United States Patent

[11] 3,577,750

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[33] **Great Britain**
[31] **34979/68**

[54] **INSPECTION APPARATUS FOR CIRCULAR KNITTING MACHINES**
7 Claims, 10 Drawing Figs.

[52] **U.S. Cl.** **66/157**
[51] **Int. Cl.** **D04b 35/18**
[50] **Field of Search** 66/157, 163, 165

[56] **References Cited**

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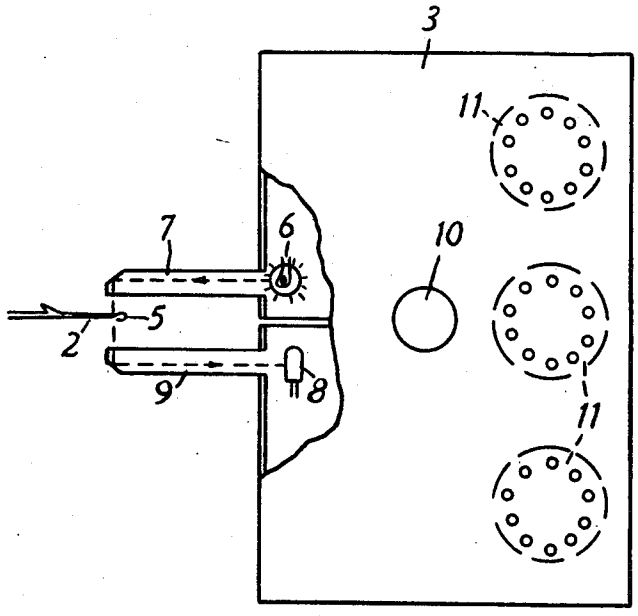
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ABSTRACT: Inspection apparatus in combination with a circular knitting machine, the apparatus performing the function of detecting a broken knitting needle and giving an alarm or stopping the machine in response to such detection. A sensing arrangement of a photoelectric or magnetic kind is positioned near the needles as they rotate and is so arranged to give curved pulses of amplitude corresponding to the size of the needle. A timing circuit gives an initial timing pulse when the amplitude of the curved pulse rises above a predetermined level and a final timing pulse when the amplitude of the curved pulse falls below the predetermined level. A multivibrator is triggered or synchronized to give reference pulses to predetermined lengths in response to each initial timing signal. Reference pulses are applied to a gate which is closed during the periods between initial timing signals and the following final timing signals. If a reference pulse or part of it is applied to the gate at any other time an alarm output signal is given. The multivibrator may be a monostable circuit, in which case gaps between groups of needles do not give an output or it may be a free-running multivibrator in which case missing needles are also detected.



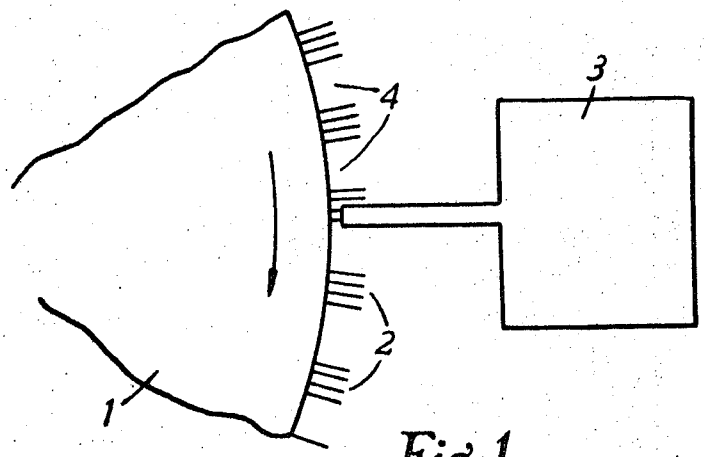


Fig. 1.

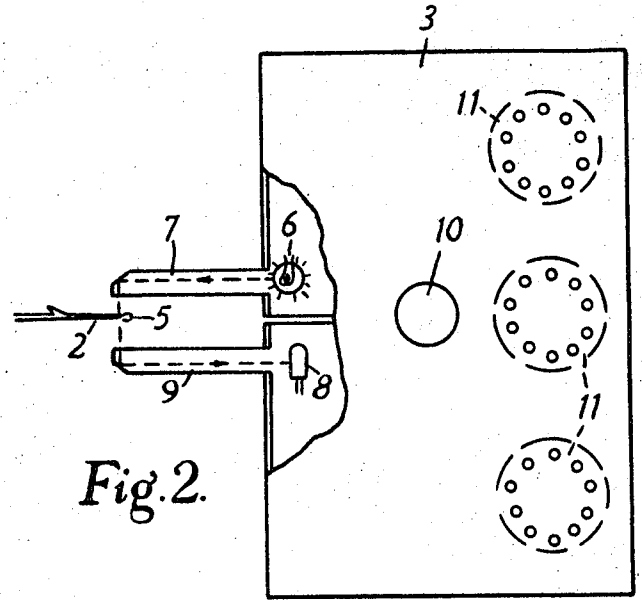


Fig. 2.

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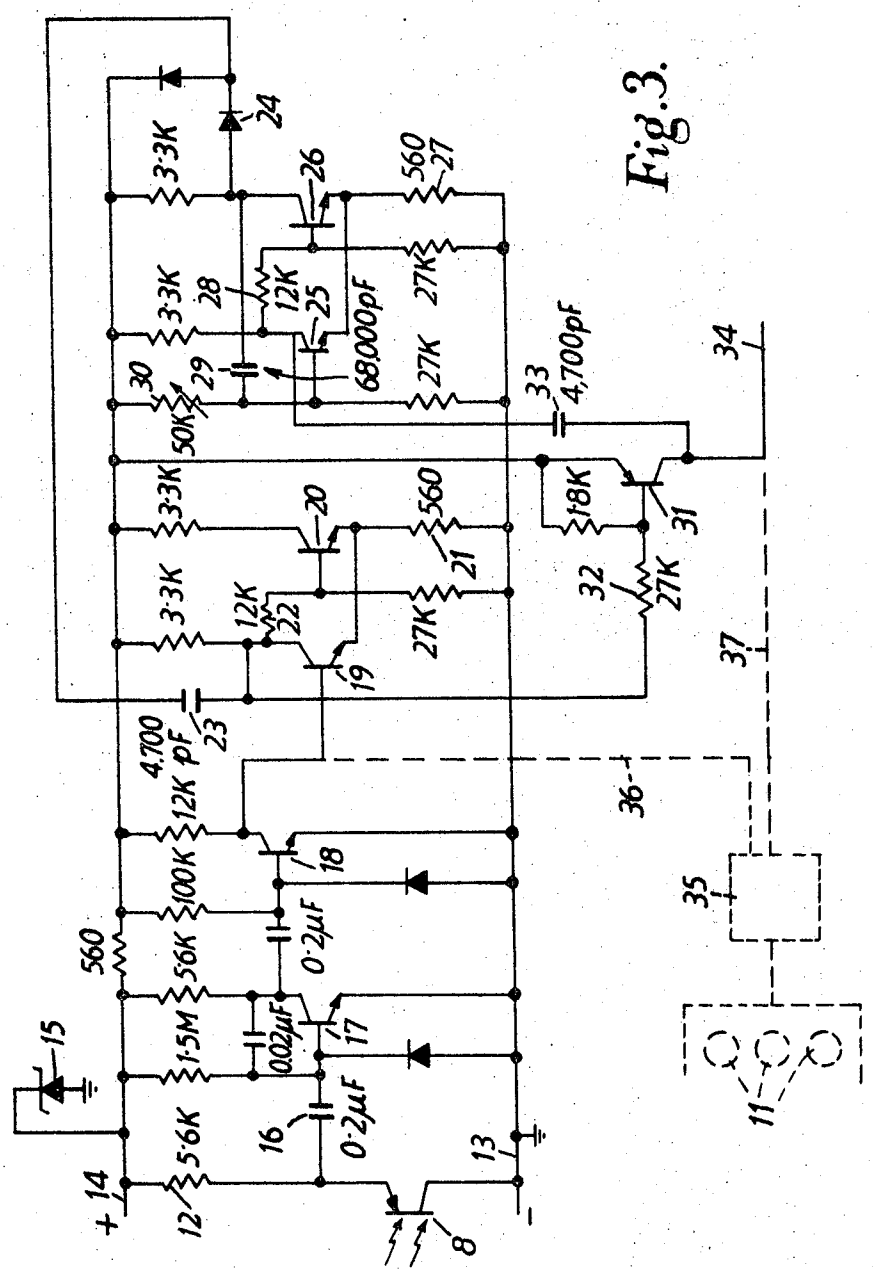


Fig.3.

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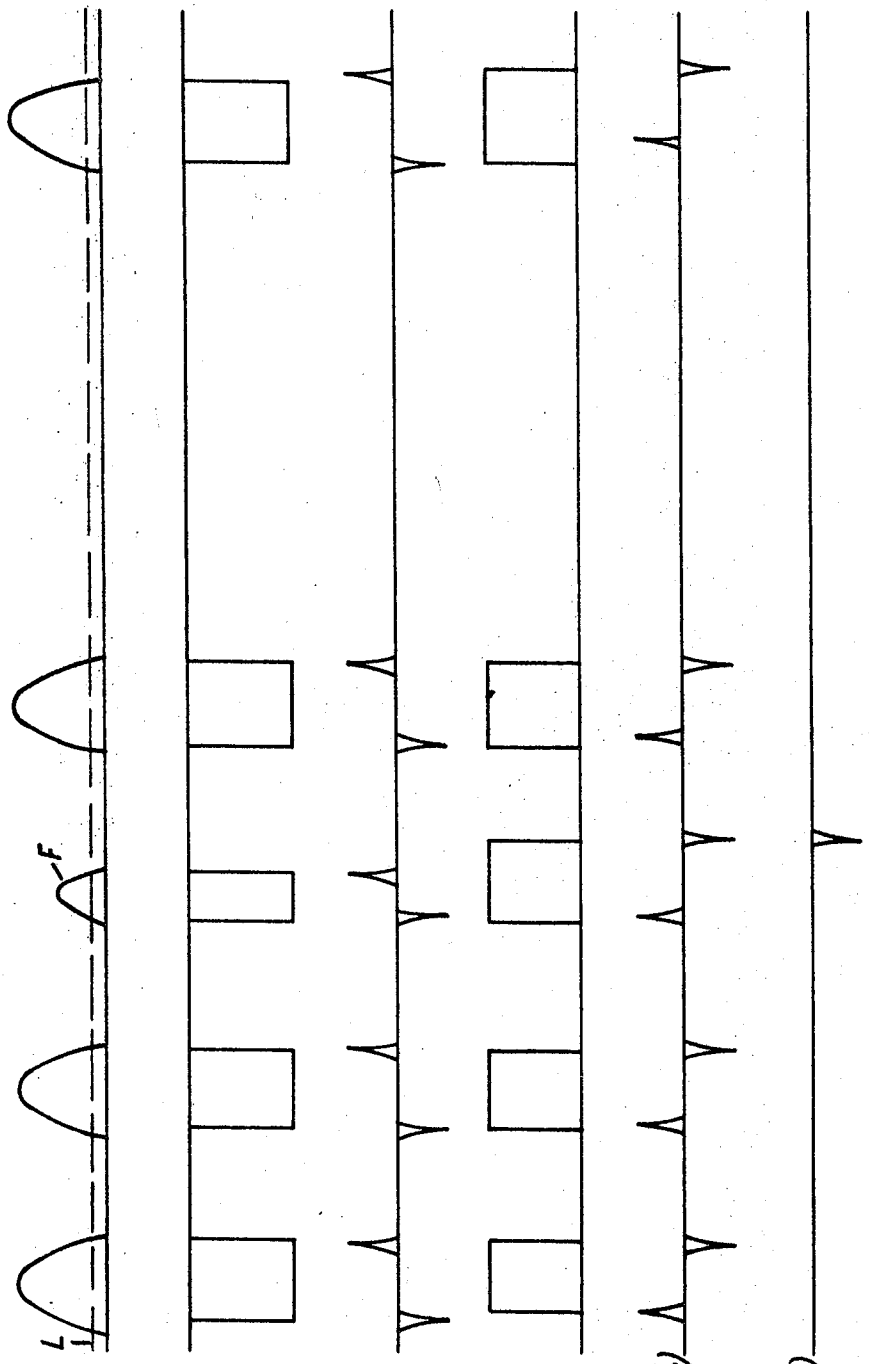


Fig. 4(a) Fig. 4(b) Fig. 4(c) Fig. 4(d) Fig. 4(e) Fig. 4(f)

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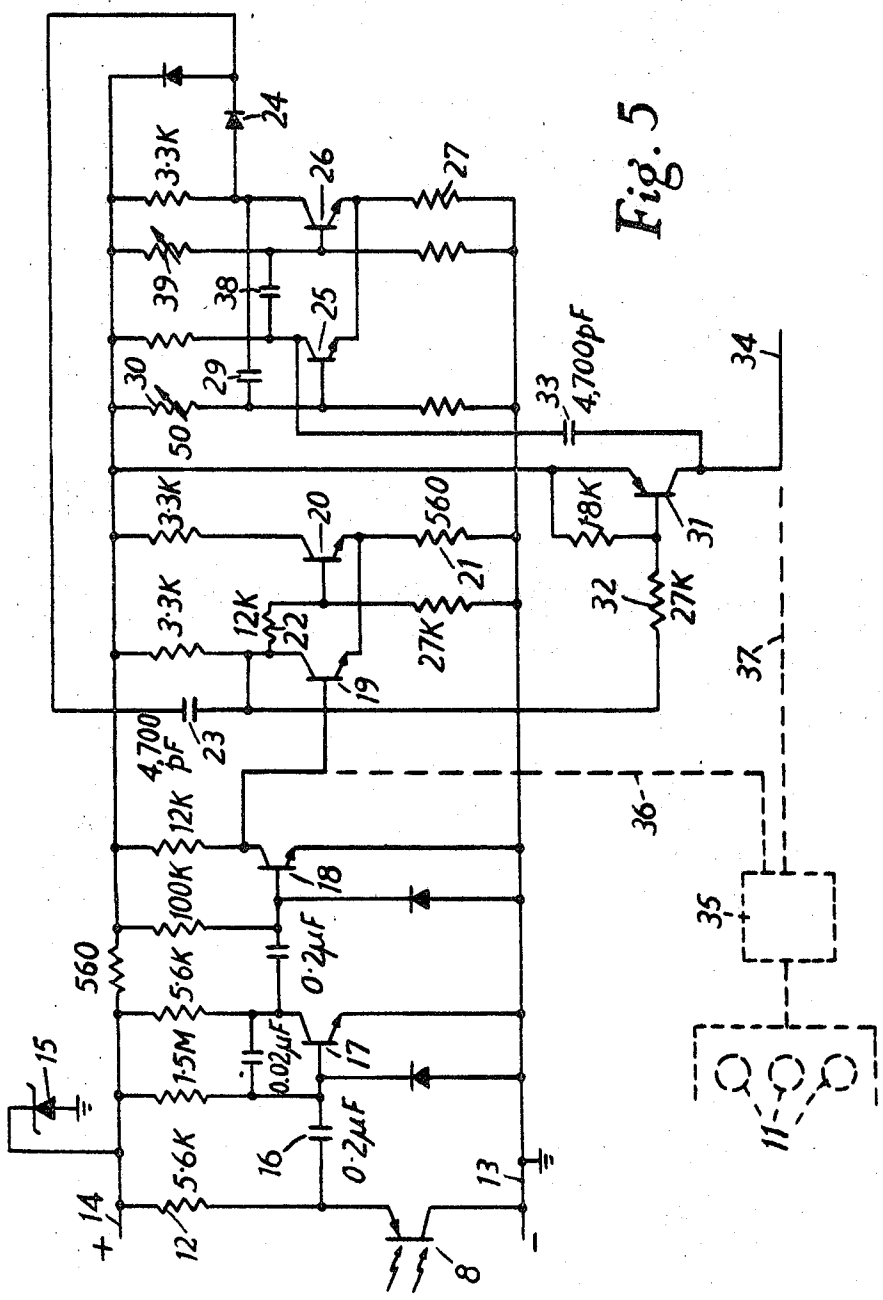


Fig. 5

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INSPECTION APPARATUS FOR CIRCULAR KNITTING MACHINES

The invention relates to inspection apparatus comprising part of a circular knitting machine for detecting broken knitting needles. In particular, the invention provides a circular knitting machine with inspection apparatus which continuously inspects the moving needles and which gives an alarm output signal if a needle breaks. This output signal may be used to give an audible or visible alarm and/or to apply automatically a brake to stop the machine.

According to the invention there is provided a circular knitting machine having a series of knitting needles on a mount which rotates, a sensing arrangement positioned to respond to both broken and unbroken knitting needles as the mount rotates, a broken knitting needle giving a lower response than an unbroken knitting needle, means for deriving from the sensing arrangement a curved output current pulse for each knitting needle, the height of the pulse being less for a broken knitting needle than for an unbroken knitting needle, a timing circuit for comparing the instantaneous amplitude of the output current pulses with a preset level and issuing an initial timing signal when the instantaneous amplitude rises above the preset level and a final timing signal when the instantaneous amplitude falls below the preset level; a pulse generator for generating reference pulses of predetermined duration, the initial timing signals being applied to the pulse generator to ensure that for each initial timing signal there is a reference pulse which starts in synchronism therewith; and a gate to which are applied as the gated input the reference pulses from the pulse generator or signals derived therefrom, the timing signal or signals derived therefrom being applied as the control input to the gate to close the gate during the period between an initial timing signal and a succeeding final timing signal; and output means responsive to reference pulse signals passing through the gate when it is open.

Preferably the sensing arrangement comprises a photosensitive device such as a phototransistor which is responsive to a beam of light which is partially obscured by a knitting needle as it passes. With this arrangement the output of the photosensitive device is a pulse of curved shape of which the amplitude is dependent on the size of the knitting needle.

Other suitable sensing means may be provided such as, for example, a magnetic sensing device sensitive to the magnetic properties of the knitting needles if they are steel.

Circular knitting machines in common use have an arrangement of knitting needles generally in one of two kinds. In the first kind the needles are arranged around the periphery of their mount in groups with spaces between the groups. For example, the needles may be arranged in groups of four. In the second kind the needles are arranged evenly around the periphery of the mount.

Inspection apparatus provided for detecting broken knitting needles in a machine of the first kind should be arranged so as not to respond if a needle is missing completely, or in other words not to respond when a gap in the needles passes the sensing means. On the other hand, inspection apparatus for the second kind of machine can be arranged to respond to a missing needle as well as a broken needle. The present invention provides two embodiments which are particularly suitable for use with machines of the first and second kinds respectively.

In the first preferred embodiment of the invention, which is suitable for use with a knitting machine of the first kind, the pulse generator is a monostable multivibrator circuit which gives a reference pulse output only in response to being triggered by an initial timing signal. With this arrangement no reference pulse is given if there is no initial timing signal, so that the circuit does not respond if a needle is missing.

In the second preferred embodiment of the invention the pulse generator is a free running multivibrator circuit running at a frequency corresponding to the rate of passage of knitting needles past the sensing arrangement, and while initial timing signals are effective to synchronize the multivibrator, the multivibrator will continue to run even in the absence of timing signals. Thus, the output is given from the gate if a needle is missing as well as if a needle is broken.

The timing circuit may comprise an amplifier of the limiting kind which produces, from a sensing means output of perhaps half-sinusoidal nature a series of square pulses. The output from such an amplifier may be of sufficient amplitude to operate the pulse generator and the gate directly. However, for the sake of convenience and accuracy it may be preferred to provide a trigger circuit, to the trigger input of which is applied an input derived from the amplifier or, if no intermediate amplifier is provided, from the sensing means itself. The trigger circuit produces an accurate square wave of which the leading and trailing edges of the square pulses are respectively the initial and final timing signals.

Preferably the pulse generating circuit or circuits has a manually variable component whereby the length of the pulses generated thereby may be adjusted.

The invention will further be described with reference to the accompanying drawings, of which:

FIG. 1 is a schematic plan view of part of a circular knitting machine according to the invention showing the disposition in relation thereto of inspection apparatus;

FIG. 2 is a schematic side elevation of the arrangement shown in FIG. 1;

FIG. 3 is a circuit diagram of the inspection apparatus of FIG. 1;

FIGS. 4*a*—4*f* are waveform diagrams showing waveforms present in the apparatus of FIG. 3; and

FIG. 5 is a circuit diagram of part of the circuit of FIG. 3 modified to detect not only broken knitting needles, but also missing knitting needles.

Referring to FIG. 1 there is shown schematically in plan view a part 1 of the periphery of a circular knitting machine. Distributed evenly in spaced groups of four around the periphery of the knitting machine are over 1000 knitting needles 2. The knitting machine is turned continuously in the direction indicated by the arrow at such a speed that the needles pass a given point at the rate of about 450 per second. The needles are provided with hooks at their ends to engage the wool being knitted and sometimes the hook of a needle or the shank breaks off. The result of a broken needle is a fault in the knitted tubular web being produced by the machine and if the fault is not detected and the broken needle replaced quickly then a substantial amount of knitted material must be rejected. The purpose of applying apparatus in accordance with the invention in such a knitting machine is to allow early detection of a broken needle to give an alarm to the operator and perhaps also to stop the machine automatically on detection of a fault. The inspection apparatus is shown at 3 and is fixed near the path of the needles 2 to inspect them as they pass. It will be noted that there are substantial gaps 4 between successive groups of needles and it is a requirement of the inspection apparatus that it should not respond to the complete absence of a needle, when it would give a signal as each gap 4 passes, but should respond only to the absence of part of a needle.

Referring now to FiG. 2 there is shown in schematic side elevation the arrangement of FIG. 1. A knitting machine needle 2 is shown with a hook 5 at its end. The apparatus 3 contains an electric lamp 6 positioned at the end of a perspex light guide 7 and a phototransistor 8 positioned at the end of a perspex light guide 9. The guides 7 and 9 have reflectors at their ends and the arrangement is such that light travels as shown in broken line from the lamp 6, to phototransistor 8, crossing, in its path, the path of the hooked end 5 of the needles 2. As each needle passes between guides 7 and 9 the phototransistor 8 will be subjected to a drop in light intensity. If the hook is broken from the end of a needle the remainder of the needle will still subject the phototransistor to a shadowing effect but this will be less than if the hook were present. The output from the phototransistor is taken as a series of pulses, the size of each pulse depending upon whether the needle which caused

it was broken or not. The pulses from the phototransistor **8** are operated on in a circuit to be described hereinafter and on detection of a lower level pulse characteristic of a broken needle the circuit illuminates an alarm lamp **10** visible to the machine operator and also operates an audible alarm signal. At the same time, the circuit is effective to operate automatically the brake of the knitting machine, so bringing it rapidly to a halt. As an extra facility to help identify the broken needle quickly, there may be provided a counting circuit which gives a display on a series of three cascaded dekatron counting tubes **11**. The counting circuit is activated by the detection circuit immediately a broken needle is detected and is effective thereafter to count the number of pulses issued by the phototransistor **8** until the knitting machine stops. Therefore, from the count registered by the counting tubes **11** and the position at which the machine stops it is easy to identify the needle which gave rise to the fault signal.

Referring now to FIG. **3** there is shown the circuit diagram of the apparatus **3**. The phototransistor **8** is connected in series with a resistor **12** between an earth line **13** and a positive supply line **14**. The voltage applied to line **14** is stabilized by a zener diode **15**. Output pulses from phototransistor **8** are passed via coupling capacitor **16** to a 2 -stage transistor amplifier comprising transistors **17** and **18**.

The operation of the circuit of FIG. **3** is explained with reference to FIG. **4** which shows the waveforms of the circuit of FIG. **3**. The nature of the output of phototransistor **8** is shown in FIG. **4***a* as comprising a series of substantially sinusoidal half waves corresponding respectively to the needles **2**. These pulses are therefore arranged in groups of four and FIG. **4** shows the effect of one complete group of four and the first pulse of the next group. In FIG. **4** the third pulse of the complete group is designated F and is indicative of a broken needle, being smaller in amplitude than the other pulses.

The amplifier constituted by transistors **17** and **18** is a limiting amplifier and is effective to significantly square the sinusoidal-type pulses emanating from the phototransistor **8**. The output from transistor **18** is applied to the trigger input of a trigger circuit comprising transistors **19** and **20** having a common emitter resistor **21** and coupled resistively by a resistor **22** between the collector of transistor **19** and the base of transistor **20**. For the sake of illustration the trigger level of the trigger circuit is shown in FIG. **4***a* at L and the output of the trigger circuit taken from the collector of transistor **19** shown in FIG. **4***b*. This output is differentiated in a simple RC network comprising a capacitor **23** to give a waveform as shown in FIG. **4***c*. The negative spikes of this waveform are passed through a diode **24** to the trigger input of a monostable pulse generator constituted by transistors **25** and **26** emitter coupled by a common resistor **27** and further coupled by a resistor **28** from the collector of transistor **25** to the base of transistor **26** and a capacitor **29** from the collector of transistor **26** to the base of transistor **25**. In response to each negative spike passed through diode **24** the monostable circuit generates a positive-going rectangular pulse of length determined by the setting of a variable resistor **30**. This resistor is manually controllable so that the generator pulse length may be varied and in practice this pulse length is arranged to be substantially equal to the pulse length in waveform *b* of FIG. **4** corresponding to a needle with an unbroken hook. The output appearing on the collector of transistor **25** is indicated in FIG. **4***d*.

A PNP gate transistor **31** is provided to the base of which is directly coupled through a resistor **32** the output from the collector of transistor **19**. The output from the collector of transistor **25** is capacitor coupled through a capacitor **33** to the collector of gate transistor **31**. The nature of the signals applied through capacitor **33** is shown in FIG. **4***e*.

During the time that negative pulses are present on the collector of transistor **19** the gating transistor **31** is held conducting. Therefore, at these times any pulses applied through capacitor **33** are effectively short circuited. The collector of transistor **31** is taken as the output from the circuit and only if a pulse is applied from capacitor **33** when there is no negative pulse from the collector of transistor **19** will there be applied output pulses on the output line **34**. This condition arises every time there is a broken needle, because, as is shown for the pulse F of FIG. **4**, the corresponding square pulse from the trigger circuit terminates before the end of the corresponding reference pulse of standard length from the pulse generator. Thus, the negative spike given by the trailing edge of the reference pulse at this time is allowed to pass to the output **34**. The output waveform is shown in FIG. **4***f*. Output **34** is connected to trigger an alarm trigger circuit which illuminates lamp **10** of FIG. **2** and activates the audible alarm as well as applying the brake of the knitting machine.

The counter referred to with reference to FIG. **2** may be provided as shown in broken line in FIG. **3** at **35**. Pulses to be counted are taken from the output of transistor **18** and applied over a line **36**. A gating signal is applied to a counter over a line **37** connected to the collector of transistor **31**. This ensures that the counter **35** produces a count which is displayed on tubes **11** only after a fault has been detected.

Referring now to FIG. **5** there is shown a modification of the circuit of FIG. **3** suitable for the detection of missing knitting needles as well as broken knitting needles. The only difference of the FIG. **5** circuit over the FIG. **3** circuit is that transistors **25** and **26** are connected as a free-running multivibrator circuit instead of a monostable multivibrator circuit. The values of the cross-coupling capacitors **29**, **38** in conjunction with variable resistors **30**, **39** are set so that the frequency of the free-running multivibrator is substantially the frequency at which the knitting needles pass the photoelectric cell. Thus normally the initial timing pulses from diode **24** are effective to synchronize the multivibrator and one reference pulse of predetermined length is issued for each knitting needle. If a needle is broken detection is effected in precisely the same way as in the FIG. **3** arrangement. If a knitting needle is missing the free-running multivibrator issues a reference pulse without receipt of an initial timing pulse and since there is then no blanking signal applied to the base of transistor **31** an output is given on line **34**.

It will be understood that the FIG. **5** circuit may be used with a knitting machine of the kind in which the knitting needles are arranged in groups around the mount with spaces therebetween provided the circuit is arranged not to respond at a space between the needles. Such response may be inhibited, for example, by providing dummy needles in the spaces or by a cam-operated microswitch actuated in accordance with the rotation of the mount so that as the gaps pass the sensing head the circuit output is inhibited.

In the drawings, exemplary values are given for resistors and capacitors, but it will be appreciated that many of these values may be changed to suit individual performance requirements of the specifically described example of the invention.

I claim:

1. A circular knitting machine having a series of knitting needles on a mount which rotates, a sensing arrangement positioned to respond to both broken and unbroken knitting needles as the mount rotates, a broken knitting needle giving a lower response than an unbroken knitting needle, means for deriving from the sensing arrangement a curved output current pulse for each knitting needle, the height of the pulse being less for a broken knitting needle than for an unbroken knitting needle, a timing circuit for comparing the instantaneous amplitude of the output current pulses with a preset level and issuing an initial timing signal when the instantaneous amplitude rises above the preset level and final timing signal when the instantaneous amplitude falls below the preset level; a pulse generator for generating reference pulses of predetermined duration, the initial timing signals being applied to the pulse generator to ensure that for each initial timing signal there is a reference pulse which starts in synchronism therewith; and a gate to which are applied as the gated input the reference pulses from the pulse generator or signals derived therefrom, the timing signal or signals derived

therefrom being applied as the control input to the gate to close the gate during the period between an initial timing signal and a succeeding final timing signal; and output means responsive to reference pulse signals passing through the gate when it is open.

2. A knitting machine as claimed in claim 1 wherein the pulse generator is a monostable multivibrator circuit which gives a reference pulse output only in response to being triggered by an initial timing signal.

3. A knitting machine as claimed in claim 1 wherein the pulse generator is a free-running multivibrator circuit running at a frequency corresponding to the rate of passage of knitting needles past the sensing arrangement, initial timing signals being effective to synchronize the multivibrator.

4. A knitting machine as claimed in claim 1 wherein the initial and final timing signals are respectively the leading and trailing edges of a square timing pulse derived by the timing circuit.

5. A knitting machine as claimed in claim 1 wherein the sensing arrangement comprises a lamp and photocell arranged so that as the mount rotates the knitting needles, both broken and unbroken, intercept light passing from the lamp to the photocell.

6. A knitting machine as claimed in claim 1 wherein the control input to the gate comprises square wave blanking pulses each starting with an initial timing signal and ending with a final timing signal.

7. A knitting machine as claimed in claim 1 wherein the gated input to the gate and thus the output from the gate, when given, comprises a spike waveform derived by differentiating the trailing edges of the reference pulses.