Nov. 14, 1967 R. C. BRANDRIFF ETAL 3,352,267

CONTROL CIRCUIT USEFUL WITH SEWING MACHINES

Filed Nov. 29, 1965

2 Sheets-Sheet 1

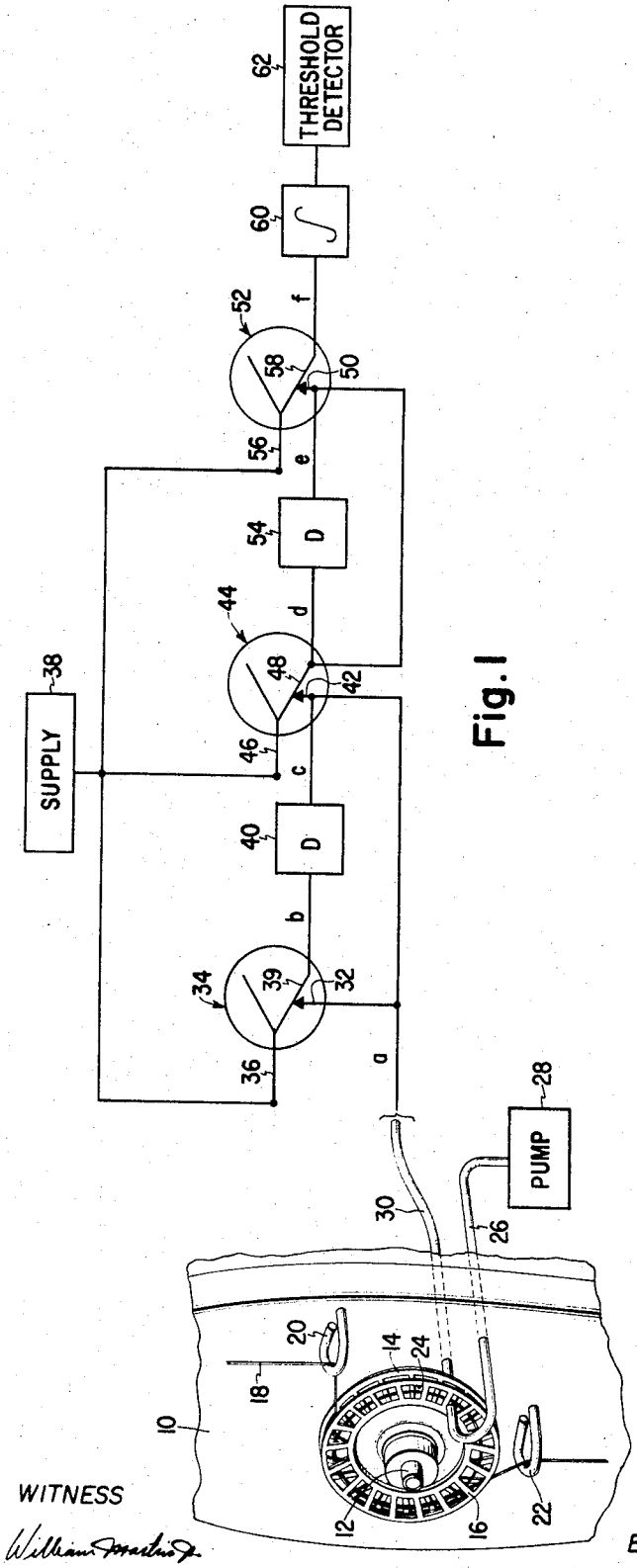


Fig. 1

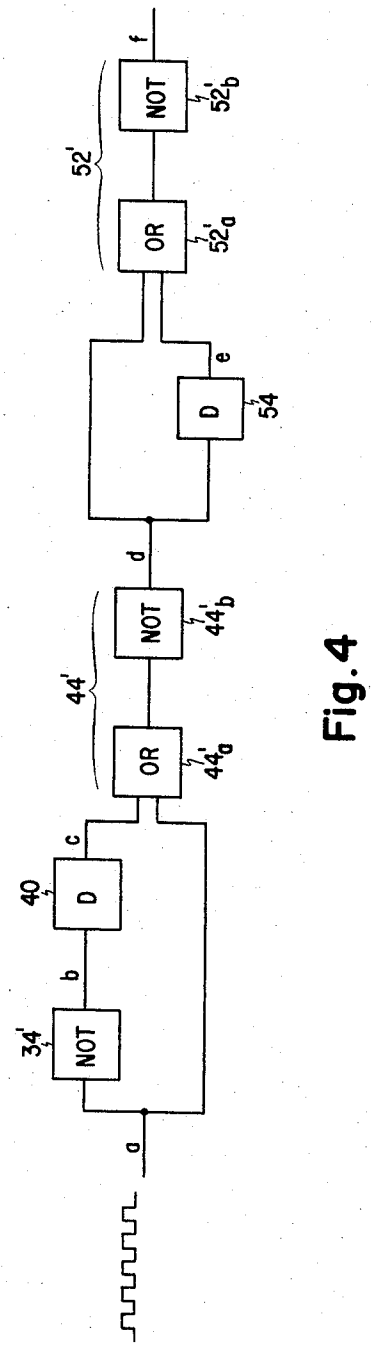


Fig. 4

INVENTORS
Robert C. Brandriff
Charles G. Pickett

BY Marshall J. Breen
ATTORNEY

WITNESS
William Martin Jr.

Nov. 14, 1967 R. C. BRANDRIFF ET AL 3,352,267

CONTROL CIRCUIT USEFUL WITH SEWING MACHINES

Filed Nov. 29, 1965 2 Sheets-Sheet 2

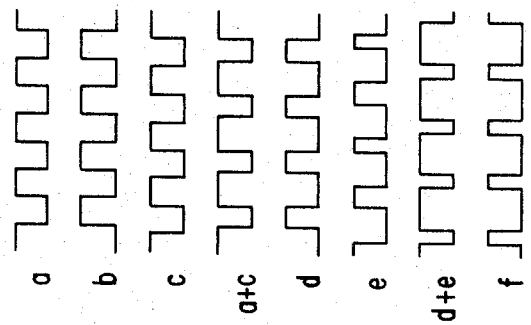


Fig.2C

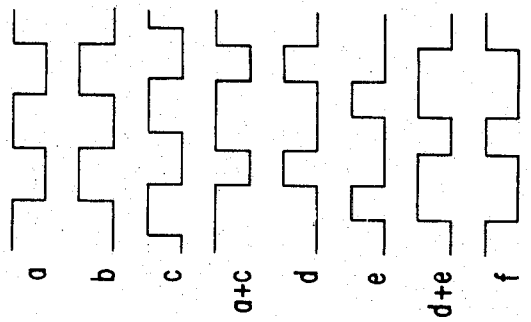


Fig.2B

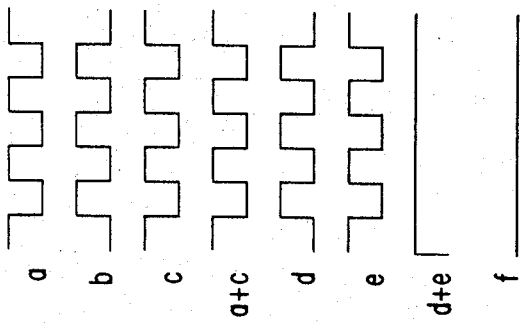
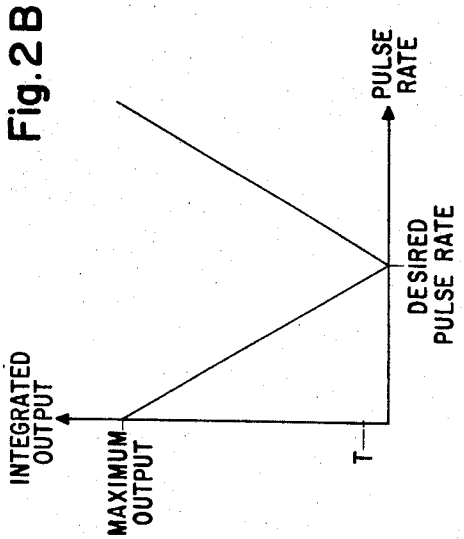


Fig.2A

Fig.3



WITNESS

William Martin Jr

INVENTORS

Robert C. Brandriff

Charles G. Pickett

BY Marshall J. Breen

ATTORNEY

United States Patent Office 3,352,267
Patented Nov. 14, 1967

3,352,267

CONTROL CIRCUIT USEFUL WITH SEWING MACHINES

Robert C. Brandriff, Williamstown, and Charles G. Pickett, Dover, N.J., assignors to The Singer Company, New York, N.Y., a corporation of New Jersey

Filed Nov. 29, 1965, Ser. No. 510,227
11 Claims. (Cl. 112—218)

This invention relates in general to control circuits and in particular to circuits for use in so controlling the modulation of a pulse train that the time duration and the spacing of pulses therein are both substantially equal in time to the same reference time period. In a presently preferred environment for the invention, the circuit is employed to monitor the rate of thread consumption of an industrial sewing machine, whereby when such rate is either too low or too high, an alarm or other control unit is excited. The circuit of the invention, while being broadly a special arrangement of Boolean logic elements which as is known may take a variety of forms, e.g. electrical, magnetic, etc., nevertheless here preferably employs an arrangement of turbulence-type fluid logic switching components (although Coanda-type components may readily be adapted for use with the invention).

In more detail, the circuit of the invention is adapted to receive a pulse train wherein the durations of the pulses therein and their spacings are necessarily substantially equal in time to each other, and wherein the time-lengths of such durations and spacings are controllable. When the pulse durations and spacings are substantially equal in time to a reference time period, the output of the instant control circuit is made to be zero; when such durations and spacings are greater or less in length of time than the reference time period, the circuit is made to produce an output the time integral of which is a signal level that is proportional to the departure in length of time, of such durations, or spacings, from the reference time period. By providing a detector unit responsive to a predetermined level of the time integral signal, modulation of the pulse train may be so maintained that the circuit output (and the time integral signal) is always kept desirously at zero.

In adapting the circuit of the invention for use as a monitor for the rate of thread consumption of an industrial sewing machine, the following factors obtain: A broken needle thread causes the sewing machine consumption rate thereof to cease, whereas a broken bobbin thread causes the consumption rate of the needle thread to decrease. By providing a pulley having spokes that are substantially equisized with the spacings therebetween, and by directing a thin steady stream of air perpendicular to and at such spokes, a pulse train as required of air pressure pulses is had if the pulley is rotated by means of the consumable thread, and if the pulley is of sufficient mass to filter the periodic demand for thread by the sewing machine. A high rate of needle thread consumption effects pulse durations and spacings that are minimal; a low rate of needle thread consumption effects pulse durations and spacings that are substantial. Hence, by adapting the circuit of the invention to provide an output the time integral of which is zero only when the pulley rotational speed is representative of a sewing machine that is functioning properly and consuming needle thread at a normal or reference rate, then monitoring of the operation of such sewing machine, and of its thread consumption, is attained.

For ease in understanding the full scope of the invention, the following description is directed first to a specific form thereof that is both in the presently preferred sewing machine environment, and also employs fluid logic components, after which time the broader aspects of the invention are described with relation to a logic circuit that is Boolean in nature.

A principal object of the invention is to provide a circuit for use in so controlling the modulation of a pulse train that the durations and spacings of the pulses thereof are timewise both substantially equal to a reference time period.

Another object of the invention is to provide a logical arrangement of elements responsive to produce a control output signal when the durations and spacings of pulses in a received pulse train are not, in length of time, the same substantially as a reference time period.

Another object of the invention is to provide a fluid logic circuit responsive to produce a control output signal when the durations and spacings of pulses in a received train of fluid pulses are not, in length of time, the same substantially as a reference time period.

Another object of the invention is to provide a logic circuit for use in monitoring the rotary speed of an element.

Another object of the invention is to provide apparatus for use in monitoring thread consumption by a sewing machine or similar instrumentality.

Another object of the invention is to provide apparatus for use in monitoring the condition of two threads of a sewing machine by sensing the consumption of only one of said threads.

The invention will be described with reference to the figures wherein:

FIG. 1 is a schematic diagram, partially in block form, of a presently preferred embodiment of the invention,

FIGS. 2A, 2B and 2C are signal diagrams useful in describing the operation of the circuit depicted in FIG. 1,

FIG. 3, is a diagram of an operational curve for the presently preferred embodiment of the invention, and

FIG. 4 is a Boolean logic diagram useful in depicting the broader aspects of the invention.

Referring to FIG. 1, a sewing machine **10** supports a journal **12** on which a pulley **14** is rotatably supported. The pulley **14** is provided with a plurality of spokes **16**; and needle thread **18** from the sewing machine **10** winds on and drives the pulley **14**. To prevent slipping of the thread **18** on the pulley, at least a full turn of thread **18** is placed on it, and to guide the thread **18** onto the pulley, thread guides **20**, **22** are employed. Ideally, the pulley spokes **16** are all substantially identical and of generally the same configuration as any one spacing **24** between adjacent spokes, the number of spokes in the pulley being directly determinative of the fineness of the control provided by the instant circuit. As a practical matter, however, the dimensions of the spokes, if desired, may be sized differently with respect to the spacings **24**, with attendantly a proportional decrease in the fineness of the control obtained.

A transmitting tube **26** directs a steady stream of air, provided by a source **28**, at the pulley spokes **16** (or spaces **24**); and a receiving tube **30** is specially aligned to receive the transmitted air stream when the pulley **14** is so rotated that the transmitting tube **26** aligns with a pulley space **24**. The transmitting and receiving tubes **26**, **30** ideally are so sized that the transmitted air stream is substantially blocked from the receiving tube whenever the pulley rotation is such that a spoke aligns with the air stream; and the needle thread **18** is disposed on the pulley **14** so as not to interfere with such air stream. Therefore, when the pulley **14** is stationary either a steady air stream, or no air stream, is directed to the receiving tube **30** depending respectively on whether a space **24** or a spoke **16** aligns with the output of the transmitting tube **26**; when the pulley rotates, a train of air pulses is received by the receiving tube **30**, and the pulses in such

train have durations and spacings as required, i.e. they are timewise substantially equal.

The output of the receiving tube **30**, whether a steady air stream or not, or whether a train of air pulses, is applied to the control input **32** of a turbulence-type fluid amplifier **34**. The intake **36** of the amplifier **34** is adapted to be continuously excited by a pressure supply **38**, and the output (at **39**) of the amplifier **34** is applied through a delay device **40** to the control input **42** of a second turbulence amplifier **44**. In addition, the output of the receiving tube **30** is applied to the control input **42** of the amplifier **44**. The delay device **40**, which may take the form of an appropriately cut length of tubing, provides a time delay equal to the duration of an air pulse as provided when the sewing machine **10** is consuming thread at a normal, or reference, rate. (Obviously the delay may be made adjustable to accommodate different "normal" rates of thread consumption for different sewing machines and/or conditions.)

The intake **46** of the amplifier **44** is excited by the pressure supply **38**, and its output (at **48**) is applied both directly to the control input **50** of a third turbulence amplifier **52**, and to the control input **50** of such amplifier via a delay device **54**. The delay device **54** which also provides a time delay equal to the duration of a reference pulse, may be identical in form to the delay device **40**. The intake **56** of the amplifier **52** is continuously excited by the pressure source **38**, and the output (at **58**) of the amplifier **52** is applied to a pressure integrating element **60**, e.g. a diaphragm actuator, the output of which controls a detector element **62**, which may for example be a microswitch that excites an alarm system.

As to operation of the circuit of FIG. 1 for monitoring the consumption of thread by a sewing machine, the description below relates to operations under the following conditions: (1) The pulley **14** is stationary, as for example when the sewing machine needle thread **18** has broken, and a steady stream of air is transmitted to the receiving tube **30** via a pulley space **24**. (2) The pulley **14** is stationary, and no air stream reaches the receiving tube, as for example when a pulley spoke **16** blocks the air stream. (3) The sewing machine is so functioning normally that the air pulses produced by means of the pulley are of the desired reference duration. (4) The produced air pulses are of longer duration than the reference duration, as for example when the pulley is rotating at too low a rate in response to, say, a broken bobbin thread. (5) When the pulley is rotating at too high a rate and the produced air pulses are of too short a duration.

Condition 1.—A steady air stream from the receiving tube **30**, while switching the amplifier **34** so that it has no output, also causes the amplifier **44** to switch and produce no output. Without a pressure signal from the amplifier **44** being applied to the amplifier **52**, such latter amplifier is prevented from switching, whereby fluid from the pressure supply **38** is applied to the integrator **60** (i.e. the diaphragm actuator) to cause the detector **62** (i.e. the microswitch) to alarm for zero thread consumption.

Condition 2.—Without a pressure signal being applied from the receiving tube **30** to the control input **32** of the amplifier **34** such amplifier does not switch and therefore produces a steady air stream output signal that flows from the pressure supply **38** through the delay device **40** to the control input **42** of the amplifier **44**, whereby such amplifier switches and thereby produces no output signal. With no pressure signal from the amplifier **44** being applied to the control input **50** of the amplifier **52**, the amplifier **52** does not switch and, as above, allows a steady air stream to flow from the supply **38** to the integrator **60** for driving the detector **62**.

Condition 3.—See FIG. 2A which shows signal waveforms *a* through *f* as they appear singularly, and in certain combinations thereof, at similarly noted points on FIG. 1. With a signal *a*, i.e. air pulses having durations equal timewise to the reference time delays of the delay devices **40**, **52** being applied to the control input **32** of the amplifier **34**, the amplifier **34** effectively inverts its applied signal to produce signal *b*, after which time the delay device **40** brings the signal *b*, now as signal *c*, again into phase with the signal *a*. With both signals *a* and *c* in phase and applied to the amplifier **44** control input **42** as a combined signal $(a+c)$, an inverted form thereof, signal *d*, is produced. Since the signal *d*, is delayed by the duration of a single reference pulse to produce the signal *e*, the combination of the signals *d* and *e* is a steady pressure signal $(d+e)$, which when applied to the input **50** of the amplifier **52** causes such amplifier to cease producing an output. Hence, the integrator **60** also produces no output signal when the rate of thread consumption is at the reference rate, and attendantly the detector **62** is not actuated.

Condition 4.—See FIG. 2B which shows a series of signal waveforms similar to those shown in FIG. 2A, but indicating that the air pulses produced by a slowly rotating pulley are of longer duration than those produced when the pulley is rotating at its reference rate. With the long duration pulses of signal *a* applied to switch the amplifier **34** off and on, the signal *b* (an inverted signal *a*) is produced. Since the time delay to the signal *b*, as provided by the delay device **40**, is equal to the reference pulse duration, the signal *c* applied to the control input **42** of the amplifier **44** is not in phase with the signal *a* (as was the case in FIG. 2A). Therefore the combined waveform signal $(a+c)$ has air pulses of still longer duration than those produced by the pulley, and attendantly the output of the amplifier **44** is a series of relatively widely spaced pulses (signal *d*). Delaying such widely spaced pulses of signal *d* by the reference duration produces the waveform signal *e*, and combining the signals *d* and *e* at the control input **50** of the amplifier **52** causes such amplifier to switch periodically, thereby producing a pulse output signal *f* (whereas when thread is consumed at its reference rate as depicted in FIG. 2A, the output signal *f* of the amplifier **52** is a steady state zero pressure signal). Integrating such amplifier **52** output pulses by means for example of a diaphragm actuator produces a steady state pressure signal which, if above a predetermined threshold level, effects actuation of the detector element **62**.

Condition 5.—In the case where the pulley **14** is rotating at too high a speed, and the pulses produced thereby are of relatively short duration as compared to pulses produced when the pulley rotates at its reference speed (see signal *a* of FIG. 2C), the amplifier **34** is turned off and on at a high rate, and thereby produces a high frequency pulse train *b* (inverted with respect to the signal pulse train *a* as produced by the pulley **14**). The delay to the signal pulse train *b* provided by the delay device **40** causes the pulse train signals *a* and *c* to be out of phase, whereby their combination at the control input **42** of the amplifier **44** effects a pulse train (signal *d*) of shorter duration pulses than are being produced by the pulley. Delaying these short duration pulses by means of the delay device **54** to produce the pulse train signal *e*, and combining the pulse train signals *d* and *e* to switch periodically the amplifier **52** off and on has the effect of causing such amplifier to have an output pulse train signal *f*. Integrating the pulsed output signal *f* by means of a diaphragm actuator results in a steady state pressure level, which if above a predetermined threshold level effects actuation of the detector **62**.

FIG. 3 indicates the manner in which the integrated pressure output signal of the diaphragm actuator varies with the speed of the pulley, and also indicates the threshold level T which must be exceeded for actuation of the detector **62**. However, it is to be appreciated that while the curve of FIG. 3 is depicted as being trough-like, this may be easily changed, e.g. by so modifying the circuit of FIG. 1 that the integrator **60** connects to the exhaust output of the amplifier **52** and the operation of the inte-

grator **60** is reversed, whereby the FIG. 3 curve will appear inverted.

As above noted the switching portion of the fluid control circuit of FIG. 1 is essentially a special form of Boolean logic circuit, which naturally may take a variety of other forms. See FIG. 4 which indicates the logical functions performed by the FIG. 1 switching elements, and employs primed notations thereon for those components having related parts in FIG. 1. The FIG. 1 amplifier **34**, by inverting its received control signal, provides a NOT function. So too, the FIG. 1 amplifier **44** by switching in response to either the signal *a* or the signal *c* provides an OR function (element $44_a'$), and since it inverts both of these signals it also provides a NOT function, i.e. the OR-NOT functions of the logic diagram components $44_a'$ and $44_b'$ together provide the NOR switching function of the FIG. 1 fluid amplifier **44**. Similarly, the amplifier **52** by switching in response to either the signal *d* or the signal *e* provides an OR function (element $52_a'$), and by inverting both of these input control signals also provides a NOT function (element $52_b'$), i.e. the NOR function of the FIG. 1 switching fluid amplifier **52** is provided by the logic diagram components $52_a'$ and $52_b'$. Integrating and detecting elements are deliberately omitted from FIG. 3 since these components serve no part of the logic circuit.

While the invention has been described in its preferred embodiments, it is to be realized that the words which have been used are words of description rather than of limitation, and that changes within the purview of the appended claims may be made without departing from the true scope and spirit of the invention. That is, other embodiments of the invention may be had so long as the following functional steps thereof are followed: (a) apply a signal modulated substantially as required by the invention to two parallel channels, (b) invert the signal in one of the two channels, (c) delay the signal in one of the two channels by the duration of substantially one pulse width, (d) logically sum the signals so operated on, and then invert the logical sum signal, (e) apply the logical sum signal to two parallel channels, (f) delay the signal in one of last named channels by substantially the duration of one pulse width, and (g) logically sum the delayed and the unoperated on sum signal to produce a new sum signal, and invert or not the new logical sum signal depending on the output function desired.

Having thus set forth the nature of the invention, what is claimed herein is:

1. Circuit apparatus for use in controlling the modulation of a train of pulses comprising a first pair of signal translating channels connected in parallel and adapted to receive said pulse train, one of said channels being provided with a first NOT logic element, and also one of said channels being provided with means for delaying its respective signal by substantially the duration of a reference time period, a first OR logic element adapted to receive the output signals from both said channels to produce a logical sum signal, a second NOT logic element adapted to receive the output logical sum signal from said first OR logic element, a second pair of channels connected in parallel and adapted to receive the output signal from said second NOT element, and one of said second pair of channels being provided with means for delaying its signal by a duration substantially the same as said reference time period, and a second OR logic element adapted to receive the signals from both channels of said second pair of channels for producing a second logical sum signal.

2. The apparatus of claim **1** including a third NOT logical element adapted to receive the output of said second OR logical element.

3. The apparatus of claim **2** wherein said pulse train is in the nature of air pulses, wherein said first NOT element is a fluid amplifier the control input of which is adapted to be excited by said pulse train, wherein said

first OR element and said second NOT element together comprise a second fluid amplifier the control input of which is adapted to receive the outputs of said first pair of channels, and wherein said second OR logic element and said third NOT logic element together comprise a third fluid amplifier the control input of which is adapted to receive the outputs of said second pair of parallel channels.

4. The apparatus of claim **3** including means adapted to receive the output of said third fluid amplifier for producing a pressure signal proportional to the time integral of such output, and actuable means responsive to a predetermined level of said time integral pressure signal.

5. The apparatus of claim **4** wherein both said means for delaying signals are substantially equisized lengths of tubing so cut that air pulses provided respectively thereto traverse the lengths of tubing in approximately the reference time period.

6. The apparatus of claim **3** wherein both said means for delaying signals are substantially equisized lengths of tubing so cut that air pulses applied respectively thereto traverse the lengths of tubing in approximately the reference time period.

7. A fluid logic control circuit comprising means for producing a train of pressure pulses, a first turbulence amplifier the control input of which is adapted to receive said train of pulses, means for delaying pressure pulses by a reference amount of time, said last named means being adapted to receive the output of said first turbulence amplifier, a second turbulence amplifier adapted to receive at its control input both the output of said means for producing said train of pressure pulses and the output of said means for delaying pulses, second means for delaying pulses by substantially said reference amount adapted to receive the output of said second turbulence amplifier, and a third turbulence amplifier adapted to receive at its control input both the output of said second means for delaying pulses and the output of said second turbulence amplifier.

8. The apparatus of claim **7** including a wheel having a plurality of spokes each of which is sized approximately the same as the spacing between any adjacent pair thereof, means for rotating said wheel, means for directing a thin stream of air transverse to and by the spokes of said wheel depending on the rotational phase of said wheel, and means for receiving the air which passes said wheel and applying it to said first turbulence amplifier.

9. The apparatus of claim **8** wherein said spoked wheel is a pulley, and wherein said apparatus includes thread handling means, the thread thereof being passed around said pulley for driving same, whereby air pulses are applied to said air receiving means at a rate proportional to the rate at which said pulley rotates.

10. The apparatus of claim **9** wherein said thread handling means is a sewing machine wherein the thread passed around said pulley is the needle thread of said machine, and wherein both said means for delaying pressure pulses provide pulse delays substantially equal timewise to the duration of a pulse as generated when said pulley is rotated by thread being consumed at the normal sewing rate for said machine.

11. The apparatus of claim **10** including actuable means responsive to a predetermined level of the pressure level signal for warning of thread failure and the like.

References Cited

UNITED STATES PATENTS

3,191,860	6/1965	Wadey	137—81.5 X
3,226,570	12/1965	Rosenbann	307—88.5
3,275,015	9/1966	Meier	137—81.5
3,302,398	2/1967	Taplin et al.	137—81.5

PATRICK D. LAWSON, *Primary Examiner.*

H. H. HUNTER, *Assistant Examiner.*