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TEST HEAD MANIPULATOR



FIELD OF THE INVENTION

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The present invention relates to the field of art of electronic test head positioners.

BACKGROUND OF THE INVENTION

5 In the automatic testing of integrated circuits (IC) and other electronic devices, special device handlers have been used which bring the device to the proper temperature and places the device to be tested in position. The electronic testing itself is provided by a large and expensive automatic testing system which includes a test head
10 which has been required to connect to and dock with the device handler. The Device Under Test (DUT) requires precision, high speed signals for effective testing; accordingly, the electronic circuits must be located as close as possible to the DUT. This causes the test head to be extremely heavy.

15 Test head positioner systems may be used to position the test head with respect to the device handler. When the test head is accurately in position with respect to the device handler, the test head and the device handler are said to be aligned. When the test head and device handler are aligned, the fragile test head and device handler electrical connectors can be brought together (i.e., docked), enabling the transfer of test signals between the test head and the device handler. Prior to docking, the fragile test head and
20 device handler electrical connectors must be precisely aligned to avoid damaging the fragile electrical connectors.

A test head positioner system may also be referred to as a test head positioner or a test head manipulator. This technology is described, for example, in the inTEST Handbook, inTEST Corporation. This technology is also described, for example,
25 in U.S. Patents No. 5,608,334, 5,450,766, 5,030,869, 4,893,074 and 4,715,574 which are all incorporated by reference for their teachings in the field of test head positioner systems.

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IS plane and pointing away from the test head. Figure 3 shows the IS 310 in the horizontal plane with upwards direction. In use, the orientation of the test head will change as it is docked with different types of equipment. Accordingly, both the plane and the direction of the IS 310 will also change.

5 It is helpful to designate test head dimensions with respect to the interface surface. With the orientation shown in Figure 3 (IS facing up), the following definitions may be used:

- T = test head thickness = dimension in the up-down direction 312.
- W = test head width = dimension in the side-to-side direction 314.
- 10 • L = test head length = dimension in the in-out direction 316.

In use, the test head may be brought upwards to contact the DUT as in a device handler. In this case, the interface surface is facing up (IS UP).

Another alternative is that the test head may be brought downwards to contact the device as in a prober. In this case, the interface surface is facing down (IS
15 DOWN).

Thirdly, both the DUT and the IS may be orientated in a vertical plane (IS vertical).

Fourthly, both the DUT and the IS may be oriented at any angle between the IS up and IS down.

20 As the test head is moved from one apparatus to another, it is clear that the test head must be rotated among IS UP, IS DOWN, and IS Vertical positions. Depending upon the manipulator, this may be effected by rotation in either the tumble (pitch) or roll (twist) coordinates.

25 The test head is connected to the test cabinet by a large, thick bundle of cables. The cables, size, weight and resistance to flexing and twisting all interfere with and constrain test head motion. Test head motion is desirably performed in a manner to protect the cable from several factors as described, for example in U.S. Patent No. 5,608,334.

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shown) of in-out plate 524 couple side-to-side plate 522 to in-out plate 524. Guides 525 of in-out plate 524 are coupled to the rails 527 of turntable 526. Turntable 526 is, in turn, coupled to base 530 with a bearing surface (not shown). Column 545 may be repositioned as desired along the x and z-axes by moving side-to-side table 522 and in-out table 524, respectively. Column 545 may also be rotated about the y-axis by rotating turntable 526 about its coupling with base 530. Of course, as column 545 is moved along these axes, test head 502 is repositioned.

Fig. 5B is similar to Fig. 5A except for the relative positions of the parts associated with translation table 521. In particular, the turntable 526 is between column 545 and side-to-side plate 522. In addition, guides 525 of in-out plate 524 are directly coupled to base 530 at rails 531. In all other aspects, Figs. 5A and 5B are similar. Therefore, the remaining details of Fig. 5B are not repeated here.

Other combinations of horizontal motions built into the manipulator base are possible. If such motions are not built into the base, they are typically provided in the arm assembly. For example the inTEST Corp. in2 manipulator first described in U.S. Patent No. 4,527,942 provides no horizontal motions in its base; an articulating arm assembly provides all horizontal motion. Further, manipulators are known which have bases that provide only swing rotation motion, such as the system described in U.S. Patent No. 5,606,262, assigned to Teradyne.

Several manipulators provide two motions in their bases. A manipulator manufactured by Teradyne and described in U.S. Patent Nos. 5,931,048 and 5,594,002 provides swing rotation and side-to-side motion in its base with the swing mechanism at the bottom; in-out motion in this manipulator is provided in the arm and cradle assemblies. A further manipulator manufactured by Reid-Ashman MFG, Inc., provides side-to-side and in-out motion in the base with swing provided by rotation the arm about a shaft attached to the column.

A manipulator manufactured by Schulmberger provides side-to-side motion and swing rotation motion in its base with the swing mechanism on top of the side-to-side mechanism. In-out and roll motions are provided in the arm assembly. This manipulator is unique in that the cable passes from the cabinet, through the center of the column above

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4. DUT clock rates have gone from 10's of MHz to at least 1 GHz.
5. Data, Address and Control signals are accordingly in at least the 100's of Mbps range.
6. Per pin frequency bandwidth requirements are at least in the 10's of GHz range.

As a result, the following test system design changes have become desirable:

1. More, faster and more complex pin-electronics circuits in the test head.
2. Greater power dissipation per pin circuit in the test head can be expected due to the higher switching rates.
3. Water cooling systems with circulating water have been added to the test heads, increasing their weight and necessitating flexible plumbing to be included in the test head cable.
4. More power supply and ground conductors of heavier gauges are in the interconnecting test head cable.
5. Moving circuitry from the system cabinet to the test head to reduce the amount of signal wiring and associated delays in the cable.

These factors have driven the size and weight of test heads to increase significantly while at the same time requiring:

1. The demand that the test head be brought into close proximity to the DUT is increasingly important.
2. The cable from test head to tester cabinet be kept as short as possible while at the same time it has become thicker and stiffer.

Thus, test heads and their associated cables have become significantly larger and heavier.

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Fig. 9 is a plan view of the test head manipulator of Figs. 7A or 7B showing various degrees of freedom;

Fig. 10 is a perspective view of the base assembly for the test head manipulator of Figs. 7A or 7B;

5 Figs. 11A-11C are detailed views of the bottom plate of the base assembly of Fig. 10;

Fig. 12A-12C are detailed views of the swing plate portion of the base assembly;

10 Figs. 13A-13C are detailed views of the in-out plate portion of the base assembly;

Figs. 14A-14C are detailed views of the side-to-side plate portion of the base assembly;

Figs. 15A-15C are a plan view and side views of the base assembly;

Figs. 16A-16C are various views of the swing indexing lock assembly;

15 Figs. 17A-17D are various views of the in-out axis lock assembly;

Figs. 18A-18C are various views of the side-to-side axis lock assembly;

Figs. 19A-19B are detailed views of the side-to-side axis lock assembly;

Fig. 20 is a front view of the roll motor and associated hardware for rotating the test head about the roll axis;

20 Fig. 21 is a partial side view of the roll motor and associated hardware;

Fig. 22 is back view of the roll motor and associated hardware;

Fig. 23 is a side view of the vertical motor and associated hardware for raising and lowering the test head;

Fig. 24 is a top view of the vertical motor and associated hardware;

25 Fig. 25 is a simplified schematic of a single axis control circuit;

Fig. 26 is a simplified schematic of a dual axis control circuit;

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axis. In this way, the vertical component of the force exerted on the test head 802 by the cable 706 may be maintained at a substantially constant value, enabling the test head 802 to remain in a freely moving, balanced state.

Column structure 712 is attached to base assembly 710 which provides motion along the X and Z axes in addition to the ability to rotate the entire manipulator assembly 702 about the Y axis at pivot point 734 in both a clockwise and counterclockwise direction. This latter rotation allows the manipulator assembly 702 to be repositioned away from any TSA so that maintenance may be performed on the probe or test head.

Column structure 712 may be either of fixed height or of variable (telescopic) height.

Fig. 7A shows column 712 moved to the end of the Z-axis that is closest to cabinet 704, and Fig. 7B shows column 712 moved to the opposite end of the Z-axis furthest from cabinet 704. Otherwise, the two figures are the same. It is observed that in Fig. 7A service loop 705 is compact and falls close to the floor; whereas in Fig. 7B service loop 705 is straightened to a degree to accommodate the increased distance between column 712 and cabinet 704. Service loop 705 is not fully straightened in Fig. 7B; additional slack remains to allow vertical motion of test head 802. In Fig. 7A, further observe that although the end of telescoping support arm piston 410 is in proximity to cabinet 704, the point where service loop 705 meets telescoping support arm cylinder 420 is substantially above pivot point 734. It is seen that the spacing between pivot point 734 and cabinet 704 is consistent with the space requirements for service loop 705.

Base assembly 710 consists of several sub-plates arranged in a stacked manner so that each sub-plate is coupled to adjacent sub-plates. Specifically, bottom plate assembly 726 is coupled to swing plate assembly 728 which is, in turn, coupled to in-out plate assembly 730, which is in turn coupled to side-to-side plate assembly 732, which is in turn coupled to column structure 712. Details of how test plates are coupled to one another is discussed in detail below.

The test head 802 is attached to main arm 736 through upper arm assembly 737 and cradle 739. The test head acts as a load. A drive system (not shown in this

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length of cable support 708 does not extend or retract during rotation through angle 806, or as the column structure 712 moves along the x or z-axes. As such, motion, wear and fatigue of the cable 706 are reduced. Cable support 708 extends or retracts as test head 802 moves along the y-axis relative to support arm 718, and/or pitches about the z-axis. It is to be noted that this extends the available motion envelope in comparison to the prior art where the end of the cable support is attached to a fixed location, such as the test cabinet.

Referring to Fig. 9, another plan view of the test head manipulator system 700 is shown which illustrates the degrees of freedom of various parts of the test head manipulator 700. As shown in Fig. 9, the test head 802 and cable support arm 708 may be subject to swing motion about the y-axis by moving in an arc 902 about a second vertical axis centered at pivot point 734. In a preferred embodiment the arc 902 may include a range of angles relative to the position where the test head is docked with the device handler (hereafter, "the docking position"). For example, if the docking position is defined to be 0°, the arc 902 may include angles of about -10° through about +30° from the docking position.

Fig. 9 also shows that test head 802 may rotate about z-axis 904. In an exemplary embodiment, rotation about axis 904 may be about $\pm 95^\circ$ from the interface surface (IS) vertical position. Test head 802 has a center of gravity (CG) 912. The combination of the vertical axes passing through CG 912, pivot point 734, and linear guide rail 738 form triangle 914. Each of these axes forming the respective vertices of triangle 914.

Fig. 9 shows that test head 802 may be subject to pitch motion about the x-axis. Axis 906 represents the degree of pitch of test head 902. It is contemplated that test head 802 may pitch about the x-axis between about $\pm 4^\circ$ from a nominal horizontal position depending upon the application.

Fig. 9 shows that test head 802 may move along the x-axis. Axis 908 represents motion of test head manipulator 700 along the x-axis. In an exemplary embodiment, it is contemplated that the x-axis motion is within a range of about 25 cm from one end to the other.

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In order to limit the rotational motion of swing plate assembly 728 relative to bottom plate assembly 726, rubber bumpers 1110 are attached to the top of bottom plate 1120. Rubber bumpers 1110 provide positive end stops for swing plate assembly 728, by edges of swing plate 728 confronting rubber bumpers 1110 mounted to bottom plate 1120. Furthermore, to provide positive detent positions, members 1114, such as cam followers, may be attached to the surface of bottom plate 1120 along the arc of travel 1116 of swing plate assembly 728. In the preferred embodiment, members 1114 provide indexing for swing plate 728 at about 10° counter-clockwise and about 30° clockwise from the operational position as viewed from above. Of course, additional members 1114 may be placed along the arc of travel 1116 to provide a greater or lesser number of positive detents as desired. It is contemplated that two additional members 1114 may be added, each spaced about 10° from one another, thereby providing indexing at about 10° and about 20° clockwise from the operational position.

Referring now to Fig. 11B, casters 1118 are attached to the bottom of bottom plate 1120 in order to allow manipulator assembly 702 to be positioned as desired on the test floor. In the preferred embodiment four casters 1118 are used although a greater number of casters may be used as desired.

Referring to Figs. 12A-12C, various views of swing plate assembly 728 are shown. In Fig. 12A, a bearing assembly 1200 mates with bearing assembly 1100 (shown in Figs. 11A-11B) allowing swing plate assembly 728 to rotate about pivot point 734 (as shown in Fig. 10). Rollers 1202 are attached to the top surface of swing plate 1216 with attaching means 1204, such as screws, allowing rollers 1202 to be replaced when worn. As discussed above, rollers 1202 roll along the surface of plates 1104, 1105 (shown in Fig. 11A). Plate 1206, which may be a durable material such as steel, is attached to the bottom of swing plate 1216 and provides a surface for rollers 1108 (shown in Fig. 11A). As shown, plate 1206 is located such that it corresponds to the locus of travel 1214 of rollers 1108. Plate 1207, which may be a durable material such as steel, is attached to the top of swing plate 1216 and provides a surface for brake pad 1704 (shown in Fig. 17). As shown, plate 1207 is located such that it corresponds to the length of travel of brake pad 1704.

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stop blocks 1404 (shown in Fig. 14A) at the limits of travel of side-to-side plate assembly 732. Sleeve 1308 is coupled to in-out plate 1310 as part of an in-out plate locking assembly discussed in detail below.

Referring to Figs. 14A-14C, the details of side-to-side plate assembly 732 are described. In Fig. 14A, slides 1400 are attached to the bottom surface of side-to-side plate 1402 and mate with linear guide rails 1306 (shown in Fig. 13A). Slides 1400 may be detachably coupled to side-to-side plate 1402 so that they may be replaced when worn. Stop blocks 1404 are attached to the bottom of side-to-side plate 1402 and, as discussed above, interface with bumper block 1302 (shown in Fig. 13A) attached to in-out plate assembly 730 preventing side-to-side plate assembly 732 from extending beyond a predetermined position relative to the in-out plate assembly 730.

Column structure 712 (not shown in this figure) is attached to the top surface of side-to-side plate 1402 as depicted in phantom by outline 1406 at locations 1408 using conventional attaching means, such as screws (not shown). To allow access to the in-out lock mechanism (described below) access hole 1410 is provided through side-to-side plate 1402. In addition, counterbore 1412 provided at the bottom surface of side-to-side plate 1402 that allows sleeve 1308 (shown in Figs. 13A-13C) to travel therein. Access hole 1410 may be covered as required by detachable cover 1416.

As shown in Fig. 14A, counterbore 1412 has a radius at each end that conforms to the shape of sleeve 1308. A pedal 1016 is attached at a side of side-to-side plate 1402 and is used to actuate the in-out lock discussed below.

Figs. 15A-15C are a plan view and side views of base assembly 710 which show the interrelationship of the various sub assemblies 726, 728, 730 and 732.

Figs. 16A-16C are various views of the combination of bottom plate assembly 726 and swing plate assembly 728. As shown in Fig. 16A, indexing pivot arm 1600 is attached to the bottom of swing plate 1216 and actuator 1606. Indexing pivot arm 1600 rotates about pivot point 1602 and engages cam follower 1114 with notch 1604 under control of actuator 1606. In the exemplary embodiment, actuator 1606 is a pneumatic actuator but may just as well be an electric actuator or a spring operated actuator, for example. When the operator desires to move the column structure 712, the

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Figs. 18A-18C are various views of the combination of in-out plate assembly 730 and side-to-side assembly 732 and describe the locking of side-to-side assembly 732 to in-out plate assembly. Fig. 19 is a detailed view of side-to-side lock assembly 1900. As shown in Figs. 18A, 19A and 19B, foot pedal 1014 is coupled to link 1800 at a first end through shaft 1806, spur gear 1804 and worm gear 1802. Rotation of foot pedal 1014 rotates link 1800 along its longitudinal axis. The second end of link 1800 is coupled to brake pad 1810 through wedge member 1808. Mounting brackets 1807 and 1809 are attached to the top surface of side-to-side plate 1402. The rotation of link 1800 moves link 1800 along its longitudinal axis, which in turn forces wedge member 1808 against wedge member 1811. The relative motion of wedge member 1808 against confronting wedge member 1811 extends brake pad 1810 (which is attached to wedge member 1811) so as to contact brake surface 1311 (shown in Figs. 13A and 13C) attached to the side of in-out plate assembly 730, thereby inhibiting movement of side-to-side plate assembly 732 relative to in-out plate assembly 730 along guide rails 1306. To retract the brake pad 1810 from brake surface 1311, foot pedal 1014 is rotated in the opposite direction. A return spring (not shown) may be provided and coupled to shaft 1804 to provide a spring force which places foot pedal 1014 in the normally locked position, thereby requiring a positive force on foot pedal 1014 in order to unlock side-to-side plate assembly. Stops 1812 may be attached to pedal 1014 to limit rotational travel by confronting the surface of side-to-side plate 1402. This prevents damage to the brake assembly due to excessive pressure or link 1800 and worm gear 1802 from becoming disengaged from spur gear 1806. In a similar fashion, stops 1820 may be attached to pedal 1016.

Figs. 20 and 22 are a front view and a rear view, respectively, of test head coupling 740. Test head coupling 740 is attached to the test head 802 and main arm 736 providing means whereby test head 802 may be rotated (rolled) about the Z-axis. In Fig. 20, test head coupling includes roll motor assembly 2006, timing belt 2010, and adapter ring 2000. Adapter ring 2000 is coupled to roll motor assembly 2006 at pulley 2016 with timing belt 2010, and rotates with respect to roll motor assembly 2006 under control of drive motor 2008 (shown in Fig. 21). In the exemplary embodiment of Fig. 20, timing belt 2010 is attached to adapter ring 2000 using clamps 2011 in order to reduce slippage

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Clutch 2014 is coupled between the gearbox 2010 and pulley 2016. In the exemplary embodiment, clutch 2014 is electrically controlled and engages upon application of electrical energy to the clutch. When electrical energy is removed from the clutch 2014, it will disengage thus preventing rotation of motor/gearbox 2008 from further driving pulley 2016. With clutch 2014 disengaged, the test head may be easily and normally rotated by hand, or by the docking actuator, about the z-axis.

Figs. 23 and 24 are a side view and a top view, respectively, of the vertical motor and associated hardware (drive system 2400) for raising and lowering the test head for moving test head 802 along a linear guide rail 738 (shown in Figs. 7A and 7B) defining a vertical (y) axis for the test head 802. As shown in Figs. 23 and 24, the major components of drive system 2400 include pulley 2406, cable 2410, electric motor/gearbox 2416, clutch 2426, small pulley 2412, timing belt 2420 and large pulley 2421. Cable 2410 is attached, at a first end 2411, to main arm 736 (shown in Figs. 7A and 7B), and at a second end to a counterbalance 2413. Main arm 736 is coupled to linear guide rail 738 and moves along linear guide rail 738 under control of cable 2410. In the exemplary embodiment two cables 2410 and two pulleys 2406 are shown, although greater or fewer pulleys and cables may be used as desired.

Pulleys 2406 are rotatably attached to columns 2402, which form the side members of column structure 712 (shown in Figs. 7A and 7B), with shaft 2408, which in the exemplary embodiment, is a single shaft common to both pulleys 2406. A motor drive assembly, including electric motor/gearbox 2416 and clutch 2426 is attached to frame assembly 2422, which, in turn is attached to mounting bar 2418 through mounting bracket 2414. Mounting bar 2418 is attached between columns 2402 at a rear portion thereof and behind pulley 2406.

Small pulley 2412 is coupled to large pulley 2421 through timing belt 2420. The large pulley 2421 is attached to one of pulleys 2606 with attaching means 2407, such as screws. Application of electrical energy to motor/gearbox 2416 provides a rotational force to electrically operated clutch 2426, which, in turn, drives small pulley 2412. As small pulley 2412 rotates, timing belt 2420 is caused to drive pulley 2606 through its coupling to large pulley 2421.

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c) In the pitch and roll axes, the test head is desirably mounted along axes passing through its center of gravity to enable the test head to be manipulated by hand. The use of the cable pivot and cable support help to maintain this effect in view of the cable.

5 d) The location of the axis of swing rotation and the vertical motion of the cable support help to achieve qualities of substantially unimpeded availability of motion throughout substantially the entire motion envelope.

10 Thus, in an exemplary embodiment of the present invention, a powered motion mode is added to any single available motion or to any selected combination of available motions, either rotational about an axis or translational along an axis. In other words, for each available motion to be powered, a motor or actuator is added, along with its appropriate control circuitry and operator interface, and arranged in a way so that it is mechanically decoupled from the positioner motion when it is not in use so that the substantially unimpeded motion remains available and unaffected. If all of the available
15 motions require only a small amount of relatively constant force, low powered actuators may be used. Thus, the following may apply:

a) The actuator may be an electric motor.

b) Gearing may be used as appropriate on the output of the motor or actuator.

20 c) The means to couple and decouple the actuator/motor to the motion axis may be a clutch.

d) A slip clutch or mechanism may be used if appropriate to limit applied force.

25 e) the force applied by the actuator may be regulated by control circuitry such that enough force is applied to cause motion but limited to an extent to cause the actuator to stall if an obstruction to substantially unimpeded motion occurs.

f) If the actuator is a dc electric motor, the force regulation is achieved by limiting the current supplied to the motor which in turn limits the torque output of the motor.

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discussed above, moving selector 2910 to the second non-center position provides the output of constant current driver 2924 to suppression circuit 2912 and motor 2914 in a polarity opposite to the first polarity. In turn, motor 2914 will rotate in the opposite direction to the direction when the first polarity voltage was applied to the motor 2914. The clutch coil 2916 is energized and engages the clutch whenever selector 2910 is in a non-center position.

The torque developed by motor 2914 is proportional to the current supplied by the constant current driver 2924 through selector 2910. This torque is transferred to a mechanical load (not shown) through clutch 2928. As discussed above, when selector 2910 is in the center position, motor 2914 is not energized, torque is not developed and clutch 2918 is not engaged. Therefore, the mechanical load is floating (i.e., free to move, without constraint imposed by a need to back drive the motor and gearbox, whether energized or not). On the other hand, when selector 2910 is in a non-center position, motor 2914 is energized and clutch 2918 is engaged. Since the current provided to motor 2914 is constant, the resulting torque output by motor 2914 is likewise constant. As discussed above, however, the current output of constant current driver 2924 may be adjustable. As such, the torque output by motor 2914 is likewise adjustable and may be adjusted as desired to match the mechanical load placed on the particular axis of motion that motor 2914 is intended to power. Adjusting the torque is desirable in order enhance safety and provide optimum performance. In the exemplary embodiment, the mechanical load may also be allowed to float, which is desirable when docking for example, or may be driven in either direction under control and with constant torque.

Optional limit switches 2920 and 2922 interrupt the current to motor 2914 when a limit of travel, such as up./down, clockwise/ counterclockwise, in/out and side-to-side is reached. The interruption of current by the limit switched 2920 and/or 2922 prevents further motion in the direction of limit without affecting motion opposite to the direction of limit. For example, if the motor 2914 encounters a clockwise limit, counterclockwise motion of motor 2914 is not inhibited. This same principle holds true for all other axes of motion. If the limit switches are not installed, current is supplied directly from the selector 2910 the motor 2914 when selector 2910 is in a non-center position.

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counterclockwise, safety block 3110 and lock block 3104 will move further apart releasing the pressure applied to the sides of linear guide rail 738 by lock block 3104.

In the exemplary embodiment shaft 3116 lies in an axis orthogonal to the axis of linear guide rail 738 and lock handle 3120 ratchets so that rapid locking and
5 unlocking using one hand may be achieved with minimal effort.

Referring now to Figs. 28A, 28B and 29, details of lock system 3100 are shown. In Fig. 28A, lock block 3104 includes calipers 3122 attached at pivot points 3124. Each one of calipers 3122 are placed along opposite sides of linear guide rail 738, each having a clearance bore through which shaft 3116 passes. As shaft 3116 tightens
10 against lock block 3104, the caliper 3122 adjacent safety block 3110 pivots, in a clockwise direction, as viewed from above, about pivot point 3124 and contacts vertical guide rail 738. Likewise, the caliper 3122 adjacent end block 3104 pivots in a counterclockwise direction, as viewed from above, about pivot point 3124 and contacts vertical guide rail 738. The combination of calipers 3122 pinching against vertical guide
15 rail 738, locks main arm 736 to vertical guide rail 738.

Referring now to Figs. 30 and 31, a fail-safe mechanism for the safety lock 3100 is described. In Fig. 30, a pawl system 3130 is included in safety block 3110. As shown in greater detail in Fig. 31, pawl mechanism 3118 includes a gear 3130 attached to shaft 3116 and pawls 3132 installed in safety block 3110, above and below gear 3130.
20 Slots 3136, such as elongated counter-bores, formed in safety block 3110, along with screws 3134, provide attachment of safety block 3110 to lock block 3104. In the exemplary embodiment slots 3136 are elongated counter-bores and screws 3134 are shoulder screws. Also attached to safety block 3110 are biasing springs 3126 that allow safety block 3110 to move vertically along slots 3136 relative to lock block 3104.

Under normal conditions, that is when the test head is attached to the test
25 head mount and the counterbalance (not shown) is attached to cable 2410, the weight of the test head and counterbalance compensate one another such that the screws 3134 are approximately centered in slot 3136 and neither pawl 3132 engages gear 3130, thereby allowing the operator to lock and unlock the main arm 736 at will. In the event that after
30 the test head is locked in place by lock system 3100 the test head is removed, an attempt

What is claimed:

1. A system for positioning a load, said load coupled to a cable, said system comprising:

a column which defines a first vertical axis;

an arm unit which supports said load and which moves a) along said first vertical axis, and b) along and relative to said column.

a rotation unit for rotating said column about a second vertical axis spaced apart from the first vertical axis;

said column positionable so that it is closer to said load than said second vertical axis is to said load;

said load positionable by said arm unit so that said cable intersects said second vertical axis and said cable is situated to a side of said column.

2. A system according to claim 1, wherein said load has a center of gravity and wherein said center of gravity, said first axis and said second axis are situated at the respective vertices of a triangle.

3. A system according to claim 1, wherein said column is forward of said second vertical axis towards said load and to a side of said second vertical axis.

4. A system according to claim 1, further comprising a cable support which supports said cable coupled to the load.

5. A system according to claim 4, wherein said cable support moves along a third vertical axis.

6. A system according to claim 1, wherein said rotation unit includes a bottom plate, and a swing plate which is coupled to said arm unit and which rotates relative to said bottom plate about said second vertical axis in order to rotate said load about said second vertical axis.

7. A system according to claim 1, wherein said rotation unit includes a side to side plate which moves said load horizontally along a first horizontal axis orthogonal to said first vertical axis.

8. A system according to claim 1, wherein said rotation unit includes an in-out plate which moves said load horizontally along a second horizontal axis which intersects said first horizontal axis and which is orthogonal to said first vertical axis.

9. A system according to claim 4, wherein said cables exit a test cabinet before being received for support by said cable support, and wherein said load is an electronic test head.

10. A system according to claim 6, wherein said rotation unit includes a plurality of indexing members for indexing rotation of said swing plate about said second vertical axis.

11. A system according to claim 4, wherein said cable support telescopes.

12. A system for positioning a load, said load coupled to a cable, said system comprising;

a column which defines a first vertical axis;

an arm unit which moves a) along said first vertical axis and b) along and relative to said column and which supports said load;

a cable support which moves a) along a third vertical axis independently of said arm unit and which supports said cable coupled to said load; and said load positionable by said arm unit so that said cable is situated to a side of said column.

13. A system according to claim 12, further comprising a rotation unit for rotating said first vertical axis about a second vertical axis spaced apart from the first

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vertical axis.

14. A system according to claim 12, wherein said cable support moves along said third vertical axis at one end thereof and said cable extends away from said one end and towards said load.

15. A system according to claim 13, further comprising a base to which said arm unit is coupled, said base including a bottom plate, and a swing plate which is coupled to said arm unit and which rotates relative to said bottom plate about said first vertical axis in order to rotate said test head about said first vertical axis.

16. A system according to claim 13, wherein said base includes a side to side plate which moves said test head horizontally along a first horizontal axis orthogonal to said first vertical axis.

17. A system according to claim 13, wherein said base includes an in-out plate which moves said test head horizontally along a second horizontal axis which intersects said first horizontal axis and which is orthogonal to said first vertical axis.

18. A system according to claim 12, wherein said cables exit a test cabinet before being received for support by said support unit, and wherein said load is an electronic test head.

19. A system according to claim 15, wherein said base includes a plurality of indexing members for indexing rotation of said swing plate about said first vertical axis.

20. A system according to claim 12, wherein said cable support telescopes.

21. A system for positioning a load, comprising:

an arm unit which supports said load and which moves along a vertical column which defines a first vertical axis,

a rotation member for rotating said first vertical axis about a second vertical axis spaced apart from said first vertical axis;

a cable support which moves along a third vertical axis and which supports a cable coupled to said load; and

a further rotation member which provides rotation of said load about a horizontal axis, wherein vertical motion of said cable is preventable while said load is rotating about said horizontal axis.

22. A system according to claim 21, wherein said arm unit moves upward and downward along said column.

23. A system according to claim 21, wherein said cable support moves along said third vertical axis at one end thereof and said cable extends away from said one end and towards said load.

24. A system according to claim 21, wherein said rotation member includes a bottom plate, and a swing plate which is coupled to said arm unit and which rotates relative to said bottom plate about said second vertical axis in order to rotate said load about said second vertical axis.

25. A system according to claim 21, wherein said rotation member includes a side to side plate which moves said load horizontally along a first horizontal axis orthogonal to said first vertical axis.

26. A system according to claim 21, wherein said rotation member includes an in-out plate which moves said load horizontally along a second horizontal axis which intersects said first horizontal axis and which is orthogonal to said first vertical axis.

27. A system according to claim 23, wherein said cables exits a test cabinet before being received for support by said cable support, and wherein said load is an electronic test head.

28. A system according to claim 25, wherein said rotation member includes a plurality of indexing members for indexing rotation of said swing plate about said second vertical axis.

29. A system according to claim 21, wherein said cable support telescopes.

30. A system for positioning a load, said load coupled to a cable, said system comprising:

a column which defines a first vertical axis;

an arm unit which supports said load and which moves a) along said first vertical axis, and b) along and relative to said column;

a rotation unit for rotating said column about a second vertical axis spaced apart from the first vertical axis;

said second vertical axis situated not more than three widths of said cable away from said test cabinet;

said load positionable by said arm unit so that said cable intersects said second vertical axis and said cable is situated to a side of said column.

31. A system for positioning a load, said load coupled to a cable, said system comprising;

a column which defines a first vertical axis;

an arm unit which supports said load and which moves along said first vertical axis;

a rotation unit for rotating said first vertical axis about a second vertical axis spaced apart from the first vertical axis;

said cable situated along an axis which intersects a center of gravity of said load;

said load positionable by said arm unit so that said cable intersects said second vertical axis and said cable is situated to a side of said column.

32. A system according to claim 1, wherein said column is an upright support.

33. A system according to claim 12, wherein said column is an upright support.
34. A system according to claim 21, wherein said column is an upright support.
35. A system according to claim 30, wherein said column is an upright support.
36. A system according to claim 31, wherein said column is an upright support.
37. A system for positioning a load according to claim 32, wherein said rotation member includes an in-out plate which moves said load horizontally along a second horizontal axis which intersects said first horizontal axis and which is orthogonal to said first vertical axis.
38. A system for positioning a load according to claim 32, wherein said cable exits a test cabinet before being received for support by said cable support, and wherein said load is an electronic test head.
39. A system for positioning a load according to claim 32, wherein said rotation member includes plurality of indexing members for indexing rotation of said swing plate about said second vertical axis.
40. A system for positioning a load according to claim 32, wherein said cable support telescopes.

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an arm unit which supports said load and which moves along said first vertical axis;

a rotation unit for rotating said first vertical axis about a second vertical axis spaced apart from the first vertical axis;

said second vertical axis situated not more than three widths of said cable away from said test cabinet;

said load positionable by said arm unit so that said cable intersects said second vertical axis and said cable is situated to a side of said column.

44. A system for positioning a load, said load coupled to a cable, said system comprising:

a column which defines a first vertical axis;

an arm unit which supports said load and which moves along said first vertical axis;

a rotation unit for rotating said first vertical axis about a second vertical axis spaced apart from the first vertical axis;

said cable situated along an axis which intersects a center of gravity of said load;

said load positionable by said arm unit so that said cable intersects said second vertical axis and said cable is situated to a side of said column.