Office de la Propriété Intellectuelle du Canada
Un organisme d'Industrie Canada

Canadian Intellectual Property Office
An agency of Industry Canada

CA 2684192 C 2017/09/19

(11)(21) 2 684 192

(12) BREVET CANADIEN
CANADIAN PATENT

(13) C

(22) Date de dépôt/Filing Date: 2009/10/30

(41) Mise à la disp. pub./Open to Public Insp.: 2011/04/30

(45) Date de délivrance/Issue Date: 2017/09/19

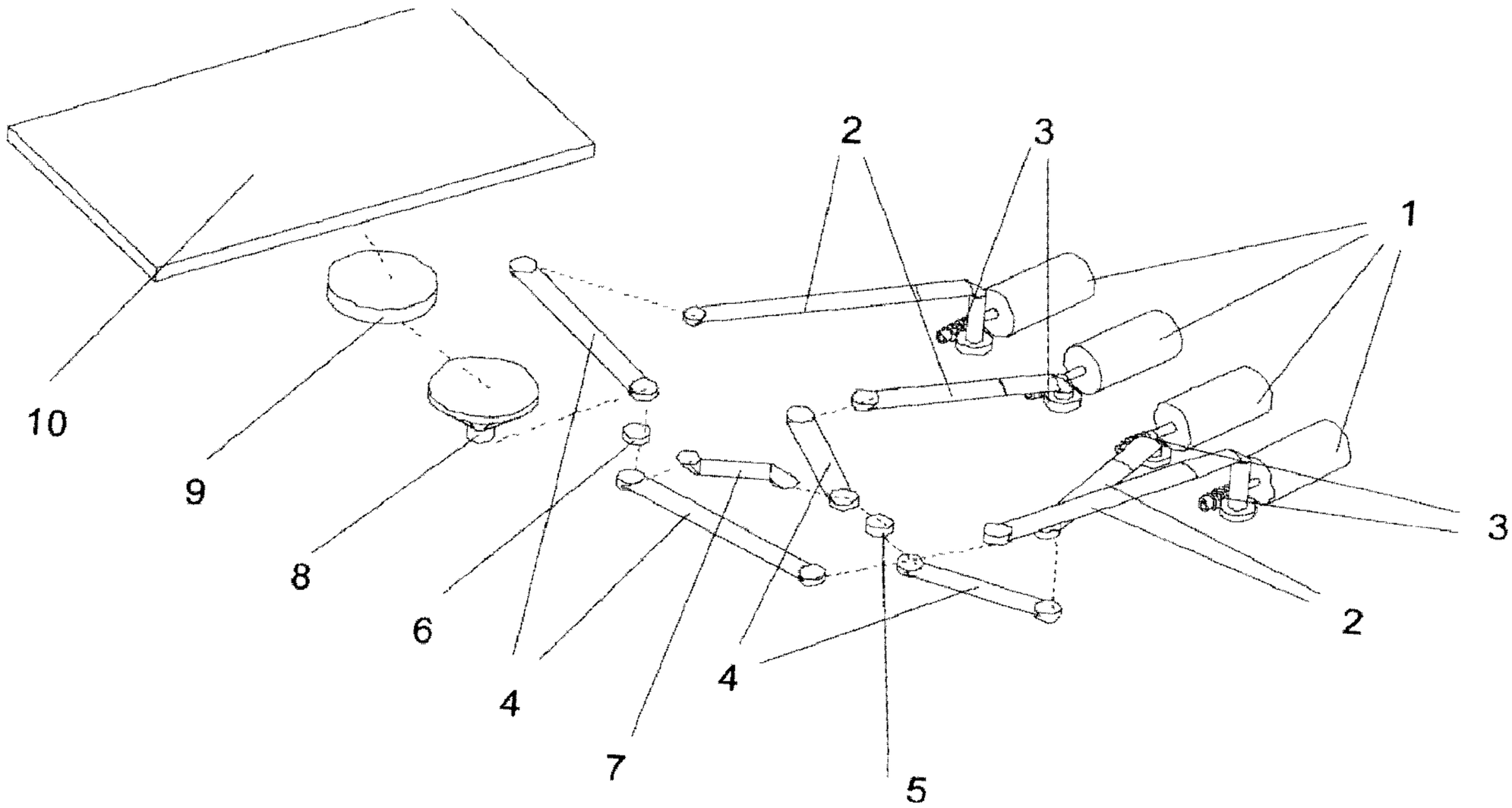
(51) Cl.Int./Int.Cl. *G09F 11/00* (2006.01),
G09F 19/12 (2006.01)

(72) Inventeurs/Inventors:
SUTHERLAND, STEPHEN, CA;
WICK, DALE, CA

(73) Propriétaire/Owner:
CROSSWING INC., CA

(74) Agent: DENNISON ASSOCIATES

(54) Titre : APPAREILLAGE ET METHODE APPLICABLES A LA CHOREGRAPHIE DE L'AFFICHAGE ROBOTISE
(54) Title: APPARATUS AND METHOD FOR ROBOTIC DISPLAY CHOREOGRAPHY



(57) Abrégé/Abstract:
The present system and method provides for a new digital media paradigm enabling tight choreography of motion, content and time able to be presented on a variety of hardware platforms consisting of robotic control of a multiplicity of display screens in the form of a movable array of 2 or more LCDs, LEDs, OLEDs, etc., with the movement and placement of each display achieved by one multi-axis manipulator arm mechanism. Motion control is achieved through software programmed onto one or more controller systems and the corresponding tools necessary for creative visual designers to produce content meeting this new paradigm are also proposed. Each arm/display screen combination is kept aware of its positioning in physical space, relative to the positioning of each and every other arm/display screen at all times, in order to prevent collisions. The pre-programmed software control takes the form of a choreographed play list of movements, content, and time that match the desired positioning of the array of display screens, in order to achieve the desired dynamic presentation of custom-produced digital content that will be presented across the array, in a fully coordinated fashion.

ABSTRACT OF THE DISCLOSURE

The present system and method provides for a new digital media paradigm enabling tight choreography of motion, content and time able to be presented on a variety of hardware platforms consisting of robotic control of a multiplicity of display screens in the form of a movable array of 2 or more LCDs, LEDs, OLEDs, etc., with the movement and placement of each display achieved by one multi-axis manipulator arm mechanism. Motion control is achieved through software programmed onto one or more controller systems and the corresponding tools necessary for creative visual designers to produce content meeting this new paradigm are also proposed. Each arm/display screen combination is kept aware of its positioning in physical space, relative to the positioning of each and every other arm/display screen at all times, in order to prevent collisions. The pre-programmed software control takes the form of a choreographed play list of movements, content, and time that match the desired positioning of the array of display screens, in order to achieve the desired dynamic presentation of custom-produced digital content that will be presented across the array, in a fully coordinated fashion.

TITLE: APPARATUS AND METHOD FOR ROBOTIC DISPLAY CHOREOGRAPHY

FIELD OF THE INVENTION

This invention relates to signage, presentation and display systems that include a "robotic display" where multiple displays are controlled to dynamically alter the orientation and spacial relationship of the displays.

BACKGROUND TO THE INVENTION

Many attempts have been made to design novel signage and presentation systems that will entertain, as well as inform and instruct, viewers. Content providers and advertisers continuously seek engaging mediums to differentiate their message amid the plethora of visual and audible commotion. However, there are essentially only four types of such display systems available to creative visual designers vying for viewer attention:

1) Traditional non-digital displays typically consist of one or more stiff flat or curved substrates made with materials such as paper, cardboard, wood, plastic, vinyl, fabric, metal and Plexiglas which are imprinted with desired visual content commonly including coloured text and graphics (pictures, symbols, maps, etc.). Many such systems are also back-lit, typically employing a light box filled with florescent or LED lights mounted behind a translucent substrate, such as Plexiglas, which carries the visual content. A more economical approach is to light from the front for night and low ambient light viewing.

To overcome the static nature of non-digital displays, sometimes a 3D effect is achieved by fixing carved, molded, or neon tube letters and shapes on top of the substrate or by etching, molding or carving such information into the substrate surface. Extreme 3D effects, whereby the designer superimposes a large 3D object on top of the substrate, sometimes also using motors to move or shake such physical object in a repetitive fashion, is also used to attract viewers. In further efforts to overcome the static nature of such displays, 3D effects are often augmented during night viewing by careful application of various lighting techniques to create an illusion of motion.

The quest to draw viewer attention to otherwise static displays has also seen advertisers tie their signage behind planes or to the sides of blimps travelling low over areas frequented by target consumers or during large sports events. Such extremes further illustrate the intense desire of advertisers to seek new mediums with which to deliver their message.

Re-skinning non-digital installations with new content is a labour and material intensive process – thus content is typically fixed for a period of time spanning months or possibly years. However, in cases such as flip-charts and various shutter billboard systems, additional content is available by flipping to the next page of a chart or, in the case of shutter billboard systems, by striping content across adjoining vertical or horizontal blinds (which are double or triple sided) such that when the blinds are synchronized during rotation, the complete content for any one given sign appears to be seamlessly displayed. In some cases, the content from one side relates to the other side's content, so a simple story may be told. Lenticular screens are also installed to achieve a similar effect, enable the viewer to see different sets of vertically striped images from varying reading angles – sometimes even presenting each eye with slightly different viewpoints, forming three-dimensional views of the static scene.

2) Electronic signage and presentation systems replace traditional substrates with one or more planar digital electronic display panels (plasma, LCD, OLED, LED, etc.) and associated circuitry capable of forming a quality rendering of the content received in digital or analog form. Typically displaying prerecorded content streams blending motion video with sequences of still images with additional text or other graphic content optionally rendered in real-time (eg: time and temperature superimposed on electronic billboards), some such systems also deliver corresponding audio information via an array of one or more speakers. Although less common, electronic displays may also be made of flexible substrates, including fabrics with embedded LEDs, which are used to cover non-planar surfaces. To expand the field of view, which is a significant limitation, particularly for LCD technology, electronic displays are often mounted back-to-back or at 30, 45 or 90 degree angles around pillars.

Installation and maintenance costs are much higher than traditional non-digital displays, particularly for larger-format applications. However, the ease to re-skin digital signage instantly with new content streams coupled with the medium's ability to play catchy motion video and animations, even outdoors in full sunlight, has made them increasingly popular choices for both advertisers and sports venues alike. But this popularity, coupled with broad consumer adoption of larger flat panel televisions within their homes, is now diminishing the ability of all but the largest of these electronic display systems to standout, wow, or even entertain viewers.

3) Projection signage and presentation systems use either analog video or digital projectors to beam rendered content onto reflective screens which although commonly flat, may also be convex or concave. Typically larger than

their digital display cousins, projection systems suffer the same challenges in attracting waning consumer attention. Attempts to grab more attention include the use of some such systems to project onto the outside or inside of transparent globes or other objects including waterfalls and mist walls. Multiple projectors are also used where larger screens or 360 degree display is deployed. Projection systems are typically deployed in indoor areas, since ambient light reflected from such screens greatly lowers impact and readability of the content.

4) Interactive signage and presentation systems, the newest medium available to creative designers, augment the digital stream flowing to the display by dynamically altering content based on either direct input from the viewer, or passive means. Direct input is typically captured via an attached keyboard or touch screen apparatus, but may also include control of the content via a cell-phone touch screen or keypad, or via laser or optical pointer devices. Indirect methods, including motion sensor and RFID tag readers, also provide the ability for attached processing circuitry to dynamically modify the content based on viewer proximity or known viewer profiles.

A prior art system involving moving display screens is shown in U.S. Patent 6,339,969.

Beyond media limitations, creative visual designers working with content providers and advertisers to vie for consumer attention are also restricted by the fact that in each of the above mediums, common digital media paradigms (eg: bitmap, vector, and video) and tools (eg: Adobe Illustrator, PhotoShop and Flash) are used to design and produce the content. Although this commonality facilitates training and communication of both ideas and completed works, the inherent lack of differentiation, at the media and tool levels, exacerbates the challenge for the creative designer attempting to deliver a message which clearly stands out from the competition.

The push to differentiate while staying within the confines of existing digital media paradigms has recently reached absurd proportions. Initially, projects such as a continuous ring of digital signage running around a stadium at balcony level seemed like a great way to capture audience attention for special advertising and entertainment during halted play – but now, for example, some soccer stadiums operate brightly lit digital displays at field level, distracting players and at the same time making it virtually impossible for play-by-play cameras to correctly adjust exposure for best televised quality of the focal sporting event itself.

The multitude of signage and presentation systems bound by current display techniques competing for consumer attention has made it increasingly difficult for advertisers to stand out. Many venues seeking corporate sponsorships are

pushing the envelope on existing approaches with brighter, sharper and larger displays appearing to be the only differentiating factors, each with diminishing gains as the techniques mature. Accordingly, there remains a need for a new medium coupled with new tools through which content providers and advertisers can standout, yet clearly deliver their message while entertaining their viewers.

SUMMARY OF THE INVENTION

The present invention provides a visual display system comprising a plurality of display devices, a separate support arrangement for each display device that accommodates substantial movement of the respective display device along first and second axes to any of a series of non-overlapped positions. The plurality of display devices are each movable in a manner to change the order of said display devices relative to at least one of said first and second axes.

A further embodiment of the invention is characterized in that each display device is movable along said first axis to at least positions either side of a neutral position and movable along said second axis to at least positions either side of said neutral position.

In yet a further aspect of the invention the separate support for each display device includes a pivot connection accommodating pivotal movement of the display device about a position that is offset relative to a central axis of the display device.

In a further aspect of the invention, each separate support includes a control bar linkage for controlling the movement and position of the respective display device.

In yet a further aspect of the invention, the pivot connection of each display device is located adjacent a rear corner of the display device.

In yet a further aspect of the invention, the separate support for each display device includes a pivot connection accommodating pivotal movement of the display device about a position that is offset relative to a central axis of the display device.

In yet a further aspect of the invention, the separate support for each display device includes a motor actuator controlling the separate support and thereby controlling the position and movement of the respective display device in the display area.

A further aspect of the invention includes a computer controller providing control

signals for each motor actuator to determine the relative position and movement of the display devices.

The present invention accommodates a new, compelling medium and supporting systems through which content providers and advertisers can entertain viewers, while clearly delivering their message. The present invention also includes a new digital media paradigm and corresponding tools necessary for creative visual designers to produce content for such system.

One aspect of the invention includes a method of synchronous rendering of multiple portions of a choreographed script onto multiple displays, where such choreography also specifies a dynamically evolving orientation and spacial relationship between such displays. The method includes acceleration, deceleration, and relative speed and position of each display through time. Using this method a creative visual designer can choreograph two or more displays to move in conjunction with displayed content and optionally, recorded sounds and music.

Preferred embodiments of the invention include one or more of the following features: The method includes precise placement of displays relative to one another and defines the maximal motion space of each display at a given moment, assuming one of a multiplicity of robotic manipulators having a multiplicity of degrees of freedom, in either two dimensional or three dimensional space depending on such manipulator's capabilities, clipped or limited by the position of neighbouring displays at such moment. The method includes further limiting of the motion space of such display at a given moment by projecting its current speed, direction and acceleration along with those of neighbouring displays to detect any unavoidable future collision scenarios. The method includes yet further limiting of the motion space of such display at a given moment based on the motor torque limits, motor thermal limits and expected momentary winding temperatures based on recent previous motions, and robotic structural limits including acceleration stress tolerances of the display hardware itself. The method includes wall, ceiling, and floor mounted robotic display systems. The method includes mounting of all or a subset of the robotic manipulators on a turntable to enable rapid rotation and orientation changes. The method includes mounting of the robotic manipulators on a rail or carriage assembly to broaden left-to-right or top-to-bottom motion. The method includes provisions, in special cases, for multiple display attachments per individual

robotic mechanism and for optionally using one or more displays or a digital projector to project rearward to create diffuse ambient patterns or motion content reflecting off walls, ceilings, and other reflective substances including smoke, waterfalls and shiny disco balls or to create detailed reflections off flat, convex or concave mirrors. The method includes display of both traditional 3D content realized by a viewer wearing special glasses, or dynamically rendered 3D perspective based on the viewer's location relative to the robotic display system. The method includes both active and passive interactive robotic display systems where viewers influence the content and choreography and may be used for way finding when coupled with a touch screen. The method includes, in cases where three dimensional robotic manipulators are deployed, the ability to accentuate a zoom feature whereby one or more displays move rapidly towards or away from the viewer. The method also includes provisions for Internet and broadcast robotic display content choreography.

Another aspect of the invention includes a computer program, residing on a computer-readable medium, having instructions for causing a computer to perform an interactive simulation of the rendering of specific choreographed content to each display while also illustrating the synchronous robotic positioning. Such interactive simulation enables a creative visual designer to synchronize content with corresponding motion and store such instructions for later execution in accordance with the methods of the invention. Motion control, not only for the position and orientation of the individual displays, but also of the geometry of the robotic manipulators and turntable is possible from within the simulator, as the mechanical aspects of the robotic display system and related choreography is part of the overall visual art design.

In another aspect of the invention, a computer program, resides on a computer-readable medium, and includes instructions for causing a computer to render and direct specific choreographed content to each display while also directing, in synchronicity with such content display, the robotic display positioning systems.

A significant aspect of the invention is the ability to combine choreographed physical display motion with digital content. An absence of motion is often associated with an absence of life – thus, the ability to add a true motion element choreographed with content is akin to adding life to digital display systems. Motion not only attracts eyeballs (attention), but can be used to convey many concepts from emotion to partnership to disunity. A multitude of advantages to creative artistic designers are possible, spanning even simple choreography for example, where one or two displays can be periodically pulled from a central group and used to highlight a narrator's or onlookers' faces looking inwards towards the main displays running the focal content stream. Contrast this approach to that of popping open a window on-top of running content – the window on-top not only obscures some of the focal content but

also stares back at you, the viewer. As proposed by this invention, the separate display, moving off to the upper left or right with the face(s) also looking towards the content, watches with you – a form of personal connection which is otherwise difficult to achieve in digital display applications. Much more sophisticated applications are certainly possible, and other features and advantages of the invention will become apparent from the following description and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the invention are shown in the drawings, wherein:

FIG. 1 is an exploded view of the compact planar manipulator.

FIG. 2A-D is a set of orthogonal views of the compact planar manipulator.

FIG. 3A-B depicts the compact planar manipulator mounted onto a railing system.

FIG. 4 depicts the compact planar manipulator mounted onto a scissor lift-type mechanism.

FIG. 5 is an exploded view of the three degree-of-freedom parallel manipulator.

FIG. 6A-C is a set of orthogonal views of the three degree-of-freedom parallel manipulator.

FIG. 7A-D are a set of orthogonal views of the three degree-of-freedom parallel manipulator, where the screens remain stationary and the hardware behind the screens is moved. FIG. 7E shows the beginning of the motion of the screens in order to end up in a plus-pattern, as depicted in FIG. 7F.

FIG. 8 depicts the screens of the three degree-of-freedom parallel manipulator rotating about their geometric centres.

FIG. 9A-F are a collection of screen shots of the three degree-of-freedom parallel manipulator being used in a golf commercial storyboard.

FIG. 10 is an exploded view of the six degree-of-freedom robotic arm manipulator.

FIG. 11A-D is a set of orthogonal views of the six-degree-of-freedom robotic arm manipulator.

FIG. 12 depict the ability of the six-degree-of-freedom robotic arm manipulator to follow/track a viewer loosely.

FIG. 13 depict the ability of the six-degree-of-freedom robotic arm manipulator to follow/track a viewer with greater accuracy.

FIG. 14 is an exploded view of the six degree-of-freedom robotic arm manipulator with dual-screens.

FIG. 15 is a set of orthogonal views of the six degree-of-freedom robotic arm manipulator with dual-screens.

FIG. 16 is a diagram of the six degree-of-freedom robotic arm manipulator mounted onto the ceiling.

FIG. 17 is a flowchart of the content creation process.

FIG. 18A-B depicts an example planar robot and its assigned coordinate frames for the D-H analysis.

FIG. 19 is a storyboard depiction of screen movement for a planar robot.

FIG. 20 is a storyboard depiction of screen movement plus the content for the screens.

FIG. 21 is a screen shot of the CDWA depicting the new project dialogue box.

FIG. 22 is a screen shot of the CDWA depicting how the designer manipulates an MVST on-screen.

FIG. 23 is a screen shot of the CDWA depicting the insertion of a new media file.

FIG. 24 is a screen shot of the CDWA depicting the designer setting the properties for a newly inserted media file.

FIG. 25 is a screen shot of the CDWA depicting the designer adjusting the entry/exit points of an MVST event.

FIG. 26 is a screen shot of the CDWA depicting the working space of the designer.

FIG. 27 is a screen shot of the CDWA depicting the export dialogue box.

FIG. 28 is a screen shot of the CDWA depicting the generated heat profile for an MVST.

FIG. 29 is a screen shot of the CDWA depicting the generated acceleration profile for an MVST.

FIG. 30 is a screen shot of the CDWA depicting the dialogue box asking for the MVST to be specified for the compilation process.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The compact planar manipulator (as seen in FIG. 1 and FIG. 2A-D) is driven by 4 DC-motors (1). Each motor is responsible for driving a lower-arm (2). Since the rotation of the motor gear shaft and the rotation of the lower-arm (2) take place in perpendicular planes, the motion of the lower-arm (2) is controlled by the motor with a worm gear apparatus (3). The worm gear apparatus connects the motor gear shaft to one end of the lower-arm (2). The other end of the lower-arm (2) connects to the upper-arm (4). The connection between the lower-arm (2) and upper-arm (4) is not actuated. The free end of the upper-arm (4) then connects to one of the circular faces of a spacer (5). The other face of the spacer (5) attaches to another arm system, like the one previously described above. The 4 DC-motors (1) are arranged so that the outer 2 arm systems connect together via a spacer (6) and the inner 2 arm systems connect together via another spacer (5). The inner arm systems are then connected to the outer arm systems via the crank shaft (7), which completes the mechanism.

A flat panel mount (8) is attached to one of the outer-arm systems. The mount supports a rotary (pancake) motor (9), which in turn is attached to the flat panel screen (10) or television which may be of any commercially-available technology including LCD, Plasma, LED, OLED, and 3D lenticular or other technologies. The robotic mechanism, excluding the panel and its accessories, allows for intricate planar motion through the precise control of the 4 motors. The limits of the planar motion are set by the lengths of the lower-arms and upper-arms, as well as the length of the crankshaft. Finally, the extra rotary motor (9) adds extra rotational freedom to the panel, enabling the designer to achieve more elaborate and attention-grabbing motions.

This mechanism is ideal for advertising areas with limited space. The system can act as a standalone unit, or can be linked up with other systems like itself, to create a chain of moving advertisements. Other possibilities include, mounting the manipulator on a railing system, allowing the screen to follow a viewer along a path, as well as incorporating a scissor lift-type mechanism to allow the manipulator to travel towards and away from the viewer. These depictions can be seen in FIG 3A-B and FIG 4 respectively.

The three degree-of-freedom planar manipulator (as seen in FIG. 5 and FIG. 6A-C) allows more manoeuvrability compared to the compact planar manipulator and creates interactions with 4 screens. The system is attached to the wall via a wall mount (11). A high-torque rotary (pancake) motor (12) is responsible for rotating the entire system. The mounting bar (13), which attaches to the rotary motor (12), is the interface for the 4 arms with the rotary motor (12). A smaller high-torque motor (14), attached to the mounting bar (13), allows the arm to rotate relative to the mounting bar (13). Spacers (15) are used to allow the outer 2 arms to rotate over the inner 2 arms without colliding, while keeping all the television screens (16) in the same plane. A motor-track system (17) is used to allow the arm member (18) to slide along its length. A final rotary motor (19) is fixed at the end of the arm member (18), allowing the television screen (16) to rotate on the spot.

Figure 7 depicts the ability of the planar system to keep the positions of the screens fixed, while re-orienting the hardware behind the screens. This is critical as a logo or other closing position of one choreography sequence can be held steady while the system is setting up for the next "scene", where the subsequent motion requirements a certain hardware starting point. Consider a storyboard where the screens are displaying a scene involving a bee in a garden. The screens in Figures 7A-7D can be playing a scene where the bee is walking up a hive (starting at screen 4 and going up towards screen 1), while the hardware in the back is re-orienting itself to display the next sequence. Figure 7E depicts the scenario where the bee takes off from the hive. Screen 1 can display the motion of the bee in flight, whereas the other screens can display the background environment during the flight. Finally, the bee comes to land on one of the petals of a sunflower. As the bee nears the sunflower, screen 1 converges with the remaining screens in a new orientation (Figure 7F), to display the bee standing on the sunflower.

This example provides the opportunity to showcase the versatility and flexibility of the hardware, as well as the ranges of motion possible when orienting the screens. Designers can use all of this to their advantage by creating either the most efficient path-plans or the most visually appealing motions, depending on their applications and preferences.

Another example of the versatility of this system can be seen in FIG. 8. This figure depicts the scenario where the 4 screens rotate about their geometric centres (point A), even though they are, in fact, actuated at their corners (point B). This 'effect' can be accomplished by taking advantage of the specialized hardware behind the screens, allowing designers to perform complex motion for the screens, while providing a viewing spectacle via the hardware.

WH-13545 CA
SN 2,684,192

An application of the three degree-of-freedom parallel manipulator can be seen in FIG. 9A-F. These are screen shots of a golf advertisement depicting the contribution of the screens throughout the video. As seen in the figures, the screens can be employed to introduce the scene by showing a fly-over view of the golf course. Then, 2 screens are used to show the golfer hitting the ball, while the other 2 screens stay fixed onto the flag, giving the viewer a sense of the breadth of the scene. As the ball soars through the air, a screen tracks its trajectory, until the ball 'drops onto' the final 2 screens, rolling into the hole. The motion of the screens add another dimension to the video graphics content, keeping the audience interested and engaged to the demonstration.

Planar systems may also be configured to completely hide their manipulator structure by suspending a large low-friction polymer surface panel between the screens and the manipulator mechanics. Ends of each manipulator and the backs of the screens would be affixed with low-friction polymer-encased attracting magnets so that although each screen would magnetically track the motion of its corresponding manipulator behind the large polymer surface, viewers would simply see the screens floating in front of such surface. Although points where the polymer panel is suspended could not be traversed, through artistic choreography, viewers will believe that there is unlimited motion. Inductive coils transfer energy to power the screens or the screens include rechargeable batteries which charge during periods when such screens move into 'docking' stations with charging contacts located towards the outsides of the polymer panel. Data can either be transferred using inductive coils or traditional wireless data protocols. A further aspect of this design is that in harsh climates, protecting the manipulators from salt, water, debris and other forms of wear and corrosion, can significantly lengthen the life of the now-enclosed robotic mechanisms. The screens themselves could also be moved up, under or into overhanging shelters in times of inclement weather if the rear apparatus was mounted on a track enabling appropriate motion.

The six degree-of-freedom robotic arm manipulator (as seen in FIG. 10 and FIG. 11A-D) provides the ultimate 3D advertising/displaying experience. The four arms provide manoeuvrability that none of the previously mentioned systems can. A high-torque rotary (pancake) motor (20) is mounted directly to the wall or ceiling, depending on the application of the system. A mounting plate (21), which houses the four 3D robotic arms, is attached to the rotary part of the motor (20). The arm is attached to the mounting plate (21) with the help of a shoulder socket (22). The shoulder joint (23) attaches to the shoulder (22), creating rotational freedom. The arm support (24) ensures that the arm member (25), which is independently actuated by a motor, rotates within the confined space. The other end of the arm member (25) has a rotary socket (26) attached to it, which, along with a rotary joint (27), creates rotational freedom. The rotary joint (27) is essentially a rotary (pancake) motor with a housing attached

to it to interface with the rest of the arm. A spacer (28) is used to separate the rotary joint (27) and arm support (24). This arrangement is replicated to achieve increased degrees of freedom. Near the end of the arm, a wrist socket (29) is attached to the arm member (25). The wrist joint (30) provides another degree of freedom, while the rotary support (31) and rotary motor mounted directly onto the television screen (32) provide the last degree of freedom.

Figure 12 illustrates the ability for the three dimensional robotic display to include choreography which stacks the displays perpendicular to the mounted wall to attract attention of side viewers, then follows such viewers as they move around the robotic display system. This is accomplished by the addition of one or more cameras (C) and a smaller camera mounted directly onto each of the screens (D). This setup allows for creative and realistic interaction of the system with people. Consider such a system mounted on a wall outside an amusement park ride. Those waiting in line will have the opportunity to interact with the system. For example, as people walk by the mechanism, the stereo cameras can pinpoint the exact location of an individual within the vicinity of the robot, allowing the screens to interact with the individual. The on-screen camera can be used to capture details about the individual, which can then be manipulated by intelligent image-processing software to pick out specific details about the individual (hat colour, hair length, type of clothing, etc.) in order to provide a more realistic interaction with the robot. Furthermore, the on-screen camera can be used to show the other individuals waiting in line, exactly what the robot "sees" on a larger screen set up to the side of the choreography or as a dynamic part of the choreography itself.

Figure 13 shows similar functionality, but with the screens tightly coupled. In this orientation, the system can follow a person as they approach from a corner (E), and continue onto their path.

The arrangement of the six degree-of-freedom robotic arm manipulator with dual-screens (as seen in FIG. 14 and FIG. 15A-D) is very similar to the one previously described; parts 20 through 29 are the same. The only change is after the wrist socket (29). A wrist joint (33) attaches directly to the wrist socket (29) and houses 2 television screens back-to-back. This results in the reduction of the last rotational degree of freedom in the previously described model, but enables designers to use the dual-screen setup in creative ways. The entire system can be installed on top of a reflective backdrop (34), which allows the designers to use this reflective surface in creative ways. Similarly, backdrops could include fog/mist walls, water falls, and smoke walls.

The effectiveness of the six degree-of-freedom robotic arm manipulator with dual-screen heads can be seen in FIG. 16, where the robot is mounted onto a ceiling such that the upper-facing display can project patterns onto the ceiling –

creating an ever-changing halo for various moods and effects. Note that it is also possible to place digital projectors on the rear of such dual-display heads which may also be coupled with 30 degree motors to rock such heads 15 degrees to the left and right. In a further implementation, such dual-screen headed systems can be mounted on a cross-bar in front of (in the case of wall-mounting), or below (in the case of ceiling mounting), a mirrored surface. Such surface may be one, or a tiled pattern of many mirrors of types: concave; flat; convex; spherical; or any combination thereof. By projecting images onto this surface in conjunction with the choreography, an entire room can be filled with moving projections.

With many of the embodiments already described, it is possible to accommodate partial overlap of screens if desired. This allows partial reduction of the viewing area and expansion thereof as the extent of overlap is reduced. This arrangement provides a number of advantages including visual opportunities for more realistic depiction of colliding objects or near miss of objects.

As can be appreciated the individual display screens can be very large commercial display screens although smaller screens can be used for other applications.

SOFTWARE COMPONENT

A choreographed presentation involves integration of several elements: motion, visual content render, sound and lighting effects, and time. Referred to as a MVST (Motion, Visual render, Sound/lighting, and Time) display system, it defines a new media paradigm.

The MVST display systems consist of screens that are driven by robotic arms with two or more degrees of freedom, controlled by a set of connected motors. The motion for the displays is expressed as a series of MVST events, described shortly. Creating a presentation in the Creative Designer's Workbench Application (CDWA) is a revolutionary experience, unlike anything seen before. Essentially, designers create MVST events, which are critical points in time during the choreography where the screens, content on the screens, music, and lighting all precisely aline. up as required.

MVST EVENTS

The content on the screens can be shared between multiple screens, or there can be individual content that targets one or more screens. Thus, all of the

screens can be playing back a single video or looking at a single image so that the screens are windows into a large virtual area. The content can also be anchored to a screen or it can follow a custom path. For each MVST event in the motion path, a new video can begin playing, or a new image can be displayed. The location of the video or image can be relative to the background, relative to one of the screens, or can be specified as a zoom and rotation relative to the centre of the robot.

Designers are required to create a minimum number of MVST events for their presentations, essentially outlining key points in the motion, such as abrupt stops, cusp motions, etc. The CDWA then interpolates and creates motion plans between MVST events, saving the designer the work of having to create the entire motion plan manually. This interpolation process takes into account the model of the specific MVST display being used and creates the optimal motion plan keeping motor acceleration limits and heat profiles in mind. The benefit of this is that the CDWA creates a motion plan that is specific to the hardware in use using the generic MVST events outlined by the designer.

As an example, consider the following scenario. A designer is working on an advertisement involving a large-scale MVST display with 4 screens. This display will be installed in a large space such as an airport, or a shopping mall. The advertisement involves all 4 screens starting off together in a square pattern, then breaking away diagonally while all the screens are spinning, and finally coming back to end in a square pattern. The designer uses the CDWA to create critical MVST events for the advertisement and the CDWA creates the motion paths between the MVST events for the large-scale MVST display being used. Now, consider a small-scale MVST display installed at a retail store-front. The designer can run the same presentation on the smaller MVST display without having to change the presentation. The MVST events are still the same, except now the CDWA interpolates a motion path for the smaller MVST display. As long as the smaller system is capable of performing the required motions, the presentation will be similar to the one seen on the large-scale system.

MVST MODEL FILE

Creating a presentation requires several steps (FIG. 17). Initially, the designer needs a model of the MVST display to be used (acquired externally). This model file includes all of the following necessary parameters (and their units) to completely characterize the MVST system:

- Denavit-Hartenberg (D-H) variables
  - link offset, d (m)

link le, a (m)

- twist angle, α (rad)

joint angle, Θ (rad)

- link masses (kg)

link centres of gravity (coordinates)

link envelopes

motor locations (coordinates)

motor limits

- peak torques (Nm)

rated speeds (m/s, rad/s)

peak Force (N)

stroke (m)

thermal resistivity (deg. C/Watt)

rated voltage (V)

rated current (A)

The four D-H variables are required to completely characterize the forward kinematics formulation of the MVST display. Treating the MVST display as a set of links and actuation points, one can easily determine the position and orientation of the end-effector (the screens in this case) based on the link lengths and the angles between consecutive links. The D-H characterization is not unique and one must make sure to account for all the degrees-of-freedom of the robot. The following is an example D-H table for one of the arms of the 4-screen planar robot. FIG. 18a-b show the planar arm and the coordinate frame assignments.

Joint	α	Θ	d	a
1	0	Θ_1	0	0
2	0	0	0	p
3	0	Θ_2	0	0

These parameters are then used in homogenous transformation matrices, in order to solve the forward kinematics problem.

The link masses and centres of gravity (CoG) are used by the CDWA to calculate the moments acting on the pivot-points, and thus the motors, in order to assess the loads on the motor. The link masses are multiplied by the acceleration due to gravity (9.807 m/s^2) to obtain the forces (*F*) in Newtons (N). The CoG is

used as the moment-arm for the moment calculation. The moments are calculated using the following vector cross-product:

$M = F \times d$ where,
M is the calculated moment (in Nm),
d is the moment-arm (in m),
and F is the force acting at d (in N)

The calculated moment can be compared to the rated torque (in Nm) of the respective motor to ensure that said motor is capable of driving the load.

Link envelopes are used to assist the CDWA in 'visualizing' the links of the MVST display. For example, stating the mass, CoG, and length of a link is not sufficient because the shape of the link is not entirely categorized by these parameters. The link envelope provides this missing information in the form of a set of coordinates, or nodes, and connection relationships of these nodes to other adjacent nodes. These nodes are used as vertices, and the connection relationships as edges, to create a box-like structure that encompasses the link as accurately as possible. This box-envelope is then used by the CDWA for collision checks during the simulation stage.

Peak torques and speeds are used to calculate the power consumption of DC motors using the following relationships:

$P = w * t$ (for rotary motors) where,
P is the power (in Watts),
w is the angular velocity (in rad/s),
and t is the torque in (Nm)

$P = F * v$ (for linear motors) where,
P is the power (in Watts),
F is the force (in N),
and v is the speed (in m/s)

For 3-phase motors, instantaneous power is calculated as follows:

$P = 3 * V_phase * I_phase * \cos(theta)$ where,
P is the power (in Watts),

V_phase is the phase voltage (in V),

I_phase is the phase current (in A),

and *theta* is the phase angle

Additional information such as stroke is provided for linear actuators, so that the CDWA always know what the limits of the actuator are. In order to calculate the heat produced, the thermal resistivity and power are required.

$$T_m = TR * P$$ where,

T_m is the motor temperature (in deg. C),
TR is the thermal resistivity (in deg. C/Watt),

and P is the power (in Watts)

$$T_{total} = T_m + T_a$$ *where,*

T_total is the combined temperature (in deg. C),

T_m is the motor temperature (in deg. C),

and H_a is the ambient temperature (in deg. C)

This information is used by the CDWA to calculate heat production during simulations and compare these values with predetermined heat profile curves to ensure the motor is operating in a safe zone.

PRESENTATION CREATION PROCESS

Initially, a sequence of illustrations, or storyboard, is developed from a concept in order to visualize the presentation. This storyboard is essentially a compilation of the series of events at designated intervals within the overall choreography. FIG. 19-20 provide examples of story-boarding for a golfing presentation. After the storyboard has been completed, the designer moves to the animatics stage. At this stage, a few more details such as musical backgrounds, camera movements, and test motions of the robotic screens are added to the storyboard. It is anticipated that other lighting effects, produced either by rear-facing projectors or displays, optionally reflecting off back mirror surfaces, or by independent light arrays, will be included in certain choreography designs.

Next, the actual MVST events are created. The designer starts by creating a new project in the CDWA. The application allows the designer to choose the type of MVST display to work with (FIG. 21). After a selection has been made, the CDWA automatically loads the MVST display using the model parameters described above. To begin, the designer moves and orients the MVST display and all of its screens to an initial position (FIG. 22). At this point, the starting

time is selected, as well as one or more screens depending on how the presentation will start. A classical piece of media is then imported or linked (FIG. 23), whether it is a picture, animation, video clip, video stream, data feed, or audio track or stream. The designer specifies the source of the media file, stream or feed, the start time, and the duration (FIG. 24) as applicable. The first MVST event can be created at the starting point of the presentation.

Subsequent MVST events are created based on important points in the presentation, such as points of high/low acceleration, cusp-motions, shaking-effects, etc. Intricate motions can be described using shape-forming tools such as Bezier curves, linear paths, or high-order splines (FIG. 25). The designer can use these tools to not only create MVST events for specific desired motions, but also to synchronize the media for the presentation accordingly. For each MVST event, the designer specifies the location and orientation of the screens, as well as the location, orientation, and zoom level of the content to be rendered on the screens, played through the speakers, or in the case of lighting effects, channelled to light sequencers. All these features can be edited at any time, by either selecting the screens or the media and changing the necessary parameters (FIG. 26). As the designer creates more MVST events, the CDWA connects the MVST events with a motion plan, based on its own interpolation algorithms. If the designer wants to change the interpolated motion plan, he/she can change the entry/exit points of the motion at the MVST event in question, using the control points for a Bezier curve for example. The CDWA then produces an updated interpolated motion plan corresponding to these changes.

It is important that the designer not add more MVST events than absolutely necessary to achieve the desired choreography if the designer intends the finished product to run on multiple different hardware configurations. Movement over time between various MVST events is important to enable 'elasticity' so that the choreography can be adapted to differing hardware configurations.

After the completion of all the MVST events and the generation of the motion plans, the designer plays back the presentation to ensure everything is working as desired. If the presentation satisfies the requirements visually and audibly, the presentation is ready to be exported.

The export function in the CDWA allows the designer to do a final test before completing the presentation (FIG. 267). Test runs display information regarding energy requirements and heat dissipation for a certain targeted hardware model. Heat profile graphs are provided for each motor (FIG. 28), enabling the designer to visualize heat levels during the presentation relative to each motor's critical

region (determined from the model file imported at the beginning of the process). Acceleration curves are also provided (FIG. 29) so that the designer can ensure that each motor is capable of delivering the performance characteristics that are dictated by the target choreography. Furthermore, the CDWA reports on any collisions between MVST display screens or linkages. All issues with heat profiles, acceleration profiles, or collisions, if any, are displayed as warnings after test runs are completed. At this point, the designer can also choose to compile the presentation for another MVST system, if the presentation is desired to be run on differing MVST system (FIG. 30). After all the issues are resolved, the designer exports compiled presentations for each target hardware model.

The CDWA exports the presentation as a package containing all the required media files, as well as an XML file containing links to all the required media and, if included, external video and audio streams. The following gives an example of the structure of the resulting XML file.

```
<?xml version="1.0" encoding="UTF-8" ?>
<!-- Start XML File -->
<!DOCTYPE choreography SYSTEM "choreography.dtd">
<choreography>
        <mvstdisplay model="CWMSVT4x60" screens="4">
                <msvtbase min="-512,0,-512" max="512,0,512"/>
                <msvtscreen id="0" aspect="16:9" width="1280" height="720"/>
                <msvtscreen id="1" aspect="16:9" width="1280" height="720"/>
                <msvtscreen id="2" aspect="16:9" width="1280" height="720"/>
                <msvtscreen id="3" aspect="16:9" width="1280" height="720"/>
        </msvtdisplay>
        <title>Golf Green Number 4</title>
        <duration>10.0</duration>
<events>
        <msvt time="0.0">
                <sound href="soundtrack.mp3"/>
                <base angle="0"/>
                <screen id="0">
                        <media href="scene1golfer.avi" width="640"
```

```
height="480">
                                        <motion crop="50%,50%" center="240,0"
angle="0">
                                                <outcurve curve="averaging" curl="0.5"/>
                                        </motion>
                                </media>
                                        <motion position="-50,0,-50" angle="0">
                                                <outcurve curve="averaging" curl="0.5"/>
                                        </motion>
                                </screen>
                                <screen id="1">
                                        <media href="scene1golfer.avi" width="640"
height="480">
                                                <motion crop="50%,50%" center="-240,0"
angle="0">
                                                        <outcurve curve="averaging" curl="0.5"/>
                                                </motion>
                                        </media>
                                        <motion position="-50,0,50" angle="0">
                                                <outcurve curve="averaging" curl="0.5"/>
                                        </motion>
                                </screen>
                                <screen id="2">
                                        <media href="scene1pin.avi" width="640" height="480">
                                                <motion crop="50%,50%" center="240,0"
angle="-90">
                                                        <outcurve curve="averaging" curl="0.5"/>
                                                </motion>
                                        </media>
                                        <motion position="50,0,-50" angle="0">
                                                <outcurve curve="averaging" curl="0.5"/>
                                        </motion>
                                </screen>
                                <screen id="3">
                                        <media href="scene1pin.avi" width="640" height="480">
```

```
                    <motion crop="50%,50%" center="240,0"
angle="90">
                        <outcurve curve="averaging" curl="0.5"/>
                    </motion>
                </media>
                <motion position="50,0,50" angle="0">
                    <outcurve curve="averaging" curl="0.5"/>
                </motion>
            </screen>
        </msvt>
        <msvt time="5.0">
            <screen id="0">
                <media>
                    <motion crop="50%,50%" center="240,0"
angle="45">
                        <incurve curve="averaging" curl="0.5"/>
                        <outcurve curve="averaging" curl="0.5"/>
                    </motion>
                </media>
                <motion position="-50,0,-150" angle="0">
                    <incurve curve="averaging" curl="0.5"/>
                    <outcurve curve="averaging" curl="0.5"/>
                </motion>
            </screen>
            <screen id="1">
                <media>
                    <motion crop="50%,50%" center="-240,0"
angle="0">
                        <incurve curve="averaging" curl="0.5"/>
                        <outcurve curve="averaging" curl="0.5"/>
                    </motion>
                </media>
                <motion position="-50,0,50" angle="0">
                    <incurve curve="averaging" curl="0.5"/>
```

```
                    <outcurve curve="averaging" curl="0.5"/>
                </motion>
            </screen>
            <screen id="2">
                <media>
                    <motion crop="50%,50%" center="240,0"
angle="-90">
                        <incurve curve="averaging" curl="0.5"/>
                        <outcurve curve="averaging" curl="0.5"/>
                    </motion>
                </media>
                <motion position="125,0,-50" angle="0">
                    <incurve curve="averaging" curl="0.5"/>
                    <outcurve curve="averaging" curl="0.5"/>
                </motion>
            </screen>
            <screen id="3">
                <media>
                    <motion crop="50%,50%" center="240,0"
angle="90">
                        <incurve curve="averaging" curl="0.5"/>
                        <outcurve curve="averaging" curl="0.5"/>
                    </motion>
                </media>
                <motion position="125,0,50" angle="0">
                    <incurve curve="averaging" curl="0.5"/>
                    <outcurve curve="averaging" curl="0.5"/>
                </motion>
            </screen>
        </msvt>
        <msvt time="7.5">
            <screen id="2">
                <media href="message2top.png" width="1024"
height="768">
```

```
                    <motion crop="50%,50%" center="240,0"
angle="-90">
                        <incurve curve="averaging" curl="0.5"/>
                        <outcurve curve="averaging" curl="0.5"/>
                    </motion>
                </media>
                <motion position="125,0,-50" angle="0">
                    <incurve curve="averaging" curl="0.5"/>
                    <outcurve curve="averaging" curl="0.5"/>
                </motion>
            </screen>
            <screen id="3">
                <media href="message2bottom.png" width="1024"
height="768">
                    <motion crop="50%,50%" center="240,0"
angle="90">
                        <incurve curve="averaging" curl="0.5"/>
                        <outcurve curve="averaging" curl="0.5"/>
                    </motion>
                </media>
                <motion position="125,0,50" angle="0">
                    <incurve curve="averaging" curl="0.5"/>
                    <outcurve curve="averaging" curl="0.5"/>
                </motion>
            </screen>
        </msvt>
        <msvt time="10.0">
            <screen id="0">
                <media>
                    <motion crop="50%,50%" center="240,0"
angle="45">
                        <incurve curve="averaging" curl="0.5"/>
                    </motion>
                </media>
                <motion position="-50,0,-150" angle="0">
```

```
                    <incurve curve="averaging" curl="0.5"/>
                </motion>
            </screen>
            <screen id="1">
                <media>
                    <motion crop="50%,50%" center="-240,0"
angle="0">
                        <incurve curve="averaging" curl="0.5"/>
                    </motion>
                </media>
                <motion position="-50,0,50" angle="0">
                    <incurve curve="averaging" curl="0.5"/>
                </motion>
            </screen>
            <screen id="2">
                <media>
                    <motion crop="50%,50%" center="240,0"
angle="-90">
                        <incurve curve="averaging" curl="0.5"/>
                    </motion>
                </media>
                <motion position="125,0,-50" angle="0">
                    <incurve curve="averaging" curl="0.5"/>
                </motion>
            </screen>
            <screen id="3">
                <media>
                    <motion crop="50%,50%" center="240,0"
angle="90">
                        <incurve curve="averaging" curl="0.5"/>
                    </motion>
                </media>
                <motion position="125,0,50" angle="0">
                    <incurve curve="averaging" curl="0.5"/>
```

```
                    </motion>
                </screen>
            </msvt>
        </events>
    </choreography>

    <!-- END XML File -->
```

This package is then uploaded to online servers to be used with various MVST displays. Each MVST display has a unique IP address, allowing for content managers to connect to systems remotely to check on operation and perform administrative tasks such as setting schedules for various choreography showings by time of day (or to preempt normal play lists for a live event) and to set the frequency of a given shows within a repeating mix of shows. The benefit of managing the system online is that it enables the content managers to access and deploy their content to multiple MVST systems from a single location.

In the event where links to real-time streams for live shows are included in a choreography, the manager must ensure that such streams are available and live at the time the MVST showing is scheduled. For example, a MVST display normally presenting a series of promotional choreography, could be programmed to re-orient screens for a live telecast such as election night, where screens would group together to show contest maps, then break apart to simultaneously show data feeds of riding results while also displaying candidate interviews and other live video feeds. These systems might find their way into homes by including special TV or IPTV channels designed to deliver multiple streams – say for a hockey game, having the score, stats and other camera views on different screens.

Another example of the invention is dynamically choreographed segments – here for example, a camera mounted above the stage in a theatre or camera integrated into one of the screens is fed directly into the choreography, optionally with some image recognition, enabling possible 'computer generated' comments about the audience or other events. For example, the computer audience attraction system reads data from audience RFID tags, then modifies part of the presentation accordingly – it could also use camera input – for example, when recognizing a pointed hat, the computer says: "Any witches in the house?" then pauses, then displays the video of the "witch" on one or more of the displays and says "You – yes you, the Witch – could you please take off your hat?"...

Multiple MVST display systems could also be configured as choreographed clusters – for example, along the wall of a building or around the circumference of an arena. In clusters, content can be rendered in conjunction with the choreography to appear to make the discrete breaks between MVST display systems within the cluster vanish.

To those skilled in the art, many modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that the present invention can be practiced otherwise than as specifically described herein and still be within the scope of the invention defined by the appended claims.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A visual display system comprising:

a plurality of electronic display devices,

a separate support arrangement for each electronic display device connected to a motor drive arrangement that accommodates pivotal movement of each electronic display to change the orientation thereof and to accommodate substantial movement of the respective display device along first and second axes to any of a series of non-overlapped positions including stacked positions relative to the second axis;

wherein said plurality of display devices via said motor drive arrangement are each controlled to move within a display area and change the order of said display devices relative to at least one of said first and second axes.

2. A visual display system as claimed in claim 1 wherein each display device is movable by said motor drive arrangement throughout said display area.

3. A visual display system as claimed in claim 1 wherein said separate support for each display device includes a pivot connection accommodating pivotal movement of the display device about a position that is offset relative to a central axis of the display device.

4. A visual display system as claimed in claim 3 wherein each separate support includes a control bar linkage connected to said motor drive arrangement to control the movement and position of the respective display device.

5. A visual display system as claimed in claim 4 wherein the pivot connection of each display device is located adjacent a rear corner of the display device.

6. A visual display system as claimed in claim 1 wherein said plurality of display devices includes at least 4 display devices.

7. A visual display system as claimed in claim 6 wherein said separate support for each display device includes a pivot connection controlled by said motor drive arrangement that determines pivotal movement and orientation of the display device about a position that is offset relative to a central axis of the display device.

8. A visual display system as claimed in claim 6 wherein said separate support for each display device includes a motor actuator forming part of said motor drive arrangement controlling the separate support and thereby controlling the position and movement of the respective display device in said display area.

9. A visual display system as claimed in claim 8 including a computer controller connected to said motor actuators and determining the relative position and movement of said display devices.

10. A visual display system as claimed in claim 9 wherein said motor actuators are mounted on a rotatable member extending generally parallel to and centrally located behind said display area such that rotation of said rotatable member causes rotation of said display devices.

11. A visual display system as claimed in claim 10 wherein said display device belongs to the group consisting of LCD screens, Plasma screens, OLED screens, 3D lenticular screens, flexible display panels, flexible display panels, convex shaped surfaces or screen, concave shaped surfaces or screens, tubular surfaces or screens, conical surfaces or screens and spherical surfaces or screens.

12. A visual display system as claimed in claim 10 wherein said display device is a projecting device.

13. A visual display system comprising a plurality of electronic display screens and a mounting system rotatably supporting said display screens, a motor drive cooperating with said mounting system to accommodate controlled movement of said display screens with respect to at least a first axis and a second axis of movement to collectively define a display screen space

corresponding to the set of possible relative positions of said display screens and said display screens are movable through actuation of said motor drive to stacked positions relative to both said first axis and said second axis.

14. A visual display system as claimed in claim 13 wherein said plurality of display screens is at least 3 display screens and said display screens are movable to alter the relative order of said display screens with respect to at least one of said at least two axes of movement.

15. A visual display system as claimed in claim 13 wherein said mounting system and said motor drive include an attachment structure for each display screen allowing rotation of the respective display screen about an off center position thereof.

16. A visual display system as claimed in claim 15 wherein the rotation of each display screen about the respective off center position rotates said display screen in a plane generally defined by two axes of said at least two axes of movement.

17. A visual display system as claimed in claim 16 wherein said attachment structure for each display screen is located adjacent a corner of the respective display screen.

18. A visual display system as claimed in claim 17 wherein each display screen is a generally rectangular, planar electronic display screen.

19. A visual display system as claimed in claim 17 wherein each display screen is a generally circular, planar electronic display screen.

20. A visual display system as claimed in claim 17 wherein each display screen is non-planar.

21. A visual display system as claimed in claim 13 wherein said display screens have two major axes of movement to define a generally planar display.

22. A visual display system as claimed in claim 13 wherein said plurality of display screens are at least 4 electronic display screens and said electronic display screens have two major axes of movement to collectively define a generally planar display;

and wherein said mounting structure and motor drive allows an off center rotation of each display screen and movement of the display screen in said display screen space.

23. A visual display system as claimed in claim 22 wherein said mounting arrangement includes a main support member supporting a control linkage for each display screen, and said main support is rotatable about a central point defining an axis of rotation generally perpendicular to said generally planar display.

24. A visual display system as claimed in claim 13 wherein said mounting arrangement includes a back support structure that accommodates movement of said display screens within the general area of said back support structure, and said mounting arrangement moves across a rear surface of said back support structure and provides a structural connection through said back support structure.

25. A visual display system as claimed in claim 1 wherein said separate support arrangement for each electronic display device additionally accommodates substantial movement of the respective display device along a third axis.

26. A visual display system as claimed in claim 25 wherein each separate support arrangement allows rotation of said display devices within said display space such that a viewing direction perpendicular to said display devices can be altered as part of the movement of each display device.

27. A visual display system as claimed in claim 26 wherein each separate support arrangement accommodates angling of the display device for multi-plane viewing of said display devices in said display space.

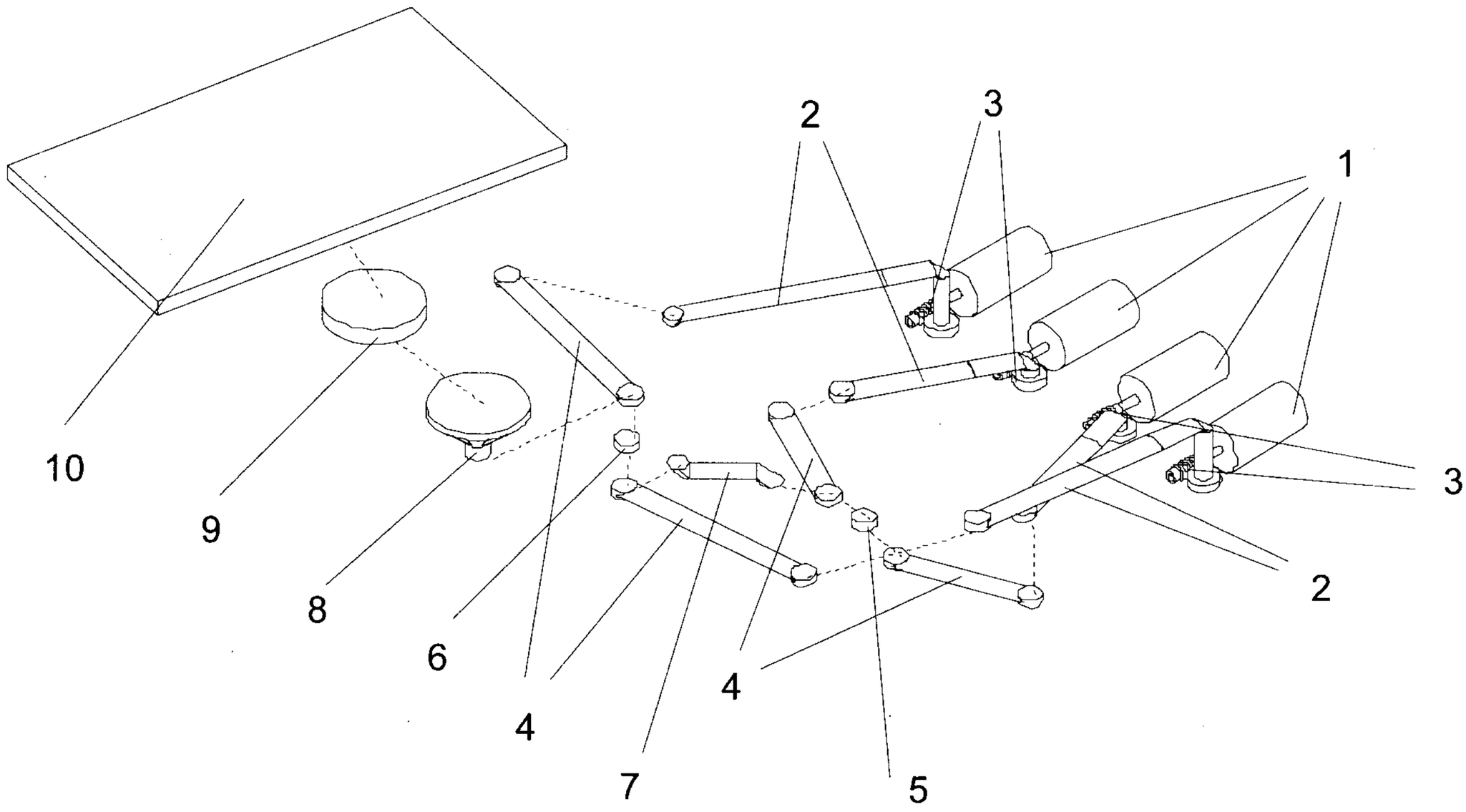


Figure 1

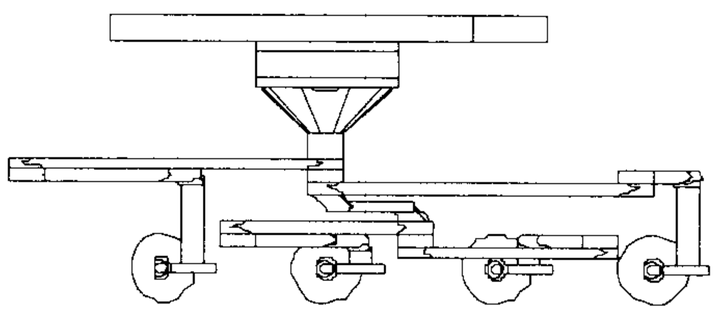


Figure 2A

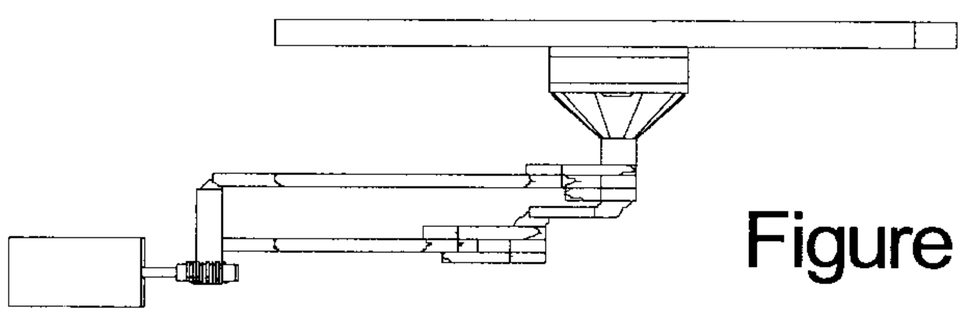


Figure 2B

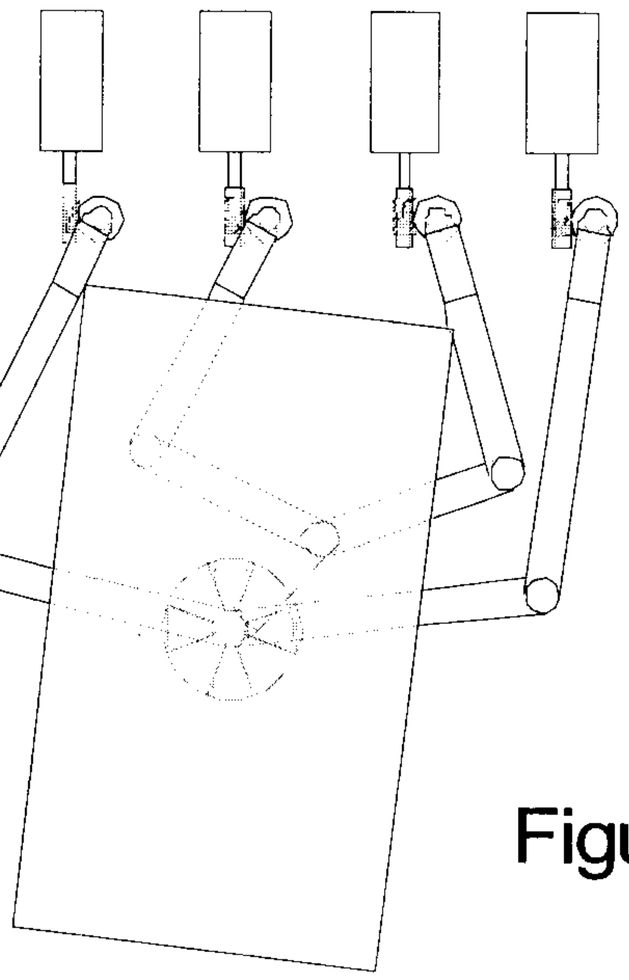


Figure 2C

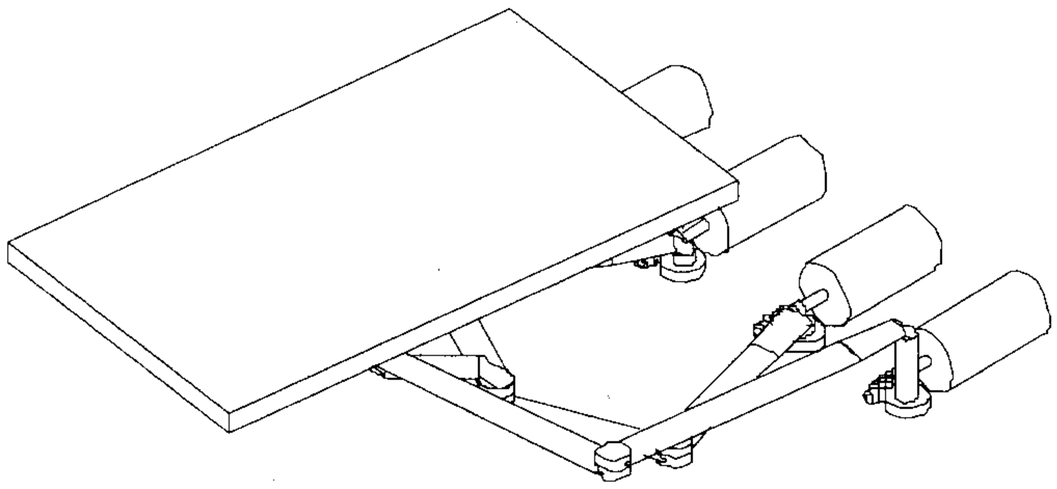


Figure 2D

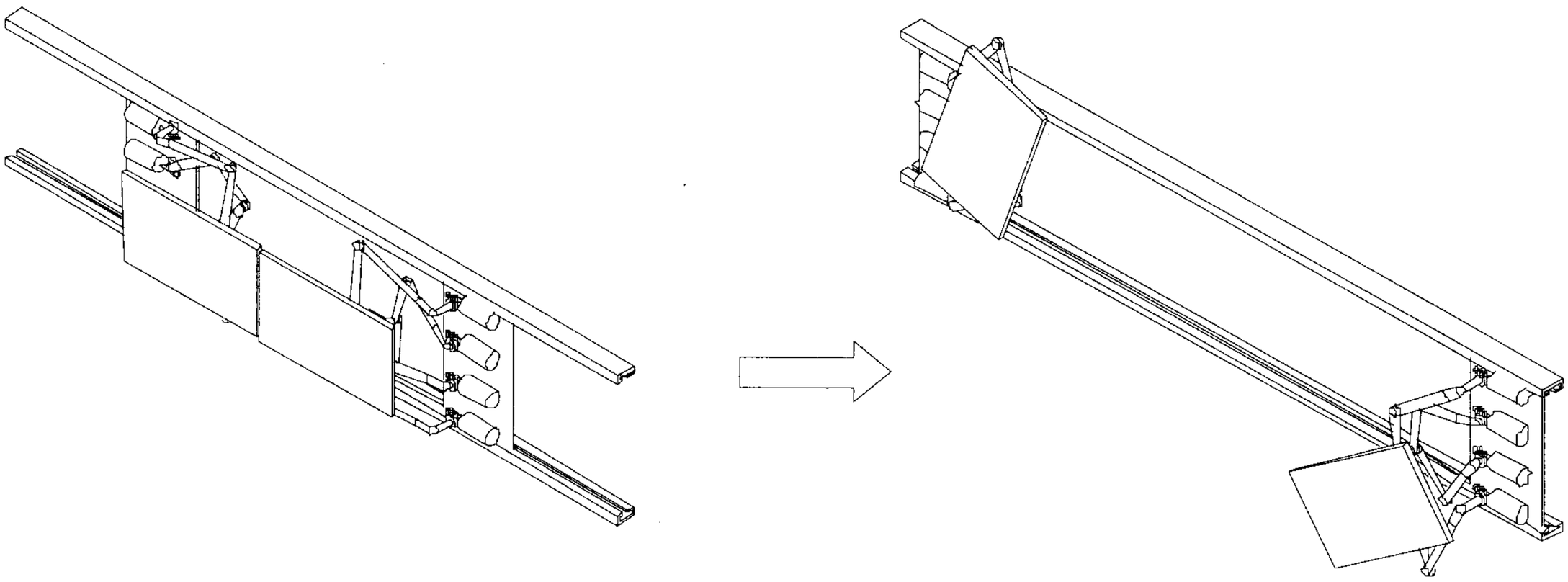


Figure 3A

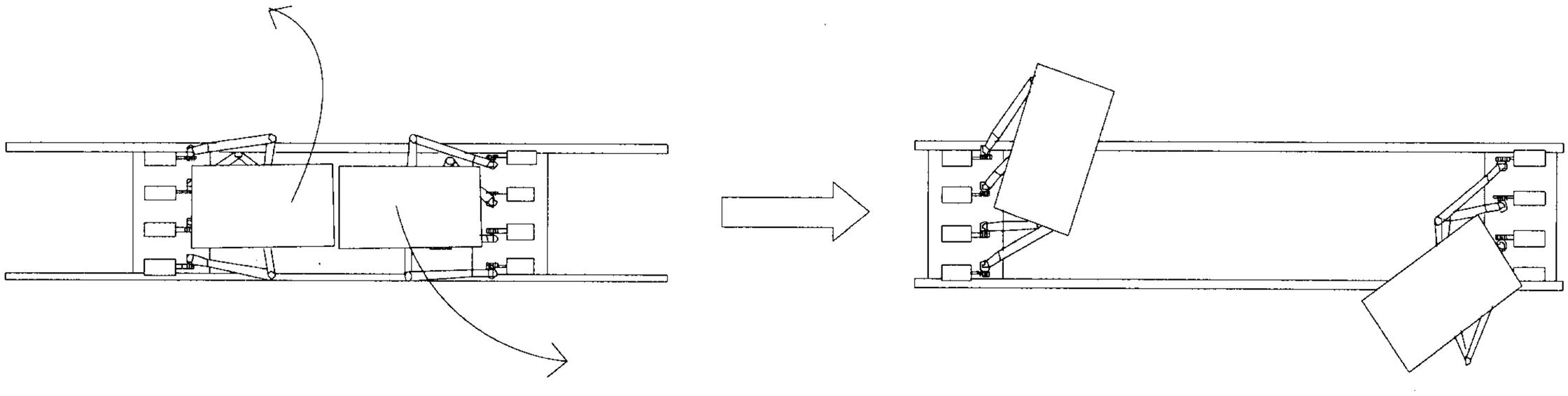


Figure 3B

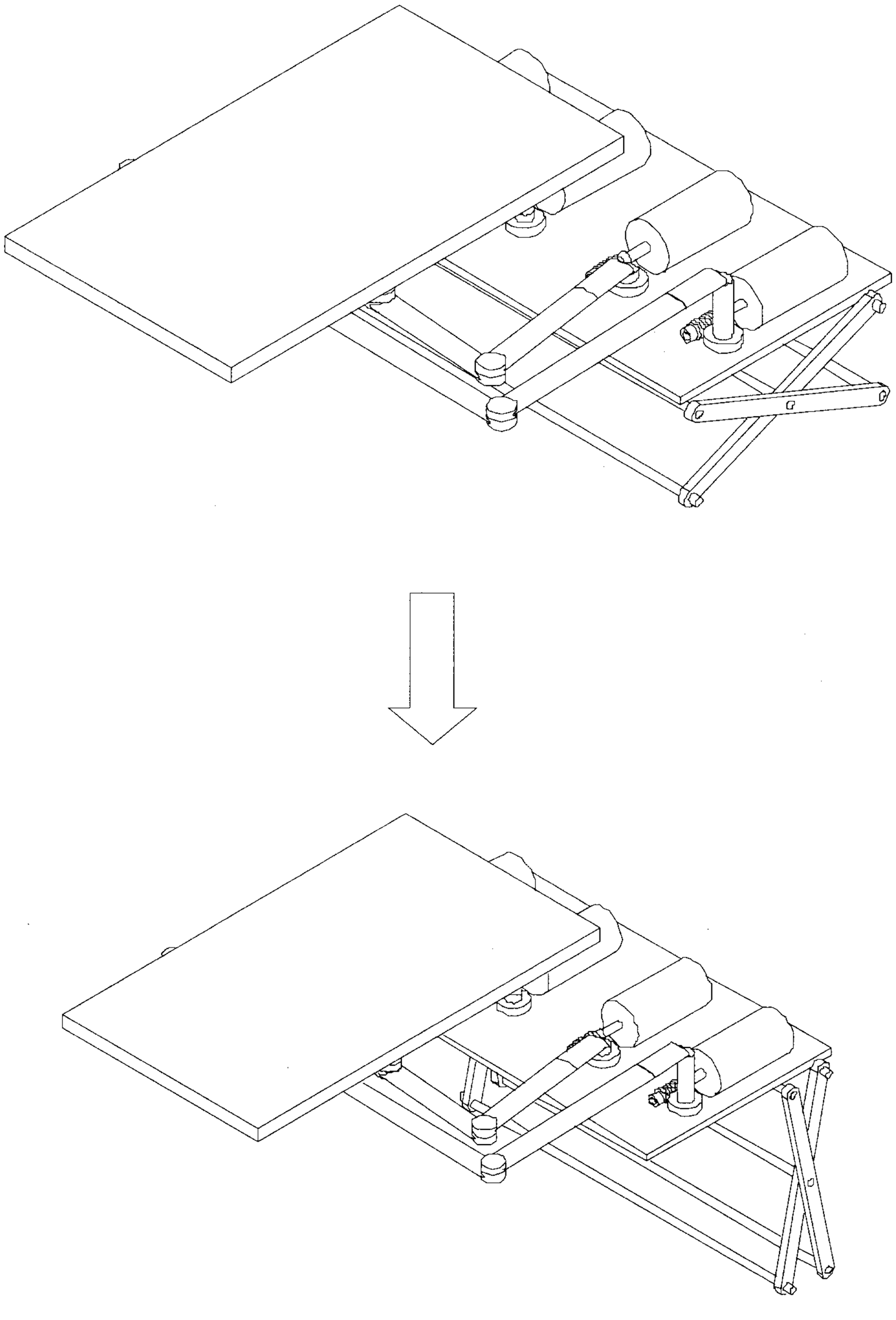


Figure 4

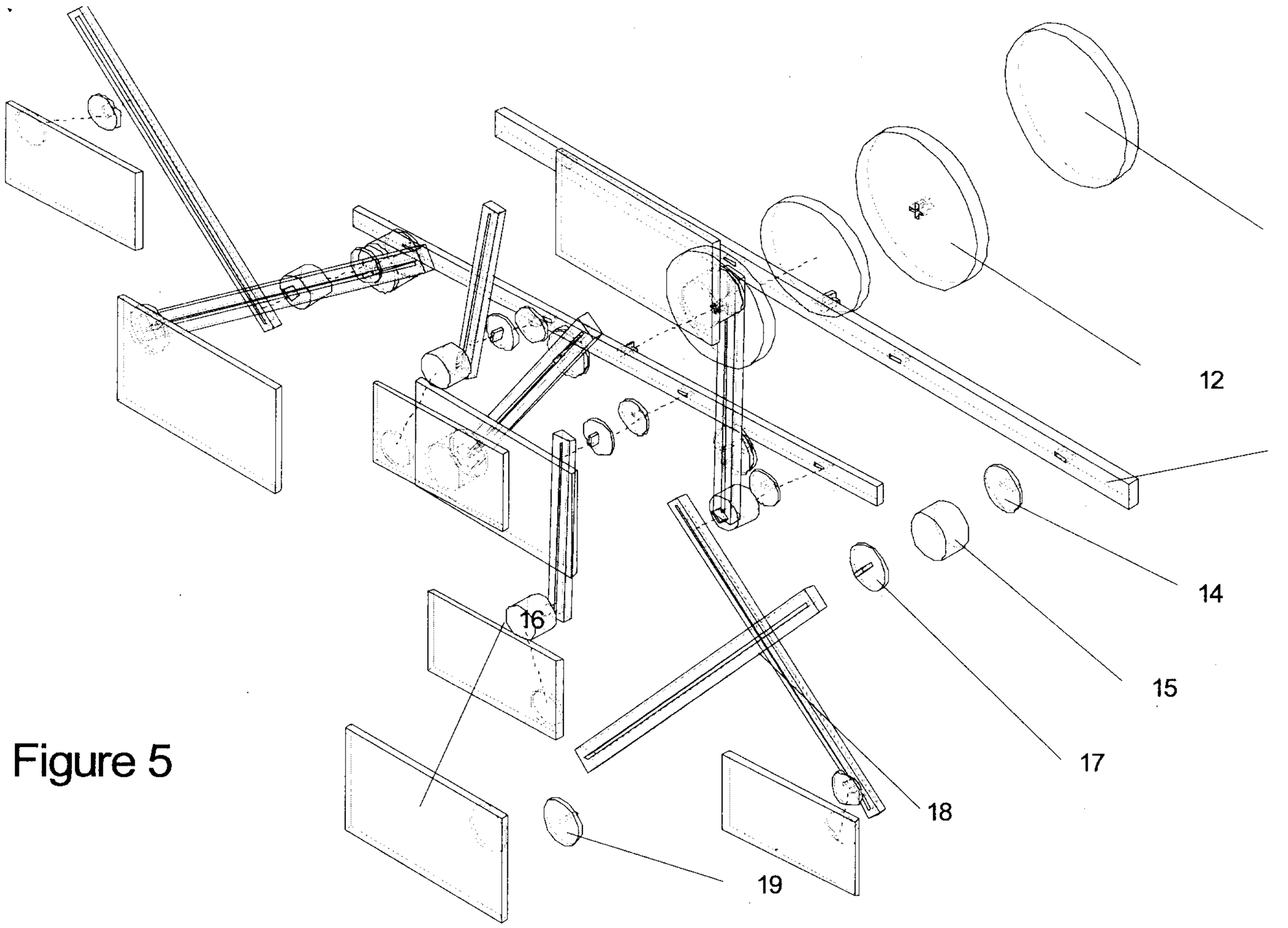


Figure 5

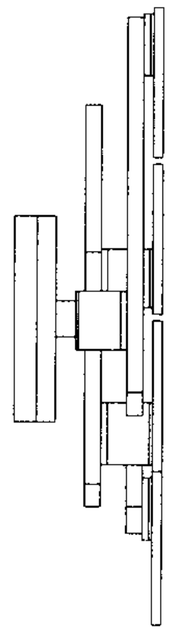


Figure 6A

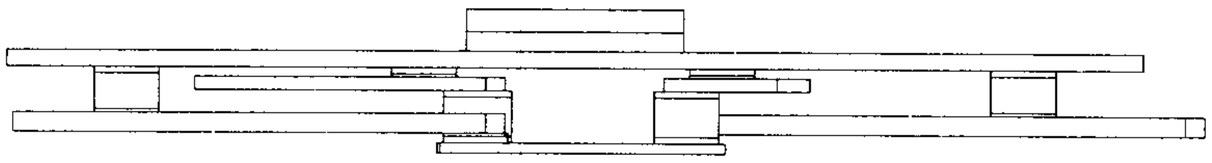


Figure 6B

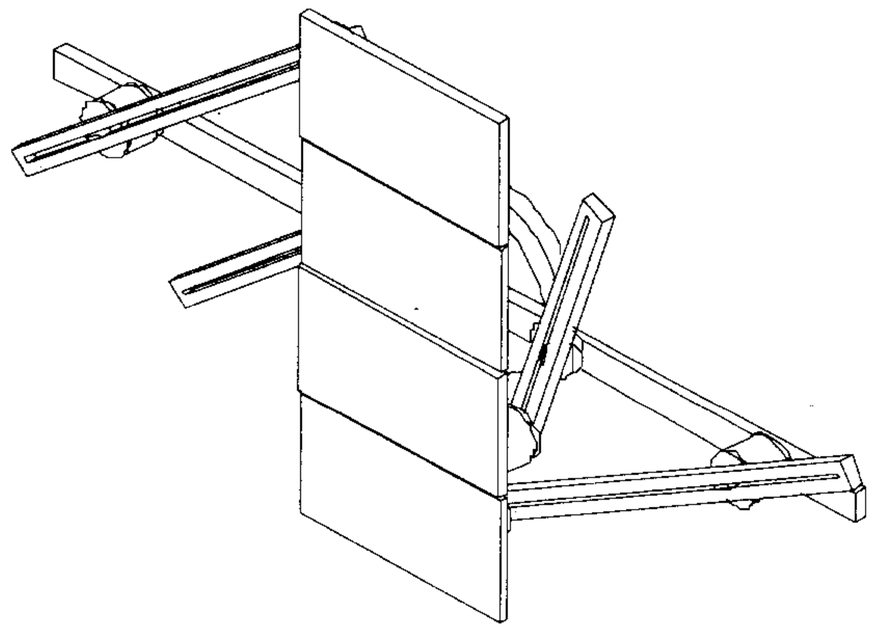


Figure 6C

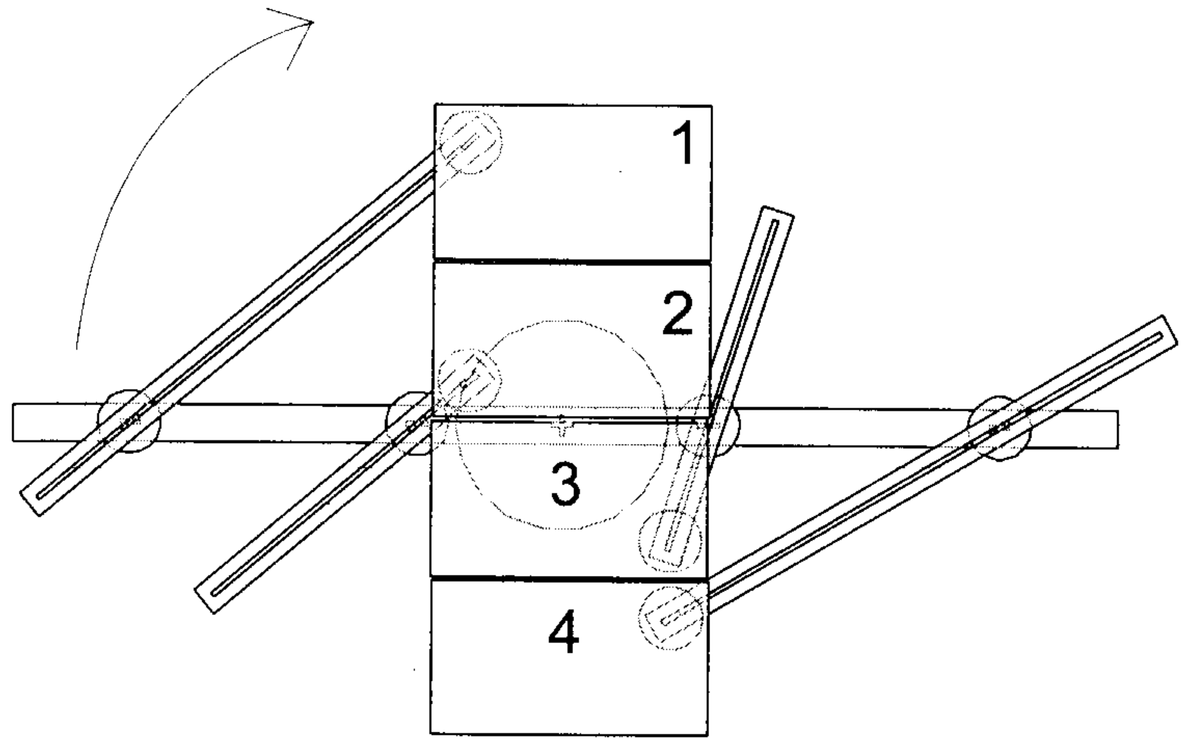


Figure 7A

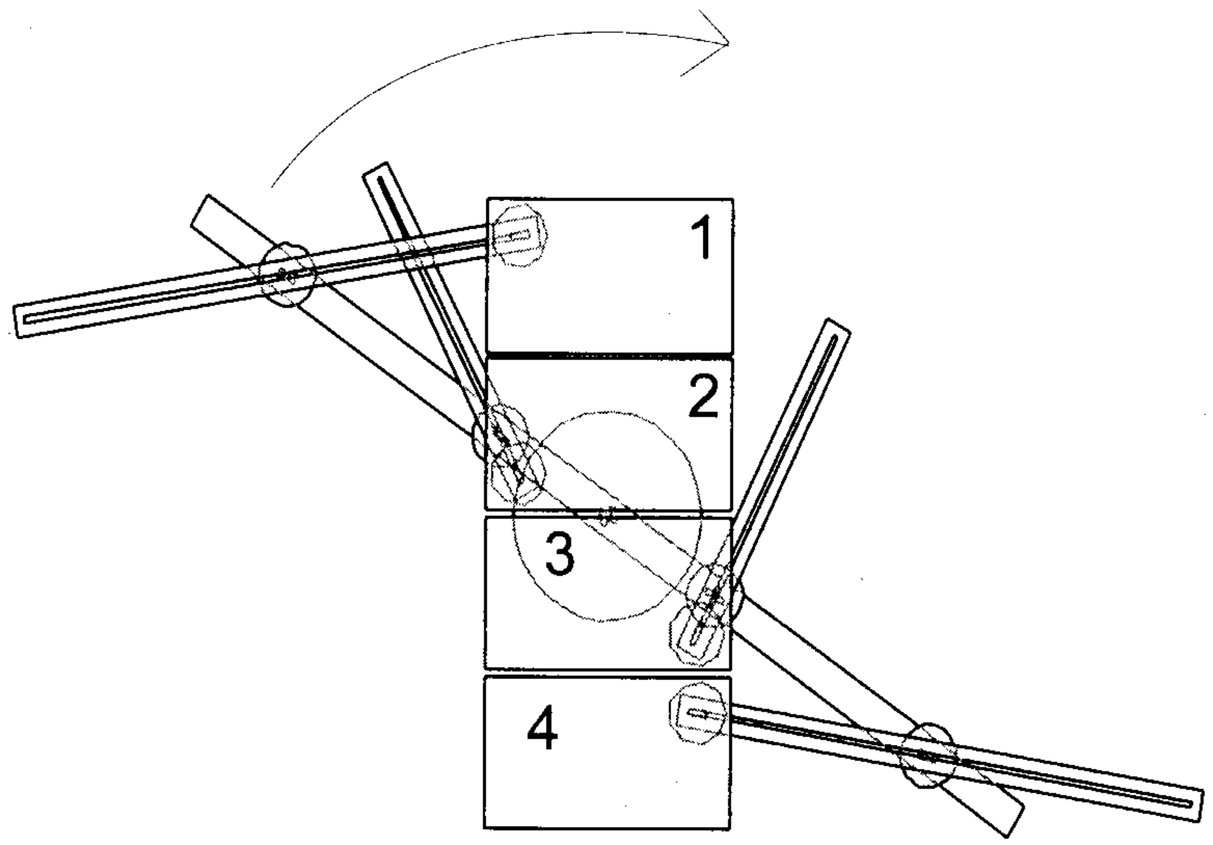


Figure 7B

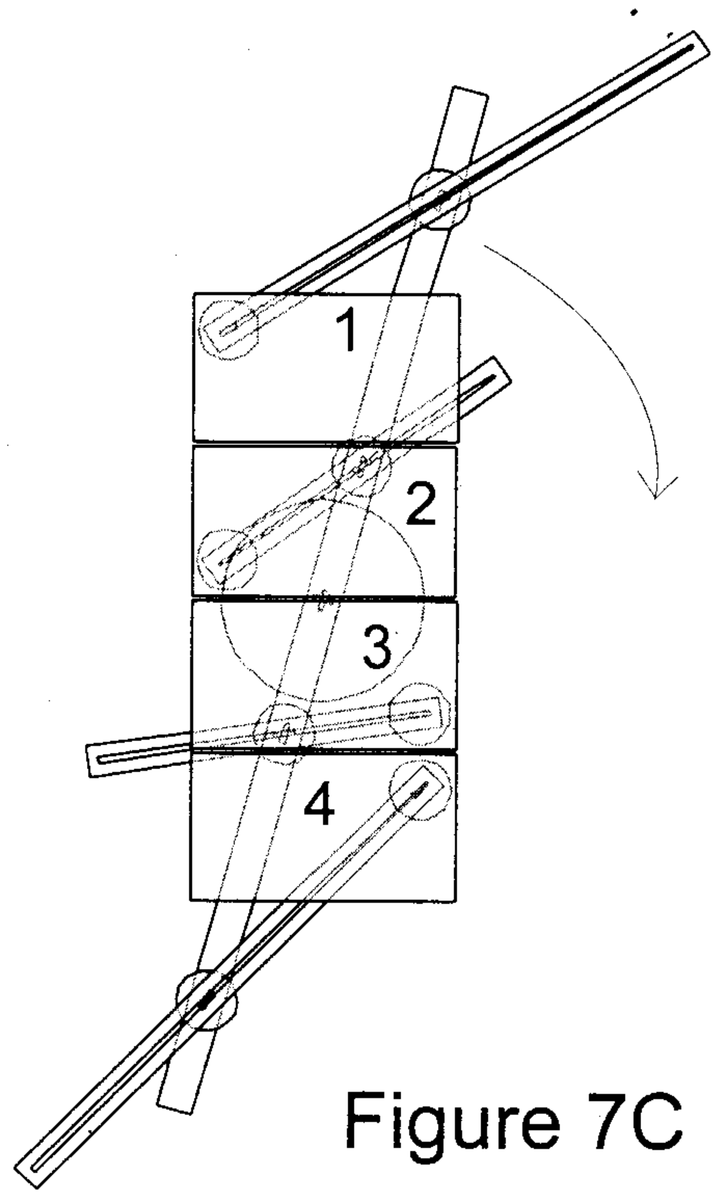


Figure 7C

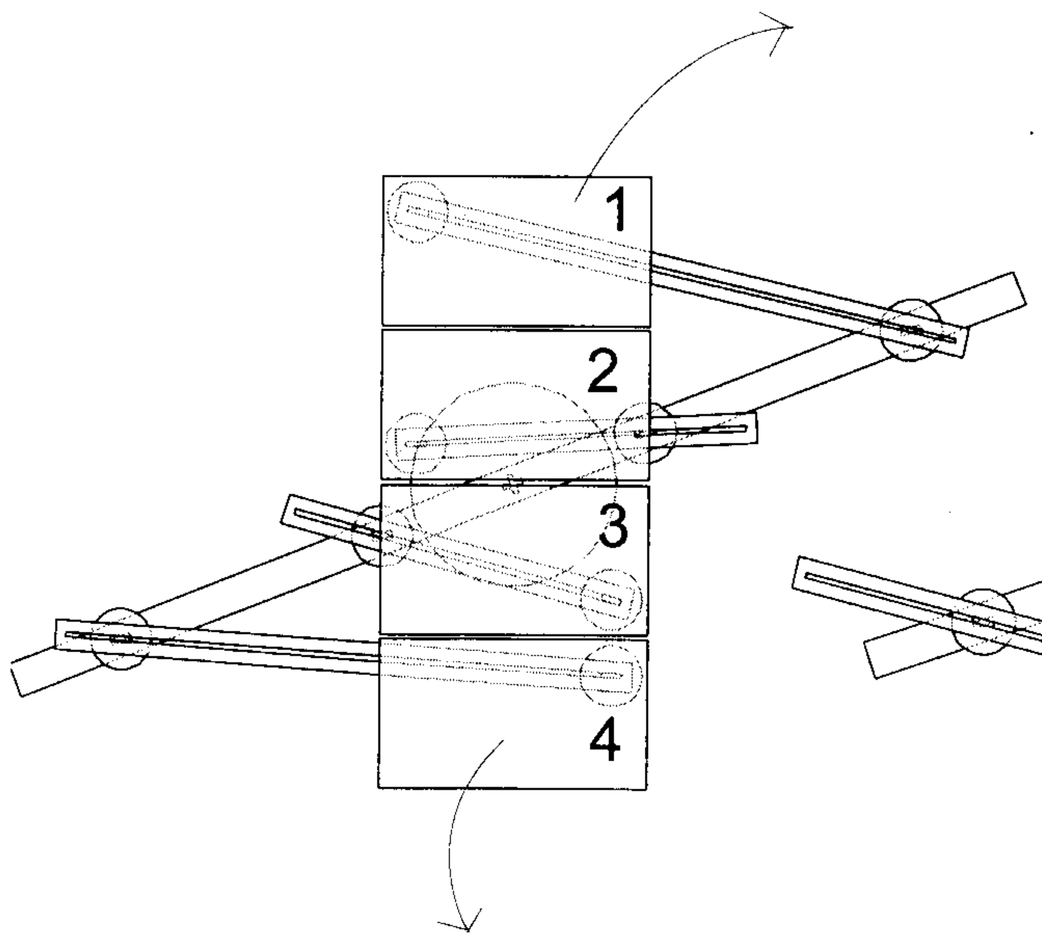


Figure 7D

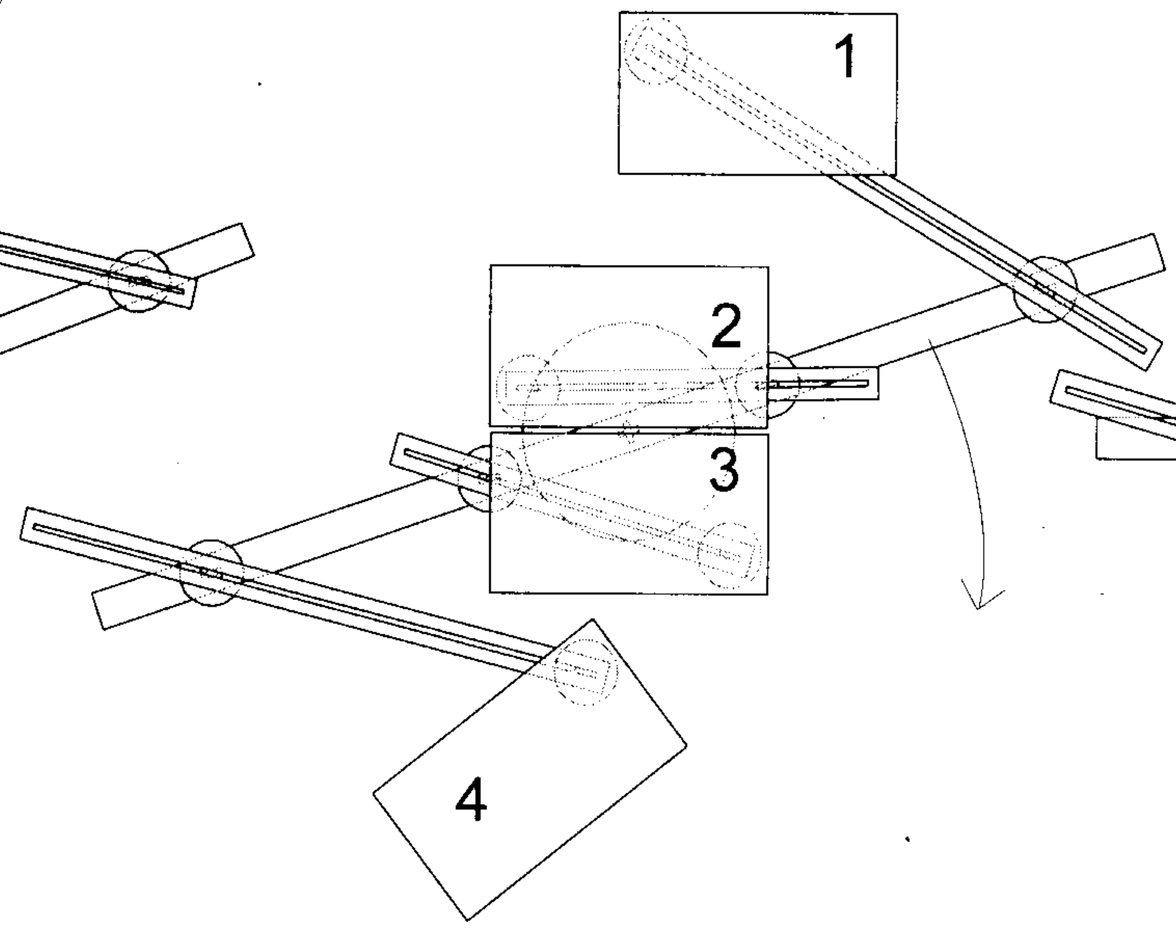


Figure 7E

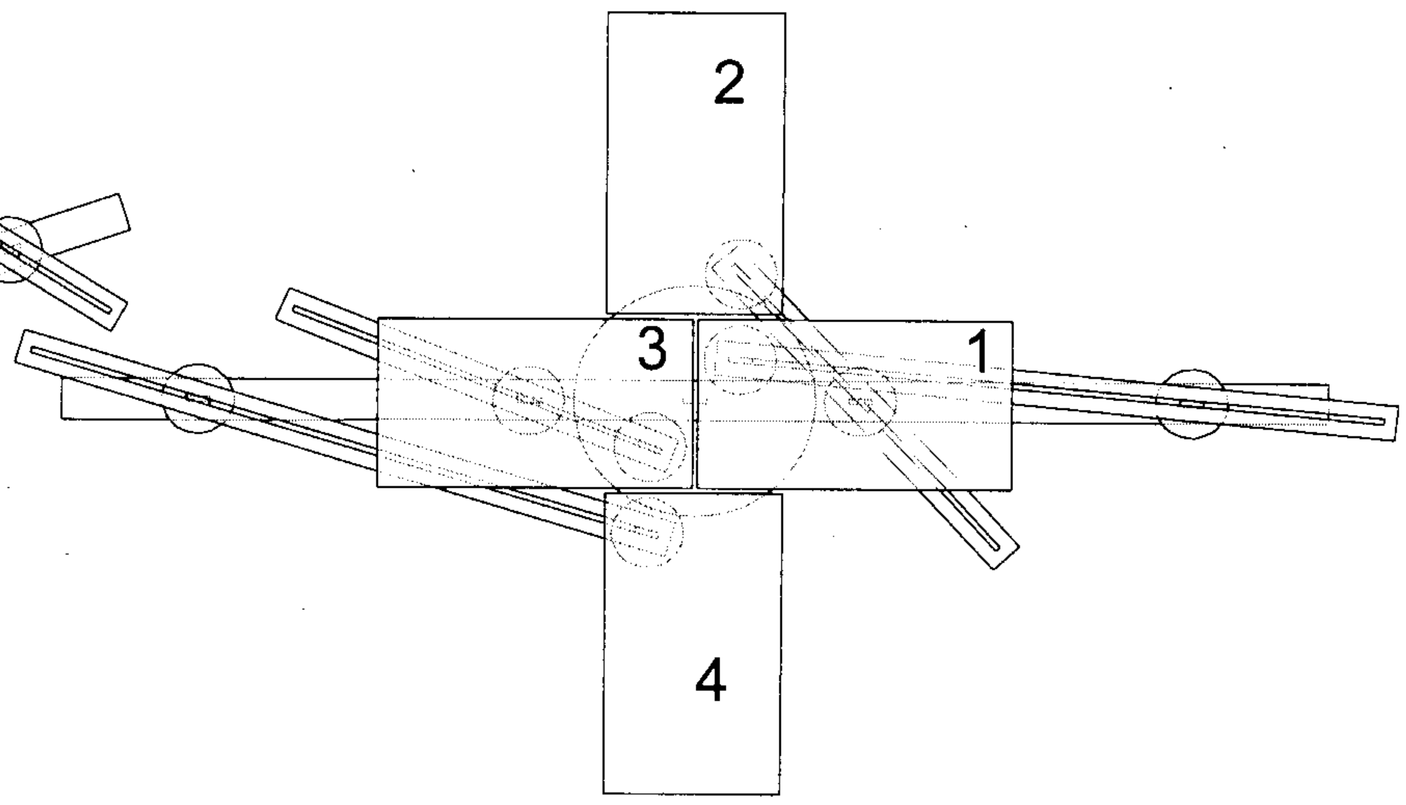


Figure 7F

CA 02684192 2009-10-30

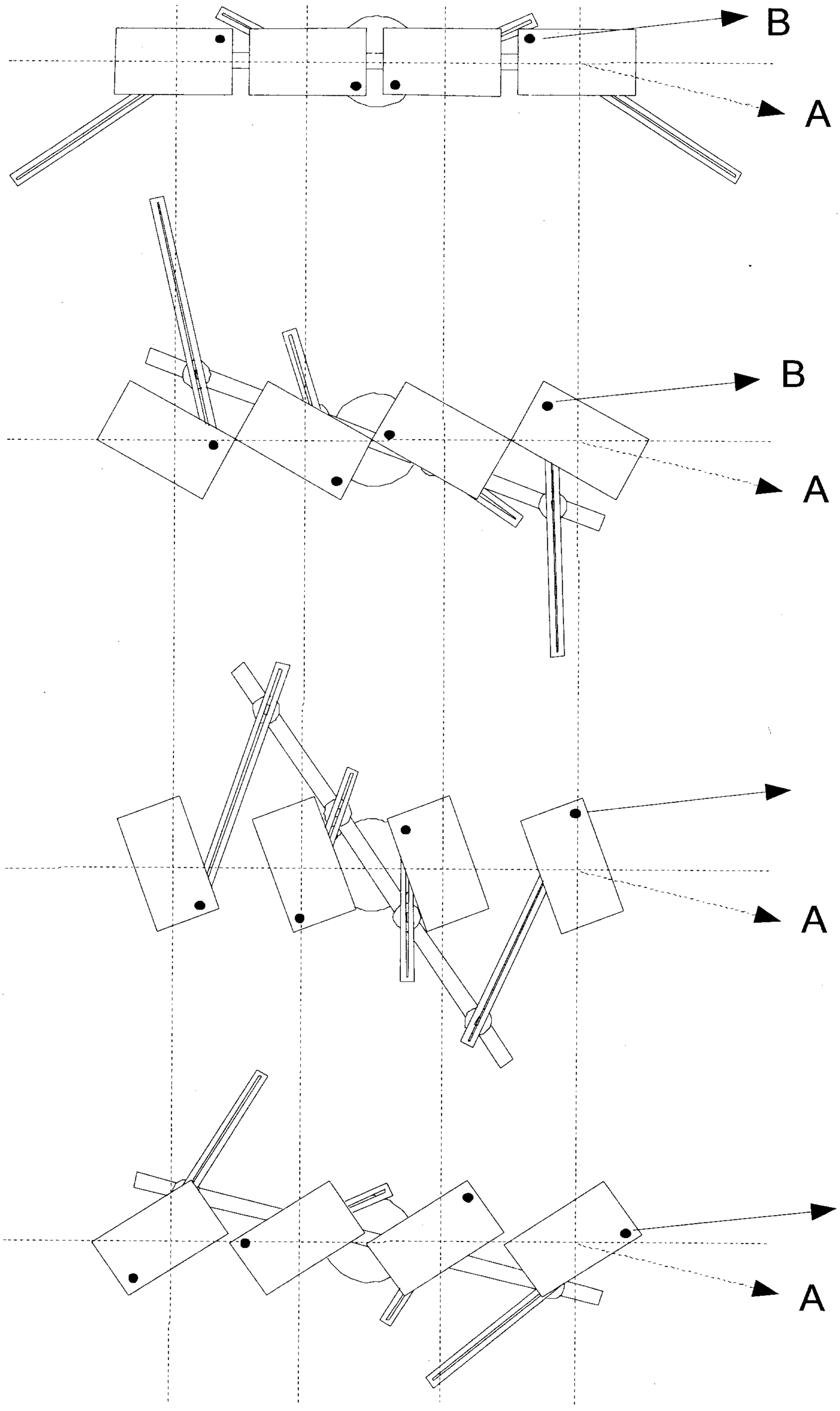


Figure 8

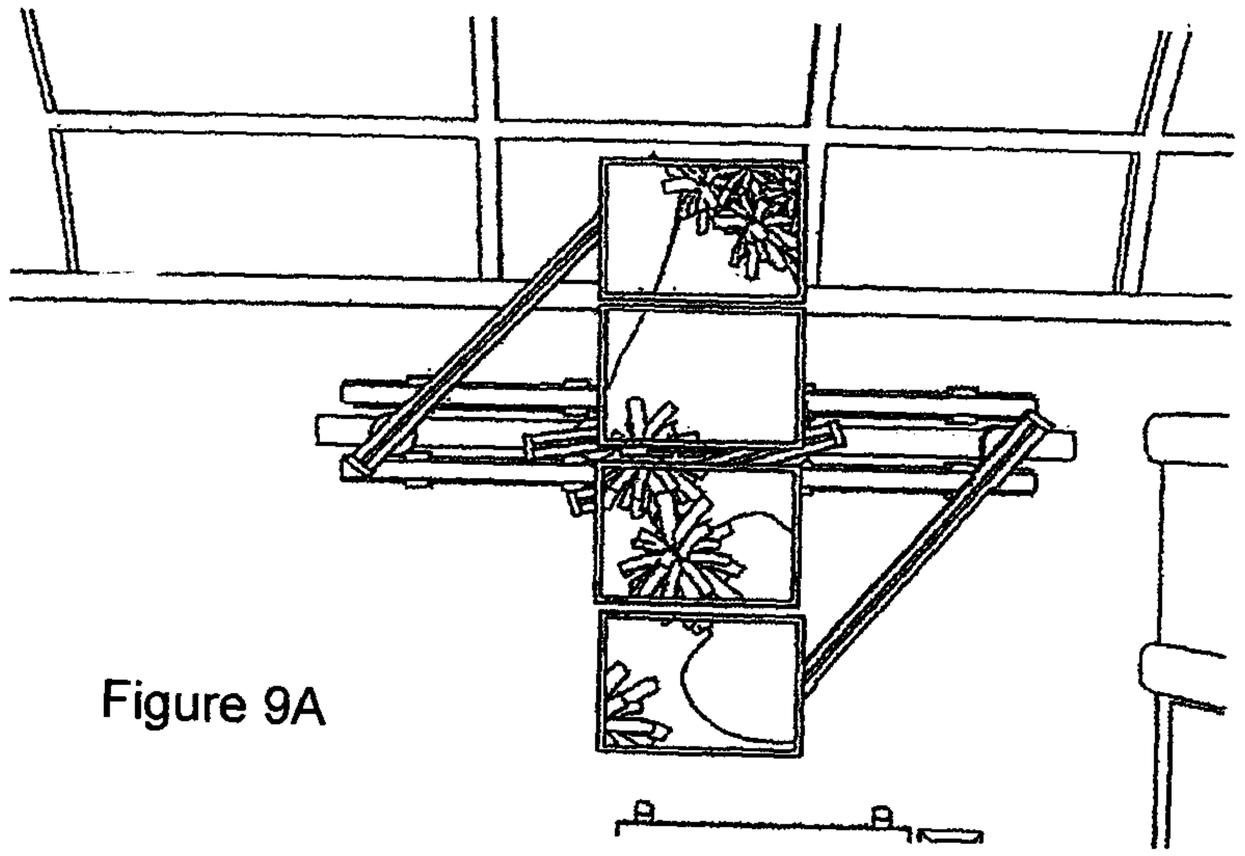


Figure 9A

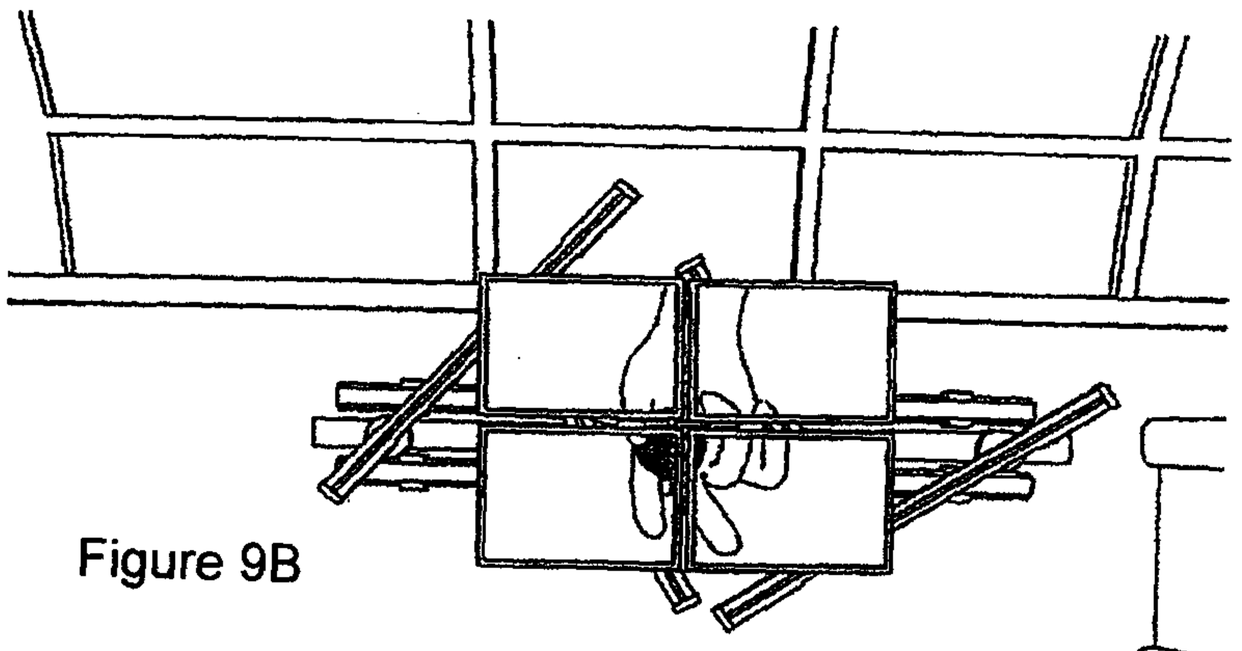


Figure 9B

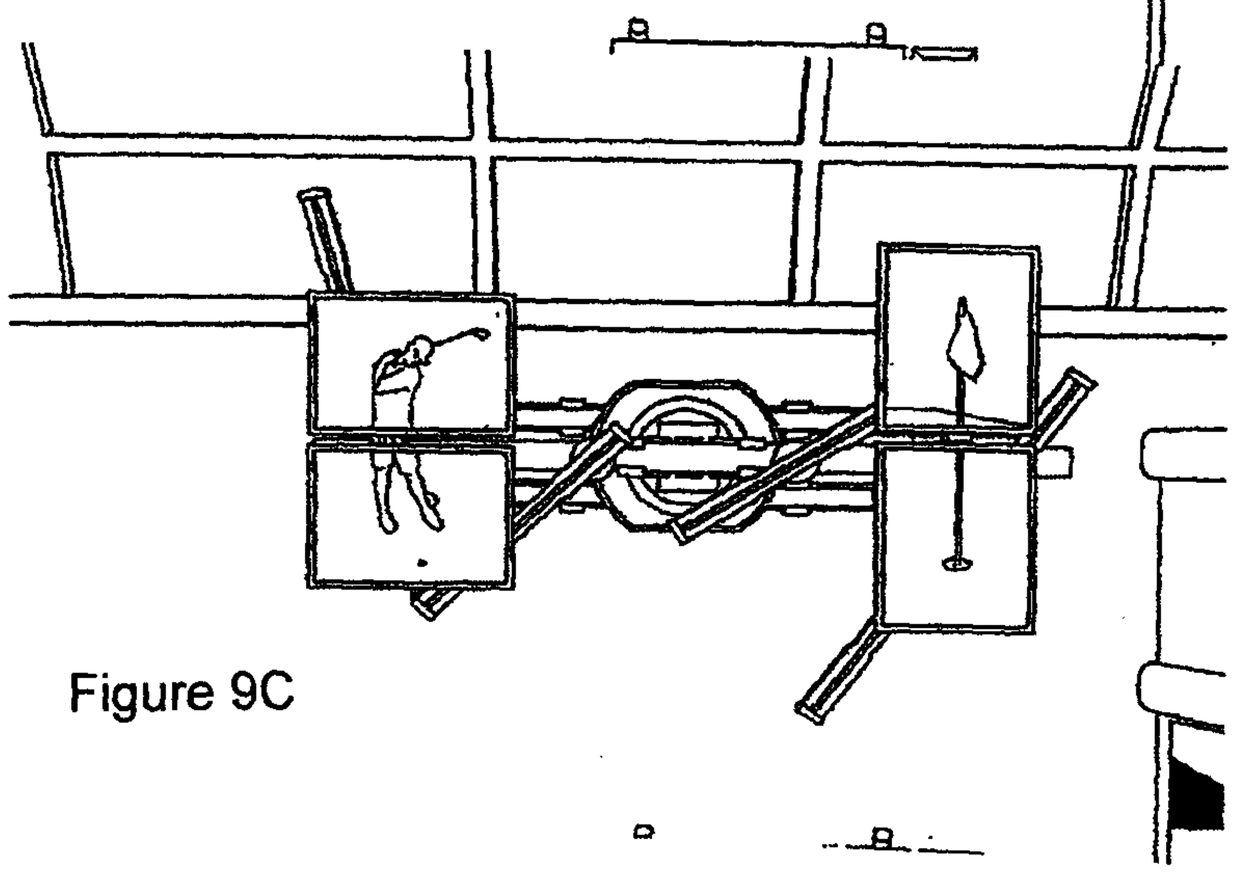


Figure 9C

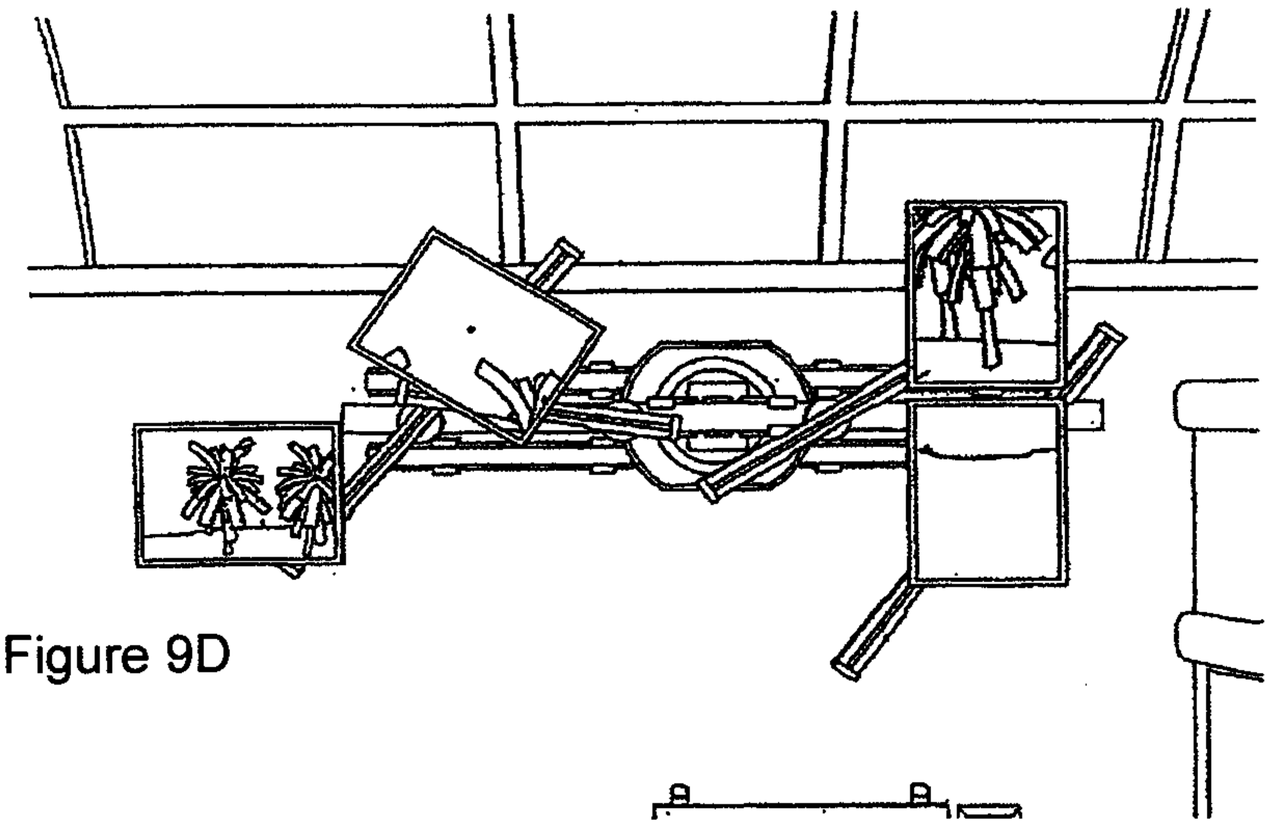


Figure 9D

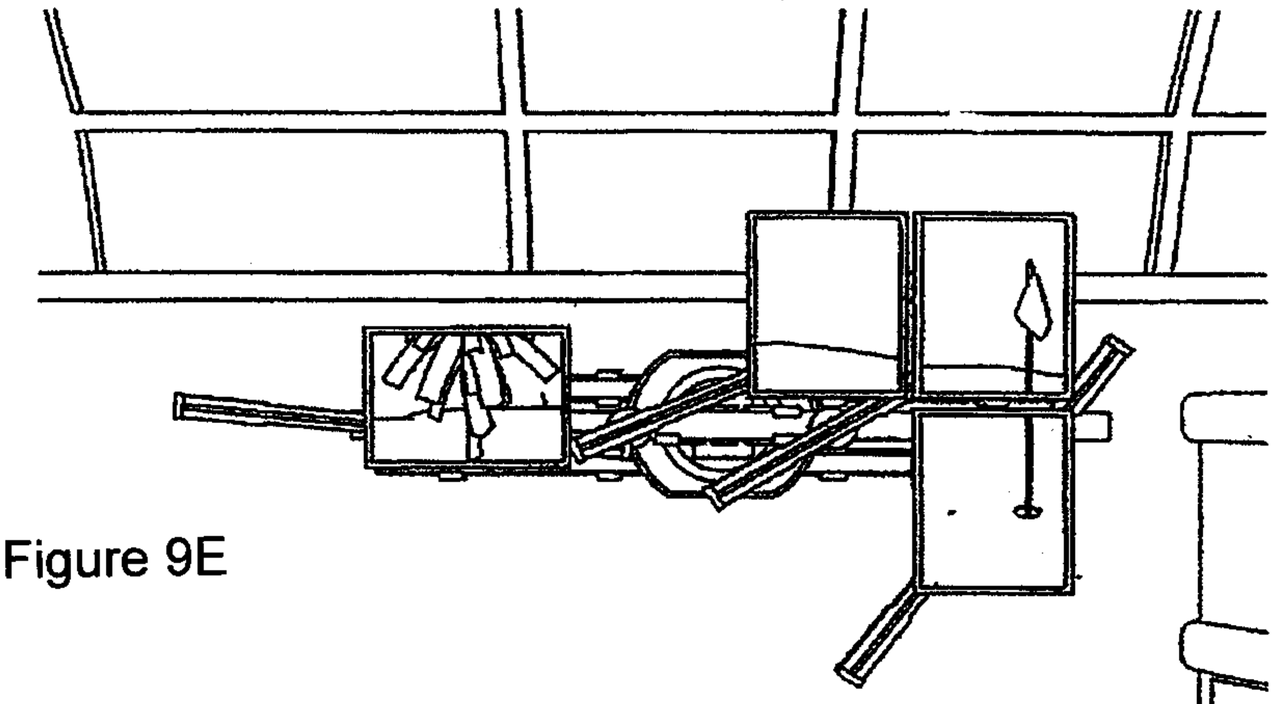


Figure 9E

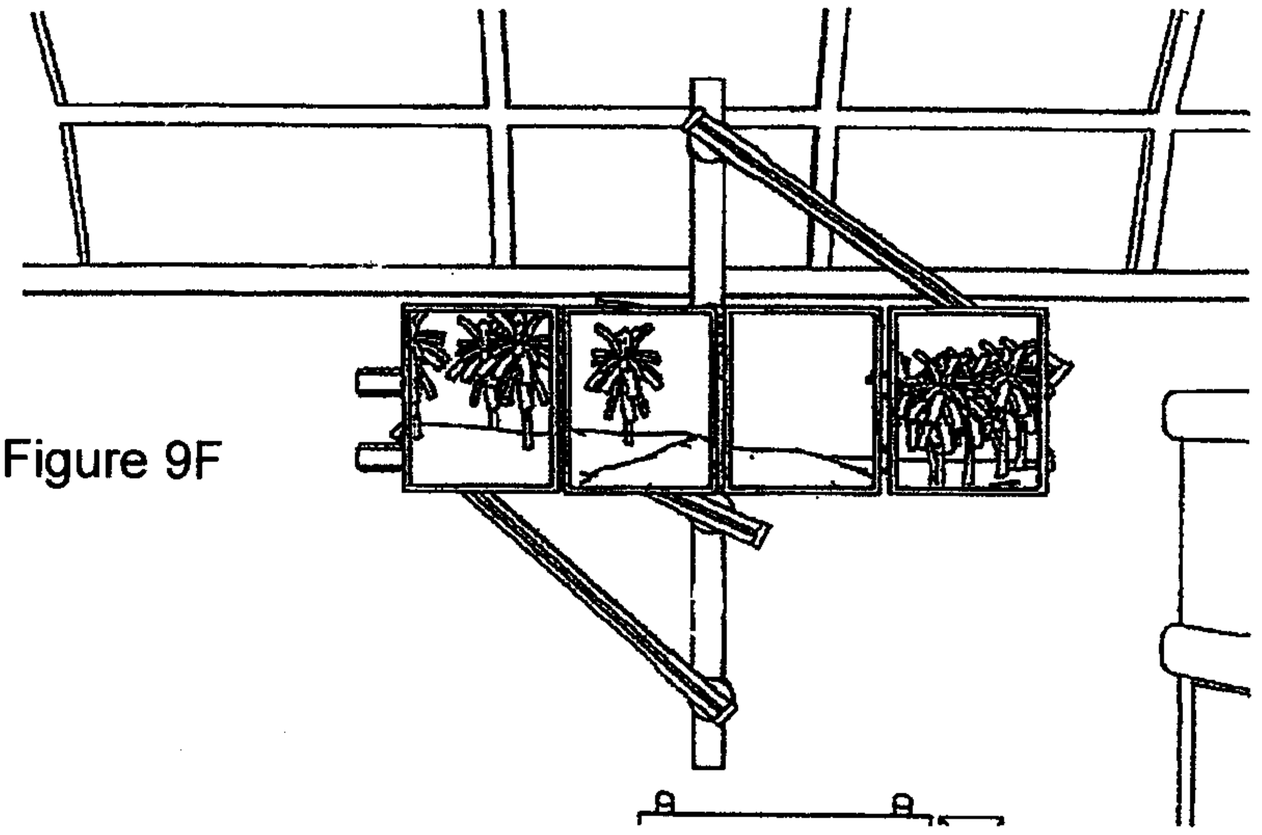


Figure 9F

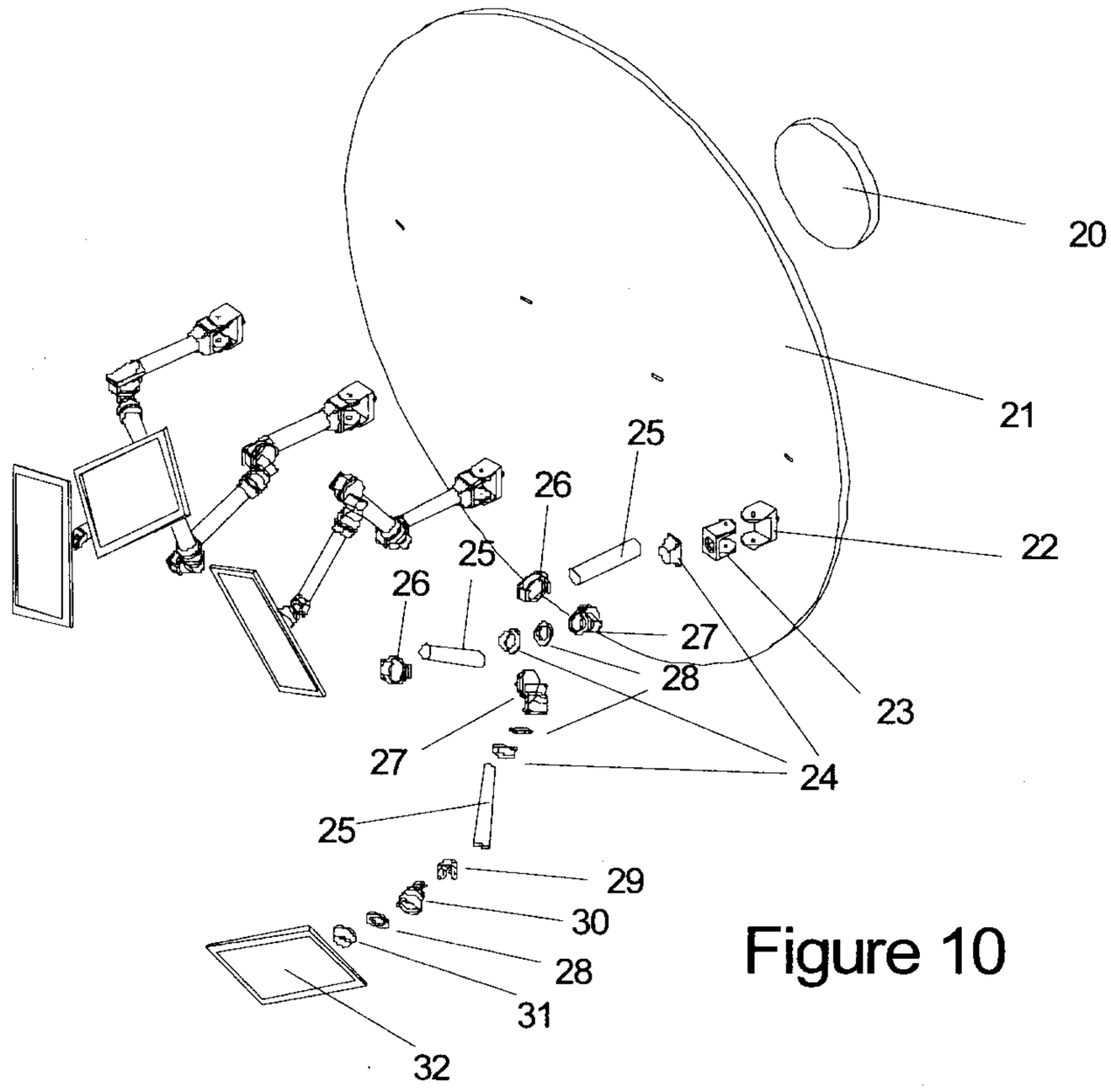


Figure 10

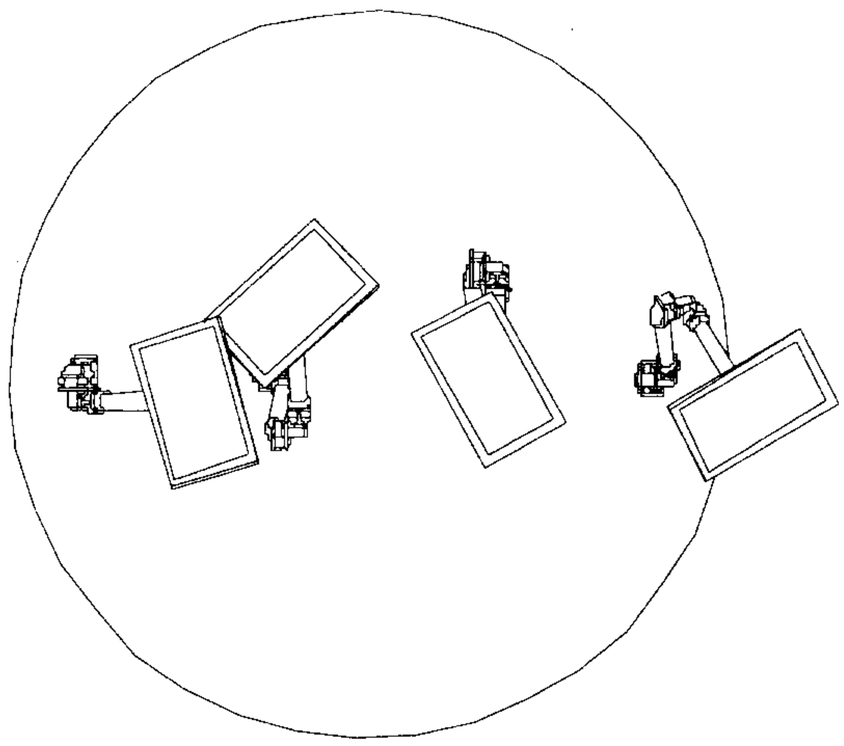


Figure 11A

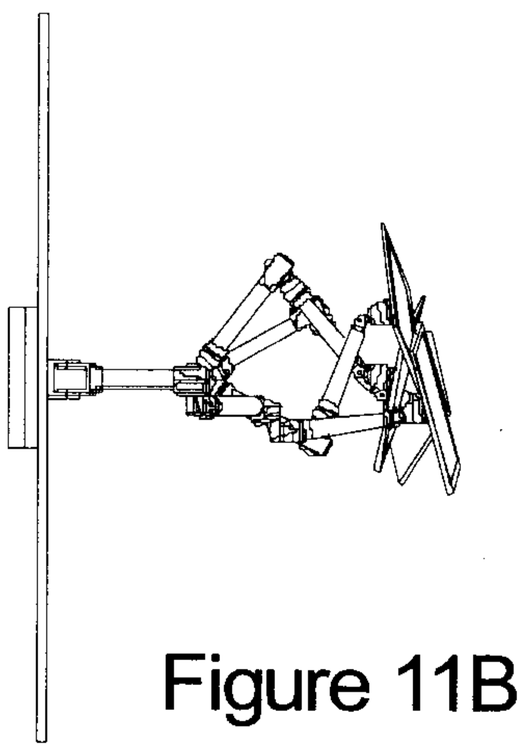


Figure 11B

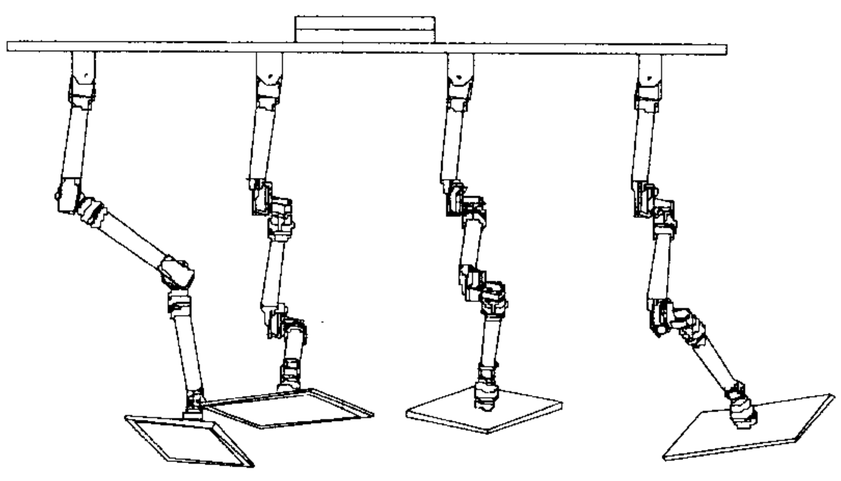


Figure 11C

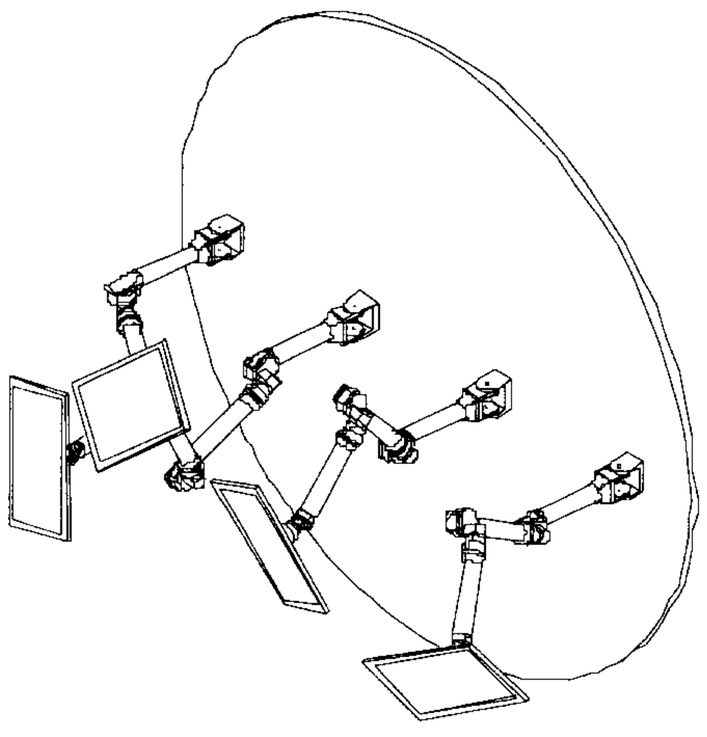


Figure 11D

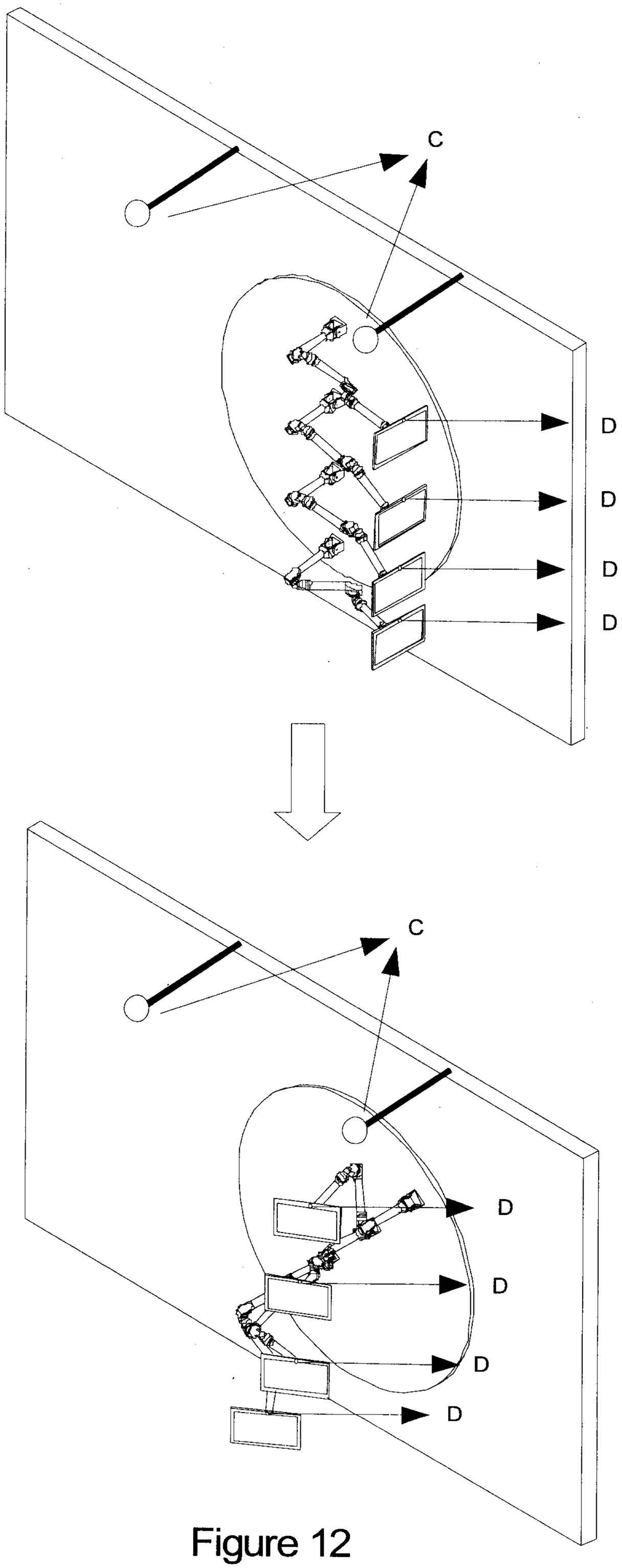


Figure 12

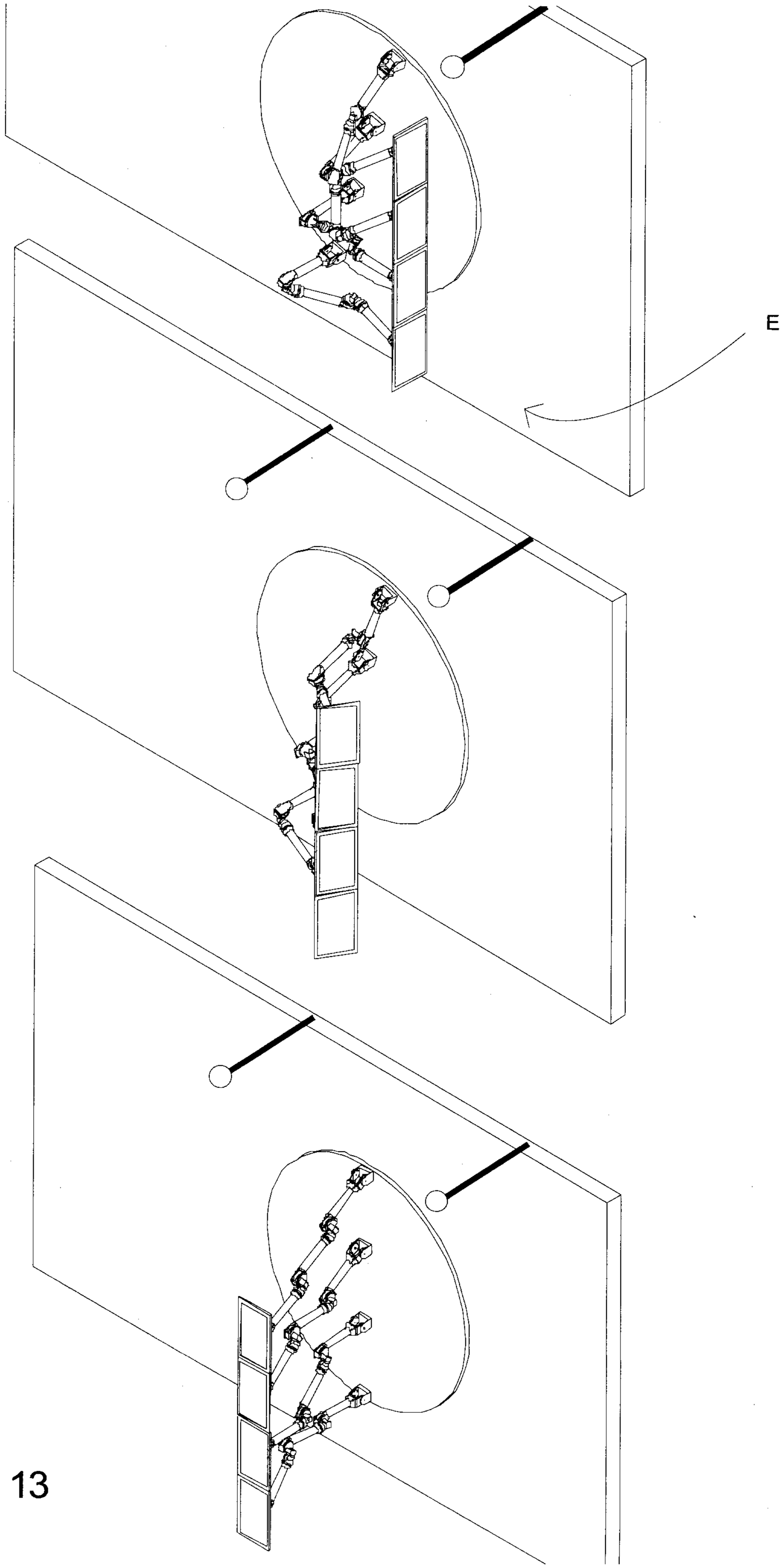


Figure 13

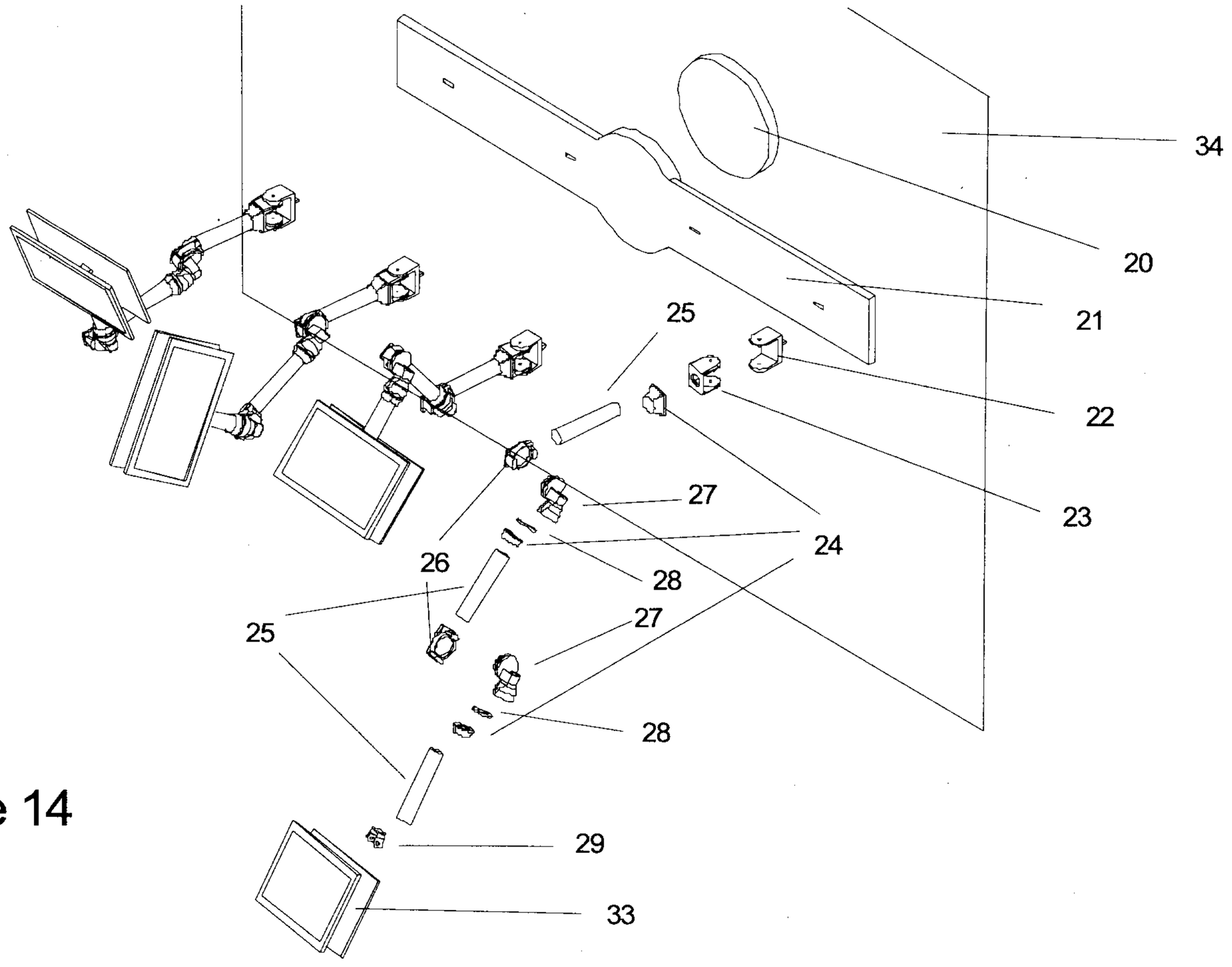


Figure 14

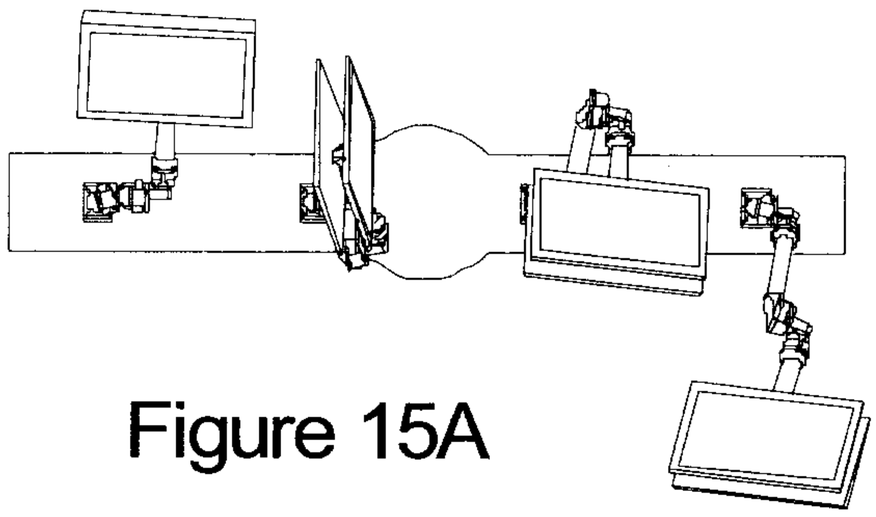


Figure 15A

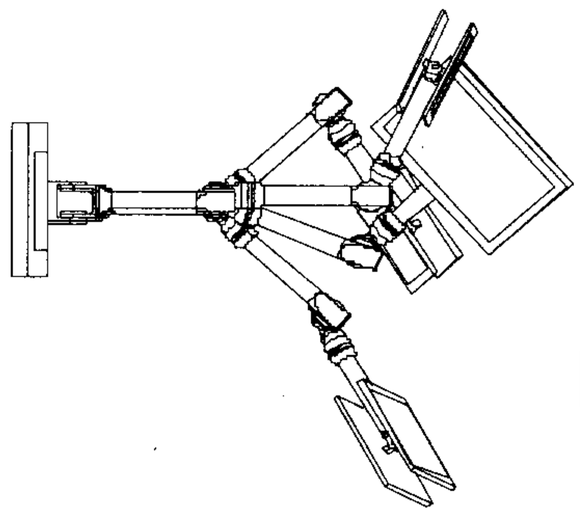


Figure 15B

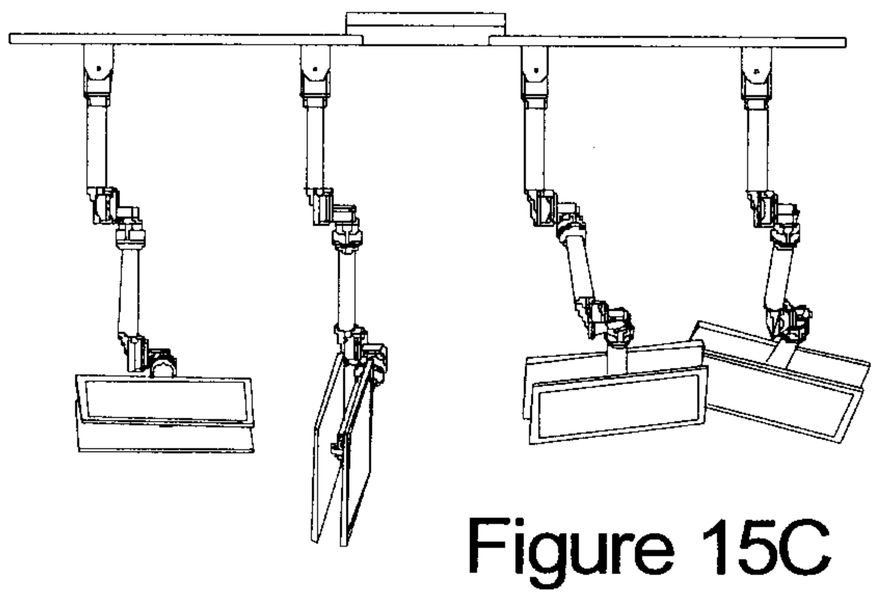


Figure 15C

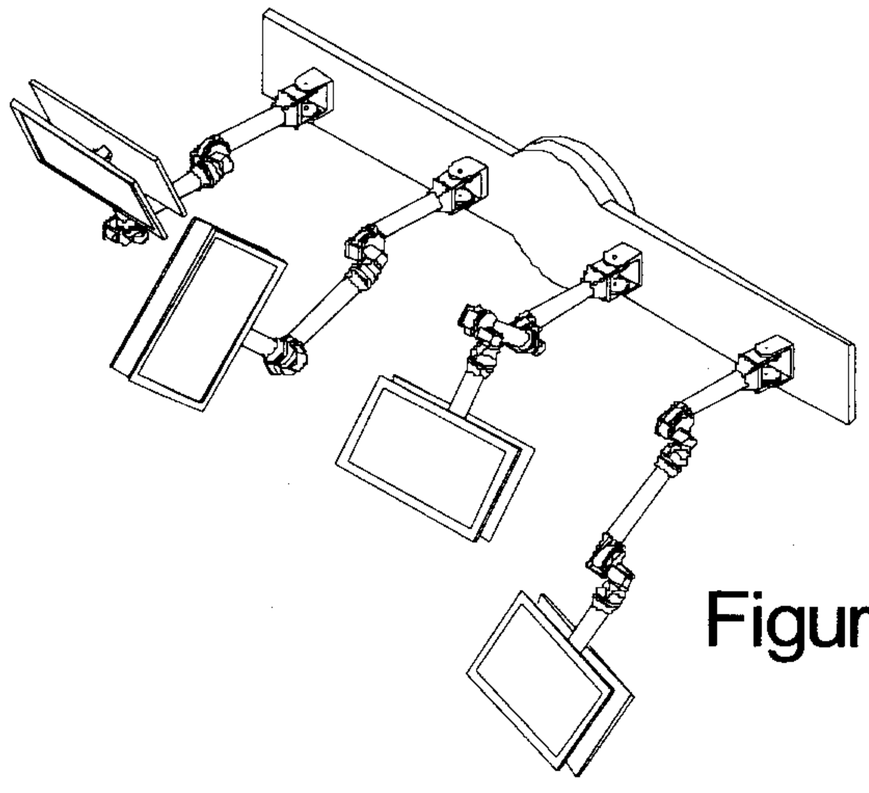


Figure 15D

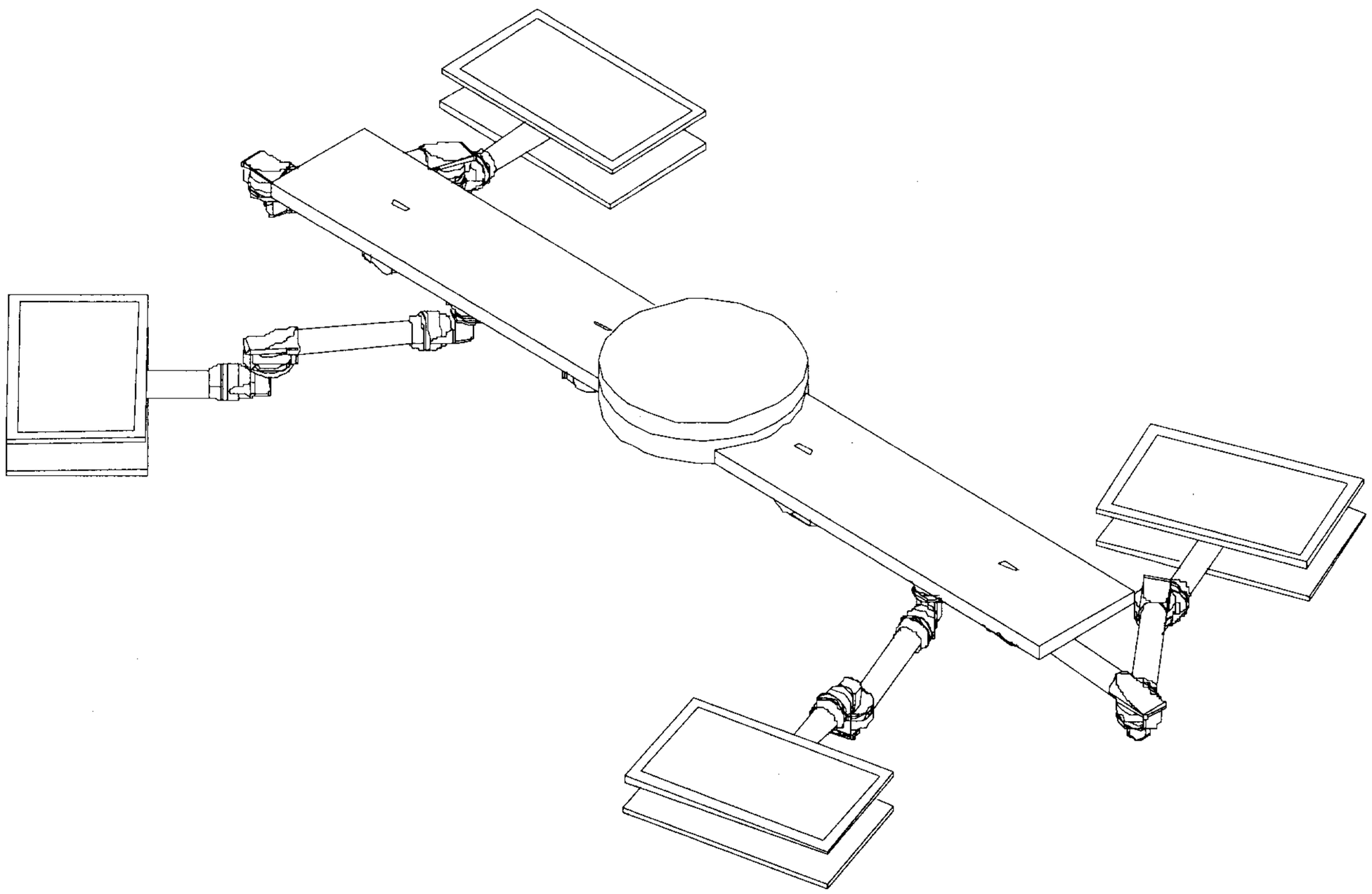


Figure 16

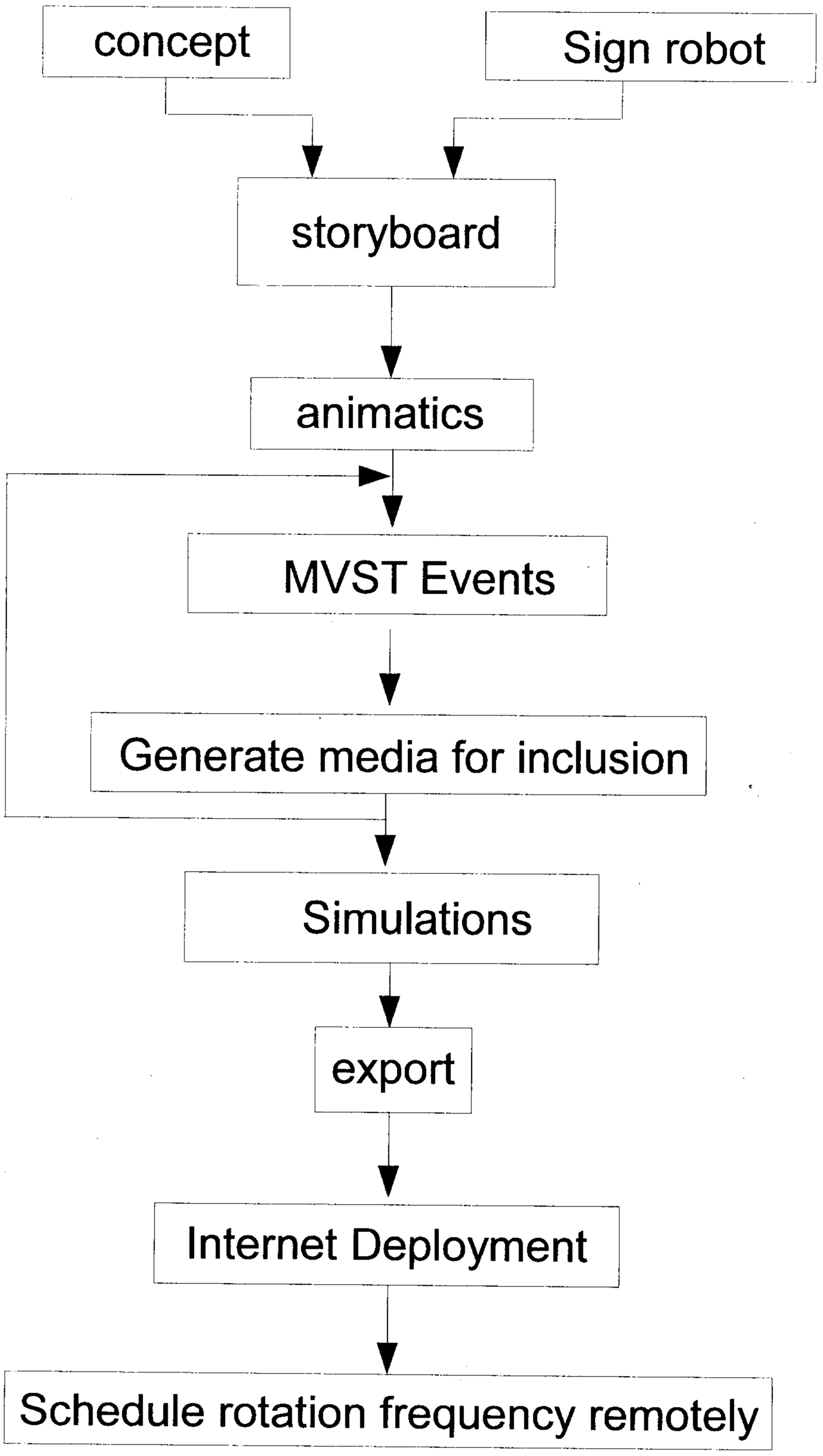

concept
Sign robot
storyboard
animatics
MVST Events
Generate media for inclusion
Simulations
export
Internet Deployment
Schedule rotation frequency remotely

Figure 17

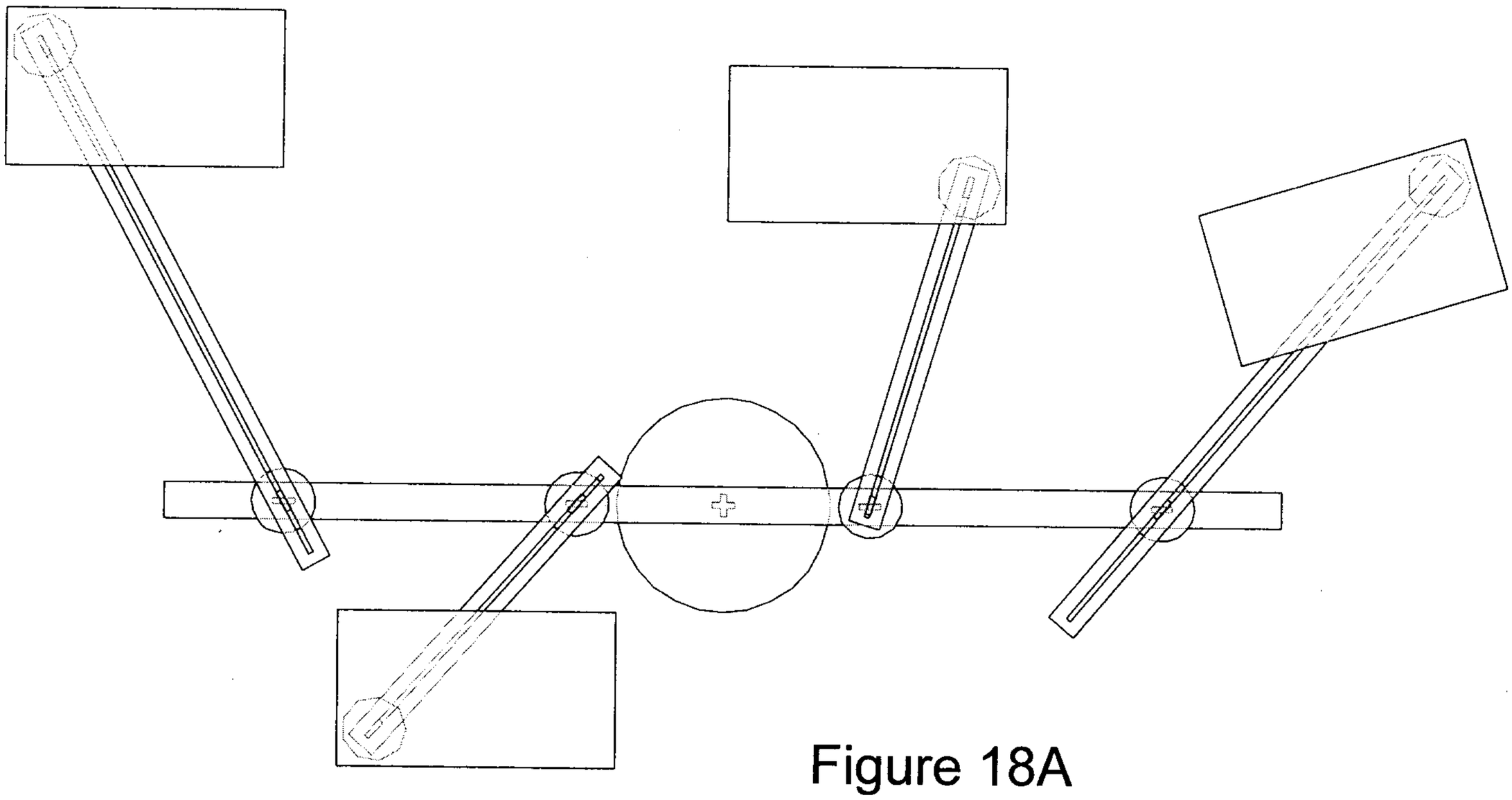


Figure 18A

x3

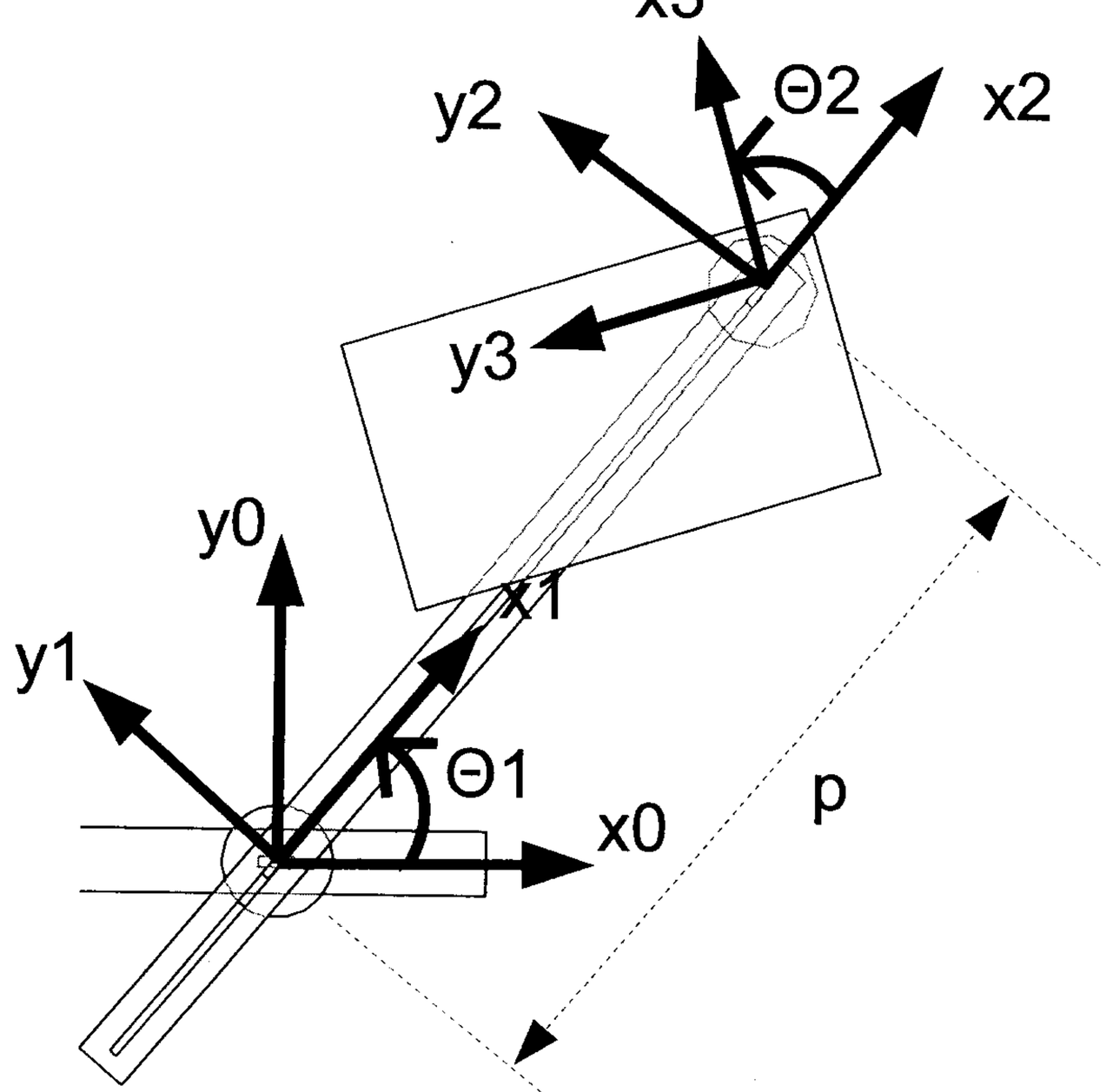


Figure 18B

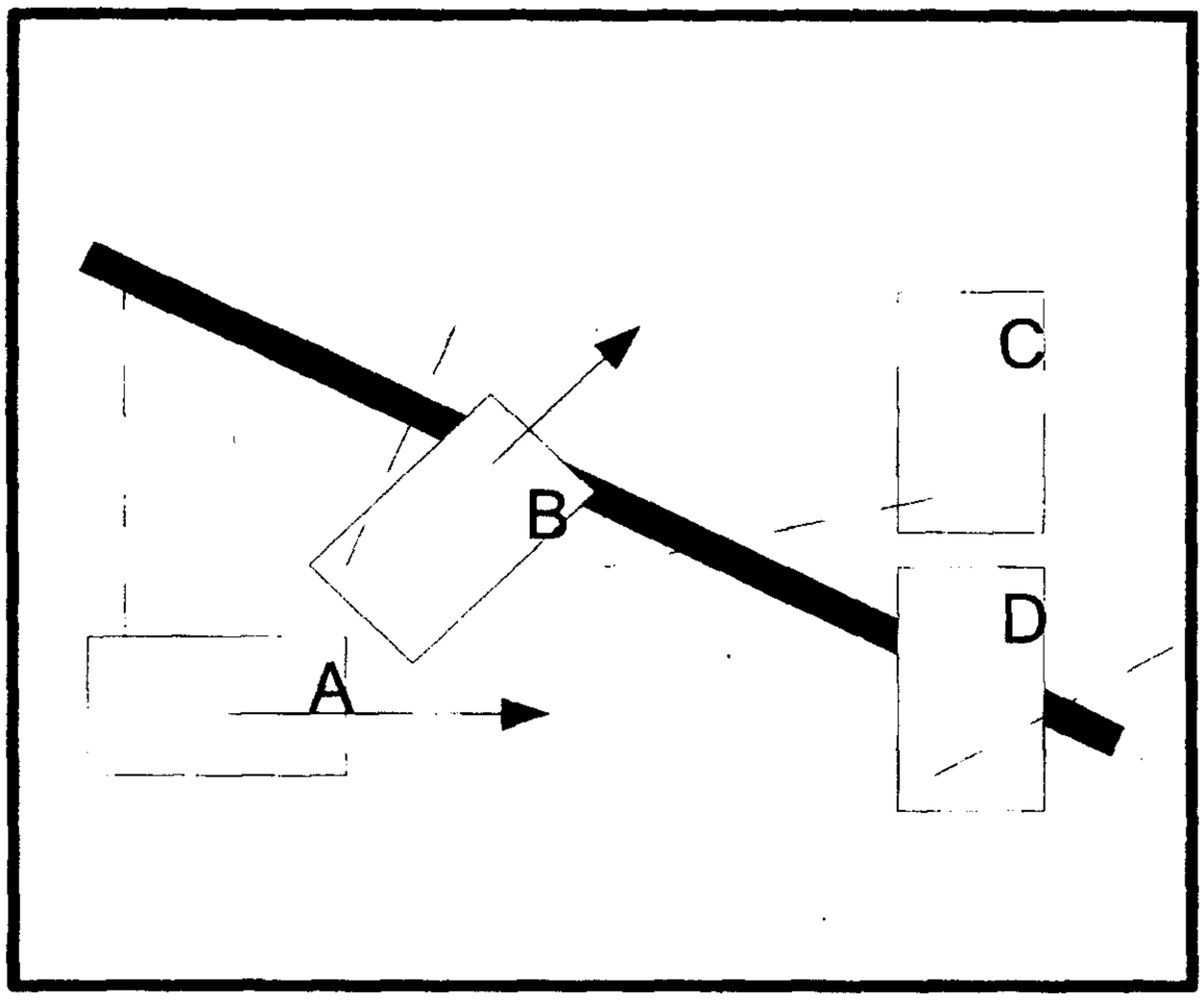


Figure 19

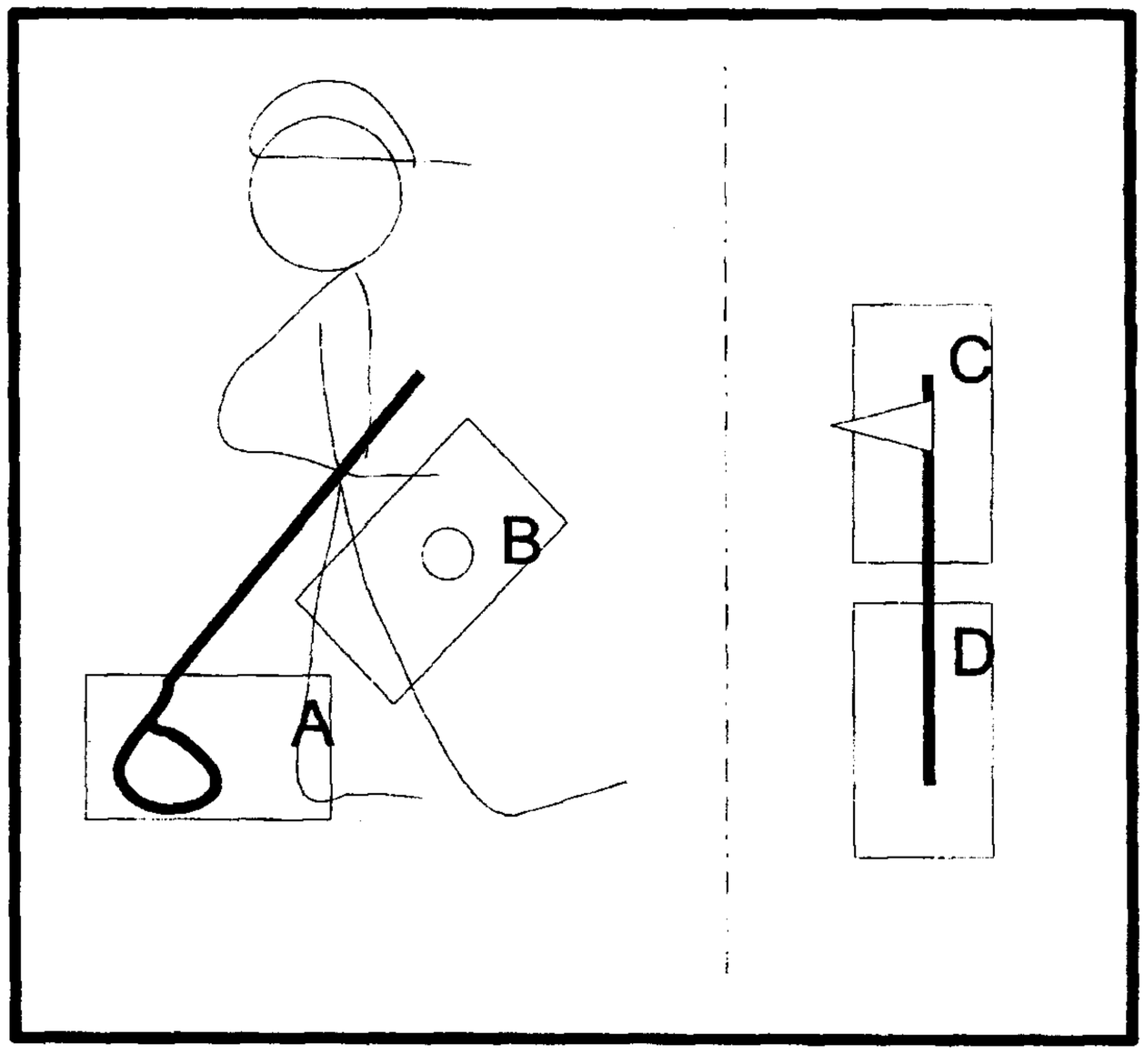


Figure 20

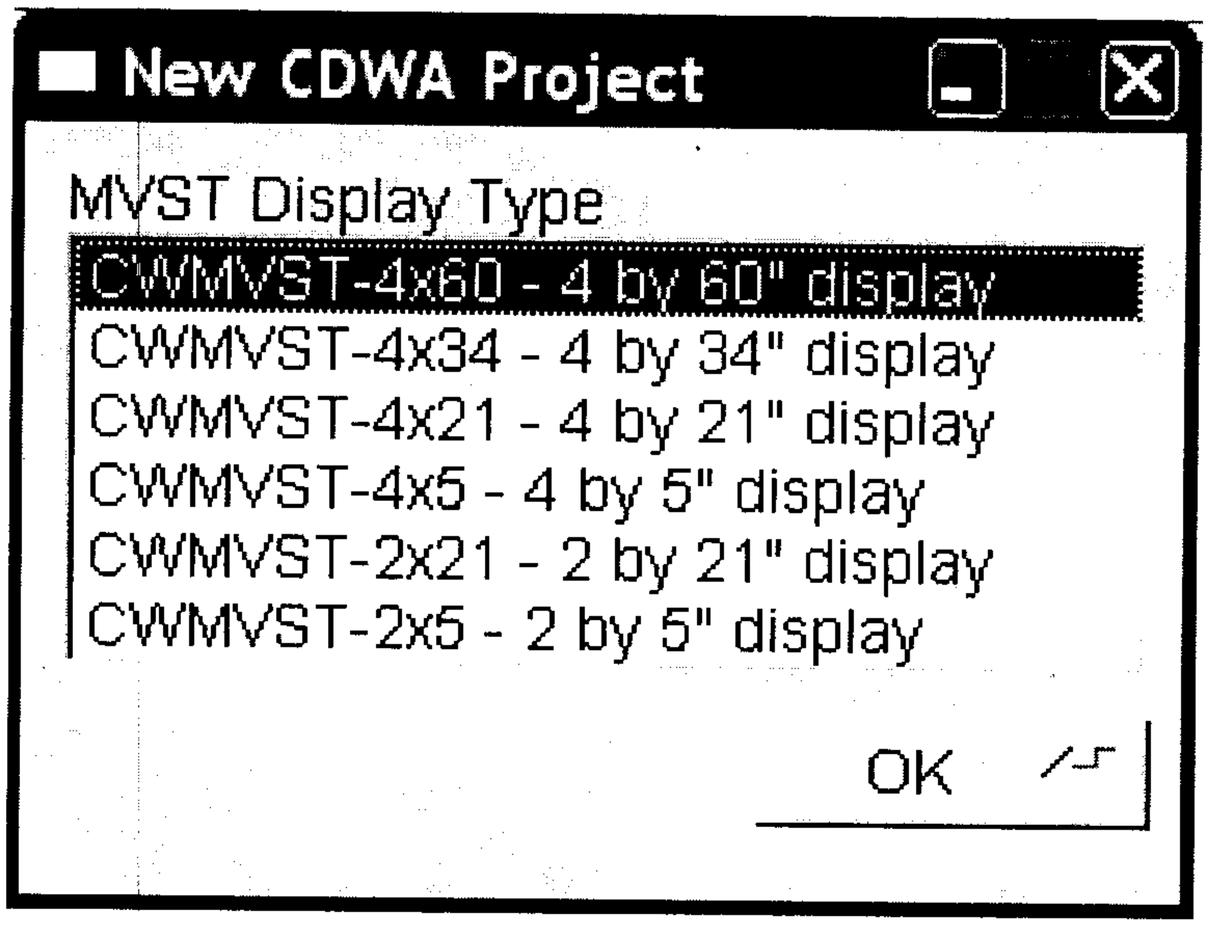


Figure 21

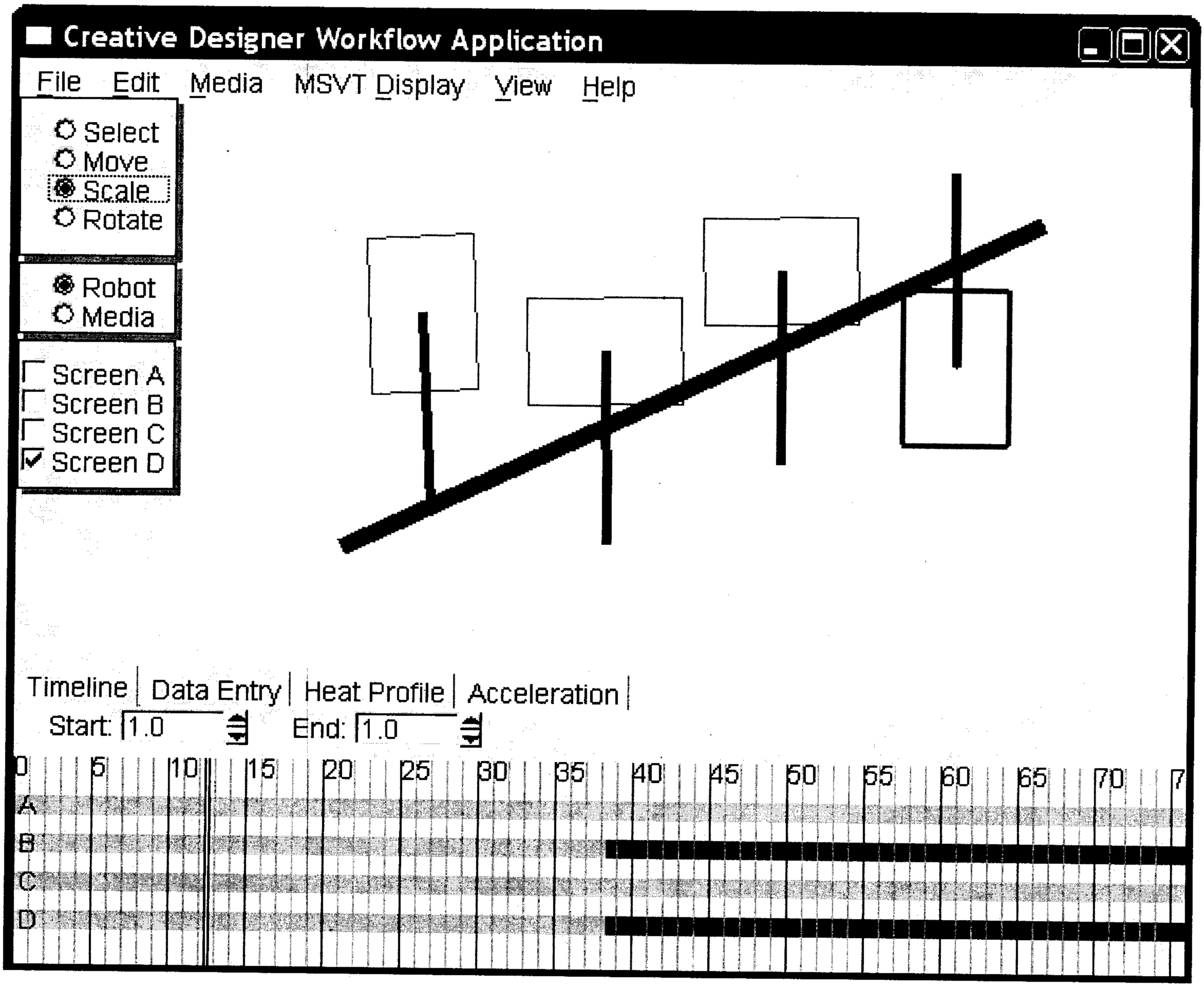


Figure 22

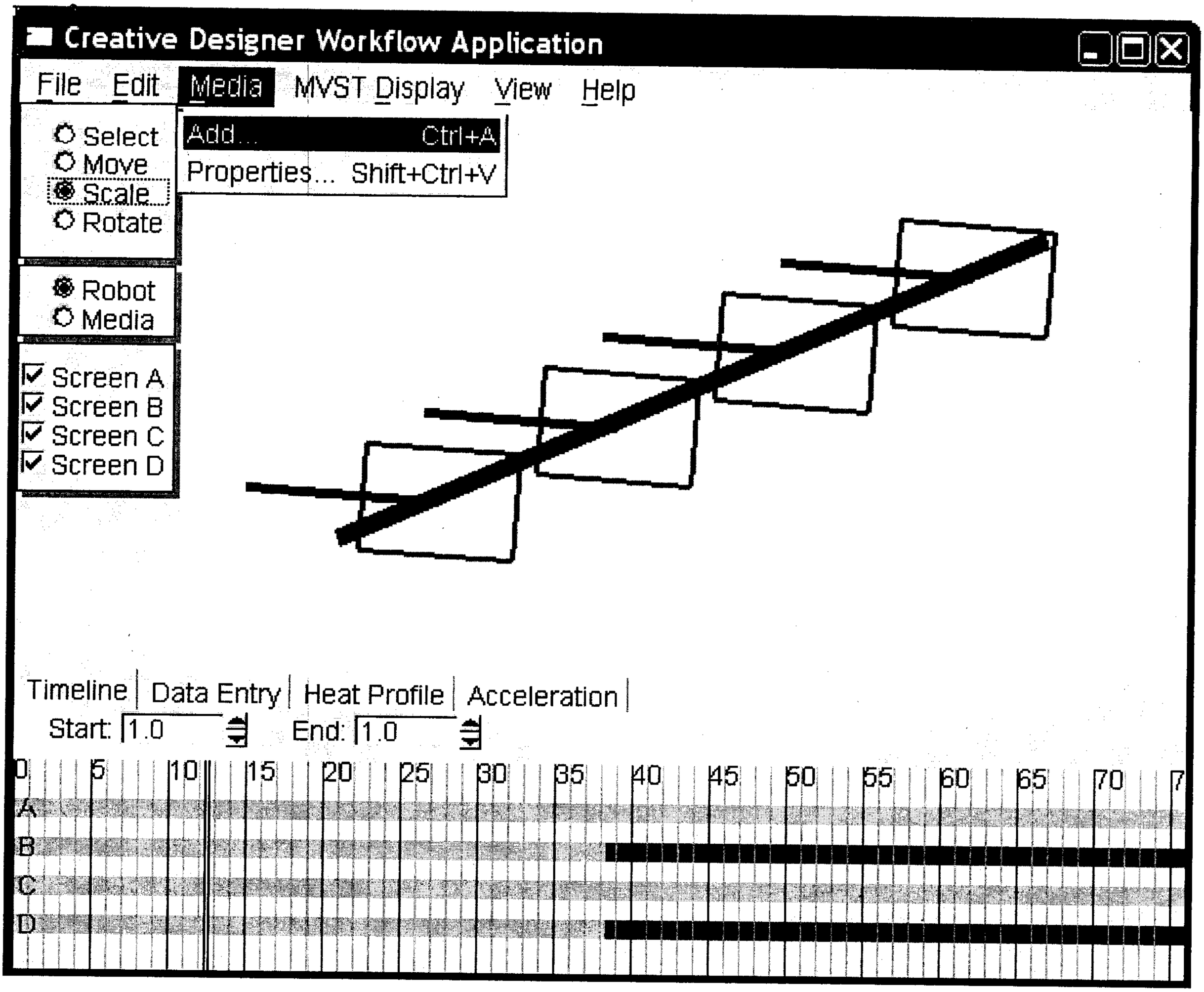


Figure 23

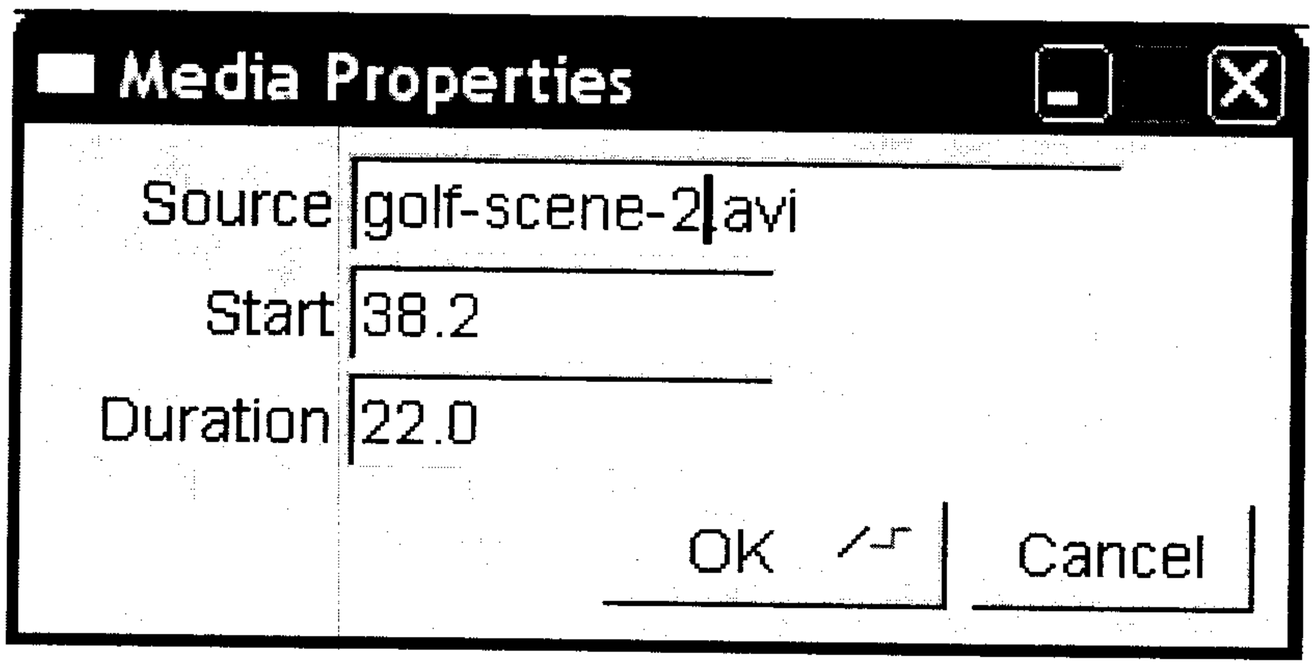


Figure 24

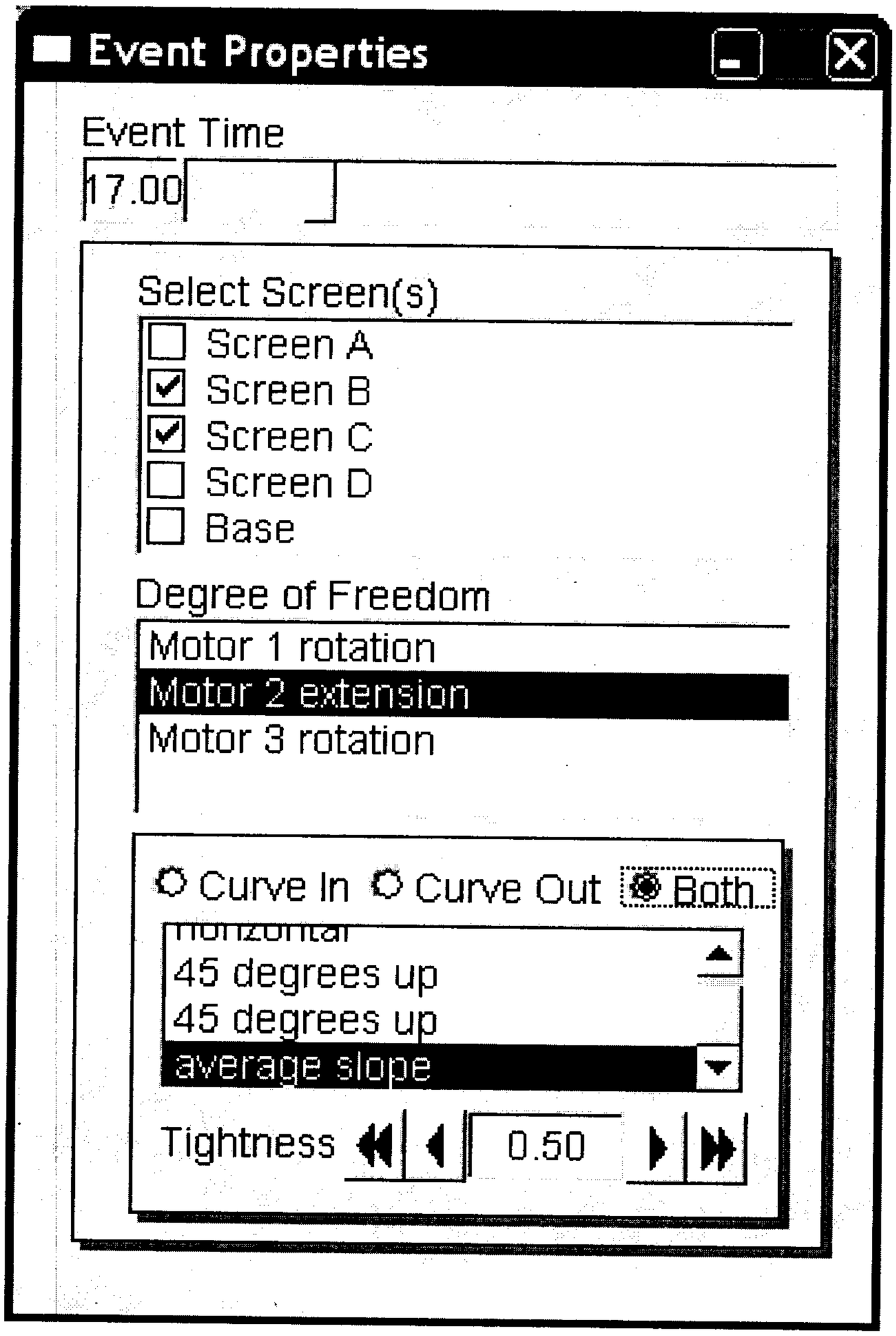

Event Properties
Event Time
17.00
Select Screen(s)
Screen A
Screen B
Screen C
Screen D
Base
Degree of Freedom
Motor 1 rotation
Motor 2 extension
Motor 3 rotation
Curve In
Curve Out
Both
45 degrees up
45 degrees up
average slope
Tightness
0.50

Figure 25

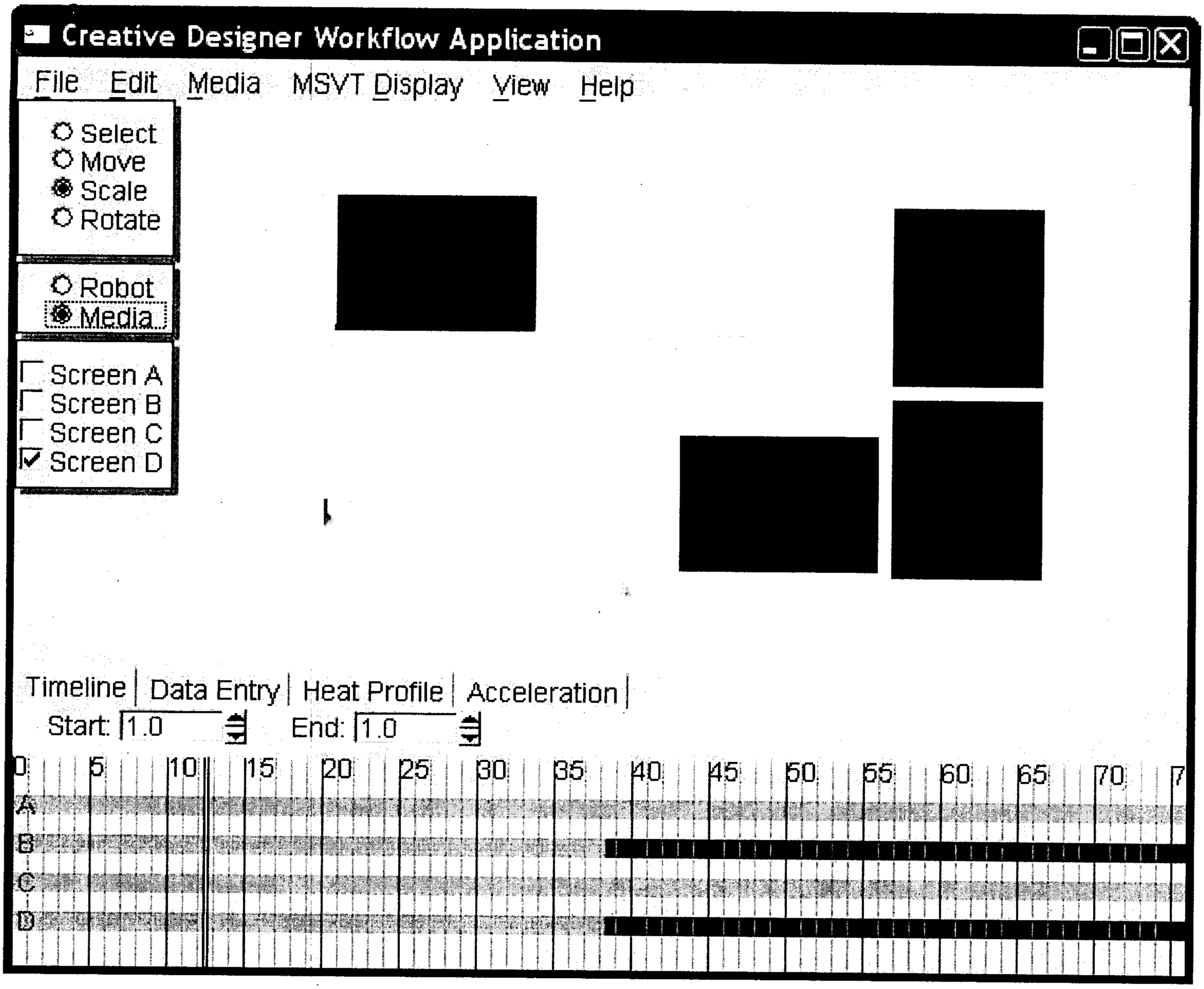


Figure 26

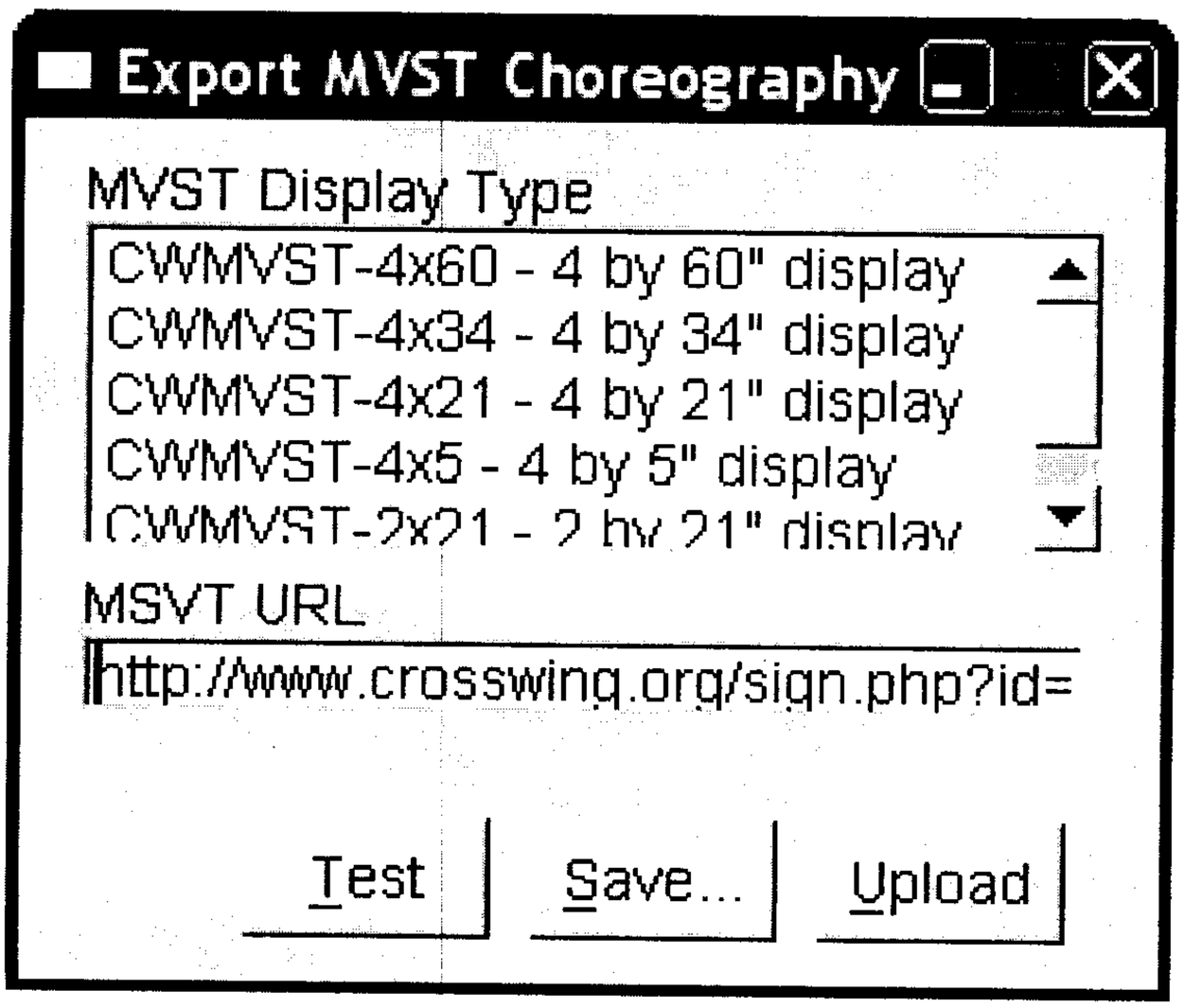


Figure 27

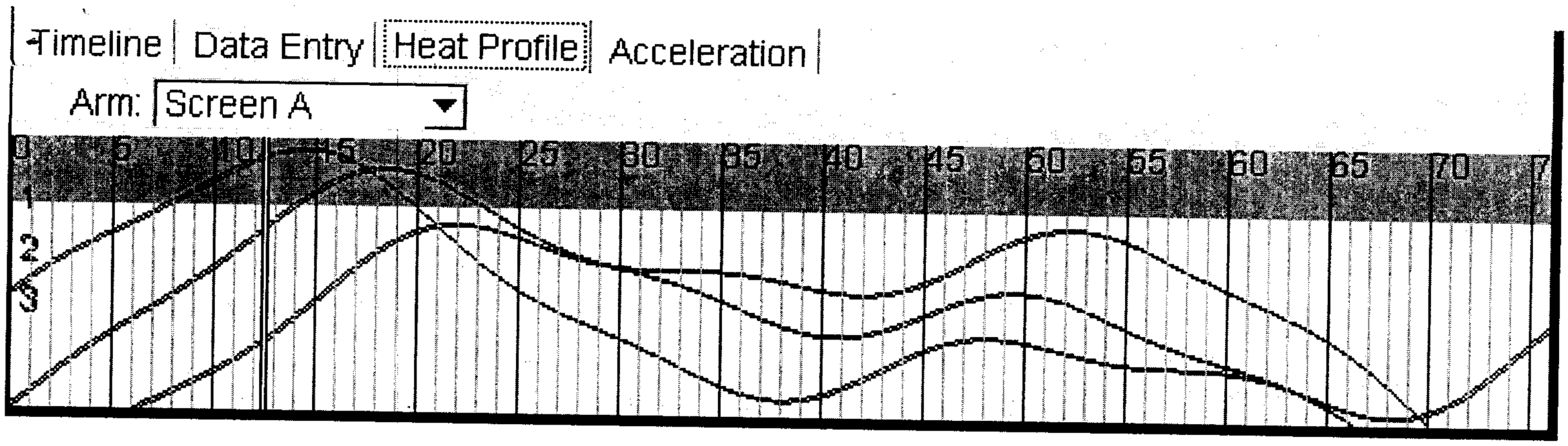


Figure 28

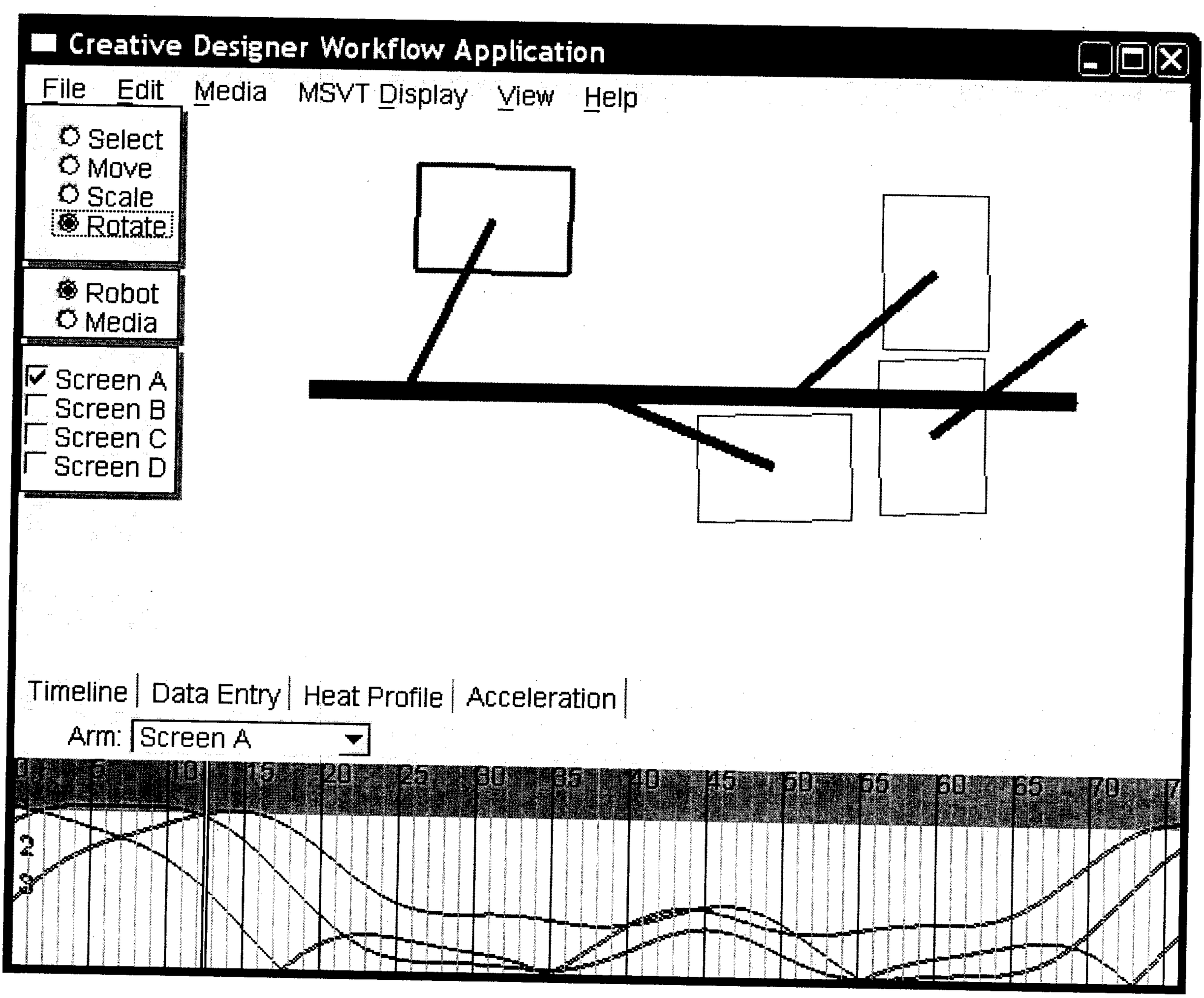


Figure 29

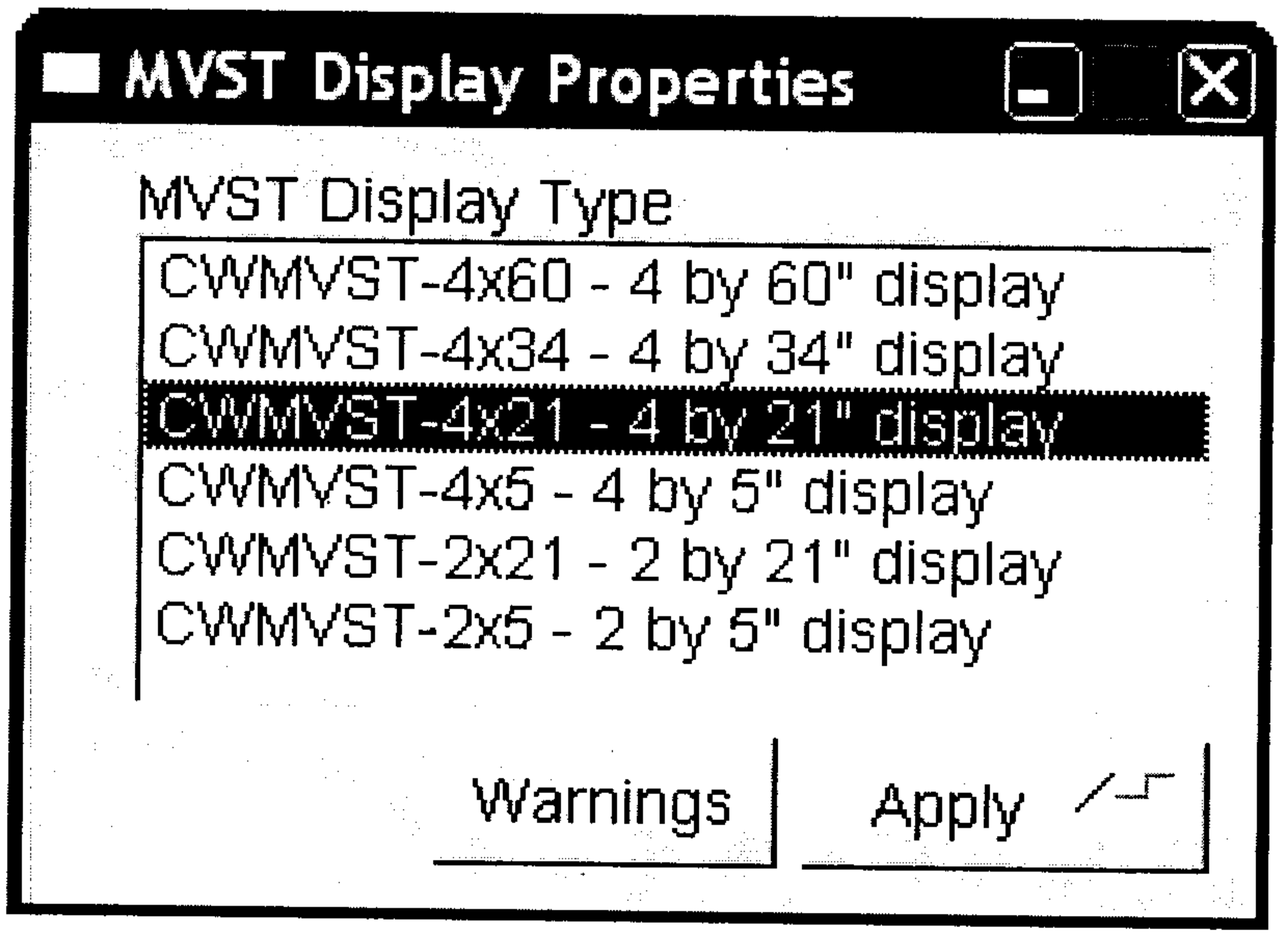
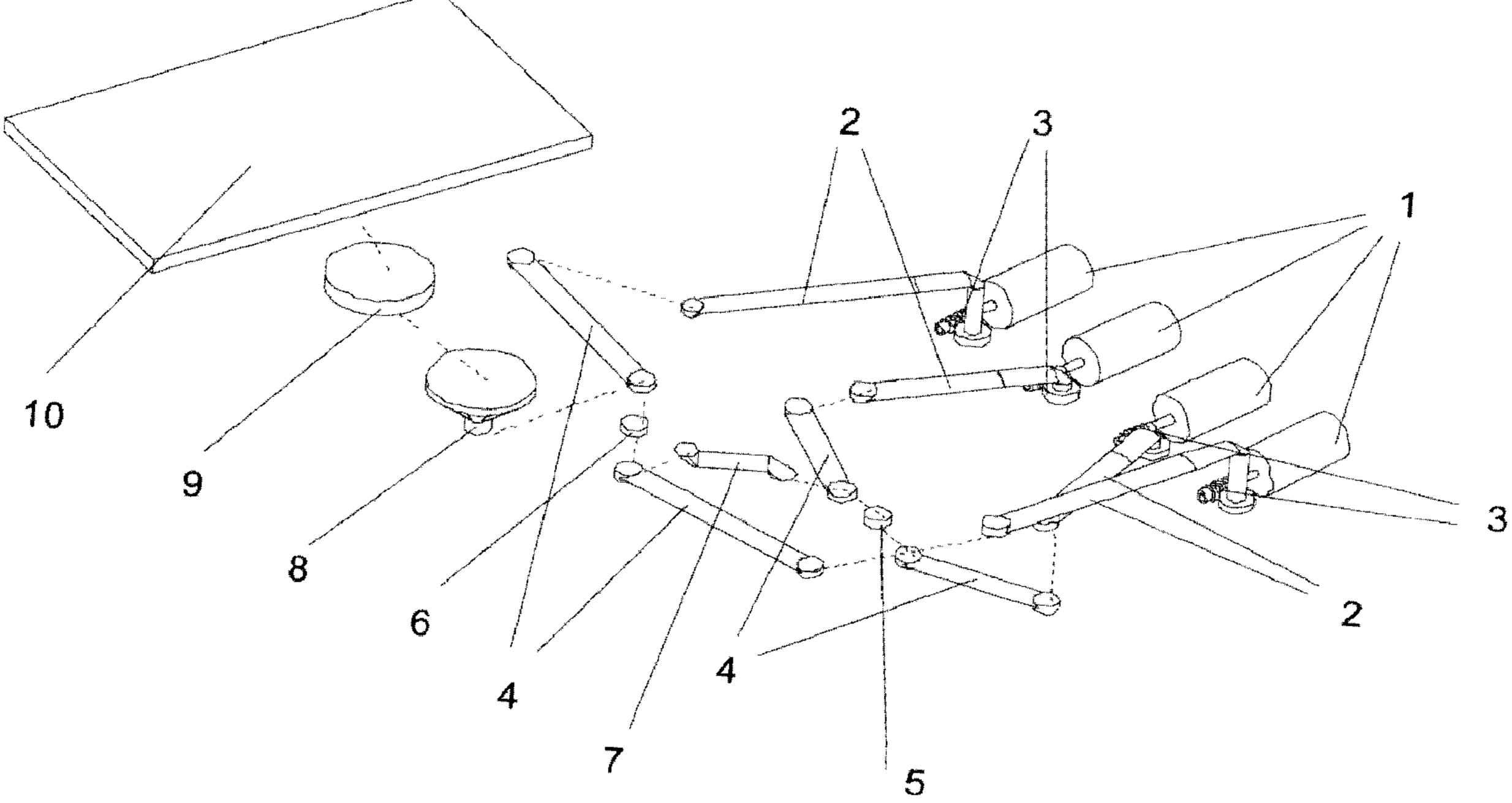

MVST Display Properties
MVST Display Type
CWMVST-4x60 - 4 by 60" display
CWMVST-4x34 - 4 by 34" display
CWMVST-4x21 - 4 by 21" display
CWMVST-4x5 - 4 by 5" display
CWMVST-2x21 - 2 by 21" display
CWMVST-2x5 - 2 by 5" display
Warnings
Apply

Figure 30


10
9
8
6
4
7
5
4
2
3
1
2
3