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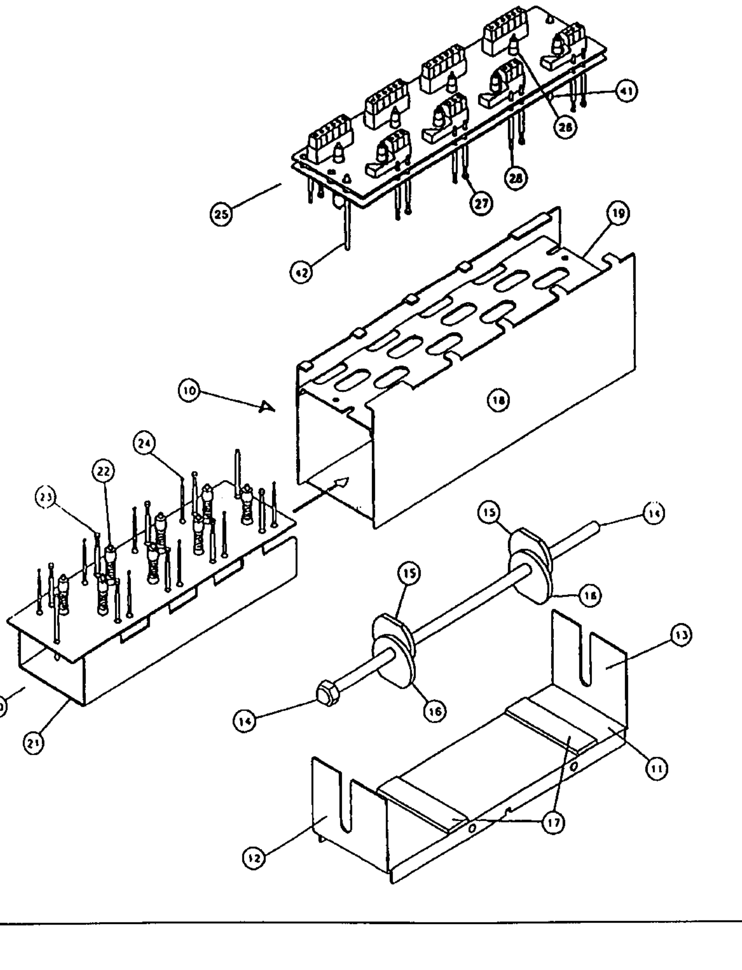
(54) Title: BATTERY TEST SYSTEM

(57) Abstract

This disclosure sets out a multiple battery tester having a tray loaded with a set of batteries. The tray is placed in a receptacle and end located terminals move vertically to clamp a battery. The contacts bear on the battery, establishing a current flow path. This loop connects in charge/discharge system for testing. Test routines can be varied and data is recorded over time.



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BATTERY TEST SYSTEM

FIELD OF THE PRESENT DISCLOSURE

This disclosure is directed to a battery testing system, and more particularly to a battery testing system which is constructed and arranged to test a large number of similar battery cells in a test of many cells simultaneously. It is intended to be used with a large manufacturing facility to provide either testing of samples or testing of the entire production thereof.

BACKGROUND OF THE DISCLOSURE

This disclosure is directed to a battery testing system. It is a testing system which is intended to be used with batteries of all types, sizes and shapes. Examples of batteries that can be tested are the high volume, low cost batteries having a nominal cell voltage of 1.5 volt DC and which are provided in cylindrical shells conforming with industry standards for batteries such as AA, AAA, B, C and D. While there are many other sizes, these are typical of the elongate cylindrical battery which has a positive terminal at the upper end and a negative terminal at the lower end. That is a first or representative size. In addition to that, there are circular batteries shaped more as a button. The positive terminal is at the upper end and the negative terminal is at the side of the button. While cylindrical, the diameter is usually two or three times greater than the thickness. Testing of cylindrical and button cells will be the primary examples, but that is not intended to exclude testing of rectangular batteries which have two terminals on the top end. These contrast with the AA cells or the button type cells (type PX625 cells) in that they may readily include two or more cells in a single housing which are connected so that they provide a desired terminal voltage which is higher than 1.5 volts. For instance, a 12 volt cell is comprised of eight serially connected individual cells which are assembled in a single structure in a single housing having one pair of terminals. Such multi-cell batteries providing higher voltage than 1.5 volts will be denoted hereafter as HVB (meaning multi-cell or high voltage batteries). It is assumed that the A, B, C and D cells can be exemplified by a particular dimension such as the AA cell, and that will be denoted hereinafter as the AAB meaning a single voltage cell of cylindrical construction conforming with the AA standard. Button shaped batteries will be known hereinafter as BB representing button batteries.

Other types of batteries can also be tested and that includes NiCd batteries, lithium type batteries, and others which happen to be rechargeable. Accordingly, the test equipment and several of the test procedures set forth below apply to batteries which are capable of multiple charges, i.e., they can be recharged. It also applies to those which cannot, namely, chemical cells which undergo an irreversible chemical conversion and are no longer chargeable.

It is not uncommon to manufacture several thousand AAB per hour. Indeed, they typically must be manufactured in large volume to be able to profitably make such batteries. Further, it is not uncommon to make a large number of batteries which pass all requirements for the particular quality control standards applied to a particular battery. Occasionally, something will go wrong with the manufacturing process. For instance, the chemicals which make up the AAB may be off standard. The assembly may be erratic and sub standard batteries are then made thereby. It is not uncommon for this to happen thereby causing the manufacture of a large number of defective batteries. When that occurs, the defective batteries need to be screened and not shipped. While the manufacturer can tolerate shipment of an occasional battery which is defective, either in terminal voltage or life, it is highly desirable that the manufacturing process be controlled with sufficient quality control (QC) that specified high QC standards are met. This involves substantial testing. Whether random individual units are tested or the entire production run, routine QC testing is helpful. In one aspect of the present disclosure, testing is enabled for all levels of QC including random or sampled selection at one extreme to testing of the entire production run at the other extreme. The present apparatus is a system which enables such testing. It will be described in the context of making perhaps 100,000 or more AAB during a production run.

FIELD OF THE PRESENT DISCLOSURE

In the production of small batteries, it is necessary to test at least selected samples of a manufacturing run. Sometimes, it may be important to test every battery made in a manufacturing facility. It is not uncommon for a manufacturing plant to manufacture batteries in any number of sizes. To be sure, there are common sizes such as a D cell, or perhaps an AA cell. In both instances, they are constructed as elongate cylindrical bodies with terminals at the opposite ends. They do, however, differ in diameter, and just as importantly in terms of testing, they can differ in thickness. They are constructed with positive and negative terminals which are at opposite ends. The terminal spacing will vary with length. The battery contact assembly of the present disclosure enables a single test assembly to accommodate batteries over a wide range of sizes and shapes. In a first embodiment, positive and negative contact terminals are deployed opposite one another and are positioned to clamp against the positive and negative terminals at the ends of the batteries. This is accomplished without regard to the length of the cylindrical battery. Testing is accomplished for longer batteries as well as those which are shaped like a button. Indeed, there are a number of extremely short batteries, those shaped like a button or small disk.

For testing, it is necessary to connect to the battery terminals with a high quality connection. The quality of the connection is normally assured by controlling the spring force of the spring which forces the battery contact against the terminal. Elaborating, suitable contact with test terminals is required to assure that accurate test data can be obtained. Should the contact force be outside a desired range, false readings may be obtained because the contact is not sufficient to enable full current flow between the battery terminal and the battery contact. The contact assembly of the present disclosure provides appropriate contact to the battery. Moreover, it is an adjustable structure which can be set momentarily for a specific length of battery and yet which will maintain that length for many cycles of testing. Later, when testing another battery length, the test assembly can be adjusted so that the length of the battery is accommodated. Since battery production usually involves thousands of batteries per day, it is sometimes desirable to replicate the test equipment. In one embodiment of the present disclosure, several units are deployed together for testing of several batteries. Again, they collectively can be adjusted to accommodate first one battery length and then another.

In a second embodiment of the present disclosure, all battery terminals are located at one end of the battery. In that instance, the battery can be rectangular, square or circular in cross-section. The battery construction features two terminals as before but they are deployed at only the common end.

Battery testing involves substantial current flows. The current flow must be provided through some kind of test circuit. Such a test circuit features two aspects, one being a load for the battery and the other being a current source. Batteries must be tested by providing timed charging current and discharge current in typical tests. Such tests are calculated to test the quality of the battery production. Therefore, a current is drained from the battery. Another aspect of testing is applying a current to the battery. These are controlled for a timed interval at selected current levels.

SUMMARY OF THE INVENTION

The present disclosure sets forth a highly effective tray which holds a number of the AAB aligned for testing. Each AAB is inserted into a tray and is held in the tray. They are aligned so that the positive terminal at the upper end and the negative or ground terminal at the lower end are appropriately registered with respect to the test equipment, and testing is thereafter initiated.

The present disclosure sets forth a mechanism which loads a number of batteries into trays and positions them between appropriate probes or contact assemblies. Consider a typical AAB; it is necessary to make firm contact at a consistent location typically on the centerline axis. The centerline axis is best to assure that there is no variation from battery to battery resultant from the point of contact by the probe assembly. Just as importantly, high quality contact must be obtained at both ends of the AAB. More than that, it is necessary to have a sure and certain contact of the probe assembly for the electric current which is required to be drawn from the battery for test purposes. Another probe assembly, preferably concentrically arranged, is involved in testing the cell voltage. The voltage contact does not require an equal current handling capability. The present structure sets forth a system which operates both the current and voltage probes. They are properly aligned so that they contact jointly and provide both signals, i.e., a current signal and a voltage signal. While the foregoing is true of the one probe, the opposite end of the AAB must contact a current return probe. These are at opposite ends of the AAB, and must be aligned so that they move vertically along a common line of travel. This common line of travel is accomplished mechanically by the equipment to be described and yet is done without the entanglement of a number of cords, wires or harnesses. Assume for instance that two batteries are loaded in a tray and are tested simultaneously. Ordinarily, this would require two wire loops, one for each battery, so that a current flow pathway can be defined through the individual battery loops extending from top to bottom of the AAB. If the tray, however, is loaded with 100 batteries, this would require 100 loops. The present disclosure avoids that requirement, i.e., it defines a system which does not need 100 loops or, indeed, does not require any wire loops. Rather, current transfer is accomplished through a different route altogether to thereby avoid wire loops.

One deleterious aspect of battery testing is that batteries occasionally fail by rupture of the case, flowing either liquid or tacky chemicals downwardly, and otherwise risking damage to the equipment located there below. The present system utilizes a tray which mounts the batteries for contact from below. The contact mechanism, however, does not include a printed circuit board (PCB). The equipment below the battery can withstand a good deal of abuse. The abuse does not pose any great risk because leaking or exploding batteries will not detrimentally damage the equipment nor will it deter its safe operation. Spillage of corrosive chemicals from the system can be readily tolerated. In one aspect of the present invention, the system incorporates a tray mounting mechanism which traverses the machinery and moves the tray of batteries upwardly and downwardly into contact. This mounting system operates between retracted and extended positions so that the mounting tray for the batteries serves as a carrier for a large number of batteries undergoing tests. The tray is mounted so that the machine can be opened, the tray inserted readily and easily, and then all the batteries on the tray are tested. They are tested as a unit or group. This means that simultaneous testing of some number of batteries, preferably a large number, can be obtained quickly. In that regard, each tray, therefore, preferably holds a relatively large number of batteries, a typical example for an AAB being a tray of perhaps two or four batteries in width and any length that might be desired. It is not uncommon to test as many as forty batteries at one time although the number can be varied upwardly or downwardly depending on the size of the tray which, in turn, is at least partly dependent on the size of the battery being tested. For an AAB, it is possible to load a relatively large number on a single tray.

The present disclosure additionally sets forth a monitoring scheme which observes battery temperature during testing. It is possible for a battery to provide successful performance, as measured, but the performance is more readily known and understood by measuring the temperature with the temperature probe applied to either one battery or to each of the several batteries. This obtains measurements which are useful in determining QC performance, and it may also be useful in preventing damage in the event that a battery overheats rapidly, well nigh approaching the explosive condition.

This disclosure is directed to a battery terminal clamp apparatus so that proper contact with battery terminals is made. Variations in size are accommodated. The system enables the tester to releasably clamp to and then release batteries during repetitive testing. Changes in battery length are accommodated by the test equipment. A first embodiment handles batteries with terminals at opposite ends while a second version tests batteries where both terminals are at a common end.

BRIEF DESCRIPTION OF THE DRAWINGS

So that the manner in which the above recited features, advantages and objects of the present invention are attained and can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to the embodiments thereof which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

Fig. 1 is an exploded view of a battery tray transport mechanism for testing a large number of batteries simultaneously;

Fig. 2 is a view of the battery transport mechanism shown in Fig. 1 further incorporating a battery tray for holding a plurality of batteries for testing;

Fig. 3A is an end view showing cam operation wherein the tray has been appropriately aligned and loaded but prior to movement and further showing the position of a set of contacts above and below the batteries;

Fig. 3B is a view similar to Fig. 3A showing the position of the contacts within the tray and batteries in the tray so that complete circuits are completed;

Fig. 4A shows a pair of concentric probes in an extended position which are mounted in a socket on a printed circuit board;

Fig. 4A is a view similar to Fig. 4A showing contact of a battery against the probe assembly in Fig. 4A wherein two separate contact paths are made;

Fig. 5 shows the electrodes connected to the probe assembly of Fig. 4A which are extended through the printed circuit board and illustrates the conductive paths on the printed circuit board;

Fig. 6 shows current flow paths for testing many batteries and illustrates current flow paths involving the battery terminals, probe contacts, battery tray and parts adjacent to the batteries to form a rigid electrical path.

Fig. 7 shows progressive movement to lock the tray to assure contact closure;

Fig. 8 shows one test schematic for testing several batteries using a multiplexed measuring system;

Fig. 9 is a front view of a battery test clamp apparatus for contacting battery terminals at the top and bottom and further illustrating a system for accommodating batteries of different lengths;

Fig. 10 is a side view orthogonal to the drawing of Fig. 9;

Fig. 11 is a sectional view along the line 11-11 of Fig. 9 showing the bottom side of an upper mounting board;

Fig. 12 is a top view of the mounting board shown in Fig. 11 and is taken along the sectional cut line at 12-12;

Fig. 13 is a bottom view of the bottom board shown in Fig. 9;

Fig. 14 is an enlarged sectional view along the line 14-14 of Fig. 9 showing an adjustable clamp on a current conducting rod;

Figs. 15 and 16 are the front and bottom views of a multiple battery testing unit showing the first embodiment for testing simultaneously several batteries;

Fig. 17 is a view similar to Fig. 9 showing a second embodiment for testing batteries where both battery terminals are at one end of the battery; and

Figs. 17, 19 and 20 show another embodiment having adjustable width contacts and also show changes in board spacing.

DESCRIPTION OF THE PREFERRED EMBODIMENT

While the foregoing summarizes one preferred embodiment of the present invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof, the present invention is exemplified below. In describing the apparatus of the present disclosure, the description will initially start on a battery tray which is intended for testing a large number of batteries simultaneously. It will be described so that the tray is loaded with a number of similar cells. A common cell such as the AAB will be used for illustrative purposes. The primary description will start with the mechanical aspects. Thereafter, the current flow paths through the AAB test cells will be given. Thereafter, other aspects of battery testing will be set forth. Since all the testing involves the proper indexing of individual cells, the cells must be initially loaded and moved into the test equipment, the test equipment will be given first and electrical testing protocols will be set forth later.

BATTERY TRAY AND TRANSPORT MECHANISM

Attention is jointly directed to Figs. 1, 2 3A and 3B which will be considered together. They set forth the transport mechanism in general and the battery tray which is loaded into it for testing of a set of cells. This is best understood by referring first to Fig. 1 of the drawings. This exploded view shows a vertical motion transport mechanism which moves individual batteries upwardly. It is best understood proceeding from the bottom of Fig. 1. Accordingly, Fig. 1 shows the battery transport mechanism 10 for loading a battery tray and moving the tray into a specific position. In the lower portions, there is a mounting bracket 11 which is fixedly anchored in a cabinet. It has front and rear upstanding tabs 12 and 13 which are aligned in parallel positions above the mounting frame member 11 to receive and support a cam shaft 14. The cam shaft supports at least a pair of spaced cams, there being two similar cams 15 rotated into one position and two different cams 16 which are rotated to a different angle. The cams 15 and 16 have flats on them which are located 180° out of phase. The cam shaft 14 is positioned in the matching notches in the alignment tabs 12 and 13 where the shaft is supported for rotation. The cams are mounted at an eccentered point so that the cam shaft 14 is raised as a result of rotation during operation. This will become more clear on review of Figs. 3A and 3B of the drawings. The cams are located so that they lift by contact against the frame 11 with contact against the contact plates 17 mounted on the frame 11. The upward movement will be correlated to the other components shown above the cam system in Fig. 1 of the drawings.

Fig. 1 shows, at a central location, a hollow elongate lower contact box 18. It is hollow to receive a rectangular member which is inserted into it and which aligns with selected holes in the top plate 19. The bottom contact assembly 20 is shown in the exploded relationship and is inserted into the hollow box 18. The bottom contact assembly 20 is constructed with a bottom plate 21 which is aligned above and, therefore, raised by the cams 15 and 16 just mentioned. The bottom plate 21 serves as a cam follower to raise and lower the lower contact assembly. The lower contact assembly 20 is guided so that a number of upstanding components on the top of it are properly aligned for movement into operative contact with a set of batteries. The contacts include, specifically, contacts 22 which bear against the AAB to be tested, and current flow contacts 23 arranged along the edge. There are also voltage contacts 24 arranged along the edge. The system is constructed so that there are separate current flow paths for each particular AAB undergoing tests, and also there are separate voltage contacts for each. The current flow path is structurally heavy duty in comparison to the gauge or weight of metal in the voltage contacts. The current flowing in the voltage contacts 24 is relatively small but it is sufficient to provide an adequate voltage signal. The current flow rates differ by several orders of magnitude. It is not uncommon for the current in the voltage contacts to be in the microampere range. The contacts 23 and 24 are located marginally along the edges for alignment with and connection to cooperating components to be explained.

Recalling that the lower contact assembly 20 is inserted into and aligned under the plate 19, the upper contact assembly 25 is placed above it. The upper contact assembly has the preferred form of a number of centerline contacts 26 which connect at the centerline axis of each of the test cells. They are deployed so that they align with the AAB cells undergoing tests. Each particular cell is thus contacted at the centerline both from the top and bottom.

The top or upper contact assembly 25 is constructed with a set of marginally located contacts 27 and 28. Again, the contacts 27 and 28 differ in size or scale just as the contacts 23 and 24 for the lower contact assembly.

As described to this juncture, important details have not yet been given with regard to the contacts marginally located along the sides of both the lower and upper contact assemblies. Also, the contacts actually bearing against the test cells have not been detailed. Details will be given below. The significance of the placement, however, should be more readily understood on viewing Fig. 2 of the drawings which is the same exploded view as shown in Fig. 1 except that the battery tray 30 has now been illustrated and it is located in a sandwiched relationship by the contact assemblies which are above and below. Going to that part of Fig. 2, the battery tray 30 locates a number of AAB cells 32 which are clamped in the structure, thereby resting on a bottom plate 33, having the lower end captured in an alignment plate 34 and they extend upwardly through the top plate 35. The plates 33 and 34 are parallel and have different size openings in them to thereby enable the individual cells 32 to rest on the plate 33. The cells cannot lean or cant to the right or left because they are captured in the plate 34. The two plates provide a recessed area where each cell is supported and is not free to move left or right. The several plates are held together by a set of alignment posts 31 which extend vertically between the plates to define a rigid structure, namely, the battery tray 30. The battery tray is complete as illustrated to define a passive device which merely holds or racks a number of AAB cells loaded prior to testing. As illustrated, eight are shown in Fig. 2 but it will be understood that this number can be markedly increased. This depends on the size of the individual cells, the length of the battery tray 30 and other scale dimensions which can be varied by one of average skill in the art. Just as the number of cells is varied, and that number is a whole number positive integer N, the contacts in the lower contact assembly and the upper contact assembly must match. The lower contact assembly 20 as well as the upper contact assembly 25 are replicated according to the same scale factors.

Summarizing what has been said to this point, Figs. 1 and 2 show how N of the AAB can be aligned and held as a unit or group for testing. The battery tray 30 is loaded remote from the equipment, and is then inserted and captured between the lower and upper contact assemblies 20 and 25. The cam is then rotated by rotating the shaft 14 to raise the battery tray as will be understood on viewing Figs. 3A and 3B of the drawings. Fig. 3A shows the cam 14 supported in a cabinet or housing member 38 which is provided with an alignment slot 39 for capturing the cam. This supports the external frame 40 extending upwardly and aligning the battery tray 30 so that it can be inserted and moved. This moves as a unit with upward translation as shown progressively in Fig. 7 of the drawings. Fig. 7 shows five different positional locations of the battery tray 30 that result from rotation of the cam. From the left, the cam is shown rotated at 0°, 45°, 90°, 135° and 180°. The tray 30 is raised progressively. As it is moved upwardly, the individual batteries 32 are then moved into operative position. It will be observed that the upper contact assembly 25 bears against the individual batteries 32 at the respective locations aligned with the battery cells. The AAB 32 are thus moved to a location for convenient testing. The N cells move together for testing. As shown in Fig. 3A, the battery tray 30 moves into operating proximity of one alignment pin 41 and then a second pin 42 which jointly register the battery tray 30 properly with the upper contact assembly 25. As further shown in the progression of the five views of Fig. 7, two sets of contacts are brought to bear against each of the batteries. The contacts along the outer edges of the upper and lower contact assemblies are also involved. They will, however, be discussed separately in conjunction with a description of the mode of operation shown in Figs. 3A and 3B.

BATTERY CONTACT MECHANISMS

Attention is now directed jointly to Figs. 3A and 3B. The battery tray is located between the two contact assemblies 20 and 25. In Fig. 3A, no contact has been made. Construction of the tray to obtain contact alignment should especially be noted. The top contact assembly 25 incorporates an upper printed circuit board (PCB hereinafter). The PCB 44 is parallel to the PCB 45, and they assist in maintaining parallel alignment in the various components. There are edge located contacts and one is exemplified at 27. As a generalization, the edge located contacts 27 and 28 are similar in construction and differ primarily in the size of the contacts at the tip. Where greater current is required, they are larger in diameter. They operate in the same fashion. The tray 30 is constructed with the upstanding post 31 which extends from top to bottom of the tray. The post 30 is incorporated for structural rigidity of the tray but it also provides the added function of being a current conductor. This is isolated electrically by means of the insulation which makes up the PCB which comprises framing members of the tray 30. The tray is rectangular and rigid and is therefore easily aligned when inserted into the test equipment. As previously noted, the tray is comprised of the parallel structural PCB members 33, 34 and 35 which are held in the properly aligned relationship by the upstanding posts 31.

Going now to Fig. 3A and in particular the contact assembly 20 which is located below the tray 30, this particular contact assembly is equipped with similar contacts as the upper contact assembly. An example is shown at 23 where a current contact assembly along the marginal edge of the tray is illustrated. More will be noted regarding that contact assembly and its operation.

SEPARATE VOLTAGE AND CURRENT FLOW PATHS

Separate current flow paths are provided for voltage and current measurements. Separate paths have an advantage which should be noted. Briefly, the current flow during a test may be several amperes while the current flow in the voltage measurements will be in the microampere range. Easily, the difference can be many orders of magnitude. This creates a problem with regard to obtaining a reference point for the measurements. For that reason, the contact assemblies 22 and 26 are shown in Figs. 1, 2, 3A and 3B. Going now to Fig. 4A, added detail is illustrated to set forth important aspects of the battery contact assemblies and in particular the dual contact mechanism.

In Fig. 4A, a contact assembly 60 is shown. It is mounted on a PCB 61. The mount is obtained from a socket 62 which has several metal stakes 63 which extend through the holes in the PCB and which are folded on the opposite side to lock the socket in place. The several stakes 63 extend through a conductor pad 64 which is large in size to define a current flow path. It is especially intended for large current levels in comparison with a smaller current conductor path 65. That conductor path is located on the centerline location and connects through a hole 66 to make connection with the center contact as will be described. The socket provides a detent 67 for snapping in place. The socket holds the dual probe assembly in the socket by snapping at the detent.

Considering the socket in Fig. 4A from the centerline, there is an inner probe 70 which is formed of conducting metal. It is received inside a metal sleeve 71 and the sleeve 71 provides electrical continuity. The probe 70 terminates at an enlargement 72 which telescopes inside the sleeve 71 and is forced upwardly by a compressed coil spring 73. It moves upwardly until it locks against the shoulder 74 which limits travel. The conductive sleeve 71 is conductively in contact with a plug 74 at the lower end and a conductive point 75 which connects with the conductor 66 through the hole formed in the PCB 61. This serves as a voltage signal path. The current which is conducted through this signal path is small, typically in the range of just a few microamperes. Moreover, it is insulated from the outer current flow path by a non conductive sleeve 76 which is supported on an integral insulative base 77. The base provides alignment for the insulative sleeve 76.

While the foregoing describes one conductor pathway, another pathway comprises the contact 80 at the outer end. It is much larger and has a very large footprint. It is sized so that it will conduct a large current flow. The contact 80 is built in an integral construction with an enlargement 81 which is concentric about the equipment for the voltage contact. The enlargement 81 has a downwardly facing shoulder which abuts against a coil spring 82. This spring forces the enlargement 81 upwardly against the shoulder 83 which limits travel. The coil spring 82 is supported on the insulative base 77. Current flow is transferred from the contact tip area 80 through the enlargement 81 into a surrounding sleeve 84. The sleeve 84 snaps to the socket 62 and current flows through the socket and to the opposite side of the PCB 61. In theory, both probes 70 and 80 are contacted against the same battery at the same terminal. They, however, have entirely different functions. A voltage signal is provided by one while the current flow is transferred out of the system by the other. The current flow in the two may differ by several orders of magnitude. They connect to different circuit components through the PCB pads 64 and 65 which are electrically insulated from each other.

Figs. 4A and 4B together show how contact is made by the contacts 70 and 80. Moreover, this contact can involve either end of the battery. As shown in dotted line, it can be contact with the centerline button which is the positive terminal on a typical flashlight cell. Likewise, however, it can be contacted against the bottom of the battery which is typically the negative terminal. It works in both instances.

Going now from the contact assembly to the deployment of the contacts shown in Fig. 3B, the following significant aspects need to be noted. Consider the fact that in Fig. 3B, the lowermost centerline probe 22 is constructed in accordance with Fig. 4A and therefore provides a large current flow through the conductor pad 64 on the back side of the PCB. That current is directed to the marginal edge where it is then delivered upwardly through the compressible probe 23 on the left side of Fig. 3B. Current flows through the compressible contact at the tip of it. That current is directed into the conductive pad 90 on the bottom side of the PCB 33. That current is then directed through the upstanding post 31 to the pad 91 on the top face of the PCB 35. In turn, that makes contact with the contact assembly 27 which completes a circuit along the left hand side of Fig. 3B. The contact assembly 27 in turn connects with a plated conductor 92 on the top of the PCB 44. In turn, that is directed to the relay assembly 48 incorporated on the PCB 44 to switch current and voltage connections as will be explained. Optionally and under control of the relay 48, current is also able to flow downwardly through the centerline contact assembly 26 which is incorporated for contact with the centerline axis of the battery.

Considering what has been stated about Fig. 3B to this point, there is an optional short circuit completely around the battery which is comprised of the upstanding post 31 parallel to the battery and which makes connection through the various contact assemblies. From the positive battery terminal, the current flow path is through the current contact assembly 26, across the PCB 44, through the contact assembly 27, to the conductive pad 91, then the post 31, then the pad 90, then the contact assembly 23, along the pad 64 and into the centerline probe assembly 22. Some testing will require the imposition of a short across the battery. Even when that does occur, the voltage probe 70 shown in Fig. 4A is able to make contact at both terminals of the battery so that voltage measurements are obtained. The voltage signal measurements are routed through similar contacts and posts 31 but they are directed along different routes. To this end, a single battery is aligned with centerline contact assemblies 22 and 26 below and above the battery. These, however, provide two signals, one being the current flow and the other being the voltage signal. Two paths are therefore arranged parallel to the battery. One path is the current flow path and the other is the voltage signal path. Both paths connect optionally through the relay 48 which is operated to change the connections of the current flow path and the voltage flow path. These two connections are altogether different depending on the operation of the relay 48. One important aspect of this construction is that it is completely devoid of wired connections. Without wiring, all connections are made through the PCB connections on the various PCB layers. As viewed in Figs. 3A and 3B, there are simply no wires to connect. This is an important aspect of the system. It is important because a wiring harness at this location is suspect. The range of travel of the contact assemblies is fairly large. Moreover, such wiring will fail because of repetitive opening and closing which creates fatigue in the wiring. In another aspect, the wiring may fail because the wiring is exposed to unwanted chemical damage as a result of failure from time to time. When a battery does fail, the chemicals within the shell will leak or bleed onto the wiring.

More importantly, not only is the system devoid of wiring, but it provides two separate signal paths. One is devoted to the current flow and the other is directed to the voltage signals.

RELAY ACTUATED TEST CONTROL

Attention is now directed to Fig. 6 of the drawings. This view shows a connection of several batteries in the tray 30 and the circuitry which is involved with the several batteries. As shown in Fig. 6, the battery tray 30 supports several identical batteries 32. As will be understood, the precise number can be increased substantially without limit. More specifically, it shows the lower contact assembly 20 which includes the centerline contact probe 22. Recall that this has two electrodes in it. One is the smaller electrode which provides a voltage point while the other is the larger surrounding external contact or electrode which provides a current flow path. As depicted in Fig. 6, they connect with conductors extending to the side under each battery. As specifically implemented, these lateral conductors are not wires but they are leads placed on the PCV as previously described. They cooperate with the marginal or edge located contact assemblies 23 and 24. In turn, they connect with vertically aligned posts on the tray 30 which are used to provide tray rigidity and which also provide the important auxiliary function of providing the needed current flow paths and signal paths. The upper contact assembly 25 is also shown. In it, the centerline contact assembly 26 which is structurally the same as the contact assembly 22 is positioned above the center electrode on the battery 32. Again, the marginal edge located contact assemblies 27 and 28 are also illustrated. While Fig. 6 is shown with conductors, they are nevertheless deployed on a PCB as discussed. The several conductors connect then with a relay 48 which is located above the battery 32. While the tray 30 will hold N of the AAB, there are N relays 48 located in immediate proximity to the N batteries. The wiring shown above the batteries in Fig. 6 is accomplished by means of paths along the PCB. Fig. 6 shows current flow lines 50 and 51 which are connected together by a switch 52. The switch 52 can readily be an SCR or relay or hand switch. It is preferably accomplished with electronic control. For the tray 30, there is an ammeter 53 and a companion volt meter 54 is connected to one of the batteries through a multiplexer 55. The multiplexer 55 enables the volt meter to be selectively connected at different locations.

The relays 48 are provided with a control signal for each relay. They can be switched so that the current flow line 50 is connected within to deploy the several batteries in series or in parallel. Alternately, the relays can be operated to provide a dead short across the terminals of the battery 32. In the later instance, it is desirable to direct the current flow through the ammeter 53 in which instance the ammeter 53 is connected between the conductors 50 and 51. The relay 48 thus determines the test that is actually applied to the individual battery. A positive charging current can be provided to the battery, or a negative charging current can likewise be provided. A short can be deployed across the battery. The charging currents can be directed to the batteries either in parallel or in series. Numerous test routines can be implemented through the use of the relay 48 which is assigned to the particular battery located just below it, referring to the physical location of the relay as shown in Fig. 3A.

Fig. 6 has been enhanced at one location to show an optional added feature. A resistor has been shown adjacent to one of the batteries. The resistor is preferably a thermistor which operates as a heat sensor. It measures the heat build up in the battery. It is preferably located on the tray 30, but location at that point requires the implementation of the spring loaded compressible contact assemblies that are used for the voltage signal transfer from the battery tray 30 to the lower contact assembly 20 and then to the upper contact assembly 25. It is preferable that the signal be taken out through this route because it is easier to install signal paths on the PCB located above the upper contact assembly 25. Recall that the lower contact assembly

20 has to levitate when actuated. The upper contact assembly is not required to move and therefore the signal flow path includes the illustrated contact assembly which communicates in the same path as discussed with regard to Figs. 3A and 3B. The thermistor 47 is thus provided with battery tray located PCB contact pads 47a which enable the compressible contacts 47b in the lower probe assembly to make contact and obtain the signals. In turn, those signals are conducted to edge located pads 47c on the lower probe assembly. In turn, they connect with the upstanding posts and associated pads. These are indicated at 47d. In turn, those connect with the contact assemblies 47e in the top contact assembly 25. The signal flow path (having the form of two PCB conductive paths), is directed out to a calibrated electronic thermometer 47f.

TEST PROCEDURE INVOLVING BATTERY CHARGING

One aspect of the present battery test system is the use of the battery tester to carry out charging tests. While this is not pertinent to many types of batteries, it is very important to rechargeable batteries and especially those which are often described as lithium batteries. This relates to testing so that the battery can be proved to accept recharging in the proper time interval. Moreover, this involves charging with a large number of batteries so that all can be tested in a batch. Again, the battery test apparatus, which is shown in mechanical detail in Fig. 1 and other aspects of the present disclosure, is ideally used. As will be understood, the relays which operate the individual batteries have to be switched so that several of the batteries are connected in series. That will be made more clear in a description of the test procedure set forth below. The mechanical support for the batteries undergoing this test is, therefore, implemented in the manner set forth in the other drawings of the present disclosure.

A typical lithium battery is charged and recharged many times during the life of the battery. The ability of the lithium battery to hold a particular charge is important. In this aspect, the ability of the battery to receive the charge, which is administered in the proper fashion, becomes important. Individual testing of an individual lithium battery is quite tedious. Each battery must be charged at a controlled rate of current over a time interval. After the charging current has been applied, the cell voltage is measured while the charging current is supplied to it so that the charging current times out, i.e., the requisite charging current can be stepwise decreased while charging to the maximum desired in a specified time window. Restated, the test involves applying a charge to the battery from an adjustable voltage, adjustable current source. After a specified interval, the total charge stored in the battery should be a specified value which is indicated by a decline in charging current measured in conjunction with the desired terminal voltage. This can be explained graphically as will be set forth in detail on reference to charging curves for an individual battery.

When many batteries must be charged, and then tested, the test could become quite tedious. While the test for a single battery might take many minutes or even hours, thereby tying up expensive test equipment, the test procedure is applied to a multitude of similar batteries so that they can be charged in series, tested and the data reported for all of the several batteries. This enables more efficient use of the capital equipment involved in charging and testing. For sake of nomenclature, an individual chargeable battery will be labeled B1. That refers to an individual chargeable cell such as a lithium battery. Several are made in a production facility so that several are connected in series, the series involving the batteries B1, B2, B3 and, BN where N is a whole number positive integer.

Attention is now directed to Fig. 8. Fig. 8 is a circuit which will be first described and examples of operation will be given. Therefore, attention also is directed to Fig. 9 which includes several curves. Beginning, however, with Fig. 8, several batteries are in a tray 30 connected in parallel or series and are indicated by the symbols B1, B2 and BN. They are connected and charged in series or parallel dependent on test needs. The system shown in Fig. 8 is generally identified by the numeral 250. It includes an adjustable voltage and current power supply 251. This is connected at a selected terminal to form an output current which is applied to the first battery B1 and perhaps all of the BN. The output of the power supply 251 is measured by a volt meter 259 connected to the power supply. The volt meter 259 forms a measurement of the output or terminal voltage and that measurement is delivered to a time based recorder 260. A chart 261 is formed by the recorder. Typically, it will record the voltage and current values which are input to it. Several different voltages may also be optionally recorded. More will be noted concerning this hereinafter. The power supply 251 forms an output current which is delivered through a relay operated sampling switch 254. The switch 254 has complete circuit control, one being shown in the illustrated position where it is connected to charge the cell B1 (see Fig. 6). When appropriately switched, charging current is delivered to the battery B1 and the cell B1 is charged by the current from the PS 251. The cell B1 is connected with the volt meter 259 connected across it. The output of the volt meter 259 is provided to the recorder 260 for recordation. As will be understood, if the PS 251 is charging only a single battery, it is discouraged because it is not efficient use of the equipment. The equipment is used more efficiently and with greater benefit by charging a number of appropriately connected battery cells. Hence, Fig. 8 includes several connected cells up to BN.

The digital voltmeter (DVM 259) measures the terminal voltage across B1 or other batteries.

Confronting any ground loop problems which may exist, using tray 30, high speed DVM operation performs fast and accurate measurements on a large number of batteries undergoing tests. Assume, as an example, the battery tray 30 shown supports 100 batteries and each battery requires testing. Assume that the battery transport system set forth generally in Figs. 1-7 is implemented so that the batteries are brought into the testing position where contacts are made with them. Assume also that the 100 batteries are to be tested with a common test protocol which involves a designated charging or discharging cycle. This test might impose a load on each battery where current is flowed from the battery for a short interval, perhaps a fraction of a second. Based on these assumptions, the equipment for testing 100 batteries would be very expensive in view of the ground loop problems just mentioned.

Moreover, the capital equipment requirements are quite expensive if multiplexing is not permitted. Heretofore, multiplexing has been substantially forbidden in the sense that great care must be taken to provide the right ground point at the right location. Otherwise, to test 100 batteries in the example given, the system would require 100 current measuring devices and 100 digital volt meters where all had carefully selected ground connections so that stability of the ground connection could be relied on.

The present disclosure sets forth in Fig. 8 a system by which testing of 100 batteries can be easily accomplished. Within the tray 30 which is represented in dotted line in Fig. 8, there are 100 replicated sets of battery contact equipment. Each particular battery of the 100 in this example is provided with its own set of contact equipment. Assuming that the battery has an electrochemical voltage of 1.5000, and assuming further that it is provided with a sample load 253 (a resistor having a value of 0.1000 ohms), when that load is placed across the battery, the current should be 15.000 amps. In the example given, the battery circuit 250 (that circuit physically situated in the tray 30 and connected with the battery) includes the PS 251 flowing current to a designated battery 252 to be tested. That current is directed through a selected load resistor 253. There is a current sampling circuit 254 also included. In accordance with the present disclosure and taking into account the problems with ground loops and false readings which derive from these, there is a current flowing through the system including the sampling circuit 254. The resistor 253 defines the current flow in an abstract sense. That current, however, has to be measured or sampled. Moreover, the current may have a transient start and then a steady state aspect. Indeed, if it flows for any interval of time, it will also have a decay curve as the battery heats and the resistance changes as a result of internal resistance in the battery. All these factors must be appropriately noted and there must be, therefore, a timing cycle for taking the sample. At a given instant, the circuit 250 is closed and made operative so that current flows through the load 253. At a related time interval thereafter, the multiplexer 255 is operated to obtain a signal from the circuit 250. The multiplexer has a "settle" time requirement also.

Fortunately, that can be in microseconds so that the multiplexer can be assumed to operate instantaneously. In turn that provides an output signal to a digital volt meter 256. The digital volt meter also has a settle time. By timing all these events in the appropriate fashion, a valid measure from the digital volt meter is provided to the recorder 257. Thus, the battery current is measured. The sample measurement is transferred at the appropriate time and represents the current flow. This is accomplished by using this timed arrangement so that the DVM output to the recorder is a signal representative of current flow at the measured instant.

Fig. 8 shows a different system for measurement of voltage. Recall that the voltage measurement may well risk a ground loop problem. To this end, the ground loop must be avoided. For that reason, Fig. 8 additionally times the voltage measurement through the multiplexer 258 and the DVM 259.

Going now to an overview of what is accomplished with the system shown in Fig. 8, if the tray 30 holds 100 batteries, multiplexers 255 and 258 are readily available which operate at sufficient speeds so that they can obtain samples with a settle time sufficiently fast utilizing the digital volt meters 256 and 259 that data is obtained for all 100 of the batteries. One benefit of this is to reduce the number of expensive electronic measuring devices required. Consider, as an example, that the tray 30 is operated so that all contacts are brought into contact against the 100 batteries. Assume further that the batteries are all tested at the same approximate beginning point in time. Signals are formed indicative of the current curve as a function of time and they are sampled for all 100 and the outputs are provided to the recorder 257. Avoiding ground loop problems, and using an assigned sampling resistor for each battery, suitable current related curves are provided for multiplexing and the necessary data can be obtained with only one DVM. This enables a tremendous reduction in cost. Also, the same aspect will be noted in regard to the voltage measurements. Moreover, and very importantly, current and voltage measurements both are made in a fashion to avoid ground loop problems that otherwise arise in this kind of system. Typically, ground loop problems will arise when attempting to test 100 batteries utilizing a heavy duty current ground.

DETAILED DESCRIPTION OF THE CLAMPING DEVICE

Attention is directed to Fig. 9 of the drawings where a first battery tester is identified generally at 310. The battery tester 310 is constructed with a pair of parallel printed circuit boards (PCB below) which are identified by the numerals 312 and 314. They are spaced from one another by a set of conductor rods 316 as will be detailed. The conductor rods provide current conductor paths arranged in parallel as will be explained. The spacing of the PCBs 312 and 316 is defined by a mechanism which will be explained to accommodate a battery undergoing tests and generally identified at 320. The battery or cell 320 is shown with a representative length in the drawings which can vary widely. The battery 320 can be as thin as a button and can be as long as the current conductor rods 316 will permit. As length is increased, changes in length are accommodated by moving the PCB 314 away or toward the top PCB 312. The length of travel is limited only by the length of the rods 316 which can be fabricated to any desired length.

Going specifically to Fig. 12 of the drawings, the top board 312 is shown in greater detail. It supports a connector 322. The connector features two terminals 324 and 326 so that circuit connections can be made to the test fixture 310. The terminals 324 and 326 connect to test circuitry. The test circuitry provides a controlled resistance across the battery, i.e., some resistance ranging from as large as needed to substantially near zero so that the current flow can be tested. Typically, the test circuitry will include an ammeter. The test circuitry typically also features a current source to impose a charging current on the battery. This is especially important in testing rechargeable batteries. For instance, it may be necessary to test a rechargeable battery by providing a controlled discharge through a low resistance and then a charging current is applied to the cell. The test circuit is implemented by connection to the terminals 324 and 326 which are on the connector 322. Fig. 12 represents the test circuit as comprising a timer connected resistor and current source. They are timed in operation so that various test routines can be done.

The board 312 is connected with four of the posts 316. They are deployed in a rectangle and extend up through the board 312 and are electrically connected to the board 312, using solder to make the connections. The four posts are connected in parallel so that they have a common circuit connection by the conductive strip 328. The strip 328 is electrically joined to the solder covered eyelets 330 which are eyelets used in PCB construction. The board 312 is preferably provided with plated-through holes and eyelets. Such construction is well known in PCB fabrication. The eyelets 330 assure current flow between the two faces of the board. In this particular instance, the connection at the eyelet 330 is accomplished by soldering to the rod 316. The rod 316 serves two purposes. In one aspect, it is a current conductor and is preferably made of a quality conducting metal. Ideally, it is copper, and more preferably a copper alloy. There are four in the preferred embodiment which assures parallel positioning of the boards 312 and 314. The rods 316 are fixedly attached to the board 312. Since the rods 316 are fixed to the board 312, they do not accommodate relative movement with the board. Relative movement is provided for the board 316. It is moved upwardly or downwardly (referring to its position in Figs. 9 and 10) so that the board 312 can be raised or lowered to handle changes in battery length. These changes are associated with a change in model being tested.

Fig. 14 illustrates an important structural detail of the construction. The rod 316 is shown in Fig. 14 passing through an assembly accommodating positional changes. Fig. 14 illustrates the PCB 314 which supports a mounting hub 332. It has the form of a metal sleeve with shoulder. It is soldered to connect with the current conductor path 334 on the lower board 314. The mounting hub (having the form of a sleeve) supports an insert which positions a set of detents 334 for deflection radially inwardly to contact, grip and drag against the rod 316. The detents provide frictional slippage of a controlled amount. The precise amount will be detailed hereinafter. The detents provide a completed current flow path into the rod 316. Electrical continuity is therefore obtained between the conductive path 336 on the board (see Fig. 13) and the rod 316 through the detents which clamp around the rod 316. Detent construction features a springy member which flexes to accommodate rod movement as required. The rod is pushed in or out of the detents 334. When motion ends, clamping is continued until the next time the rod is moved. The grasp of the detents 334 is sufficient to assure high quality electrical contact. Also, it is helpful to assure the electrical current flow path just mentioned.

Going now to the lower board 314, it is shown in Fig. 13 which includes a current conductor path 336 which connects the four rods in parallel. All four of the rods are connected in common. One important aspect of this connection is the ground connection. Assume for purposes of definition that the ground terminal of the battery 320 is at the lower end. This involves the location of the mounting post 338 shown in Fig. 13 which extends through the board 314. The negative or ground terminal is on the top side of the board at 340, see Fig. 9. Current for the ground terminal from the battery is directed through the terminal 340. The ground connection is completed to the ground terminal 324 in the connector 322. The ground terminal 340 thus connects through the mounting post 338, through the conductive ribbon 336 on the bottom board 314 and then to the rods 316 through the detent mechanism 334 (see Fig. 14). Current is conducted upwardly through the several rods 316 to the top board 312. The top board is better shown in Fig. 12 where the conductor path 328 connects with the four rods at the respective corners of the rectangular boards 312 and the conductor path 328 is connected to a terminal in the connector 322.

As shown in Fig. 9 of the drawings, the battery ground terminal 340 is centered in the structure and is deployed so that it contacts the bottom terminal. Contact of the top of the battery is also shown in Fig. 9. More specifically, a mounting sleeve 342 supports a movable contact rod 344 which is forced downwardly by a spring on the interior of the sleeve 342. The rod 344 supports the top battery contact 350. The contact 350 has a relatively large contact area and is typically serrated so that it bears with several points on the terminal of the battery 320. It moves upwardly and downwardly. The force on the spring moves it downwardly against the battery for testing.

The sleeve 342 is fixed on the board 312 by solder. As shown in Fig. 11, the sleeve is connected electrically to a conductive path 352 on the bottom of the board 312. Moreover, the conductor 352 extends from the sleeve to complete the circuit through the connector 322. Typically, a single conductor path 352 will suffice. It can, however, be assisted by providing a second conductor path 354, and a second parallel current flow path. The conductors 352 and 354 can therefore connect with a single terminal in the connector 322. In this particular instance, the positive terminal of the battery 320 undergoing test is contacted by the movable contact assembly 350 which bears against the battery for such connection.

Operation of the embodiment 310 should now be considered. First, the length of the battery 320 is measured. Spacing between the facing contacts 340 and 350 is then considered. The contact 350 should be positioned so that it moves against the battery 320. When that occurs, proper contact is achieved on mounting the battery 320 between the contacts 340 and 350. This adjustment in position may require movement of the board 314. The board 314 is pushed evenly up or down as required so that it slides on the mounting rods 316. The several rods 316 serve two purposes. For one, they provide parallel positioning of the two boards. This is maintained even when the boards are relatively moved to change spacing. In addition to that, the rods are current conductors. Collectively, they provide current flow along the rods so that the output of the system is easily obtained through the connector 322. The terminals 324 and 326 provide these connections A completed current flow path is made through the test circuit. For instance, if a short were connected across the terminals 324 and 326 (and effectively that is done in one aspect of testing), then current flows from the positive terminal of the battery contacted at the top end. This involves the contact 350. Current will flow from the positive terminal, and ultimately back to the ground terminal 340 through the conductors 316. The conductors 316, being structurally arranged as posts, serve the purpose of completing the circuit in the system. Current flow through the posts 316 is accomplished from the board 312, the posts 316 and to the board 314. Current flows through the detents 334 which grasp the rods 316.

The detent assembly shown in Fig. 14 enables current flow as just mentioned and also enables repositioning. The four detent assemblies holding or grasping the four rods 316 must hold with sufficient force to overcome the weight of the battery 320 plus the downward force applied at the contact 350. Typically, finger strength is all that is required to move the board 314 up or down. It slides on the rods. Sliding movement is accomplished easily to reset the board 314 for changes in battery length. It can be pushed up as viewed in Fig. 9 until the contact 340 bears against the moveable contact 350. When that occurs, the contact 350 can still be raised to slide a button thick battery between the two contacts.

An alternate embodiment is shown in Figs. 15 and 16 considered together. The embodiment 370 utilizes the structure shown in Fig. 9 and replicates it with a common board 372 positioned parallel to a lower common board 374. The boards 372 and 374 correspond to the individual boards 312 and 314 just described. The embodiment 370 does not require four of the mounting rods 316 for each test module. Fig. 15 shows four different test modules. Ordinarily, this would require sixteen of the mounting rods shown in Fig. 9, but with longer boards, fewer rods are needed. Moreover, adequate current flow can be obtained with about two rods per module. Elaborating, the four rods shown in Fig. 9 are connected in parallel but only two rods are needed in Fig. 15. Going to Fig. 16, the current conductor path 376 connects with the bottom post 338 at the central portion of the conductor 376, and connects with two rods at the remote ends. There are four rods along one edge of the board 374 and four rods along the opposite edge. This defines four isolated test modules for the embodiment 370. Four batteries can be tested simultaneously. If desired, only one or two batteries can be tested in the device. Whether all modules are in use at a given moment or not, the individual test modules are electrically isolated because the boards 372 and 374 are fabricated of non conductive material. This deployment of four test modules therefore assists in isolating the four batteries and four test circuits. As before, several batteries can be tested in a batch, and then the boards 372 and 374 are repositioned to test batteries which are shorter or taller.

Now, attention is directed to Fig. 17 of the drawings where an embodiment 380 is illustrated for testing a battery 390 which has two terminals at one end. The embodiment 390 is structurally constructed in the same fashion as the embodiment 310 shown in Fig. 9. This requires the top board 312, the lower board 314 and the four rods 316 which connect in the same manner illustrated in Fig. 14 of the drawings. The lower board 314, however, need not have electrical conductors on it and does not need to connect electrically to the rods 316. Rather, the upper board 312 is constructed with duplicate terminal contacts 382 and 384. These are mounted in the same fashion as discussed with the embodiment 310 and differ only in that two are located on the board 312. In this embodiment 312, the rods are structurally involved but not electrically in the test circuit. The embodiment 380 is assured of electrical contact. The battery test clamp 380 is adjusted in the same fashion as before.

One variation in the present apparatus is the incorporation of a voltage probe central to the positive terminal contact 350. In that instance, it is desirable to have two leads or conductors out of the positive battery terminal. One is obtained by a large footprint contact area against the positive battery terminal so that the current flow is directed through that. A second contact point to the positive terminal provides terminal voltage output through an appropriate conductor. Two contacts, one with large surface area and the other with small surface area can be deployed in a concentric construction as illustrated above. In that particular version, two conductors are thus involved in the movable contact assembly 350. While one carries the current, the other provides a voltage signal. It is generally better to measure the voltage with an independent point of contact to the battery terminal. This results from the desire to have a separate signal path for voltage measurements. Battery testing normally involves substantial momentary current flows through the current flow path connected with the battery. In contrast, the signal path for voltage measurements involves a current flow of an infinitely small amount, typically one microampere or less depending on the quality and nature of the voltage measuring circuit. Suffice it to say, the voltage measurement terminal or point of contact should have little involvement in the current flow path.

Figs. 18, 19 and 20 illustrate the embodiment 400 which is similar to the embodiment 380 shown in Fig. 17 except that the dual contact assembly at the top end is adjustable in width. More specifically, the battery 390, constructed with dual terminals at the top end, sometimes varies in width. The battery terminals are deployed in accordance with battery types. They can vary significantly in spacing. It is not uncommon for batteries to be made in accordance with three standards. The three standards involve positioning the battery terminals at spacings of 0.50, also 0.75 and 1.00 inches. Figs. 18, 19 and 20 illustrate a set of contacts deployed for such variations. The embodiment 400 is constructed with three similar parallel sleeves 402 and a second set at 404. Movable contacts 406 and 408 are mounted on appropriate elongate rods 410 and 412. In Fig. 18 they are positioned at the most narrow dimension. In Fig. 19, the spacing is intermediate while the spacing is maximum in Fig. 20. Again, the contacts are urged by springs downwardly against the battery terminals.

Fig. 20 shows the lower PCB adjusted upwardly and very close to the terminal contact assemblies. There are extremely thin batteries which are formed of sheet material. This spacing can be used to test them. For instance, film packs installed in instant cameras utilize such wide spacing for a battery which is substantially no thicker than a sheet of paper. It is equipped with a pair of spaced tabs which conform to the spacing of the contacts, and they are therefore able to test that type battery construction. Many other examples are known and can be tested by the adjustable width battery contact assembly 400.

While the foregoing is directed to different embodiments of a battery test clamp mechanism, the scope is determined by the claims which follow.

CLAIMS:

1. A battery test apparatus for testing a battery having different polarity terminals thereon, comprising:

(a) a first battery test contact;

(b) a second aligned battery test contact wherein said first and second test contacts are spaced apart to enable a battery to be positioned in proximity prior to testing;

(c) upper and lower test boards supporting said test contacts for operatively connecting to and releasing a battery for testing; and

(d) a structural member electrically connected to said test contacts to define a battery test circuit for said battery during testing.

2. The battery test apparatus of claim 1 further comprising posts extending between said boards to space said boards so that a battery can be releasably contacted and tested through said contacts.

3. The battery test apparatus of claim 2 wherein said posts define a relatively rigid test clamp wherein said boards and said posts are movable to clamp said battery.

4. The battery test clamp of claim 3 including post grips comprising a circular mounting hub for engagement with one of said boards and positioned around a post extending therethrough, and each grip includes inwardly directed post contacting surfaces enhancing frictional engagement so that post movement is restrained.

5. The apparatus of claim 1 including:

(a) a test circuit connector mounted on one of said boards;

(b) a board supported conductor path extending to said connector and also extending to said battery test contact on said board to make electrical connection therewith; and

(c) a conductor flow path on the other of said boards extending from the contact thereon.

6. The apparatus of claim 5 wherein said connector includes one terminal connected electrically with one of said posts to define a current flow path from the other of said boards.

7. The battery test clamp of any of claims 1 to 6 wherein said upper and lower boards are printed circuit boards, and two of said battery test contacts are aligned opposite one another to enable a battery to be inserted between said battery contacts, and at least one of said battery contacts is movable to extend operatively against a battery terminal.

8. The battery test clamp of claim 7 wherein said test contacts connect on said boards to electrical current flow paths on said boards.

9. The battery test clamp of claim 7 wherein one of said test contacts is relatively movable.

10. The battery test clamp of any of claims 1 to 9 including a current flow path there through wherein the flow path begins and ends at a connector mounted on one of said boards and serially connects through:

(a) a terminal at said connector;

(b) a current flow path from said connector and the board on which said connector is mounted extending to the contact supported by said board;

(c) a current flow path from said remaining battery test contact;

(d) a current conductive mounting hub engaging at least one of said set of posts to complete a circuit through;

(i) one of said posts, and

(ii) a connection from said one post to a second terminal in said connector.

12. The apparatus of any of the foregoing claims wherein said upper board supports:

(a) at least two spaced apart battery test contacts;

(b) at least two spaced apart battery test contacts on said lower board wherein said upper and lower board battery test contacts are aligned to define at least two test modules between said boards for testing simultaneously two batteries there between; and

(c) separate test module current flow paths connected with the separate upper and lower battery test contacts and including current flow paths through electrically dedicated and isolated posts in said set of posts.

13 . The apparatus of claim 12 wherein said set of posts are electrically connected in said separate test modules.

14. The battery test clamp of any of the foregoing claims wherein said first and second battery test contacts are mounted on one of said boards and are spaced on said board to thereby position said battery test contacts at a spacing in accordance with an industry standard to make contact against a battery having terminals thereon in accordance with said industry standard.

15. The battery test clamp of claim 14 wherein said battery test contacts all comprise movable contacts mounted in first or second differently spaced battery contact sleeves for adjustments in spacing.

16. The battery test clamp of claim 2 wherein said posts and said post grips are relatively positioned on said upper and lower test boards for alignment to define a rigid structure, and said post grips permit sliding frictional movement to accommodate changes in spacing between said boards.

17. An apparatus for testing a battery having spaced positive and negative terminals thereon, the apparatus comprising:

(a) a battery tray for holding the battery in a fixed position so that the positive and negative terminals thereof are exposed;

(b) said battery test contacts for contacting the battery including a positive terminal contact and a negative terminal contact;

(c) test signal responsive apparatus responsive to testing of the battery;

(d) a clamp mechanism cooperative with said test boards to initiate and then terminate engagement and disengagement with the terminals of the battery; and

(e) a current flow path including said test responsive apparatus, positive and negative contacts, and said battery wherein said current flow path is implemented by operation of said clamp mechanism.

18. The apparatus of claim 17 wherein said battery tray is constructed and arranged to hold N batteries (where N is a positive integer greater than 1) where said N batteries are all positioned with the positive and negative terminals thereof exposed for contact in like fashion, and said battery tray is removable from said clamp mechanism so that said battery tray can be loaded with N batteries and thereafter unloaded after testing and testing is conducted through said clamp mechanism.

19. The apparatus of claim 18 wherein said battery tray comprises spaced planar members with a space there between so that N batteries are held in a common orientation and are parallel thereby exposing the positive terminals in a common manner, and also exposing the negative terminals in a common manner, and said tray inserts into and from engagement with said clamp mechanism to form battery test circuit connections through said clamping mechanism with no wiring.

20. The apparatus of claim 19 wherein said battery tray also includes N individual current flow structural members there through for the N batteries in said battery tray to avoid wiring in the battery test circuits

21. The apparatus of claim 20 wherein said battery tray incorporates an individual control switch for each of said N batteries and said switches are selectively operable to control connection of said N batteries into said current flow path for testing by said test apparatus and said test circuit connections are through said battery test circuits to avoid wiring.

22. The apparatus of any of claims 17 to 21 wherein said N switches comprise N relays, and one relay is uniquely connected to each battery of said N batteries, and said relays and batteries are controllably switched so that the batteries for testing are selectively connected in series and selectively connected in parallel by said tray and said clamp assembly to avoid wiring and circuit connections are solely through said clamp mechanism.

23. The apparatus of claims 17 to 22 wherein said positive and negative terminal contacts are aligned to move toward a battery for testing and are relatively movable away from a battery after testing.

24. The apparatus of any of claims 17 to 23 wherein said terminals include a current terminal contact and a separate voltage terminal contact.

25. The apparatus of claim 24 wherein said separate current and voltage contacts are arranged concentrically on a common axis.

26. The apparatus of claim 25 wherein said contacts are spring biased.

27. The apparatus of any of claims 17 to 26 wherein said clamp mechanism comprises a rotatable shaft supporting a cam thereon and said cam is positioned to move said battery tray in a direction for contacting said contacts against the terminals of batteries in said battery tray.

28. The apparatus of claim 27 wherein said cam and cam shaft are rotatable between first and second positions wherein said first position permits said tray to be inserted and removed to an operative position with respect to said cam shaft, and wherein said second position moves said tray supporting said batteries into said contacts.

29. The apparatus of claim 28 wherein said tray mounts in a spaced relationship separated from said contacts, and said tray is retracted from the mounted position for loading or unloading batteries therein.

30. The apparatus of claims 27, 28 or 29 wherein said clamp mechanism comprises said rotatable cam and shaft below said tray; and said tray is an elongate rectangular frame sliding to a position between said positive and negative terminal contacts so that test circuits for said batteries are connected in N current flow paths with no wiring.

31. The apparatus of claim 30 wherein replicated positive terminal contacts are spaced from replicated negative terminal contacts, there being N each positive and negative terminal contacts for testing N batteries.

32. The apparatus of claim 31 wherein said positive terminal contacts define a plane and said negative terminal contacts define a spaced and parallel plane and said two planes are spaced apart to receive said tray therebetween to form N current flow paths having structurally rigid conductors.

33. The apparatus of claims 31 or 32 wherein said tray holds N batteries and supports said batteries aligned so that said batteries are aligned for simultaneous movement into operative connection to said contacts.

34. The apparatus of claims 30, 31, 32 or 33 wherein said batteries each are held with parallel axes and said axes are coincident with said contacts.

35. The apparatus of any of claims 17 to 34 including dedicated and isolated, structurally rigid current flow members supported by said tray to complete isolated current flow paths through said tray for each of said batteries.

36. The apparatus of any of claims 17 to 35 further comprising:

(a) a battery tray receptacle for said tray;

(b) first and second battery terminal contacts in said receptacle and located therein so that said tray, after positioning therein, positions the upstanding battery in aligned relationship with the terminal contacts;

(c) a tray transport engaging said tray for movement in said receptacle so that said tray moves the upstanding battery to the terminal contacts and thereby connects said upstanding battery in current conducting communication with a battery test circuit; and

(d) said tray transport moves the upstanding battery to end current conducting communication with the battery test circuits.

37. The apparatus of claim 36 wherein said battery tray is constructed and arranged to hold N batteries where said N batteries are all positioned with the positive and negative terminals thereof exposed for contact in like fashion, and said battery tray is removable so that said battery tray can be loaded with N batteries and can be unloaded of N batteries after testing.

38. The apparatus of claims 36 or 37 wherein said battery tray comprises spaced structurally rigid members with a space there between so that batteries are held in a common orientation and are parallel thereby exposing the positive terminals in a common manner, and also exposing the negative terminals in a common manner.

39. The apparatus of claims 36, 37 or 38 wherein said battery tray also includes N individual current flow structural members there through for the N batteries in said battery tray.

40. The apparatus of claims 36, 37, 38 or 39 wherein said battery tray incorporates an individual control switch for each of said N batteries and said switches are selectively operable to control connection of said N batteries into said current flow path for testing by said current measuring apparatus.

41. The apparatus of claim 40 wherein said switches comprise N relays, and one relay is uniquely connected to each battery, and said relays and batteries are controllably switched so that the batteries are selectively connected in series and selectively connected in parallel.

42. The apparatus of any of claims 36 to 41 wherein said positive and negative terminal contacts are aligned to move toward a battery for testing and are relatively movable away from a battery after testing.

43. The apparatus of claim 42 wherein said terminals include a current terminal contact and a separate voltage terminal contact.

44. The apparatus of claim 43 wherein said separate current and voltage contacts are arranged concentrically on a common axis.

45. The apparatus of claim 44 wherein said contacts are spring biased.

46. The apparatus of any of claims 36 to 45 wherein said tray transport comprises a clamp mechanism having a rotatable shaft supporting a cam thereon and said cam is positioned to move said battery tray in a direction for contacting said contacts against the terminals of batteries in said battery tray.

47. The apparatus of claim 46 wherein said cam and cam shaft are rotatable between first and second positions wherein said first position permits said tray to be inserted and removed to an operative position with respect to said cam

shaft, and wherein said second position moves said tray supporting said batteries into said contacts.

48. The apparatus of claim 46 wherein said tray mounts in a spaced relationship separated from said contacts, and said tray is retracted from the mounted position for loading or unloading batteries therein.

49. The apparatus of any of claims 46 to 48 wherein said clamp mechanism comprises said rotatable cam and shaft below said tray; and said tray is an elongate rectangular frame sliding to a position between said positive and negative terminal contacts.

50. The apparatus of claim 49 wherein replicated positive terminal contacts are spaced from replicated negative terminal contacts, there being N each positive and negative terminal contacts for testing N batteries.

51. The apparatus of claim 49 wherein said positive terminal contacts define a plane and said negative terminal contacts define a spaced and parallel plane and said two planes are spaced apart to receive said tray there between.

52. The apparatus of claim 49 wherein said tray holds N batteries and supports said batteries aligned so that said batteries are aligned for simultaneous movement into operative connection to said contacts.

53. The apparatus of claim 52 wherein said batteries each are held with parallel axes and said axes are coincident with said contacts.

54. The apparatus of claim 52 including dedicated and isolated, structurally rigid current flow members supported by said tray to complete isolated current flow paths through said tray for each of said batteries.

55. The apparatus of claim 52 including a separate load resistor for each battery.

56. A battery test system comprising:

(a) a battery test tray;

(b) an alignment device positioning said tray relative to a set of battery contacts to enable testing of a plurality of batteries in said tray;

(c) a motive mechanism moving said tray relative to said contact initiate operative contact between said plural batteries and said set of battery contacts for initiate testing; and

(d) wherein said motive means later moves said tray to end said operative contact.

57. The apparatus of claim 56 wherein said contacts are above and also below said plural batteries, and said motive means moves said contacts toward and later away from said batteries.

58. The apparatus claim 57 wherein said contacts are spring biased to extend and are retracted on battery engagement.

59. A battery test apparatus comprising:

(a) a first test contact;

(b) a second test contact;

(c) a insulative support member supporting said test contacts on a base on said support member;

(d) a first and second separate electrically conductive pathways supported by said support member; and

(e) means for moving a battery for testing against said first and second contacts to initiate battery testing.

60. The apparatus of claim 59 including a concentric base for said contacts positioning said first and second contacts concentrically for electrically and mechanically independent movement.

61. The apparatus of claim 60 including a compressible spring extending said first contact, a second compressible spring extending said second contact, and an insulative sleeve between said first and second contacts.

62. The apparatus of claims 59 to 61 wherein said first and second contacts serially connect through separate first and second solid tabs extending through a printed circuit board to the lower side to connect separately on the lower side of said board.

63. The apparatus of any of claims 59 to 62 including a rigid structural member electrically connected to one of said contacts to complete an electrical short circuit through a battery.

64. A method of positioning batteries for testing comprising the step of:

(a) positioning a first test contact above and spaced from a terminal on a battery to be tested;

(b) positioning a second test contact and spaced from a second terminal on the battery to be tested;

(c) moving said first and second terminals into operative contact with the battery;

(d) forming a completed circuit through the battery for testing; and

(e) wherein the step of forming includes the step of placing only rigid structural members in series in the completed circuit.

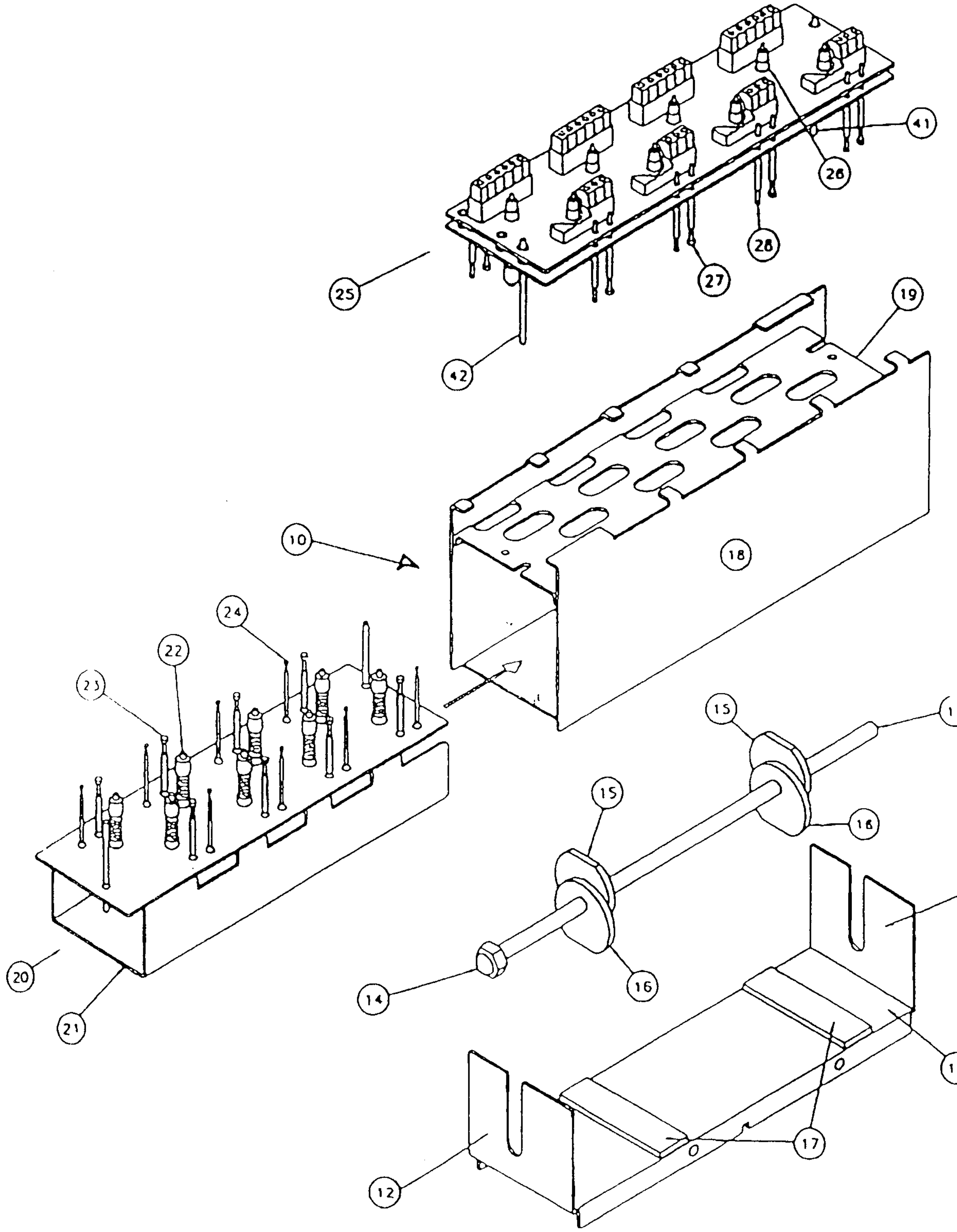

FIG 1

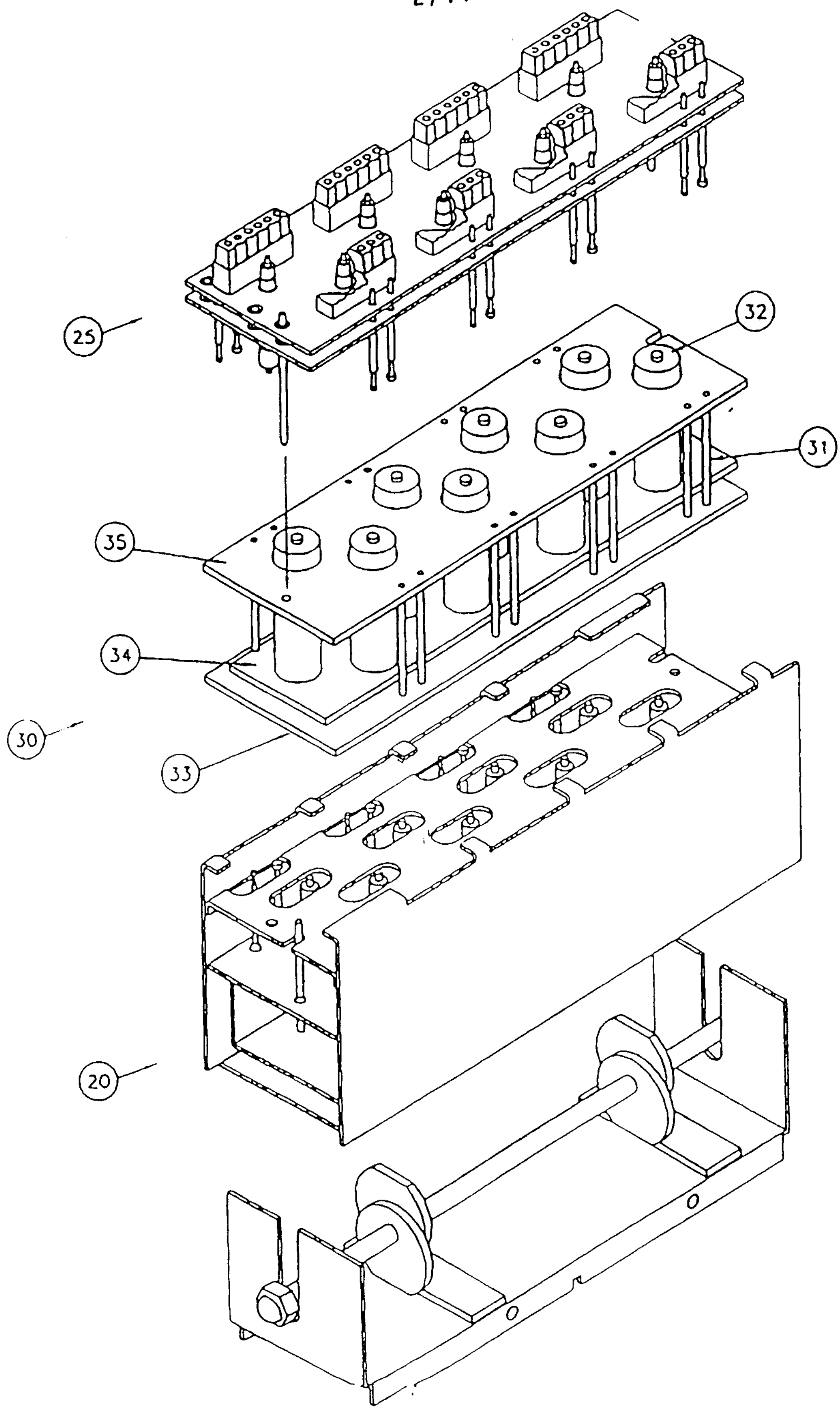

FIG.2

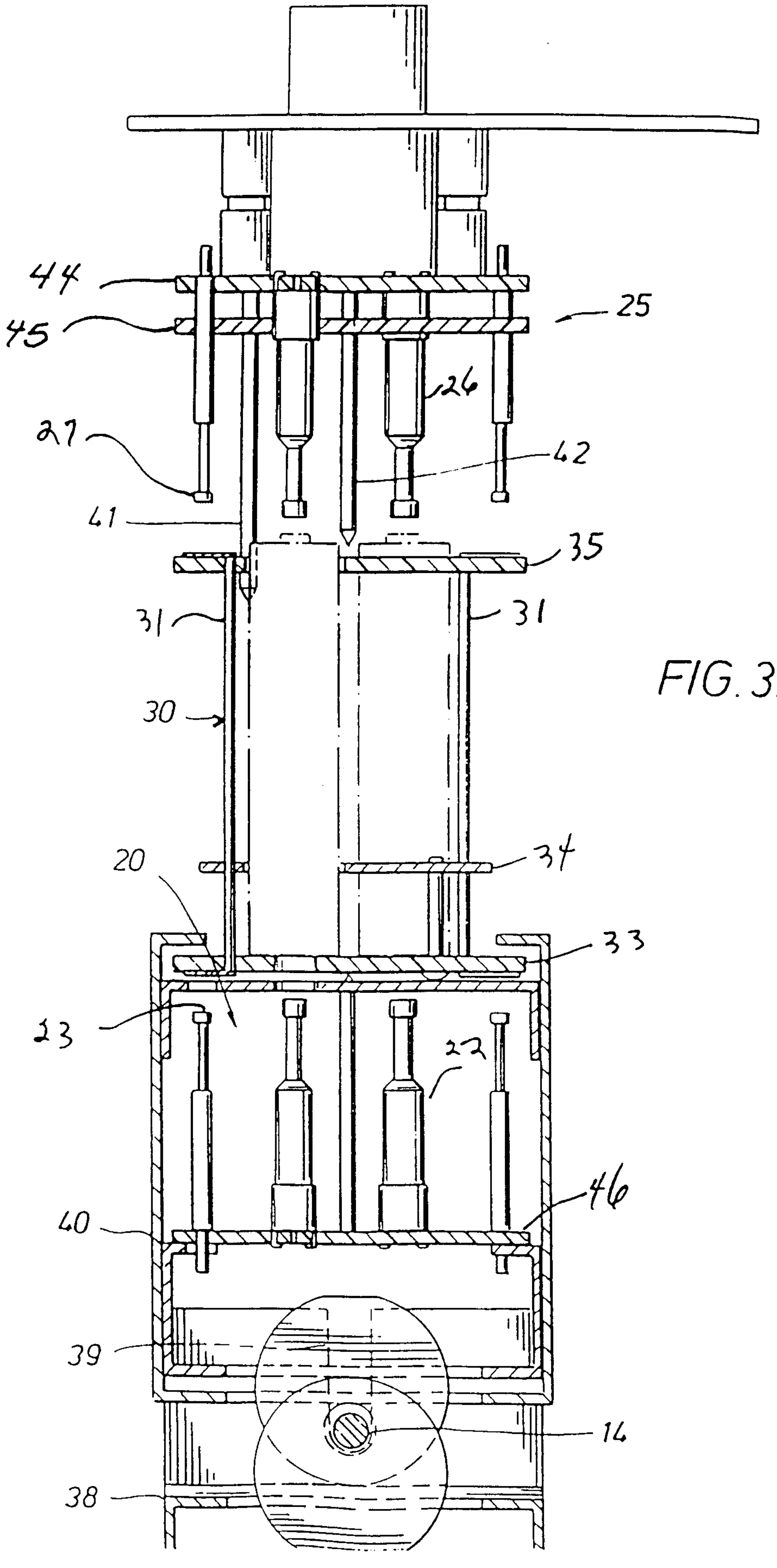

FIG. 3A

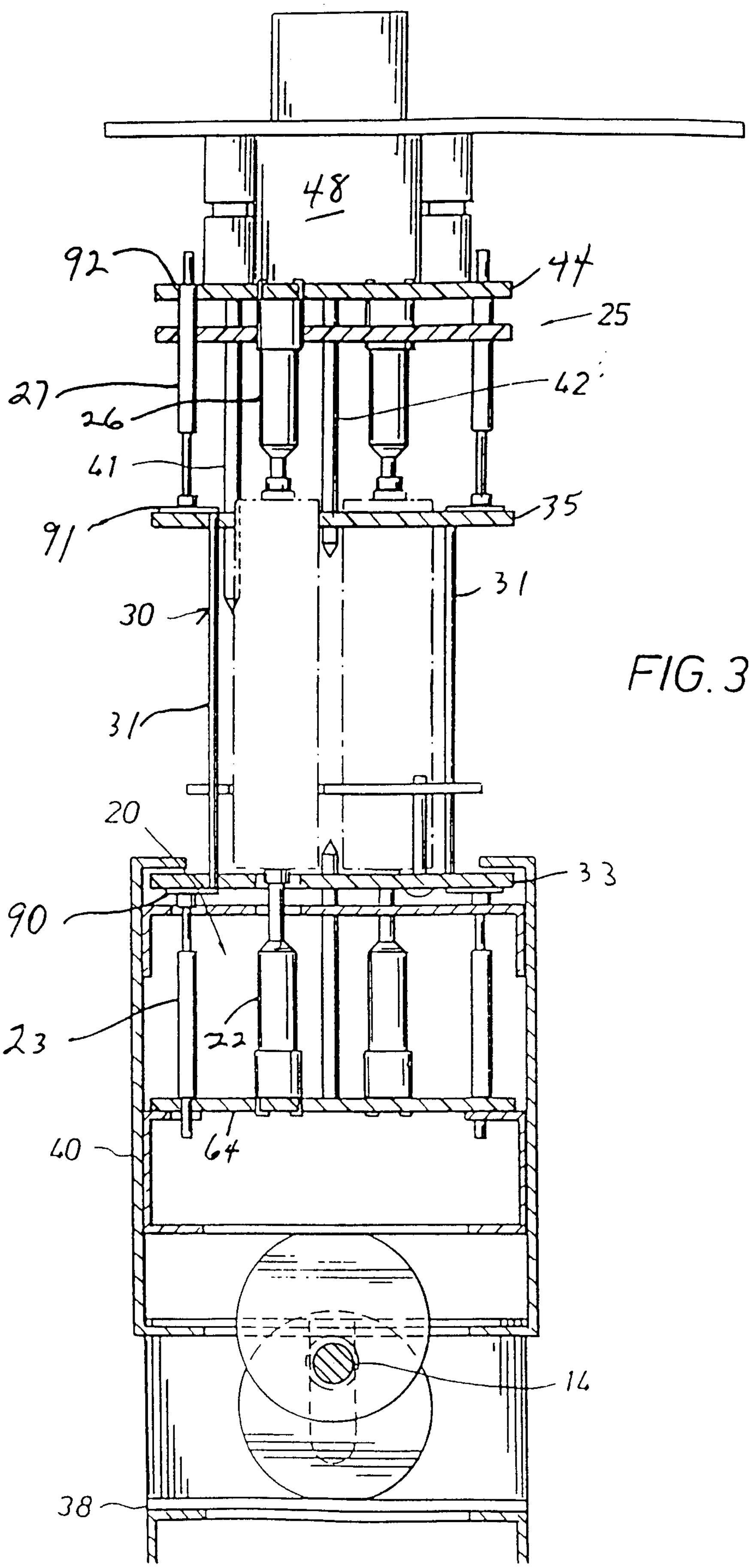

FIG. 3B

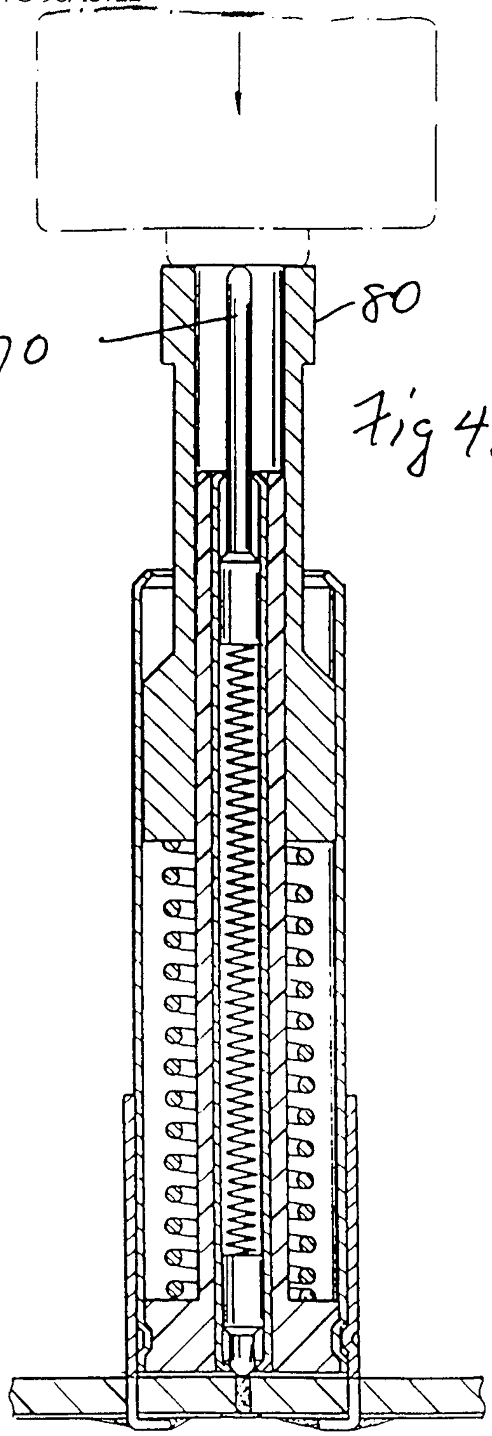
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Fig 4B

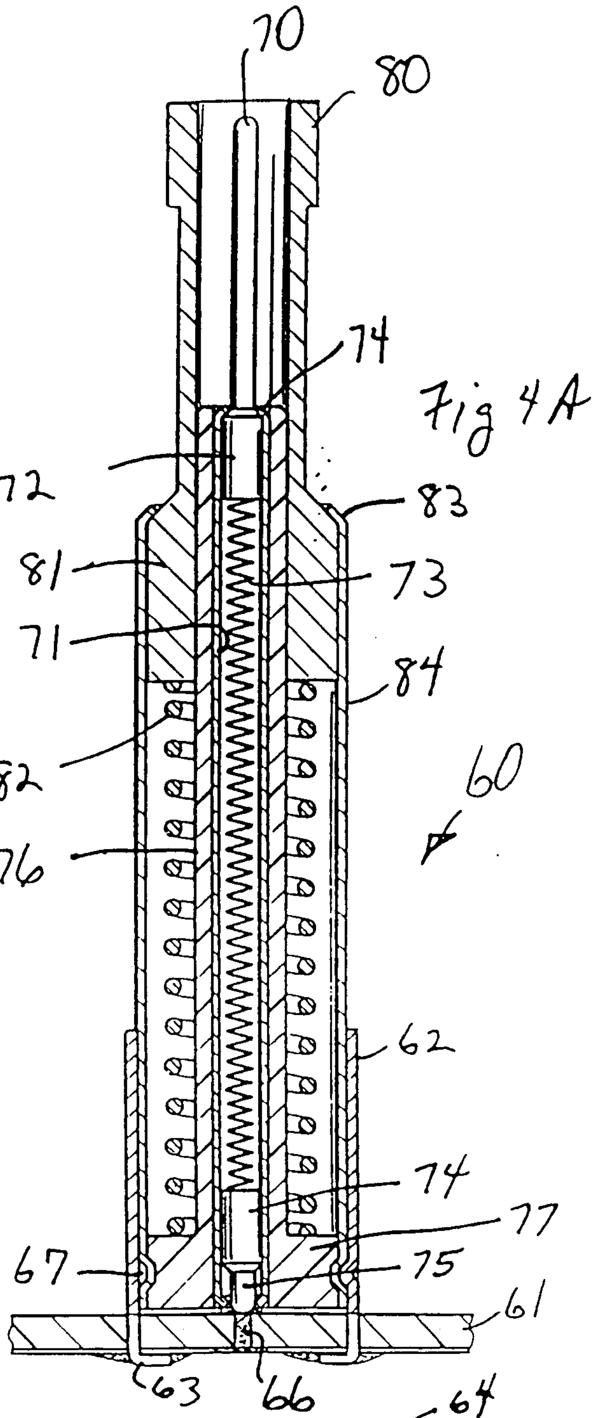
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Fig 4A
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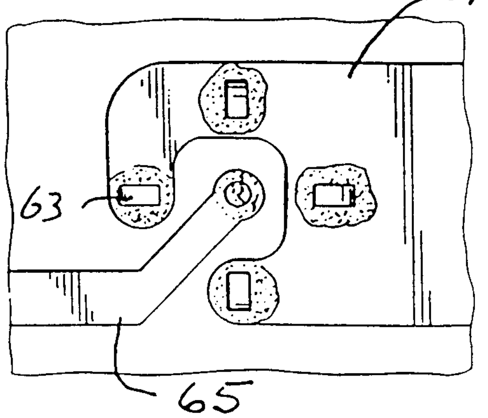
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63
65

Fig 5

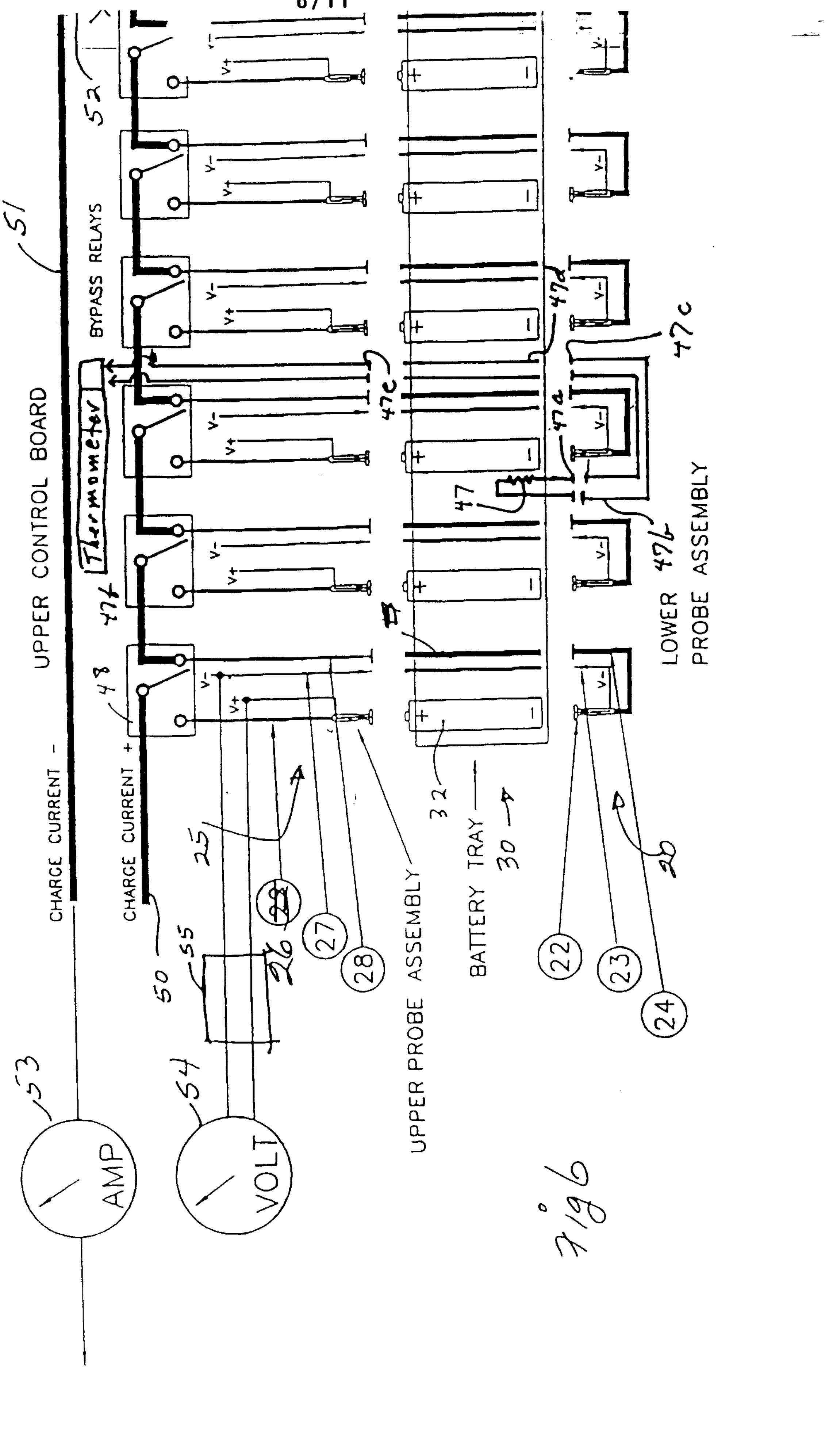

UPPER CONTROL BOARD
BYPASS RELAYS
Thermometer
CHARGE CURRENT -
CHARGE CURRENT +
UPPER PROBE ASSEMBLY
BATTERY TRAY
LOWER PROBE ASSEMBLY
AMP
VOLT
V+
V-
51
52
48
47
47a
47b
47c
47d
47f
50
53
54
55
25
26
27
28
22
23
24
20
30
32

Fig 6

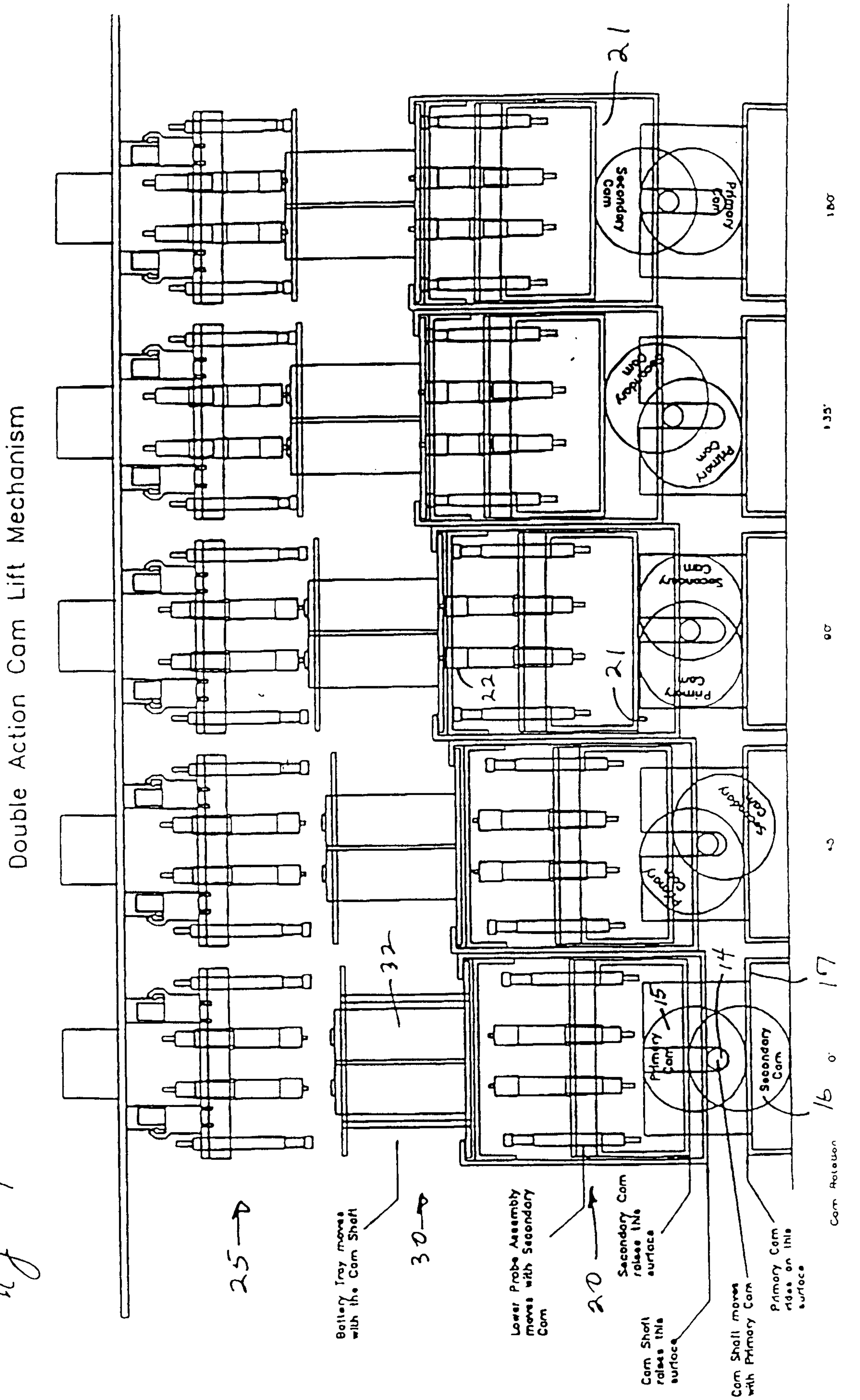

Double Action Cam Lift Mechanism
Primary Cam
Secondary Cam
180
135
90
0
Cam Rotation
21
22
32
25
30
20
14
15
16
17
Battery Tray moves with the Cam Shaft
Lower Probe Assembly moves with Secondary Cam
Secondary Cam raises this surface
Cam Shaft raises this surface
Cam Shaft moves with Primary Cam
Primary Cam rides on this surface

Fig 7

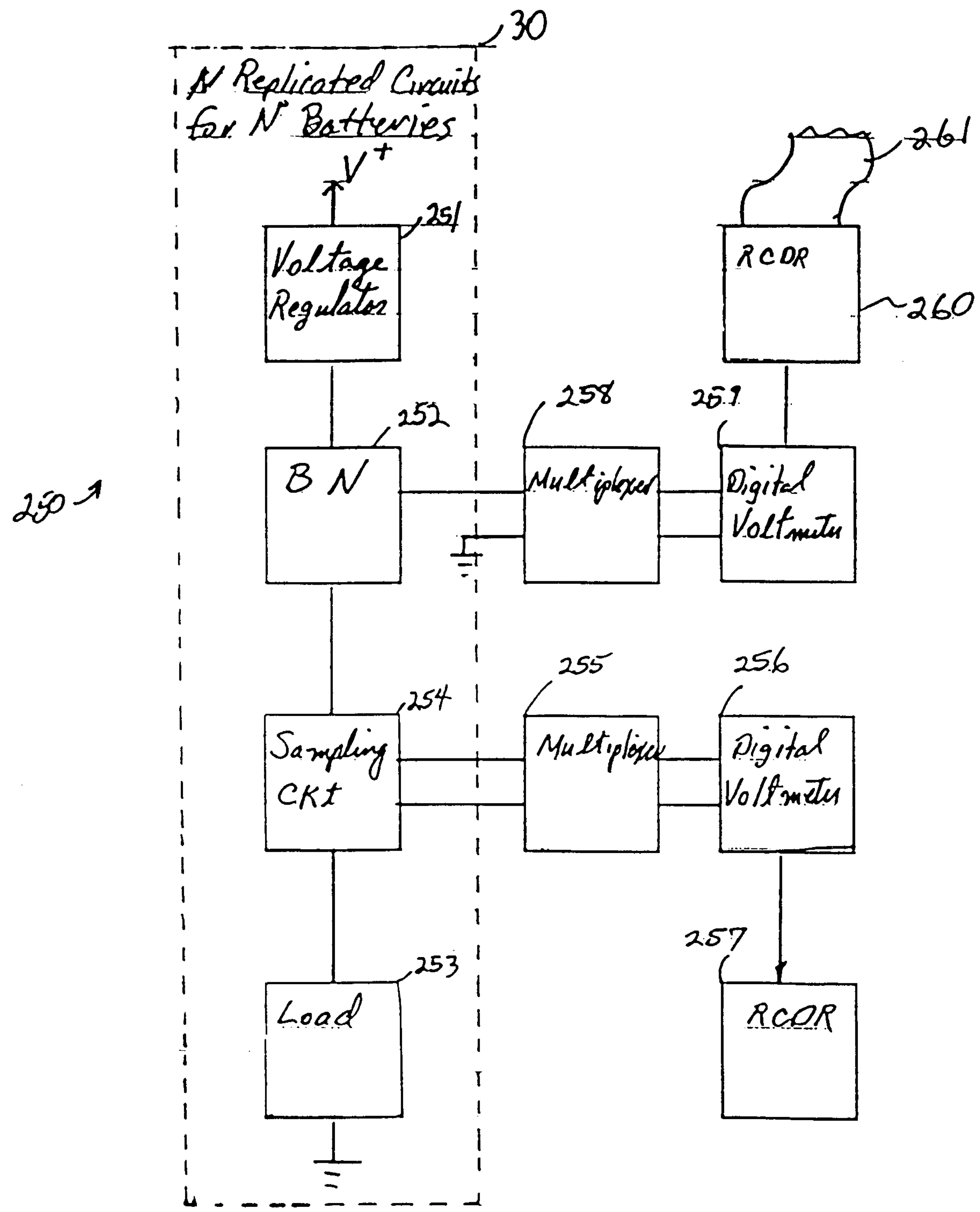

30
N Replicated Circuits for N Batteries
V+
251
Voltage Regulator
252
B N
250
254
Sampling CKt
253
Load
258
Multiplexer
259
Digital Voltmeter
261
RCDR
260
255
Multiplexer
256
Digital Voltmeter
257
RCDR

Fig 9

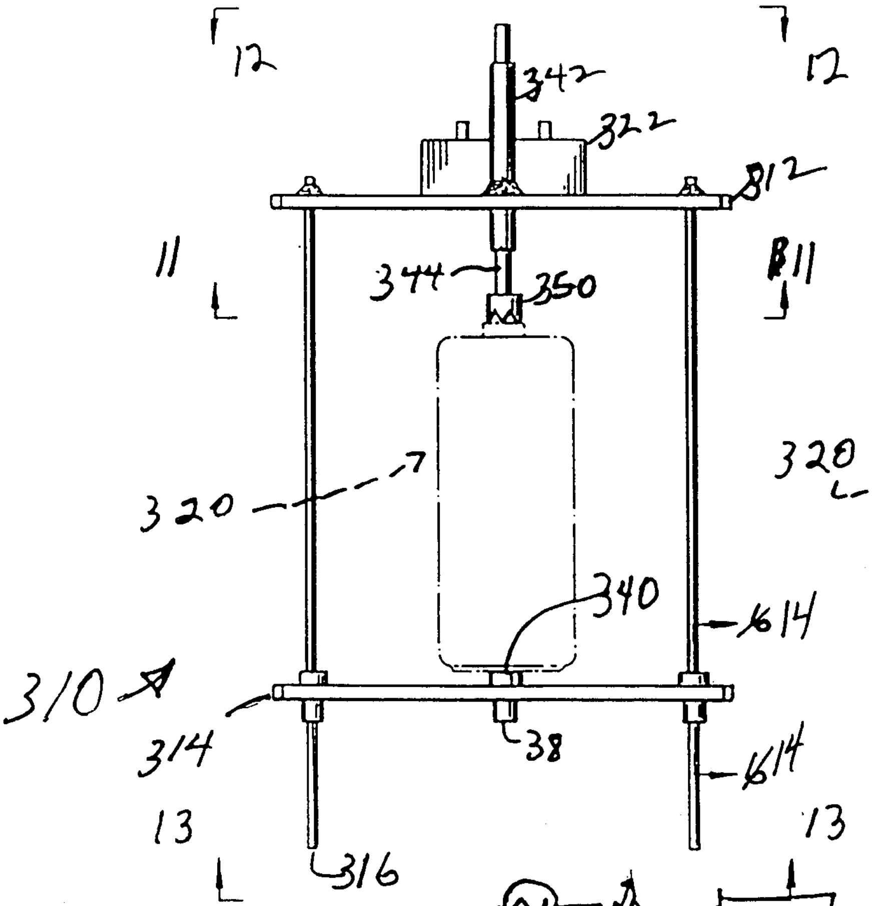
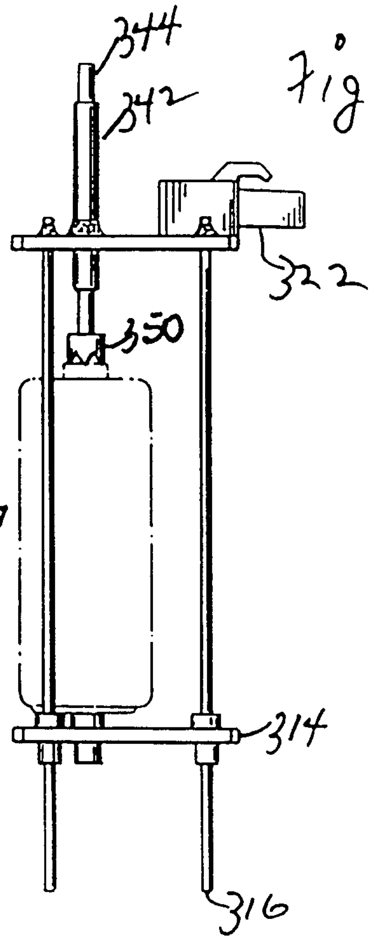


Fig 10



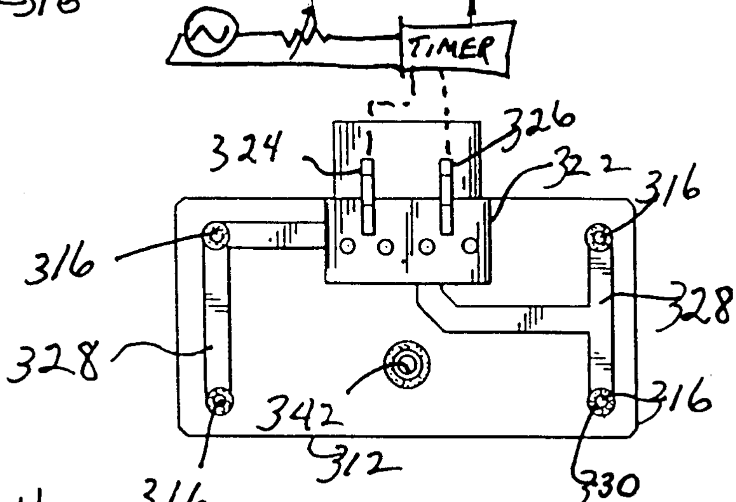


Fig 12

Fig 11

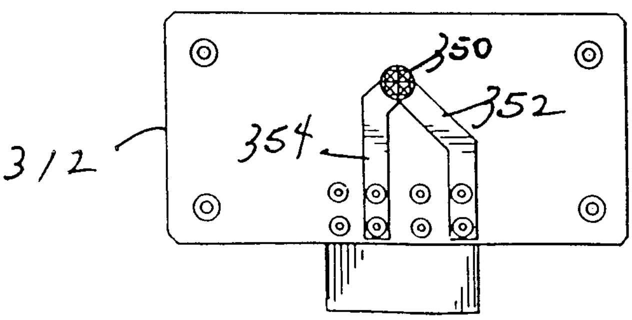
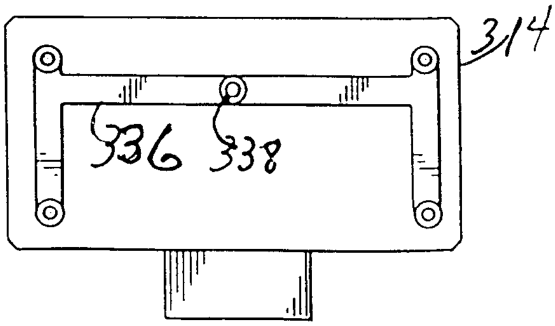


Fig 13



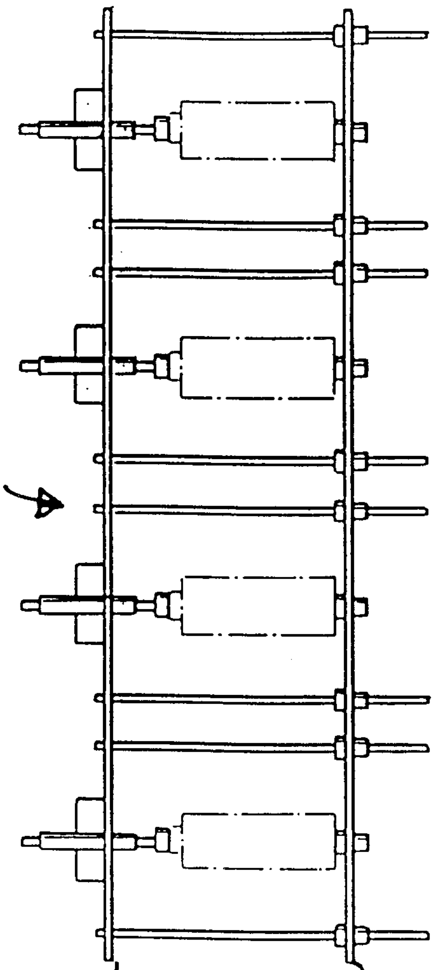


Fig 15

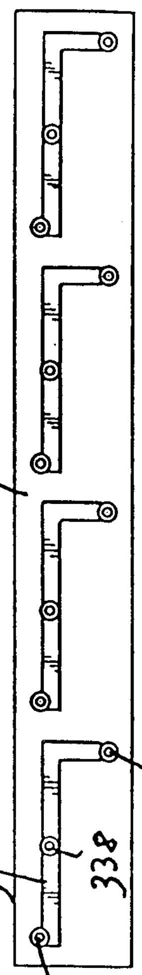
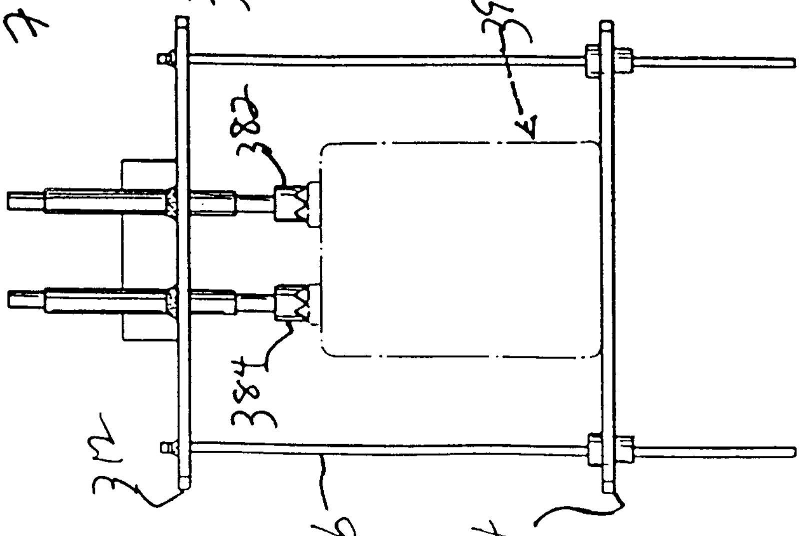


Fig 16

Fig 17



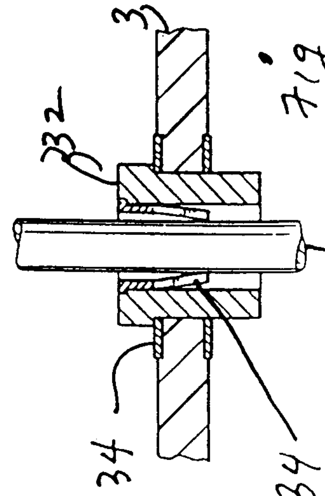


Fig 14

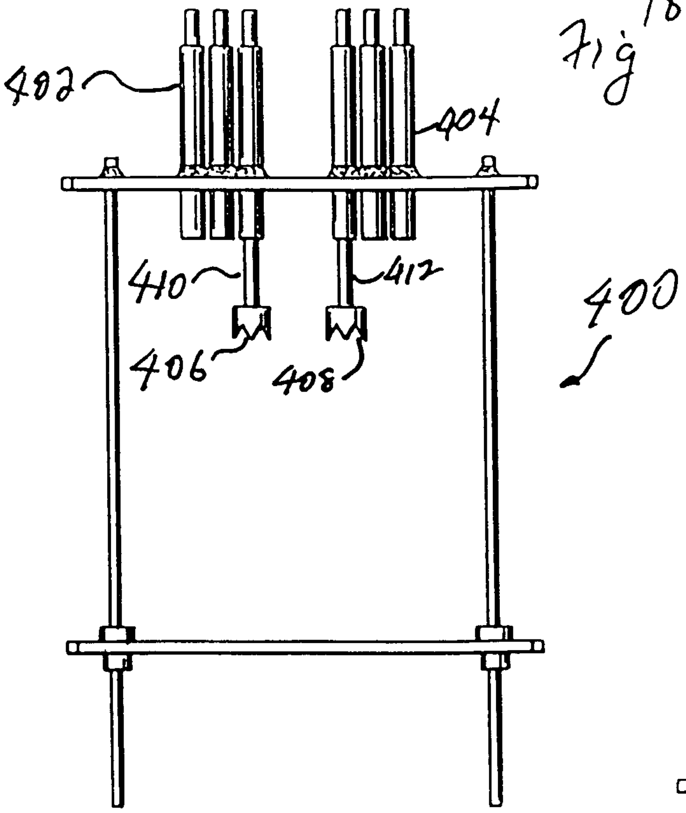
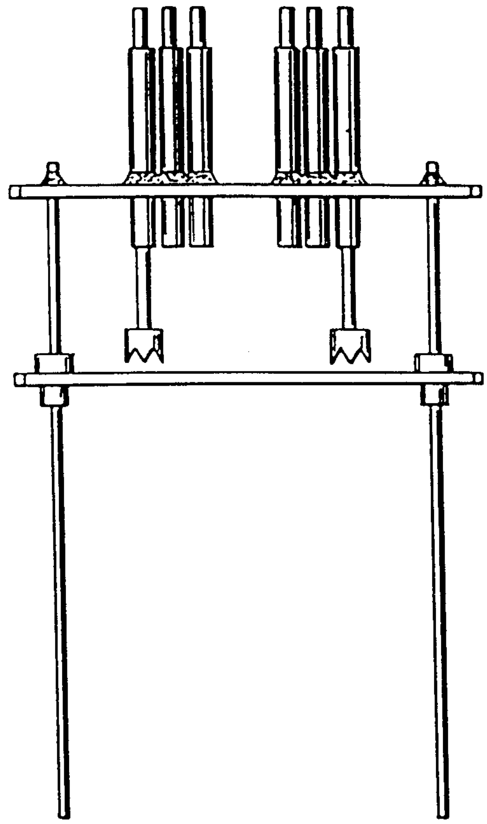


Fig 18

Fig 20



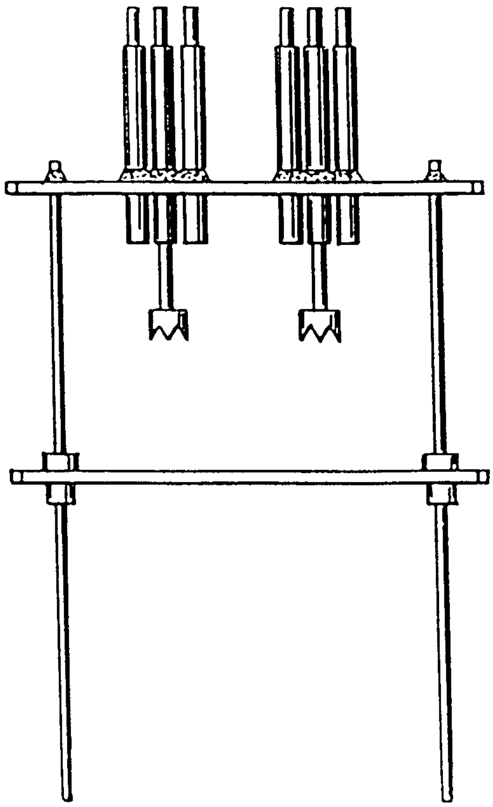


Fig 19

INTERNATIONAL SEARCH REPORT

Inte ional Application No
PCT/US 98/07085

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G01R31/36

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G01R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 360 780 A (SKUTCH) 23 November 1982 see column 1, line 34 - column 2, line 26; figures 1,2	1,64
X	US 4 204 161 A (STRICKLAND) 20 May 1980 see column 3, line 34 - line 68; figures 1-5	17,59
A	PATENT ABSTRACTS OF JAPAN vol. 95, no. 11, 26 December 1995 & JP 07 226234 A (TOSHIBA BATTERY), 22 August 1995, see abstract	18,19, 37,39, 45,56,61
A	PATENT ABSTRACTS OF JAPAN vol. 8, no. 215 (P-305), 2 October 1984 & JP 59 099271 A (MATSUSHITA) see abstract	1,59,64

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
9 July 1998	29/07/1998

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Iwansson, K

1

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 98/07085

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 95, no. 7, 31 August 1995 & JP 07 097004 A (SONY), 11 April 1995, see abstract -----	17,56

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INTERNATIONAL SEARCH REPORT

Information on patent family members

In ational Application No
PCT/US 98/07085

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4360780 A	23-11-1982	JP 58094771 A	06-06-1983
US 4204161 A	20-05-1980	NONE	