

Jan. 21, 1941.

G. H. GORDON

2,229,324

TIMING APPARATUS

Filed March 1, 1938

2 Sheets-Sheet 1

Fig. 1.

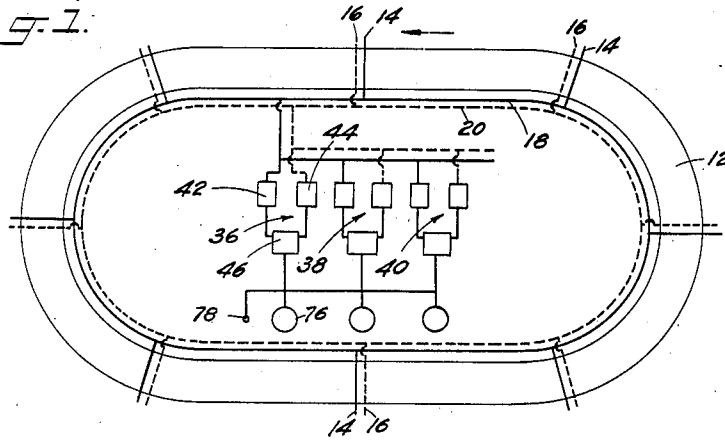


Fig. 2.

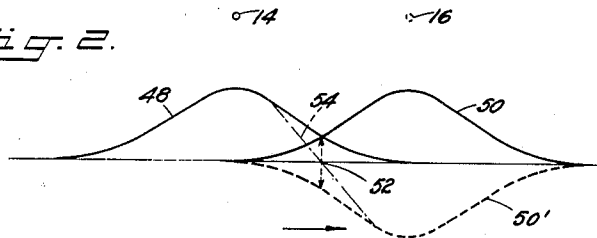


Fig. 3.

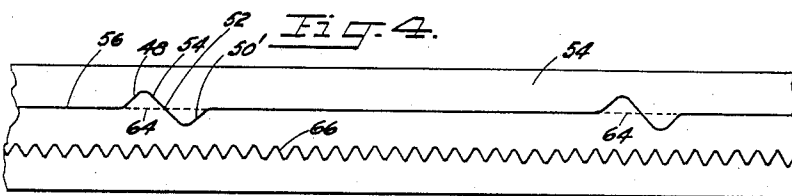
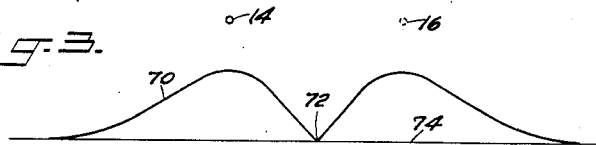


Fig. 5.

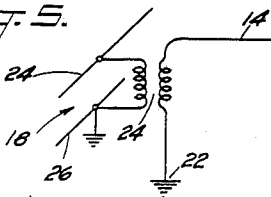
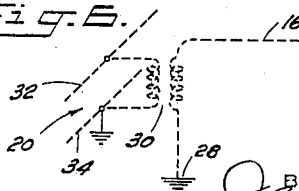


Fig. 6.



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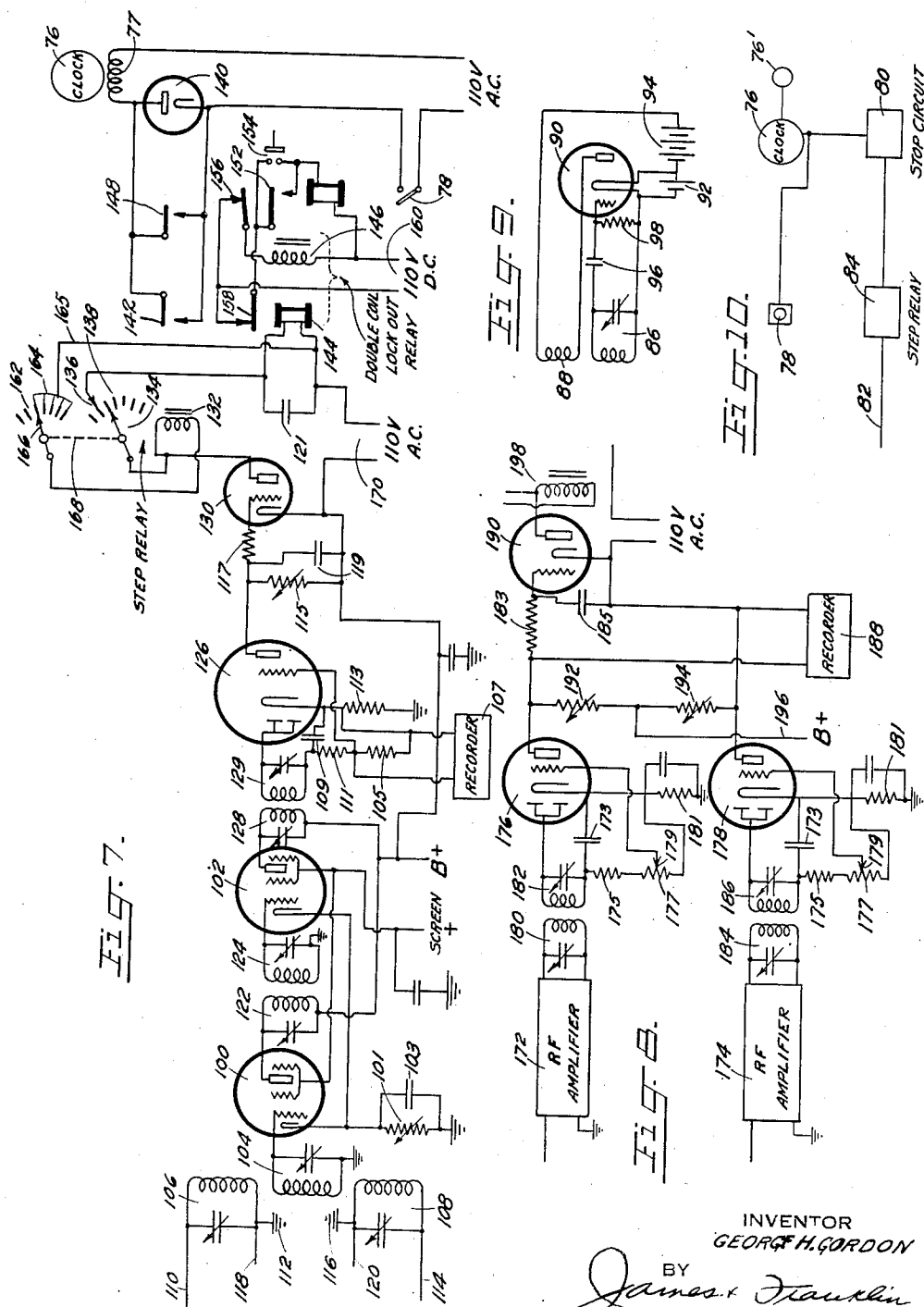
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TIMING APPARATUS

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2 Sheets-Sheet 2



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2,229,324

TIMING APPARATUS

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Application March 1, 1938, Serial No. 193,225

19 Claims. (Cl. 234—36.5)

This invention relates to timing apparatus, more particularly for timing travelling objects, and especially for race timing.

5 The primary object of my invention is to generally improve apparatus of the character specified. A more particular object is to provide apparatus for timing a moving object or animal, such as a racing auto, or horse. For convenience, I shall refer in the specification to horse racing as a particular example. Another object is to
10 time the horse at a plurality of spaced timing points, thus enabling a more accurate study of the progress and characteristics of the horse, at eighth mile or sixteenth mile, or other convenient intervals. In accordance with a still further
15 feature and object of the invention, the progress and timing of the horse at the specified intervals is permanently recorded on a travelling tape on which a standard timing wave may also be
20 recorded, thereby producing a record which is both permanent and extremely accurate. This record is suitable for subsequent study of the performance of the horse. It may also be displayed to spectators at the track by projection.
25 A further object of the present invention is to provide direct timing or clocking of the horse. Clocks may be set up in the judges' stand, and large display clocks may be set up in front of the grandstand. The clocks are started at the be-
30 ginning of the run and are automatically stopped at a selected timing point corresponding to the end of the run, thereby instantly displaying the time taken for that particular run.

35 I have so far written in terms of a single horse, and the invention is well adapted to timing and clocking a single horse during trial runs, for, as above explained, the record shows not only the total elapsed time, but also, the timing and progress at different intervals in the course of
40 the complete run. However, the invention is applicable to actual races in which there are a number of horses running at the same time, and, in accordance with a feature and object of my
45 invention, a tape record and display clock timing is obtained for each of the horses running in the race.

In furtherance of the above objects, I provide each horse with an exceedingly compact miniature radio frequency oscillator or transmitter.
50 These oscillators are negligible in weight and are standardized and calibrated in frequency so that each has a characteristic frequency different from the others. An appropriate antenna is disposed across the track at each timing point. This an-

tenna may extend overhead or be buried underground. The spaced antennas at the various timing points about the track are interconnected by a suitable transmission line. A bank of receivers is connected to the transmission line, each receiver being selective to the characteristic frequency of one of the oscillators. These selective
5 receivers control their own individual tape recorders and timing clocks.

A further object of my invention is to obtain
10 an exact measure of the passage of the oscillator at the timing point. To the attainment of this object, I employ two antennas at each timing point, these being disposed in substantially
15 equally spaced relation on opposite sides of the theoretical timing point. The leading antennas of each pair are connected by one transmission line, and the trailing antennas of each pair are
20 connected by another transmission line. The energies from the transmission lines are combined at each receiver in phase opposition, and in this way, the energies neutralize and cancel one another at the timing point halfway between the
25 antennas constituting a pair of antennas. A true zero reading is obtained at this point, and that zero is employed to mark the passage of the timing point on the track.

Further objects of my invention center about
30 the clock for direct timing of the horse. I prefer to employ an electric clock of the synchronous motor type. Such clocks are accurate and are readily started at the beginning of the race by simply closing the alternating current supply circuit thereto simultaneous with the start of the
35 race. The Telechron motor used for this purpose is, of course, of the self-starting type. I find that it is not sufficient to merely interrupt the supply circuit at the end of the race, for there is a tendency for the motor to coast and the clock
40 to overrun. It is important to lock the clock against continued rotation at the end of the race, and a further object of my invention is to accomplish this result in a convenient and dependable manner. I find that the motor is locked
45 against continued rotation if supplied with direct current instead of alternating current, and, in accordance with my invention, this result may be obtained by supplying the alternating current to the clock through appropriate rectifying means,
50 said means being normally shunted by closed contacts, which contacts are, however, opened at the end of the run, thus converting the alternating current supply to direct current, and so not only
55 stopping but "freezing" the clock in proper posi-

tion. A further object of my invention is to prevent stoppage of the clock when the horse passes any one of the timing points or antennas preceding the terminal timing point corresponding to the end of the race. With this object in view, I provide a step relay which is connected to each receiver and which is stepped up as the horse passes the successive timing points until it passes the timing point preceding the desired terminal timing point corresponding to the end of the race. At this time, the step relay functions to so connect the receiver to the contacts shunting the clock rectifier that the contacts are opened when the horse passes the next or terminal timing point. The clock is thus supplied with direct current and is thereby locked against movement.

To the accomplishment of the foregoing and other more detailed objects which will hereinafter appear, my invention consists in the radio transmitting, receiving, and timing elements and their relation one to the other, as hereinafter are more particularly described in the specification and sought to be defined in the claims. The specification is accompanied by drawings in which:

Fig. 1 is a schematic plan view of a race track and is explanatory of my invention;

Fig. 2 is a graph explanatory of the manner in which the energies from the leading and trailing antennas may be combined in phase opposition after rectification;

Fig. 3 is a graph explanatory of how the radio frequency energies may be combined in phase opposition before rectification;

Fig. 4 illustrates a piece of recording tape;

Fig. 5 shows the coupling of a leading antenna to its transmission line;

Fig. 6 shows the coupling of a trailing antenna to its transmission line;

Fig. 7 is a wiring diagram explanatory of a receiver for controlling a recorder and associated with relay mechanism for controlling an electric timing clock;

Fig. 8 illustrates a modification of the apparatus shown at the left-hand part of the diagram of Fig. 7, the apparatus being modified to combine the energies from the leading and trailing antennas after rectification;

Fig. 9 is a wiring diagram for a simple form of oscillator carried by the horse; and

Fig. 10 is a schematic diagram explanatory of the clock control circuits.

Referring to the drawings, and more particularly to Fig. 1, the invention is shown applied to a race track 12. Pairs of antennas 14 and 16 are arranged transversely of track 12 at preferably equally spaced intervals about the track. For convenience in understanding the diagram, the leading antennas 14 have been shown in solid lines and the trailing antennas 16 have been shown in broken lines, but it will be understood that, in actual practice, these antennas are alike. They may be disposed overhead, so that the horses or other racing objects run beneath the antennas, or they may be buried somewhat underground. It will be understood that each pair of antennas corresponds to a timing point which is located exactly halfway between the antennas, neglecting, for the moment, the question of oscillator location on the horse. In practice, the timing points are first selected and marked, these timing points being, say, at sixteenth mile intervals, or at any other convenient interval. The antennas are then disposed at equal distances on

opposite sides of the timing point (or adjusted distances, as later described). For convenience of reference, I refer to one of the antennas in each pair as a leading antenna and the other as a trailing antenna.

The leading antennas 14 are all connected to a common transmission line 18 running about the track. Similarly, the trailing antennas 16 are all connected to a common transmission line 20, also running about the track. Transmission lines 18 and 20 have each been shown as a single line, but it will be understood that, in practice, each comprises a pair of conductors. Thus, referring to Fig. 5, it will be seen that antenna 14 is grounded at 22 and is coupled by a suitable radio frequency transformer 24 to transmission line 18 made up of a pair of conductors 24 and 26. Referring to Fig. 6, it will be seen that the trailing antenna 16 is similarly coupled to transmission line 20 by grounding the antenna at 28 through the primary of a radio frequency transformer 20, the secondary of said transformer being connected to the conductors 32 and 24 of the transmission line 20.

Reverting now to Fig. 1, I provide a bank of receivers 36, 38, 40, etc., at any convenient point about the track. There is one such receiver for each entry in the race. Each receiver is in reality an assembly of units. Thus, referring to Fig. 1, the receiver assembly 36 comprises a first radio frequency selective amplifier 42 connected to transmission line 18, and thus connected to the leading antennas. It further comprises a similar selective radio frequency amplifier 44 connected to transmission line 20, and thus to the trailing antennas. These amplifiers are selective to one only of the travelling oscillators, and the entire receiver assembly 36 is used to record and time that oscillator alone. The amplifiers 42 and 44 terminate with rectifiers, and the rectified outputs are combined in phase opposition in a suitable combining unit and tape recorder schematically indicated by box 46.

Referring now to Fig. 2, the rectified output from amplifier 42 rises and falls, as is indicated by the wave 48, as the oscillator passes the leading antenna 14. Similarly, the rectified output from amplifier 44 rises and falls, as is indicated by the wave 50, as the oscillator passes the trailing antenna 16. The spacing of the antennas is less than the radio range of the travelling oscillator, and the waves 48 and 50, therefore, overlap. The energies indicated by the waves 48 and 50 are combined in phase opposition, and this is schematically indicated by the dotted line wave 50'. It will thus be seen that, at a point midway between the antennas 14 and 16, that is, at the timing point 52, the rectified energies neutralize and cancel one another, thus bringing the actual energy applied to a recorder, stylus, or other such device, down to true zero value. The summation or combined wave is indicated by the dot-and-dash line 54.

Referring now to Fig. 4, the strip of tape 54 is moved through a recording apparatus at a preferably uniform speed. A line 56 is traced thereon by a stylus which is responsive to the energies from the transmission lines combined in phase opposition, as was explained in Figs. 1 and 2. When the oscillator passes beneath a leading antenna, the stylus is displaced and traces a wave, such as that indicated at 48. When the oscillator passes a trailing antenna, the stylus is displaced in opposite direction and traces a wave, such as that indicated at 50'. Between the antennas, the stylus traces the combined line 54. The point of

intersection 52 of line 54 with the zero line 64 marks the passage by the oscillator of the theoretical timing point on the track, this timing point being midway of the pair of antennas. A standardized timing wave 66 of uniform periodicity may be traced on tape 54 by another stylus, and the timing of the horse between timing points may be computed against the timing wave 66. This obviates any error which might otherwise result from variation in the rate of feed of tape 54 through the recording apparatus.

It is also possible to combine the energies from the transmission lines while still in radio frequency form. I prefer to use radio frequencies of moderate amount, say, 1 to 100 microvolts, and corresponding to a wavelength of, say, 200 meters or up, and this very greatly exceeds the contemplated spacing between the trailing and leading antennas 14 and 16. It is, therefore, possible to ignore the matter of space change of phase in the radio wave radiating from the oscillator as it moves between the leading and trailing antennas. It may be mentioned, however, that, if any attempt is made to use oscillators which radiate ultra-short waves, it would then be necessary to combine the energies after rectification, as previously explained.

Assuming the use of the above relatively long wave-lengths, the energies from the transmission lines may be applied in phase opposition directly to the input of a single radio frequency amplifier. This is the essential difference between the arrangements of Figs. 7 and 8, for, in Fig. 8, separate radio frequency amplifiers and rectifiers are employed, while in Fig. 7, the radio frequency energies are applied in phase opposition to a single amplifier and rectifier. Referring now to Fig. 3, the curve 70 represents the envelope of the combined radio frequency waves from leading antenna 14 and trailing antenna 16. The combined wave falls to zero at the mid-point or timing point 72, but, in this case, both sides of the wave lie on the same side of the zero line 74. It will be understood that the curve 70 may be considered representative of the envelope of the combined radio frequency wave, or it may also be considered representative of the rectified output resulting from the combined radio frequency wave.

Referring to Fig. 1, each receiver assembly has a display clock or/and judge's clock associated with it. Thus, in receiver assembly 36, the clock is schematically indicated at 76. The clocks are all connected to an appropriate starting switch 78, and it will be understood that this starting switch is closed and the entire bank of clocks is started simultaneously with the start of the race. Each receiver assembly and clock corresponds to one of the oscillators, and the problem is to stop the clock when its corresponding oscillator passes a desired one of the timing points corresponding to the end of the race. A further problem is to prevent stoppage of the clock as the oscillator passes timing points ahead of the terminal timing point.

The manner in which this is done may be preliminarily explained by reference to the schematic diagram of Fig. 10. The clock 76 (along with all of the other clocks) is started by an appropriate starter's button or switch 78. The clock 76 is arranged to run in parallel with a judge's clock 76', and both are stopped by an appropriate stop circuit 80. This stop circuit is controlled by a receiver connected to line 82. However, between the receiver and the stop circuit 80, I interpose step relay mechanism 84. This step relay

mechanism functions to absorb, in a harmless or non-functional manner, the impulses produced as the mating oscillator passes the timing points preceding the terminal timing point. The relay is merely stepped or notched upwardly for each timing point (or twice, one for each antenna), until a critical step is reached, at which time the receiver may be connected to the stop circuit so that the clock will be stopped when the oscillator passes the next timing point. The critical step referred to depends on the length of the race and the spacing of the timing points, and is variably selective.

Referring now to the more detailed wiring diagrams, the travelling oscillator may be entirely conventional. It is preferably a vacuum tube oscillator of compact design, using miniature dry cells, and a typical circuit suitable for the purpose is shown in Fig. 9. The frequency is determined by tuned circuit 86, and this circuit is calibrated and sealed so as to definitely identify the horse carrying the oscillator in question. Regeneration is obtained by means of coil 88 coupling the output circuit of oscillator tube 90 with the tuned input circuit 86. The filament is heated by dry cell 92; the plate is polarized by battery 94; and the grid is suitably biased by means of a condenser and resistance combination 96, 98. Other oscillator circuits of known type may be employed. No special antenna for radiating the transmission energy is needed, for the transmission distance is very small, the receiving antenna, whether located underfoot or overhead, being quite close to the oscillator.

The wiring diagram for a receiver circuit is shown in Fig. 7. I provide a two-stage radio frequency amplifier employing the tubes 100, 102. These tubes may be of the screen grid type, known commercially as type 6D6. The tuned input circuit of tube 100 is indicated at 104, and this is coupled to the transmission lines 18 and 20 through tuned coupling circuits 106 and 108. If the transmission lines are grounded on one side, the circuit 106 may be connected to one line through conductor 110 and grounded at 112, while circuit 108 is connected to the other line through conductor 114 and is grounded at 116. In Fig. 5, I show conductor 26 grounded, and in Fig. 6, I show conductor 34 grounded, and it will be understood that, in actual practice, a common conductor may be used instead of separate conductors 26 and 34. The feed of the radio frequency energies to input circuit 104 is in phase opposition, as the diagram indicates. The circuits 106 and 108 may be connected to the two wire transmission lines, if four conductors are used, by the additional connections 118 and 120, precaution being taken, of course, to see that the energies are combined in opposed phase.

The amplified output of tube 100 is fed to the input of tube 102 through coupled circuits 122, 124, and the amplified output of tube 102 is fed to rectifier tube 126 through coupled circuits 128 and 129. The gain of the radio frequency amplifier may be varied by volume control resistor 101, preferably shunted by condenser 103. Practically all of the tubes shown in the drawings are of the cathode heater type, and it is merely for simplification of the drawings that I have omitted the heater filaments and supply circuits therefor. These may be wholly conventional. The tube 126 is a dual diode triode, which may be of the type known commercially as #75, and which functions both as a diode rectifier and as an amplifier for the rectified energy. The rectified out-

put is taken off the diode circuit across a resistor 105, and is applied to a suitable tape recorder 107 functioning generally as was previously described in connection with Fig. 4, except that, in this case, the timing wave will be of the character shown in Fig. 3, rather than of the character shown in Fig. 4. Condenser 109 and resistor 111 form a filter for the radio frequency energy. Resistor 113 is not essential but is merely a stabilizing resistor for the tube.

The rectified potential across resistor 105 is applied to the cathode and grid of tube 126, and the amplified output across the anode cathode circuit is supplied to a tube 130, which is preferably a Thyatron tube, such as the type commercially designated #885. The tube is so negatively biased, by a negative bias potential obtained across a variable resistor 115 in the anode circuit of tube 126, that the tube is normally non-conductive. The Thyatron tube is kept just below ionization, or just below its firing point, and resistor 115 is adjusted for the proper bias. When the travelling oscillator passes a timing point, the decreased anode current is accompanied by an increase in anode potential, and this lowers the negative bias of the Thyatron and causes it to "fire." When the oscillator is midway of the pair of antennas, the energy supplied to the receiver is neutralized and the Thyatron negative bias rises to normal and the tube is deionized or "defires." As the oscillator passes midpoint and approaches the second antenna of the pair, the Thyatron again fires. This tube acts essentially as a sensitive trigger. Resistor 117 and condenser 119 act as a radio frequency filter for any radio frequency passing rectifier 126, and resistor 117 also acts to limit any surge of grid current going back to tube 126.

The output of tube 130 is applied to the stepping coil 132 of a step relay, and it causes the armature or moving arm 134 of the relay to step upwardly each time that tube 130 is fired. Arm 166 moves with arm 134, and its function is described later. A movable contact or plug 136 is plugged into that one of the contacts 138 which corresponds to a timing point just preceding the terminal timing point of the race. With the present arrangement, the tube 130 is fired once for each antenna or twice for each timing point, and the number of steps selected when plugging in the plug 136 should take this fact into account, there being twice as many steps as there are timing points.

The clock to be controlled by the receiver is indicated at 76, and the field coil thereof at 77. This really represents a clock group, for there may be more than one clock, all connected together, most simply in parallel. Most frequently there will be one for the judges, and one or more for public display. The clock group is, for simplicity, frequently treated and referred to herein as a clock, the group being supplied with alternating current from a regular 110-volt line, and the current supply is controlled by a starter's switch 78. It will be understood that, in practice, the starting switch 78 controls the supply of current to bus wires from which a plurality of clock groups are energized, there being one clock group for each receiver. A rectifier 140 is connected in series with the motor field coil 77. A separate rectifier is provided for each clock group, or, in other words, the rectifiers are connected between the common bus line controlled by switch 78 and each of the clock groups. Full wave rectifiers may be used, but the arrangement is here illus-

trated in simplest form with a single wave rectifier. The rectifier is shunted by contacts 142 which are opened at the end of the race. These contacts form part of a double coil lock-out relay, the companion coils of which are indicated at 144 and 146, coil 146 being a locking coil. The contacts 142 are shown open because they are normally open and are closed only during energization of coil 144.

The rectifier 140 is also shunted by contacts 148. These contacts are controlled by a relay coil 150, and contacts 148 are normally open when coil 150 is not energized. Relay 150 is a "stick relay," it being provided with a pair of normally open contacts 152 arranged in series with coil 150. These contacts are shunted by a normally open switch 154 of the push-button type. At the beginning of a race, and before the race is actually started, the button 154 is pressed, thereby energizing coil 150, which, in turn, closes contacts 152 and contacts 148. The closing of contacts 152 keeps the coil energized, and this, in turn, keeps contacts 148 closed, thus shunting the rectifier 140. The circuit has thus been made ready for the start of the race, and when the starting switch 78 is closed by the starter, the clock 76 is supplied with alternating current and is thereby started. Relay coil 150 also controls a pair of normally closed contacts 156. When coil 150 is energized, the contacts 156 are opened, and they remain so at the start of and during most of the race. This deenergizes lock-out coil 146, and so permits coil 144 to function if and when energized by the Thyatron and step relay circuit previously referred to. Coil 144, besides controlling the normally open contacts 142, also controls the normally closed contacts 158, the purpose of which is later described.

It was previously mentioned that plug 136 connected to relay coil 144 is plugged into that one of step relay contacts 138 corresponding to a timing point preceding the terminal timing point. It will thus be seen that, as Thyatron tube 130 fires for the successive timing points, it merely steps up the step relay and does not energize coil 144, and, at the timing point preceding the terminal timing point, the Thyatron steps switch 134 as far as the contact receiving plug 136, thus preparing the way for energization of relay coil 144 when the Thyatron is fired the next time, that is, at the terminal timing point. When the Thyatron is next fired at the first antenna of the final timing point, the relay coil 144 is energized. This causes closing of contacts 142, thus maintaining, for a brief additional time, the desired shunt around rectifier 140. At the same time, it opens contacts 158, thereby opening the circuit through relay coil 150, and this, in turn, permits opening of contacts 148 and 152. It also permits closing of contacts 156, thus energizing locking coil 146 from the direct current source 160. When the oscillator reaches the true timing point, and is midway between the antennas, the radio frequency energies supplied to the receiver neutralize one another and the Thyatron defires, thus deenergizing relay coil 144 and opening contacts 142. The clock rectifier 140 is no longer short-circuited and instantly functions, so that the current supply to clock coil 77 is changed from alternating current to direct current and the clock is stopped and frozen in position. Contacts 158 are closed at the same time, but this is without consequence because contacts 152 and switch 154 are both open.

It has been mentioned that, at next to the

last timing point, the step relay is stepped to the plug 136, and that, at the last timing point, the energy is fed to relay coil 144. It is important, however, that the Thyatron energy should not further step the step relay, for it will then move beyond plug 136. This is accomplished by using another set of contacts 162, the lower group of which are connected to one another, as indicated at 164, and are connected in the circuit from coil 132 down through wire 165 to the supply source 170. The arrangement is such that, when contact arm 134 is stepped to the plug 136, the companion contact arm 166 which moves mechanically with arm 134 (as is schematically indicated by link 168) is moved one step beyond the connected bank of contacts 164, thereby opening the circuit through the stepping coil 132. Thus, the stepping relay is made inoperative and does not step the arms 134, 166 any further than the plugged contact 136. Instead, the energy from the Thyatron flows through contact arm 134 and plug 136 to the relay coil 144, and thence to the supply source 170.

Any later firing of the Thyatron, as when the oscillator passes the second antenna of the terminal pair, or should the oscillator continue its travel past another timing point beyond the terminal timing point, has no effect on the clock, and the circuits remain in the terminal condition because of the influence of locking coil 146 which, when it is energized and has attracted the relay armature to itself, dominates the influence of coil 144, the latter being unable to pull the armature back. Of course, when manual push-button 154 is pressed at the beginning of the next race, the lock-out coil 146 is deenergized because of the opening of contacts 156 resulting from energization of relay coil 150.

The condenser 121 is connected across relay 144 in order to prevent chattering of the relay, but this condenser is not made large enough to smooth out the pulsating nature of the current in the anode circuit of the Thyatron 130 resulting from the use of alternating current at the source 170. Alternating current is there used in order to insure instantaneous cut-off or defiring of the Thyatron when the grid potential is restored to normal, as at the timing point. It may be mentioned that direct current with a chopper may be used instead of alternating current, but the latter is so commonly available that it is convenient to use the same.

Fig. 8 shows a modification of the left-hand part of Fig. 7, such as may be used when the energies from the leading and trailing antennas are to be combined after rectification. Referring to Fig. 8, the energy from one transmission line is fed to a selective radio frequency amplifier 172, while the energy from the other transmission line is fed to a similar radio frequency amplifier 174. With the circuit connected and arranged as here shown, the amplifier 172 should be connected to the leading antennas, and the amplifier 174 should be connected to the trailing antennas. The amplified radio frequency output is applied to the input of tubes 176 and 178, by means of coupled tuned circuits 180, 182 and 184, 186. Tubes 176 and 178 are similar to tube 126 of Fig. 7, that is, they may be of the type known commercially as #75, which function not only as a diode rectifier but also, to amplify the rectified energy. Condensers 173 and resistors 175 act as a radio frequency filter. Resistors 177 are in series with the diode rectifiers, and the rectified potentials to be amplified are developed

thereacross and are applied to the grids, all as was previously described. The quantitative value of the potential may be varied by taps 179. The resistors 181 are merely stabilizing resistors, similar to resistor 113 in Fig. 7. The rectified energies are combined in phase opposition and are then coupled to a tape recorder 168 and a Thyatron tube 190. The connection of the rectified outputs in phase opposition is indicated by the anode resistors 192 and 194 which are connected to one another and to a common anode potential supply lead 196. The Thyatron tube 190 corresponds to the tube 130 in Fig. 7, and the coil 198 corresponds to the stepping relay coil 132 in Fig. 7. The remainder of the circuit has not been redrawn but may be identical with that shown in Fig. 7.

The bias potential on the grid of Thyatron 190 is made such that the tube is just below ionization. This bias may be regulated by the use of a special biasing battery and potentiometer, or the like, or, as in the present case, the plate current resistors 192 and 194 may be made variable, and these may be so relatively adjusted as to obtain the desired bias, assuming, of course, that the bias needed is so small as not to disadvantageously affect the accuracy of response in the recorder 188. If any noticeable error appears in the recorder, then it is preferable to use a perfectly symmetrical push-pull arrangement with equal resistors 192 and 194, and to obtain the grid bias of the Thyatron by external biasing means. In operation, when the oscillator passes the leading antenna, there is a current loss through resistor 192 and a consequent fall in bias potential. The resulting change in bias causes firing of the Thyatron tube and consequent stepping of the step relay. When the travelling oscillator comes midway between the antennas, the potential drop across the resistors 192 and 194 is equalized and the Thyatron defires. When the oscillator passes the second antenna, there is decreased current through resistor 194 and there is an increase in the negative bias of the Thyatron, thus preventing firing. With this arrangement, the Thyatron fires only once for each timing point. It fires ahead of the true timing point and stops firing at the timing point.

The operation and control of the clock will be understood by recollecting the operation of the arrangement in Fig. 7, the only change being the use of half as many steps in the step relay. The firing of the Thyatron at the timing point before the last, brings the step relay into connection with plug 136, and prevents further operation of the step relay coil. The firing of the Thyatron at the first antenna of the finish line momentarily closes the clock rectifier contacts 142 and opens the contacts 148. When the oscillator passes the true finish line midway between the antennas, the Thyatron defires and contacts 142 are opened and the clock is stopped.

Reverting to Fig. 8, it will be understood that the resistor 183 and condenser 185 form a filter for radio frequency energy, and that resistor 183 also functions to prevent backward surge of grid current, all as was described in connection with resistance 117 and condenser 119 in Fig. 7.

It is believed that the construction and operation, as well as the many advantages of my improved timing apparatus will be apparent from the foregoing detailed description thereof. At the beginning of the race, the horses are each supplied with a miniature transmitter of char-

acteristic frequency, this being appropriately mounted in the saddle equipment. The plugs 136 of the various receivers are plugged in at the proper point, depending upon the length of the race. Connections 164 are similarly adjusted but to one less step. Push-buttons 154 are depressed, thus setting the various relays in desired manner and closing the shunting contacts 148. A switch, not shown in the drawings, is also closed to begin operation of the tape feeding motors of the various tape recorders. The starter, as a part of starting the race, closes switch 78, thus beginning operation of all of the clocks. As the horses pass the successive timing points, a record of their progress is made on their respective tape recorders. The exact time of each horse, and their relative timing, may be determined from comparison of the tapes after the race has been completed. In the meantime, the clocks count off the timing of the race, and the clock-stopping mechanism is inoperative as the horses pass the early timing points because of the stepping relay. At the terminal timing point, however, the shunt around the clock rectifier is opened, thus converting the current supply reaching the clock from alternating current to direct current, and this not only stops the clock but freezes it in position. As the successive horses pass the finish line, their respective clocks are thus stopped. (Each clock may be a clock group, as previously explained.) The circuits remain in that condition due to the action of lock-out coil 146. Coil 146 holds the relay armature even if coil 144 is again energized. Yet coil 146 will not attract the armature away from coil 144 if coil 144 is already energized and is already holding the armature. When coil 144 is first energized by the leading antenna just ahead of the finish line, the coil 146 is deenergized because contact 156 is open. In other words, during most of the race, both coil 144 and coil 146 are deenergized. The coil 144 is energized, and attracts the relay armature, and only thereafter is coil 146 energized (by opening of contacts 158 followed by closing of contacts 156). Coil 146 cannot attract the armature because it is already drawn to coil 144. At the finish line coil 144 is deenergized, and coil 146 attracts the armature and holds it thereafter. This condition is not changed until the start of the next race, when the push-button 154 is again depressed.

The oscillator and cells may be located at the saddle of the horse, or the oscillator, which may be made exceedingly tiny, may be located at the head with the cells at the saddle, or the oscillator and cells may be located at the saddle with an antenna or radiating means located at the head of the horse, if an antenna is to be used, though no antenna is needed. If it is desired to compensate for the distance between the oscillator at the saddle and the head of the horse, without attempting to produce the radiation at the head of the horse, the stationary antennas may be shifted relative to the timing point. In other words, the leading antenna distance may be made greater, and the trailing antenna distance may be made less by an amount equal to the average distance between the standardized saddle oscillator location and the nose of a horse. With other racing vehicles, say, autos, the antenna may be located at the forward end of the vehicle, or the oscillator may be located a standardized distance back from the forward end, and the antennas may be compensated for that distance as above explained. The result of shifting

the antennas may be considered as being a shift of the timing point by the desired amount, to deal with the location of the oscillator on the moving object, instead of dealing with the forward end of the object in its relation to the true timing point.

In order not to unduly complicate the drawing, I have not included therein the means for marking the beginning of the timing on the tape. This is preferably done by a circuit connected to the starter's switch (see Fig. 1) so that the starter's switch, when closed, not only starts the clocks, but also causes the stylus of the recorder to be sharply displaced in order to make a starting mark on the moving tape. This is done by a circuit arranged in shunt with the regular stylus moving circuit, said auxiliary shunt circuit being energized only at the moment of closing of the starter's switch and thereafter having no further function.

The condenser 121 around relay 144 is not needed if the relay is designed to operate on pulsating current.

It will be apparent that, while I have shown and described my invention in preferred forms, many changes and modifications may be made in the circuits and structures disclosed without departing from the spirit of the invention defined in the following claims. In the claims, clock includes clock group. The statement that the antennas are equally spaced on each side of the timing point includes the adjustment for distance between the oscillator and forward end of the moving object.

I claim:

1. Race timing apparatus comprising a plurality of portable radio frequency oscillators, each having a characteristic radio frequency different from the others, an antenna mounted at a timing point to receive energy radiated from said oscillators, a plurality of receivers connected to said antenna and each selective for the characteristic radio frequency of one of the oscillators, a timing device connected to each receiver and responsive to the receiver output so as to be operated when the oscillator passes a timing point.

2. In a timing apparatus comprising a portable radio frequency oscillator, a pair of antennas mounted in equally spaced relation on opposite sides of a timing point to receive energy radiated from said oscillator, a receiver connected to said antennas and so arranged as to combine the energies from the antennas in phase opposition, whereby the resultant energy is zero when the oscillator is at the timing point.

3. Timing apparatus comprising a portable radio frequency oscillator, a pair of antennas mounted in equally spaced relation on opposite sides of a timing point to receive energy radiated from said oscillator, a receiver connected to said antennas and so arranged as to combine the energies from the antennas in phase opposition, whereby the resultant energy is zero when the oscillator is at the timing point, and a timing device connected to the receiver and responsive to the receiver output so as to be operated when the oscillator passes a timing point.

4. In a race timing apparatus comprising a plurality of portable radio frequency oscillators, each having a characteristic frequency different from the others, a pair of antennas mounted in equally spaced relation on opposite sides of a timing point to receive energy radiated from said oscillators, a plurality of receivers connected to said

antennas and each so arranged as to combine the energies from the antennas in phase opposition, whereby the resultant energy is zero when the oscillator is at the timing point, each of said receivers being selective for the characteristic frequency of one of the oscillators.

5. Race timing apparatus comprising a plurality of portable radio frequency oscillators, each having a characteristic frequency different from the others, a pair of antennas mounted in equally spaced relation on opposite sides of a timing point to receive energy radiated from said oscillators, a plurality of receivers connected to said antennas and each so arranged as to combine the energies from the antennas in phase opposition, whereby the resultant energy is zero when the oscillator is at the timing point, each of said receivers being selective for the characteristic frequency of one of the oscillators, a timing device connected to each receiver and responsive to the receiver output so as to be operated when the oscillator of respective characteristic frequency passes a timing point.

6. Timing apparatus comprising a portable radio frequency oscillator, a plurality of antennas distributed at spaced timing points around the path of travel to be followed by the oscillator, a transmission line connecting said antennas, a receiver connected to said transmission line, a timing device, means responsive to the output of said receiver for stopping the timing device, and a discriminating means to make said stopping means effective solely when the oscillator passes a selected one of the timing points.

7. Timing apparatus comprising a portable radio frequency oscillator, a plurality of antennas distributed at spaced timing points around the path of travel to be followed by the oscillator, a transmission line connecting said antennas, a receiver connected to said transmission line, a timing device connected to the receiver and responsive to the receiver output so as to be operated when the oscillator passes each timing point.

8. Timing apparatus comprising a portable radio frequency oscillator, a plurality of antennas distributed at spaced timing points around the path of travel to be followed by the oscillator, a transmission line connecting said antennas, a receiver connected to said transmission line, a first timing device connected to the receiver and responsive to the receiver output at all of the timing points, a second timing device, means responsive to the output of said receiver for stopping the second timing device, and a discriminating means to make said stopping means effective solely when the oscillator passes a selected one only of the timing points.

9. Race timing apparatus comprising a plurality of portable radio frequency oscillators, each having a characteristic frequency different from the others, a plurality of antennas distributed at spaced timing points around the race track, a transmission line connecting said antennas, a plurality of receivers connected to said transmission line and each selective for the characteristic frequency of one of the oscillators, a timing device for each receiver, means responsive to said receiver for stopping the associated timing device, and a discriminating means to make said stopping means effective solely when the respective oscillator passes a selected one of the timing points.

10. Race timing apparatus comprising a plurality of portable radio frequency oscillators, each having a characteristic frequency different from

the others, a plurality of antennas distributed at spaced timing points around the race track, a transmission line connecting said antennas, a plurality of receivers connected to said transmission line and each selective for the characteristic frequency of one of the oscillators, a timing device connected to each receiver and responsive to the receiver output so as to be operated when the oscillator of respective characteristic frequency passes each timing point.

11. Race timing apparatus comprising a plurality of portable radio frequency oscillators, each having a characteristic frequency different from the others, a plurality of antennas distributed at spaced timing points around the race track, a transmission line connecting said antennas, a plurality of receivers connected to said transmission line and each selective for the characteristic frequency of one of the oscillators, a first timing device connected to each receiver and responsive to the receiver output at all timing points, a second timing device for each receiver, means responsive to said receiver for stopping the second timing device, and a discriminating means to make said stopping means effective solely when the respective oscillator passes a selected one only of the timing points.

12. Timing apparatus comprising a portable radio frequency oscillator, a plurality of pairs of antennas distributed at spaced timing points around the path of travel to be followed by the oscillator, the antennas in each pair being in equally spaced relation leading and trailing the timing point for that pair of antennas, a first transmission line connecting all of the leading antennas, and a second transmission line connecting all of the trailing antennas, a receiver connected to said transmission lines and so arranged as to combine the energies from the transmission lines in phase opposition, whereby the resultant energy is zero when the oscillator is at the timing points, a timing device, means responsive to said receiver for stopping the timing device, and a discriminating means to make said stopping means effective solely when the oscillator passes a selected one of the timing points.

13. Timing apparatus comprising a portable radio frequency oscillator, a plurality of pairs of antennas distributed at spaced timing points around the path of travel to be followed by the oscillator, the antennas in each pair being in equally spaced relation leading and trailing the timing point for that pair of antennas, a first transmission line connecting all of the leading antennas, a second transmission line connecting all of the trailing antennas, a receiver connected to said transmission lines and so arranged as to combine the energies from the transmission lines in phase opposition, whereby the resultant energy is zero when the oscillator is at the timing points, and a timing device connected to the receiver and responsive to the receiver output so as to be operated when the oscillator passes each timing point.

14. Timing apparatus comprising a portable radio frequency oscillator, a plurality of pairs of antennas distributed at spaced timing points around the path of travel to be followed by the oscillator, the antennas in each pair being in equally spaced relation leading and trailing the timing point for that pair of antennas, a first transmission line connecting all of the leading antennas, a second transmission line connecting all of the trailing antennas, a receiver connected to said transmission lines and so arranged as to combine the energies from the transmission lines

in phase opposition, whereby the resultant energy is zero when the oscillator is at the timing points, a first timing device connected to the receiver and responsive to the receiver output at all of the timing points, a second timing device, means responsive to said receiver for stopping the second timing device, and a discriminating means to make said stopping means effective solely when the oscillator passes a selected one only of the timing points.

15. Race timing apparatus comprising a plurality of portable radio frequency oscillators, each having a characteristic frequency different from the others, a plurality of pairs of antennas distributed at spaced timing points around the race track, the antennas in each pair being in equally spaced relation leading and trailing the timing point for that pair of antennas, a first transmission line connecting all of the leading antennas, a second transmission line connecting all of the trailing antennas, a plurality of receivers connected to said transmission lines and so arranged as to combine the energies from the transmission lines in phase opposition, whereby the resultant energy is zero when the oscillator is at the timing points, each of said receivers being selective for the characteristic frequency of one of the oscillators, a timing device for each receiver, means responsive to said receiver for stopping the timing device, and a discriminating means to make said stopping means effective solely when the respective oscillator passes a selected one of the timing points.

16. Race timing apparatus comprising a plurality of portable radio frequency oscillators, each having a characteristic frequency different from the others, a plurality of pairs of antennas distributed at spaced timing points around the race track, the antennas in each pair being in equally spaced relation leading and trailing the timing point for that pair of antennas, a first transmission line connecting all of the leading antennas, a second transmission line connecting all of the trailing antennas, a plurality of receivers connected to said transmission lines and so arranged as to combine the energies from the transmission lines in phase opposition, whereby the resultant energy is zero when the oscillator is at the timing points, each of said receivers being selective for the characteristic frequency of one of the oscillators, and a timing device connected to each receiver and responsive to the receiver output so as to be operated when the oscillator of respective characteristic frequency passes each timing point.

17. Race timing apparatus comprising a plu-

ality of portable radio frequency oscillators, each having a characteristic frequency different from the others, a plurality of pairs of antennas distributed at spaced timing points around the race track, the antennas in each pair being in equally spaced relation leading and trailing the timing point for that pair of antennas, a first transmission line connecting all of the leading antennas, a second transmission line connecting all of the trailing antennas, a plurality of receivers connected to said transmission lines and so arranged as to combine the energies from the transmission lines in phase opposition, whereby the resultant energy is zero when the oscillator is at the timing points, each of said receivers being selective for the characteristic frequency of one of the oscillators, a first timing device connected to each receiver and responsive to the receiver output at all timing points, a second timing device for each receiver, means responsive to said receiver for stopping the second timing device, and a discriminating means to make said stopping means effective solely when the oscillator passes a selected one only of the timing points.

18. Timing apparatus comprising a portable radio frequency oscillator, a plurality of antennas distributed at spaced timing points around the path of travel to be followed by the oscillator, a transmission line connecting said antennas, a receiver connected to said transmission line, a timing device, a starting means to be used at the start of a run in order to start the timing device, a step relay connected to said receiver and functioning to step up as the oscillator passes the successive timing points until it passes the timing point preceding a desired terminal timing point, said step relay then functioning to so connect the receiver to a stopping means for the timing device in order to stop the timing device when the oscillator passes the terminal timing point.

19. Signalling apparatus for use with a moving object, said apparatus comprising means adapted to be mounted on said object for radiating radio frequency energy, spaced stationary antennas to receive energy radiated from said moving object, a receiver connected to said antennas and so arranged as to combine the energies from the antennas in phase opposition, and means functioning when subjected to zero resultant energy as the moving object passes midway between the antennas for thereupon controlling a desired mechanism.

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