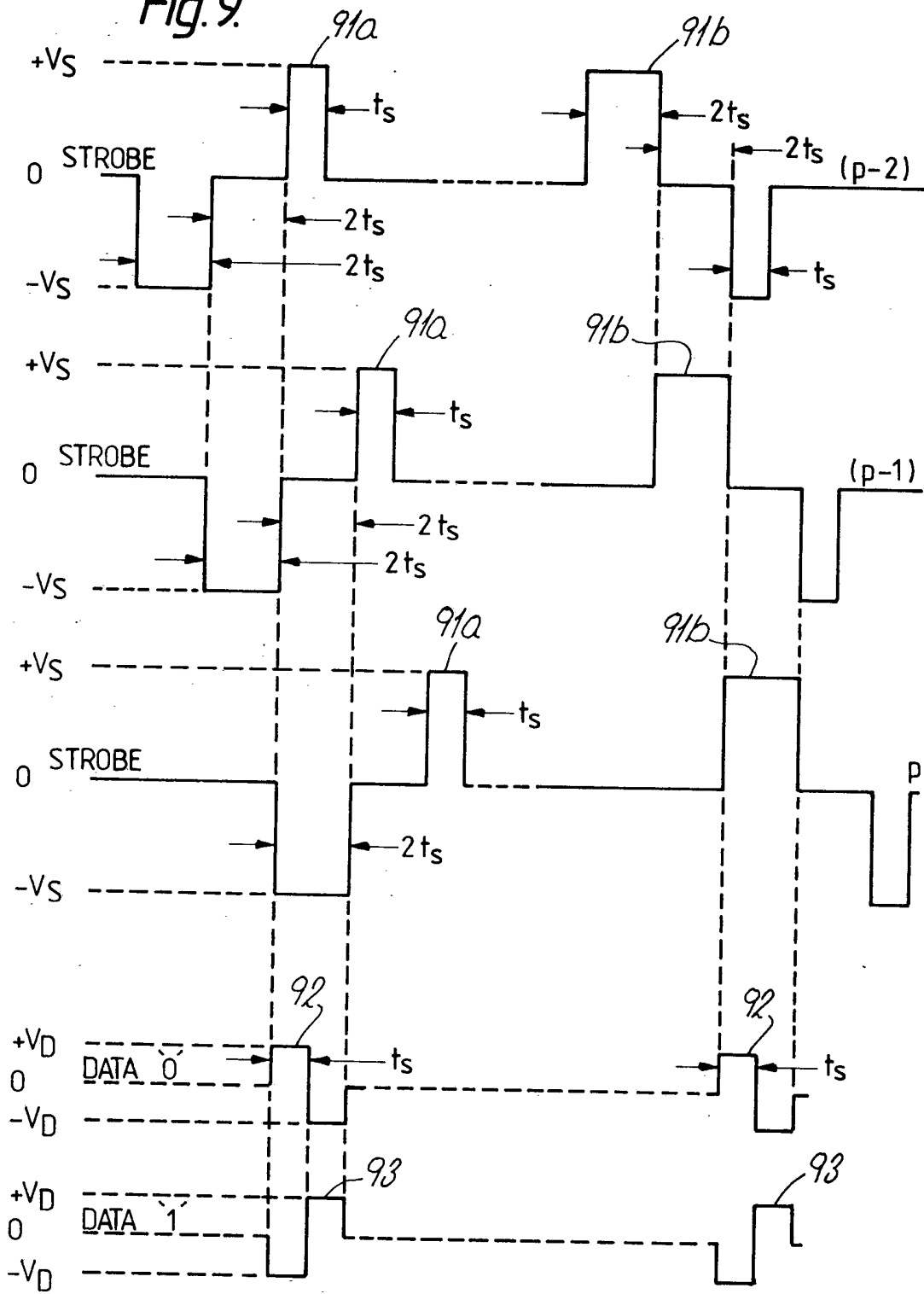drive or an a.c. one, whereas field effect
10 mode liquid crystal devices have generally
been operated using an a.c. drive in order to
avoid performance impairment problems asso-
ciated with electrolytic degradation of the
liquid crystal layer. Such devices have em-
15 ployed liquid crystals that do not exhibit ferro-
electricity, and the material interacts with an
applied electric field by way of an induced
dipole. As a result they are not sensitive to
the polarity of the applied field, but respond
20 to the applied RMS voltage averaged over ap-
proximately one response time at that voltage.
There may also be frequency dependence as
in the case of so-called two-frequency ma-
terials, but this only affects the type of re-
25 sponse produced by the applied field.
In contrast to this, a ferroelectric liquid crys-
tal exhibits a permanent electric dipole, and it
is this permanent dipole which will interact
with an applied electric field. Ferroelectric
30 liquid crystals are of interest in display,
switching and information processing applica-
tions because they are expected to show a
greater coupling with an applied field than that
typical of a liquid crystal that relies on cou-
35 pling with an induced dipole, and hence ferro-
electric liquid crystals are expected to show a
faster response. A ferroelectric liquid crystal
display mode is described for instance by
N.A. Clark et al in a paper entitled 'Ferro-
40 electric Liquid Crystal Electro-Optics Using the
Surface Stabilized Structure' appearing in Mol.
Cryst. Liq. Cryst. 1983 Volume 94 pages 213
to 234. By way of example reference may
also be made to an alternative mode that is
45 described in the specification of British Patent
Application No. 8426976.
A particularly significant characteristic pecu-
liar to ferroelectric smectic cells is the fact
that they, unlike other types of liquid crystal
50 cell, are responsive differently according to the
polarity of the applied field. This characteristic
sets the choice of a suitable matrix-addressed
driving system for a ferroelectric smectic into
a class of its own. A further factor which can
55 be significant is that, in the region of switch-
ing times of the order of a microsecond, a
ferroelectric smectic typically exhibits a rela-
tively weak dependence of its switching time
upon switching voltage. In this region the
60 switching time of a ferroelectric may typically
exhibit a response time proportional to the in-
verse square of applied voltage or, even
worse, proportional to the inverse single
power of voltage. In contrast to this, a (non-
65 ferroelectric) smectic A device, which in cer-

tain other respects is a comparable device ex-
hibiting a long-term storage capability, exhibits
in a corresponding region of switching speeds
a response time that is typically proportional
70 to the inverse fifth power of voltage. The sig-
nificance of this difference becomes apparent
when it is appreciated first that there is a
voltage threshold beneath which a signal will
never produce switching however long that
75 signal is maintained; second that for any cho-
sen voltage level above this voltage threshold
there is a minimum time t_s for which the sig-
nal has to be maintained to effect switching;
and third that at this chosen voltage level
80 there is a shorter minimum time t_p beneath
which the application of the signal voltage
produces no persistent effect, but above
which, upon removal of the signal voltage, the
liquid crystal does not revert fully to the state
85 subsisting before the signal was applied.
When the relationship $t_s = f(V)$ between V
and t_s is known, a working guide to the rela-
tionship between V and t_p is often found to
be given by the curve $t_p = g(V)$ formed by
90 plotting (V_1, t_2) where the points $(V_1, t_1$ and
$V_2, t_2)$ lie on the $t_s = f(V)$ curve, and where t_1
$= 10 t_2$. Now the ratio of V_2/V_1 is increased
as the inverse dependence of switching time
upon applied voltage weakens, and hence,
95 when the working guide is applicable, a con-
sequence of weakened dependence is an in-
creased intolerance of the system to the inci-
dence of wrong polarity signals to any pixel,
that is signals tending to switch to the '1'
100 state a pixel intended to be left in the '0'
state, or to switch to the '0' state a pixel
intended to be left in the '1' state.
Therefore, a good drive scheme for ad-
dressing a ferroelectric liquid crystal cell must
105 take account of polarity, and may also need
to take particular care to minimise the inci-
dence of wrong polarity signals to any given
pixel whether it is intended as '1' state pixel
or a '0' state one. Additionally, the wave-
110 forms applied to the individual electrodes by
which the pixels are addressed need to be
charge-balanced at least in the long term. If
the electrodes are not insulated from the liquid
crystal this is so as to avoid electrolytic
115 degradation of the liquid crystal brought about
by a nett flow of direct current through the
liquid crystal. On the other hand if the elec-
trodes are insulated, it is to prevent a cumula-
tive build up of charge at the interface be-
120 tween the liquid crystal and the insulation.
According to the present invention there is
provided a method of addressing a matrix-ar-
ray type liquid crystal cell with a ferroelectric
liquid crystal layer whose pixels are defined by
125 the areas of overlap between the members of
a first set of electrodes on one side of the
liquid crystal layer and the members of a sec-
ond set on the other side of the layer, in
which method the pixels are addressed on a
130 line-by-line basis after erasure, wherein unipo-

lar blanking pulses are applied to the members
of the first set of electrodes to effect erasure,
wherein for selective addressing of the pixels
unipolar strobing pulses are applied serially to
5 the members of the first set of electrodes
while charge balanced bipolar data pulses are
applied in parallel to the members of the sec-
ond set, the positive going parts being syn-
chronised with the strobe pulse for one data
10 significance and the negative going parts being
synchronised with the strobe pulse for the
other data significance, and wherein the polari-
ties of the strobe and blanking pulses are per-
iodically reversed to provide charge balance
15 for the individual members of the first set of
electrodes.
   There follows a description of a ferroelectric
liquid crystal cell and of a number of ways by
which it may be addressed. With the excep-
20 tion of the first method, which has been in-
cluded for the purposes of comparison, all
these methods embody the present invention
in preferred forms. The first method is one of
the methods described in Patent Specification
25 No. 2146473A. The description refers to the
accompanying drawings in which:
   Figure 1 depicts a schematic perspective
view of a ferroelectric liquid crystal cell;
   Figure 2 depicts the waveforms of a drive
30 scheme previously described in Patent Specifi-
cation No. 2146473A, and
   Figures 3 to 9 depict the waveforms of
seven alternative drive schemes embodying
the invention in preferred forms.
35 Referring now to Figure 1, a hermetically
sealed envelope for a liquid crystal layer is
formed by securing together two glass sheets
11 and 12 with a perimeter seal 13. The in-
ward facing surfaces of the two sheets carry
40 transparent electrode layers 14 and 15 of in-
dium tin oxide, and each of these electrode
layers is covered within the display area de-
fined by the perimeter seal with a polymer
layer, such as polyimide (not shown), provided
45 for molecular alignment purposes. Both poly-
imide layers are rubbed in a single direction so
that when a liquid crystal is brought into con-
tact with them they will tend to promote pla-
nar alignment of the liquid crystal molecules in
50 the direction of the rubbing. The cell is as-
sembled with the rubbing directions aligned
parallel with each other. Before the electrode
layers 14 and 15 are covered with the poly-
mer, each one is patterned to define a set of
55 strip electrodes (not shown) that individually
extend across the display area and on out to
beyond the perimeter seal to provide contact
areas to which terminal connection may be
made. In the assembled cell the electrode
60 strips of layer 14 extend transversely of those
of layer 15 so as to define a pixel at each
elemental area where an electrode strip of
layer 15 is overlapped by a strip of layer 14.
   The thickness of the liquid crystal layer con-
65 tained within the resulting envelope is deter-

mined by the thickness of the perimeter seal,
and control over the precision of this may be
provided by a light scattering of short lengths
of glass fibre (not shown) of uniform diameter
70 distributed through the material of the peri-
meter seal. Conveniently the cell is filled by
applying a vacuum to an aperture (not shown)
through one of the glass sheets in one corner
of the area enclosed by the perimeter seal so
75 as to cause the liquid crystal medium to enter
the cell by way of another aperture (not
shown) located in the diagonally opposite cor-
ner. (Subsequent to the filling operation the
two apertures are sealed.) The filling operation
80 is carried out with the filling material heated
into its isotropic phase as as to reduce its
viscosity to a suitably low value. It will be
noted that the basic construction of the cell is
similar to that of for instance a conventional
85 twisted nematic, except of course for the par-
allel alignment of the rubbing directions.
   Typically the thickness of the perimeter seal
13, and hence of the liquid crystal layer, is
about 10 microns, but thinner or thicker layer
90 thicknesses may be required to suit particular
applications depending for instance upon
whether or not bistability of operation is re-
quired and upon whether the layer is to be
operated in the S_C^* phase or in one of the
95 more ordered phases such as S_I^* or S_F^*.
   Some drive schemes for ferroelectric cells
are described in Patent Specification No.
2146473A. Among these is a scheme that is
described with particular reference to Figure 1
100 of that specification, a part of which has been
reproduced herein in slightly modified form as
Figure 2. This employs bipolar data pulses
21a, 21b to co-act with unipolar strobe pulses
20. The strobe pulses 20 are applied serially
105 to the electrode strips of one electrode layer,
while the data pulses 21a, and 21b are ap-
plied in parallel to those of the other layer. In
this particular scheme the unipolar nature of
the strobe pulses dictates that pixels are
110 capable of being switched by these pulses in
one direction only. Accordingly, some form of
blanking is required between consecutive ad-
dressings of any pixel. In the description it is
suggested that this may take the form of a
115 pulse (not shown) applied to the strobe line
which is of opposite polarity to that of the
strobe pulses.
   A pixel is switched on by the coincidence
of a voltage excursion of V_s, of duration t_s, on
120 its strobe line with a voltage excursion of
$-V_D$, for an equal duration, on its data line.
These two voltage excursions combine to pro-
duce a switching voltage of $(V_s + V_D)$ for a
duration t_s. Since the switching voltage thresh-
125 old for duration t_s is close to $(V_s + V_D)$, a
blanking pulse applied to the strobe lines with-
out any corresponding voltage excursion on
the data lines will not be sufficient to achieve
the requisite blanking if it is of amplitude V_s
130 and duration t_s. Therefore, if no voltage is to

be applied to the data lines, the amplitude of
the blanking pulse must be increased to (V_s +
V_D), or its duration must be extended beyond
t_s. Both these options have the effec of re-
5 moving charge balance from the strobe lines.

Attention will now be turned to Figure 3
which depicts waveforms according to one
preferred embodiment of the present inven-
tion. Blanking, strobing, data '0' and data '1'
10 waveforms are depicted respectively at 30,
31, 32 and 33.

As before, the data pulse waveforms are
applied in parallel to the electrode strips of
one of the electrode layers 14, 15, while
15 strobe pulses are applied serially to those of
the other electrode layer. The blanking pulses
are applied to the set of electrode strips to
which the strobe pulses are applied. These
blanking pulses may be applied to each elec-
20 trode strip in turn, to selected groups in turn,
or to all strips at once according to specific
blanking requirements.

The data pulses 32 and 33 are balanced
bipolar pulses, each having positive and nega-
25 tive going excursions of magnitude $|V_D|$ and
duration t_s to give a total duration $2t_s$. If the
operating constraints allow consecutive lines
to be addressed without interruption, then
unaddressed pixels receiving consecutive data
30 pulses may see a data '1' followed immedi-
ately by a data '0', or alternatively a data '0'
followed immediately by a data '1'. In either
instance the liquid crystal layer at such a pixel
will be exposed to a potential difference of V_D
35 for a period of $2t_s$. Therefore, the magnitude
of V_D must be set so that this is insufficient
to effect switching from either data state to
the other.

The first illustrated strobe pulse 31a is a
40 positive going unipolar pulse of amplitude V_s
and duration t_s. All strobe pulses are syn-
chronised with the first half of their corre-
sponding data pulses. (They could alternatively
have been synchronised with the second
45 halves, in which case the data significance of
the data pulse waveforms is reversed.) The
liquid crystal layer at each pixel addressed by
that data pulse will, for the duration of that
strobe pulse, be exposed to a potential differ-
50 ence of (V_s − V_D) if that pixel is simultane-
ously addressed with a data '0' waveform, or
a potential difference of (V_s + V_D) if it is
simultaneously addressed with a data '1' wa-
veform. The magnitudes of V_s and V_D are cho-
55 sen so that (V_s + V_D) applied for a duration t_s
is sufficient to effect switching, but (V_s − V_D),
and V_D, both for a similar duration t_s, are not.

The data pulses are thus seen to be able to
switch the pixels in one direction only, and
60 hence, before they are addressed, they need
to be set to the other state by means of
blanking pulses 30. The blanking pulse pre-
ceding any strobing pulse needs to be of the
opposite polarity to that of the strobing pulse.
65 Thus positive going strobe pulses 31a are

preceded by negative going blanking pulses
30a, while negative going strobe pulses 31b
are preceded by positive going blanking pulses
30b. Each blanking pulse is of sufficient ampli-
70 tude and duration to set the electrode strip or
strips to which it is applied into data '0' or
'1' state as dictated by polarity. It may for
instance be of magnitude $|V_s$ + $V_D|$ and dura-
tion t_s, but a shorter or longer duration pulse,
75 with correspondingly increased or reduced am-
plitude, may be preferred to suit specific re-
quirements.

The first blanking pulse of Figure 3 is a
negative going pulse which sets the pixels to
80 which it is applied into the data '0' state. If it
is applied to only one electrode strip, then a
fresh blanking pulse will be required before
the next strip is addressed with a strobing
pulse, whereas if the blanking pulse is applied
85 in parallel to group of electrode strips, or to
the whole set of electrode strips of that elec-
trode layer 14 or 15, then each one of the
strips which have been blanked can be serially
addressed once with an individual strobe pulse
90 before the next blanking pulse is required. Per-
iodically the polarity of the blanking pulse is
reversed, directly after which the polarity of
the succeeding strobe pulse or pulses is also
reversed. Such polarity reversals may occur
95 with each consecutive blanking of any given
electrode strip, or such a strip may receive a
small number of blanking pulses and address-
ings with strobe pulses before it is subject to
a polarity reversal. The periodic polarity rever-
100 sals may be effected on a regular basis with a
set number of addressings between each re-
versal, or it may be on a random basis. A
random basis is indicated for instance when
the blanking pulses are applied to selected
105 groups of strips, and a facility is provided that
enables the sizes of those groups to be
changed in the course of data refreshing.
These polarity reversals ensure that in the
course of time each strip is individually ad-
110 dressed with equal numbers of positive going
and negative going blanking pulses. A conse-
quence of this is that each strip also ad-
dressed with equal number of positive going
and negative going strobe pulses. Hence over
115 a period of several addressings charge balance
is maintained.

Previously it was suggested that if the
blanking pulse were to have a duration t_s, it
should have a magnitude $|V_s$ + $V_D|$ in order to
120 be sufficient effect blanking. This is true if the
set of electrode strips to which the blanking
pulses are not applied are kept at zero volts
when the blanking pulses are applied to the
other set of electrodes. The blanking pulse
125 voltage can however in certain circumstances
be reduced to V_s without expanding the dura-
tion provided that, while this is applied to (se-
lected) members of one set of strips, it is
synchronised with an oppositely directed vol-
130 tage excursion of $-V_D$ applied to all the mem-

bers of the other set of strips. This introduces a momentary charge imbalance on the individual members of this other set of strips, but in the longer term this is removed by the per-
5 iodic inversion of the polarity of the blanking pulses.

When an electrode strip is addressed with a negative going blanking pulse 30a the pixels associated with that strip are all set into the
10 data '0' state. The succeeding strobe pulse is a positive going pulse 31a. The only data pulse to co-operate with a positive going strobe pulse to develop a potential difference of $(V_s + V_D)$ across the liquid crystal layer is
15 a data '1' waveform 33. When however, the strip is addressed with a positive going blanking pulse 30b, the pixels associated with that strip are set into the data '1' state. The succeeding strobe pulse 31b is negative going.
20 This co-operates with the data '1' waveform 33 to develop a potential difference of on $(V_s - V_D)$ across the liquid crystal layer, and hence the effect upon pixels addressed with this data waveform is to leave those pixels in
25 the data '1' state. Thus it is seen that the data significance of the two data waveforms is invariant under change of polarity of the strobe and blanking pulse waveforms.

When using the pulse waveforms of Figure
30 3 for addressing a ferroelectric cell in a frame blanking mode in which the blanking pulse is applied in parallel to all the electrode strips of one of the electrode layers 14, 15, the minimum line address time is seen to be $2t_s$.
35 There is then an interval between frames to allow for frame blanking. The minimum value of the line address time $2t_s$ is related to the choice of the full switching voltage $(V_s + V_D)$. It has been found however, that in some cir-
40 cumstances the minimum conditions for achieving switching are adversely affected if the switching stimulus is immediately followed by a stimulus of the opposite polarity. This is the situation prevailing when using the data
45 entry waveforms of Figure 3. Each time a pixel is switched by strobe and data pulse waveforms co-operating to produce a potential difference across the liquid crystal layer of $(V_s + V_D)$, this is immediately followed by an op-
50 positely directed potential difference of V_D. At least under some conditions the switching criteria can be somewhat relaxed, for instance to allow a shortening of the duration t_s, or a reduction of the switching voltage $V_s + V_D$.
55 This may be achieved by introducing a gap of duration t_{01} between the two halves of the data pulse waveforms 42 and 43 as depicted in Figure 4. In all other respects the waveforms are the same as those depicted in Fig-
60 ure 3. The corresponding strobe pulse waveform 41 still has its leading and trailing edges synchronised with the leading and trailing edges of the parts of the data pulses preceding the zero voltage gaps t_{01}. Typically the
65 duration t_{01} is approximately 60% of the dura-

tion t_s. It should be noted however, that any relaxation of the switching criteria afforded by this introduction of the zero voltage gap between the positive and negative going parts of
70 the data pulse waveforms is achieved at the expense of increasing the line address time from $2t_s$ to $(2t_s + t_{01})$.

A similar effect has also been found upon occasion where switching response has been
75 adversely affected by a reverse polarity stimulus that immediately preceds the switching stimulus. This is alleviated by including a further gap of t_{02} (not shown) to precede the first halves of the data pulses, thereby in-
80 creasing the line address time to $(2t_s + t_{01} + t_{02})$. The durations of t_{01} and t_{02} may be the same, but are not necessarily so.

Examination of the switching characteristics of certain ferroelectric cells has revealed that
85 it is possible in some circumstances to modify the data pulse waveforms of Figure 3 to achieve a line address time of less than $2t_s$. The modified data '0' and data '1' waveforms are depicted respectively at 52 and 53 in Fig-
90 ure 5. The parts before the zero-crossing are unchanged: they are synchronised with the strobe pulse of magnitude $|V_s|$ and duration t_s, and are themselves of magnitude $|V_D|$ and duration t_s. For each type of data pulse the vol-
95 tage excursion of the second part, the part after the zero-crossing, is m times that of the first part, but charge balance is restored by reducing the duration of the second part by a factor m in relation to the duration of the first.
100 The factor m is typically not more than 3. The line address time is reduced by the use of these asymmetric waveforms from $2t_s$ to $(1 + 1/m)t_s$.

The Figure 5 data entry waveforms involve
105 following a switching stimulus immediately with a stimulus of opposite polarity. This can be avoided by incorporating a short duration gap between the two parts of the data waveforms after the manner previously described
110 with reference to Figure 4. This produces the '0' and '1' data waveforms 62 and 63 of Figure 6. The line address time in this instance is $(1 + 1/m)t_s + t_{01}$.

When operating a ferroelectric cell of n lines
115 with waveforms as depicted in Figures 3, 4, 5 or 6, if the line address time is t_L and the blanking time is t_B, then the time taken to refresh a whole frame is $nt_L + t_B$ when the cell is operated in frame blanking mode. How-
120 ever, if it were operated in line blanking mode in which each line is individually blanked, the refresh time is expanded to $n(t_L + t_B)$. This problem is avoided with the waveforms of Figure 7. This uses a modified form of strobe
125 pulses 71 the first part of which functions to blank one line during the data entry for the preceding line.

The strobe pulses 71 are bipolar pulses, but are individually unbalanced and therefore exist
130 in two forms 71a and 71b which are the in-

verse of each other and are periodically alternated to provide charge balance in the long term. Strobe pulse 71a is negative going to a voltage $-V_s$ for a duration $2t_s$, is then imme-
5 diately positive going to a voltage $+V_s$ for a duration t_s and then remains at zero volts for a further duration t_s. The co-operating '0' an '1' data pulses 72 and 73 are identical with those of Figure 3, being balanced bipolar
10 pulses ranging from $+V_D$ to $-V_D$, and of total duration $2t_s$. The leading edges of the strobe pulses are synchronised with those of the data pulses so that a data pulse that is synchronised with the first half of a strobe pulse
15 applied to electrode strip 'p' is also synchronised with the second half of the strobe pulse applied to electrode strip (p-1). From a study of these waveforms of Figure 7 it is seen that a data '0' synchronised with the first half of
20 the first type of strobe pulse 71a will set a pixel to the '0' state in the first half of that data '0', and leave it in the '0' state for the second half. If on the other hand the data waveform was that of a data '1' pulse, then
25 the pixel would not be switched in the first half of that data pulse waveform, but would be set into the '0' state by the second half of the data pulse. Then the next data pulse will co-operate with the second half of the strobe
30 pulse waveform to set the pixel into the data '1' state if that next data pulse is a data '1' pulse, but will leave it in the data '0' state if it is a data '0' pulse. Similarly, it will be seen that with the second type of strobe pulse 71b
35 a pixel is set into the data 1 state by a data pulse synchronised with the first half of the strobe pulse, and is left in that '1' state if the next data pulse is a data '1' pulse, but will be restored to the '0' state if that next data
40 pulse is a data '0' pulse waveform. Typically, the strobe pulse waveforms 71a and 71b are alternated with each frame.

The waveforms of Figure 7 illustrate another example of drive system in which a switching
45 stimulus is immediately followed by a stimulus of opposite polarity. Hence it is another example of a system that can be modified to introduce gaps in the waveforms which separate the reverse polarity stimulus from the
50 switching stimulus by a short duration period during which no field is maintained across the liquid crystal layer. The resulting waveforms are depicted in Figure 8. The data '0' and data '1' pulse waveforms 82 and 83 each
55 have a zero voltage gap of duration t_{01} inserted between their first and second halves which remain of amplitude V_D and duration t_s. Additionally, a zero voltage of duration t_{02} is introduced between consecutive data wave-
60 forms. The durations of t_{01} and t_{02} may be the same, but are not necessarily so. Corresponding gaps are also inserted into the strobe pulse waveforms 81a and 81b. Since however, the potential across the liquid crystal is
65 not reversed at a pixel between the first and second parts of the strobe pulse, there is no need for the strobe potential to return to zero for the period t_{01} between these two parts, and it may be found more convenient to main-
70 tain the potential for the full period of $(2t_s + t_{01})$ as indicated by broken lines 81c.

Alternatively the line blanking may be performed more than one line in advance of the data entry as for instance depicted in Figure
75 9. As before, strobe pulses 91a and 91b, which are the inverse of each other, are periodically alternated to provide charge balance in the long term. Strobe pulse 91a has a total duration of $6t_s$. In the first third it is negative
80 going to a voltage $-V_s$ for a duration $2t_s$. In the second third it remains at zero volts for the whole duration $2t_s$, and in the final third it is first positive going to a voltage $+V_s$ for a duration t_s and then reverts to zero volts for
85 the final duration t_s. The co-operating '0' and '1' data pulses 92 and 93 are identical with those of Figure 3, being balanced bipolar pulses ranging from $+V_D$ to $-V_D$, and of total duration $2t_s$. The leading edges of the strobe
90 pulses are synchronised with those of the data pulses so that a data pulse that is synchronised with the first third of a strobe pulse applied to electrode strip 'p' is also synchronised with the middle third of the strobe pulse
95 applied to electrode strip (p-1), and with the final third of the strobe pulse applied to electrode strip (p-2). From a study of these waveforms it is seen that the first third of a strobe pulse 91a will set a pixel into '0' state
100 whether it is synchronised with a '0' data pulse or a '1' data pulse; that in the second third the voltages are insufficient for switching; and that in the final third the pixel will be left in the '0' state if that final third is syn-
105 chronised with a data '0' pulse waveform, but will be restored to the '1' state if it is synchronised with a data '1' waveform.

A line is then blanked for two line address times before being written instead of for only
110 one line address time provided by the waveforms of Figure 7. However, whereas with the waveforms of Figure 7 data entry that induces switching of a pixel in a period t_s can be preceded by exposure of that pixel in the im-
115 mediately preceding period of duration t_s by an opposite polarity stimulus of magnitude $|V_s + V_D|$, with the waveforms of Figure 9 the maximum reverse polarity stimulus that can occur in this period t_s immediately preceding
120 the data entry switching is a reverse polarity stimulus of magnitude $|V_D|$.

CLAIMS
1. A method of addressing a matrix-array
125 type liquid crystal cell with a ferroelectric liquid crystal layer whose pixels are defined by the areas of overlap between the members of a first set of electrodes on one side of the liquid crystal layer and the members of a sec-
130 ond set on the other side of the layer, in

which method the pixels are addressed on a
line-by-line basis after erasure, wherein unipo-
lar blanking pulses are applied to the members
of the first set of electrodes to effect erasure,
5 wherein for selective addressing of the pixels
unipolar strobing pulses are applied serially to
the members of the first set of electrodes
while charge balanced bipolar data pulses are
applied in parallel to the members of the sec-
10 ond set, the positive going parts being syn-
chronised with the strobe pulse for one data
significance and the negative going parts being
synchronised with the strobe pulse for the
other data significance, and wherein the polari-
15 ties of the strobe and blanking pulses are per-
iodically reversed to provide charge balance
for this individual members of the first set of
electrodes.
    2. A method as claimed in claim 1, wherein
20 the polarities of the strobe and blanking
pulses are periodically reversed on a regular
basis.
    3. A method as claimed in claim 1, wherein
the polarities of the strobe and blanking
25 pulses are periodically reversed on a random
basis.
    4. A method as claimed in claim 1, 2 or 3,
wherein a gap separates the positive and
negative going portions of each balanced bipo-
30 lar data pulse.
    5. A method as claimed in any preceding
claim, wherein a gap always precedes or fol-
lows each data pulse.
    6. A method as claimed in any preceding
35 claim, wherein the positive and negative going
portions of each balanced bipolar data pulse
are asymmetric, one part having m times the
amplitude of the other and $1/m^{th}$ the duration.
    7. A method as claimed in any claim of
40 claims 1 to 5, wherein the blanking pulses
and strobing pulses are combined so that,
while the strobing part of one of these com-
bined blanking and strobing pulses is being
used for data entry on one line, the same
45 data co-operates with the blanking part of the
succeeding, and partially overlapping in time,
combined blanking and strobing pulse to ef-
fect blanking of a succeeding line.
    8. A method as claimed in claim 7, wherein
50 said succeeding line is the next succeeding
line.
    9. A method as claimed in claim 7, wherein
said succeeding line is the next but one suc-
ceeding line.
55   10. A method of addressing a matrix array
type liquid crystal cell with a ferroelectric
liquid crystal layer, which method is substan-
tially as hereinbefore described with reference
to Figure 1 and Figure 3, 4, 5, 6, 7, 8 or 9
60 of the accompanying drawings.