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54 **A monitor and method of monitoring.**

57 A gripper loom for the production of tufted carpets comprises a plurality of grippers and a plurality of knife blocks (6) for cutting yarn held by the grippers. A yarn monitor comprises infra-red sensors (8) mounted on respective knife blocks (6) and signal processing circuitry for processing the sensor outputs to make it acceptable for analysis by a computer. Each yarn produces a pulse and the gap between each pair of adjacent pulses is compared by the computer with the average gap of the eight preceding pairs to indicate whether the gap is so large as to signify a missing yarn. The computer can be set to alarm when a missing yarn is detected so that a fault in the carpet does not result. The monitor can be applied to other types of loom or indeed to other apparatus and processes where a plurality of elements are being processed.

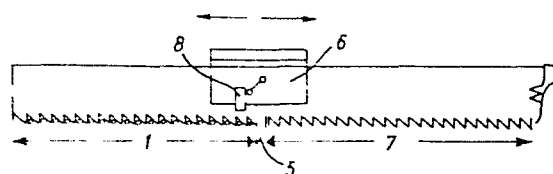


FIG. 1a

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A MONITOR AND METHOD OF
MONITORING

The present invention relates generally to a monitor and particularly, but not exclusively, to
5 a monitor for monitoring the presence of yarns or other elongate elements in looms, braiding machines, knitting machines and other similar such apparatus.

Looms including fault monitoring systems are known in the United Kingdom. In one such known loom,
10 which is a carpet loom, a device is provided for scanning the carpet produced by the loom to produce an electrical signal. The signal is then examined and any deviation from the norm indicative of a fault noted. This solution therefore is curative rather
15 than preventive with all the disadvantages that that entails. In another carpet loom known in the United Kingdom, a mechanical device is employed to detect the presence of yarns. This system necessitates the yarns being subject to a force by the mechanical device
20 and such physical contact can lead to problems with the yarn and should be avoided if at all possible.

According to one aspect of the present invention there is provided a monitor for monitoring the presence of a plurality of elements comprising a sensor comprising a trans-
25 mitter for emitting a beam of radiation towards the elements, a receiver for receiving the beam of radiation, signal

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processing circuitry for processing the output of the receiver and means for assessing the processed signal in order to determine the absence of a missing element in the elements being monitored.

5 A preferred embodiment of the invention may comprise any one or more of the following preferred features:-

- (a) The transmitter and receiver are infra-red devices.
- 10 (b) The transmitter is connected to transmitter circuitry operative to pulse the transmitter at a certain frequency.
- (c) The signal processing circuitry comprises a differentiator in order to detect the presence
15 of pulses in the signal produced by the receiver.
- (d) The signal processing circuitry comprises a threshold device which is triggered only by pulses above a certain amplitude in order to cut out unwanted noise.
- 20 (e) The threshold device of (d) comprises a Schmitt trigger circuit.

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- (f) The signal processing means comprises means for producing pulses of a predetermined duration on receipt of an appropriate trigger signal.
- 5 (g) The means for producing pulses of (f) comprises a monostable circuit.
- (h) The transmitter and receiver are disposed relative to one another so that the receiver receives the signal emitted by the transmitter after reflection by an element being monitored.
- 10 (i) A computer is provided set to receive the output from the signal processing circuitry.
- (j) The computer is programmed to analyse the output from the signal processing circuitry in accordance with a predetermined programme and to produce an output when the analysis indicates the absence of an element from the plurality of elements being monitored.
- 15 (k) An audio or visual alarm is connected to the output from the computer.
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The above defined monitor may be incorporated in

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a gripper loom for the production of tufted carpets.
In such a case the sensor is mounted on the knife
block so that the presence of yarns is sensed thereby
prior to cutting to produce the tufts and whilst
5 . . . being held by the associated grippers. The loom may
have several knife blocks with respective sensors.
An additional sensor may be included on a knife block
to enable the grippers to be counted.

10 According to another aspect of the present invention,
there is provided a method of monitoring the
presence of a plurality of elements including the steps
of scanning the elements with a sensor comprising a
transmitter and receiver processing the output produced
by the receiver and assessing the processed signal
15 in order to determine the absence of a missing element
in the elements being monitored.

In order that the invention may be more clearly
understood, one embodiment of the invention will now
be described, by way of example with reference to the
20 accompanying drawings, in which:-

Figures 1a, 1b and 1c show diagrammatically partial
views of the saw bar, and knife box of a gripper carpet
loom, (in Figure 1c gripper spacing has been increased
for clarity),

Figure 2 is a detail partial view in side elevation of a sensor head of a monitor according to the invention adjacent a gripper in a gripper carpet loom of the type shown in Figure 1,

5 Figure 3 is a circuit diagram of the receiving and signal processing circuitry associated with the sensor of Figure 2,

Figure 4 is a circuit diagram of the transmitter circuitry associated with the sensor of Figure 2,

10 Figure 5 is a waveform diagram showing the waveform of the signal at various points in the circuitry of Figure 3 for yarn scanned as shown at the head of this figure,

Figure 6 is a waveform diagram of the envelope of
15 the signal produced at the sensor output and of the corresponding signal at the input to the computer when a plurality of yarns of different colour are scanned, and

Figure 7 shows complete pulse trains produced by sensors of the type shown in Figure 2.

20 The monitor of the invention will be described as

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applied to a gripper carpet loom. Referring to Figures, 1a, 1b and 1c, in such a loom lengths of yarn 1 are gripped and drawn from respective yarn carriers (not shown) between respective pairs of teeth 2 of a saw bar 3 by respective grippers 4. These lengths of yarn 1 are subsequently cut by a knife blade 5 mounted on a knife box 6, to produce carpet tufts 7 and the tufts transferred to the weft shed of the carpet being woven (not shown) by the grippers 4 before being locked into the weave of the carpet by a weft shot being beaten over it. If a tuft 7 is missing this will automatically result in a fault being woven into the carpet if the missing tuft is not detected before the weft shot corresponding to that line of tufts.

The monitor of the invention therefore seeks to monitor the tufts at the time they are produced. To this end the monitor comprises a sensor 8 which is monitored on the knife box 6 directly ahead of the blade 5 in the cutting direction thereof and which effectively operates to establish the presence of yarn 1 immediately before that yarn 1 is cut to produce a tuft 7.

Referring to Figure 2, the sensor comprises a head 20 moulded from "acetal" synthetic plastics material.

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This head defines apertures which accommodate a diode 21 and a phototransistor 22. The positioning of the diode and transistor may be reversed if desired. The slit is made by a saw cut and is about 1mm deep to promote easy cleaning. Behind the slit are first placed two infra-red filters, one for each photo-device, made of gelatin and then the photo devices themselves. The focal length of the devices is such as to give maximum reflection at 5 to 6mm from the tip of their lenses and these are therefore arranged at this distance ('d' in Figure 2) from the tuft being viewed. Space is also provided for the connecting wire to the devices and means for securing this wire included to reduce chafing as the loom moves. The diode 21 emits in the infra-red region of the electromagnetic spectrum but emitting and receiving devices operating in other parts of the spectrum could be used if desired as could other forms of radiation such as ultrasonics. The disposition of the diode 21 and phototransistor 22 in the head 20 is such that the infra-red beam is directed in a confined manner towards the yarn 1 to be detected and reflected by the yarn to be received by the phototransistor 22. As can be seen from Figure 2, the head 20 moves closely adjacent the yarn 1 at the point at which it is gripped by the corresponding gripper 4. Each such gripper comprises a pair of jaws 23 pivotally connected together at 24. The sensor head 20 forms part of a transmitter and the circuitry of this transmitter is shown

in Figure 4. The purpose of the circuit is to provide a pulsed current through the infra-red emitting diode 21. It comprises two integrated circuits IC1(a) and IC1(b) connected in series. IC1(a) is an astable
5 multivibrator circuit having unequal mark space ratio. The output of IC1(a) is inverted by IC1(b) to produce a train of pulses of approximately 6 μ S duration and amplitude 8.2 volts at a frequency of about 16 KHz.

This signal is used to drive two NPN transistors
10 TR1 and TR2 which are connected as a darlington pair to produce a current through the diode 21 with a duty cycle of approximately $\frac{1}{9}$.

The frequency of the pulse is adjustable by means of the 100 K potentiometer P in the feedback circuit of
15 integrated circuit IC1(a).

The phototransistor 22 forms part of a receiver which includes a signal processing circuitry and the overall circuit of which is shown in Figure 3. An exemplary signal waveform produced at the output of the phototransistor
20 and the corresponding waveform after being processed for input to a computer is shown in Figure 6. The signal produced by the phototransistor 22 on receipt of the reflected signal from each tuft being viewed is a pulse of substantially triangular shape and at a frequency of
25 about 16 KHz. As the knife block with the sensor attached traverses the yarns, the sensor "sees" the yarns and

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peaks and troughs occur to modulate the amplitude of this signal superimposed on a d.c. level. This resultant waveform for a series of black yarns B scanned with one yarn M missing is shown at A on Figure 5. This signal occurs at point A on the circuit of Figure 4. The carrier signal is referenced CS and the D.C. threshold level DC on waveform A. The D.C. level is determined largely by the ambient light level and there may also be superimposed a signal at 100 Hz a 50Hz due to reflection or 'pick-up' by mains operated equipment or overhead lights.

The output from the phototransistor 22 is connected in the input of an integrated circuit operational amplifier IC1 741. This acts as a high pass filter with a cut off below about 10KHz. At the output of IC1 741, the D.C. and low frequency components have been removed to produce a waveform of the form shown at B on Figure 5. Two further integrated circuits IC2 531 and IC3 531 are provided to form a non-inverting amplifier circuit with a maximum overall gain of 600. The gain of IC2 531 is fully adjustable by means of a 100 K potentiometer 3P. This is normally preset to give a fully clipped output at IC3 531 when the sensor is directly above a yarn that is at the point where maximum reflection occurs. Integrated circuits IC2 531 and IC3 531 have diodes in their feedback connection so only positive going output

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pulses are obtained. The waveform of the fully clipped signal at IC3 531 is shown at C in Figure 5.

5 In order to detect the 'envelope' rise and fall due to the presence of peaks and troughs as the sensor traverses the yarns it is necessary to separate the modulating signal from the 16 KHz carrier.

10 This is done in three stages. First of all at tpl the diode D1 and .01 μ F capacitor CP demodulate the signal and decouple most of the 16 KHz signal. The proportion of 16 KHz remaining however is still too high and the signal then, passes through two further integrated circuits IC4 (a) and IC4(b). Each of these circuits constitute $\frac{1}{4}$ of a 348 integrated circuit. These stages 15 comprise a low pass filter with a cut off of 11.25 KHz and a tuned notch filter with $f_o \approx 16$ KHz respectively. The frequency of the oscillator provided by IC1(a) already described in the transmitter circuit (Figure 4) is adjusted to be exactly equal to that at which maximum 20 attenuation occurs in the notch filter. The form of the signal at the output of IC4(b) with the carrier signal removed is shown at D in Figure 5.

Because the output from different thicknesses or different colours of yarns or threads varies it is not

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sufficient to detect their presence simply by their amplitude of the signals which they produce. Too high a trigger level for example would permit black threads which have a low reflectivity to be missed. Accordingly the pulses which emerge from integrated circuit IC4(b) are differentiated in a further integrated circuit IC4(c) which gives an output which is proportional to the rate of change of the input signal. IC4(c) constitutes a further $\frac{1}{4}$ of the previously mentioned 348. The rate of change of the input is zero only at the peaks and troughs. Since IC4(c) also inverts the signal its output goes from zero in a positive direction immediately after a peak has occurred that is after a yarn has been detected. The waveform of the signal at the output of IC4(c) is shown at E on Figure 5. This positive going signal is detected by a Schmitt trigger circuit - IC4(d) which constitutes the fourth $\frac{1}{4}$ of the 348 previously described. Integrated circuit IC4(d) is provided with a sensitivity or 'threshold' control below which it will not respond. This is necessary to prevent accidental operation due to the presence of unwanted noise on the signal. The output from IC4(d) is normally at approximately +12V and when triggered by a thread it goes to approximately -12V.

25 The leading edge of the negative going signal is

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used to trigger a monostable multivibrator consisting of integrated circuits IC5(b) and (c). The monostable produces one pulse of fixed duration for every input trigger pulse. Integrated circuit IC5(d) inverts the pulse to give a positive going pulse which varies from 0 to +12V. This pulse set for a duration of 700 μ s, for example, is suitable for transmission by cable to the computer and its waveform is shown at F in Figure 5. The integrated circuits IC5(a) to (d) constitute four quarters of a 4011B. An alternative output is provided by IC5(a). This gives pulses of varying duration depending on the width of the thread and the speed of traverse of the sensors.

Having processed the output signal into a form in which it can be assessed by a computer, the processed signal is then sampled every 300 microseconds by the computer. This sampling period is chosen having regard to the duration of the pulses of the signal so that no pulse is missed. In the particular carpet loom under consideration, there are 1008 grippers divided in eight groups. Eight knife blocks 6 are provided for respective groups and eight sensors 8 are mounted on respective blocks 6. Transmitter and receiver circuitry as described above is associated with each sensor 8. In addition to the yarn sensors an additional sensor is mounted on one of the knife blocks 6 in order to count the grippers of the associated group. Thus the computer must be capable of accepting signals from nine sensors.

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The computer assesses the input signals fed to it in order to detect missing yarns. This is achieved by programming the computer with an algorithm or set of instructions. These "tell" the computer to compare the gap between adjacent pulses which represent the gap between adjacent yarns with the average of the gaps of say eight preceding pairs of adjacent pulses. If a gap greater than 1.8 times this average is detected this indicates a missing yarn. Of course the 1.8 ratio can be altered as desired to fit differing sets of circumstances. This method of assessing the pulses cannot be used satisfactorily for those pulses produced at the beginning and end of the travel of the knife blocks because the pulse gap is affected by the acceleration and decleration of the block and an acceptable comparison cannot be made. The effect on the pulse trains of this acceleration and deceleration can be seen at the beginning and end of the trains shown in Figure 7. At the beginning and end of the pulse train, however, the comparison of the gap between adjacent pulses is made with the gap between similar pulses on the preceding shot or cutting stroke.

In addition to detecting a missing yarn, the position of this yarn can be indicated by counting pulses

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using the most extreme right hand yarn, which is the first yarn "counted" by the sensor on the right hand knife block, as a reference. It may happen that the knife blades may not accurately divide the 1008
5 yarns into eight equal groups and, for the other sensors, some zero error correction may be necessary using this reference otherwise a misleading result may occur. In addition the gripper sensor can be employed to give an indication in the travel of the knife blades (since
10 they all have the same travel) where the missing yarn is positioned. Thus if a missing yarn is sensed half way through the travel of the third blade from the right the fact that the blade has travelled half its full travel can be checked as the gripper sensor will have
15 sensed half of the grippers in the associated group. Having identified which end is missing the system can be programmed either to operate a warning to the weaver or to stop the machine after a predetermined number of misses of a particular end or group of ends.

20 It will be appreciated that the above described arrangement enables a missing yarn to be detected early on the weaving process and before a corresponding fault is produced in the carpet being woven thus enabling fault preventative action to be taken with considerable
25 cost savings. The system described may also be used on other types of loom than gripper looms and on other

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processes when numbers of elongate elements are an
essential part of the process. It will also be
appreciated that the described computerisation facilitates
data logging. Records can be maintained and later
5 printed out of the duration and nature of loom stop-
pages due to missing ends. The system is capable of
expansion to hold in memory predetermined patterns
of missing ends in various sectors of the carpet
design which would operate visual or audible alarms
10 or warning or stop circuits. Furthermore, there is
no physical contact between the sensors and the ends
being detected which is most important particularly
where damage to the yarn is a possibility.

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CLAIMS

1. A monitor for monitoring the presence of a plurality of elements comprising a sensor (8) comprising a transmitter (21) for emitting a beam of radiation towards the elements, a receiver (22) for receiving the beam of radiation, signal processing circuitry (Figure 3) for processing the output of the receiver and means for assessing the processed signal in order to determine the absence of a missing element in the elements being monitored.
2. A monitor as claimed in Claim 1, in which the transmitter (21) and receiver(22) are infra-red devices.
3. A monitor as claimed in Claim 1 or 2, in which the transmitter (21) is connected to transmitter circuitry (Figure 4) operative to pulse the transmitter at a certain frequency.
4. A monitor as claimed in Claim 1, 2 or 3, in which the signal processing circuitry (Figure 3) comprises a differentiator (IC4(c)) in order to detect the presence of pulses in the signal produced by the receiver.
5. A monitor as claimed in any preceding claim, in which the signal processing circuitry comprises a threshold

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device (IC4(d)) which is triggered only by pulses above a certain amplitude in order to cut out unwanted noise.

5 6. A monitor as claimed in Claim 5, in which the threshold device (IC4(d)) comprises a Schmitt trigger circuit.

7. A monitor as claimed in any preceding claim, in which the signal processing means (Figure 3) comprises means for producing pulses of a predetermined duration (IC5(b) and IC5(c)) on receipt of an appropriate trigger signal.

8. A monitor as claimed in Claim 7, in which the means for producing pulses comprises a monostable circuit (IC5(b) and IC5(c)).

15 9. A monitor as claimed in any preceding claim, in which the transmitter (21) and receiver (22) are disposed relative to one another so that the receiver receives the signal emitted by the transmitter after reflection by an element being monitored.

20 10. A monitor as claimed in any preceding claim comprising a computer set to receive the output from the signal processing circuitry.

11. A monitor as claimed in Claim 10, in which the com-

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puter is programmed to analyse the output from the
signal processing circuitry in accordance with a
predetermined programme and to produce an output
when the analysis indicates the absence of an element
5 from the plurality of elements being monitored.

12. A monitor as claimed in Claim 11, in which an
audio or visual alarm is connected to the output from
the computer.

10 13. A gripper loom for the production of tufted carpets
comprising a monitor as claimed in any preceding claim,
in which the sensor (8) is mounted on the knife block
so that the presence of yarns is sensed thereby prior to
cutting to produce the tufts and whilst being held by
the associated grippers.

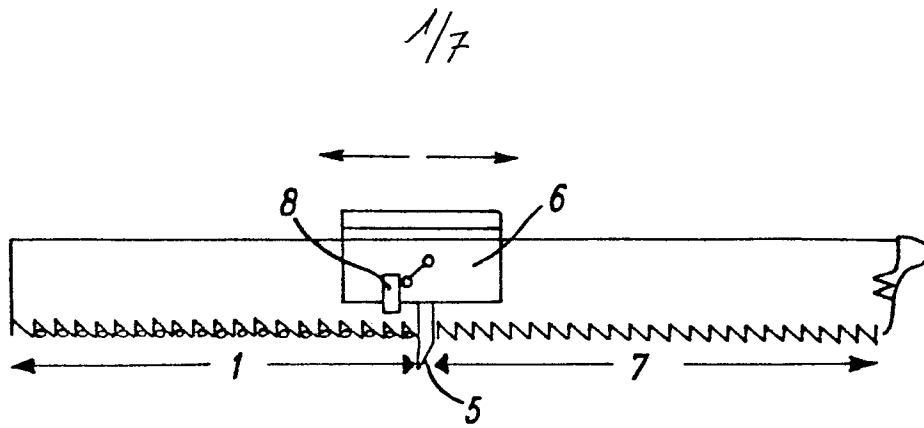
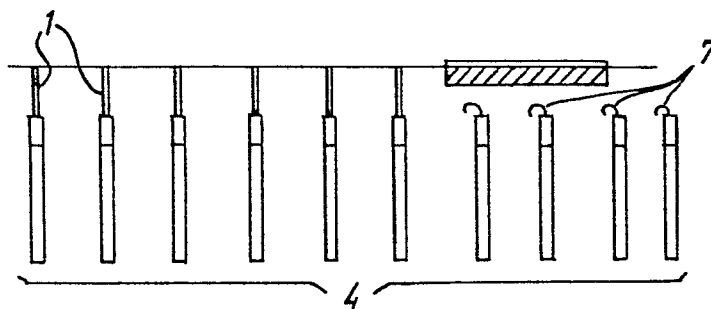
15 14. A gripper loom as claimed in Claim 13, in which
there are a plurality of knife blocks and sensors mounted
on respective knife blocks.

20 15. A gripper loom as claimed in Claim 13 or 14, in
which an additional sensor is mounted on one knife block
operative to count the number of grippers during the
travel of that knife block.

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16. A method of monitoring the presence of a plurality
of elements including the steps of scanning the
elements with a sensor (8) comprising a transmitter
(21) and receiver(22) processing the output produced
5 by the receiver' (22) and assessing the processed signal
in order to determine the absence of a missing element
in the elements being monitored.

17. A method of monitoring the presence of a plurality
of elements as claimed in Claim 16, in which the elements
10 being monitored are the yarns in a gripper loom and
the sensor is used to scan these elements directly
before the yarns are cut to produce tufts.

Fig. 1aFig. 1bFig. 1c

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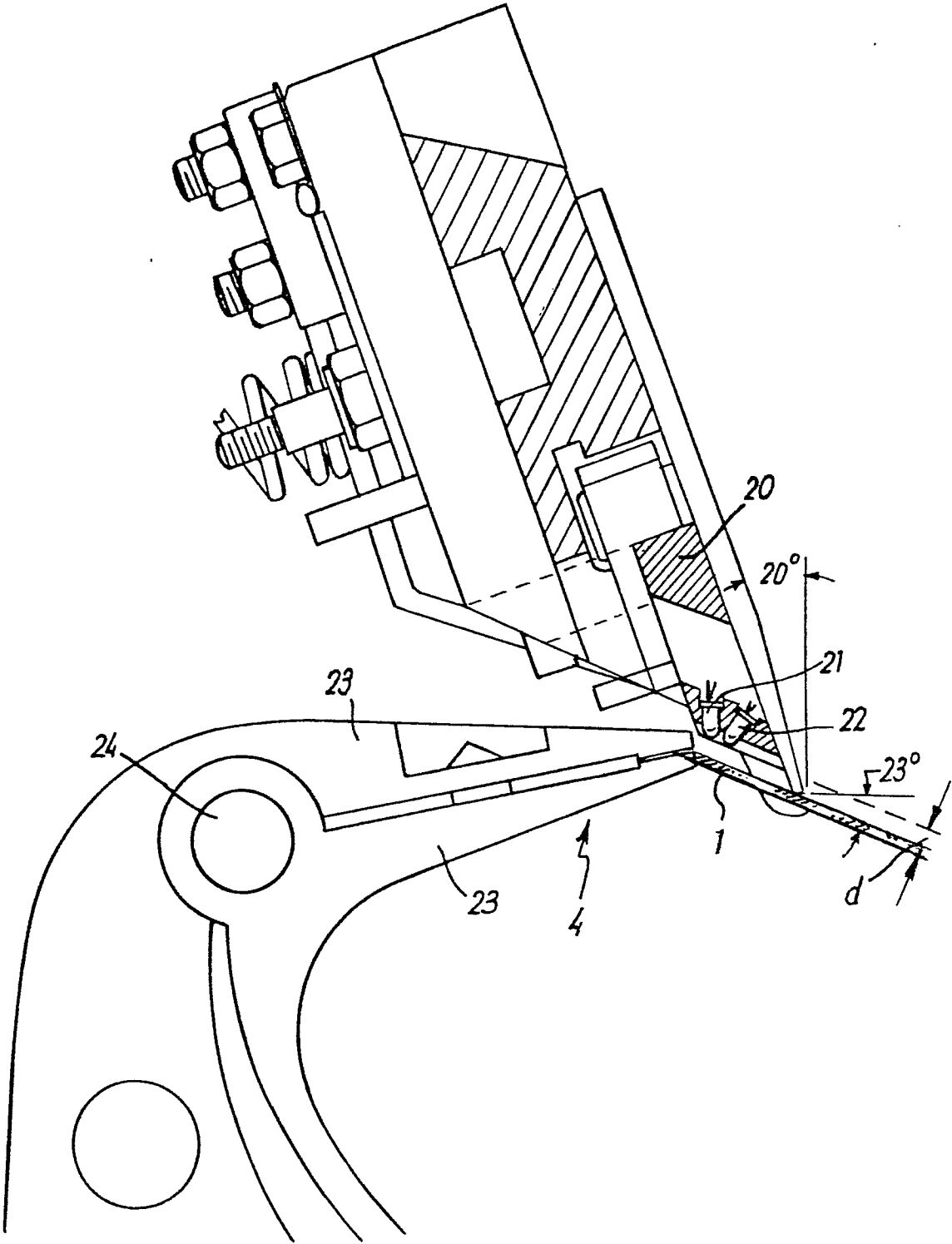


FIG. 2

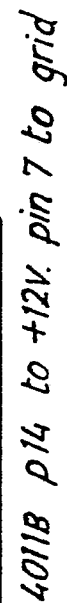
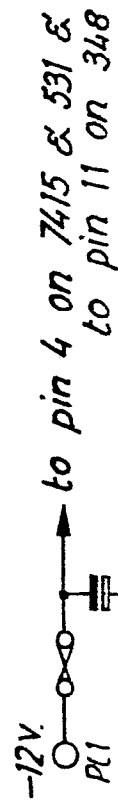


Fig. 3

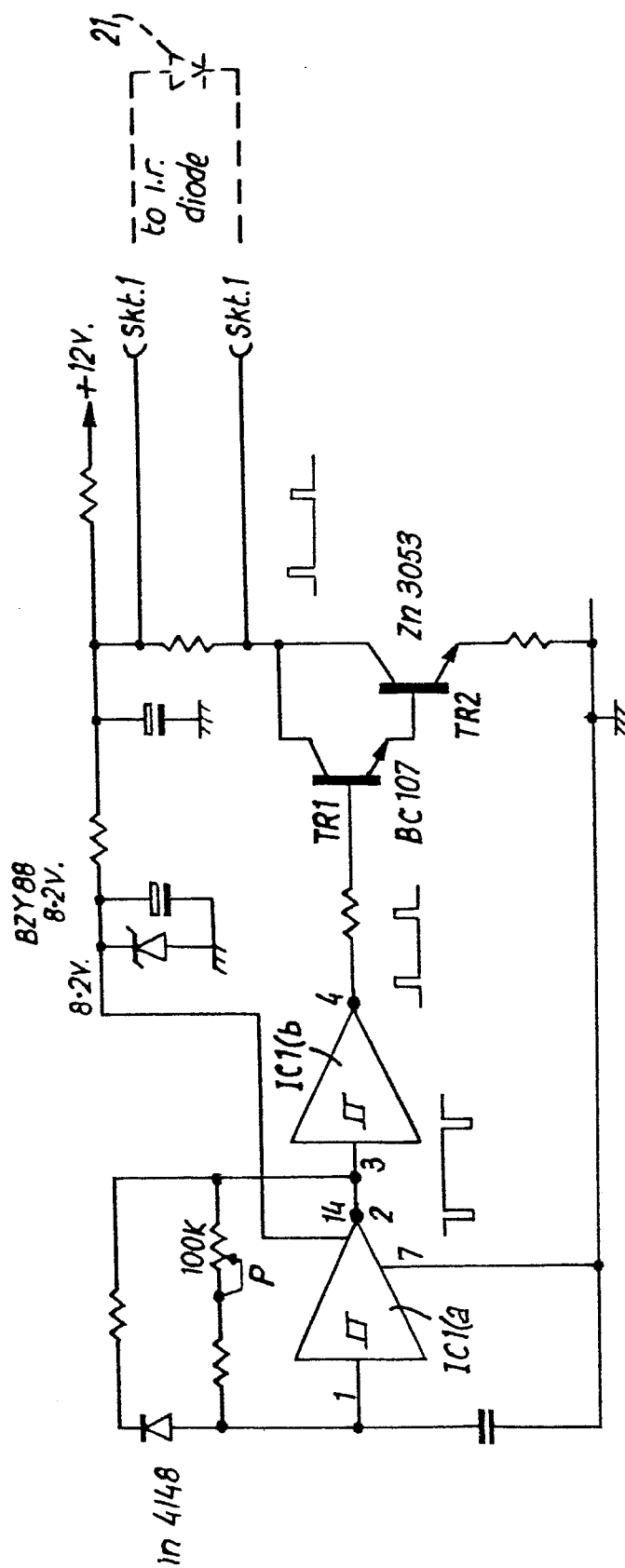
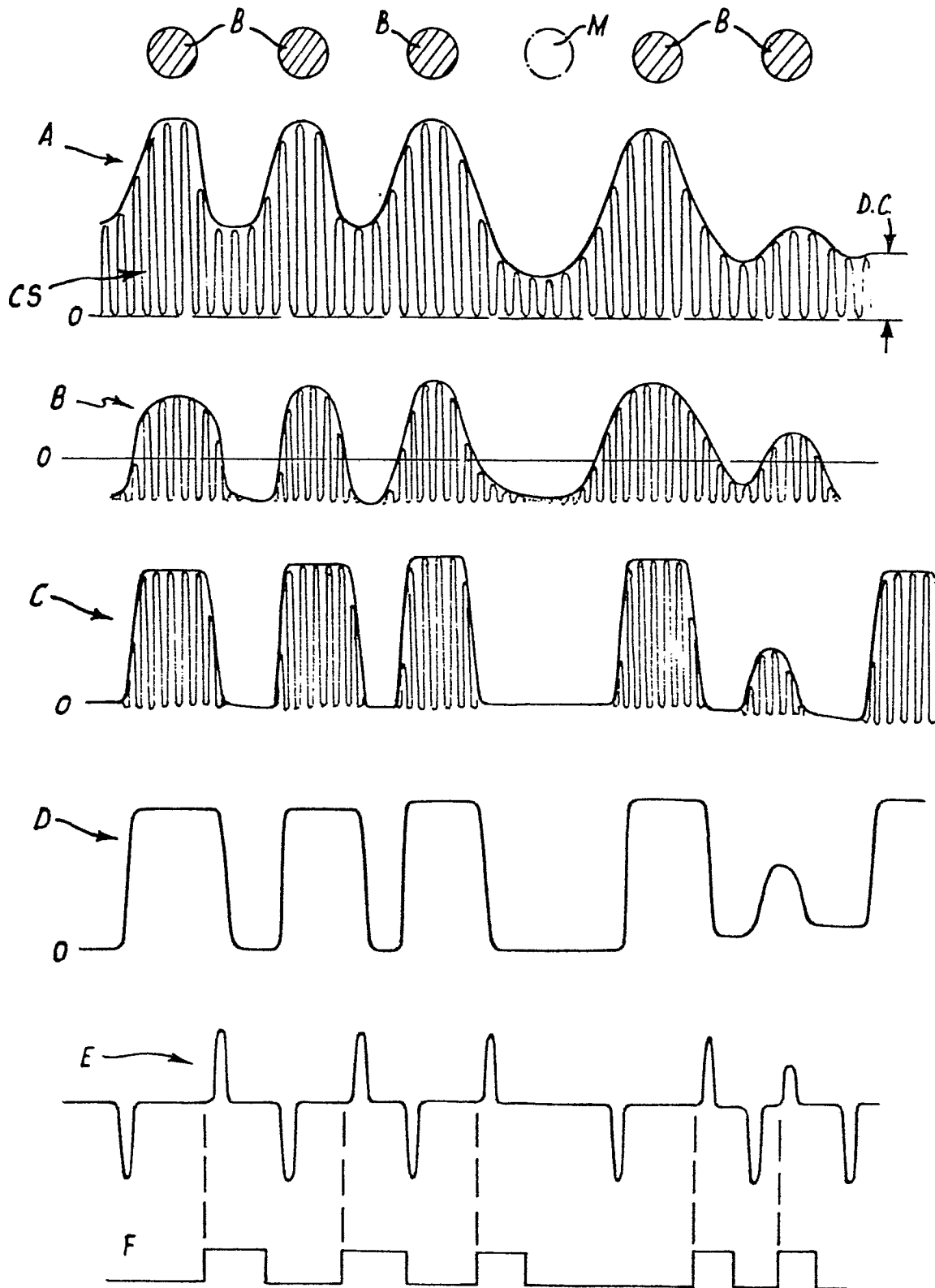


FIG. 4

FIG. 5

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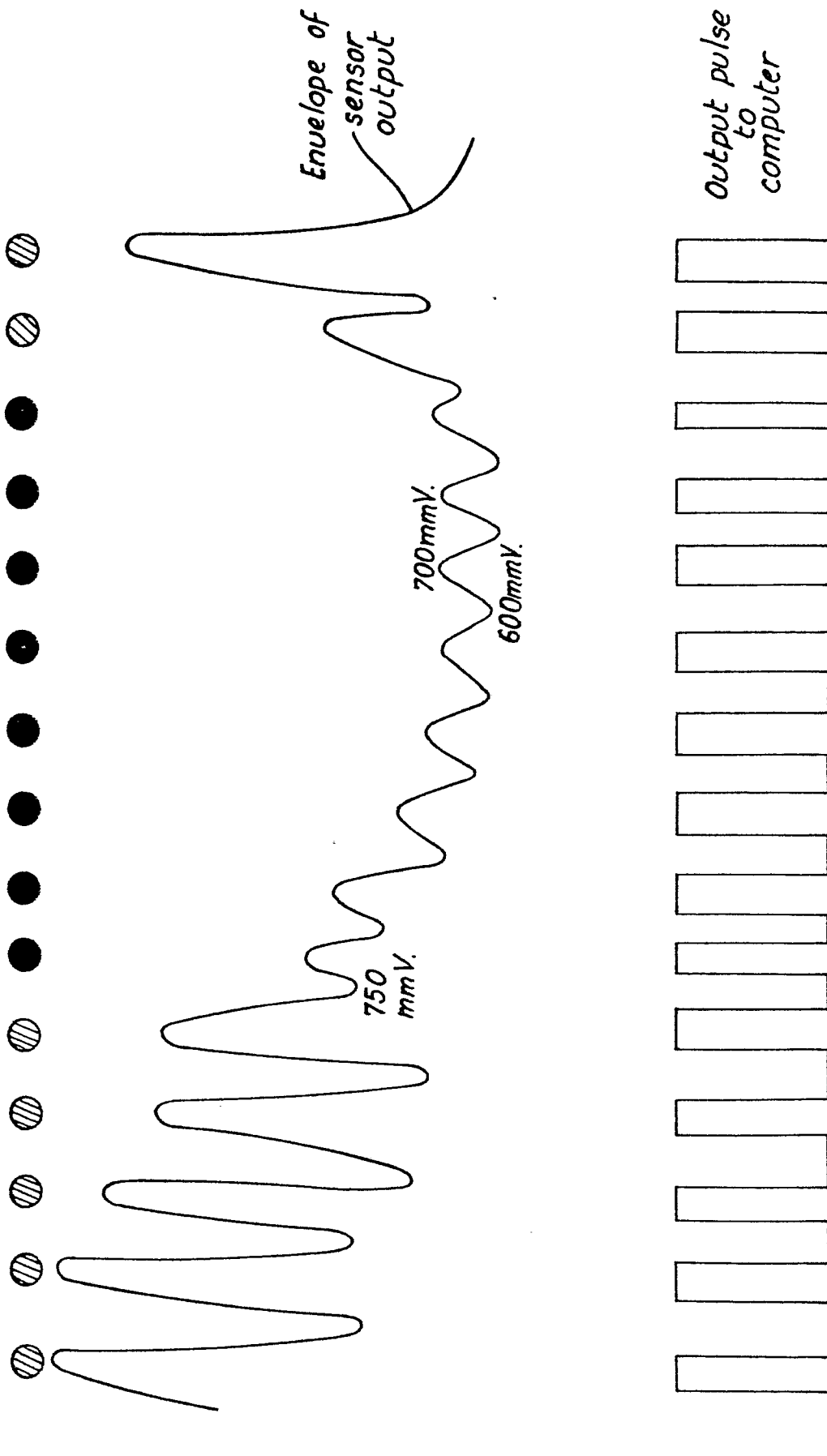
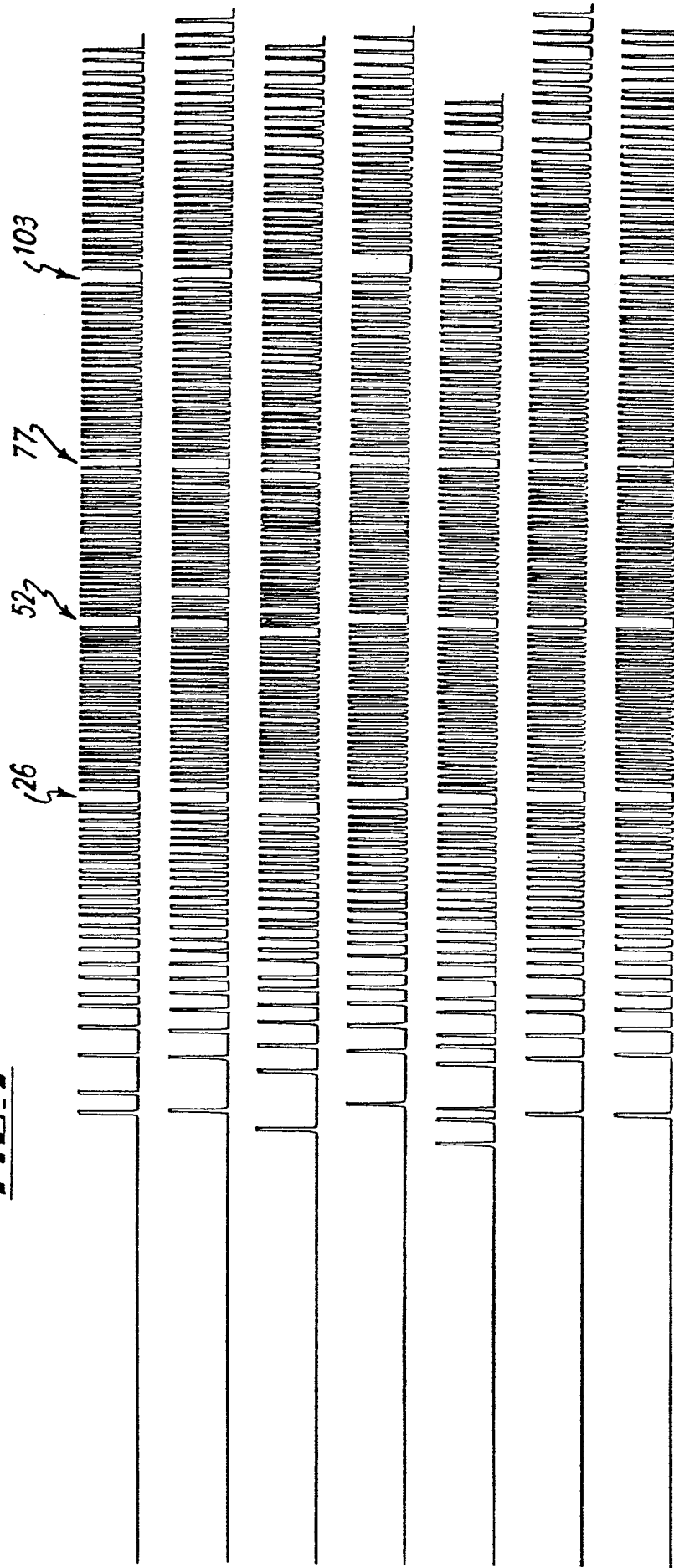
Fig. 5

FIG. 7



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Threads 24. 50. 75 & 102 removed