This invention relates to an apparatus for detecting holes in fabric, and more particularly tubular knitted fabric. Various types of apparatus have been developed for detecting holes in tubular knitted fabric. These machines for the most part employ feeder fingers movable through a hole in the fabric to contact with some metallic portion of the knitting machine to complete an electrical circuit to sound an alarm, illuminate a warning light, stop the apparatus, or otherwise perform some function to indicate that a defect has been found. Such forms of apparatus are easily adaptable for use for detecting holes in tubular knitted fabric as it leaves the knitting machine, since one side of the detecting or warning circuit can be grounded on the knitting machine, thus rendering it comparatively simple to complete a circuit through the feeder fingers when a hole passes one of these fingers.

On the other hand, such an apparatus is not adaptable for use where the fabric moves relatively rapidly past the feeder fingers, since the period during which electrical contact is established by the fingers does not provide the interval of time necessary for causing the operation of the warning devices, etc. In mechanical devices associated with the detecting circuits, the inertia of the moving parts does not permit them to become operative. Moreover, apparatus of the character referred to can be used only on tubular knitted fabric as it leaves the knitting machine, and it is highly desirable to provide hole detecting means for fabric of this kind, which will be operative at relatively high speeds of movement of the fabric and will be operative on fabric moving from machines or equipment not associated with the knitting machine, for example after such operations as bleaching, centrifuging, and drying, and in some instances also after dyeing the material.

An important object of the present invention is to provide a novel hole detecting mechanism particularly adapted for use in detecting holes in tubular knitted fabric after it has left a knitting machine, and wherein such apparatus is operative for performing the desired functions of operating a warning signal, etc., even though the material is moving at a relatively high speed.

A further object is to provide such an apparatus which possesses such characteristics that even though the fabric is moving at a relatively high speed and the normal period of electrical contact of the feeder fingers is extremely short, the problem of overcoming the inertia of movable parts, etc. is not present. A further object is to provide an apparatus of this character having novel means for completing a circuit through any feeder finger when the latter encounters a hole in the fabric.

A further object is to provide a novel apparatus which is operative mechanically by any feeder finger for establishing a holding circuit for the proper operation of warning signals, etc. A further object is to provide a novel type of what may be termed a "floating" spreader formed of electrical conducting material and arranged in the tubular goods passing thereover, and to provide novel means for connecting the spreader in a circuit so as to render it ready for operation at all times for completing a detecting circuit through any feeder finger which may encounter a hole in the knitted fabric.

A further object is to provide in an apparatus of this character a rotating member mounted within the spreader and having needle-like contact elements which project through the fabric to maintain constant electrical engagement with a rotary member outside the fabric so as to complete a circuit at all times for the detecting mechanism, except at the feeder fingers, whereby contact of any such fingers with the spreader operates the detecting mechanism.

A further object is to provide a novel type of spreader wherein the fabric is caused to partake of an abrupt bend at each side of the spreader at the points where the feeder fingers contact with the fabric, thus rendering the fingers operative for detecting relatively small holes in the fabric. A further object is to provide an apparatus of this general character wherein mechanical movement imparted to any feeder finger is translated into operation of a switch to energize a signal or similar holding circuit and wherein the mechanical operation is accomplished without undue resistance against movement of an operative feeder finger, thus preventing the latter from substantially enlarging the hole which is in engagement with such finger.

A further object is to provide, in combination with an apparatus of this character, a highly efficient electronic control circuit which permits the use of a low voltage detecting circuit to prevent arcing at any of the contact points in such circuit, and which is operable even if the feeder contact is established for a very small fraction of a second, to insure the operation of the alarm or warning circuit.

Other objects and advantages of the invention will become apparent in the course of the following description.

In the drawings there have been shown two embodiments of the invention. In this showing:

Figure 1 is a diagrammatic representation of the apparatus and its detecting and alarm or control circuits;

Figure 2 is a fragmentary sectional view through the spreader and the fabric feed rolls which maintain the spreader in position, a portion of the fabric being shown passing through the apparatus and feeder fingers being illustrated at opposite sides of the spreader;

Figure 3 is a fragmentary end elevation of what may be termed the needle wheel and a portion of its cooperating contact wheel, a layer of fabric passing between these wheels being shown in dotted lines;

Figure 4 is a fragmentary sectional view on line 4—4 of Figure 2;

Figure 5 is a similar view on line 5—5 of Figure 2;

Figure 6 is a sectional view similar to Figure 2 showing a modified form of the invention; and

Figure 7 is a plan view of the switch operating means employed in the form of the invention shown in Figure 6.

Referring to Figures 2, 4, and 5, the numeral 10 designates a spreader shown in the present instance as being a relatively thin metallic plate arranged vertically, and of such horizontal width as to facilitate its entering a tubular fabric 11 of a particular size. The spreader's horizontal cross section area will be such as to slightly stretch the tubular fabric so that the latter will be maintained smooth and flat on opposite sides of the spreader. The edges of the spreader are preferably rounded, as indicated by the numeral 12. Such edge at the top of the spreader facilitates smooth entrance of the top of the spreader into the fabric as the latter moves downwardly thereover, and the rounding of the side edges of the spreader facilitates...
the smooth sliding movement of the fabric thereover, as will be apparent.

Beneath the spreader are a pair of feed rolls 13 mounted on shafts 14 to be driven thereby in any suitable manner, these rollers rotating in the direction of the arrows in Figure 2. These rollers may be covered on their surfaces with any layer of material 15 which will possess a sufficient degree of surface friction to facilitate the feeding of the tubular fabric downwardly between the rollers. The space between the rollers is only sufficient for the passage of the fabric therebetween, and this space is much narrower than the thickness of the spreader 10. Therefore, while the adjacent sides of the rollers move downwardly to feed the fabric therebetween, the rollers act as supporting means for the spreader 12.

The spreader is provided at opposite sides with undercut shoulders 16 beneath which the spreader is relatively thin and tapers to increase in width as at 17, the spreader above the shoulders 16 and beneath the tapered portion 17 having each of its opposite faces lying in a common plane. It will be apparent that the fabric passing over the shoulders 16 partakes of an abrupt bend, and it is at this point that feeder fingers engage the fabric to slide thereover unless and until a hole in the fabric, for example as indicated by the numeral 18, passes over one of the fingers to operate the detecting circuit.

Each of the feeder fingers is indicated as a whole by the numeral 20. A set of these fingers is arranged outwardly of each side of the spreader and the fingers of each set are arranged in close proximity, for example one-eighth inch apart in actual practice, as so to render it substantially impossible for a hole to pass between any adjacent pair of fingers. All of the fingers will be identical and only one need be described in detail. Each finger is made of spring wire of circular section, and the end remote from the spreader is coiled as at 21 and has its extremity projecting through a supporting bar 22. From the coil 21 each finger extends downwardly and inwardly toward the spreader 10, as at 23, and then curves upwardly, as at 24, toward the adjacent shoulder 16. Just beneath such shoulder, the spreader is looped as at 25 and has its extremity 26 extending downwardly and away from the spreader. The loop 25 of each feeder finger provides a smooth surface under which the fabric is adapted to slide, but when a hole 38 passes one of the loops 25, this loop will extend through the hole and engage the spreader 10 to close a detecting circuit in a manner to be described.

The tensioning of each finger 23 is such that the tendency for each loop 25 is to move upwardly and inwardly toward the shoulders 16, substantially as indicated by the small arrows in Figure 2. This tensioning of the fingers greatly facilitates the entrance of any loop 25 through a hole 18 as the latter takes its abrupt bend in passing around one of the shoulders 16.

As previously stated, it is a simple matter in a hole detecting device associated with a knitting machine to provide a detecting circuit on such machine. The present apparatus may be used anywhere it may be desired, wholly dissociated from a knitting machine, and it will be apparent that the spreader 10 is housed wholly within the tubular fabric, thus rendering it difficult to connect the spreader into a detecting circuit. The present apparatus, in the form shown in Figures 1–5 inclusive, provides a means for connecting the rollers to the spreader 10 of a detecting circuit so that such circuit is normally broken solely at the feeder fingers. Referring to Figures 3 and 5, the numeral 30 designates a wheel mounted in a recess 31 formed in the spreader plate, assuming this plate to be a solid member, as specifically illustrated. The roller 30 is mounted on a shaft 32 extending over the width of the spreader 10 at opposite sides of the recess 30, but obviously not projecting beyond the outer surfaces of the spreader since this would interfere with the movement of the fabric thereover. The wheel 30 is metal, as is its shaft 32 and, accordingly, the wheel is grounded on the metallic spreader 10. Around its periphery, the wheel 30 is provided with closely arranged "needles" 33. These elements are contact elements made of resilient material of small diameter and are actually needle-like in that they may be pointed for the free passage thereof through the fabric 11. In actual tests it has been found that the needles 33 may be radially arranged without damage to the fabric, but possible damage is completely eliminated by inclining the needles away from the direction of rotation of the wheel 30, as indicated in Figure 3.

The needles 33 are longer than the thickness of the fabric passing over the wheel 30, as shown in Figures 3 and 5, and the needles engage a contact wheel 34 suitably supported on a shaft 35 parallel to the shaft 32. The wheel 34 of course is made of electrically conducting material, and preferably of a commercially available rubber material having occluded conducting substances therein which are concentrated to provide the necessary conductivity. Alternatively, the wheel 34 may be a steel bristle brush with the steel bristles closely arranged, or it may be made up of steel or copper wool clamped between round plates. Various other types of wheels may be employed including soft lead or other alloy. In other words, as a practical matter, the wheel 34 should be made of such material as to establish good electrical contact with the needles 33 without rapidly wearing the ends of such needles. These needles, in any event, preferably possess a substantial degree of resiliency, and the length of the needles, the spacing of the needles, and the diameter of the wheels 30 and 34 are such that the wheel 34 is never without firm contact with at least one needle and preferably two, as shown in Figure 3. Therefore, whenever the circuit otherwise is closed, there can be a continuous flow of current between wheels 30 and 34 without any making or breaking of the circuit between these wheels, and arcing is effectively prevented.

In Figure 1, highly efficient electrical control circuits for the apparatus are illustrated. A source of current, such as a battery 36, of the order of 45 volts, has the positive terminal thereof connected by a wire 37 to the bars 22, which are formed of conducting material, and connected in parallel, as shown in Figure 1. The spreader 10 has been merely diagrammatically indicated in Figure 1 without reference to the mounting of the wheel 30 thereon, and this wheel has been shown for the purpose of illustration as being electrically connected to the spreader, as at 38. It will be apparent that the wheel 30 is parallel to the opposite faces of the spreader 10 and, accordingly, normally occupies a position perpendicular to its position as diagrammatically shown in Figure 1.

The negative terminal of the battery 36 is connected to a wire 39 which connects to the grid 42b of electron tube 42. Electron tube 42 includes, in addition to control grid 42a, cathode 42a, and anode or plate electrode 42c. The input circuit to the tube 42 is completed through lead 49 which connects to the wheel 34 with a suitable condenser 41 connected between grid 42b and cathode 42a. The electrical elements described constitute the detecting circuit portion of the apparatus, and what may be termed the "control" circuit is controlled from the detecting circuit.

The circuit components of the detecting circuit are all selected so that tube 42 operates on very high contact resistance which is highly necessary for the successful functioning of the hole detector. I have successfully used a 6J5 tube as the tube 42 and have so designed the circuit that contact between the finger 20 and the spreader 10 may be extremely light and rapid and yet sufficient to impress a voltage of minute magnitude on the control grid 42b resulting in a current flow of the order of microamperes to effect the required control without contact arcing. Arcing within the textile fabric is dangerous due to liability of injury and the hazard of fire. The microamperes current necessary to perform a control function is so low that contact arcing is invisible and cannot be
come a source of hazard. A contact interval as rapid as .003 second is sufficient to effect a functioning of the relay shown at 43 in the output circuit of the control system which makes it possible to operate the inspection device at approximately sixty feet per minute without taking into consideration the wiping effect of the probe fingers which can double or treble the speed of operation of the system of my invention.

The output circuit of tube 42 includes an appropriate source of plate potential 44 of the order of 45 volts and there is a suitable source of potential 45 for supplying the cathode heating current with a suitable switch 46 for turning on the electronic circuit by closing the cathode heating circuit when the device is to be placed in operation. The relay 43 is a high-resistance, highly-sensitive single pole, double throw device including armature 43a spring biased by spring 43b to a position normally in contact with contact 47 for preparing the circuit through arm horn 51 and through a switch 53 to the power supply circuit 49. Switch 53 is not closed until tube 42 is brought up to full operating condition. The relay armature 43a is movable when relay 43 is energized to open contact 47 and close contact 58, connecting lamp 48 to the alternating current power supply circuit 49. The condenser 41 which shuts the cathode 42a and control grid 42b is arranged in the input circuit.

When the electronic circuit is conditioned for operation by closing switch 46 to heat the cathode, current flows in the output circuit and with the control grid 43b substantially floating by reason of the fact that the circuit through fingers 20 and spreader 10 is opened, relay winding 43 is energized as soon as the tube 42 is raised to operating temperature, moving armature 43a to contact 50 and energizing signal lamp 48, thus showing that the electronic circuit of tube 42 is in proper operating condition. The circuit to the horn 51 is normally maintained open while the circuit of tube 42 is being conditioned for operation.

Thus the cathode 42a preferably is conditioned for the required electronic emission before the circuit for the horn 51 is conditioned to respond to operation of the detecting circuit. For accomplishing this end, the switch 46 is first closed, and after a suitable time interval, switch 53 in the circuit of the horn 51 is closed. By the time the switch 53 has been closed, plate current will be passing through winding 43 so that the circuit through contact 47 and armature 43a will be closed, and the horn 51 will be silent. However, when a contact occurs between fingers 20 and spreader 10, the plate current is immediately blocked and winding 43 is de-energized, whereby armature 43a is released and moves under tension of spring 43b to establish connection with contact 47, thus completing the circuit through closed switch 53, horn 51 and power source 49, sounding the alarm denoting a fault in the cloth. The capacity of condenser 41 predetermines the time period of operation of the circuits. Condenser 41 in the input circuit is charged when the negative potential from battery 36 is applied to control grid 42b and continues to hold its charge after the momentary contacts between fingers 20 and spreader 10 of the hole detector are opened. As soon as the grid 42b of tube 42 becomes negative, as hereinbefore pointed out, current flow to the anode is stopped, winding 43 de-energized and relay contact 47 closed by virtue of 43a being released under tension of spring 43b, thus closing the circuit through horn 51. The condenser 41 is relatively large and maintains the grid voltage at a sufficient level long enough for relay 43 to remain de-energized and the alarm circuit closed.

When the opening in the fabric has passed by the fingers 20 and spreader 10, the negative potential from battery 36 is removed from grid 42b and current again flows in the output circuit of tube 42 exciting winding 43 and moving armature 43a into connection with contact 50, closing the circuit between armature 43a and contact 50 and lighting signal lamp 48 from the power source 49. The circuit to the alarm or horn 51 is broken between contact 47 and armature 43a subject to be made as soon as fingers 22 again encounter an opening in the fabric passing over spreader 10.

In lieu of the battery powered circuit that I have diagrammatically shown, I have shown a modified form of the invention in which the same type of spreader and feed rolls 13 and 14 have been employed, and these elements have been indicated by the same numerals in Figure 6, together with other elements which are common to the two forms of the invention. In the modified form the spreader 10 is not depended upon as an electrical conductor, and needle 23 and fingers function mechanically to close an alarm circuit in a novel manner. The feeder fingers are identical with those described above, except that instead of the terminating end 26, the fingers beneath and outwardly of the loops 25 extend downwardly as at 65 to form a mechanical contact loop 66, and then upwardly as at 67 to be braced or welded to the finger portions 23.

Outwardly of each side of the spreader is arranged a switch operating wheel 70 fixed to a shaft 71 to be rocked thereby. Beyond the ends of the feelers, sleeves 72 are fixed to each shaft 71, and a substantially U-shaped frame 73 is provided at its ends with arms 74 fixed to the sleeves 72. Each frame 73 further includes a mechanical contact arm 75 connected between the arms 74, this bar being parallel to the shaft 71 and parallel to the adjacent side face of the spreader 10.

Each wheel 70 is provided in its periphery with a curved notch 76 to receive a cam follower 77 forming on a switch operating finger 78, supported as at 79. The free end of each finger 78 engages a rod 80 capped by an insulating element 81. The cap 81 engages a switch finger 82 the contact of which is spaced from a second switch finger 83. A source of current, for example, a battery 84, has one terminal connected by a wire 85 to the switch arm 83 and has its other terminal connected as at 86 to the switch arm 82 with an alarm or indicator 87 connected in such wire, for example, an electrically operated horn or the like.

Operation

As previously stated, the present invention is particularly intended to provide means for detecting holes in tubular knitted fabric after the fabric leaves the knitting machine. For example, the fabric subsequent to knitting may have been subjected to bleaching, centrifuging, and drying; and, in some instances, may have been dyed prior to being subjected to the action of the present apparatus. From whatever operation the tubular fabric is brought to the machine, it is slipped over the spreader 12 and its advancing end is engaged between the rollers 13 to be fed downwardly thereby as viewed in Figure 1. In the absence of any holes therein, the fabric will move between the loops 25 of the finger fingers and the spreader, and no operation will take place. At all times, however, the movement of the fabric (Figure 3) over the needle 33 rotates the wheel 30, the needles penetrating the fabric and establishing constant electrical connection between wheels 30 and 34. Both of these wheels are freely rotatable, and the fine pointed needles extend through the fabric and move therewith between the wheels 30 and 34 without causing any damage to the fabric.
Assuming that a hole 18 comes into position with respect to one of the finger loops 25, the fabric adjacent the hole will partake of an abrupt bend around the shoulder 16, thus tending to open the hole and render it easier for the loop 25 to move therethrough into electrical contact with the spreader 10. When this occurs, a detecting circuit will be completed from the battery 36 through which- ever finger feeder is in electrical engagement with the spreader 10 and across wheels 30 and 34. The closing of this circuit is used to render operative the electronic alarm or control circuit as described above.

In the form of the invention shown in Figures 1–5 inclusive, and assuming that the tubular fabric is passing through the device at a speed of 60 feet per minute, the duration of the contact of one of the finger loops 25 will depend upon the size of the hole in the fabric. In the case of a one-eighth inch hole the duration of the contact will be only 0.10 second. As previously stated, this interval of the closing of the detecting circuit is not sufficient for the operation of any previously known mechanical device in an alarm circuit, and this deficiency is overcome by the novel electronic means described herein. In Figures 6 and 7, there is provided a form of the device which is rendered highly efficient in operation because of the use of the mechanical advantage for mechanically establishing and maintaining an alarm or control circuit without utilizing the spreader 10 as an electrical conductor. Assuming that a hole 18 in the fabric passes over one of the shoulders 16 and engages one of the small finger loops 25, the abrupt bending of the material around the shoulder insures the entrance of the finger loop therethrough, and consequently insures mechanical engagement of the upper edge of the fabric in the loop 25. This mechanical engagement of the hole with the finger fingers is far more positive with the type of spreader illustrated than would be true with a flat-sided spreader.

The loading of the spring loops 23 of the finger fingers is not substantial but is sufficient to tend to maintain the loop 25 of each finger in engagement with the hole in the goods, and without exerting any very great mechanical force against the loop 25, force will be transmitted through the finger portion 65 to the loop 66 to press downwardly on the bar 75. In practice, the leverage represented between the length of each arm 74 and the radius of the wheel 70 will be such that little force will be required to rock the wheel 70 associated with the finger finger being operated to turn such wheel and lift the cam element 72 out of the associated notch 76. The arm 78 will be biased downwardly by its own resilience or by a spring, when the cam portion 71 is in the notch 76, to support the weight of the frame 73, thus making it possible to rock the wheel 70 with very little force and thus avoiding enlarging the hole in the fabric.

Upon the lifting of the finger 78, the rod 80 and its insulating cap 81 will be moved upwardly to engage switch arm 82 with the arm 83 and thus close a circuit through the alarm 87. The frame 73 may drop to a lower vertical position but will move no further and, accordingly, the circular portion of the wheel 70 will maintain the switch 82 closed, and this circuit will remain closed until the operated frame 73 is manually restored to its normal position as shown in Figure 6.

I claim:

1. Apparatus for detecting holes in tubular fabric comprising a spreader of conducting material around and over which the fabric passes in one direction lengthwise of the fabric, a feeder engageable with the fabric outwardly of said spreader and movable into electrical contact therewith upon the passing of a hole in the fabric under said feeder, and a detecting circuit comprising said feeder and said spreader, said circuit further comprising a pair of contact devices, one carried by and electrically connected to said spreader, and the other arranged externally of the fabric, said rotary contact device having circumferentially spaced needle-like fingers projecting from the periphery thereof to be engaged by the fabric to rotate said rotary contact device as the fabric passes therover, at least one of said needle-like fingers projecting through the fabric and electrically contacting the other of said contact devices at all times during movement of the fabric over said spreader.

2. Apparatus for detecting holes in tubular fabric comprising a spreader of conducting material around and over which the fabric passes in one direction lengthwise of the fabric, a feeder engageable with the fabric outwardly of said spreader and movable into electrical contact therewith upon the passing of a hole in the fabric under said feeder, and a detecting circuit including said feeder and said spreader, said circuit further comprising a pair of contact devices, one carried by and electrically connected to said spreader, and the other of which is arranged externally of the fabric, said rotary contact device having circumferentially spaced needle-like fingers projecting from the periphery thereof to be engaged by the fabric to rotate said rotary contact device as the fabric passes therover, at least one of said needle-like fingers projecting through the fabric and electrically contacting the other of said contact devices at all times during movement of the fabric over said spreader.

3. Apparatus for detecting holes in tubular fabric comprising a spreader of conducting material around and over which the fabric passes in one direction lengthwise of the fabric, a feeder engageable with the fabric outwardly of said spreader and movable into electrical contact therewith upon the passing of a hole in the fabric under said feeder, and a detecting circuit including said feeder and spreader, said circuit further comprising a pair of rotatable contact devices, one of which is mounted in and rotatably supported by said spreader and in electrical contact therewith and is provided on its periphery with a plurality of relatively closely arranged needle-like fingers each of a length greater than the thickness of the fabric and projecting therethrough adjacent the other of said contact devices, said other contact device being formed of relatively deformable conducting material and being engaged by at least one of said needle-like fingers, to be rotated thereby and to complete the circuit between said contact devices at all times during movement of the fabric over said spreader.

4. Apparatus for detecting holes in tubular fabric comprising a spreader around and over which the fabric passes, common means for feeding the fabric in one direction over said spreader and for preventing movement of said spreader in said direction, a feeder supported outwardly of said spreader and having a free resilient end engageable against the fabric passing therover to be movable through a hole in the fabric, and detecting means responsive to such movement of said feeder end through the fabric.

5. Apparatus for detecting holes in tubular fabric comprising a spreader around and over which the tubular fabric passes, a pair of feed rolls at one end of said spreader and between which the fabric is gripped to move it in one direction over said spreader, the space between said rolls being less than the thickness of said spreader to prevent movement thereof in said direction, a feeder supported externally of said spreader and having an end biased into engagement with the fabric passing over said spreader to move through a hole in the fabric if such hole exists.

6. Apparatus for detecting holes in tubular fabric comprising a spreader around and over which the tubular fabric passes, a pair of feed rolls at one end of said spreader and between which the fabric is gripped to move it in one direction over said spreader, the space between said rolls being less than the thickness of said spreader to prevent movement thereof in said direction, a feeder supported externally of said spreader and having an end biased into engagement with the fabric passing over said spreader to move through a hole in the fabric if such hole exists.
passes beneath said end of said feeler, a control circuit and switch means for said circuit having mechanical connection with said feeler to be closed by the latter upon movement thereof through a hole in the fabric.

3. Holes in tubular fabric comprising a relatively thin spreader having opposite faces and insertable in tubular knitted fabric, means for feeding the fabric in one direction over said spreader, said opposite faces having shoulders undercut in said direction, a plurality of feelers supported outwardly of each face of said spreader and having free ends resiliently engageable with the fabric to move through an opening passing beneath any such feeler, the free end of each of said feelers being arranged beneath one of said shoulders, whereby the fabric partsake of a relatively sharp bend around each shoulder to facilitate the entrance of any feeler end through a fabric hole passing thereover, and means responsive to movement of any feeler through a hole in the fabric for closing a control circuit.

8. Apparatus constructed in accordance with claim 7 wherein the means for closing said control circuit comprises a switch in such circuit, an operating member for said switch biased therewith to an open-switch position, and means responsive to movement of any of said feelers through the fabric for moving said switch operating member to close said switch.

11. Apparatus for detecting holes in tubular fabric, comprising a spreader having opposite faces and insertable into the tubular fabric, feed rolls at one end of said spreader engageable with the fabric to move it in one direction over said spreader, the space between said roll being less than the thickness of said spreader whereby the latter is prevented from moving in said direction, each of said opposite faces having a shoulder undercut in said direction, a plurality of feeler fingers arranged outwardly of said opposite faces and each having a free end resiliently engaging against the fabric just beneath one of said shoulders whereby the fabric is caused to partake of an abrupt bend over said shoulders in passing beneath said ends of said fingers to facilitate the entrance of said feeler finger ends through holes in the fabric, said feeler fingers and said spreader being formed of conducting material, and a detecting circuit including said feeler fingers and said spreader, said detecting circuit comprising electrical means responsive to the closing of said detecting circuit.

14. In apparatus for detecting holes in tubular fabric means for feeding the fabric in spread condition, an electric detecting circuit including an electron tube having input and output circuits, a circuit-closing element projectable through a hole in the fabric and the hole passes a predetermined position during the feeding of the fabric for establishing a conductive connection through the hole in the fabric for closing an electric circuit through the input circuit of said electron tube, a potential source in said circuit, means connected with said input circuit comprising a condenser having a capacity sufficient to receive a charge from said potential source while said circuit closing element is closed for a time interval as small as 0.10 second and to effect change for prolonging the effect of said circuit-closing operation beyond the time interval that said circuit-closing element remains closed, and an alarm operative over the time period that said effect of said circuit-closing operation is prolonged powered from the discharge of said condenser.

15. In apparatus for detecting holes in tubular fabric, means for feeding the fabric in spread condition, an electric detecting circuit including a circuit-closing element projectable through a hole in the fabric when the hole passes a predetermined position during the feeding of the fabric for closing an electric circuit, a potential source an electron tube including at least a cathode, a control grid and an anode, an input circuit connected with said control grid and cathode, an output circuit connected with said anode and cathode, a relay in said output circuit, a visual signal, an audible signal, a two-position armature controlled by said relay, contacts opened by said armature and respectively connected with said signals and a power source for separately energizing said signals, means for energizing said visual signal while the fabric is operated by said feeding means and said circuit-closing element moves through a hole of contact, means for energizing said audible signal when said circuit-closing element closes said electric circuit through a hole in the moving fabric and a condenser connected in shunt with
said input circuit, said condenser having a capacity sufficient to receive a charge from said potential source and to maintain said charge for prolonging the time interval over which said input circuit is controlled for correspondingly controlling the time interval during which said audible signal is operated.

16. An apparatus for detecting holes in tubular fabric as set forth in claim 15 in which said condenser is electrically connected in said input circuit in a position intermediate said control grid and said source of potential for receiving an electric charge simultaneously with the closing of said circuit-closing element, and means for utilizing the charge in said condenser for determining the potential on said grid and maintaining said relay in a position for operating said audible signal for a predetermined time period subsequent to the opening of said circuit-closing element.

17. An apparatus for detecting holes in tubular fabric as set forth in claim 15 in which said condenser is electrically charged from said source prior to the completion of the electrical connection of said audible signal with said contactors.

18. Apparatus for detecting holes in tubular fabric comprising a spreader around and over which the fabric passes, a feeler supported outwardly of said spreader and having a portion biased against the fabric passing therewith to be movable through a hole in the fabric, and detecting means responsive to such movement of said feeler portion through the fabric.

19. In an apparatus for detecting holes in fabric and capable of detecting holes in tubular fabric, feeding means for feeding the fabric in spread condition, an electric detecting circuit capable of detecting holes in the fabric while the fabric is moving, said detecting circuit including a circuit-closing element projectable through holes in the fabric, said feeding means operating at a speed such that holes of approximately one-eighth inch passing said circuit-closing element in a time interval as short as 0.03 seconds effects the establishment of a conductive connection through the hole in the fabric for closing an electric circuit, an electron tube system having input and output circuits, a potential source, a condenser connected in said input circuit, a circuit extending from one side of said condenser through said circuit-closing element and returning through said potential source to the other side of said condenser, said condenser having a capacity sufficient to receive a charge from said potential source while said circuit-closing element is closed and maintain said charge after said circuit-closing element is open for prolonging the effect of said circuit-closing operation upon said electron tube system beyond the time interval that said circuit-closing element remains closed, and an alarm connected with said output circuit and operative over the time period that said effect of said circuit-closing operation is prolonged powered from the discharge of said condenser through the input circuit of said electron tube system.

References Cited in the file of this patent

UNITED STATES PATENTS

701,248 Bannon .......................... May 27, 1902
1,149,018 Beregh .......................... Aug. 3, 1915
1,631,476 Moos .......................... June 7, 1927
1,980,294 Ross et al. ................. Nov. 13, 1934
2,105,185 Degnan .......................... Jan. 11, 1938
2,304,513 Stearns ........................ Dec. 8, 1942
2,611,017 Bailey .......................... Sept. 16, 1952