

- [54] **ELECTRIC TIMEPIECE DRIVE**
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 [73] Assignee: **Engler Instrument Company**, Jersey City, N.J.
 [22] Filed: **Oct. 9, 1973**
 [21] Appl. No.: **404,174**

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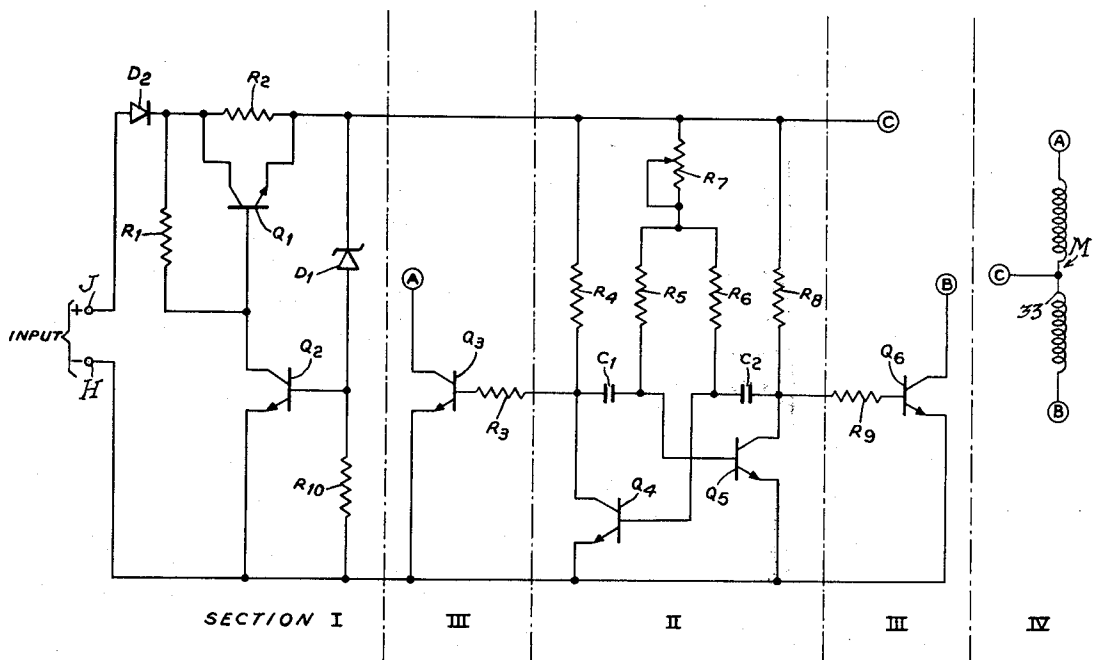
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 Attorney, Agent, or Firm—Harry B. Rook

- [52] U.S. Cl..... 58/23 A; 58/23 R; 58/23 D; 58/125 C
 [51] Int. Cl.²..... G04C 3/00; G04B 19/02
 [58] Field of Search.... 58/23 R, 23 A, 23 D, 125 B, 58/125 C, 126 E; 318/138, 171; 321/2; 323/8, 22 T; 310/162

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[57] **ABSTRACT**
 An electric drive includes a self-starting synchronous motor operable on low voltages, and a worm and spiral gear assembly and an electronic circuit for use wherever accurate timing is required, for example, in driving elapsed time hour meters, clocks and charts. An electronic circuit including a voltage regulator, an astable multivibrator and amplifiers, receives the power input at any voltage between predetermined minimum and maximum voltages, for example, from 4 to 50 volts or from 10 to 130 volts and controls the output to the voltage and frequency required for operating the motor. Means is provided to ensure that the motor shaft shall rotate in only one direction.

13 Claims, 10 Drawing Figures



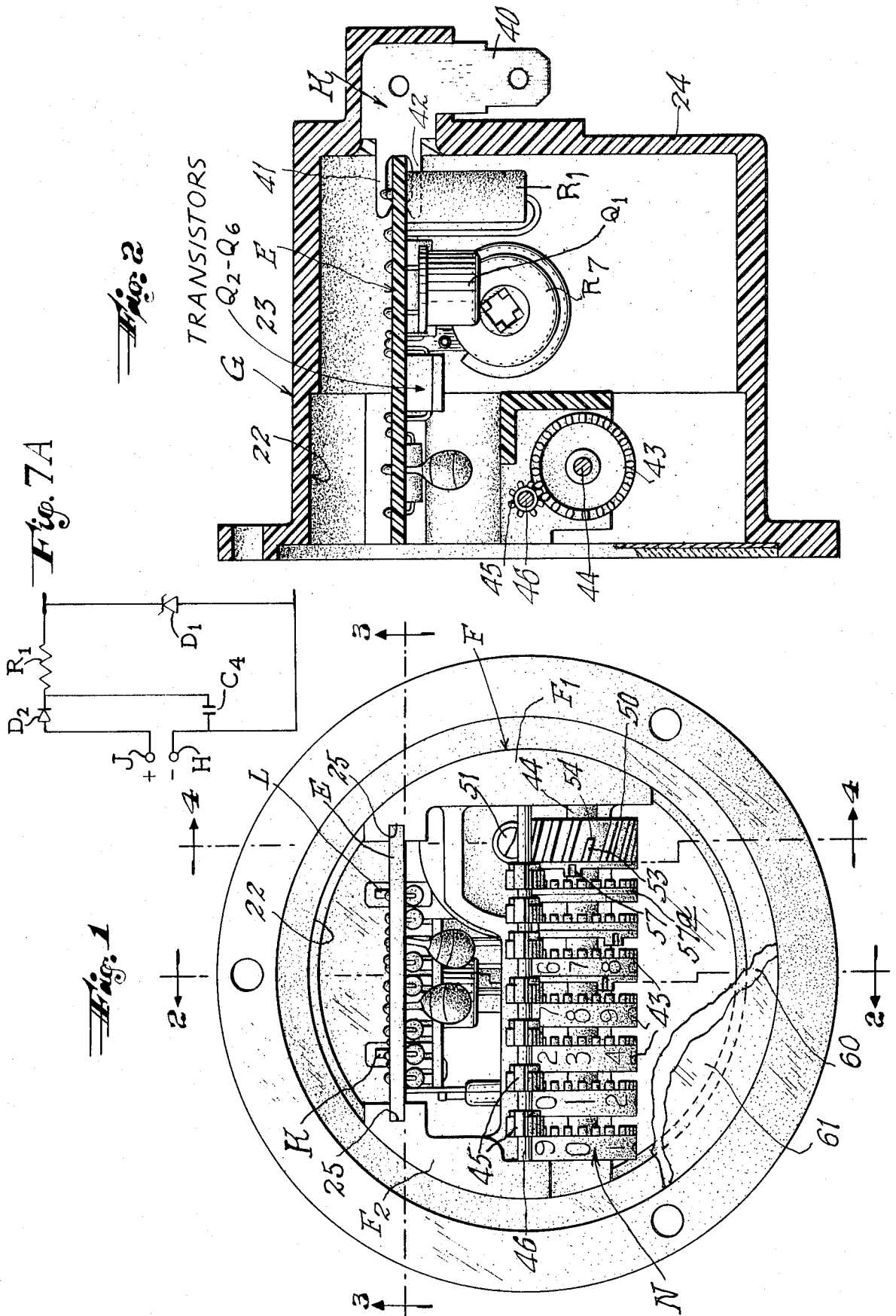


Fig. 1

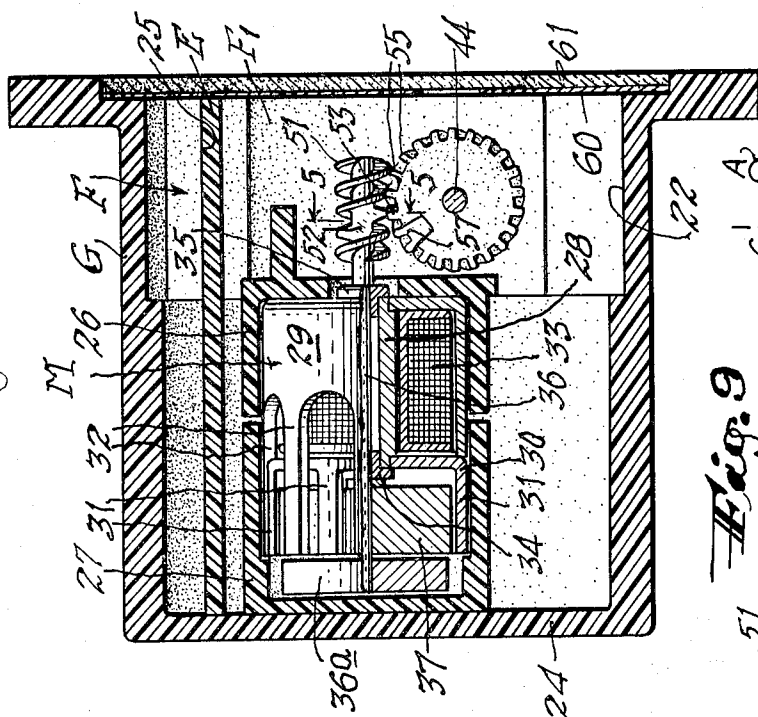


Fig. 9

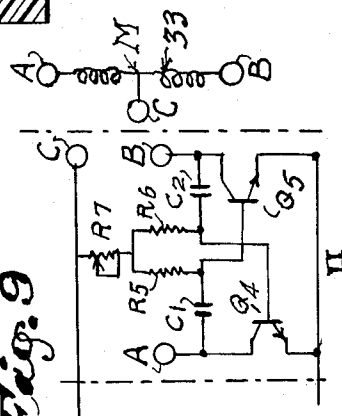


Fig. 5

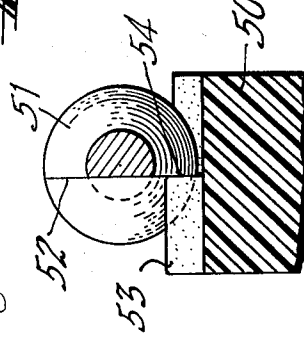


Fig. 3

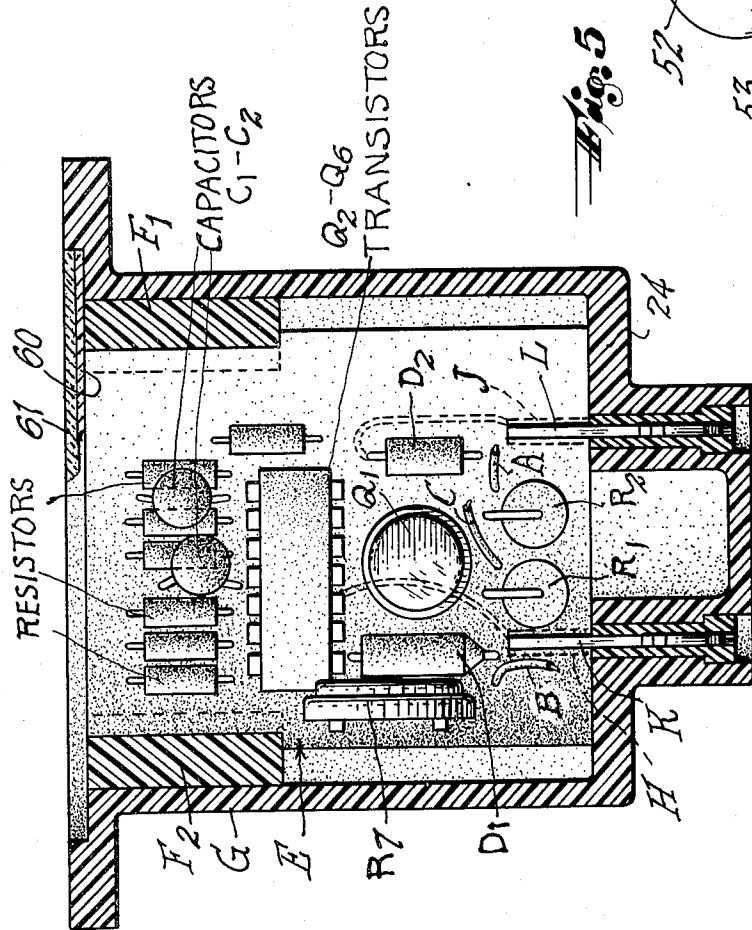


Fig. 6

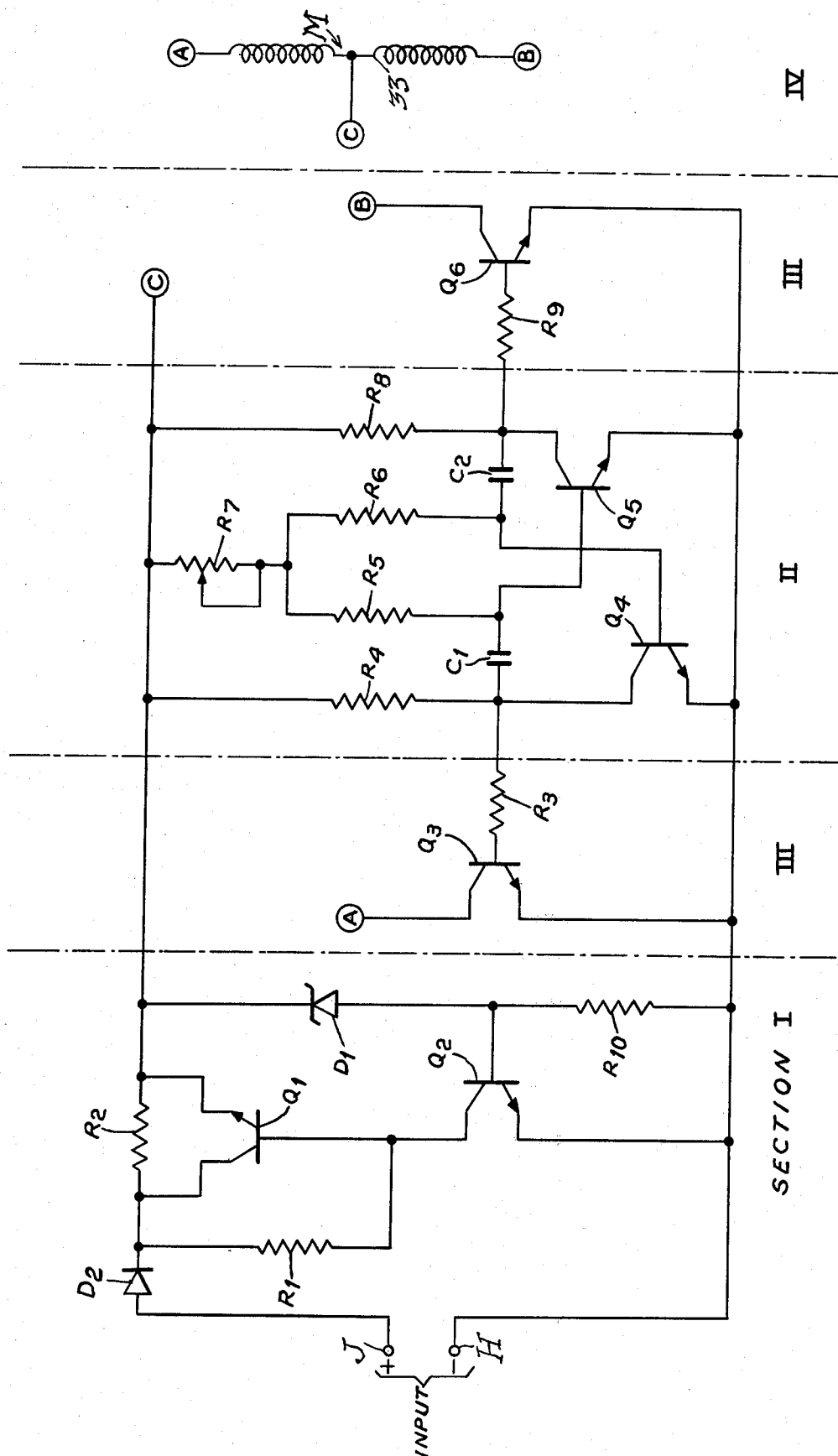


Fig. 1

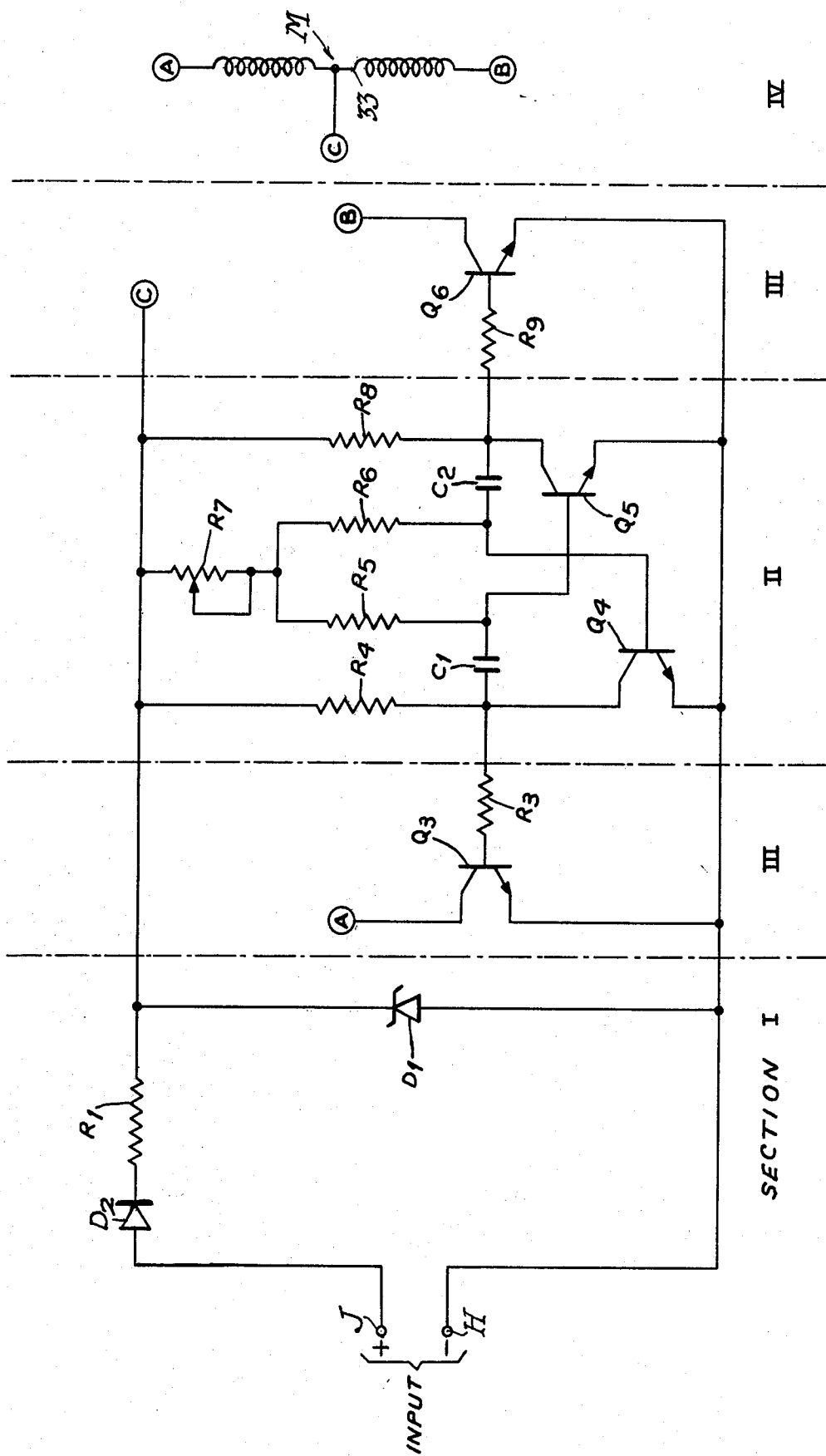
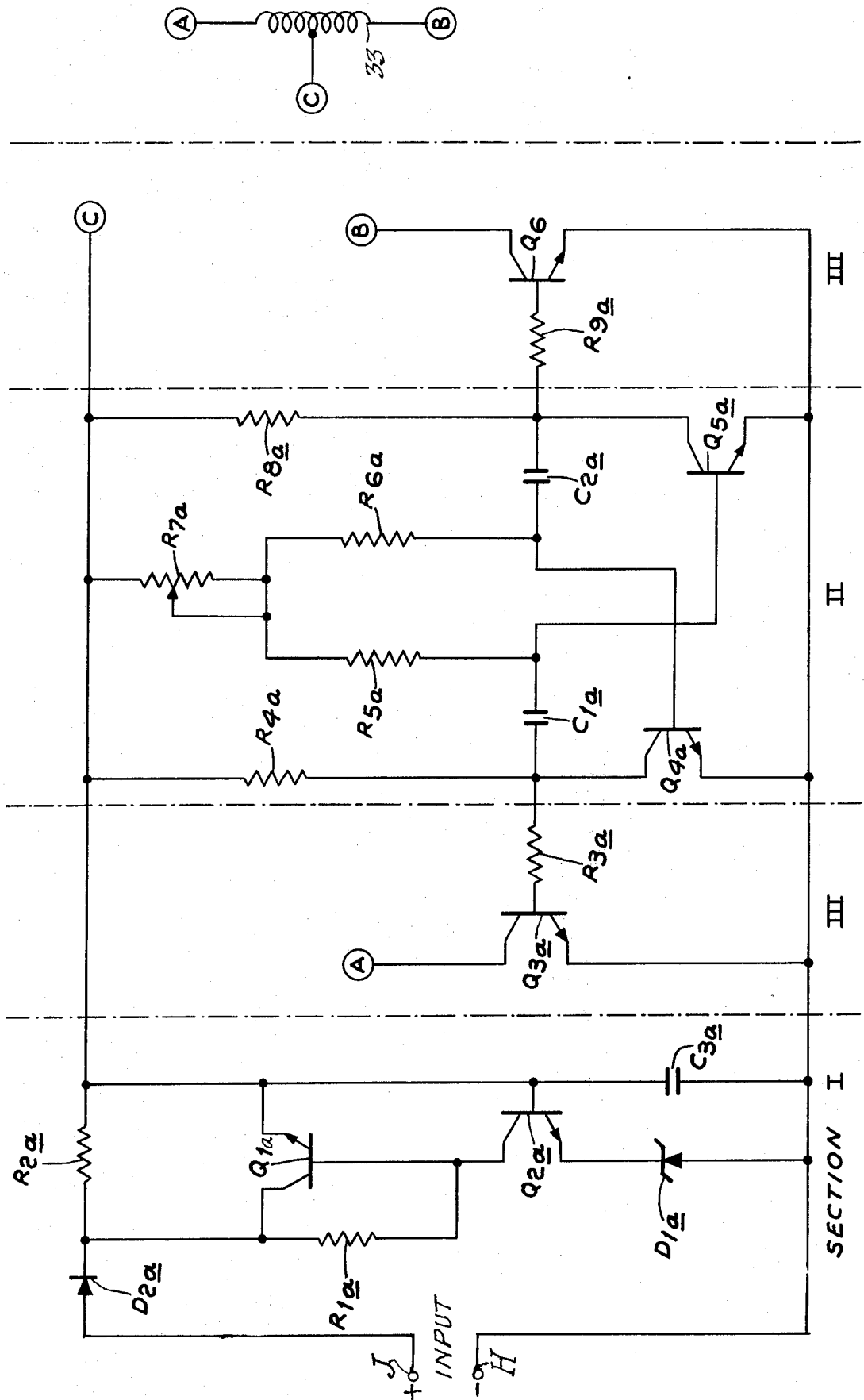


Fig. 8



ELECTRIC TIMEPIECE DRIVE**BACKGROUND OF THE INVENTION**

This invention relates to an electric drive for a timepiece, for example, a clock drive, chart recorder drive, and particularly a drive for an elapsed time hour meter, powered by a direct current source such as a battery.

The prior art discloses electric drive systems including an electronic circuit, a synchronous motor, and a gearing assembly connecting the motor to apparatus to be driven. For example, U.S. Pat. No. 3,566,600 describes an astable multivibrator used to drive a two-phase synchronous motor for timing purposes. However, one drawback is that external means is required to control the frequency of the multivibrator, which is not always available. Also, the system is designed to apply a constant voltage to the oscillator of a battery operated timepiece and only compensates for minor changes in voltage due to battery aging and therefore the electric drive cannot be operated over a wide voltage range, for example, between 4 and 50 volts, and the area of use of the system is correspondingly limited because there are many apparatus installations each operating on a different specific voltage level that may be different from that for which the system is designed.

While some of the prior art apparatus includes means for controlling the voltage, this is primarily to compensate for minor variations in voltage due, for example, to battery aging and no provision is made for operation of a device, for example, a synchronous motor, over a wide voltage range. While self-starting synchronous motors that are capable of starting in either clockwise or counter-clockwise direction are known, as are also means for preventing rotation in one direction while permitting rotation in the other direction, they leave much to be desired for a timepiece drive in that either they are not reliable, or are too complicated or too bulky or too expensive.

SUMMARY OF THE INVENTION

The prior art utilizes a mechanical balance wheel escapement movement which incorporates a main spring wound usually by an electrical solenoid and contact arrangement, and in contrast the system of the invention consists of a solid state circuit powering a synchronous motor. This system is less vulnerable to malfunction than the art because of a total lack of fragile balance wheels, springs which may change tension and electrical contacts which may arc and pit and have a limited life.

Furthermore, the system of the invention is designed to be powered by any voltage over a wide range between predetermined minimum and maximum limits of the order of 1 to 15, for example, in one embodiment from between 4 and 50 volts and in another embodiment from 10 to 130 volts direct current and may be operated at extreme temperatures and vibration. Life expectancy is indefinite and its manufacturing costs are competitive with previous art.

A primary object of the invention is to provide a novel and improved simple and relatively inexpensive electronic timepiece drive including a synchronous motor for, for example, a clock, a chart or an elapsed time hour meter, designed to operate on any direct current voltage within wide ranges, for example, in one embodiment from 4 to 50 volts, or in another embodiment from 10 to 130 volts and over a temperature

range of the order of -55°C. to $+70^{\circ}\text{C.}$ It is important that the same drive be operable over such wide voltage ranges so the same drive can be used in any of many different installations which may be adapted to supply only a specific voltage within a particular range of voltages.

It is contemplated that the invention be especially adapted to an elapsed time hour meter which has a drum type register capable of recording 10,000 hours and is also equipped with a running indicator.

In general the invention includes (1) an electronic circuit, (2) a synchronous motor, (3) a gearing assembly and (4) a time piece device to be driven, for example, said drum type register, or a clock, or a chart.

The electronic circuit can be divided into three sections (a) a voltage regulator which accepts as an input voltage any voltage between wide predetermined limits, such as 4 to 50 volts or 10 to 130 volts and controls its output to a constant voltage, (b) a temperature compensated multivibrator which controls its own frequency and whose output is a two-phase square wave signal adjusted to a specific frequency, and (c) two output amplifiers which increase the signal to the proper level for operation of the synchronous motor.

The synchronous motor consists of a bifilar wound coil, a motor housing, a stator, a core, two bearings, a shaft, a permanent magnet type rotor and a fly wheel. The rotor is magnetized with multiple poles on its circumference and is fastened to the shaft. The pole design of the rotor includes several poles that are out of symmetry with the remaining poles. This enables the motor to be self-starting. The characteristic of this motor is such that its shaft speed is directly related to the frequency of the incoming electrical current. Thus the shaft speed is directly controlled by the electronic circuit.

It is also a characteristic of this type of motor that it may rotate in either the clockwise or counter-clockwise direction. To prevent this, mechanical means is employed to prevent rotation in one direction while allowing rotation in the other.

The gearing assembly comprises a worm and spiral gear and is designed to reduce the shaft speed of the motor to a speed useful for example in registering hours. The gearing is connected to the device to be operated, for example, to the first wheel of the drum-type register.

The first three wheels of the drum register are used as a 1000 to 1 gear reduction and the first wheel is a part of the gearing assembly and also is used as a motion indicator. The remaining wheels are numbered and form the elapsed time indicator.

A BRIEF DESCRIPTION OF THE DRAWINGS

For a complete understanding of the invention, reference should be had to the following description in conjunction with the accompanying drawings in which:

FIG. 1 is a front elevational view of an elapsed time hour meter embodying the invention with the major portions of the dial plate and casing cover broken away.

FIG. 2 is a longitudinal vertical sectional view approximately on the plane of the line 2—2 of FIG. 1;

FIG. 3 is a horizontal sectional view approximately on the plane of the line 3—3 of FIG. 1;

FIG. 4 is a vertical sectional view approximately on the plane of the line 4—4 of FIG. 1;

FIG. 5 is a greatly enlarged fragmentary sectional view approximately on the plane of the line 5—5 of FIG. 4;

FIG. 6 is a diagrammatic or schematic view of the electronic circuit and the synchronous motor, illustrating one embodiment of the invention;

FIG. 7 is a similar view showing another embodiment of the invention, and

FIG. 7A is a fragmentary view illustrating a modification of the circuit shown in FIG. 7;

FIG. 8 is a like view illustrating still another modification of the electronic circuit.

FIG. 9 is a schematic view of the output side of the circuit with the amplifiers omitted.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Inasmuch as the invention is primarily concerned with electronic circuits for powering synchronous motors, the circuits will be described first schematically, after which the structural features of the invention will be described.

With reference to FIG. 6 of the drawings, section I is a voltage regulator and is comprised of resistors R₁, R₂ and R₁₀, transistors Q₁ and Q₂, and a zener diode D₁. The input to section I may be any voltage within a range between predetermined minimum and maximum limits of the order of 1 to 15 respectively, for example, from 4 volts to 50 volts, thus making it usable for the majority of battery powered devices. The output of section I is a constant voltage and is held constant independent of the input voltage. The output of Section 1 is used to power the remaining sections. R₁ and R₂ are resistors. D₁ is a voltage reference device, for example, a zener diode. R₁₀ is a resistor. Q₁ is a high voltage power transistor. Q₂ is a small signal transistor. D₂ is a series diode to prevent possible damage to the circuitry if the device were accidentally connected to the wrong polarity.

Section II is an astable multivibrator which switches the supply voltage between two out-of-phase outputs at a predetermined frequency depending upon the required motor shaft speed, for example, 24 cycles per second. The components are as follows: Q₄ and Q₅ are transistors. R₅, R₆, R₄ and R₈ are fixed resistors. R₇ is a variable resistor serving as a trimmer. C₁ and C₂ are capacitors. The circuit is well known in the art and comprises a two-stage non-sinusoidal oscillator in which one stage is allowed to conduct while the other is cut off. Capacitors C₁ and C₂ allow regenerative feedback and in cooperation with resistors R₅ and R₆ determine the frequency of operation.

Section III consists of two amplifier stages, each connected to an output of Section II. The purpose of this stage is to increase the power to a sufficient level to drive the synchronous motor generally designated M. The outputs of stage III are terminals A and B. These terminals are connected to similarly marked terminals of the motor in section IV. One amplifier consists of a transistor Q₃ and a resistor R₃. The other amplifier consists of a transistor Q₆, and a resistor R₉.

The particular connections of the components in the circuit are verbally set forth in the appended claims, and as shown in the drawings the transistors Q₂, Q₃, Q₄, Q₅ and Q₆ preferably are parts of an integrated circuit, wherefore the characteristics of all of the tran-

sistors closely match and help stabilize the frequency of the circuit, especially under changes in temperature.

In this specific embodiment, the component values preferably are:

R ₁	1.6 K	2 watt
R ₂	1.6 K	hms 2 watt
R ₃	2.7 K	" ¼ watt
R ₄	1.0 K	" ¼ watt
R ₅	5.6 K	" ¼ watt
R ₆	5.6 K	" ¼ watt
R ₇	3. K	" "
R ₈	1.0 K	" ¼ watt
R ₉	2.7 K	" ¼ watt
R ₁₀	100	" ¼ watt
C ₁	4.7 MF Capacitor	
C ₂	4.7 MF Capacitor	
Q ₁	high voltage transistor - gain amplification factor greater than 10	
Q ₂ , Q ₃ , Q ₄ , Q ₅ , Q ₆	are small signal transistors with gain amplification factor between 40 and 200	
D ₁	is a 4.2 volt zener diode.	

It may be desirable to provide for operation of the drive of the invention over other voltage ranges, for example from 10 to 130 volts. In such a case, the following would be typical circuit values for the various electrical units shown in FIG. 6:

R ₁	15 K	
R ₂	8.2K	hms Resistor
R ₃	8.2K	" "
R ₄	2.7K	" "
R ₅	10 K	" "
R ₆	10 K	" "
R ₇	5 K	" "
R ₈	2.7K	" "
R ₉	8.2K	" "
R ₁₀	100	" "
D ₁	6.2 V Zener Diode	
C ₁	2.5 MF Capacitor	
C ₂	2.5 MF Capacitor	
Q ₁	high voltage transistor	
Q ₂ , Q ₃ , Q ₄ , Q ₅ , Q ₆	are small signal transistors with gain amplification factor between 40 and 200	

For operation of this electric time piece drive circuit, when a wide voltage range is not required (i.e., power supply 11 to 14 volts) a modification of the basic circuit shown in FIG. 6 may be made as illustrated in FIG. 7. This circuit is substantially the same as the circuit shown in FIG. 6, the difference being that in Section I, the voltage regulator is greatly simplified, for example, to compensate for only minor variations in supply input voltage within a range between predetermined minimum and maximum limits of the order of 1 to 1.5. The value of R₁ is determined by the power supply voltage. A typical value for a 12 volt power supply would be 100 Ohms.

FIG. 8 illustrates another variation in the circuitry of the invention. This variation differs from the other embodiments of the invention only in Section I, the voltage regulation circuit, and this particular circuit provides for operation with a lower power level at the higher voltages than the other embodiments. The values of the electrical components such as resistors, transistors and capacitors will vary depending upon the input voltage and desired output voltage, but for the purposes of illustration the circuit here shown is designed to operate over a voltage range of 10 to 130 volts. For clarity in description the letter *a* has been added to the reference characters of FIGS. 6 and 7, for example, the reference character R_{2a} designates a com-

ponent resistor corresponding with the resistor R_2 of FIG. 6 but having a different electrical value. In this particular case the values for the various electrical components or units shown in FIG. 8 preferably are as follows:

R_{1a}	20 K Ohms
R_{2a}	15 K "
R_{3a}	8.2 K "
R_{4a}	2.7 K "
R_{5a}	6.8 K "
R_{6a}	6.8 K "
R_{7a}	5 K "
R_{8a}	2.7 K "
R_{9a}	8.2 K "
D_{1a}	6.2 V Zener Diode
C_{1a}	4.7 MF
C_{2a}	4.7 MF
C_{3a}	.02 MF
Q_{1a}	gain amplification factor greater than 10
$Q_{2a}, Q_{3a}, Q_{4a}, Q_{5a}, Q_{6a}$	gain amplification factor between 40 and 200

It will be understood that the particular component values mentioned are primarily for the purpose of illustrating the principles of the invention and that the specific values may be varied depending upon the input voltage range at the voltage regulator and the output power and frequency of the astable multivibrator in Section III desired for driving the particular synchronous motor.

As hereinbefore stated, the invention is designed for use in various types of apparatus such as elapsed time totalizing meters, chart recorder drives, clocks and wherever constant rotational speed of a motor shaft is required. For an example, the invention is here shown in an elapsed time hour meter.

Referring to FIGS. 1 to 5, inclusive, the circuit components are assembled on a small printed circuit board generally designed E, which is secured in and supported by a mounting frame F which is preferably formed of molded plastic insulating material and includes spaced apart side portions F_1 and F_2 having coaxial complemental segmentally cylindrical surfaces separably engaging an interior cylindrical surface 22 of a housing G which has a cylindrical side wall 23 and an end wall 24, all preferably molded of plastic insulating material. The circuit board is shown seated in longitudinal grooves 25 in said side portions F_1 and F_2 of the mounting frame. The mounting frame also includes a motor compartment that has a main cup-shaped portion 26 and a separable cover 27 which support and enclose between them a synchronous motor M.

The motor includes a tubular metal core 28 on one end of which is rigidly secured the bottom wall of the cup-shaped motor housing 29 while its other end has rigidly secured thereon the stator 30 which has circumferentially spaced poles 31 each disposed between two poles 32 circumferentially spaced at the free end of the housing. Within the housing and surrounding the core is a bifilar wound coil 33.

Journalled in bearings 34 and 35 at the ends of the core is the motor shaft 36 on which is rigidly mounted a permanent magnet type rotor 37 which is rotatable coaxially within the stator and relatively to the stator poles. The motor is designed to be self-starting and, as shown, the rotor is magnetized with multiple poles on its circumference and the pole design includes several poles that are out of symmetry with the remaining poles. Also mounted on the shaft is a fly-wheel 36a. The characteristic of the motor is such that its shaft

speed is directly related to the frequency of the incoming electrical current, and therefore the shaft speed is directly controlled by the electronic circuit. As shown for example in FIG. 6 the circuit board has five terminals, three, namely A, B and C for connection to the motor and two, namely H and J, for connection to the power input.

The terminals H and J are in the printed circuit and coact with terminals K and L, respectively, which are mounted in the housing G as best shown in FIGS. 1 and 2. The terminals K and L are identical in construction, each one being formed of heavy sheet metal and with two angularly related arms 40 and 41. The terminals are rigidly secured in the end wall 24 of the housing G with one arm, in the present instance, the arm 40 exposed outside the housing for connection to the power line, and the other arm 41 extending into the housing. This arm 41 has two resilient fingers 42 spaced apart to snugly frictionally receive the edge portion of the circuit board between them with at least one finger contacting the corresponding printed circuit terminal H or J as the board in the mounting frame is slid into the housing through the open end thereof. The printed circuitry can be easily and quickly connected to the power line by the terminals H, J, K and L and to the motor by the terminals A, B and C which may be constructed in any suitable known manner.

In the embodiment of the invention shown in the drawings, the motor M drives the wheels of a generally known drum type register N for an hour meter. The motor as described has the characteristic that it may rotate in either the clockwise or counter-clockwise direction, so that some means is necessary to prevent rotation in one direction while allowing rotation in the other direction so the register will be driven properly in one direction.

One simple and especially satisfactory means is described and claimed in a copending application of Walter L. Lechner, Ser. No. 404,621. As here shown, the motor drives the hour meter register by a worm and spiral gear assembly wherein the worm and spiral gear are specially constructed for coaction to achieve the desired result.

The drum type register N includes the usual number wheels 43 rotatable on a shaft 44 and transfer pinions 45 mounted on a shaft 46. Both shafts are mounted in and between the side portions of the mounting frame with their axes perpendicular to the axis of the motor shaft 36.

As stated in said application of Walter L. Lechner a special spiral gear 50 is journaled on the shaft 44 and is in mesh with and directly driven by a special worm 51 fast connected to the motor shaft 36. The worm has a portion of the screw cut away to provide a flat abutment surface in a plane parallel to but at one side of the axis as indicated at 52 (FIGS. 4 and 5), and the spiral gear has one tooth 53 cut away or formed shorter than the other teeth to provide a flat abutment surface on the tooth approximately in axial plane of the worm and intermediate with the width or thickness of the gear as indicated at 54 in FIGS. 1 and 5. Desirably, a few of the gear teeth, here three, at one side of the abutment tooth 53 are made thinner than the other teeth as indicated at 55 to provide play or looseness with respect to the worm.

With this construction, the motor and gear assembly will run freely in one desired direction, but should the

motor start to rotate in the opposite direction, the abutment surface 52 on the worm will strike, abut or contact the abutment surface 54 on the spiral gear tooth 53 as shown in FIGS. 4 and 5 so as to stop rotation in the second-mentioned direction, whereupon the motor will rotate in the desired first-mentioned direction.

The gearing assembly is designed to reduce the shaft speed of the motor to a useful speed, for example, a speed required for driving the number wheels in registering hours, and here the first three wheels are used as a 1,000 to 1 speed reduction and the first wheel is a part of the gearing assembly and also used as a motion indicator. The side of the helical gear has teeth 57 to coact with the first transfer pinion which in turn actuates the next wheel 57a, and the other wheels are actuated in known manner.

As usual a dial plate 60 having a window to expose the number wheels and a transparent cover plate 61 are provided to close the open end of the housing.

The amplifier sections or stages are included or omitted depending upon the power requirements required by the particular synchronous motor utilized in the drive. As shown by FIG. 9 of the drawing when the amplifier stage is omitted from any of the circuits shown in FIGS. 6, 7 and 8, terminals A and B of the motor M are connected to the correspondingly denoted output terminals of the multivibrator stage II while motor terminal C is connected to the correspondingly denoted terminal of the power source.

Whenever it is desirable to utilize the same electric drive of the invention with either alternating current power source of various frequencies such as 50 Hz, 60 Hz or 400 Hz, or a direct current power source, a filter circuit could be added to any of the circuits and may include a capacitor C₁ inserted between the negative input terminal H and the junction of diode D₂ and resistor R₁ of any of the circuits as illustrated in FIG. 7A.

I claim:

1. An electric timepiece drive including in combination a synchronous motor having a driving connection between the motor shaft and the timepiece mechanism, an electronic circuit including components which may be, for convenience, divided into a plurality of sections, namely first, a voltage regulator section having two terminals to receive the power input from a source at any voltage within a range between predetermined minimum and maximum voltage limits and whose output is a substantially constant voltage independent of the power input voltage, second, an astable multivibrator section to receive the output of said voltage regulator and whose outputs are two out-of-phase square wave signals at a predetermined frequency, third, two amplifier stages to receive the output of said multivibrator stage and whose output powers, fourth, a two-phase synchronous motor section:

a. said voltage regulator section being the source of power for all other sections and being constructed to operate with supply input voltage within a range between predetermined minimum and maximum limits of the order of 1 to 15 and comprising a plurality of components, namely,

1. a transistor (Q1) hereafter referred to as the first transistor which acts as a series resistance and whose collector is connected to one of the two power input terminals and whose emitter is con-

nected to one of the two outputs of the voltage regulator section,

2. A resistance (R2) connected between said collector and emitter to lessen the power dissipation of said first transistor,
3. a voltage divider comprising a resistance (R1) which is connected between the collector and base of said first transistor, and another transistor hereafter referred to as the second transistor (Q2) whose collector is connected to the base of the first transistor and whose emitter is connected to the other input terminal which also forms the other output terminal,
4. a voltage reference element (D1) connected between the emitter of the first transistor and the base of the second transistor,
5. a resistance (R10) which is connected between the base and emitter of the second transistor,
6. a diode (D2) in series with the power input terminal to protect against accidental polarity reversal;

b. said stable multivibrator section which generates a specific predetermined frequency comprising as components;

1. at least two like transistors (Q4, Q5) operating in identical common-emitter amplifier circuits, the collectors of said transistors forming the output connections,
2. capacitors (C1 and C2) each connected from the collector of one of said like transistors to the base of the other like transistor enabling regenerative feedback,
3. resistors (R4 and R8) connecting the collectors of the transistors (Q4 and Q5) respectively to the source of power,
4. resistance (R5, R6) connected from the base of each of said like transistors to one terminal of an adjustable resistance (R7) the other terminal of (R7) being connected to the source of power, these said resistances and capacitances forming an RC time constant which governs the frequency of operation of the multivibrator;

c. two amplifier sections comprising a resistance (R3) connected in series with the collector of transistor (Q4) and the base of another transistor (Q3) whose emitter is connected to the power input terminal and a resistance (R9) connected in series with the collector of (Q5) and the base of another transistor (Q6) whose emitter is connected to the power input terminal, the collectors of transistors (Q3) and (Q6) forming the output of the amplifier stages,

d. said two-phase synchronous motor section having connections to the outputs of said amplifier and power source and transducing the electrical signal outputs of said multivibrator into the mechanical form of a rotating shaft the angular rate of which is controlled by the frequency of the output of the said amplifier.

2. A timepiece drive according to claim 1 wherein said synchronous motor is constructed of the self-starting type.

3. An electric timepiece drive according to claim 1, the voltage regulator of whose circuit is constructed to compensate only for minor variations in supply input voltage within a range between predetermined minimum and maximum limits of the order of 1 to 1.5.

4. An electric timepiece drive according to claim 1 the voltage regulator of whose circuit is constructed to operate with supply input voltage within a range between predetermined minimum and maximum limits of the order of 1 to 15.

5. An electric timepiece drive as defined in claim 4 whose component values are such as to enable operation of the timepiece drive over a voltage range of 4 to 50 volts.

6. An electronic timepiece drive as defined in claim 4 whose component values are such as to enable operation of the timepiece drive over a voltage range of 10 to 130 volts.

7. An electric timepiece drive as defined in claim 1 wherein the component values are such as to enable operation of the timepiece drive over a voltage range of four to fifty volts and are of the order of:

resistor	R ₁	1.6 K Ohms	2 watt
resistor	R ₂	1.6 K Ohms	2 watt
resistor	R ₃	2.7 K Ohms	¼ watt
resistor	R ₄	1.0 K Ohms	¼ watt
resistor	R ₅	5.6 K Ohms	¼ watt
resistor	R ₆	5.6 K Ohms	¼ watt
resistor	R ₇	3. K Ohms	
resistor	R ₈	1.0 K Ohms	¼ watt
resistor	R ₉	2.7 K Ohms	¼ watt
resistor	R ₁₀	100 Ohms	¼ watt
capacitor	C ₁	4.7 MF	
capacitor	C ₂	4.7 MF	
transistor	Q ₁	high voltage transistor - gain amplification factor greater than 10	
transistors Q ₂ , Q ₃ , Q ₄ , Q ₅ , Q ₆ are small signal transistors with gain amplification factor between 40 and 200 in an integrated circuit.			
Zener diode D ₁ is a 4.2 volt.			

8. An electric timepiece drive as defined in claim 1 wherein the driving connection between the motor and the timepiece mechanism comprises a frame on which the motor is mounted, a worm on the motor shaft, a spiral gear meshing with said worm and mounted to rotate on a support that is fixed with respect to said motor, there being mechanical means to prevent rotation of said shaft in one direction while permitting rotation in the opposite direction, said spiral gear is mounted on a secondary shaft and said timepiece mechanism comprises a drum type register including number wheels and speed reduction wheels mounted on said secondary shaft and the usual transfer pinions, and said spiral gear and one of said transfer wheels have coacting parts providing said driving connection between the motor and the timepiece mechanism.

9. An electric timepiece drive including in combination a synchronous motor having a driving connection between the motor shaft and the timepiece mechanism, an electronic circuit including components which may be, for convenience, divided into a plurality of sections, namely first, a voltage regulator section having two terminals to receive the power input from a source at any voltage within a range between predetermined minimum and maximum voltage limits and whose output is a substantially constant voltage independent of the power input voltage, second, an astable multivibrator section to receive the output of said voltage regulator and whose outputs are two out-of-phase square wave signals at a predetermined frequency, and, third, two amplifier stages to receive the outputs of said multivibrator stage and whose output powers a fourth stage consisting of a two-phase synchronous motor;

a. said voltage regulator section being the source of power for all other sections and being constructed

to operate with supply input voltage within a range between predetermined minimum and maximum limits of the order of 1 to 15 and comprising a plurality of components, namely,

1. at least two transistors, at least one of which, hereafter referred to as the first transistor (Q1a), acts as a series resistance and whose collector is connected to one of the two power input terminals and whose emitter is connected to one of the two outputs of the voltage regulation stage,
2. a resistance (R2a) connected between said collector and emitter to lessen the power dissipation of said first transistor,
3. a voltage divider comprising a resistance, (R1a) which is connected between the collector and base of said first transistor and another transistor, hereafter referred to as the second transistor (Q2a) whose collector is connected to the base of the first transistor and whose base is connected to the emitter of the first transistor,
4. a voltage reference element (D1a) connected between the emitter of the second transistor and to the other input terminal which also forms the other output terminal,
5. a capacitance (C3a) connected between the base and emitter of the second transistor by said voltage reference element (D1a) which will prevent spontaneous oscillation of the voltage regulation stage,
6. a diode (D2a) in series with the power input terminal to protect against accidental polarity reversal,
- b. said astable multivibrator section which generates a specific predetermined frequency comprising
 1. at least two like transistors (Q4a, Q5a) operating in identical common-emitter amplifier circuits, the collectors of said transistors forming the output connections,
 2. capacitors (C1a, C2a) each connected from the collector of one of said like transistors to the base of the other like transistor enabling regenerative feedback,
 3. resistors (R6a, R5a) each connected from the base of one of the transistors to one terminal of a variable resistance (R7a), these said resistances and capacitances forming an RC time constant which governs the frequency of operation of the multivibrator, the other terminal of resistance (R7a) being connected to the source of power,
- c. two amplifier sections comprised of a resistance (R3a) connected in a series with the collector of transistor (Q4a) and the base of another transistor (Q3a) whose emitter is connected to the power input terminal and resistance (R9a) connected in series with the collector of transistor (Q5a) and the base of another transistor (Q6a) whose emitter is connected to the power input terminal, the collectors of transistors (Q3a) and (Q6a) forming the output of the amplifier stages,
- d. said two-phase synchronous motor section having connections to the outputs of said amplifier and power source and transducing the electrical signal outputs of said multivibrator into the mechanical form of a rotating shaft the angular rate of which is controlled by the frequency of the output of said amplifier.

10. An electric timepiece drive as defined in claim 9 wherein the component values are such as to enable operation of the timepiece drive over a voltage range of 10 to 130 volts and are of the order of:

resistor	R _{1a}	20	K Ohms
resistor	R _{2a}	15	K Ohms
resistor	R _{3a}	8.2	K Ohms
resistor	R _{4a}	2.7	K Ohms
resistor	R _{5a}	6.8	K Ohms
resistor	R _{6a}	6.8	K Ohms
resistor	R _{7a}	5	K Ohms
resistor	R _{8a}	2.7	K Ohms
resistor	R _{9a}	8.2	K Ohms
Zener diode	D _{1a}	6.2	V
Capacitor	C _{1a}	4.7	MF
Capacitor	C _{2a}	4.7	MF
Capacitor	C _{3a}	.02	MF
transistor	Q _{1a}	gain amplification factor greater than 10.	
transistors	Q ₂ , Q ₃ , Q _{4a} , Q _{5a} , Q _{6a}	gain amplification factor between 40 and 200.	

11. An electric timepiece drive including in combination a synchronous motor having a driving connection between the motor shaft and the timepiece mechanism, an electronic circuit including components which may be, for convenience, divided into a plurality of sections, namely first, voltage regulator section having two terminals to receive the power input from a source at any voltage within a range between predetermined minimum and maximum voltage limits and whose output is a substantially constant voltage independent of the power input voltage, second, an astable multivibrator section to receive the output of said voltage regulator and whose outputs are two out-of-phase square wave signals at a predetermined frequency, and, third, two amplifier stages to receive the outputs of said multivibrator stage and whose output powers a fourth stage consisting of a two-phase synchronous motor:

a. said voltage regulator section being the source of power for all other sections and being constructed to operate with supply input voltage within a range between predetermined minimum and maximum limits of the order of 1 to 1.5 and comprising a plurality of components, namely,

1. a resistance (R₁) in series with a diode (D₂) and one of the two power input terminals,
2. a voltage reference element (D₁) which is connected in series between said resistance and the other input power terminals which also forms one of the two output power terminals, the other output power terminal being formed at the junction of the said series resistance and said voltage reference element,

3. a diode (D₂) in series with the positive power input terminal to protect against accidental polarity reversal,

b. said astable multivibrator section which generates a specific predetermined frequency comprising:

1. at least two like transistors (Q₄, Q₅) operating in identical common-emitter amplifier circuits, the

collectors of said transistors forming the output connections,

2. capacitors (C₁, C₂) each connected from the collector of one of said like transistors to the base of the other transistor enabling regenerative feedback,

3. resistances (R₄ and R₈) connected from the collectors of transistors (Q₄) and (Q₅) respectively to the source of power,

4. resistances (R₅, R₆) connected from the base of each of said like transistors to one terminal of resistances (R₇) connected to the source of power, these said resistances and capacitances forming an RC time constant which governs the frequency of the operation of the multivibrator,

c. two amplifier sections comprising a resistance (R₃) connected in series with the collector of transistor (Q₄) and the base of another transistor (Q₃) whose emitter is connected to the power input terminal and resistance (R₉) connected in series with the collector of transistor (Q₅) and the base of another transistor (Q₆) whose emitter is connected to the power input terminal, the collector of transistors (Q₃) and (Q₆) forming the output of the amplifier stages.

d. said two-phase synchronous motor section having connections to the outputs of said amplifier and power source and transducing the electrical signal outputs of said multivibrator into the mechanical form of a rotating shaft the angular rate of which is controlled by the frequency of the output of said amplifier.

12. An electric timepiece as defined in claim 11 wherein the component values are such as to enable operation of the timepiece drive over a voltage range of eleven to fourteen volts and are of the order of:

Resistance	R ₁	100 ohms
Resistance	R ₃	2.7K ohms
Resistance	R ₄	1.0K ohms
Resistance	R ₅	5.6K ohms
Resistance	R ₆	5.6K ohms
Resistance	R ₇	3.0K ohms (variable)
Resistance	R ₈	1.0K ohms
Resistance	R ₉	2.7K ohms
Zener Diode	D ₁	4.2 volt
Capacitor	C ₁	4.7 MF
Capacitor	C ₂	4.7 MF
Transistor Q ₃ , Q ₄ , Q ₅ , Q ₆ small signal transistors with gain amplification factor between 40 & 200.		

13. A timepiece drive as described in claim 11 wherein a filter circuit between the said resistance (R₁), said diode (D₂), and said one of the two power input terminals is provided in the voltage regulator circuit providing for operation of the same timepiece drive when powered by either direct current or alternating current of various frequencies.

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