United States Patent

[15] 3,676,993
[45] July 18, 1972

Bergey et at.

[54] ELECTRONIC WATCH
[72] Inventors: John M. Bergey; James 0. Le Van; Richard S Walton, all of Lancaster; Louis G. Brethauer, Landisville, all of Pa.
[73] Assignee: Hamilton Watch Company, Lancaster, Pa.
[22] Filed: Aug. 13, 1970
[21] Appl. No.: 63,390
[521 U.S.CI 58/23,58/28B
[51] Int.Cl G04c3/04
[58) Field of Search 58/23,28,34,85.5

[56] References Cited

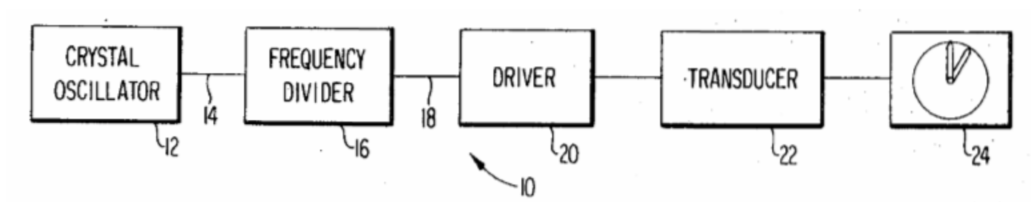
UN1TED STATES PATENTS

3,212,252 10/1965	Nakai	58/23 R
3,526,088 9/1970	Meitinger	58/23 BA

Primary Examiner —Richard B. Wilkinson
Assistant Examiner —Edith C. Simmons
Attorney —Le Blanc & Shur

[57] ABSTRACT
Disclosed is an electronic wristwatch in which a crystal oscillator drives an electromechanical resonator tuned to the oscillator output. The high frequency oscillator is connected through an integrated circuit divider and driver to the resonator coil so that the coil oscillations are slaved to the frequency of the divider output. A lever, rotatable on an eccentric forming a part of the resonator staff, drives an index wheel, in turn connected through a gear train to the watch hands. Provision is made for rapid calendar setting, automatic calendar drive and an on-oft switch breaks the electronic circuit from a 3 volt battery in the watch when the setting arbor is moved to the off position.

27 Claims, 55 Drawing Figures



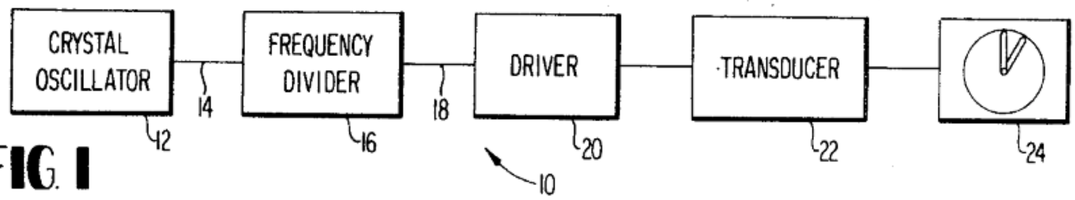


FIG. 1

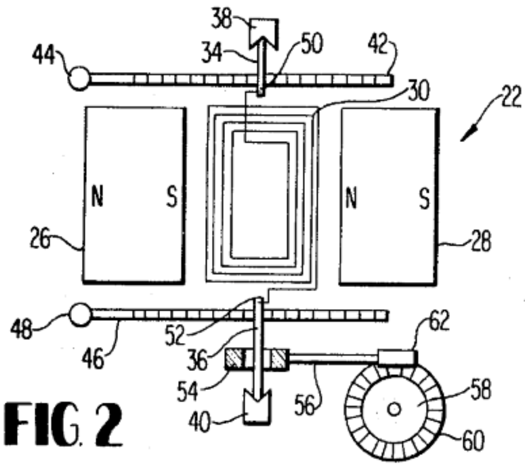


FIG. 2

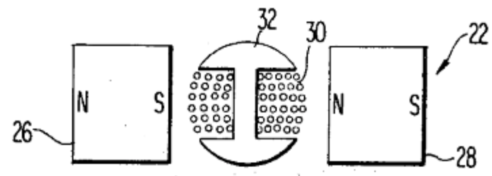


FIG. 3

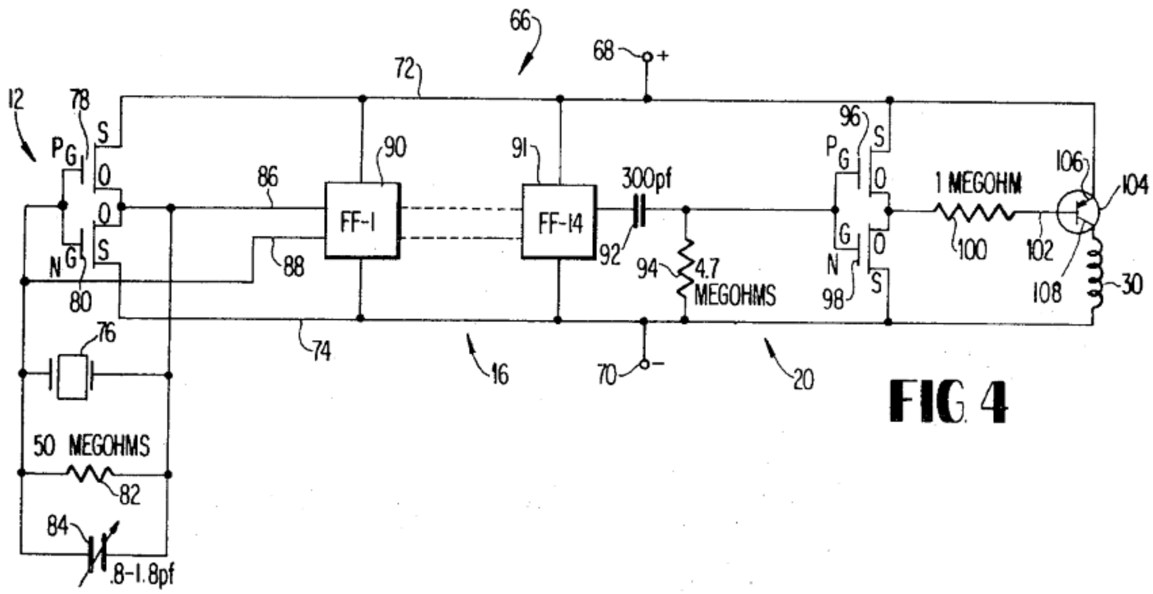


FIG. 4

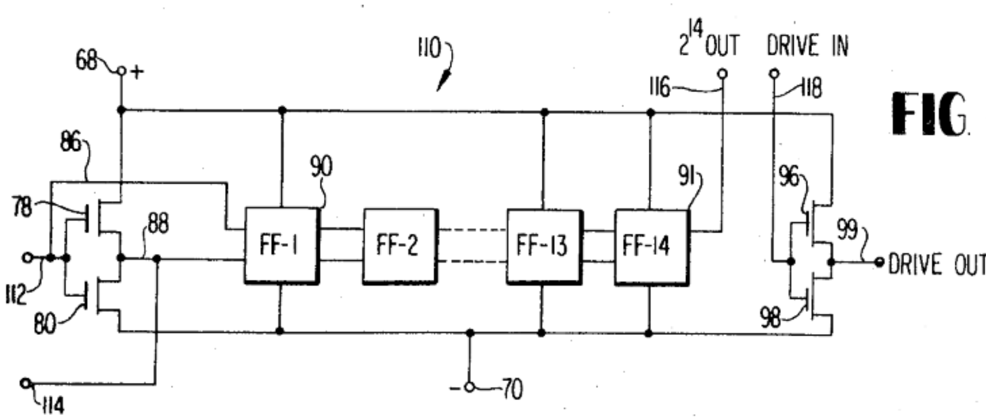


FIG. 4A

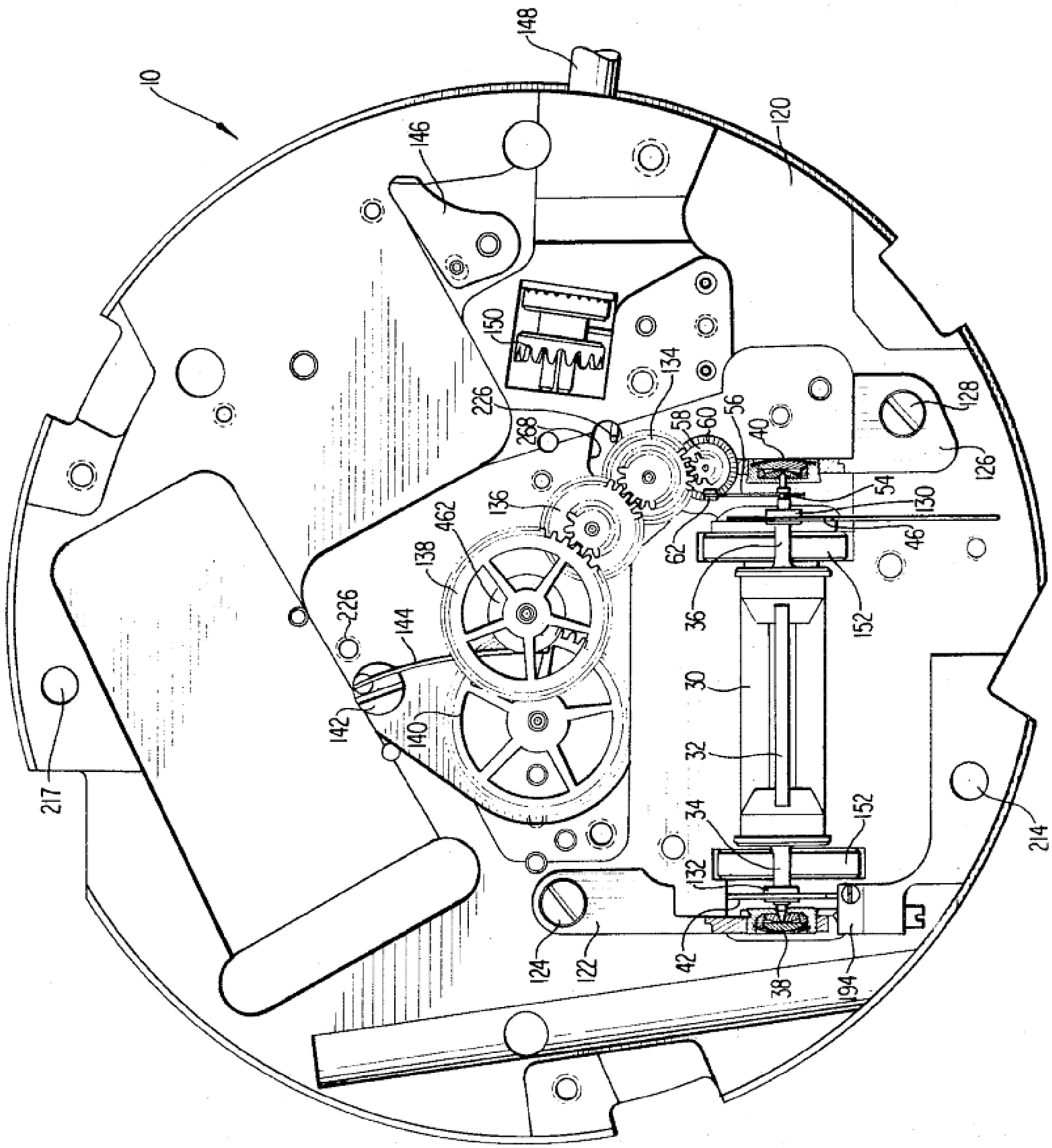

10
148
120
146
150
134
226
268
58
60
56
40
128
126
54
130
46
62
136
462
138
36
152
226
144
30
32
142
140
34
152
132
217
124
122
42
38
94
214

FIG. 5

PATENTED JUL 18 1972 3,676,993

SHEET 03 OF 15

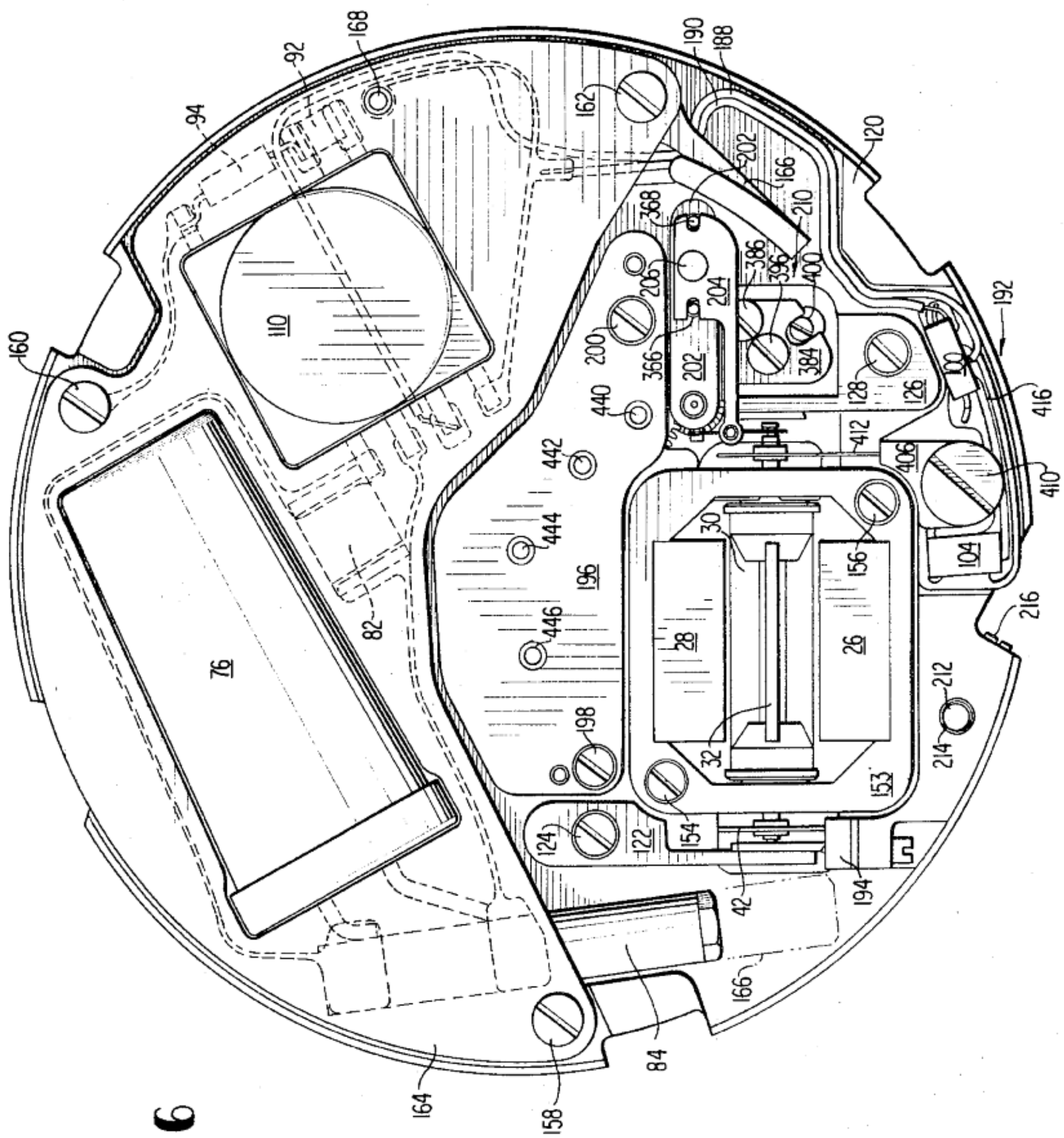


FIG 6

PATENTED JUL 18 1972

3,676,993

SHEET 04 OF 15

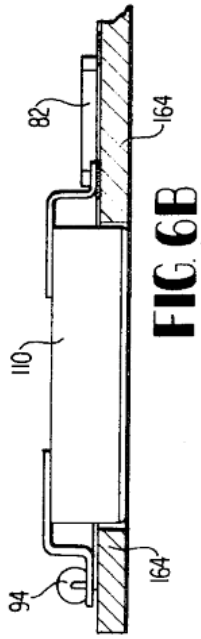


FIG 6B

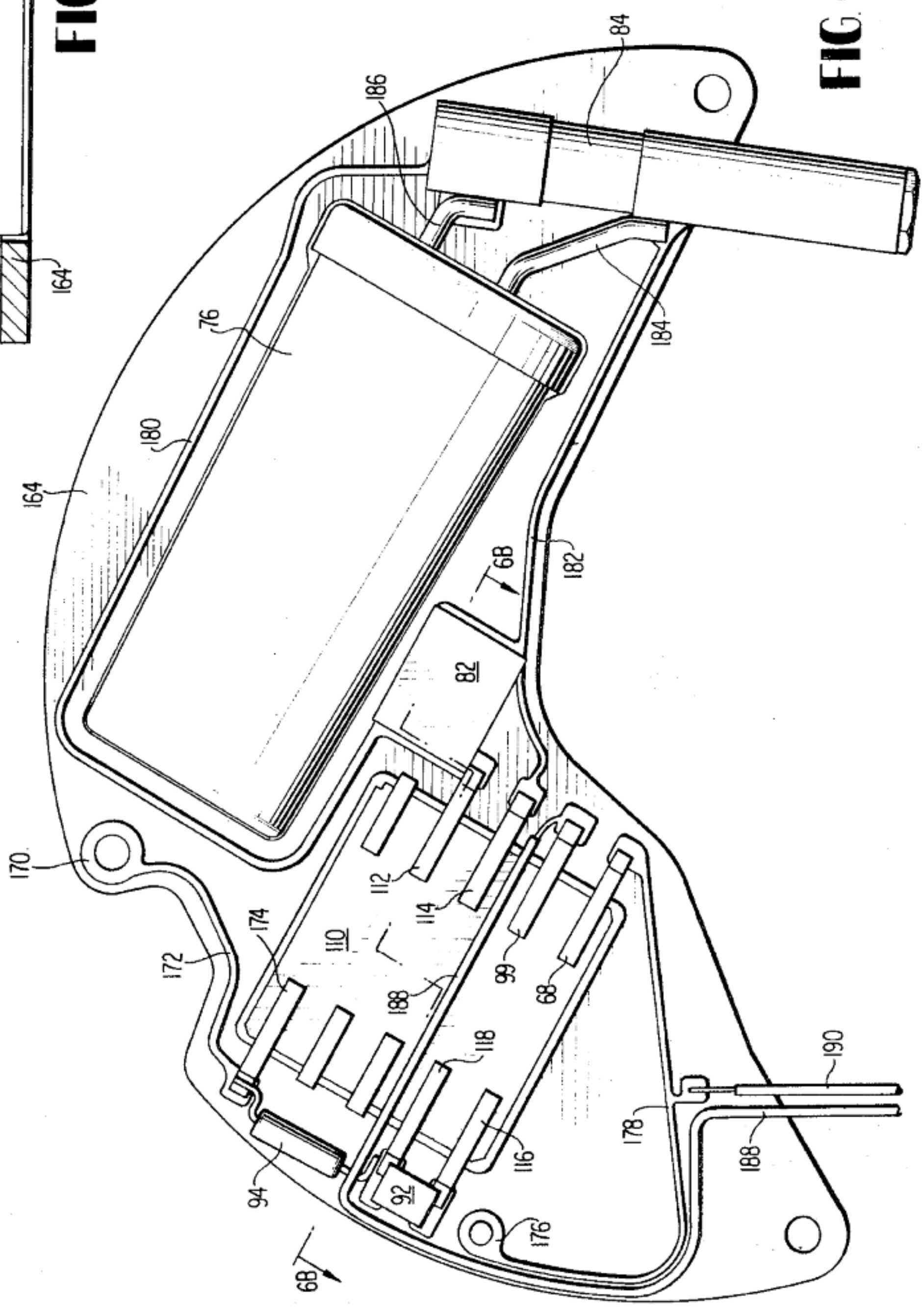


FIG 6A

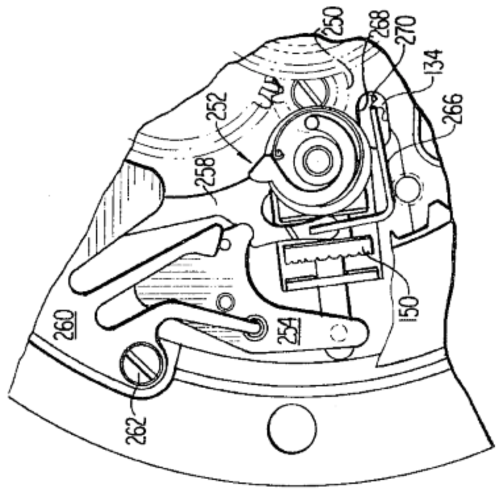

250
268
270
134
266
252
258
150
254
260
262

FIG 8

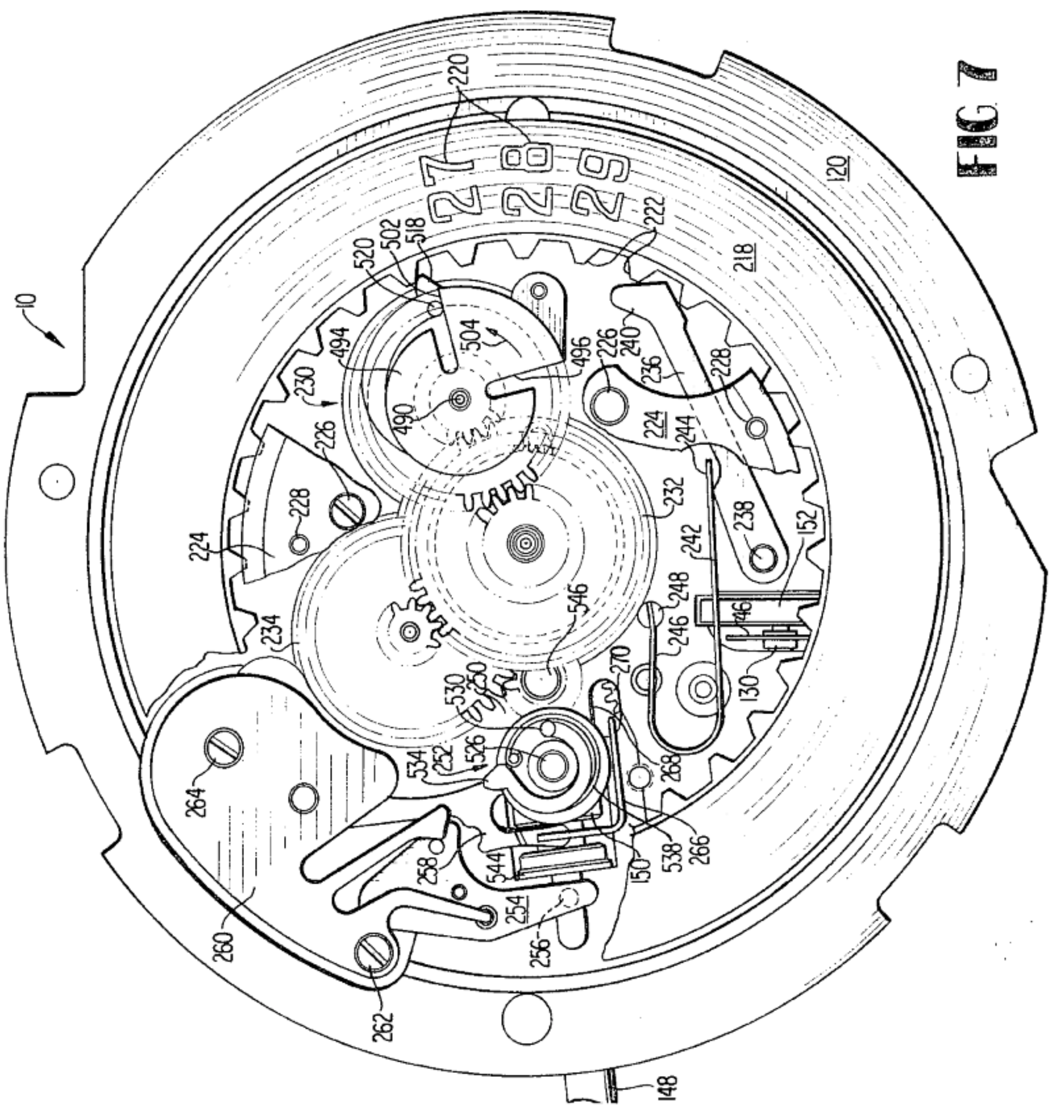

10
220
27
28
29
120
218
222
502
518
520
494
504
496
226
240
236
228
230
490
224
244
232
238
152
242
248
246
146
130
546
234
270
530
250
526
534
252
268
264
258
544
150
538
266
254
256
260
262
148

FIG 7

Back to Accutrons.com Back to Patents Page

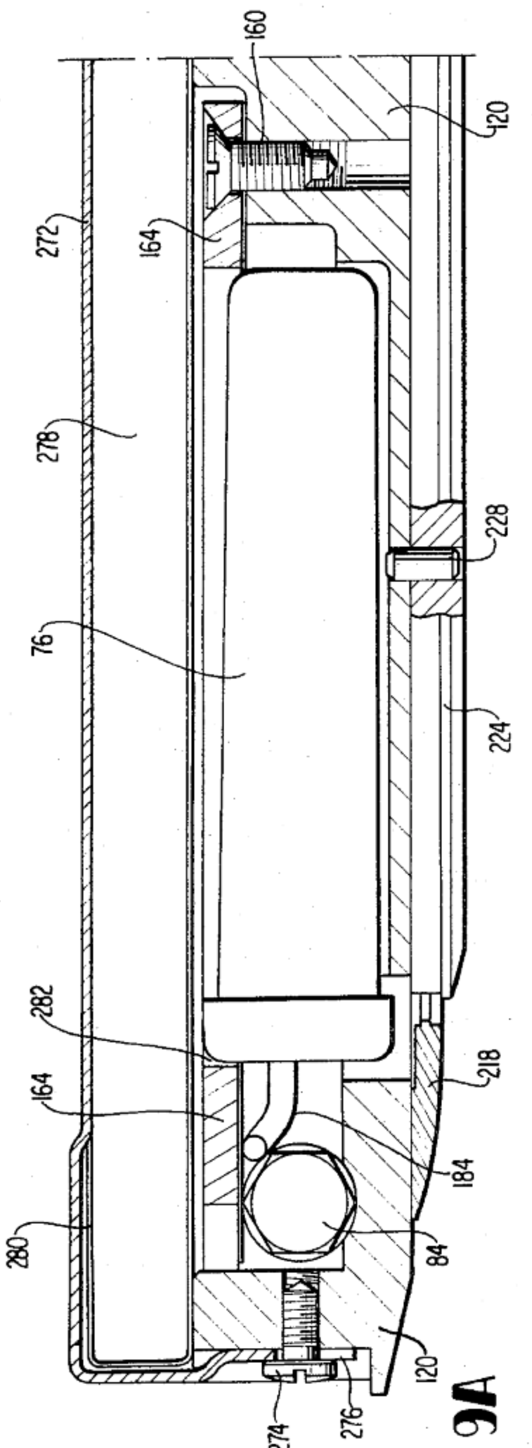


FIG 9A

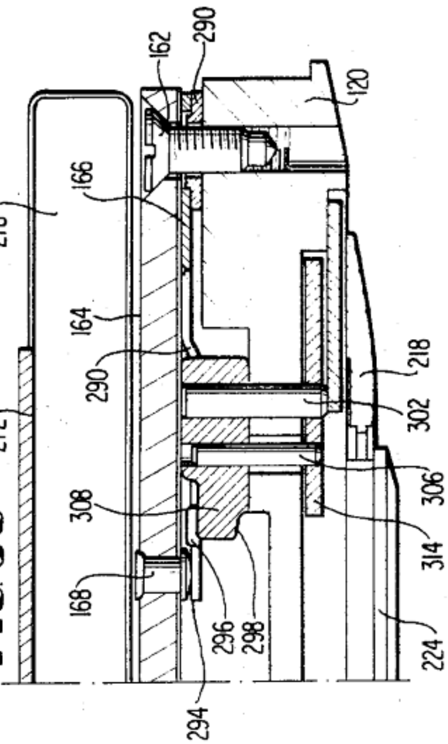


FIG 9C

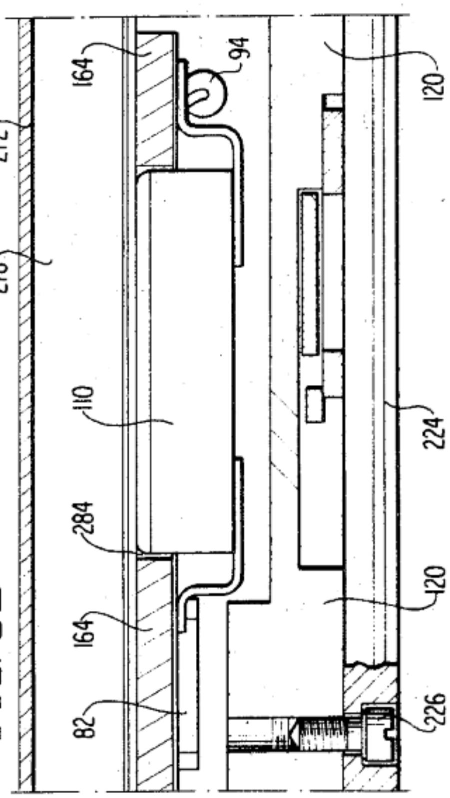


FIG 9B

Back to Accutrons.com

Back to Patents Page

FIG 10B

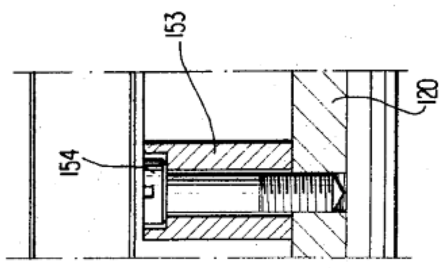


FIG 10A

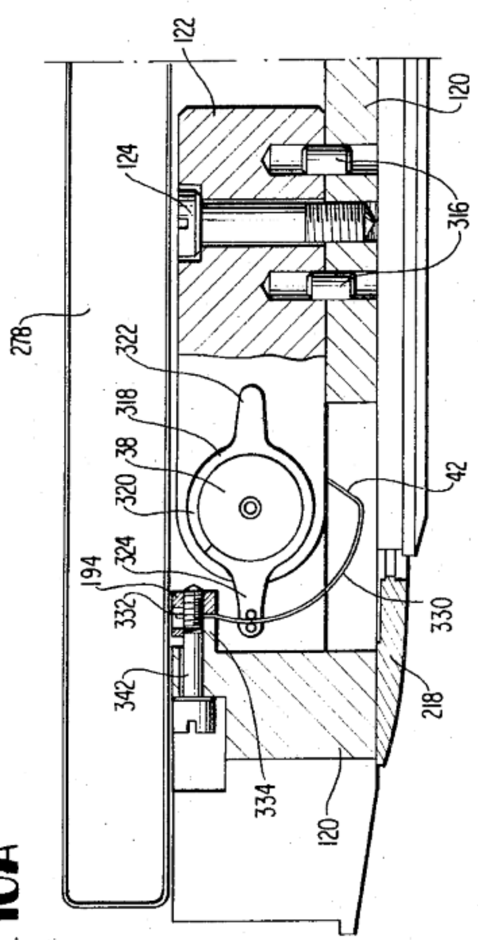


FIG 10D

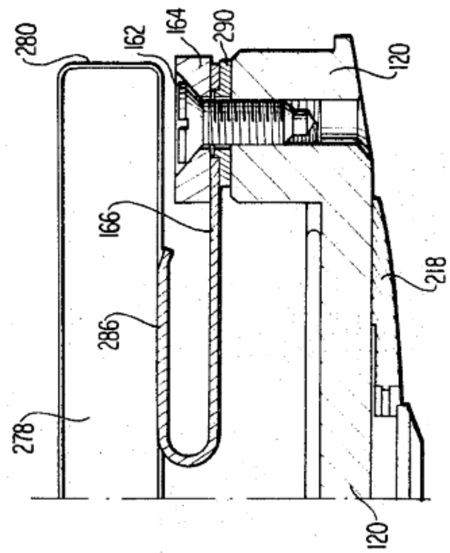
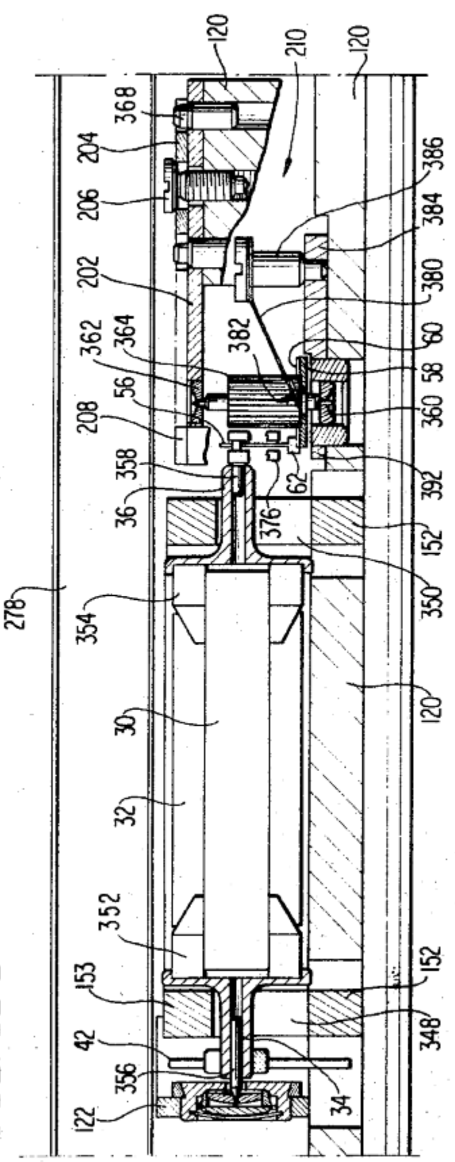


FIG 10C



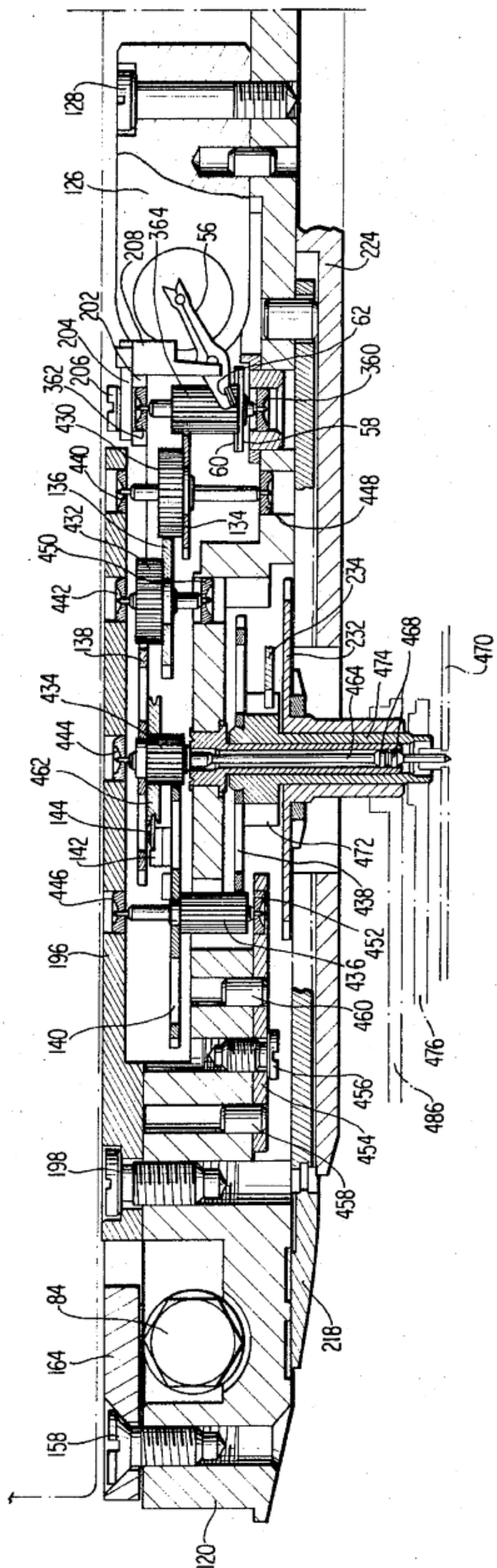


FIG IIIA

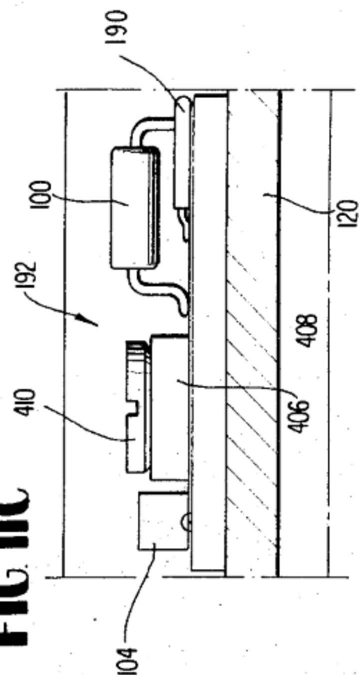


FIG IIIC

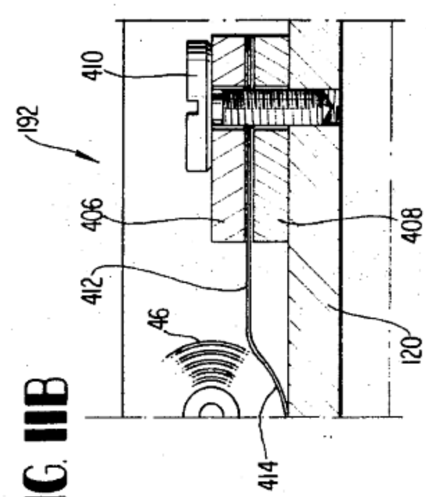


FIG IIIB

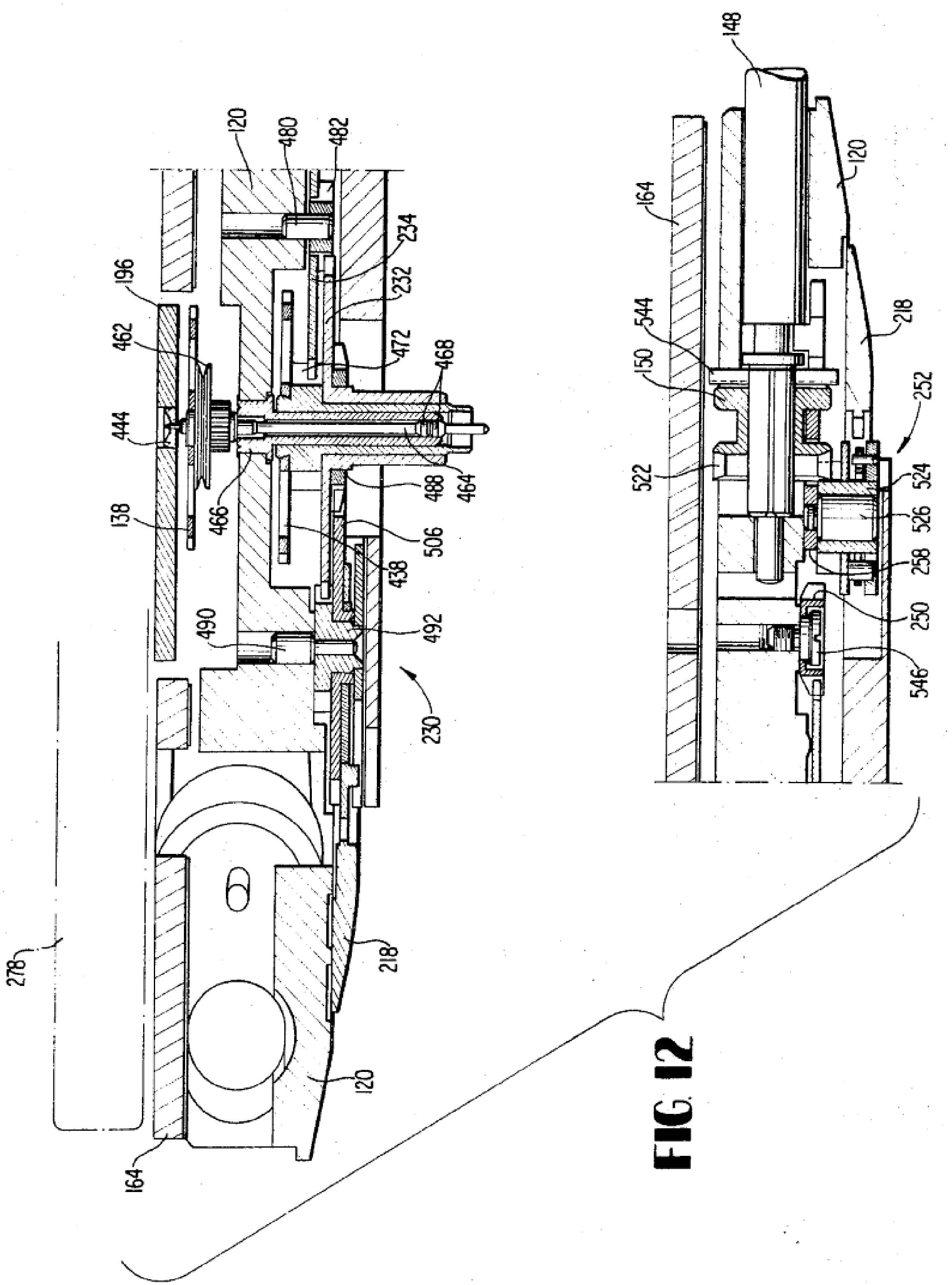
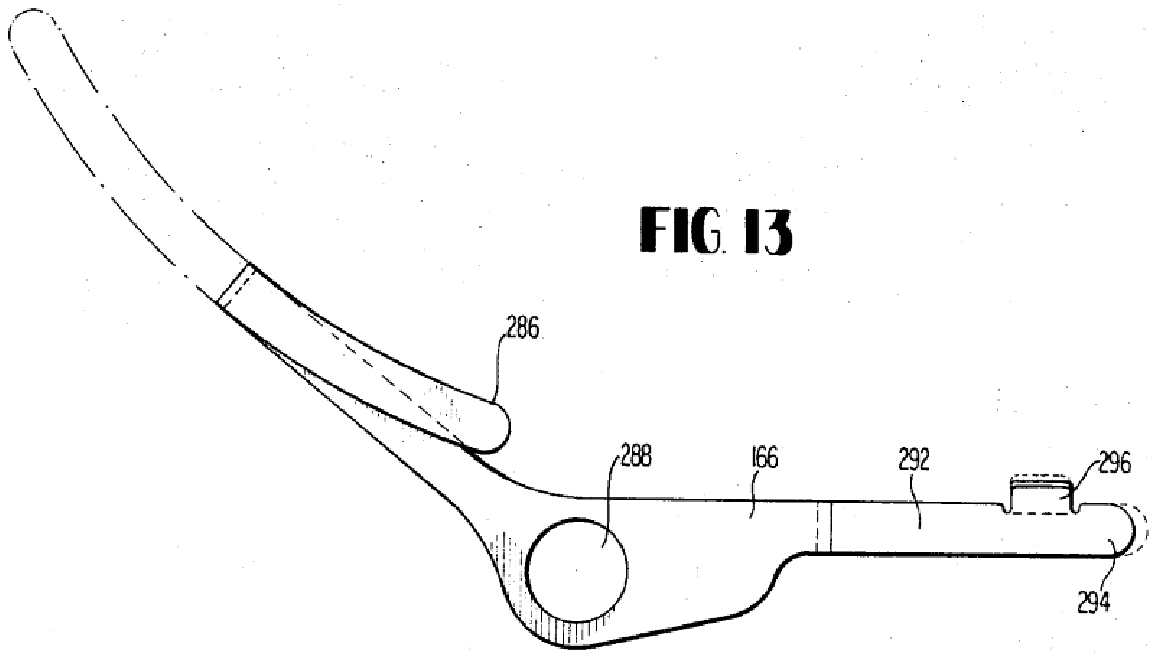

120
480
482
234
232
472
468
464
488
506
438
492
230
196
462
444
138
466
490
278
218
120
164
148
120
164
218
544
150
252
522
524
526
258
250
546

FIG 12

FIG. 13



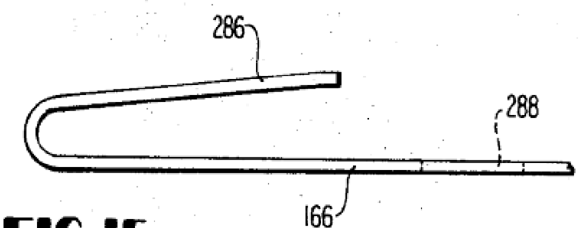


FIG. 15

FIG. 14

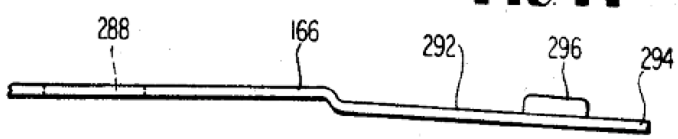


FIG. 16

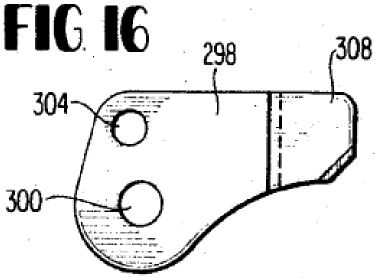
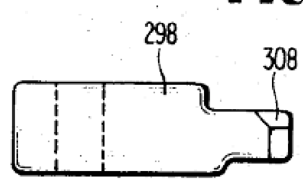


FIG. 17



Back to Accutrons.com Back to Patents Page

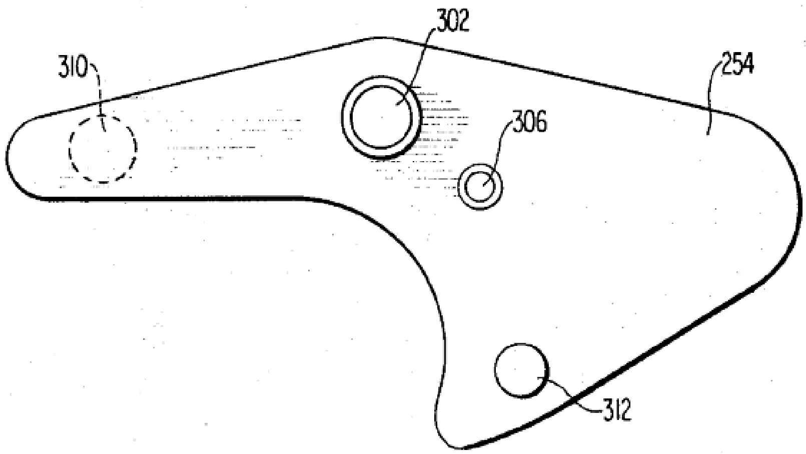


FIG. 18

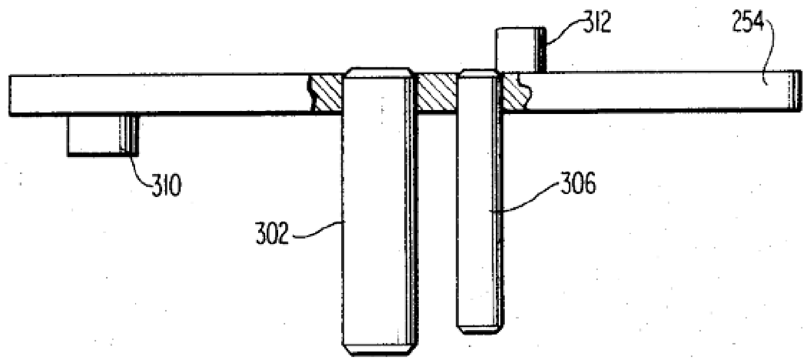


FIG. 19

FIG. 20

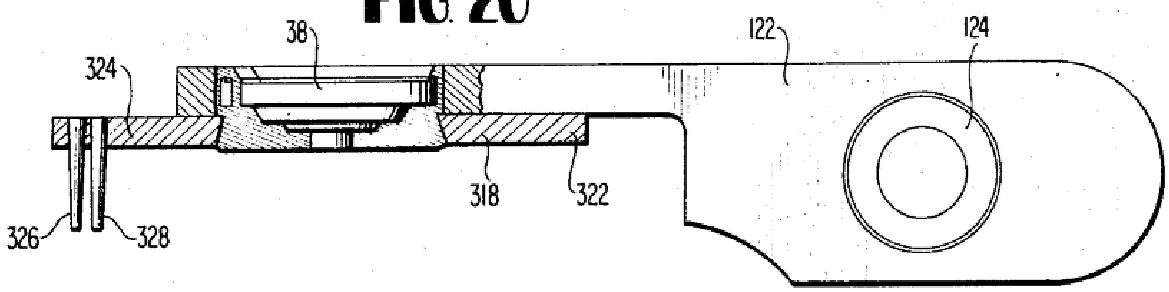
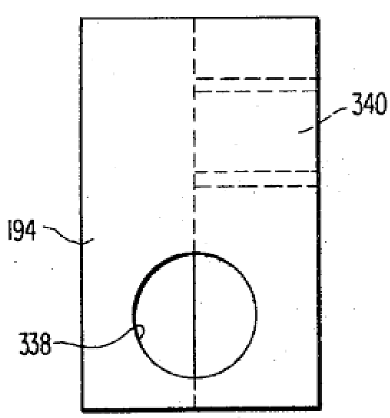


FIG. 21



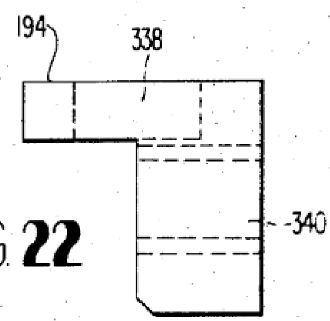


FIG. 22

Back to Accutrons.com Back to Patents Page

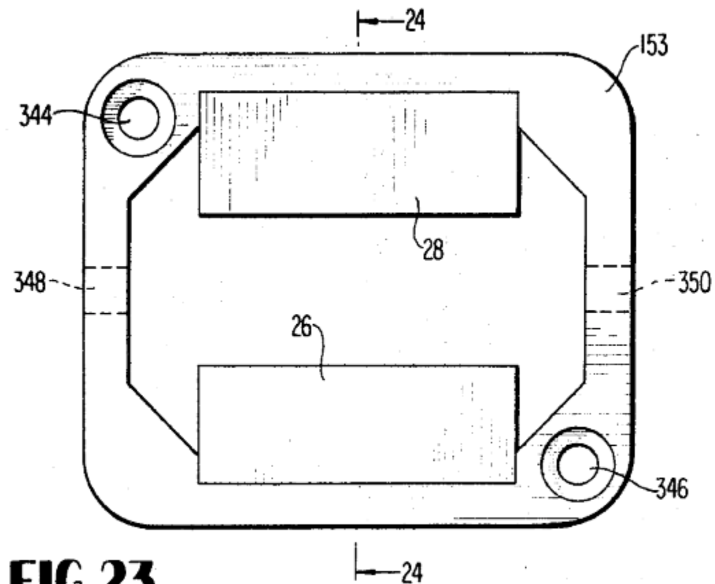


FIG. 23

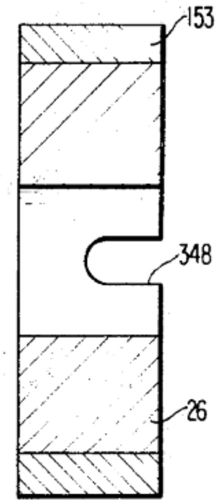


FIG. 24

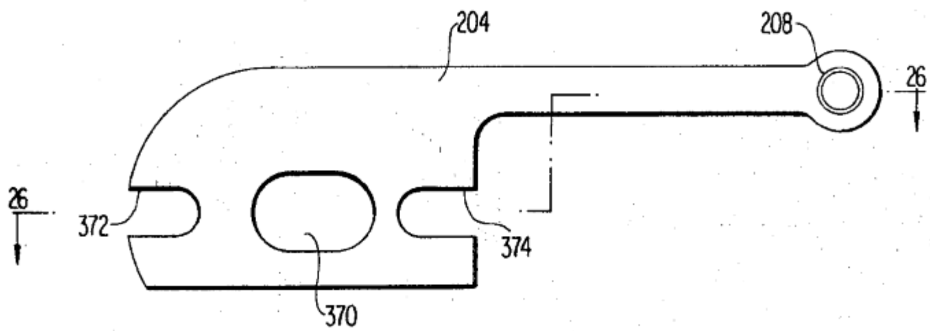


FIG. 25

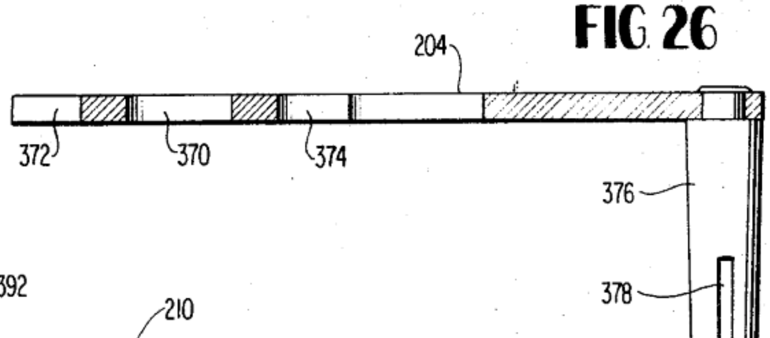


FIG. 26

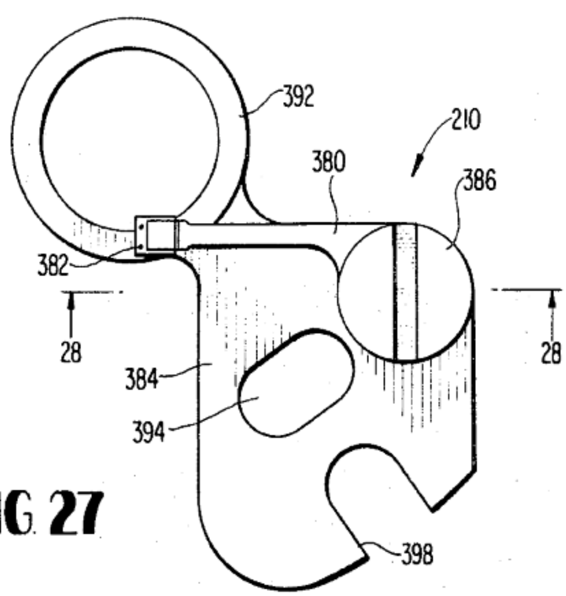


FIG. 27

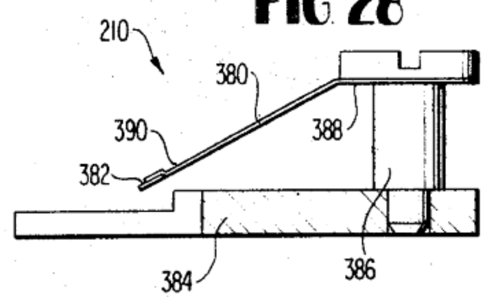
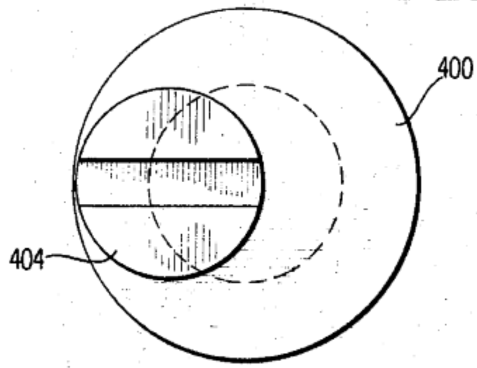


FIG. 28

FIG. 29



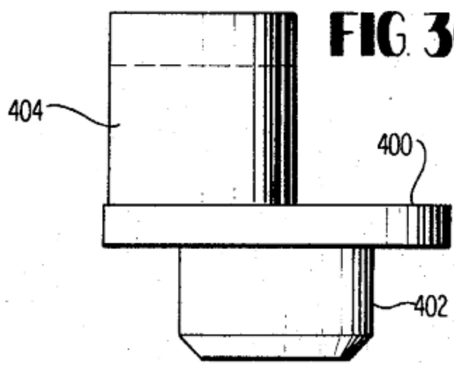


FIG. 30

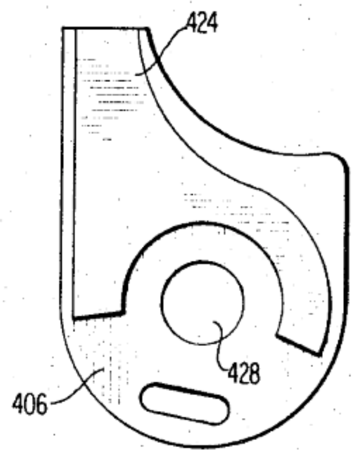


FIG. 31

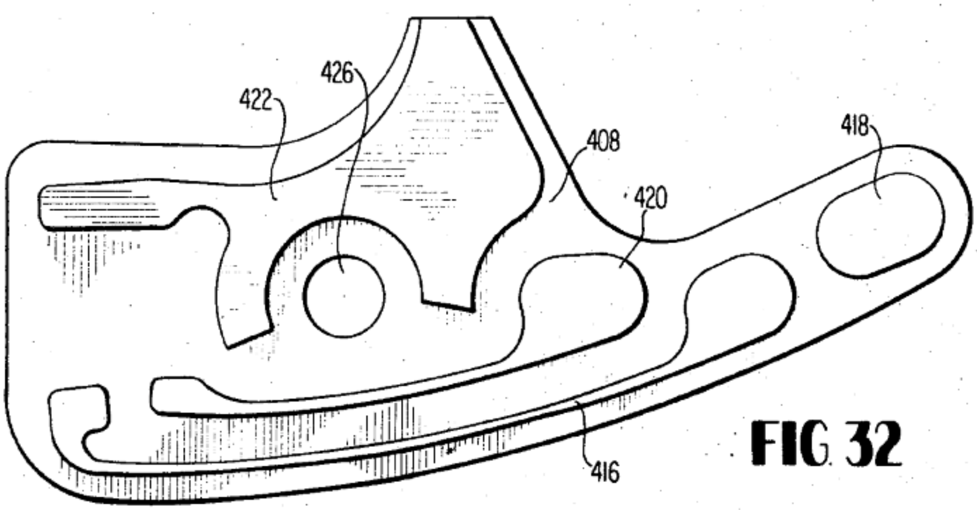
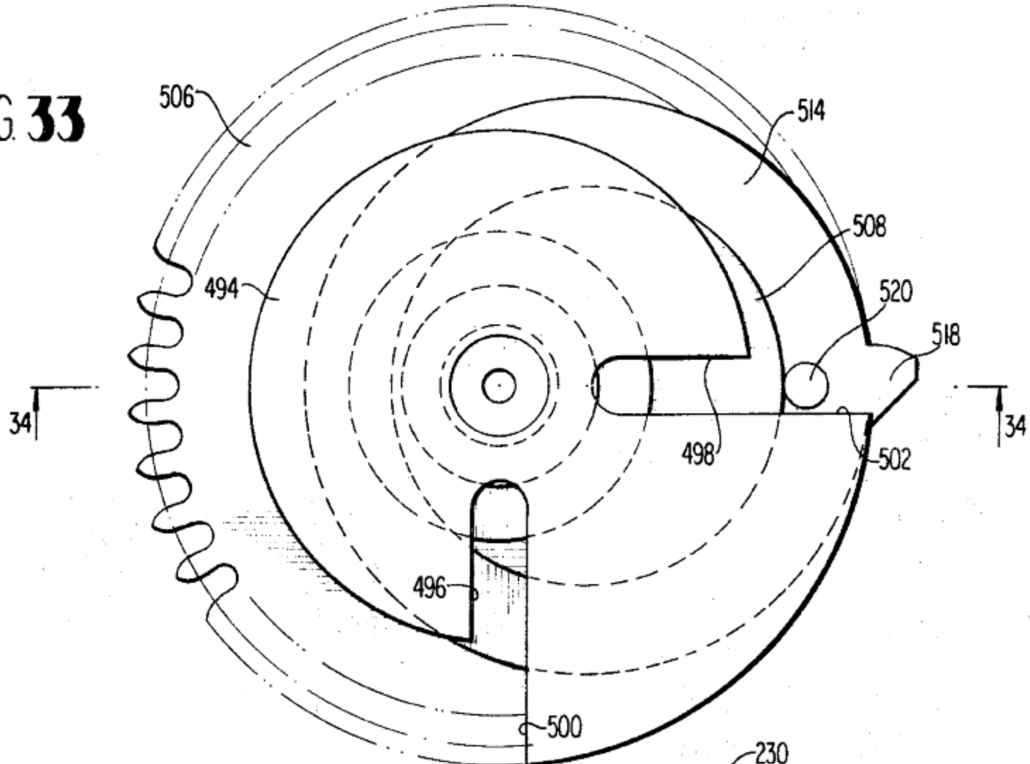


FIG. 32

FIG. 33



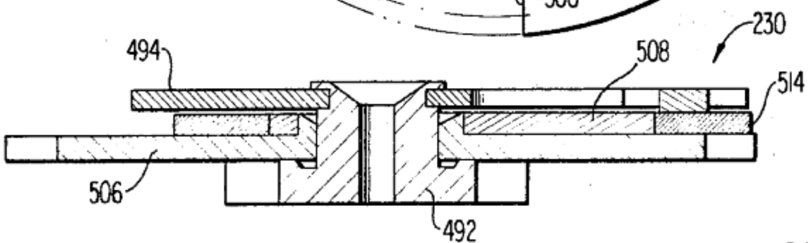


FIG. 34

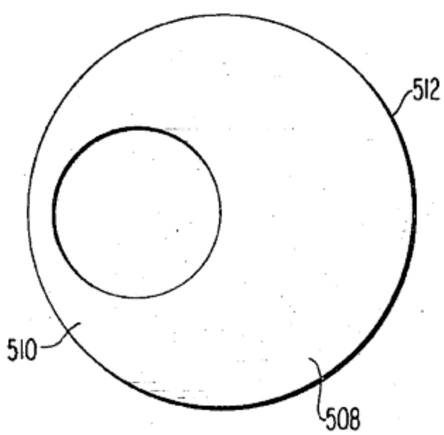


FIG. 35

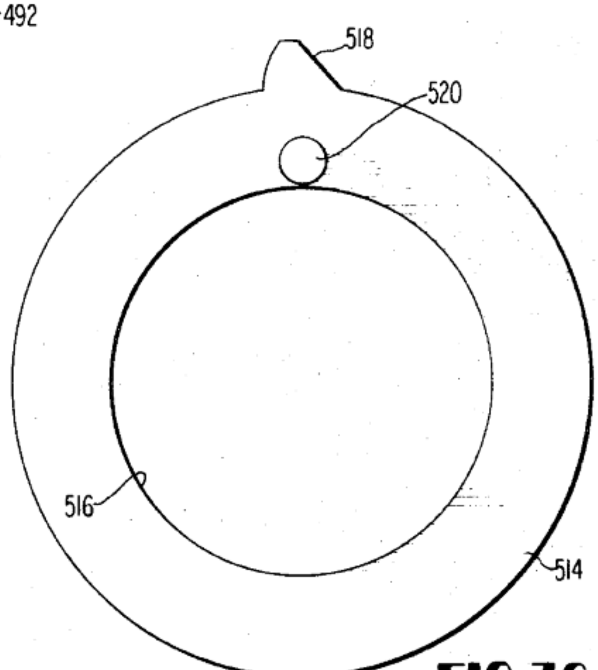


FIG. 36

FIG. 37

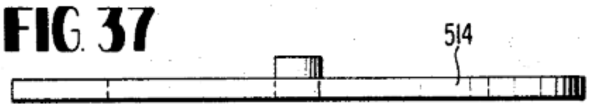
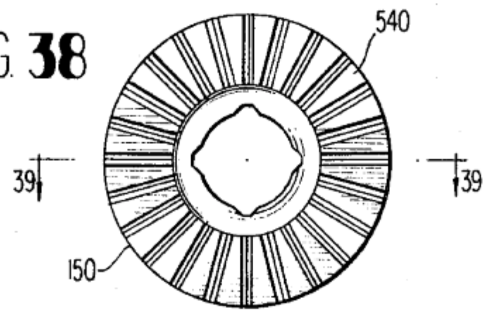


FIG. 38



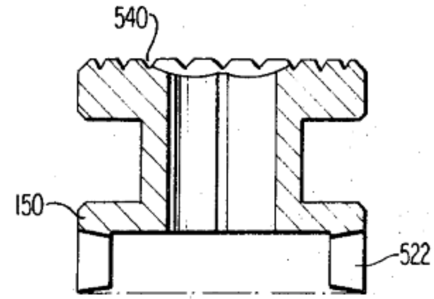


FIG. 39

FIG. 40

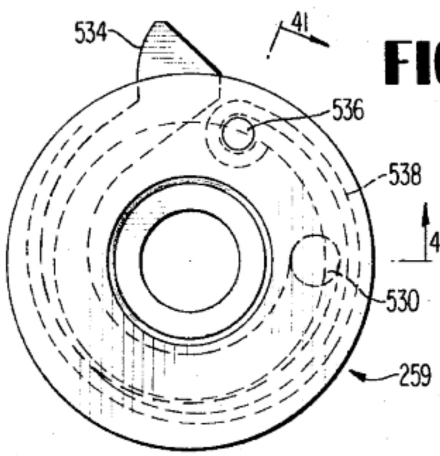


FIG. 41

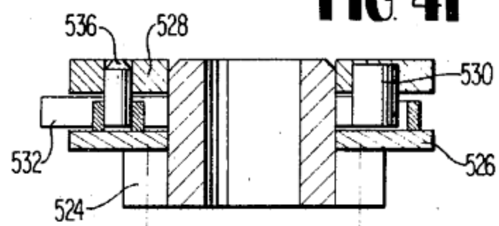
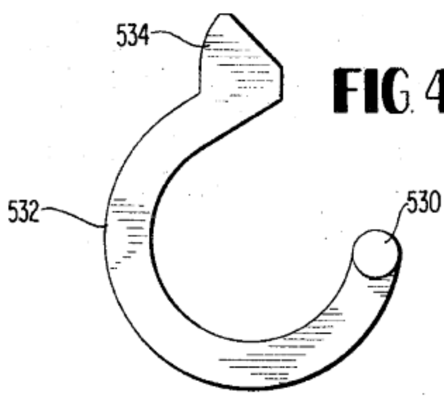


FIG. 42



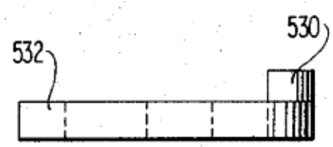
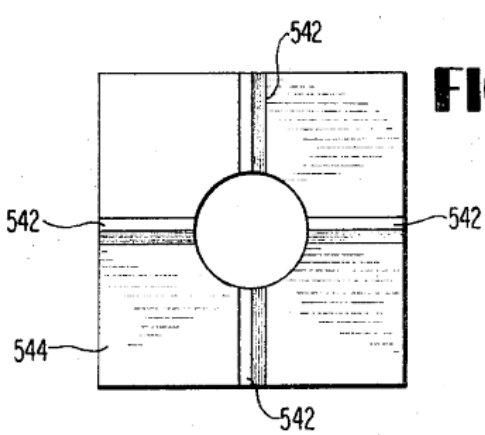


FIG. 43

FIG. 44



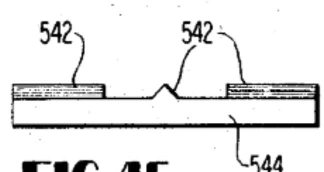


FIG. 45

ELECTRONIC WATCH

This invention relates to electrical timepieces and more particularly to a crystal controlled electronic watch having reduced size and increased reliability and efficiency of operation. In the preferred embodiment disclosed, the timepiece takes the form of a watch in which the output of a crystal controlled oscillator operating at a frequency of 262,144 Hz passed through a frequency divider to drive an electromechanical transducer resonator at a frequency of 16 Hz. The resonator is tuned to the output frequency of the frequency divider so that it is slaved to the quartz crystal oscillator and acts through an eccentric indexing mechanism to advance the gear train of the watch and ultimately rotate the watch hands over a conventional watch dial. Important features of the invention include the provision of a transducer in the form of an electromechanical resonator which is separately tuned or regulated to the appropriate frequency so as to insure maximum power transfer to the watch hands and to provide maximum utilization of the limited amount of energy available the relatively small battery incorporated in the watch case and forming the energy source for the watch

Battery powered wristwatches and other small portable timekeeping devices of various types are well known and are commercially available. The first successful commercial electric watch was of the type shown and described in assignee’s U.S. Pat. No. RE 26,187, issued Apr. 4, 1967 to John A. Van Horn et al for Electrical Watch. Electric watches of this type employ a balance wheel and hairspring driven by the interaction of a current carrying coil and a magnetic field produced by small permanent magnets. Other types of mechanically regulated battery operated wristwatches are also known.

Considerable effort has recently been directed toward the development of a high accuracy wristwatch which does not employ electromechanical oscillators as the master time reference. One approach which has been considered and has been subjected to substantial investigation is the use of completely electronic circuitry to generate a master drive signal. For example, it has been proposed to provide a low frequency oscillator or pulse generator operating at the desired timekeeping rate for a direct drive of the time display through an electromechanical energy converter. However, difficulties have been encountered in implementing this construction the difficulty in providing a low frequency oscillator having sufficient stability and realistic size and power dissipation for use in a wristwatch. In order to overcome these and other difficulties, it has been proposed to use high frequency oscillator as the frequency standard in conjunction with a quartz crystal for maintaining frequency stability and a divider for dividing down the frequency of the crystal controlled oscillator to produce an output at a suitable rate. A structure of this type is disclosed, for example in assignee’s copending application Ser. No. 768,076, now U.S. Pat. No. 3,560,998 filed Oct. 16, 1968, and in assignee’s copending application Ser. No. 568, filed Jan. 5, 1970. The present invention is directed to a crystal controlled wristwatch of the same general type as disclosed in the above-mentioned copending applications which are both incorporated herein by reference, and, more particularly, to an watch construction which evidences the substantially increased accuracy of a relatively high frequency crystal controlled oscillator, while at the same time providing for maximum power transfer and minimum power drain, all in a small, compact arrangement suitable for use as a wristwatch of conventional size. In the present invention, the output of a crystal controlled oscillator operating at a frequency determined by the crystal of 262,144 Hz is passed through an integrated circuit flip-flop counting chain forming a 14-stage frequency divider to produce a binarily related output electrical signal at a frequency of 16 Hz. The electrical output from the frequency divider passes through a driver which amplifies and shapes the 16Hz for application to the coil of an electromechanical transducer in the form of a hairspring regulated oscillatory coil having a natural frequency tuned to the divider output of 16 Hz. An eccentrically mounted index lever drives an index wheel to convert the resonator oscillations into a unidirectional rotary drive for the watch hands which are driven from the resonator through a series of gears and pinions forming a watch train. The crystal oscillator, frequency divider and driver are all preferably formed from integrated circuits employing complementary pairs of MOS transistors to Insure minimum power drain from the watch battery which, because of the reduced power drain and maximum power transfer afforded by the watch construction, may take the form of a 3 volt power supply. Since the resonator is in the form of an electrical coil through which current is passed from the output of the oscillator, the transducer coil oscillates in synchronism with and is slaved to the crystal oscillator output. The transducer comprises a single multi-turn coil mounted between a pair of permanent magnets and adapted to oscillate in the permanent magnetic field established by the magnets. Resonator oscillations are sustained by a pair of hairsprings which also function to establish electrical connection from the crystal oscillator by way of the frequency divider and driver to the opposite ends of the coil. The natural frequency of the resonator is regulated by a pair of more or less conventional regulator pins engaging one of the resonator hairsprings so that the optimum resonator frequency may be selected for maximum power transfer through the system to the watch hands. Forming a part of the watch construction is a two-position setting arbor which acts through a clutch assembly when in a first or arbor-in position to permit the watch to run in a normal fashion and at the same time makes it possible through rotadon of the arbor to set a calendar ring or date mechanism in the watch. When the watch arbor is pulled out to a second position, the gear train is stopped, the power supply circuit from the battery to the electrical components of the watch is opened and rotation of the arbor in the outermost of two possible positions acts through the clutch assembly to set the watch hands. An additional important feature of the present invention includes the provision of a rapid set feature for rapidly setting the calendar or date ring to the desired position as might be required at the end of a month or after the watch has been stopped for a substantial period of time. In conjunction with the rapid calendar set, an automatic calendar drive system assures that the calendar ring will be advanced one date every 24 hours at or near midnight. It is therefore one object of the present invention to provide an improved electronic timepiece. Another object of the present invention is to provide an improved crystal controlled watch. Another object of the present invention is to provide an improved electronic wristwatch having the accuracy of a relatively high frequency crystal controlled oscillator. Another object of the present invention is to provide an improved wristwatch utilizing complementary MOS Circuits throughout substantially the entire watch so as to minimize power drain on the energy source or battery incorporated in the limited space available in the watch case. Another object of the present invention is to provide an electronic wristwatch in which an electromechanical transducer in the form of a hairspring controlled resonator is slaved to the output frequency of a crystal controlled oscillator. Another object of the present invention is to provide an electronic watch in which a crystal controlled oscillator drives an electromechanical resonator through a frequency divider and in which the resonator is separately tuned to the output frequency of the divider for maximum power transfer through the system. Another object of the present invention is to provide a crystal controlled wristwatch having reduced size, weight and power drain so that the wristwatch may be operated from a conventional 3 volt battery incorporated in the watch case. Another object of the present invention is to provide an improved hand and calendar setting mechanism for an electronic watch. Another object of the present invention Is to provide an improved watch calendar drive and calendar setting mechanism particularly adapted for an electronic watch. Another object of the present invention is to provide a crystal controlled electronic watch in which a major portion of the electronic circuitry is formed from integrated circuits so as to occupy a minimum space within the watch case. Another object of the present invention is to provide an electronic watch having an improved electromechanical transducer coupled to the watch hands through an improved gear train construction. These and further objects and advantages of the invention will be more apparent upon reference to the following specification, claims, and appended drawings, wherein:

FIG. 1 is a simplified overall block diagram of a crystal controlled wristwatch constructed in accordance with the present invention;

FIG. 2 is a partially schematic diagram of the electromechanical transducer in the form of a hairspring controlled resonator forming a part of the watch of FIG. 1;

FIG. 3 is a view taken at right angles to that of FIG. 2;

FIG. 4 is an overall electrical circuit diagram for the electronic watch of the present invention;

FIG. 4A is a circuit diagram of the integrated circuit forming the overall circuit of FIG. 4;

FIG. 5 is an internal train side plan of the movement assembly of an electronic watch constructed in accordance with the present invention;

FIG. 6 is an external train side plan of the movement assembly of the watch of FIG. 5;

FIG. 6A is a view of the underside of the circuit board forming a part of the watch;

FIG. 6B is a cross section taken along line 68—68 of FIG. 6A;

FIG. 7 is a dial side plan view of the movement assembly of the watch of FIG. 5;

FIG. 8 is a partial plan view corresponding to FIG. 7 showing the setting clutch mechanism moved to a second or outermost watch hand setting position;

FIG. 9A is a vertical cross section through the watch of FIGS. 5 —8 showing the tuning capacitor and quartz crystal;

FIG. 9B is a vertical section through the watch showing the integrated circuit package mounting;

FIG. 9C is a vertical section showing a portion of the on-off switch for the watch;

FIG. 10A is a vertical section showing the resonator regulator;

FIG. 10B is a vertical cross section showing the manner of mounting the permanent magnet shunt forming a part of the resonator assembly;

FIG. 10C is a vertical cross section showing the hairspring controlled resonator and the eccentric index mechanism of the watch;

FIG. 10D is a vertical cross section showing a portion of the switch spring establishing electrical connection to one side of the watch battery;

FIG. 11A is a vertical cross section showing a portion of the gear train for driving the watch hands;

FIG. 11B is a vertical cross section showing the arrangement for establishing electrical connection to one end of the resonator coil through one end of the resonator hairsprings;

FIG. 11C is a vertical cross section taken at right angles to the cross section of FIG. 11B and further illustrating the hair- spring contacts and a portion of the watch driver circuit;

FIG. 12 is a vertical cross section through the watch of FIGS, 5—8 showing a portion of the gear train and illustrating the watch setting and calendar setting mechanisms;

FIG. 13 is a plan view of the switch spring forming a part of the on-off switch for the watch of the present invention;

FIG. 14 is an elevational view of a portion of the spring of FIG. 13;

FIG. 15 is an elevational view of an additional portion of the switch spring of FIG. 13;

FIG. 16 is a plan view of the switch arm forming a part of the on-off switch of the watch of the present invention;

FIG. 17 is an elevational view of the switch arm of FIG. 16; FIG. 18 is a plan view of the watch setting lever used to actuate the on-off switch;

FIG. 19 is an elevational view with parts in section of the setting lever of FIG. 18;

FIG. 20 is a plan view with parts in section of the regulator cock assembly showing the regulator for the stronger hair- spring of the resonator;

FIG. 21 is a plan view of the stud for securing the end of the regulator hairspring;

FIG. 22 is an elevational view of the regulator spring stud of FIG. 21;

FIG. 23 is a plan view of the shunt and permanent magnet assembly for the resonator of the watch of the present invention;

FIG. 24 is a cross section through the shunt and permanent magnet taken along line 24—24 of FIG. 23;

FIG. 25 is a plan view of the index lever guide forming a part of the watch of the present invention;

FIG. 26 is a cross section through the index lever guide taken along line 26—26 of HG. 25;

FIG. 27 is a plan view of the pawl bridge assembly for the index wheel of the watch of the present invention;

FIG. 28 is a cross section taken along line 28—28 of FIG. 27;

FIG. 29 is a plan view of the eccentric post used to adjust the position of the pawl bridge assembly of FIGS. 27 and 28;

FIG. 30 is an elevational view of the eccentric post of FIG. 29;

FIG. 31 is a plan view of the upper connector for establishing electrical connection to the weaker or resonator coil hair- spring of the resonator;

FIG. 32 is a plan view of the resonator hairspring lower connector;

FIG. 33 is a plan view of the date indicator drive assembly for driving the date indicator or calendar ring from the watch train;

FIG. 34 is a cross section taken along line 34—34 of FIG. 33 through the date indicator drive assembly,

FIG. 35 is a plan view showing the cam forming a part of the date indicator drive assembly of FIGS. 33 and 34;

FIG. 36 is a plan view of the index ring forming a part of the indicator drive assembly of FIGS. 33 and 34;

FIG. 37 is an elevational view of the index ring of FIG. 36;

FIG. 38 is an elevational view of the clutch forming a part of the setting assembly of the watch of the present invention;

FIG. 39 is a cross section through the clutch of FIG. 35 taken along the line 39—39 of that FIGURE;

FIG. 40 is a plan view of the rapid set assembly forming a part of the watch of the present invention;

FIG. 41 is a cross section through the rapid set assembly taken along the line 41—41 of FIG. 40;

FIG. 42 is a plan view of the pawl forming a part of the rapid set assembly of FIGS. 40 and 41;

FIG. 43 is an elevational view of the pawl of FIG. 42;

FIG. 44 is a plan view of the friction washer forming a part of the setting mechanism of the present invention; and

FIG. 45 is an elevational view of the friction washer of FIG. 44. Referring to the drawings, FIG. 1 is a simplified block diagram of an electronic watch constructed in accordance with the present invention and generally indicated at 10. The watch comprises a frequency standard 12, preferably in the form of a crystal controlled oscillator which produces output pulses having a frequency of 262,144 Hz with the stability of the controlling crystal. The output from oscillator 12 is applied by way of lead 14 to a multistage frequency divider 16 where the frequency of the electrical signal is reduced to a value useful for driving the hands of a watch. In the preferred embodiment, the output of frequency divider 16 appearing on lead 18 has a frequency of 16 or 32 Hz and, in the preferred embodiment, the frequency divider takes the form of a 14 stage binary chain of flip_flops to produce an output frequency of 16 Hz. This output is applied to a driver 20 which acts as a pulse shaper to shape the pulses and apply them to a transducer 22. The transducer converts the electrical pulses into physical motion to actuate a watch display 24 which, in the preferred embodiment, of a gear train and conventional watch hands rotating about the dial of a conventional watch face. Oscillator 12 and frequency divider 16 are preferably made from integrated circuit components utilizing complementary MOSFET transistors as disclosed in assignee's copending application Ser. No. 768,076, filed Oct. 6, 1968, and incorporated herein by reference. Driver 20 is preferably also formed partially from MOSFET transistors and is of the type disclosed in a copending application Ser. No. 568, filed Jan. 5, 1970, and also incorporated herein by reference. The transducer 22 takes the form generally illustrated in FIGS. 2 and 3 and more fully described In assignee's copending application Ser. No. 46,936, filed June 17, 1970, U.S. Pat. No. 3,641,761. The transducer comprises a pair of permanent magnets 26 and 28 positioned on opposite sides of an electrical coil 30. Coil 30 is formed of many turns of wire, illustrated in FIG. 3, and is mounted on a core 32 connected to a pair of resonator sections or balance staff sections at it upper and lower ends consisting of upper section 34 and lower resonator section 36. The ends of the resonator staff are received in bearings 38 and 40 so that the coil, core, and balance staff are all mounted for oscillating movement in the magnetic field formed by permanent magnets 26 and 28. Attached to upper section 34 of the resonator staff is the inner end of a regulating hairspring 42 having its other end secured to a fixed portion of the watch as indicated at 44. A lower hair-spring 46 similarly has its inner end connected to the lower section 36 of the balance staff and its outer end 48 secured to a fixed portion of the watch. The upper end of coil 30 is connected to ground as at 50, through section 34 to hairspring 42 and the lower end of coil 30 is similarly electrically connected to driver circuit 20 as at 52, through lower section 36 to hair- spring 46 and stud 48. Hairsprings 42 and 46 are electrically connected to opposite sides of a suitable power supply, such as a 3 volt battery, located in the watch case, through driver circuit 20 which controls electrical current flow from one side of the battery to the other through the coil by way of the hairsprings and the balance staff sections. Power takeoff from the oscillating coil is by way of an eccentric, generally indicated at 54, mounted on the lower section 36 of the resonator staff and by way of an index lever 56 to an index wheel 58, in turn connected through the watch train to the watch hands. Index wheel 58 is provided with ratchet-shaped teeth 60 which are engaged by an index jewel 62 on the outer end of an index lever 56 so that index wheel 58 rotates in accordance with the oscillating movement of the coil and resonator staff. FIG. 4 is an overall circuit diagram showing the electrical Circuit for the watch of the present invention. The circuit, generally indicated at 66, comprises a positive supply terminal 68 and a negative supply terminal 70 connected to opposite sides of the watch battery and supplying power by way of leads 72 and 74 to the crystal oscillator 12. The oscillator comprises a quartz crystal 76 dimensioned to establish an operating frequency for the oscillator of 262,144 Hz. The quarts crystal is connected between the gates and drains of a pair of complementary connected MOSFET transistors comprising P-channel transistor 78 and N-channel transistor 80. Connected in parallel with crystal 76 is a 50 megaohm resistor 82 and a variable tuning capacitor 84 tunable over a range of from 0.8 to 1.8 picofarads. By suitably adjusting the value of tuner or tuning capacitor 84, the output frequency of the oscillator can be adjusted to 262,144 Hz. Complementary output signals are developed from the oscillator on leads 86 and 88 and applied to the first stage 90 of a 14 stage integrated circuit flip-flop chain forming frequency divider 16. The output from the 14th stage of the divider passes to driver 20 which includes an RC differentiator comprising a 300 picofarad capacitor 92 and a 4.7 megaohm resistor 94. The differentiated impulses are applied to the gates of a pair of complementary connected MOSFET transistors 96 and 98. The output signal developed on the two drains of these transistors is passed through a 1 megaohm resistor 100 to the base 102 of a P-N-P junction transistor 104 which acts as a switching transistor and includes an emitter 106. and collector 108. The transducer resonator coil 30 is connected between transistor collector 108 and the negative terminal 70 of the power supply. As a result, the resonator is driven to oscillate at a frequency of 16 Hz in accordance with the output frequency from the 14th stage of divider 16.

FIG. 4A is a circuit diagram of the integrated circuit forming a major portion of the overall watch circuit 66 of FIG. 4. The integrated circuit 110 of FIG. 4A includes MOSFET transistors 78 and 80, the 14 complementary MOSFET flip-flop stages of the divider, and the complementary MOSFET transistors 96 and 98 forming a part of the driver circuit. Integrated circuit 110 is provided with leads 112 and 114 connected to the crystal 76 of FIG. 4 and with additional leads 116 and 118 connectable to opposite sides of capacitor 92 of FIG. 4. FIG. 5 is an internal train side plan view of the movement assembly of the watch 10 of the present invention. A major support element in the watch comprises the pillar plate 120 on which is mounted a regulator cock 122 by means of screw 124 which carries bearing 38 supporting one section 34 of the resonator staff mounted coil 30 and coil bobbin or core 32. Similarly secured to the pillar plate is a coil cock 126 attached by screw 128 and carrying the bearing 40 supporting the other end of the coil assembly, i.e.. the end of the other resonator staff section 36. While bearings 38 and 40 are illustrated in FIG. 5 as jewel bearings, it is understood that oil-less shockproof bearings as shown and described in assignee’s copending application Ser. No. 9,287, filed Feb. 6, 1970, and incorporated herein by reference, may be substituted for the jewel bearings 38 and 40 illustrated in the drawings. Hairspring 46 is connected to resonator staff section 36 by a collar 130 and the regulator hairspring 42, which preferably has a strength approximately six times the strength of hairspring 46, is similarly connected to resonator staff section 34 by a second collar 132. Index lever 56 is rotatably mounted on the eccentric 54 forming a short portion of resonator staff section 36 and carries an index jewel 62 which meshes with the ratchet teeth 60 of index wheel 58. Rotation of the index wheel 58 in conjunction with oscillations of coil 30 acts through a gear train to drive the watch hands which train includes a sixth wheel 134, a fifth wheel 136, a fourth wheel 138, and a third wheel 140. Pillar plate 120 is also provided with an adjustable post 142 which carries one end of a friction spring 144 engaging a portion of the gear train for a purpose more fully described below. Additional elements shown in FIG. 5 are the on-off switch plate 146, a two-position setting arbor 148, a clutch 150 carried for rotation with setting arbor 148, and a pair of bar shunts 152. FIG. 6 is a train side plan view of the movement assembly of the watch of the present invention in which like parts bear like reference numerals. In FIG. 6 coil 30 is shown as centered between the permanent magnets 26 and 28. These magnets engage and are secured to a hollow rectangular shunt or keeper 153 which cooperates with bar shunts 152 and is secured to the pillar plate 120 by shunt screws 154 and 156. Also mounted to the pillar plate 120 by three screws 158, 160, and 162, is printed circuit board 164 which is apertured to receive the crystal 76 and the integrated Circuit package 110 of

FIG. 4A. Located partially between the pillar plate and the printed circuit board 164 is the tuner or tuning capacitor 84 which is adjustable between the solid line position illustrated and the dashed line position 166. Carried by the underside of the circuit board 164 in FIG. 6 is an electrical printed circuit which is grounded to the pillar plate which is in turn connected to the negative side of the watch battery by screw 160. The positive side of the power supply battery is connected through a switch spring, a portion of which is illustrated at 166 in FIG. 6, to a post 168 which forms the positive or un75 grounded terminal for the electrical circuit 66 of FIG. 4. FIG. 6A is a view of the underside of the circuit board 164 flipped over 180° showing the printed circuitry on the underside of the board and FIG. 6B is a cross section through the printed circuit package taken along line 6B—6B of FiG. 6A. Referring to FIGS. 6, 6A and 6B, the electrical circuit may be traced as follows. The negative side of the battery is grounded to the pillar plate which makes connection through screw 160 of FIG. 6 to a conductive pad 170 and printed circuit lead 172 to the negative power supply terminal 174 of integrated circuit package 110 and to one side of resistor 94. The other side of this resistor is connected to integrated circuit terminal 118 as is one side of capacitor 92. The other side of capacitor 92 is connected to integrated circuit terminal 116. The positive side of the power supply is through pin 168 in FIG. 6 to printed circuit pad 176 in FIG. 6A and by way of printed circuit lead 178 to integrated circuit terminal 68. Connected across integrated circuit terminals 112 and 114 is resistor 82 and also connected across these terminals by printed circuit leads 180 and 182 is the tuning capacitor 84. Leads 184 and 186 connect crystal 76 in parallel with the tuner 84. An output is taken from the integrated circuit package 110 by way of terminal 99 and lead 188. A second lead 190 supplies B+ power from the printed circuit board 164 to the remaining portions of the watch circuit. Referring again to FIG. 6, the two leads 188 and 190 extend along the edge of pillar plate 120 to a connector assembly, generally indicated at 192, provided to establish electrical connection through hairspring 46 to the active end of coil 30. The connector assembly includes the driver resistor 100 and the driver transistor 104. The other end of coil 30 is grounded to the pillar plate by way of regulator hairspring 42 and a hair- spring stud 194. Other elements illustrated in FIG. 6 are the train bridge 196 secured to the pillar plate by screws 198 and 200, an index cock 202 which supports index wheel 60 and index lever guide 204 which is secured to the index cock 202 by a screw 206 and includes a head 208 overlying index lever 56 and also shown is a pawl bridge assembly 210 which supports a pawl engaging the teeth 60 of the index wheel. Also shown in FIG. 6 is the foot 212 of a dial which is received through an aperture 214 in the pillar plate and secured by a set screw or dial foot screw 216. It is understood that a second dial foot is secured by a similar screw in a second aperture 217 on the opposite side of the pillar plate as illustrated near the top of FIG. 5. FIG. 7 is a dial side plan view of the watch 10 and FIG. 8 is a partial plan view similar to FIG. 7 showing the clutch mechanism when the setting stem is pulled to its outermost position. Rotatably mounted on the pillar plate 120 is a date indicator or calendar ring 218 provided with date indicia 220 and internal teeth 222 by means of which the ring 218 is rotated and driven to provide an indication through an appropriate window in the dial (not shown) of the correct date. Calendar ring 218 is retained on the pillar plate by a calendar bridge, portions of which are indicated at 224 and which is secured by screws, such as screws 226 and pins 228. The calendar ring is driven from the watch train by a date indicator drive assembly, generally indicated at 230. The watch train is illustrated as including the hour wheel 232 and the minute wheel 234. Calendar ring 218 is restrained by a date jumper 236 pivotal at one end about pin 238 and carrying at its other end a head 240 engaging the calendar ring teeth 222. Head 240 is biased into engagement with the calendar ring teeth by a substantially U-shaped date jumper spring 242 having one end 244 engaging the date jumper and its other end 246 secured in a recess of bridge 224. The watch is set by rotating the setting arbor 148 on which is mounted the clutch 150. When the two-position setting arbor 148 is in its innermost position, as illustrated in FIG. 7, the watch runs normally. Rotation of the setting arbor in this positions causes a rapid set assembly 252 to rotate the calendar ring 218 to provide calendar setting. During rotation of the calendar ring, date jumper 236 slides over successive teeth 222 by slightly compressing spring 242. When the setting arbor is pulled to its outermost position, the setting assembly assumes the position illustrated in FIG. 8. At this time, the watch train is positively braked, the on-off switch is open removing power from the electrical circuit, and rotation of the stem in this outermost position acts through an intermediate setting wheel 250 to set the hands of the watch including date indicator assembly 230. Principal components of the setting mechanism include the intermediate setting wheel 250, clutch 150, the rapid set assembly 252, a clutch lever 258 having its lower end received in the clutch slot, and a setting cap spring 260 secured to the pillar plate by screws 262 and 264. Secured to the clutch lever at one end is an L-shaped brake spring 266 which has one end bent downwardly into the plane of the paper in FIGS. 7 and 8 to extend through an elongated slot 268. When arbor 148 is moved outwardly from the position illustrated in FIG. 7 to the position illustrated in FIG. 8, the bent over end of spring 266 engages the teeth 270 on the sixth wheel 134 of the gear train, thus resiliently stopping the train. FIGS. 9 through 12 show various cross sections illustrating principal components of the watch construction of FIGS. 54. FIG. 9A is a vertical cross section through a portion of the watch showing the quartz crystal 76 controlling the watch frequency. FIG. 98 is a vertical cross section illustrating the mounting of the integrated circuit package 110. FIG. 9C is across section illustrating a portion of the on-off switch which is opened to break the supply of power to the electrical circuit from the battery when the setting arbor is pulled to its outermost position of FIG. 8. FIG. 10A is a cross section showing the regulator cock and regulator for the stronger hairspring 42 of the resonator. FIG. l0B is a cross section through one of the shunt screws showing the manner of mounting the permanent magnet shunt to the pillar plate. FIG. 1OC is a cross section through the resonator showing the oscillatory coil 30 and its mounting and also illustrating the eccentric assembly for coupling the oscillations of coil 30 to the index wheel 58. FIG. 10D is a cross section showing the remaining portion of the on-off switch spring and illustrating the electrical connection of the positive or ungrounded side of the watch battery, FIG. 11A is a vertical cross section showing a portion of the gear train and also illustrating additional features of the eccentric drive to the index wheel. FIG. 1lB is a cross section through the contact assembly showing how electrical connection is made from the positive side of the power supply to the weaker of the two hairsprings 46. FIG. 11C is a further cross section of the Contact assembly taken at right angles to FIG. 11B. Finally, FIG. 12 is a vertical cross section showing additional portions of the gear train, and also illustrating a portion of the setting mechanism and a portion of the calendar drive assembly. Referring to FIG. 9A, the back of the watch is closed off by a battery spring 272 which is secured to the outer periphery of the pillar plate 120 by a plurality of screws, such as the screw 274. Spring 272 is slotted at appropriate points, such as is illustrated at 276, to receive the shanks of screws 274. Positioned between spring 272 and the pillar plate 120 is a conventional 3 volt battery 278 which is of circular cross section and which extends over the entire back of the watch. Battery 278 is preferably provided with an annular coating of electrical insulating material 280 extending over its upper, lower and side edges to insulate the battery from the pillar plate. The upper side or negative side of the battery is electrically connected to the conductive spring 272 which is in turn grounded to the pillar plate 120 by the screws 274. The printed circuit board 164, which is made of several laminations of electrical insulating material, has conductive circuitry on its underside, as illustrated in FIG. 9A. and is secured to the pillar plate by a plurality of screws as previously described, such as the screw 160 in FIG. 9A. The circuit board is apertured as at 282 to receive the upper end of piezoelectric crystal 76 and the crystal is mounted to the circuit board by suitable potting material (not shown), such as epoxy or the like. As previously described, the calendar bridge 224 is secured to the pillar plate 120 by screws such as screws 226 (FIG. 9B) and pins 228 as to retain for rotation about the pillar plate 120 the date indicator or calendar ring 218. Tuner or tuning capacitor 84 is connected to the crystal 76 by a pair of leads as previously described, one of which is illustrated at 184 in FIG. 9A. FiG. 9B shows one of the screws 226 attaching the calendar bridge 224 to the pillar plate 120. It also shows the printed circuit board 164 apertured as at 284 to receive the upper end of the integrated circuit package 110 which is secured to the circuit board by suitable potting compound (not shown), such as epoxy or the like. The integrated circuit package 110 is illustrated as connected to the resistor 82 forming a part of the oscillator and to the resistor 94 forming a part of the driver circuit RC differentiator. The battery is again illustrated at 278 in FIG. 9B. Referring for a moment to FIG. 10D, electrical connection is made with the underside of the battery 278 which forms the positive side of the battery through a switch spring 166. This switch spring includes an upwardly curved arm 286 which resiliently engages the underside of the battery interiorly of electrical insulation 280 to form an electrical conductive contact with the battery. The switch spring 166 is shown in detail in FIGS. 13, 14 and 15. Switch spring 166 is apertured as at 288 to pass screw 162 (FIG. 10D) mounting the circuit board 164 to the pillar plate 120. Switch spring 166 is electrically insulated from the conductive pillar plate 120 by an electrical insulator 290. In addition to upwardly bent arm 286 making electrical contact with the positive side of the battery, switch spring 166 includes a slightly downwardly bent arm 292, the outer end of which forms an electrical contact at 294 and which includes along it edge an upwardly bent tab 296. Movable contact 294 on the end of arm 292 of the switch spring is adapted to engage and make electrical contact with the pin or button 168 mounted on and passing through the electrical circuit board 164. Pin 168 is in electrical contact with the printed circuit on underside of the printed circuit board 164 in FIG. 9C as previously described. Switch spring arm 292, as illustrated in FIGS. 13 and 14, is normally biased downwardly with the movable contact 294 away from the stationary contact 168 so that there is an open circuit between the battery and the printed circuit board 164. This is the condition which obtains when the stem is out, the watch is stopped, and the hands are being set. Movable contact 294 of the switch spring arm is adapted to be urged into engagement with the stationary contact 168 which is the position illustrated in FIG. 9C by a pivotaily mounted switch arm 298 which is the condition when the stem is in and the watch in its normally running condition. Switch arm 298 is shown in detail in FIGS. 16 and 17. Switch arm 298 is apertured as at 300 to receive a pivot pin 302 about which it pivots and is apertured at 304 to receive a drive pin 306 which drives it or causes it to pivot about pin 302. The end 308 of switch arm 298 forms a cam surface adapted to cam against tab 296 of switch spring 166 so as to force movable contact 294 into engagement with stationary contact 168 when switch arm 298 is rotated about pin 302. Switch arm 298 is rotated in conjunction with the inward and outward movement of the setting stem by rotation of the setting lever 254, the details of which are illustrated in FIGS. 18 and 19. The setting lever 254 carries a pair of small or short pins 310 and 312, one on each surface, and press-fit into it are the switch pins 302 and 306. Pillar plate 120 in FIG. 9C is provided with an elongated slot 314 providing clearance for the drive pin 306 so that rotation of setting lever 254 with movement of the setting arbor causes lever 254 to drive switch arm 298 by way of pin 306 causing it to open and close the contacts 168 and 294 of FIG. 9C. FIG. 10A is a vertical cross section showing the regulator cock 122 and the regulator assembly for the stronger hair- spring 42. Regulator cock 122 is mounted to the pillar plate 120 as previously described by screw 124 and also by friction pins 316. Regulator cock 122 carries the end shake bearing 38 supporting for oscillatory movement one end of the resonator assembly and surrounding the bearing setting is a hairspring regulator 318. Details of the regulator construction are illustrated in FIG. 20. The regulator comprises an annular ring 320 rotatable about the bearing assembly with a friction fit and including outwardly extending ears 322 and 324. Regulator ear 322 is adapted to be manually engaged for rotation of the regulator ring about the setting of bearing 38. Extending outwardly from ear 324 are a pair of spaced regulator pins 326 and 328 between which pass the outer elongated turn 330 of hairspring 42. By rotating regulator 318 with the pins slidably bearing against the end of the spring, the effective spring length is changed, thus modifying the spring strength in a well known manner to provide fine tuning of the resonator frequency. The outer end of hairspring turn 330, as indicated at 332, is clamped between the outer edge of a ledge 334 of the electrically conductive pillar plate and the adjacent cooperating surface of a stud 194. Details of stud 194 are illustrated in FIGS. 21 and 22. The stud is apertured as at 338 to pass the outer end 332 of the hairspring and is provided with an internally threaded aperture 340 adapted to receive the threaded end of screw 342 shown in FIG. 1OA passing through an aperture provided in pillar plate 120. When screw 342 is tightened, end 332 of the hairspring is tightly clamped between the pillar plate and the stud 194. This not only positively fixes and supports the end of the hairspring, but also establishes electrical connection through the hairspring 46 from the other side of the resonator coil 30 to ground, i.e., to the pillar plate 120.

FIG. l0B is a cross section showing one of the screws 154 mounting the permanent magnet shunt 153. The details of the shunt and magnet surrounding coil 30 are illustrated in FIGS. 23 and 24, the latter being a cross section taken along line 24—24 of FIG. 23. Shunt 153 is preferably constructed of soft iron, such as Armco iron, and has secured to it the permanent magnet 26 and 28. The shunt is apertured as at 344 and 346 to pass the screws 154 and 156 of FIG. 6. The shunt is also provided with a pair of slots 348 and 350 which permit passage through the shunt of the resonator staff sections 34 and 36. FIG. 1OC shows the resonator construction and illustrates the eccentric takeoff to the index wheel 58. The resonator comprises the coil 30 of many turns wound around a flat rectangular core 32. The coil passes through slots in bobbins 352 and 354 received over the ends of core 32. Resonator staff 34 rigidly receives a stub shaft 356 whose end is rotatably received in end shake bearing 38. The other resonator staff section 36 receives a second stub shaft 358 with a friction fit which includes a short eccentric section on which one end of the index lever is rotatably or pivotally mounted. The index lever carries an index jewel 62 which engages the teeth 60 of the index wheel 58. The index wheel is fixed to a shaft whose lower end is rotatably received in an index bearing 360 and the other end of this shaft is rotatably received in a similar bearing 362 carried by the index cock 202. Secured and rotatable with the index wheel 58 is an index pinion 364. As previously described, index cock 202 is secured to the pillar plate 120 by a screw 206 and by a pair of pins 366 and 368. Also secured to pillar plate 120 and to the index wheel cock 202 by screw 206 is index lever guide 204. The details of the index lever guide 204 are illustrated in FIGS. 25 and 26. The guide is provided with an aperture 370 to receive the screw 206 and with slots 372 and 374 to receive the pins 366 and 368. Aperture 370 is elongated and this aperture, in conjunction with the slots 372 and 374, permit longitudinal adjustment of the position of the index lever guide 204. At its head 208, index lever guide 204 carries a guide pin 376 bifurcated as at 378 in FIG. 26 such that the bifurcations overlie opposite sides of the index lever 56. Thus, the guide pin 376 acts to guide the index lever and to prevent excessive lateral movement of this lever. Also illustrated in FIG. 1OC is an index pawl assembly including a pawl spring 380 carrying a pawl jewel 382 which also engages the teeth 60 of index wheel 58 to act to index the wheel as it is advanced by the lever 56 and index jewel 62. Pawl spring 380 is mounted on a pawl bridge 384 by means of a pawl post 386, all as illustrated in more detail in FIGS. 27 and 28. Pawl spring 380 includes an annular end 388 surrounding and secured to the shank of past 386 so that is rotatable for adjustment with post 386. The other downwardly bent end 390 of the pawl spring carries the jewel 382 on its underside. Pawl bridge 384 also includes an annular end 392 which surrounds the setting of index wheel bearing 360 and includes an elongated slot 394 adapted to pass a screw 396 by means of which the pawl bridge is secured to the pillar plate 120. Slot 394 is elongated so that the paw! Bridge 384 and the elements which it carries may be adjusted about the rotational axis of index wheel 58 which passes through the center of annular end or ring 392. Adjustment is effected through the provision of a slot 398 in the pawl bridge through which passes an eccentric post 400 shown in FIG. 6 and also illustrated in detail in FIGS. 29 and 30. This post includes a lower end 402 frictionally received for adjustable pivotal movement in pillar plate 120 and an upwardly extending eccentric pin 404 which, then the post 400 is rotated about the axis of lower section 402, is adapted to engage the edges of slot 398 and pivot the entire pawl bridge 384 with a camming action for adjustment about the rotational axis of the index wheel. This affords a simplified arrangement for zeroing the stroke on both sides of the rest position. FIGS. 1lB and 11C are cross sections showing the details of the connector assembly 192 of FIG. 6 for establishing electrical connection from the positive side of the power supply through hairspring 46 to the other side of the coil, it being understood that current passes through hairspring 46, through resonator coil 30, and then through hairspring 42 to ground. The connector assembly is formed from an upper connector 406 and a lower connector 408, both formed from printed circuit board laminations. The details of the upper connector 406 are illustrated in FIG. 31 and the details of the lower connector 408 are illustrated in FIG. 32. These connectors have electrically conductive printed circuits on adjacent surfaces and are held together by a screw 410 which when tightened down into pillar plate 120 clamps the end 412 of the outer turn 414 of hairspring 46 between the electrically conductive printed circuits on the two boards 406 and 408. This not only serves as a rigid clamping support for the outer end of hairspring 46, but also serves to establish electrical connection to the hairspring. Lower connector 408 supports the transistor 104 and the resistor 100 forming a part of the watch driver circuit. Power supply lead 190 of FIG. 6 is connected to a conductive segment 416 on lower connector 408 which, in turn, is coupled to transistor 104. Lead 188 in FIG. 6 is connected to one side of resistor 100 by way of conductive pad 418. The other side of the resistor is connected to printed circuit conductor 420, in turn connected to a second terminal of transistor 104. The third terminal of the transistor is connected to conductive segment 422 (FIG. 32) on the lower connector which cooperates with a similarly tapered conductive segment 424 on the adjacent surface of upper connector 406 to establish electrical connection to the hairspring 46. Specifically, end 412 of the hairspring is clamped between conductive segment 422 on the lower connector and conductive segment 424 on the upper connector. Lower connector 408 is apertured as at 426 and upper connector 406 is apertured as at 428 to pass the screw 410. FIGS. 11A and 12 show details of the watch train. A portion of the drive may be traced from the oscillating resonator coil eccentric through the index lever 56 to the index wheel 58. Energy is transferred from the index pinion 364 in FIG. 11A to the sixth wheel 134, from the sixth wheel pinion 430 to the fifth wheel 136, from the fifth wheel pinion 432 to the fourth wheel 138, from the fourth wheel pinion 434 to the third wheel 140, and from the third wheel pinion 436 to the center wheel 438. Train bridge 196 is secured to the pillar plate by screws 198 and 200 (FIG. 6) and carries bearings 440, 442, 444, and 446 supporting the upper ends of the shafts for the sixth wheel 134, fifth wheel 136, fourth wheel 138, and third wheel 140, respectively. The other end of the shaft for sixth wheel 134 is rotatably received in a bearing 448 carried by pillar plate l20 and the lower end of the shaft for fifth wheel 136 is similarly supported in a bearing 450. Bearing 452 supporting the lower end of the shaft for third wheel 140 is mounted in one end of a rectangular third cock 454 secured to the pillar plate by screw 456 and a pair of friction pins 458 and 460. Carried for rotation with fourth wheel 138 is a friction sleeve 462, also shown in FIG. 5, against which bears the end of friction spring 144 mounted at its other end on post 142. Carried for rotation with the fourth wheel 138 is fourth pinion 434 including an elongated shaft 464 rotatable in center post 466 and including an additional pair of bearing surfaces 468 and carrying at its lower end the seconds hand indicated by dashed lines at 470 in FIG, I 1A. Center wheel 438 has rotatable with it a cannon pinion 472 including a bearing sleeve 474 and carrying at its lower end the minute hand indicated by dashed lines at 476 in FIG. HA. Rotatable with center wheel 438 is the cannon pinion 472 which drives the minute wheel 234 rotatably mounted on pillar plate 120 by a pin 480. Minute pinion 482 in turn drives the hour wheel 232 on the lower end of which is mounted the hour hand indicated by dashed lines at 486 in FIG. 11A. FIG. 12 also shows a cross section through the date indicator drive assembly for driving the calendar ring from the gear train. The watch is constructed so that the calendar ring advances one date every 24 hours by engagement of the drive assembly 230 with one of the calendar ring teeth 222. The engagement of the drive assembly with one of the calendar ring teeth 222 occurs somewhere around midnight and the engagement continues for a sufficient length of time to advance the calendar ring one date after which the drive assembly 230 disengages from the tooth 222 it was driving. After something less than 24 hours, the drive assembly is brought into engage with the next calendar ring tooth 222 (FIG. 6) to repeat the operation and rotate the calendar ring to the next date indication. For this purpose, hour wheel 232, which rotates once every 12 hours, i.e., twice every 24 hours, carries for rotation with it an upper hour gear 488. Rotatably mounted on a pin 490 in the pillar plate 120 and forming a part of the indicator or calendar ring drive assembly 230, which is shown in more detail in FIGS. 33 and 34, is a date indicator drive pinion 492. This date indicator drive pinion is drive by the hour wheel 484 at a fairly rapid rate, which, by way of example only, may cause the date indicator drive pinion 492 to rotate about pin 490 five times every 24 hours. Rigidly mounted to the date indicator drive pinion for rotation with it is a cover 494 which is preferably riveted to the upper end of the pinion and is provided with radial slots 496 and 498 defining radially extending drive surfaces 500 and 502. The normal direction of rotation for cover 494 is in the counterclockwise direction in FIG. 7 as illustrated by the arrow 504 in that FIGURE. Mounted for rotation about the hub of date indicator drive pinion 492 is a date indicator drive wheel 506. The date indicator drive wheel 506 is driven from upper hour gear 488 at a much slower rate, for example, one revolution every 24 hours. Fixedly secured to and rotatable with date indicator drive wheel 506 is an eccentric cam 508. This cam is illustrated in FIG. 35 and is provided with an aperture 510 adapted to be press fit over the hub of date indicator drive pinion 492 so that the cam rotates with the pinion about an axis passing through the center of aperture 510. Rotatable about the outer surface 512 of cam 508 is an index ring 514 shown in detail in FIGS. 36 and 37. The index ring is provided with a large center aperture 516 adapted to be slidably received about the periphery 512 of cam 508. Index ring 514 carries a radially outwardly extending projection 518 adapted to engage and drive one of the calendar ring teeth 222 of FIG. 7 to advance the calendar ring one date. Index ring 514 is also provided with an upwardly projecting pin 520 adapted to be engaged by one of the drive surfaces 500 and 502 of cover 494, conventionally the drive surface 502 when the cover is driven in the counterclockwise direction as illustrated by the arrow 504 in FIG. 7. The elements are originally assembled to assume the position illustrated in FIG. 7 where projection 518 engages one of the calendar ring teeth to drive it to a new date around midnight. The calendar ring is set by the cover 494 which engages pin 520 causing projection 518 to be forced up against the calendar ring tooth 222. Once the calendar ring has been advanced a sufficient amount, projection 518 clears the calendar ring tooth 222 and the date jumper 236 further advances and then holds the calendar ring by engaging two adjacent teeth as illustrated in FIG. 7 to Set the calendar ring to the proper position for displaying the new date. Cover 504 continues to drive pin 520 at a fairly rapid rate, i.e., five revolutions every 24 hours, causing the ring to rotate about cam 508. However, during this time the cam itself is carried for rotation with the date indicator drive wheel at a much slower rate, i.e., for example, one revolution every 24 hours, such that the next time the pin 520 comes around under the influence of cover 494, the cam has rotate sufficiently so that projection 518 on the ring misses the teeth 522 of the date indicator or calendar ring. Each successive time the pin and index ring come around, the cam has assumed a new position such that the projection 518 does not engage a calendar ring tooth 222 until the fifth revolution of the cover (one revolution of the cam) after a period of approximately 24 hours has elapsed, i.e., around the following midnight when the calendar ring is to be advanced to the next date. FIG. 12 also shows a cross section through the rapid set assembly 252 which cooperates with the setting arbor 148 and the setting clutch ISO carried by the arbor. The arbor is con nected to a conventional setting crown (not shown) for movement with it during manual adjustment of the watch. Clutch 150 is shown in detail in FIGS. 38 and 39 and is provided with 15 crown teeth 522 which, as illustrated in FIGS. 7 and 12, continuously engage with the teeth of a setting wheel 524 forming a part of the rapid set assembly shown in derail in FIGS. 40 and 41. Setting wheel 524 is rotatable about a pin 526 rigidly secured to setting lever 258. Secured to and rotatable with the setting wheel 524 is a flat annular ring 526 and a collar 528 spaced above the ring. The collar pivotally receives the pin 530 at one end of a pawl 532, shown in detail in FIGS. 42 and 43. The pawl is of curved configuration to curve about the hub of setting wheel 524 and at its other end carries a projection 534 adapted to engage one of the teeth 222 of the calendar ring and advance the ring one date for each revolution of setting wheel 524. Collar 258 also carries a pin 536 to which is secured one end of a curved spring 538 shown in FIG. 7 which inwardly biases pawl 532 about pivot pin 530. When setting wheel 526 is rotated in a counterclockwise direction in FIG. 7, by rotation of the setting arbor 148, projection 534 engages the calendar ring teeth to advance the calendar ring. Rotation of the arbor in the opposite direction, i.e., causing setting wheel 524 to move in a clockwise direction in FIG. 7, causes the pawl 532 to pivot about pin 530 and slip over the calendar ring teeth 222 against the resiliency of spring 538. Clutch 150 is of the type shown and described in assignee’s copending application Ser. No. 12,210, filed Feb. 19, 1970, and incorporated herein by reference. With the arbor 148 in the innermost position illustrated, clutch 150, which is provided with a ratchet tooth surface 540 as illustrated in FIGS. 38 and 39, engages a corresponding ratchet surface formed by four ridges 542 on a friction washer 544 shown in detail in FIGS. 44 and 45. In this position, the crown teeth 522 on the clutch engage setting wheel 524 so that manual rotation of the arbor rotates the rapid setting mechanism 252 causing the calendar ring to be rapidly advanced, i.e., one date for each revolution of the index wheel. Friction clutch 544 insures that a substantial amount of friction must be overcome to rotate the clutch to set the calendar ring in this position. Furthermore, with the setting arbor in the innermost position, the circuit is closed and the watch is running. When the setting arbor is pulled to it’s outermost of two possible positions, the clutch and rapid setting assembly 252 moves to the positions illustrated in FIG. 8. Setting lever 254 which moves with the arbor, cams against clutch lever 258 moving the clutch radially inwardly towards the center of the watch along with the rapid set assembly 252, also carried by clutch lever 258. In this position, the teeth of setting wheel 524 engage the teeth of intermediate setting wheel 250 (FIG. 12) causing this wheel to rotate about the shank of a screw 546 securing it to the pillar plate 120. When arbor 148 is rotated in this position, the clutch drives the setting wheel which in turn rotates the intermediate setting wheel 254) to rotate minute wheel 234 and set the hands of the watch. In this position, the bar 266, which is preferably of spring material, acts as a brake engaging the teeth 270 of an element of the gear train, preferably the teeth of the sixth wheel, and assures that the substantial resiliency of this spring will not be overcome in setting the hands by slipping the cannon pinion 472 in center wheel 438. It is apparent from the above that the present invention provides an improved timepiece and particularly an improved electronic wristwatch in which an electromechanical resonator which acts as an electrical to mechanical transducer is slaved to the output of a crystal controlled oscillator through a frequency divider. Tuner or tuning capacitor 84 makes it possible to tune the output of the oscillator to the exact frequency desired, in this case 262,144 Hz. At the same time the electromechanical resonator is provided with a hairspring regulator so that the resonator may be independently tuned by the regulator to its desired frequency, which may, by way of example, be 16 or 32 Hz. and in the preferred embodiment is a resonator having a natural frequency of 16 Hz. By independently tuning the electromechanical resonator, it is possible to obtain maximum power transfer through the watch system for optimum energy to the watch hands and minimum drain on the limited power supply available from the small 3 volt battery incorporated in the watch. The resonator is tuned by the hairspring regulator to give maximum amplitude oscillations which assures maximum power to the hands. Oscillation amplitude of the resonator is from about ±90° of its center or rest position to about ±145° and during normal operation, the resonator staff will swing close to 145° to each side of its rest position. The electronic circuit is provided with complementary MOS transistors, also for minimum power drain on the battery. Also incorporated in the watch is an automatic switching device for opening the circuit from the battery to de-energize the electronics when a two-position setting arbor is moved to the hand-setting position. At the same time, a spring brake is applied to the watch train so that the mechanical elements are resiliently braked when the electronic circuit is open. Subsequent rotation of the setting arbor overcomes the friction of center wheel to cannon pinion so that the hands may be set to the desired position. Also disclosed is a novel quick-set arrangement for rapidly setting a date indicator or calendar ring when the setting arbor is in its innermost or normal run position for the watch. This obviates the necessity of first reversing the calendar movement as is required in some constructions and makes it possible to rapidly advance the calendar ring to the new date. Calendar setting is accomplished in a rapid manner such as may be desirable when passing through date zones, at the end of the month, or at times when the watch may have been stopped for a period of as much as several days. A novel automatic drive arrangement acts to rotate the calendar ring in synchronism with the watch train so that the calendar ring is advanced for a short period around midnight of each day to the next date. A friction spring acting on a friction disc connected to the watch train provides a resistance which must be overcome during calendar setting and assures against inadvertent displacement of the setting arbor when the arbor is in the normal run position. The present invention makes possible in a small size commensurate with a conventional size of a wristwatch an electronic device having the significantly improved accuracy of the crystal controlled oscillator. Because of the small amount of energy required, the watch may be driven from a 3.0 volt power supply preserving space and maintaining the relative thinness and small diameter of the watch. The watch train is of optimum construction for minimum power drain and includes an improved assembly for mounting the second hand so that the watch is provided both with date indication and with a sweep second hand (if desired). Finally, by using integrated circuit components in conjunction with a printed circuit board, it is possible to provide a maximum amount of electrical equipment in a minimum size and space as is required for the small construction described. The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiment is therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein. What is claimed and desired to be secured by United States Letters Patent is:

1. An electronic timepiece having sufficiently small size for use as a wristwatch comprising an oscillator for producing a series of electrical timing impulses of precise frequency, a divider coupled to the output of said oscillator for reducing the frequency of the timing impulses, an electromechanical resonator coupled to said divider for converting said electrical timing impulses into a mechanical drive, said resonator including a coil coupled to the output of said divider and mounted for oscillatory motion, a mechanical time display coupled to said resonator, and means coupled to said resonator for adjusting its natural frequency to the output frequency of said divider.

2. A timepiece according to claim 1 wherein said coil is mounted on a resonator staff rotatably supported by bearings at each end.

3. A timepiece according to claim 2 including a hairspring coupled to said resonator staff for sustaining the oscillations of said coil.

4. A timepiece according to claim 3 wherein said coil oscillates between about ±90° and ±145° from its rest position during normal operation of said timepiece.

5. An electronic timepiece having sufficiently small size for use as a wristwatch comprising a crystal controlled oscillator for producing a series of electrical timing impulses, an integrated circuit frequency divider coupled to the output of said oscillator for reducing the frequency of the timing impulses, an electromechanical resonator including a coil coupled to said divider for converting said electrical timing impulses into a mechanical drive, a mechanical time display coupled to said resonator, said coil being mounted for oscillatory motion, a hairspring coupled to said coil for sustaining the coil oscillations, and a regulator coupled to said hairspring for tuning the natural frequency of said resonator to the frequency of the divider output.

6. A timepiece according to claim 5 wherein said resonator is tuned to a natural frequency of about 16 Hz.

7. A timepiece according to claim 5 wherein said resonator is tuned to a natural frequency of about 32 Hz.

8. A timepiece according to claim 5 wherein said oscillator includes a variable capacitor for tuning the output frequency of said oscillator.

9. A timepiece according to claim S wherein said regulator comprises a pair of regulator pins adjustable along the length of an outer turn of said hairspring.

10. A timepiece according to claim 5 including a resonator staff rotatably mounted at each end and carrying said coil, said hairspring being coupled to said staff and establishing electrical connection to one end of said coil, and a second hairspiing coupled to the other end of said resonator staff and establishing electrical connection to the other end of said coil.

11. A timepiece according to claim 10 wherein said hair- spring coupled to said regulator is substantially stronger than said second hairspring. 12. An electronic timepiece according to claim 5, wherein said time display comprises a plurality of watch hands, said resonator including an eccentric, an index wheel, a lever pivoted at one end to said eccentric and having a jewel at its other end driving said index wheel, and a gear train coupling said index wheel to said watch hands.

13. A timepiece according to claim 12 including a pawl bridge, a pawl mounted on said bridge and engaging said index wheel, and means for adjusting said pawl bridge about the rotational axis of said index wheel to balance the stroke of said lever.

14. A timepiece according to claim 12 including an index lever guide having a bifurcated end received over said lever to restrain said lever against excessive lateral movement.

15. A timepiece according to claim 12 wherein said hands comprise a sweep second hand, a minute hand and an hour hand, said watch train including a fourth wheel coupled to said second hand, a center wheel coupled to said minute hand and an hour wheel coupled to said hour hand.

16. A timepiece according to claim 15 wherein the drive through said watch train is from said index wheel to a sixth wheel, from said sixth wheel to a fifth wheel, from said fifth wheel to said fourth wheel, from said fourth wheel to a third wheel, from said third wheel to said center wheel, from said center wheel to a minute wheel and from said minute wheel to said hour wheel.

17. An electronic timepiece having sufficiently small size for use as a wristwatch comprising a crystal controlled oscilla30 tor for producing a series of electrical timing impulses, an integrated circuit frequency divider coupled to the output of said oscillator for reducing the frequency of the timing impulses, an electromechanical resonator including an oscillatory coil and a hairspring for converting said electrical timing impulses into a mechanical drive, a mechanical time display coupled to said resonator, a regulator coupled to said hairspring, and a printed circuit board mounted in said timepiece, said printed circuit board carrying said oscillator and said integrated circuit divider and including printed circuit leads establishing electrical connection between the oscillator and divider.

18. A timepiece according to claim 17 including a driver coupling said divider to said resonator coil.

19. A timepiece according to claim 18 wherein said oscillator, divider and driver each include integrated circuit components contained in a common integrated circuit package mounted on said printed circuit board.

20. A timepiece according to claim 19 wherein said integrated circuit components comprise complementary pairs of MOSFET transistors.

21. A timepiece according to claim 17 including a battery, a fixed contact on said circuit board electrically coupled to said oscillator and divider, and a manually movable switch coupling said battery to said fixed contact.

22. A timepiece according to claim 21 wherein said switch comprises a switch spring having one end resiliently engaging one side of said battery.

23. A timepiece according to claim 22 including a setting arbor, said switch spring having a second end with a contact movable into and out of engagement with said fixed Contact, and means coupling said arbor to said second end of said switch spring whereby said second end of said switch spring is moved in accordance with the position of said arbor.

24. A timepiece according to claim 23 wherein said contacts are open when said arbor is in its outermost position.

25. A timepiece according to claim 24 including a clutch and clutch lever coupled between said arbor and said spring, said movable contact being actuated by said clutch lever.

26. A timepiece according to claim 25 including a watch train coupling said resonator to said display, and a setting wheel coupling said clutch to said train whereby the display may be adjusted by rotation of said arbor in said outermost position.

27. A timepiece according to claim 26 including a brake spring movable with said clutch lever for engagement with said train when said arbor is in said outermost position.

* * * * *