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[45] **Nov. 18, 1975**

[54] **ELECTRICAL FENCING SCORING METHOD AND APPARATUS**

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[52] **U.S. Cl.** ..... **273/1 F**

[51] **Int. Cl.**[2] **A63B 69/02**

[58] **Field of Search** ..... 273/1 E, 1 F; 272/57 C

[56] **References Cited**

FOREIGN PATENTS OR APPLICATIONS

127,932	8/1960	U.S.S.R.	273/1 F
1,162,554	9/1958	France	272/57 C
81,004	6/1963	France	273/1 F
1,293,068	4/1962	France	273/1 F
1,148,004	12/1957	France	273/1 F

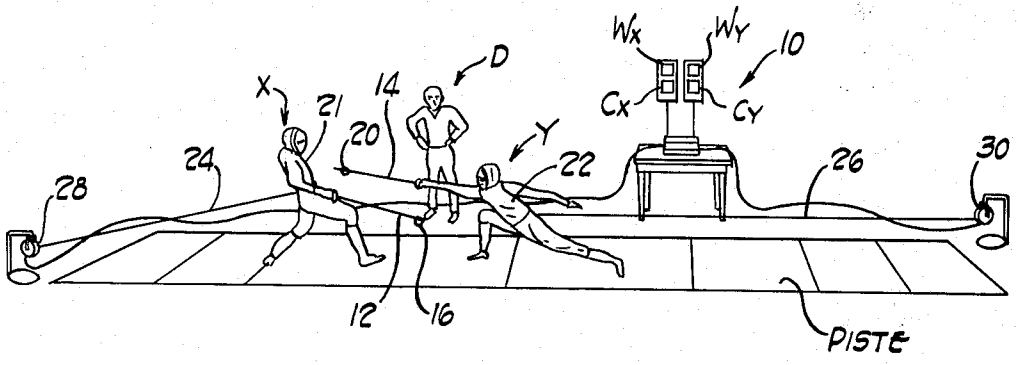
Primary Examiner—Paul E. Shapiro

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[57] **ABSTRACT**

An apparatus and method for electrically scoring fencing matches is disclosed. The apparatus operates to produce visual and audible scoring signals in response to valid and invalid touch signals produced in response to execution of valid and invalid touches with a fencing weapon. The apparatus can be conditioned to produce valid and invalid scoring signals in foil competition, and valid scoring signals in epee competition in which there are no invalid touches. An indicator control circuit responds in accordance with occurrence of the touch signals to actuate invalid and valid touch indicators. The indicator control circuit includes a first delay circuit to prevent actuation of the invalid touch indicator by spurious signals having less than a predetermined duration, and a second delay circuit to prevent actuation of the valid touch indicator by noise signals having duration of less than a predetermined period. An amplitude sensor in the indicator control circuit prevents actuation of the valid touch indicator by signals of less than a predetermined amplitude. The first delay circuit is convertible from its function of preventing response to spurious invalid touch signals to that of timing 40 millisecond time lapses after valid touches in epee competition during which simultaneous valid touches may be made.

10 Claims, 5 Drawing Figures



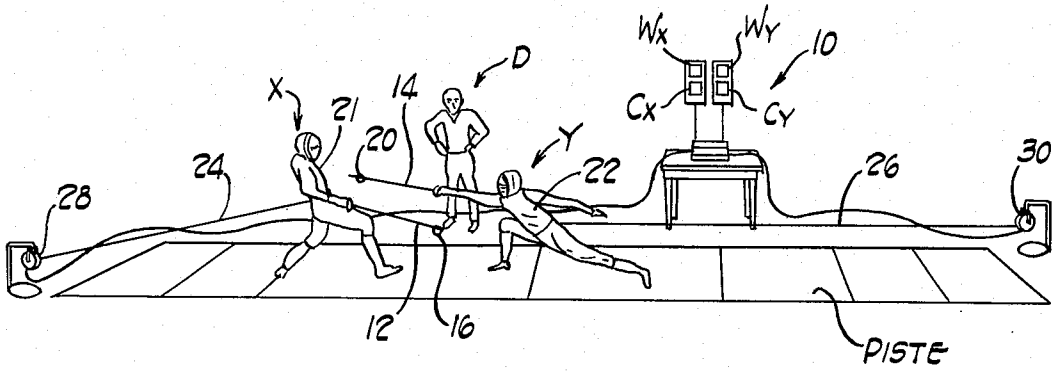

Wx
Wy
10
D
X
21
14
Cx
Cy
20
Y
22
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30
28
12
16
PISTE

Fig. 1

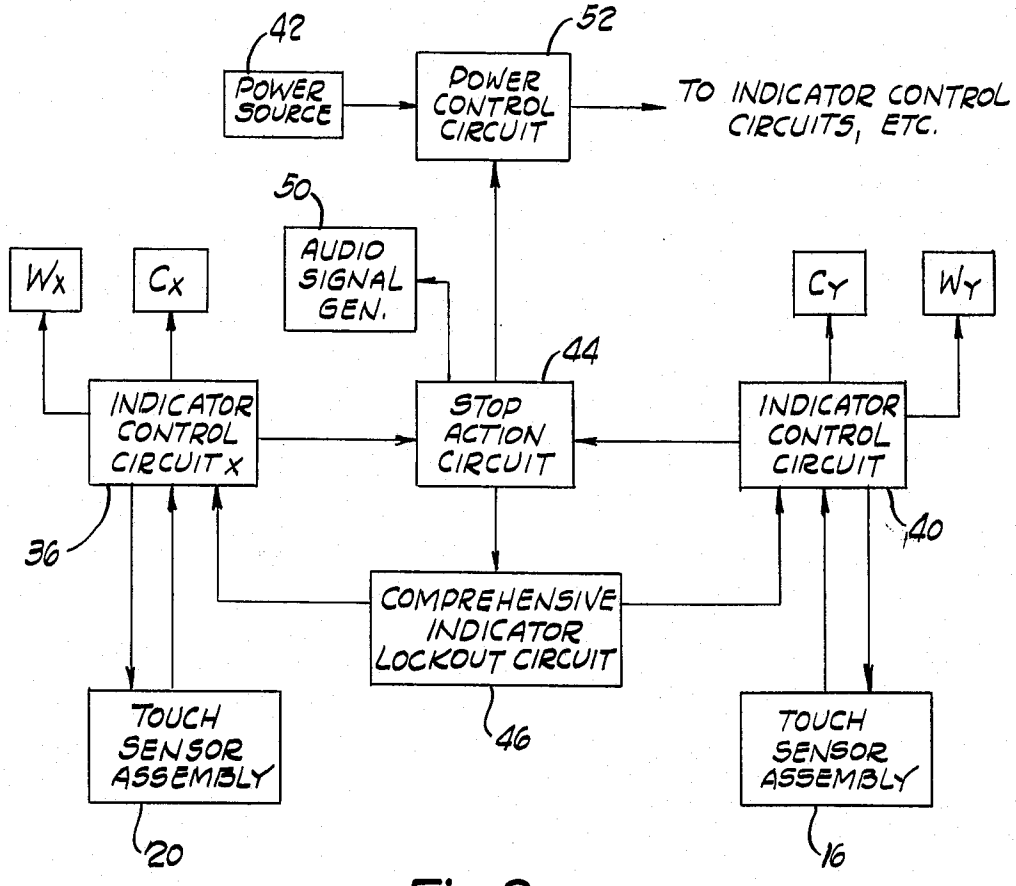

42
52
POWER SOURCE
POWER CONTROL CIRCUIT
TO INDICATOR CONTROL CIRCUITS, ETC.
50
AUDIO SIGNAL GEN.
Wx
Cx
Cy
Wy
44
INDICATOR CONTROL CIRCUIT x
STOP ACTION CIRCUIT
INDICATOR CONTROL CIRCUIT
36
40
COMPREHENSIVE INDICATOR LOCKOUT CIRCUIT
46
TOUCH SENSOR ASSEMBLY
TOUCH SENSOR ASSEMBLY
20
16

Fig. 2

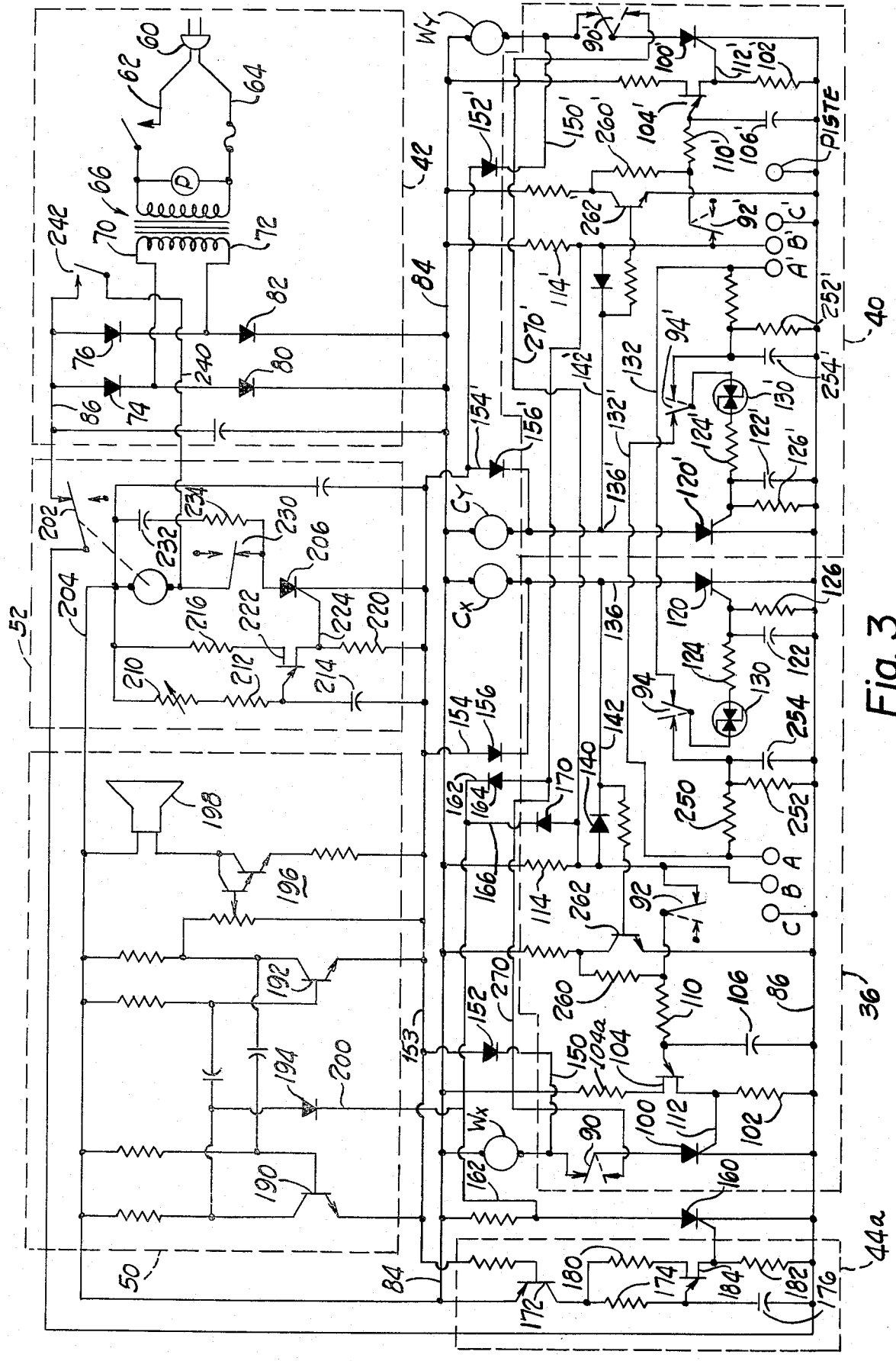

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220
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212
214
198
196
192
194
200
190
50
Wx
Cx
Cy
90'
100'
112'
102'
PISTE
152'
150'
260'
104'
110'
106'
262
92'
C'
B'
A'
114'
270'
252'
40
94'
132'
142'
254'
130'
154'
156'
124'
122'
126'
136'
120'
126
94
124
122
130
254
140
170
162
164
166
250
252
C
B
A
36
153
104a
160
44a
180
174
184
182
176
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Fig. 3

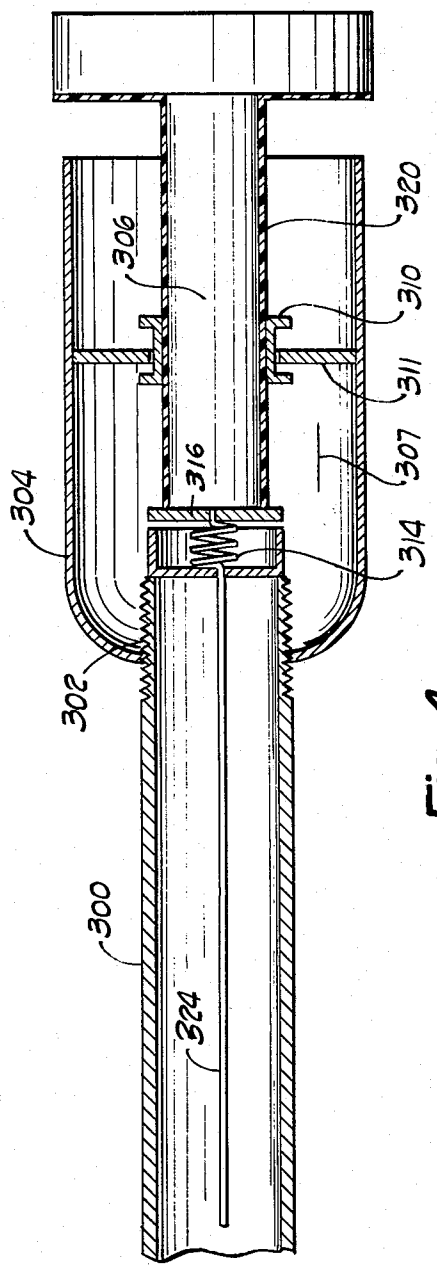

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300
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Fig. 4

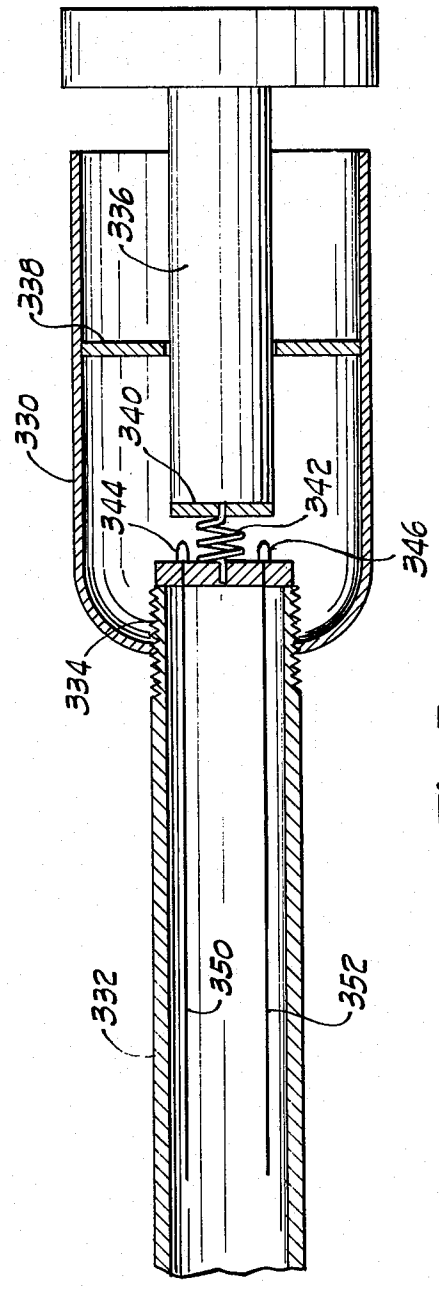

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352

Fig. 5

ELECTRICAL FENCING SCORING METHOD AND APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention pertains to apparatus and method for electrically scoring fencing matches.

The sport of fencing is the modern analogy to the ancient martial art of dueling. As presently practiced, fencers wearing protective garb contest with lightweight weapons, each attempting to score points against the other by touching the other with his weapon. The fencers tread on a mat, called a piste, which defines the permitted boundary for the contest.

Two of the weapons used in fencing are the foil and the epee. In foil competition, one fencer may score points against his opponent only be touching him with the tip of his weapon in a target region generally defined by the upper torso. Such touches are known as "valid touches". No point may be awarded either fencer for touching his opponent with the point of the foil other than on the permitted target. In epee competition, the valid target is the entire body, and a fencer scores points by touching his opponent anywhere with the tip of the epee.

The fencer first accumulating five valid touches against his opponent is declared the winner of the match.

The oldest method of scoring fencing matches is by visual observation by officials, variously referred to as presidents, judges and directors.

Modern fencing weapons are so light that skilled fencers can manipulate them with extreme speed in flurries of action. This speed renders it difficult to determine when touches are scored. Even where several officials are employed to judge a match, visual identification of scoring maneuvers is difficult. Disagreement between officials often occurs, due to the inconsistency in the quality of perspective enjoyed by the various officials. Moreover, judgmment by visual observation is a subjective criterion, and the acuity of vision may vary among officials, and even in the same official.

To obviate these problems, resort has been made to electrical scoring apparatus having touch indicators. Such apparatus employs touch sensing assemblies attached to the weapon tips, which produce valid and invalid touch signals in response to which the apparatus actuates the indicators.

Foil Scoring

A valid touch signal in foul includes the breaking of a first circuit and completing a second. A foil has a movable contact on its tip, which is depressed whenever the tip touches an object, breaking the first electrical circuit.

Each contestant wears a vest-like garment which covers the valid target portion of his body. The vest has a conductive surface, and is connected in a second circuit between the electrical scoring apparatus and the opponent's foil. The movable contact on each foil is itself conductive. When the movable contact of one fencer's foil touches the opponent's conductive vest, the second electrical circuit is completed, and the first circuit is broken, producing a valid touch signal.

An invalid touch in foil is indicated merely by the breaking of the first circuit, since in an invalid touch, the foil fails to contact the opponent's vest.

Epee Scoring

A touch signal in epee constitutes simply the making of one circuit. The movable contact in the epee touch sensor assembly completes the circuit on depression in the course of a touch.

Errant touches on the piste or on the opponent's weapon body are not scored. Accordingly, if a fencer's epee tip touches the piste, or his opponent'weapon, the electrical scoring apparatus disables the scoring indicators, preventing the registration of a touch in response to such errant touches.

The movable contact on the epee tip is condutive as in the case of the foil. It is connected to a portion of the electrical scoring apparatus which, if grounded, prevents actuation of the valid touch indicators. The piste is grounded, as is the body of each weapon, so that errant touches on the weapon body or the piste are not counted as scores.

2. Description of the Prior Art

In electric scoring systems for fencing, lamps are commonly used as indicators of the execution of valid and invalid (off target) touches represented by the valid and invalid touch signals. Generally, a while lamp indicates an off target or invalid touch, and a colored lamp indicates a valid touch. One set of white and colored lamps is connected to the scoring apparatus corresponding to each fencer. When a touch is made, the appropriate color lamp is actuated which corresponds to the touched fencer.

When any touch is made, and any scoring lamp is actuated, the electrical scoring apparatus operates to stop the action by preventing acutation of any further lamps after the lapse of a predetermined time following the first actuation of a lamp. Moreover, the actuation of any lamp indicative of a valid touch immediately prevents the actuation of the invalid touch indicating lamp in the same set of lamps.

Upon the actuation of any indicator lamp, the electrical scoring equipment commonly provides for the actuation of a bell, buzzer or other audio indicator device for a predetermined period after the actuation of the lamp

A reset circuit is commonly provided so that the match officials can deactuate all the lamps and reset the apparatus after any touch has been noted, and it is desired to resume action.

In epee competition, if each fencer touches the other substantially simultaneously, i.e., within **1/25**th of a second (**40** milliseconds) a touch is scored against each fencer. Accordingly, modern electric scoring equipment provides that when such substantially simultaneous touches occur as represented by the occurrence of first and second valid touch signals, a first valid touch indicator lamp is lighted in response to the first signal, and a second valid touch indicator is lighted in response to the second signal. Since there are no off target body touches in epee, the white, or invalid touch indicator lamps, are not used. Upon the expiration of **1/25**th second following an epee touch, no further valid touch indicator lamps may be lighted.

While modern electrical scoring equipment for fencing matches has improved substantially the ease and accuracy of scoring, the performance and accuracy of such systems is sometimes adversely affected by extraneous factors. In the course of a fencing match, the

weapons are moved about rapidly, and the fencers clash them together frequently in countering opponents' attempted touches. These conditions sometimes cause momentary depression of the movable contacts on the touch sensor assemblies without there being a touch. Generally such depressions are brief, and the signals they produce of smaller amplitude than in the case of actual touches. Such spruious signals, however, are prone to cause indication of touches when in fact no touch has taken place.

In practically any electrical circuitry such as used in electric scoring equipment for fencing matches, noise signals from various sources are transmitted about the circuitry. Such noise signals can result from RF energy in the region of the circuitry, unwanted mutual inductive or electrical couplings among the various components of the circuitry, or ambient electromagnetic energy amanating from the power source. Such noise signals likewise sometimes actuate a touch indicator, in instances in which not touch in fact has occurred.

Early electrical scoring equipment has not been inordinately sensitive to such spurious signals and noise. This earlier equipment was generally made from vacuum tube circuits and mechanical magnetic relays. The mechanical inertia and large inductance of such relay equipment was sufficiently great that it was not generally responsive to the brief duration or low amplitude signals which characterize most noise and spuriour signals.

More recently, however, circuits for scoring fencing matches have utilized solid state components with attendant advantages of light weight, compactness and low power requirement. Due to the absence of mechanical inertia and large coil inductances in the solid state equipment, however, these newer circuits are much more sensitive to brief and low amplitude signals than the previous relay circuits.

It is desirable in electric scoring equipment for fencing that the circuitry be sufficiently flexible in its operation to accommodate scoring for both foil and epee. Epee competition, with its requirement for scoring of simultaneous touches occurring within **1/25**th of a second, commonly requires the provision of a separate timing circuit to enable lockout of the valid touch indicators following the lapse of **1/25**th of a second after the actuation of the first actuated valid touch indicator lamp. Such separate circuits add to the cost and complexity of the apparatus.

Present electric fencing scoring equipment provides that all the indicator lamps be reset to the actuated state upon the actuation of a manual reset circuit. This requires repeated attention of an official, which may be distracting and otherwise inconvenient.

SUMMARY OF THE INVENTION

This invention provides a method and apparatus for improved electric scoring of fencing matches. The invention includes method and apparatus for identifying noise and other spurious signals and preventing actuation of touch indicators in response to such signals. The invention eliminates the need for a separate delay circuit for indicating simultaneous touches in epee competition by employing portions of the circuitry in dual function.

The invention employs at least a valid and an invalid touch indicator. An indicator control circuit actuates the indicators to register touches, which are represented by the occurrence of valid and invalid touch signals. The touch signals are produced by touch sending assemblies on the fencing weapons.

According to one feature of a preferred embodiment, the indicator control circuit includes a first delay circuit connected to the invalid touch indicator. The first delay circuit provides for actuation of the invalid touch indicator by only those invalid touch signals having at least a predetermined duration. This prevents actuation of the invalid touch indicator by momentary operations of the touch sensing assemblies due to weapon motion and clashing.

A preferred feature of such a first delay circuit provides that an invalid touch signal must be at least eight milliseconds in duration to cause actuation of the invalid touch indicator.

According to a feature of another preferred embodiment, a second delay circuit is connected to the valid touch indicator to prevent its actuation in response to noise signals having a duration of less than a predetermined time period. Such preferred embodiment additionally includes an amplitude sensor connected to the valid touch indicator to prevent its actuation by signals such as noise having an amplitude less than a predetermined minimum.

According to another preferred feature, the apparatus of the invention includes circuitry for converting the function of the first delay circuit connected to the invalid touch indicator to timing for determining the occurrence of simultaneous touches in epee competition. Circuitry is provided to impress an input to the first delay in response to selected valid touch signals and to redirect the output of the first delay circuit from the invalid touch indicator to disable a second means for actuating the second valid touch indicator in response to second valid touch signals, should they occur. Converting circuitry is also provided for changing the time constant of the first delay circuit to disable the second means **1/25**th of a second after the first valid touch is indicated.

Other features and advantages of this invention will become apparent from the following drawings and detailed description of the invention.

DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective viow of a fencing match scored by the apparatus of this invention;

FIG. **2** is a simplified block diagram of electrical scoring apparatus embodying this invention;

FIG. **3** is a schematic diagram of an electrical apparatus embodying this invention;

FIG. **4** is an elevational view of a touch sensing assembly for use on the tip of a foil, showing parts of the touch sensing assembly in cross-section;

FIG. **5** is an elevational view of a touch sensing assembly for use on an epee, showing portions of the touch sensing in cross-section.

DESCRIPTION OF THE PREFERRED EMBODIMENT

An apparatus **10** for scoring fencing matches is shown in FIG. **1**. FIG. **1** depicts the apparatus in use in a match between the fencers X and Y, officiated by a director D. The fencers hold the weapons **12** and **14** and each attempts to score points by touching his opponent with his weapon tip.

The apparatus **10** indicates touches made by the fencers with the tips of their weapons in the course of the match. The apparatus **10** indicates both valid and invalid touches, in foil and epee competition, by actuating the appropriate one or more of the indicators Wx, Cx, Cy and Wy.

The apparatus **10** scores touches in response to the occurrence of touch signals. The touch signals are produced by the touch sensor assemblies **16** and **20** mounted on the tips of the weapons **12** and **14,** respectively, in cooperation with two similar conductive surfaced vests **21** and **22,** worn respectively by the fencers X and Y.

The touch signals are directed to the apparatus **10** by way of the electrical cables **24** and **26** which are connected to the vests and touch sensor assemblies of the repective fencers. The cables are respectively connected to the reels **28** and **30,** which feed out cable resiliently in response to moderate tension to accommodate the fencers' movement without tangling the cables.

The apparatus **10** is adapted for scoring both foil and epee competition. In foil competition, two kinds of touch signals can be produced. A valid touch signal occurs when one fencer touches the other on the vest with the tip of his weapon. An invalid touch signal occurs when one fencer touches the other with the tip of his weapon on a part of his opponent's body other than that covered by the vest.

In epee competition, on vests are worn, and only valid touch signals are produced. These are produced by the touch sensor assemblies adapted for epee.

The apparatus **10** indicates touches by actuating the indicators Wx, Cx, Wy and Cy, as shown in FIG. **1.** Actuation of either of the indicators Wx and Cx indicates a touch by the fencer Y against the fencer X, while actuation of the indicators Cy and Wy indicate a touch by the fencer X against the fencer Y. Preferably the indicators are lamps, with the indicators Wx and Wy being white lamps, the lighting of which indicates invalid touches, and the indicators Cx and Cy being colored lamps the lighting of which indicates valid touches.

FIG. **2** shows a simplified block diagram of the apparatus **10.** The apparatus **10** includes the indicator control circuit **36** connected to actuate the touch indicators Wx and Cx in response to touch signals from the touch sensor assembly **20,** and the indicator control circuit **40** connected to actuate the touch indicators Cy and Wy in response to touch signals from the touch sensor assembly **16.** A power source **42** supplies power for operating the indicator control circuits **36** and **40** and associated components of the apparatus **10.**

The indicator control circuit **36** actuates the indicator Wx in response to the receipt of an invalid touch signal from the touch sensor assembly **20,** and is responsive to the receipt of a valid touch signal from the touch sensor assembly **20** to actuate the indicator Cx. Similarly, the indicator control circuit **40** responds to invalid touch signals from the touch sensor assembly **16** to actuate the indicator Wy and to valid touch signals to actuate the indicator Cy.

The indicator control circuits **36** and **40** are preferably identical in construction, and only the operation of the indicator control circuit **36** is further discussed in detail, the operation of the indicator control circuit **40** being analogous with respect to the touch indicators Cy and Wy.

The indicator control circuit **36,** in response to actuation of the valid touch indicator Cx, substantially instantaneously locks out and prevents actuation of the invalid touch indicator Wx.

The indicator control circuit **36** is prevented from actuating the indicator Wx in response to invalid touch signals having less than a predetermined duration. This feature prevents spurious signals of brief duration not actually representing invalid touches from actuating the indicator Wx. The indicator control circuit **36,** moreover, actuates the valid touch indicator Cx only in response to valid touch signals having a duration greater than a predetermined time period. This feature prevents actuation of the indicator Cx by noise signals having brief duration which may arise in the circuitry of the apparatus **10.**

The indicator control circuit **36** is profoundly adjustable to lock out the valid touch indicator Cy in response to the lapse of **40** milliseconds following actuation of the valid touch indicator Cx. Preferably this adjustment of the indicator control circuit **36** is selectively performed in instances in which the apparatus **10** is used to score epee matches, to allow for determination of simultaneous touches.

The indicator control circuits **36** and **40** are each connected to a stop action circuit **44.** The stop action circuit is connected to a comprehensive indicator lockout **46,** an audio signal generator **50,** and a power control circuit **52.** The comprehensive indicator lockout **46** is connected to each of the indicator control circuits **36** and **40.**

Upon the actuation of any of the indicators Wx, Cx, Cy and Wy, the stop action circuit **44** produces a stop action signal which actuates the audio signal generator **50** to produce an audio signal indicating that an indicator has been actuated and a touch has occurred. The stop action circuit **44,** after a predetermined time has elapsed following the actuation of any of the indicators, directs a signal to the comprehensive indicator lockout **46** which in turn operates on the indicator control circuits to prevent the further actuation of any indicators. During the time between the first actuation of an indicator and the time at which the predetermined time period lapses, additional indicators may be actuated.

At the time that the comprehensive indicator lockout **46** operates to prevent further indicator actuation, the stop action circuit **44** deactuates the audio signal generator **50** to cease the audio signal.

Upon the actuation of any indicator, the stop action circuit **44** also directs the stop action signal to the power control circuit **52.** Upon the expiration of a predetermined time following receipt of the stop action signal, the power control circuit **52** cuts off the power directed to the indicator control circuits **36** and **40,** and thereby causes the deactuation of all the indicators which have been actuated, resulting in a resetting of the apparatus **10** in preparation for resumed action in a fencing match.

FIG. **3** is a schematic diagram of the apparatus **10** embodying this invention.

The power source **42,** provides power to the indicator control circuits **36** and **40,** and to the other components of the apparatus **10.** The power source **42** is indicated by the box formed of dotted lines in FIG. **3** and includes a plug **60** of conventional design for connecting to a **120** volt **60** Hz. supply line, the power being transmitted by way of the leads **62** and **64** to a trans-

former **66.** The transformer **66** reduces the voltage by a factor of **10,** such that **12** volt **60** Hz. A.C. appears at the outputs **70** and **72** of the transformer **66.** This **12** volt A.C. power supply signal is converted to D.C. by a full wave rectifier which includes diodes **74, 76, 80** and **82.** Operation of the power source **42** establishes a **12** volt D.C. signal appearing between the high voltage lead **84** and the low voltage lead **86.**

The apparatus **10** is designed for adaptation to battery power as well. The components of the apparatus **10** are all designed to operate satisfactorily when fed from a **12** volt D.C. source, a readily available type of battery power.

It can be seen from FIG. **3** that power is fed to the components of the indicator control circuit **36,** indicated in FIG. **3** by the dotted box bearing the same reference numeral, and to the indicator control circuit **40,** indicated by the dotted box in FIG. **3** designated by reference numeral **40.** Ppwer is also applied to the touch indicators Wx, Cx, Cy and Wy between the high voltage lead **84** and the low voltage lead **86.**

The invalid and valid touch signals are input to the indicator control circuits **36** and **40** by way of terminals A, B, C, and A′, B′, and C′, respectively, and represent the occurrence of valid and invalid touches. In the absence of a touch, the teminal pairs B-C and B′-C′ are each conductively coupled, while the terminal pairs A-B and A′-B′ are open circuits.

With respect to the indicator control circuit **36,** a valid touch signal in foil includes breaking the circuit between the terminals B-C and completing the circuit between the terminals B-A′. An invalid touch signal in foil is represented by breaking of a circuit between the terminals B-C. In epee, only valid touch signals are used and these constitute breaking the circuit between the terminals B-C and completing the circuit between the terminals B-A.

The apparatus **10** is convertible for scoring either foil or epee matches. This conversion is accomplished in the preferred embodiment by, for example in the indicator control circuit **36,** changing the position of the switches **90, 92** and **94.** As illustrated in FIG. **3,** the switches **90, 92** and **94** are disposed in the appropriate positions indicated by solid lines for scoring foil matches. The structure and operation of the apparatus **10** in the scoring of foil matches will be discussed first.

The indicator control circuits **36** and **40** are preferably identical in construction. Accordingly, only the operation of the indicator control circuit **36** will be discussed in detail, the operation of the indicator control circuit **40** being analogous to that of the indicator control **36.** The components of the indicator control circuit **40** are indicated in FIG. **3** by primed reference numerals which correspond to the reference numerals of the elements of the indicator control circuit **36.**

The indicator Wx is actuated by the indicator control circuit in response to an invalid touch signal. The actuation of the invalid touch indicator Wx is accomplihed by applying a positive voltage to the gate of the SCR **100** (see FIG. **3**) which causes the SCR **100** to assume a conductive condition, allowing current to flow from the high voltage lead **84** through the indicator Wx, the switch **90,** and the SCR **100,** to the low voltage lead **86.**

The SCR **100** is caused to assume a conductive state in response to an output of a first delay circuit including a resistor **102,** a resistor **104***a*, a unijunction transistor **104,** a capacitor **106** and a resistor **110.** The unijunction transistor **104** is normally in a nonconductive state, there being a relatively low voltage at its emitter. When a positive voltage is applied to the right-hand terminal of the resistor **110,** the voltage on the emitter of the unijunction transformer **104** begins to rise at a rate which is a function of the time constant of the RC series circuit represented by the resistor **110** and the capacitor **106.**

When the voltage on the emitter of the unijunction transformer **104** becomes sufficiently high, the unijunction transistor **104** begins to conduct, and the voltage at the upper terminal of the resistor **102** rises. This imparts a positive voltage over lead **112** to the gate of the SCR **100,** causing the SCR **100** to fire and the indicator WX to be actuated.

The values of the resistor **110** and the capacitor **106** of the first delay circuit are preferably chosen such that the unijunction transformer **104** will fire approximately **8** milliseconds after the application of a positive voltage to the right-hand terminal of the resistor **110.**

As stated above, the terminals B and C are normally connected in the absence of a touch. An invalid touch signal is represented by the breaking of the circuit between the terminals B and C. Upon the breaking of the circuit between the terminals B and C, the potential at the right-hand terminal of the switch **92** rises, the potential at that terminal being previously low because of the voltage drop across a resistor **114** connected between the high voltage lead **84** and the terminal B. This breaking of the circuit between the terminals B and C furnishes a positive pulse to the right-hand terminal of the resistor **110,** which actuates the first delay circuit. Upon the expiration of approximately **8** milliseconds following the breaking of the circuit between the terminals B and C, the SCR **100** is fired, actuating the invalid touch indicator Wx.

This feature assures that the actuation of the invalid touch indicator Wx will not take place in response to invalid touch signals having a duration of less than approximately **8** milliseconds. The advantage of this is that spurious invalid tough signals of briefer duration, generated by motion and clashing of the weapons, but not representing actual invalid touches, will not cause the invalid touch indicator Wx to indicate an invalid touch.

The valid touch indicator lamp Cx associated with the indicator control circuit **36** is actuated in response to a valid touch signal by the application of a positive voltage to the gate of the SCR **120,** in FIG. **3.** Such a pulse is derived by the application of a positive voltage to the left-hand terminal of the resistor **124.** A second delay circuit including the resistor **124.** the capacitor **122,** and the resistor **126,** is connected to the gate terminal of the SCR **120.** The positive voltage on the gate of the SCR **120** is obtained by the application of a positive voltage to the left-hand terminal of the resistor **124.** When such a pulse is applied, the SCR **120** is fired after the lapse of a predetermined time period, the magnitude of the predetermined period being a function of the time constant established by the values of the resistors **124** and **126,** and the capacitor **122,** which comprises a second delay circuit.

The positive voltage applied to the left-hand terminal of the resistor **124** is derived from a positive voltage appearing at the right-hand terminal of the switch **94.** An amplitude sensor comprising a breakdown diode **130** is interposed between the right-hand terminal of the

switch **94** and the resistor **124.** Unless the voltage appearing at the right-hand terminal of the switch **94** is above a predetermined minimum, no voltage will be transmitted to the delay circuit and the SCR **120** will not fire.

The voltage pulse appearing at the switch **94** is directed there over the lead **132** extending to the terminal A′ of the indicator control circuit **40.** The voltage pulse is impressed on the lead **132** in response to the occurrence of a valid touch signal.

A valid touch signal is represented by the completing of a circuit between the terminal B and the terminal A′, and by the breaking of the circuit between the terminals B and C. The circuit between the terminals B and A′ is completed slightly previous to the breaking of the circuit between B and C.

When the circuit between the terminals B and C is broken, the potential of terminal B rises, as in the case of actuation of the invalid touch indicator Wx, discussed above. Because the terminal B is connected to the terminal A′, a positive voltage is impressed upon the lead **132,** passing through the switch **94** to the breakdown diode **130.** If the voltage impressed on the lead **132** is greater than the predetermined minimum breakdown voltage of the breakdown diode **130,** a positive voltage will appear at the left-hand terminal of the resistor **124,** and actuate the second delay circuit, to fire the SCR **120** a short time after the initiation of the positive signal to the resistor **124.**

The presence of the breakdown diode **130** assures that noise signals having small amplitude will not trigger the valid touch indicator Cx. The second delay circuit further assures that noise signals, which are characteristically brief, will likewise not actuate the valid touch indicator Cx.

Another function of the second delay curcuit is to enable the actuation of the valid touch indicator Cx substantially simultaneously, or slightly after, the breaking of the circuit between the terminals B-C. Since the breaking of the circuit between the terminals B-C occurs slightly after the completion of the circuit between the terminals B-A′ it is desirable to delay the actuation of the valid touch indicator Cx until the voltage at the terminal B has had an opportunity to build up, to a level greater than the minimum breakdown voltage of the breakdown diode **130.**

The actuation of the valid touch indicator Cx prevents the subsequent actuation of the invalid touch indicator Wx, by means of a lockout circuit including the lead **142** and the diode **140.** Before the actuation of the valid touch indicator Cx, the terminal **136** is a relatively high potential. Upon actuation of the valid touch indicator Cx, the potential at the terminal **136** drops to a relatively low level, approximately that of the low voltage lead **86.** This causes the grounding of the terminal B to the low voltage lead **86** through the diode **140,** the lead **142** and the SCR **120.** When the terminal B is so grounded, the potential of that terminal cannot rise, and therefore it is not possible subsequently to apply a positive voltage pulse to fire the SCR **100** to actuate the invalid touch indicator Wx.

A stop action circuit is provided in the apparatus **10** to signal when a touch is made and to limit further activity of the apparatus after the first touch occurs. The stop action circuit includes a timer generally indicated by the dotted box **44a** in FIG. **3,** and a timer actuation circuit. The timer actuation circuit incudes a lead **150** extending from the bottom terminal of the indicator Wx to a bus **153** and having interposed therein a diode **152.** The timer actuation circuit further includes a lead **154** having a diode **156** and extending between the lower terminal of the touch indicator Cx to the bus **153.**

The timer actuation circuit and the timer **44*a*** operate conjunctively to prohibit the actuation of any further touch indicators at aa time following the first actuation of a touch indicator. This function is performed by a comprehensive light lockout circuit which includes an SCR **160,** a lead **162** containing a diode **164,** and a lead **166** having interposed therein a diode **170.**

The comprehensive light lockout circuit operates in response to the application of a positive pulse to the gate of the SCR **160,** normally nonconductive, which renders the SCR **160** in a conductive state. When the SCR **160** becomes conductive, the lead **162** is effectively grounded to the low voltage lead **86.** This grounding in turn operates by way of the lead **166** and diode **170** to ground the terminal B of the indicator control circuit **36** and by the lead **162** and the diode **164** to ground the terminal B′ of the indicator control circuit **40.** The grounding of the terminals B and B′ render it impossible for a positive tending pulse applied to either of these terminals to raise their potential appreciably, and thus prevents the actuation of any further touch indicators.

The timer **44*a***, in response to a low voltage stop action signal, generates and applies to the gate of the SCR **160** a positive pulse at a given time following the receipt of the stop action signal. The timer **44*a*** includes a pnp transistor **172,** a resistor **174,** a capacitor **176,** and resistors **180** and **182** having interposed between them a unijunction transistor **184.** The emitter of the transistor **172** is provided with power from the high voltage lead **84.**

the transistor **172** is normally in a nonconductive state, and is rendered conductive by the application of the low voltage stop action signal at its base. Upon the application of the low voltage, the transistor **172** conducts, and the voltage at the upper terminal of the capacitor **176** begins to rise at a rate which is a function of the time constant established by the values of the resistor **174** and the capacitor **176.** When the voltage at the upper terminal of the capacitor **176** has reached a sufficient value, the unijunction **184** is fired, causing the base **2** terminal of the unijunction **184** to go from a potential substantially equal to that of the low voltage lead **86** to a higher potential which is a function of the ratio of the resisitors **180** and **182.** The ratio of these resistances is appropriately selected such that when the unijunction **184** fires, a positive pulse of sufficient magnitude will be applied to the gate of the SCR **160** to fire that SCR, which in turn causes the grounding of the lead **162** and of the terminals B and B′.

preferably, the values of the resistor **174** and capacitor **176** are chosen such that the SCR **160** is fired by the timer **44*a*** at a time approximately two seconds after the application of the stop action signal to the base of the transistor **172.**

The stop action signal is a lowering at the potential applied to the base of the transistor **172** by way of the bus **153.** When none of the touch indicators is actuated, the lower terminal of each is at a relatively high potential, which maintains the bus **153** at a correspondingly high potential. When any one or more of the touch indicators is actuated, the potential at the lower

terminal of each actuated indicators drops to essentially that of the low voltage lead **86,** and this lowering of potential is transmitted to the bus **153.** This lowering of potential represents the stop action signal which, when applied to the base of the transistor **172,** renders that transistor conductive, actuating the timer **44***a* which, after a two second interval following the occurrence of the stop action signal, grounds out the terminals B and B' of the indicator control circuits, preventing any further actuation of the touch indicators.

The occurrence of the stop action signal also actuates the audio signal generator **50** to produce an audio signal indicating that a touch has occurred. The audio signal generator includes an audio oscillator of known design comprising transistors **190** and **192,** a diode **194,** and associated resistive and capacitive circuit elements illustrated in FIG. **3.** The audio signal generator also includes an audio amplifier generally indicated at **196** in FIG. **3,** having its input connected to the audio oscillator and a loudspeaker **198** connected to the output of the audio amplifier.

The operability of the audio oscillator and the audio amplifier is determined by the potential condition of the bus **153,** which is in turn altered by the occurrence of the stop action signal. When the bus **153** is at a relatively high potential, its potential is substantially equal to that of the high voltage lead **84** which renders the audio signal generator inoperative due to an insubstantial voltage drop across it. It is only when the potential of the bus **153** is maintained at a relatively low level that power can flow through the audio oscillator and audio amplifier in order to actuate the loudspeaker to emit the audio signal for indication of a touch. As discussed above, the actuation of any of the touch indicators causes the potential of the bus **153** to drop to a relatively low level, and therefore the occurrence of the stop action signal immediately actuates the audio signal generator **50** to produce the audio signal.

The cessation of the audio signal occurs in response to the firing of the SCR **160** by the timer **44***a* after the expiration of the two second period following the occurrence of the stop action signal. When the SCR **160** is fired, the line **162** is effectively grounded through the low voltage lead **86.** The line **162** is connected to the audio oscillator by a lead **200.** The lead **200** is thereby grounded by the firing of the SCR **160,** which results in the substantially immediate grounding out of the audio oscillator. This renders the oscillator inoperative and causes the audio signal to stop.

The power control circuit **52** is triggered by the occurrence of the stop action signal to cause the deactuation of all actuated touch indicators after the lapse of a predetermined time interval following the occurrence of the stop action signal. The deactuation of the actuated touch indicators is accomplished by momentarily opening a relay **202** interposed in the low voltage lead **86.**

The relay **202** is series connected to a line **204** and to a switch **230** and an SCR **206.** The opening of the relay **202** interrupts the circuit of the apparatus **10** by opening the low voltage load **86.** This causes the low voltage line to assume a voltage which is substantially equal to that of the high voltage line **84.** This condition results in the absence of any substantial potential across the components of the apparatus **10,** and results in the resetting of the components to conditions such as prevailed before the actuation of any of the indicators.

The relay **202** is normally biased in a closed position, and is opened by the flow of current through the line **204,** which is supplied with a relatively high voltage by the high voltage line **84.** Current is permitted to flow through the line **204** by the application of a positive voltage to the gate of the SCR **206.** The positive pulse to the gate of the SCR **206** is supplied by a timing circuit which includes a variable resistor **210,** a resistor **212,** and a capacitor **214,** connected in parallel with voltage dividing resistors **216** and **220** and separated by a unijunction transistor **222.** The positive pulse to the gate of the SCR **206** is provided by firing the unijunction transistor **222,** which results in a positive voltage appearing on a lead **224** connected to the gate of the SCR **206.**

The timing circuit for the power control circuit **52** is connected between the lead **204,** (supplied with a relatively high voltage by the high voltage lead **84**) and the bus **153.** When, before the occurrence of the stop action signal, the bus is at a relatively high potential, no current flows through the timer circuit, and the timer circuit is not operative. Upon the occurrence of the stop action signal, and the grounding of the bus **153** to the low voltage lead **86,** the timer becomes operative by virtue of current flowing through it between the lead **204** and the bus **153.** The emitter voltage of the unijunction transistor **222** rises in response to the grounding of the bus **153** at a rate which is a function of the values of the combined resistances of the variable resistor **210** and the resistor **212,** and the capacitance **214.** When the emitter voltage of the unijunction transistor **222** has risen sufficiently, the unijunction fires, and a positive voltage appears at the lead **224,** firing the SCR **206,** causing current to flow through the relay **202,** and through the SCR **206** by way of the switch **230.**

A series connected capacitor **232** and a resistor **234** are coonnected in parrallel around the relay **202** and the switch **230** in order to provide a means for energy storage which serves to latch the relay **202** in an open position sufficiently long to effect deactuation of the actuated indicators. Without this feature, the relay **202** would be subject to chatter.

Preferably, the variable resistor **210,** the resistor **212,** and the capacitor **214** are selected such that the relay **202** is opened and the indicators deactuated after the lapse of a period variable from two to seven seconds following the occurrence of the stop action signal, depending on the value setting of the variable resistor **210.**

Provision is also made for control of the resetting function by manual means, independently of the timer, if desired. This is provided by a lead **240** extending from the lower terminal of the relay **202** to the low voltage lead **86,** having interposed therein a manual reset switch **242.** For such manually controlled resetting, the contact of the switch **230** is moved from the "auto" to the "manual" position, as shown in FIG. **3.** This places the relay **202** under sole control of the manual reset switch **242.** When the manual reset switch **242,** normally opened, is depressed, the relay **202,** normally closed, is opened for as long as the reset switch **242** is depressed. In this way manual resetting of the apparatus **10** may be accomplished.

The discussion of the apparatus **10** has thus far been concerned with its operation in the configuration for

scoring foil competition. The following discussion relates to adjustment and operation of the apparatus **10** for scoring epee competition.

In epee competition the apparatus **10** actuates the valid touch indicators Cx and Cy in response to the occurrence of valid touch signals. The invalid touch indicators Wx and Wy are not used in epee competition.

Preparatory to utilizing the present apparatus for epee scoring, each of the switches **90, 92** and **94** in the indicator control circuit **36** are adjusted to the positions shown by the dotted lines in FIG. **3.**

The actuation of a valid touch indicator Cx in epee competition, as in foil competition, is accomplished by applying a positive voltage to the gate of the SCR **120.** This positive voltage is applied by way of the left-hand terminal of the switch **94,** as opposed to the right-hand terminal of the switch in foil scoring. This requires that the switch **94** be moved to its left-hand position for epee competition, as shown by the dotted line in FIG. **3.**

The positive voltage pulse at the left-hand terminal of the switch **94** is provided in response to the occurrence of a valid touch signal at the terminals A, B, C. In epee competition, the valid touch signal constitutes the breaking of the circuit between the terminals B-C, and the making of the circuit between the terminals B-A. Another delay circuit, including resistors **250** and **252,** and a capacitor **254,** is connected to the left-hand terminal of the switch **94.** When the B-C terminal circuit is broken, the potential of terminal B rises, and when the B-A terminal circuit is completed, a positive voltage is applied to the delay circuit including the resistors **250, 252** and the capacitor **254.** Following the delay imposed by the resistors **250, 252** and the capacitor **254,** the positive voltage is applied to the breakdown diode **130,** after which the SCR **120** is fired in the manner as in the case of foil competition described above.

Providion is made for preventing actuation of second valid touch indicator Cy after the lapse of **1/25**th of a second (**40** milliseconds) following the actuation of the valid touch indicator Cx. The components of the first delay circuit including the unijunction transistor **104,** the resistors **102** and **110,** and the capacitor **106** are used to accomplish this purpose. This is in addition to the function of these elements in preventing the actuation of the invalid touch indicator Wx by invalid touch signals less than **8** milliseconds in duration, as has been explained above.

To accomplish this dual function, the output of the first delay appearing at the top of the SCR **100** at point **113** is redirected from the invalid touch indicator Wx to means for disabling the actuating circuitry of the second valid touch indicator Cy. The time constant of the first delay is changed by connection of additional circuitry thereto to provide for indication of the **40** millisecond time lapse during which simultaneous touches may be made in epee. The first delay is actuated through the additional circuitry to produce its output in response to actuation of the valid touch indicator Cx.

The value of the voltage at the point **113** selectively controls disabling of the valid touch indicator Cy. The output **113** is connected by a line **270** to the terminal B'. When the voltage of the output at the upper teminal of the SCR **100** drops, in response to the firing of the SCR **100,** the terminal B' is grounded and the valid touch indicator Cy can no longer be actuated. Firing of the SCR **100** is accomplished by operation of the first delay.

The time constant of the first delay circuit is increased by addition of circuitry to its RC timing branch. A resistor **260,** connectable in series with the RC branch of the first delay including resistor **110** and the capacitor **106,** is connected at its upper terminal to the collector of a transistor **262.** The time constant change is accomplished by electronically switching the resistor **260** into series with the resistor **110** and the capacitor **106.**

This is done by appropriate control of the transistor **262.** When the valid touch indicator Cx is not actuated, the terminal **136** is at a relatively high potential, which potential is transmitted through the lead **142** to the base of transistor **262,** rendering that transistor conductive. In its conductive state, power applied to the collector terminal of the transistor **262** proceeds virtually unimpeded to the emitter terminal of the transistor **262,** and the upper terminal of the resistor **260** is effectively grounded to the low voltage lead **86.** In this condition, virtually no electrical potential is applied across the RC branch represented by the resistors **260** and **110,** and the capacitor **106,** and the first delay circuit is not actuated.

When the circuit between the terminals B-C is broken, the potential at the terminal B rises, and this rising potential is applied by way of the closing of the B-A terminal circuit to actuate the valid touch indicator Cx. When the valid touch indicator Cx is actuated, the terminal **136** drops to a relatively low potential, which is transmitted to the base of the transistor **262,** rendering that transistor nonconductive. When the transistor **262** becomes nonconductive, power from the high voltage line **84** is diverted through the RC branch of the delay circuit, including through the resistor **260.** The delay circuit then operates in a fashion similar to that in which it operates in foil competition, (except with a different time constant) producing an output on lead **112** as a result of the firing of the unijunction transistor **104** after a predetermined time.

Preferably, for epee competition, the value of the resistor **260** is chosen such that the resistor **260** in combination with the resistor **110** and the capacitor **106** will yield a time constant for the RC branch which results in the firing of the unijunction transistor **104** approximately **40** milliseconds following the actuation of the valid touch indicator Cx.

FIG. **4** shows in detail a typical touch sensor assembly **16** for a foil. The touch sensor assembly **16** generates valid and invalid touch signals in accordance with touches executed with the foil. For the purposes of this discussion, the touch sensor assembly **16** shall be considered to be connected to the terminals A, B, C of the indicator control circuit **36.**

The sensor assembly **16** is mounted on the tip of a foil. A hollow blade **300** of a foil is shown in FIG. **4,** having a threaded portion **302** at its outer end. A sleeve **304,** generally enclosing the other components of the sensor assembly **16** is threadedly engaged with the threaded portion **302** of the blade **300.** Both the sleeve **304** and the blade **300** are made of a conductive material.

A plunger **306** is mounded for slidable movement within the sleeve **304.** The plunger **306** fits generally slidably into a collar **310** mounted inside and concentric with the sleeve **304,** for motion in the direction of

the arrows **307.** The collar **310** is supported by conduction elements **311** stationarily with respect to the sleeve **304.**

A spring **314** is mounted between the blade **300** and the plunger **306** in order to resiliently bias the plunger **306** toward an outwardly extending position with respect to the sleeve **304.** The plunger **306** has a conductive base member **316** conductively connected to the plunger. The extent of permitted outward movement of the plunger is limited by the engagement of the outer portion of the base member **316** with the collar **310.**

Electrical connections among the various components of the touch sensor assembly generate the invalid and valid touch signals. The collar **310** is electrically insulated from the plunger **306.** An insulating coating **320,** preferably made of a plastic material, extends about the plunder **306.** When the plunger is in its outermost position collar **310** is electrically connected to the base member **316.**

When the plunger **306** is in tis outermost position, it is also electrically connected to the sleeve **304,** and to the blade **300** by way of the conductive members **311.**

The plunger **306** and its base member **316** are electrically coupled to the spring **314,** which in turn is electrically connected to a lead **324.** The lead **324** is connected to the terminal B of the indicator control circuit **36,** by conventional electrical coupling means, (not shown). The blade **300** is electrically connected to the terminal C of the indicator control circuit **36** by way of further conventional electrical coupling structure (not shown).

When the plunger **306** is in its outer most permitted position, the terminals B and C of the indicator control circuit **36** are electrically connected together. The circuit between the terminals B and C is completed through the lead **324,** the spring **314,** the base member **316,** the collar **310,** the conductive elements **311,** the sleeve **304,** and the blade **300.** This condition endures as long as the plunger **306** is in its outermost permitted position of movement.

When the plunger **306** is depressed, as in the instance of a touch against any object, such as in the case of an invalid touch against an opposing fencer, the electrical connection between the collar **310** and the base member **316** is broken, interrupting the circuit between the terminals B and C. The interruption of the circuit between B and C represents an invalid touch signal, produced in response to the execution of an invalid touch with the foil of which the blade **300** is a part.

The depression of the plunger **306** against a conductive surface connected to the terminal A′ of the indicator control circuit **40** generates a valid touch signal. When the plunger **306** is depressed by contact with a conductive surface connected to the terminal A′, the circuit between the terminals B and C is interrupted, in the manner described above with respect to the generation of an invalid touch signal. Additionally, the circuit extending between the terminals B and A′ becomes completed, by way of contact of the conductive plunger **306** with the conductive surface of the vest of the opposing fencer, (which as described above, is connected to the terminal A′ of the indicator control circuit **40**) and by way of the spring **314.**

FIG. **5** shows a touch sensor assembly for use in connection with the epee. The touch sensor assembly generates valid touch signals in response to the execution of valid touches with the epee on the body of the opposing fencer.

The components of the touch sensor assembly are generally mounted within a sleeve **330** which is attached to a blade portion **332** of an epee by means of threaded engagement with the threaded portion **334** of the blade portion **332.** The sensor assembly includes a plunger **336,** an annular member **338,** a contact **340** on one end of the plunger **336,** a spring **342,** and a pair of terminals designated **344** and **346.**

The valid touch signals are derived by motion of the plunger **336** within the sleeve **330** resultant on touches made by the plunger **336** against the opposing fencer. Depression of the plunger **336** results in the completion of the circuit between the terminals A and B of the indicator control circuit **36.**

The plunger **336** slides movably within the sleeve **330** by engagement with the annular member **338** mounted concentrically within the sleeve **300.** The contact **340** is aligned across the terminals **344** and **346.** The spring **342** is interposed between the contact **340** and the terminals **344** and **346,** and serves to maintain the plunger and the contact **340** in a normally extended position from the sleeve **330.** Upon depression of the plunger **336** such as by way of a touch, plunger **336** moves inwardly and to the left as shown in FIG. **5,** and closes the contact **340** across the terminals **344** and **346,** completing the circuit therebetween. The contact **344** is connected to the terminal A of the indicator control circuit **36** by way of a lead **350.** The terminal **346** is connected to the terminal B of the indicator control circuit **36** by a lead **352.**

As has been explained above, a valid touch signal in epee competition is represented by the completion of the circuit extending between the terminals A and B of the indicator control circuit **36,** with the circuit between the terminals B-C being open.

When an errant touch is made in epee against a surface which is not a part of the opposing fencer's body, the touch sensor assembly renders the indicator control circuit inoperative to indicate a valid touch. This is done by grounding out the terminal B of the indicator control circuit whenever the conductive plunger **336** is touched against such a surface, and by defining such off target surfaces by grounding them.

When the plunger **336** is depressed against such a grounded surface, not only is the circuit between the leads **350** and **352** completed, completing the circuit extending between the terminals B and A of the indicator control circuit, but a circuit is also made between the low voltage lead **86** (terminal C) of FIG. **3,** and the terminal B of the indicator control circuit. This serves to ground out both terminals A and B, and render impossible the actuation of the valid touch indicator Cx in response to such a touch.

Preferably, the piste is grounded to define an offtarget surface. Likewise, the body of the epee, including the blade **332,** the sleeve **330,** and the bell portion (not shown) is grounded to the low voltage lead **86,** so that depression of the plunger **336** against the piste or the body of the opponent's weapon will likewise prevent actuation of a valid touch indicator in response to such a contact.

What is claimed is:

1. An electrical apparatus connectable to a power supply for scoring a fencing match in response to touch signals indicating at least one of valid and invalid

touches executed with a fencing weapon, said apparatus comprising:

a. an invalid touch indicator;

b. a valid touch indicator;

c. an indicator control circuit for actuating said valid and invalid touch indicators in response to the occurrence of valid and invalid touch signals, respectively, the indicator control circuit comprising a first delay circuit for preventing actuation of said invalid touch indicator in response to invalid touch signals of less than a predetermined duration, to prevent actuating said invalid touch indicator in response to spurious signals, not actually representing invalid touches.

2. The apparatus of claim **1,** wherein

said predetermined duration is approximately **8** milliseconds.

3. An electrical apparatus for scoring a fencing match, in response to at least one valid touch signal produced by execution of at least one valid touch with a fencing weapon, said apparatus comprising:

a. a valid touch indicator; and

b. An indicator control circuit connected to said valid touch indicator for actuating said valid touch indicator in response to the occurrence of a said valid touch signal, said indicator control circuit comprising a second delay circuit connected to said valid touch indicator for preventing the actuation of said valid touch indicator in response to signals having a duration less than a predetermined period to avoid actuation of the valid touch indicator by noise signals not representing valid touches.

4. The apparatus of claim **3,** wherein:

said second delay circuit comprises a resistive and a capacitive element connected in parallel.

5. The apparatus of claim **3,** wherein said indicator control circuit further comprises:

an amplitude sensor for preventing actuation of the valid touch indicator by signals having less than a predetermined amplitude, to prevent actuation of the valid touch indicator by noise signals not representing valid touches.

6. The apparatus of claim **5,** in which the amplitude sensor comprises a breakdown diode.

7. An electrical apparatus for scoring fencing matches in response to first and second valid touch signals and invalid touch signals produced by execution of first and second valid and invalid touches with fencing weapons, said apparatus comprising:

a. an invalid touch indicator;

b. first and second valid touch indicators;

c. an indicator control circuit comprising:

i. first means for actuating said first valid touch indicator in response to a first valid touch signal,

ii. second means for actuating said second valid touch indicator in response to a second valid touch signal,

iii. a first delay circuit producing an output signal capable of actuating the invalid touch indicator upon a predetemined time lapse after the initiation of an input signal thereto;

iv. first control means for initiating said input signal to said first delay circuit in response to selected first valid touch signals, and

v. second control means for selectively directing said output of said first delay circuit to disable said second means from actuating said second valid touch indicator in response to said second valid touch signals following said predetemined time lapse.

8. The apparatus of claim **7,** further comprising:

converting means connected to said first delay circuit for changing the magnitude of said time lapse between initiation of said input signal and production of said output signal.

9. The apparatus of claim **8,** wherein said changed predetermined time lapse is approximately **40** milliseconds to enable scoring of simultaneous valid touches in epee fencing competition.

10. The apparatus of claim **9,** wherein:

a. said first delay circuit comprises a series RC branch having a time constant; and

b. said converting means comprises:

i. an additional resistive element, and

ii. electronic switching means for connecting the additional resistive element in series with said series RC branch to change its time constant.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 3,920,242

DATED : November 18, 1975

INVENTOR(S) : William E. Reith and John A. Overman

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 2, line 9, add --s-- to "opponent'";
Col. 3, line 20, change "not" to --no--;
Col. 4, line 27,change "the" to --this--;
Col. 4, line 46, change "viow" to --view--;
Col. 7, line 19, change "Ppwer" to --Power--;
Col. 8, line 52, after 124, change the period (.) to a comma (,);
Col. 9, line 36, change "curcuit" to --circuit--;
Col. 10, line 8, change "aa" to --a--;
Col. 10, line 37, change "the" to --The--
Col. 10, line 56, change "preferably" to --Preferably--;
Col. 12, line 45, after "the" first occurrence, insert --values of the--;
Col. 13, line 39, change "Providion" to --Provision--;
Col. 15, line 20, after "in", change "tis" to --its--.

Signed and Sealed this

twenty-fourth Day of *February 1976*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks