

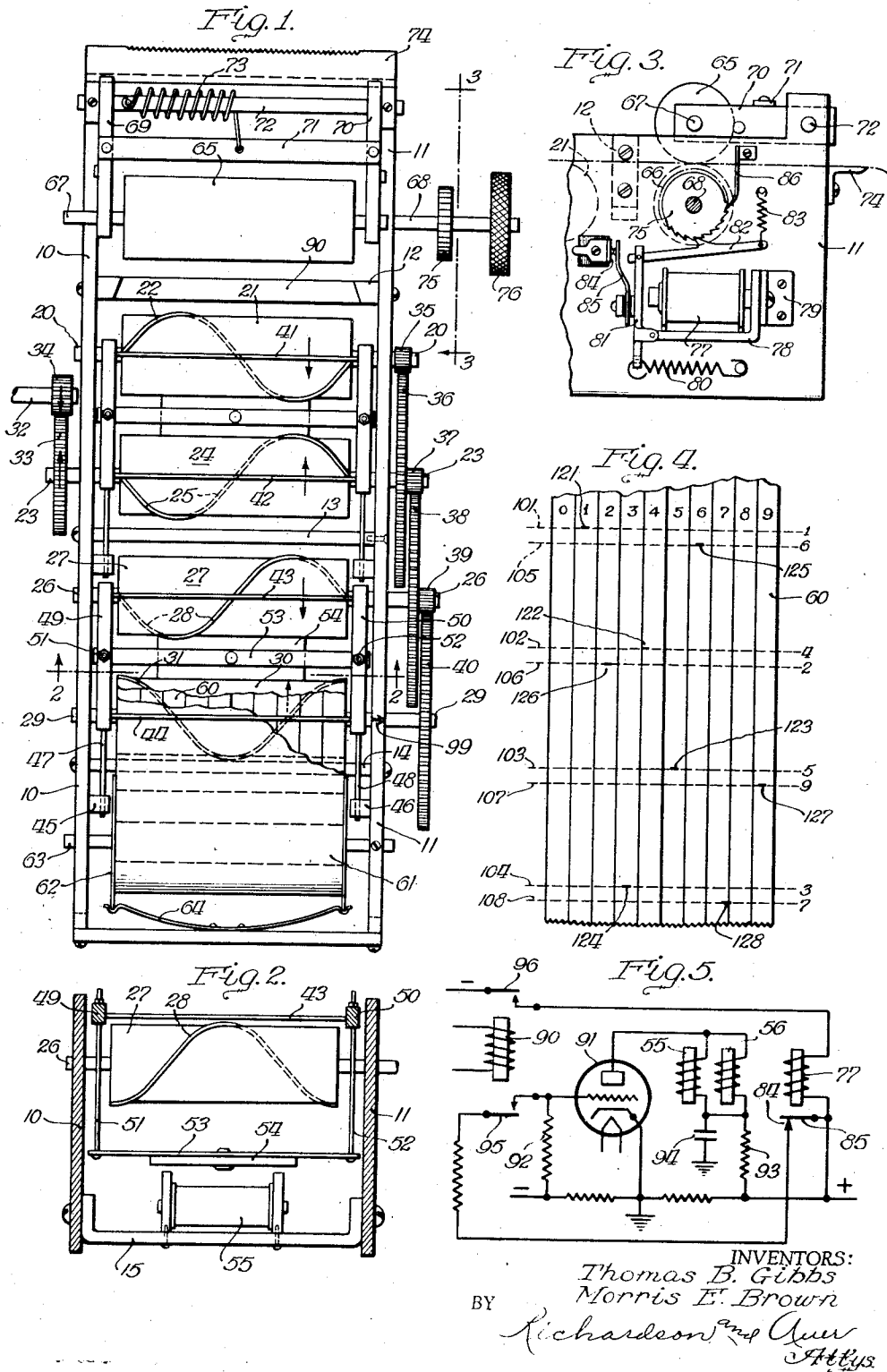
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TIMING APPARATUS

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TIMING APPARATUS

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The present invention relates in general to timing apparatus, and more in particular to apparatus for measuring short periods of elapsed time. The object of the invention is to produce a new and improved timing apparatus of this character.

A special object of the invention is a timing apparatus by means of which a time interval can be measured with extreme accuracy, the result in seconds being readable to at least three decimal places.

A further object of the invention is to produce a timing apparatus, or time measuring apparatus, of the recording type in which extremely accurate records are made at the beginning and end of a time interval to be measured. These records are in seconds and decimal fractions of a second. By subtracting the first record from the last, the duration of the time interval is obtained.

The invention and various features thereof will be fully described hereinafter, reference being had to the accompanying drawings, in which—

Fig. 1 is a top or plan view of a timing apparatus constructed in accordance with the invention;

Fig. 2 is a cross-section taken on the line 2—2, Fig. 1;

Fig. 3 is a partial cross-section taken on the line 3—3, Fig. 1;

Fig. 4 shows a strip of record material on which records of the beginning and end of a time interval have been made; and

Fig. 5 is a diagrammatic representation of the control circuit.

Referring to the drawings, it will be seen that Figs. 1, 2 and 3 are more or less conventional as regards the showing of some of the parts, although the working principles of the invention are fully shown therein. It may be remarked further that in order to simplify the drawings as much as possible certain parts fully shown in one figure are omitted from another figure in which they might be expected to appear. For example, the ratchet mechanism shown in Fig. 3 has been omitted from Fig. 1.

The various parts of the timing apparatus are supported on a frame which includes the two side plates 10 and 11, of brass or other suitable material. These side plates are secured together in spaced relation by three straight cross members or bars 12, 13 and 14, Fig. 1, and by two U-shaped members such as 15, Fig. 2. The frame parts may be secured together by means of machine screws as indicated in the drawing.

The reference character 20 indicates a rotatable shaft which has bearings in the side plates 10

and 11 of the frame. Mounted on the shaft 20 for rotation therewith is a cylinder 21, preferably of aluminum, which is provided with a spiral scanning rib 22. This scanning rib may conveniently be made of a piece of piano wire which is inserted in a groove cut in the surface of the cylinder and secured by a swaging operation. The depth of the groove is less than the diameter of the wire so that the latter projects above the surface of the cylinder. The spiral rib 22 extends from end to end of the cylinder and makes one complete turn of 360 degrees.

There are three additional shafts, indicated at 23, 26 and 29, which are similar to shaft 20 and which are similarly provided with bearings in side plates 10 and 11. The cylinders 24, 27 and 30 are mounted on shafts 23, 26 and 29, respectively, and are provided with the spiral scanning ribs 25, 28 and 31, respectively. The cylinder 27 and spiral scanning rib 28 are the same as the cylinder 21 and spiral scanning rib 22. The cylinders 24 and 30 and scanning ribs 25 and 31 are the same also, except that the spirals extend around their respective cylinders in the reverse direction.

The shaft 20 is coupled to the shaft 23 by means of a pinion 35 and gear 36. Shaft 23 drives shaft 26 by means of a pinion 37 and gear 38, while shaft 26 drives shaft 29 by means of pinion 39 and gear 40. The gear ratio in each case is 1 to 10.

The four cylinders and their scanning ribs which have been described form part of the recording mechanism, which includes also four printer bars 41, 42, 43 and 44, which are associated with the four cylinders 21, 24, 27 and 30, respectively. The arrangement of these printer bars and the means for actuating them will next be described.

The two printer bars 43 and 44 are made of stiff rod or wire, such as piano wire, for example, and are rigidly supported on two square metallic bars 49 and 50 in any suitable manner. Holes may be drilled in bars 49 and 50, for example, in which the ends of the printer bars 43 and 44 are received with a press fit. In a similar manner the bars 49 and 50 are secured to the two stiff but somewhat flexible rods 47 and 48, which in turn are secured to the two studs 45 and 46 on the inside of the frame. The parts are so assembled that the printer bars 43 and 44 are directly above the two shafts 26 and 29, respectively, and clear the spiral ribs on the associated cylinders 27 and 30 by about $\frac{1}{64}$ of an inch. Means for adjusting the printer bars relative to the cylinders

may be provided, if desired, but is not strictly necessary.

The arrangement for actuating the printer bars 43 and 44 includes the electromagnet 55 and armature 54, Fig. 2. The electromagnet 55 is supported on the member 15 of the frame, which should be made of non-magnetic material such as brass, for example, to avoid short-circuiting of the magnetic field. The armature 54 is secured to the under side of a stiff metal strip 53, which is suspended from the bars 49 and 50 by means of two adjustable pull rods 51 and 52. It will be seen that when the electromagnet 55 is energized, the resulting attraction of armature 54 is effective to depress the two printer bars 43 and 44 toward their respective cylinders 27 and 30.

The arrangement for actuating the printer bars 41 and 42 is the same as the above described arrangement for actuating printer bars 43 and 44, and includes an electromagnet 56 which is shown in the circuit drawing, Fig. 5.

The record material is a strip of paper tape 60, having lines extending parallel to the edges and dividing the width of the tape into ten equal parts. The tape 60 is carried on a supply spool 62, along with a superimposed strip of carbon paper 61. The spool 62 is rotatable on the shaft 63 against the friction produced by spring 64, the ends of which press against the heads of the spool, as shown. The shaft 63 is removable, whereby an exhausted spool of tape may readily be replaced by a fresh spool.

The tape-feeding mechanism includes the two cylinders or rollers 65 and 66. The roller 66 is just beneath the roller 65 and is shown in dotted lines in Fig. 3. The rollers are preferably made of rubber, or at least have surfaces made of rubber or other suitable friction material.

The roller 65 is mounted on the shaft 67, which is rotatably mounted on a frame comprising the side members 69 and 70 and the transverse member 71. The frame is pivoted on the cross rod 72. A spring 73 is arranged so as to press the roller 65 against the lower roller 66.

The roller 66 is mounted on the shaft 68, which is rotatable in bearings in the side plates 10 and 11. The shaft 68 may be manually rotated by means of the knurled knob 76.

The shaft 68 may also be rotated by means of a ratchet mechanism which includes the electromagnet 77, the armature 81, pawl 82, and ratchet wheel 75. The electromagnet 77 has a heel piece 78 and is supported on the frame plate 11 by means of a bracket 79. The armature 81 is pivoted on the heel piece 78 and carries an insulated contact spring 85 which is normally held in engagement with an insulated fixed contact 84 by means of the spring 80, which tends to rotate the armature on its pivot in a counter-clockwise direction. The pawl 82 is pivoted on the end of the armature 81 and is held against the ratchet wheel 75 by a spring 83. When the electromagnet 77 is energized, the armature 81 is attracted, breaking the contact at 85-84 and causing the pawl 82 to move into operative relation with the next adjacent tooth on the ratchet wheel 75. When the electromagnet 77 is deenergized, the armature 81 is retracted, contact 85-84 is again closed, and pawl 82 rotates the ratchet wheel through the angular distance of one tooth. The ratchet wheel 75 is fixed to shaft 68 and accordingly rotates the shaft and the roller 66 mounted thereon. Retrograde

movement of these parts is prevented by a spring detent 86.

The upper edges of the cross members 13 and 14 of the frame are even with or preferably slightly higher than the upper horizontal plane defined by the spiral scanning ribs on the cylinders, and function as supporting means for the record tape. The cross member 12 functions in a similar manner and in addition is arranged to provide lateral guides for the tape. At the ends the cross member 12 is flush with the side plates 10 and 11, but there is a central portion 90, equal in length to the width of the tape, where the member 12 is cut away to a sufficient depth so that the elevation of the portion 90 is the same as that of the cross members 13 and 14.

The supply spool 62 is preferably mounted low enough in the frame so that when the spool is full the record tape will be supplied from a point which is on a level with or lower than the upper edge of the cross member 14. On leaving the spool 62, the record tape and the accompanying strip of carbon paper 61 pass over the cross member 14 and between the cylinder 30 and the printer bar 44. From this point the tape and carbon paper strip pass over the cylinders 27, 24 and 21, and underneath the printer bars 43, 42 and 41, and then pass between the feed rollers 65 and 66. The tape and carbon paper strip are supported by the cross members 14, 13 and 12, as already mentioned, and are supported by the member 74 as they leave the machine at the end. The record tape and carbon paper strip are readily threaded in by hand as far as the feed rollers 65 and 66, a sufficient length of the material having first been pulled off the supply spool. The tape and strip are then inserted between the feed rollers and roller 66 is rotated by turning the knob 76, thereby taking up the slack and leaving the record tape and carbon paper strip stretched taut between the feed rollers and the supply spool.

The cylinders such as 21 are driven at constant speed by a small synchronous motor which runs on alternating current of constant frequency, the power being supplied from a standard frequency source in known manner. The motor is not shown, but the motor shaft is partly shown at 32. The motor shaft 32 is coupled to shaft 23 by means of the pinion 34 and gear 33.

In the embodiment of the invention described herein the cylinder 24 rotates at a speed of exactly 10 R. P. S., or 600 R. P. M. In order to obtain this speed, a standard frequency source having an output frequency of 60 cycles per second may conveniently be used, and the synchronous motor may be a four-pole motor running at 1800 R. P. M. The gear ratio between the motor shaft 32 and shaft 23 is 1 to 3.

As hereinbefore mentioned, the gear ratio between the cylinder shafts is 1 to 10. Accordingly, cylinder 21 rotates at a speed of 100 R. P. S., cylinder 24 at a speed of 10 R. P. S., as above stated, cylinder 27 at a speed of 1 R. P. S., and cylinder 30 at a speed of .1 R. P. S.

Referring now to Fig. 5, the reference character 90 indicates a relay which is energized momentarily at the beginning and at the end of a time interval which is to be measured. The circuit arrangements for operating relay 90 will depend on the nature of the situation or apparatus with which the time interval is concerned, and as they form no part of the present invention they are not shown herein. The reference character 91 indicates a discharge device of the

gas-filled type. A suitable device which may be used is a tube commonly known as a Thyatron. The other circuit elements are indicated in conventional manner and require no explanation. Current is supplied from a suitable source of direct current. In this connection it will be understood that the conductors labeled + and - extend to the positive and negative terminals of the direct current source.

The operation of the apparatus in measuring a time interval may now be explained. For this purpose it may be assumed that the record tape 60 and carbon paper strip 61 are extended through the apparatus in the manner previously explained, and that the cylinders 21, 24, etc. are rotating at their respective speeds, as previously stated. The discharge device 91 is non-conductive, since the control grid has a negative bias due to the connection to the negative pole of the current source through the resistor 92. The condenser 94 is in charged condition, since it is connected between ground and the positive terminal of the current source through the resistor 93.

Due to the rotation of the cylinders 21, 24, etc., the spiral scanning ribs such as 22, 25, etc. scan the record tape 60 along parallel lines which are perpendicular to the edges of the tape. These lines are imaginary lines located just beneath the printer bars and are indicated in Fig. 4 by the dotted lines 101 to 104, inclusive. The cylinders rotate in the directions shown by the arrows, and the spiral scanning ribs traverse their respective cylinders in such directions that the direction of scanning is from left to right in each case.

When the relay 90 is energized at the beginning of the time interval to be measured, it closes a circuit at contact 95 for placing a positive potential on the grid of the Thyatron tube 91. The tube 91 accordingly becomes conductive and a circuit is established over which the condenser 94 is discharged in series with the electromagnets 55 and 56. Upon the discharge of the condenser, which takes place in a very small fraction of a second, the voltage across the tube falls to such a low value that the discharge can no longer be maintained and the circuit is opened. The condenser 94 then charges up slowly in series with the high resistance 93.

By the discharge of the condenser 94 as described in the foregoing, a very short but powerful current impulse is produced, which traverses the windings of the electromagnets 55 and 56 in parallel. The electromagnets are therefore energized momentarily and the printer bars 41 to 44, inclusive, are pulled sharply downward, whereby the carbon paper strip 61 and the record tape 60 are pressed together and against the scanning ribs 22, 25, 28 and 31, and four record marks such as 121 to 124, inclusive, are made on the record tape. These marks lie on the scanning lines 101 to 104, inclusive, and their transverse positions along the respective lines depends on the instant positions of the cylinders at the time the marks are made.

When relay 90 energizes, it also closes a circuit at contact 96 for the electromagnet 77. Upon energizing, the electromagnet 77 prepares the ratchet and pawl mechanism for rotating the roller 66 and separates the contact 85 from contact 84, thus removing the positive potential from the grid of the tube 91. The object of the latter operation is to avoid any danger of a second discharge of the tube 91 in case the relay 90 should

remain energized longer than the charging time of the condenser 94. The design of the control circuits for relay 90 is thus made independent of any special consideration having to do with the proper functioning of the timing apparatus.

When relay 90 deenergizes, the contacts 95 and 96 are opened. The opening of contact 96 breaks the circuit of the electromagnet 77, which deenergizes and releases the armature 81. The retraction of the armature by spring 80 advances the ratchet wheel 75 and roller 66 one step by means of the pawl 82. Thus the record tape and carbon paper strip are automatically advanced and the scanning operations now take place along the lines 105 to 108, inclusive, Fig. 4.

When the relay 90 is energized again at the end of the time interval, the same operations as described in the foregoing are repeated. Since the operations are the same, it will not be necessary to go through the explanation in detail, but it will suffice to say that a second time record is made on the record tape 60, comprising the marks 125 to 128, inclusive. The record is made by the momentary energization of the electromagnets 55 and 56, which operate the printer bars as before.

Upon the deenergization of relay 90, the electromagnet 77 is deenergized and the record tape is automatically advanced as previously described.

The time records having been made at the beginning and end of the time interval, the operator will now rotate the knob 76, Fig. 1, in the proper direction to feed the record tape and accompanying strip of carbon paper through the machine, the operation being continued until all of the tape bearing the records has passed the member 74. The tape and strip are now torn off along the serrated edge of member 74. In order to conserve the material, the carbon paper strip is preferably marked with a pencil along the printer bar 44 before starting to feed the tape through the machine. The operator can watch the pencil mark and stop the feed as soon as the mark comes even with or slightly past the edge of member 74.

The carbon paper strip is now separated from the record tape, which exposes the latter as shown in Fig. 4. In the drawing the record tape is somewhat shortened at the top, due to lack of space. All of the records are shown, however. The manner in which the records are interpreted and the time interval is calculated will now be explained.

The record last made, corresponding to the end of the time interval, is considered first. The mark 128 was made by the printer bar 44 cooperating with the scanning rib 31 on cylinder 30. The cylinder 30 rotates at a speed of .1 R. P. S.; that is, it requires ten seconds for a complete rotation in which the record tape is scanned once. Accordingly, the ten sections into which the scanning line 108 is divided each correspond to one second of time. The transverse location of mark 128 indicates that seven whole sections had been scanned at the time the mark was made and possibly also the eighth section, since the mark touches the dividing line between the eighth and ninth sections. Whether the eighth section was completely scanned or not may be determined by inspection of the mark 127. This mark was made by the printer bar 43 cooperating with the scanning rib 28 on cylinder 27. The cylinder 27 has a speed which is ten times the speed of cylinder 30 and scans

the line 107 in one second, or while cylinder 30 is scanning only one section of line 108. The location of mark 127 in the last section of scanning line 107 shows that the scanning of the eighth section of scanning line 108 had not been completed at the time the record was made, and accordingly the mark 128 must be interpreted as representing the digit 7. It will be understood that we are concerned with whole digits corresponding to completely scanned sections, in interpreting each mark. The fraction, if any, is taken care of by the marks of lower order.

For convenience the record tape may have the digits 0 to 9 printed thereon at frequent enough intervals so that at least one set of digits will appear with each pair of time records. It will be noted that, as shown in Fig. 4, the first section is numbered 0, the second section 1, the third section 2, and so on. Each digit therefore refers to the number of sections preceding the section in which it is found. This numbering is of considerable convenience in interpreting the records, but is not absolutely essential, especially if the middle line on the record tape is made heavy, as shown.

Continuing with the explanation, it has been determined that the mark 128 corresponds to the digit 7, and this digit is accordingly written down as the first digit of the number represented by the record under consideration. Since each section on the scanning line 108 corresponds to one second of scanning time, the first digit 7 represents that many seconds; that is, it is a whole number. The location of mark 127 identifies it as representing the digit 9, which is written as the second digit of the number. Since each section on the scanning line 107 is scanned in .1 of a second, the second digit 9 represents .9 seconds of scanning time and is written in the first position to the right of the decimal point. The marks 126 and 125 obviously represent digits 2 and 6, respectively, which are written in the second and third places to the right of the decimal point, for reasons which will be clear from the foregoing explanation. The complete number corresponding to this record is therefore the number 7.926.

The record made at the beginning of the time interval is converted into a numerical expression in the same manner, and the number 3.541 is written down beneath the number derived from the record made at the end of the time interval. The digits represented by the marks 124, 123, 122 and 122 are obvious except in the case of mark 122, which is interpreted as representing the digit 4 rather than the digit 3 because of the location of the mark 121.

In order to obtain the length of the time interval, the number 3.541 is now subtracted from the number 7.926 and the difference, equal to 4.385, is the duration of the time interval in seconds. It will be seen that the result is accurate to three decimal places. It is possible, in fact, to estimate the value of the digit in the fourth decimal place, which in the case of the records shown is approximately the digit 1.

In case the number which corresponds to the record made at the end of the time interval is smaller than the number which corresponds to the record made at the beginning of the time interval, the former number must be increased by 10 before the length of the time interval is calculated. For example, the numbers corresponding to the records may be 2.456 and 8.234. Increasing the first number by 10, the number

12.456 is obtained; and subtracting from this number the number 8.234, the difference 4.222 is obtained, which is the duration of the time interval in seconds.

The apparatus shown herein is intended for use in measuring relatively short time intervals, ten seconds or less in duration. However, it may be used also to measure somewhat longer time intervals. To this end one of the teeth in the gear wheel 40 may be marked in a distinctive manner and a reference mark 99 may be stamped in the edge of frame plate 11. During the measurement of a time interval longer than ten seconds the operator observes the marked tooth and counts the number of times it passes the reference mark on the frame. The number thus ascertained is diminished by 1 and multiplied by 10, and the product is added to the result obtained by calculation of the time interval from the two time records. If desired, an ordinary type of resettable counter may be coupled to the shaft 29 to count the number of rotations of the shaft.

It will be understood also that the number of scanning cylinders may be increased, if desired. For example, five cylinders may be employed instead of four, the additional cylinder being inserted ahead of cylinder 30 and being driven at a speed of .01 R. P. S. With this modification time intervals up to 100 seconds in duration can be measured and calculated from the records made on the machine.

The invention having been described, that which is believed to be new and for which the protection of Letters Patent is desired will be pointed out in the appended claims.

We claim:

1. In combination, a strip of record material, lines extending lengthwise of said strip and dividing the surface thereof into equal spaces corresponding to the ten digits, respectively, means including a scanning device for marking said strip at a random point along an imaginary transverse line, the scanning speed being such that the digit corresponding to the space in which the mark is made represents a whole number of time units, and means including another scanning device for making a second mark on said strip at a point on a second transverse line, the scanning speed of said other device being such that the digit which corresponds to the space in which the other mark is made represents a decimal fraction of one of said time units.

2. In combination, a strip of record material, lines extending lengthwise of said strip and dividing the surface thereof into equal spaces corresponding to the ten digits, respectively, a plurality of devices for scanning said strip along separate transverse lines, marking devices co-operating with said scanning devices to mark said strip at a plurality of points, and means for driving said scanning devices at speeds such that the digit corresponding to the space in which the first mark is made is the first digit of a number constituting a time record and the digits corresponding to the spaces in which the other marks are made are the remaining digits of said number.

3. In a device for making a numerical time record comprising a plurality of digits, means including scanning devices for marking a strip of record material at points on separate transverse lines, and means for driving said devices at speeds so related that the marks correspond to the different digits in said time record, the

transverse position of each mark being indicative of the value of the corresponding digit.

4. Apparatus for measuring a time interval, comprising a plurality of scanning devices for scanning a strip of record material, means for driving said scanning devices at speeds which are related to each other as consecutive orders of digits in the decimal system, marking devices cooperating with said scanning devices to mark said strip at points on separate transverse lines, means for operating said marking devices at the beginning and the end of a time interval to make two time records on said material, and means for automatically advancing said strip during said time interval to space said records apart.

5. In a time measuring apparatus, a plurality of rotatable elements, means for rotating said elements at constant speeds which are related to each other as consecutive orders of digits in the decimal system, and means responsive to the beginning of a time interval for making a record of the instant position of said elements.

6. In a time measuring apparatus, a plurality of rotatable elements corresponding, respectively, to a plurality of orders of digits, means operated at the beginning and end of a time interval for making a record of the instant position of said elements, and means operative throughout said time interval for driving said elements at speeds proportionate to said orders of digits.

7. In a time measuring apparatus, a plurality of rotatable elements corresponding, respectively, to a plurality of digit orders in the decimal system, means operated at the beginning and end of a time interval for recording the instant position of said elements, means for ascertaining the values of the digits in the several orders from the positional records to derive numbers constituting time records, and means operative throughout said time interval for driving said elements at speeds proportionate to said digit orders, whereby the difference between said numbers is a measure of said time interval.

8. In a time measuring apparatus, a plurality of devices for scanning a strip of record material along transverse lines displaced from each other longitudinally of the strip, and means cooperating with said scanning devices to make a plurality of marks on said strip representing the digits of a number, the order of the digit corresponding to each mark being determined by the longitudinal position of the mark and the value of the digit corresponding to each mark being determined by the transverse position of the mark.

9. In combination, a plurality of devices for scanning a strip of record material on separate transverse lines, means for driving said scanning devices at constant speeds such that the scanning speed of each device except the first is ten times the scanning speed of the preceding device, marking devices cooperating with said scanning devices, respectively, to mark said strip, and means for simultaneously operating said marking devices.

10. In combination, a plurality of cylinders arranged in a row with their axes parallel to each other, each cylinder having a spiral scan-

ning rib, means for rotating one of said cylinders at constant predetermined speed, gears connecting said cylinders, the gear ratio between adjacent cylinders being one to ten, whereby a strip of record material extending across all said cylinders is adapted to be scanned by the ribs thereon along separate transverse lines and at different speeds, marking devices cooperating with said ribs, respectively, to mark said strip, and means for simultaneously actuating said marking devices.

11. In a time measuring machine, a frame, a plurality of rotatable scanning cylinders supported on said frame with their axes parallel to each other, a spool containing a strip of record material supported at one end of said frame in line with said cylinders, a pair of feed rolls at the opposite end of said frame, said strip being extended past said cylinders and between said feed rolls, means cooperating with said cylinders to mark said strip at a plurality of points, and manually operated means for operating said feed rolls to feed the marked portion of said strip through the machine.

12. In a time measuring machine, a frame, a plurality of rotatable scanning cylinders supported side by side on said frame, a spool containing a strip of record material supported at one end of said frame in line with said cylinders, a pair of feed rolls at the opposite end of said frame, said strip being extended past said cylinders and between said feed rolls, means cooperating with said cylinders to mark said strip at a plurality of points, and means for automatically rotating said feed rolls after each operation of said marking means.

13. In a time measuring machine, a constant speed element for scanning a strip of record material along a transverse line, means cooperating with said scanning element to mark said strip at a point on said line, electromagnetic means for actuating said marking means, a circuit for said electromagnetic means including a space discharge device, means normally providing a negative bias on the grid of said device, a relay for placing a positive potential on the grid of said device, and a second relay energized by said first relay for removing said positive potential within a predetermined time.

14. In a time measuring machine, a constant speed element for scanning a strip of record material along a transverse line, means cooperating with said scanning element to mark said strip at a point on said line, electromagnetic means for actuating said marking means, a circuit for said electromagnetic means including a space discharge device and a condenser, a circuit for slowly charging said condenser, means for normally maintaining a negative bias on the grid of said device, a relay for placing a positive potential on the grid of said device to discharge said condenser through said electromagnetic means, and means including a second relay energized by said first relay for removing said positive potential before said condenser can recharge.

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