



(22) Date de dépôt/Filing Date: 2003/11/03

(41) Mise à la disp. pub./Open to Public Insp.: 2005/05/03

(51) Cl.Int.⁷/Int.Cl.⁷ G09B 21/00, A63H 3/28

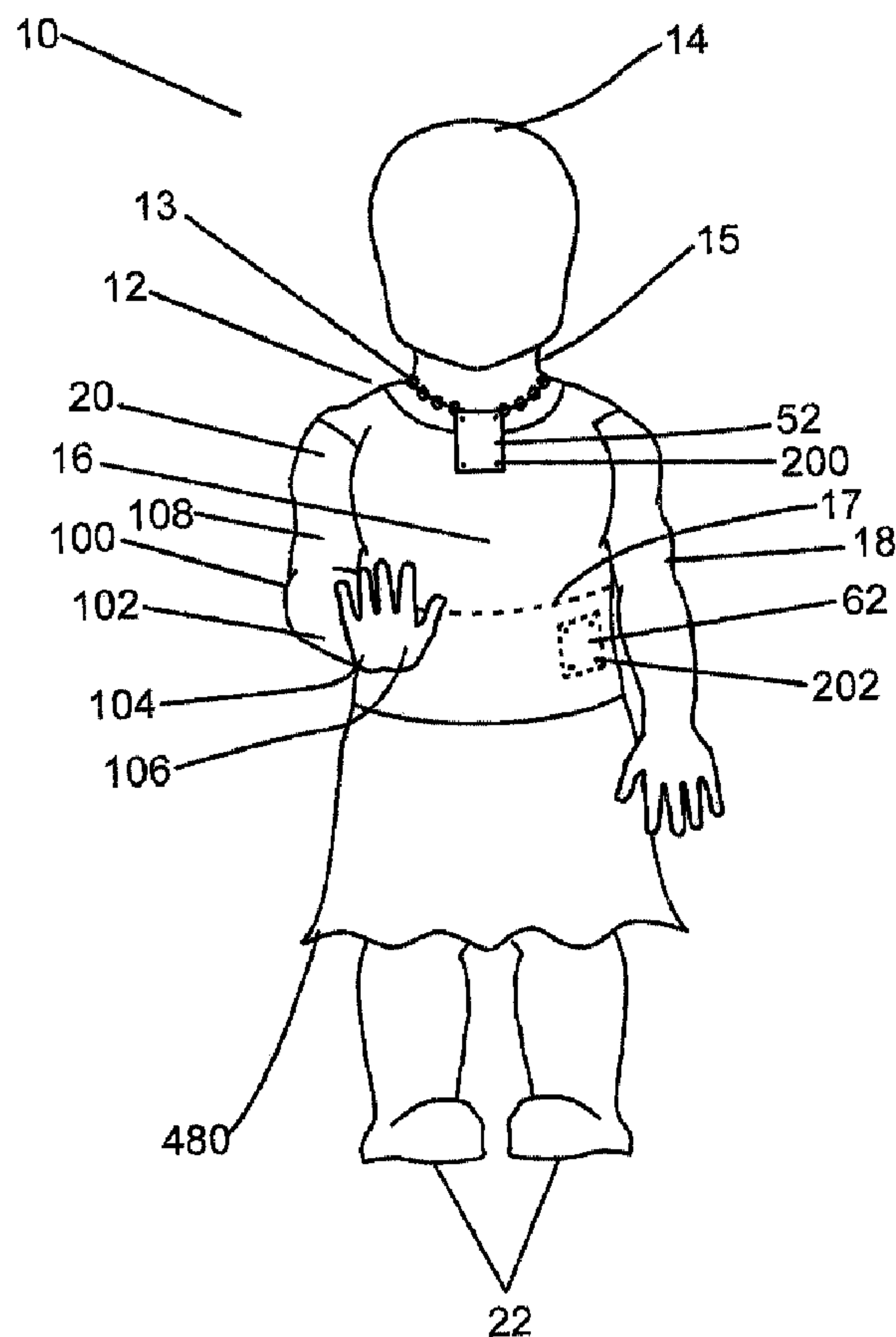
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(54) Titre : **POUPEE EDUCATIVE POUR ENSEIGNER LE LANGAGE PAR SIGNES**

(54) Title: **SIGN LANGUAGE EDUCATIONAL DOLL**



(57) Abrégé/Abstract:

An apparatus and method are disclosed for a doll for demonstrating sign language elements, particularly the American Manual Alphabet ("AMA"). The doll comprises an electromechanical arm and hand controllable to demonstrate sign language. The doll also comprises an audio means for vocalizing the verbal equivalent of the AMA sign, and a display means for displaying the Latin



(57) **Abrégé(suite)/Abstract(continued):**

alphabet equivalent of the sign language element. The doll also comprises an electronic controller including a circuit board, a processor, a memory and interface headers. The doll includes an electromechanical arm and hand with solenoid and spring driver moveable components. A method of demonstrating sign language with an electromechanical hand is also provided. The hand is controllable to demonstrate sign language either on demand or in sequence, and in combination with audio components including the alphabet song, and visual components.

ABSTRACT

An apparatus and method are disclosed for a doll for demonstrating sign language elements, particularly the American Manual Alphabet ("AMA"). The doll comprises an electromechanical arm and hand controllable to demonstrate sign language. The doll also comprises an audio means for vocalizing the verbal equivalent of the AMA sign, and a display means for displaying the Latin alphabet equivalent of the sign language element.

The doll also comprises an electronic controller including a circuit board, a processor, a memory and interface headers. The doll includes an electromechanical arm and hand with solenoid and spring driver moveable components. A method of demonstrating sign language with an electromechanical hand is also provided. The hand is controllable to demonstrate sign language either on demand or in sequence, and in combination with audio components including the alphabet song, and visual components.

SIGN LANGUAGE EDUCATIONAL DOLL

1. TECHNICAL FIELD

The present invention relates generally to electronic devices which teach or demonstrate sign language. The present invention relates specifically to a doll that serves as a means for teaching sign language both visually and audibly.

2. BACKGROUND OF THE INVENTION

Technology relating to communication with sign language may be divided into three major areas: educational devices used to teach sign language; systems that provide a means for inputting data into a computer using sign language; and devices that receive input from a computer keyboard then demonstrate sign language using some form of hand.

Educational Devices

U.S. Pat. No. 4,378,215 ("215") to Sparks discloses an educational apparatus for teaching the American Manual Alphabet ("AMA") to individuals, especially to the blind and/or deaf. The apparatus consists of a plurality of three-dimensional moulded figures of the human hand mounted on a base and each formed in a respective letter of the AMA. A disadvantage of the '215 apparatus is that the apparatus can only demonstrate the final hand positions of the AMA letters and not the required interim movements. A further disadvantage is that the '215 apparatus is limited to visual demonstration of the AMA. Finally, the apparatus is not engaging for children and therefore has limited educational potential.

U.S. Pat. No. 4,799,889 to Yockey discloses a stuffed bear for teaching sign language to deaf children. The stuffed bear utilizes a pair of hollow tubular arms through which the arms of a teacher pass, so that the hands project beyond the front edge surface of each arm. The complete articulation of the arm may be achieved to allow for the signs of sign language to be performed. This doll requires a skilled operator in AMA to manipulate the doll and provide educational value.

U.S. Pat. No. 4,878,843 to Kuch discloses a process and an apparatus for a system of animation and a system of teaching finger spelling. The Kuch patent is limited to providing visual images of hands which demonstrate finger positions and does not provide a physical hand that can be looked at and touched and so is uninteresting to children.

Systems for Inputting Data and Translating Sign Language

U.K. Pat. No. 2,302,583 ("583") to Klein et al. discloses gloves and a hand tapper for communicating with deaf-blind people. The '583 patent teaches that words can be entered into a computer character by character using sign language read via a pair of gloves having electrodes disposed on their surfaces worn by the operator. Circuitry is used to uniquely identify the hand sign being made, and a hand tapper reads out the signs for a deaf-blind individual.

U.S. Pat. No. 5,047,952 to Kramer et al. discloses a communication system for deaf, deaf-blind, or non-vocal individuals using an instrumented glove for obtaining electrical signals indicative of a hand configuration of the individual. These electrical signals are processed and applied to a computer which subsequently outputs to a second individual. The output means depends upon the visual, vocal and hearing capabilities of the individuals but could comprise a voice synthesizer, LCD monitor, or Braille display.

U.S. Pat. App. No. US 2002/0152077 A1 to Patterson discloses a method and apparatus for translation of hand positions into symbols. The invention comprises a glove for detecting the configuration of an individual's hand and an output device that produces either a visual or audio output corresponding to the hand position.

The above data input systems are limited to taking sign language as input; they do not demonstrate or teach how to perform the finger movements of sign language.

Devices Which Receive Input From a Keyboard

U.S. Pat. No. 4,074,444 ("444") to Laenger, Sr. et al. discloses a method and apparatus for

communicating with deaf-blind individuals. The apparatus comprises a keyboard controlled electromechanical arm. The electromechanical arm is programmed to form the letters of the standard one-hand manual alphabet through the use of an electronic buffer between the electric typewriter and the electromechanical arm. Deaf and/or deaf-blind individuals feel or observe the configuration of the electromechanical arm and are able to identify the letters being typed on the keyboard.

The '444 patent discloses an electromechanical arm that is mounted on a controlling means. Such a design is not suitable or convenient for a doll. Further, the hand in the '444 patent consists of cable-pulled fingers, which is impractical in a doll. The disclosure that the electromechanical arm can not effectively demonstrate the more complicated hand movements required for letters such as J or Z. Finally, the controlling means requires input from the typewriter means, and it cannot operate autonomously.

The manual alphabet can be found in Riekehof, *The Joy of Signing*, Gospel Publishing House, 1445 Boonville Ave., Springfield, Mo., p.15 (ISBN-0-88243-518-3).

Devices that communicate and teach sign language are not unique. There is, however, a need for a teaching apparatus which provides a physical hand and additional educational aids to teach people sign language in a fun and pedagogically sound manner.

3. SUMMARY OF THE INVENTION

An apparatus for a sign language element demonstrating doll comprising an electromechanical arm and hand positionally adjustable in a manner operative to demonstrate sign language elements is provided. Advantageously, the doll may further include an audio system for vocalizing the verbal equivalent of the sign language elements and a display system for displaying the Latin alphabet equivalent of the sign language elements. The audio and visual systems may comprise a speaker and a display screen which simultaneously broadcast and display the equivalent of the sign language elements which are being demonstrated by the doll.

Preferably the sign language elements are the American Manual Alphabet ("AMA") signs corresponding to the characters of the Latin alphabet. The electromechanical hand displays the AMA signs in sequence, while simultaneously broadcasting the equivalent name of the sign in a spoken language and displaying the Latin alphabet equivalent of the sign on the display screen. The sign language element may be a sign representing a single letter of an alphabet, a word or a phrase.

Further, the doll for demonstrating sign language may comprise an electromechanical arm attached to a right shoulder having a forearm segment, a hand segment and finger segments, an electronic controller including circuit board, a processor, a memory and interface headers, an electronic display, an audio means, an electronic display screen, an audio output and a power supply.

Further advantageously, a hand of the doll is comprised of a plurality of joints, springs and solenoids such that when the solenoids are activated, the finger segments are flexed about the corresponding joint, and when the solenoids are deactivated, the springs return the finger segments to a neutral extended position. The doll may also comprise a wrist joint and an elbow joint including multi-position solenoids, operable in at least three positions.

The electronic display is may be an alphanumeric light emitting diode display, and the audio means may be a piezo-electric speaker. The processor may be a microcontroller, and the power

supply may be a 6 volt rechargeable battery.

Advantageously the electromechanical hand may have a hand segment and finger segments for demonstrating sign language comprised of: four independently controllable fingers with at least one joint each and moveably attached to the hand segment by one joint; an independently controllable thumb with at least one joint and moveably attached to the hand segment by one joint; and
a controller having a processor and a memory and being attached to the hand. The hand may additionally comprise an electromechanical arm having a forearm segment, the hand being moveably attached at a distal end of the forearm segment, such that the forearm segment is moveable to demonstrate sign language.

Advantageously, the electronic display may be an alphanumeric light emitting diode or a backlit liquid crystal display attached to the electromechanical arm. The audio output may be a piezo-electric speaker. The memory may be an interchangeable memory card.

The doll may include at least one spring and at least one electric solenoid disposed at each joint wherein when the solenoids are activated, the segments are flexed and wherein when the solenoids are deactivated, the springs extend the segments to a neutral anatomical position.

A method of sequentially demonstrating the hand and finger positions of the American Manual Alphabet using an electromechanical arm while concurrently displaying the letter being signed on a digital display and concurrently providing an audial representation of the letter being signed through an audio device is also disclosed. The method includes the steps of: turning a switch on the doll to an on position; controlling an electromechanical arm, hand, and fingers to form a physical representation of a sign language component and simultaneously controlling an audio output device to emit a sound corresponding to the sign language component; and simultaneously controlling a display device to show the Latin character corresponding to the sign language component.

A method of demonstrating sign language with a doll having an electronic control device, an audio output device, a visual display device and a plurality of joints manipulatable by a flexional

device comprising the steps of: controlling the manipulatable joints in at least one finger, and an elbow and wrist of the doll to form a sign language; and simultaneously emitting the sound corresponding to the sign from the audio output device; and simultaneously displaying the Latin letter equivalent of the sign on the visual display device is disclosed.

Advantageously, the flexional devices are electrical solenoids, which may be controlled to flex the fingers, hand and wrist to form the sign character by deactivating the solenoids then returning the fingers, hand and wrist to a neutral position by means of at least one spring under tension.

4. BRIEF DESCRIPTION OF THE DRAWINGS

The apparatus and method of the present invention will now be described with reference to the accompanying drawing figures, in which:

Figure 1 is a front view of the doll according to the invention.

Figure 2 is a rear view of the doll with the cavity in the open position, according to the invention.

Figure 3 is a detailed top view of the electromechanical arm according to the invention.

Figure 4 is a detailed top view of the plunger assembly according to the invention.

Figure 5 is a detailed top view of the electromechanical hand according to the invention.

Figure 6 is a detailed bottom view of the electromechanical hand according to the invention.

Figure 7 is a diagrammatic view of the controller board according to the invention.

Figure 8 is a diagrammatic view of a variation of the control section according to the invention.

Figure 9 is a diagrammatic view of a variation of the control section according to the invention.

5. DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Figure 1 is a front view of a doll 10 which is a fun and educational learning tool for children. The doll 10 is an accessible educational tool from which all individuals, regardless of physical limitations, can learn. Blind individuals can learn sign language by feeling the hand and listening to the audible accompaniment. Deaf individuals can learn by observing the hand position and the corresponding letter being displayed on the electronic display. Individuals without physical limitations will benefit from three concurrent learning aids.

The preferred embodiment of the invention is a toy-like doll 10 that demonstrates the finger and hand movements of the American Manual Alphabet ("AMA"). The preferred embodiment of the invention teaches the AMA, and variations of the present invention teach other forms of sign language.

An advantage of the doll 10 is its form. An isolated hand is not as conducive to learning for

children as the doll 10. The doll 10 presents the opportunity for a child to form a bond with the doll 10, which has a far-reaching value for educating children.

The doll 10 is comprised of a body 12 with a head 14, torso 16, left arm 18, hollow right upper arm 20 and legs 22. In the preferred embodiment the body 12 is modelled on a human child and the height of the body 12, including the head 14, torso 16 and legs 22, is between 68cm (28") and 90cm (36"). Optimally, the doll 10 is approximately 73 and (30") in length. The body 12 is made of a human skin coloured toy-grade plastic such as polyurethane. Any other material that has equivalent strength and durability may be substituted.

The doll 10 is covered by clothing such as a dress 480 which serves to make the doll 10 more lifelike. The clothing 480 may be removed so that a child may dress and undress the doll 10. A variety of clothing 480 styles and types may be used to dress the doll 10.

An electronic letter display 52 is recessed in the upper left front chest area of the torso 16 by fasteners 200 which are preferably commercially available nuts and bolts. Any other fastening means such as screws may be used. In the preferred embodiment, the electronic letter display 52 is an alphanumeric such as FairchildTM Semiconductor part number MSA5460C. Any suitable electronic letter display technology can be used, such as alphanumeric LED (light emitting diode) displays and LCD's (liquid crystal displays).

An audio output device 62 is recessed in the lower left front chest area of the torso 16 by fasteners 202 which are preferably commercially available nuts and bolts. Any other fastening means such as screws may be used. The audio output device 62 is preferably a piezoelectric-type speaker. Any such audio device, with sufficient dynamic range to reproduce clearly the human voice, specifically a frequency range of approximately 30Hz to 14kHz, can be used. This includes, for instance, a cone speaker.

An electromechanical arm subsystem 100, comprising a forearm 102, a hand 104, and a skin covering 108, is attached to the hollow right upper arm 20. The proximal end of forearm 102 is attached (the details of the attachment provided below) to the distal end of the upper arm 20 and fixed at an approximately 45 degree angle. The hand 104 is attached to the forearm 102 (details of

attachment provided below). The arm subsystem **100** is positioned so that the hand **108** is generally above the waistline **17** of the doll **10** with the palm **106** facing generally forward and in front of the torso **16**. This position is the most common signing position. The arm subsystem **100** is covered by a skin covering **108** which serves to protect the components of the arm, described below, and make the doll **10** look more lifelike. The skin **108** must be flexible enough to allow the fingers and wrist of the hand **104** to move and bend. The skin **108** is preferably a human skin coloured polyurethane rubber. Other materials may be used such as silicon rubber; fur may be used to make the doll look like a teddy bear.

Referring now to Figure 2, a diagrammatic rear view of the doll **10** according to the invention, the torso **16** includes a cavity **24** that is disposed in the back area of the torso **16**. The cavity **24** is generally shaped like an open cube or box. In the preferred embodiment, the cavity **24** is approximately 51mm (2") in depth, 102mm (4") in width and 102mm (4") in height. The cavity **24** is comprised of a back wall **26**, a top wall **28**, a left wall **30** and a right wall **32**. A display opening **34** is disposed in the upper area of the back wall **26** and provides access to the backside of the display **52**. An audio opening **36** is disposed in the lower area of the back wall **26** and provides access to the backside of the audio device **62**. An arm opening **38** is disposed in the top wall **28** and provides access to the arm subsystem **100**. A power switch opening **40** is disposed in the lower area of the left wall **30** and provides access to the backside of the power switch **192**. the display opening **34**, audio opening **36**, arm opening **38** and power switch opening **40** are generally circular and approximately 13mm (1/2") in diameter.

Access to the components contained in the cavity **24**, for servicing and maintenance, is provided by a generally rectangular opening **42** disposed in the back area of the torso **16**. The opening **42** is covered with a generally rectangular cover **44** shown here in the open position. When the cover **44** is closed, the opening **42** is completely covered by the cover **44** and damage to the components contained in the cavity **24** is thereby prevented. The proximal edge of the cover **44** is attached to the body **12** by at least two hinges **46** and the distal edge of the cover **44** is secured by a cover fastener **204**. The cover fastener **204** is preferably a commercially available nut and bolt or screw.

A controller **70** is attached to the upper portion of the back wall **26** by fasteners **206** which

are preferably commercially available nuts and bolts. Any other fastening means such as screws may be used. The controller **70** is comprised of a circuit board **71**, display header **80**, audio header **82**, arm power header **84**, arm control header **86**, power switch header **88**, and power supply header **90**.

The backside of the display **52** is connected by a plurality of display power wires **462** and display control wires **452** to the display header **80** through the display opening **34**. The backside of the audio output **62** is connected by a plurality of audio output wires **454** to the audio header **82** through audio opening **36**. A plurality of arm control wires **456** are connected between arm subsystem **100** and the arm control header **86** through arm opening **38**. A plurality of arm power wires **464** are also connected between arm subsystem **100** and the arm power header **84** through arm opening **38**.

A power switch **192** is recessed in the lower left rear area of the torso **16** by switch fasteners **208** which are preferably commercially available nuts and bolts. Any other fastening means such as screws may be used. In the preferred embodiment the switch **192** is a commercially available toggle switch. Other switch types such as pushbutton switches may be used. The switch **192** is connected to the power switch header **88** by a plurality of switch power wires **466**.

A power supply **190** is attached to the lower portion of back wall **30** by fasteners **210** which are preferably commercially available nuts and bolts. Any other fastening means such as screws may be used. A plurality of controller power wires **468** are connected at one end to the power supply **190** and at the other end to the power supply header **90**. The power supply **190** preferably comprises a rechargeable 6 volt battery. Other battery types may be used, such as standard C cell or D cell batteries. Alternatively, an AC-DC power supply may be used. In the preferred embodiment 6 volts direct current is used, but the voltage may increase or decrease for variations of the doll **10**.

All electric control wires **450** and electrical power wires **460** are preferably tie-wrapped and attached to torso **16** at a multiplicity of plastic clips moulded within torso **16** in a method common to the art.

Referring now to Figure 3, a detail, top view of the electromechanical arm, generally referred

to by **100**, is shown. The electromechanical arm **100** is a human-like arm that is capable of reproducing the finger and hand movements of the American Manual Alphabet. The AMA is inherently tolerant to inaccuracies in finger and hand position. Meaning is not lost as long as fingers are held in an approximate position representative of the correct AMA hand position. Although the arm subsystem **100** has been designed to accurately form the AMA hand positions, some flexibility in accuracy is permissible due to the typical and allowable variation of hand position for the AMA.

The arm subsystem **100** is composed of a plurality of cylindrical segments. The segments are preferably constructed from polyethylene plastic, but may be constructed from any other commercially available light weight, rigid material such as aluminium metal. Each segment is connected by a joint generally referred to by **350** which is preferably a ball and socket joint. In the preferred embodiment the arm subsystem **100** is preferably between approximately 18cm (7") and 22cm (9") in length.

The arm subsystem **100** is comprised of a forearm segment **102**, a hand **104**, and solenoids **132** and **134**. The solenoids **132** and **134** are comprised of a housing **301** and a plunger **302**. The housing **301** of the elbow solenoid **132** is attached to the left side of the distal end of the hollow right upper arm **20** by elbow solenoid fasteners **212** which are preferably commercially available nuts and bolts. The left side of the proximal end of the forearm segment **102** is connected to the plunger **302** of the solenoid **132** by forearm fasteners **214**. The forearm **102** is preferably between approximately 10cm (4") and 13cm (5") in length. The housing **301** of the wrist solenoid **134** is attached to the underside of the distal end of the forearm **102** by wrist solenoid fasteners **216** which are preferably commercially available nuts and bolts. The proximal end of the hand **104** is attached to the plunger **302** of the solenoid **134** by wrist fasteners **218**. Both the solenoid **132** and **134** are preferably multi-position solenoids and comprise a proximal end, and a distal end. The proximal and distal ends correspond to the proximal and distal end ends of the forearm segment **102**.

The hand **104** is comprised of a plurality of cylindrical segments. The segments are preferably constructed from polyethylene plastic, but may be constructed from any other commercially available light weight, rigid material such as aluminium metal. Each segment is connected by a joint **350** which is preferably a ball and socket joint, but may also be connected using tongue/groove/pin connections. In the preferred embodiment the hand **104** is preferably between

approximately 8cm (3") and 10cm (4") in length.

The interconnection of the cylindrical segments will now be described. The hand **104** is comprised of a palm **106**, a thumb **500**, a first finger **502**, a second finger **504**, a third finger **506** and a fourth finger **508**. The palm **106** is generally quadrilateral in shape and is preferably constructed from polyethylene plastic, but may be constructed from any other commercially available lightweight, rigid material such as aluminium metal.

The thumb **500** is comprised of a lower thumb segment **111** and an upper thumb segment **112**. The housing **301** of a first thumb solenoid **136** is attached to the left side of the palm **106** by thumb solenoid fasteners **220**. The plunger **302** of solenoid **136** is connected to the proximal end of a lower thumb segment **111** by a thumb segment fastener **222**. The distal end of the lower thumb segment **111** is connected to the proximal end of an upper thumb segment **112** by a joint **352**. The first thumb solenoid **136** is preferably a commercially available multi-position solenoid.

The first finger **502** is comprised of a first finger lower segment **113** and a first finger upper segment **114**. The proximal end of a first finger lower segment **113** is connected to the distal end of the palm **106** by a joint **353**. The distal end of first finger lower segment **113** is connected to the proximal end of a first finger upper segment **114** by a joint **354**.

The second finger **504** is comprised of a second finger lower segment **115** and a second finger upper segment **116**. The proximal end of a second finger lower segment **115** is connected to the distal end of the palm **106** by a joint **355**. The distal end of second finger lower segment **115** is connected to the proximal end of a second finger upper segment **116** by a joint **356**.

The third finger **506** is comprised of a third finger lower segment **117** and a third finger upper segment **118**. The proximal end of a third finger lower segment **117** is connected to the distal end of the palm **106** by a joint **357**. The distal end of third finger lower segment **117** is connected to the proximal end of a third finger upper segment **118** by a joint **358**.

The fourth finger **508** is comprised of a fourth finger lower segment **119** and a fourth finger upper segment **120**. The proximal end of a fourth finger lower segment **119** is connected to the

distal end of the palm **106** by a joint **359**. The distal end of the fourth finger lower segment **119** is connected to the proximal end of a fourth finger upper segment **120** by a joint **360**.

Referring now to Figure 4, a top view of the preferred embodiment of the solenoid plunger fastening means **300** is shown. Note that the components are not shown to scale, as indicated by the breakline in plunger **302**. A solenoid **130** is comprised of a housing **301** and a plunger **302**. The plunger **302** is connected internally within the housing **301**. The distal end of the plunger **302** is preferably comprised of a metal fork **303** with a hole **304** there through. A rod **305** is inserted transversely between the tines of the fork **303** and a pin **307** is inserted through both the tynes and the rod **305**. The rod **305** is inserted through a hole **308** in the finger segment **309** and a nut **306** is attached to the opposite end of the rod **305** thereby retaining it to the finger segment **309**. The pin **307** is preferably a commercially available cotter pin. The nut **306** is preferably a commercially available nut. The rod **304** is preferably a commercially available bolt, with a hole drilled through the non-threaded end. The components such as the plunger **302**, rod **305** and finger segment **309** are not shown to scale. The lengths of the components must be sized to permit flexion and extension of the finger segments.

Referring now to Figure 5, a top view of the preferred embodiment of the hand **104** is shown. A plurality of springs **160** and solenoids **130** are attached to certain locations on the fingers **500-508** and the hand **104**. The solenoids **130** are comprised of a proximal end, and a distal end. The proximal and distal ends correspond to the proximal and distal end ends of the finger segments **111-120**.

The housing **301** of a second thumb solenoid **138** is connected to the right side of lower thumb segment **111** by fasteners **224**; the plunger **302** of solenoid **138** is connected to thumb segment **112** by a plunger assembly **300**. Thumb spring **161** is connected at one end to the left side of the thumb segments **111** and at the other end to the left side of thumb segment **112** by fasteners **226**.

The housing **301** of a first finger solenoid **140** is connected to the left side of the palm **106** by first finger solenoid fasteners **228**. The plunger **302** of the first finger solenoid **140** is connected to the finger segment **113** by a plunger assembly **300**. A first finger side spring **162** is connected at

one end to the distal end of the palm 106 by a fastener 232 and at the other end to the left side of the finger segment 113 by the fastener 230. A first finger lower spring 164 is attached at one end to the top side of the palm 106 by a fastener 234 and at the other end to the top side of the finger segment 113 by a fastener 236. A first finger upper spring 166 is attached at one end to the top side of the finger segment 113 by a fastener 236 and at the other end to the top side of the finger segment 114 by a fastener 238.

A second finger lower spring 168 is attached at one end to the top side of the palm 106 by a fastener 240 and at the other end to the top side of the finger segment 115 by a fastener 242. A second finger upper spring 170 is attached at one end to the top side of the finger segment 115 by a fastener 242 and at the other end to the top side of the finger segment 116 by a fastener 244.

The housing 301 of a third finger solenoid 142 is recessed in the distal end side of the palm 106, on the right side of finger segment 117, by third finger solenoid fasteners 246. The plunger 302 of the third finger solenoid 142 is connected to the finger segment 117 by a plunger assembly 300. A third finger side spring 172 is connected at one end to the distal end of the palm 106 on the left side of finger segment 117 by a fastener 250 and at the other end to the right side of the finger segment 117 by the fastener 248. A third finger lower spring 174 is attached at one end to the top side of the palm 106 by a fastener 252 and at the other end to the top side of the finger segment 117 by a fastener 254. A third finger upper spring 176 is attached at one end to the top side of the finger segment 117 by the fastener 254 and at the other end to the top side of the finger segment 118 by a fastener 256.

The housing 301 of a fourth finger solenoid 144 is connected to the right side of the palm 106 by fourth finger solenoid fasteners 258. The plunger 302 of the fourth finger solenoid 144 is connected to the finger segment 119 by a plunger assembly 300. A fourth finger side spring 178 is connected at one end to the distal end of the palm 106 by a fastener 262 and at the other end to the left side of the finger segment 119 by the fastener 260. A fourth finger lower spring 180 is attached at one end to the top side of the palm 106 by a fastener 264 and at the other end to the top side of the finger segment 119 by a fastener 266. A fourth finger upper spring 182 is attached at one end to the top side of the finger segment 119 by a fastener 266 and at the other end to the top side of the finger segment 120 by a fastener 268.

All springs **160** are under tension when the corresponding finger segments **111-120** are in the flexed position, and relaxed when the corresponding finger segments **111-120** are in the extended position.

Referring now to Figure 6, a bottom view of the preferred embodiment of the hand **104** is shown. The housing **301** of a first finger lower solenoid **146** is connected to the bottom side of the palm **106** by first finger lower solenoid fasteners **270**. The plunger **302** of the first finger lower solenoid **146** is connected to the finger segment **113** by a plunger assembly **300**. The housing **301** of a first finger upper solenoid **148** is connected to the bottom side of the finger segment **113** by first finger upper solenoid fasteners **274**. The plunger **302** of the first finger upper solenoid **148** is connected to the finger segment **114** by a plunger assembly **300**.

The housing **301** of a second finger lower solenoid **150** is connected to the bottom side of the palm **106** by second finger lower solenoid fasteners **278**. The plunger **302** of the second finger lower solenoid **150** is connected to the finger segment **115** by a plunger assembly **300**. The housing **301** of a second finger upper solenoid **152** is connected to the bottom side of the finger segment **115** by second finger upper solenoid fasteners **282**. The plunger **301** of the second finger upper solenoid **152** is connected to the finger segment **116** by a plunger assembly **300**.

The housing **301** of a third finger lower solenoid **154** is connected to the bottom side of the palm **106** by third finger lower solenoid fasteners **286**. The plunger **302** of the third finger lower solenoid **154** is connected to the finger segment **117** by a plunger assembly **300**. The housing **301** of a third finger upper solenoid **156** is connected to the bottom side of the finger segment **117** by third finger upper solenoid fasteners **290**. The plunger **302** of the third finger upper solenoid **156** is connected to the finger segment **118** by a plunger assembly **300**.

The housing **301** of a fourth finger lower solenoid **158** is connected to the bottom side of the palm **106** by fourth finger lower solenoid fasteners **294**. The plunger **302** of the fourth finger lower solenoid **158** is connected to the finger segment **119** by a plunger assembly **300**. The housing **301** of a fourth finger upper solenoid **159** is connected to the bottom side of the finger segment **119** by fourth finger upper solenoid fasteners **298**. The plunger **302** of the fourth finger upper solenoid **159**

is connected to the finger segment 120 by a plunger assembly 300.

The use of solenoids 130 and springs 160 in the preferred embodiment is not intended to limit the scope of the invention. Other technologies which provide the same functionality, such as air-piston solenoids, may be used in place of the electric solenoids.

Referring now to Figure 7, the controller 70 which is comprised of a circuit board 71 with a control section 72 and an interface section 73, is shown. The circuit board 71 is preferably a commercially available printed circuit board with etched traces, and is generally referred to by 310.

The control section 72 is comprised of a memory 75, a processor 76, and an input/output ("I/O") 77. In the preferred embodiment, the control section 72 is implemented using a single microcontroller 98 (otherwise known in the art as an embedded system). The memory 75, the processor 76 and the I/O 77 are contained within the microcontroller 98 which is a single hermetically sealed package. In the preferred embodiment the microcontroller 98 is implemented using a commercially available microcontroller such as the MotorolaTM MC68CH11.

The interface section 73 is comprised of a display header 80, an audio header 82, an arm power header 84, an arm control header 86, a power switch header 88, a power supply header 90, a display controller 54, an audio driver 64, a solenoid driver 94, and a power regulator 96. The headers 80, 82, 84, 86, 88, and 90, audio driver 64, solenoid driver 94, display controller 54, power regulator 96 are commercially available components.

In the preferred embodiment, the microcontroller 98 is soldered to circuit board 71. The I/O section 78 of the microcontroller 98 is connected electrically via etched traces 310 to the interface section 73. The I/O section is connected to the audio driver 64 by traces 312, to the solenoid driver 94 by traces 314 and to the display controller 54 by traces 316.

The audio driver 64 is connected by traces 318 to the audio header 82. The audio header 82 is connected to the audio output 62 by a plurality of wires 454. The display controller 54 is connected by traces 320 to the display header 80. The display header 80 is connected to the display 52 by a plurality of display power wires 462 and display control wires 452. The solenoid driver 94

is connected by traces **322** to the arm control header **86**. The arm control header **86** is connected to the solenoids **140** by a plurality of arm control wires **456**. The power regulator **96** is connected by traces **324** to the microcontroller **98**. The power regulator **96** is also connected to the power switch header **88** by traces **326**. The power switch header **88** is connected to the power switch **192** by wires **466**. The power regulator **96** is also connected to the power supply header **90** by traces **328**. The power supply header **90** is connected to the power supply **190** by wires **468**. The power regulator **96** is also connected to the arm power header **84** by the traces **330**. The arm power header **80** is connected to the solenoids **140** by arm power wires **464**.

An explanation of the function and interaction of these subsystems is now provided. The electronic letter display subsystem **50**, comprising a display **52** and a display controller **54**, provides supplementary visual representation of the AMA letter being signed. The audio subsystem **60**, comprising a speaker **62** and a speaker driver **64**, provides an audible representation of the AMA letter being signed. The arm subsystem **100**, comprising a plurality of solenoids **130** and springs **160**, forms the hand positions for the letters of the AMA. Controller **70** controls the subsystems through control wires **450**. The controller **70** also synchronizes the display output and the audio output with the movements of the arm subsystem **100**. The power supply **190** supplies power to the display subsystem **50**, the audio subsystem **60**, the controller **70**, and the arm subsystem **100** via electrical power wires **460**.

The control section **72** controls the operation of these subsystems by issuing control signals to them. The control section **72** determines which control signals to issue in the processor **76**. In operation, the processor **76** receives input from the memory **75**, processes the input, and generates output for the subsystems via the I/O **77**. In particular, the processor **76** has the function of sending control signals to the solenoid driver **94** which cause the driver **94** to output control signals to the solenoids **150** in the arm subsystem **100**; sending signals to the display controller **54** so that appropriate letter is displayed; and translating the digital audio samples from the memory **75** into analog audio signals that are output to the audio driver **64**. Further, the processor **76** synchronizes the various subsystems so that they operate concurrently.

Referring now to Figure **5** and Figure **6** in combination with Figure **7**, an example of the mechanics of a finger movement in the preferred embodiment is now provided. Lower solenoid **146**

connects to the underside of the palm 106 and to the underside of the finger segment 113. Upon receiving a control signal from the controller 70, the solenoid driver 94 activates the lower solenoid 146 which retracts the plunger 302. The solenoid plunger 302 retracts thereby rotating the attached finger segment to the flexional position. The spring 164 connects to the top side of the palm 106 and the top side of finger segment 113. When the solenoid driver 94 deactivates the lower solenoid 146, and the spring 164, now under tension, returns the finger to the extensional position, and simultaneously extends the plunger 302. Similarly, the upper solenoid 148 connects to the underside of the finger segment 113 and to the underside of the finger segment 114. When the solenoid driver 94 activates the solenoid 148, the solenoid pulls the segment to the flexional position. The spring 166 connects to the topside of finger segment 113 and the topside of the finger segment 114. When the solenoid driver 94 deactivates solenoid 148, the spring 166 returns the finger to the extensional position. The remaining fingers (not shown) attached to the hand 104 operate in an identical way.

The elbow solenoid 132 and wrist solenoid 134 enable the up/down and side-to-side (or left-right) motions required only for certain letters, including 'J' and 'Z'. Both elbow solenoid 132 and wrist solenoid 134 are optimally multi-position solenoids where the plunger 302 may be in three positions, a retracted position, neutral, or extended. The elbow solenoid 132 allows the arm subsystem 100 to move horizontally to the left and right and return to neutral. When the plunger 302 of elbow solenoid 132 is retracted, the arm subsystem 100 is displaced to the left. Conversely, when the plunger 302 of the elbow solenoid 132 is extended, the arm subsystem 100 is displaced to the right. The midway position where the forearm 102 is parallel with the upper arm 20 is the neutral position. The solenoid 134 enables the hand 104 to move vertically up and down and return to neutral. Wrist solenoid 134 may be in a (retracted) downward position, neutral, or an (extended) upward position.

Alternatively, a two position solenoid and spring system may be employed to displace the wrist 103 and elbow 105 joints 107.

The first finger solenoid 140, third finger solenoid 142 and fourth finger solenoid 144 and first finger side springs 162, third finger side spring 172 and fourth finger side spring 178 enable the first finger 502, third finger 506 and fourth finger 508 to alternatively spread and close. For

example, when the solenoid driver **94** activates the solenoid **140**, the solenoid **140** plunger **302** retracts, thereby pulling the finger segment **113** laterally to the left. When the solenoid driver **94** deactivates solenoid **140**, the spring **162**, now under tension, returns the segment **113** to its neutral position by pulling the segment to the right.

Three examples of the control process according to the invention are now provided. In order to form the letter "A", upon initiation of the sequence by the user activated power switch **192**, the following series of principal steps will be followed:

1. The elbow **105** will return to neutral position.
2. The wrist **103** will return to neutral position.
3. The wrist **103** bends upwards.
4. First finger **502**, second finger **504**, third finger **506**, fourth finger **508** bend at the 2nd joint.
5. The letter "A" is displayed on the digital display **50**.
6. The sound "A" is broadcast through the audio device **60**.
7. pause.

To achieve these high level steps, the controller **70** performs the following steps:

1. Deactivate elbow solenoid **132** thereby returning the plunger **302** into the housing **301**.
2. Deactivate wrist solenoid **134** thereby returning the plunger **302** into the housing **301**.
3. Activate wrist solenoid **134** to the extended position of the plunger **302**.
4. Activate first finger upper solenoid **148**, second finger upper solenoid **152**, third finger upper solenoid **156**, fourth finger upper solenoid **160** (refer to Figure 5) thereby retracting the plungers **302**.
5. Read "A" from the memory **75**.
6. Send "A" to the display controller **54**; the display controller outputs "A" to the display **52**.
7. Read "A" from the memory **75**.
8. Send analog signals for "A" to the audio driver **62**.
9. Processor **76** waits for a short time, (5 seconds in the preferred embodiment).

A similar series of steps is performed for each of the letters of the alphabet. Further examples are provided.

In order to form the letter "J", upon initiation of the sequence by the user activated power switch **192**, the following series of principal steps will be followed:

1. The elbow **105** will return to neutral position.
2. The wrist **103** will return to neutral position.
3. The wrist **103** bends upwards.
4. First finger **502**, second finger **504**, and third finger **506** bend at the 1st and 2nd joints (fourth finger **508** remains vertical).
5. The thumb **500** bends at the thumb joint **352** across first finger **502** and second finger **504**.
6. The wrist **103** bends forwards (downwards) simultaneously as the forearm **102** moves horizontally to the right.
7. The forearm **102** moves horizontally to the left.
8. The letter "J" is displayed on the digital display **50**.
9. The sound "J" is broadcast through the audio device **60**.
10. pause.

To achieve these high level steps, the controller **70** performs the following steps:

1. Deactivate elbow solenoid **132** thereby returning the plunger **302** into the housing **301**.
2. Deactivate wrist solenoid **134** thereby returning the plunger **302** into the housing **301**.
3. Activate wrist solenoid **134** thereby extending the plunger **302**.
4. Activate first finger upper solenoid **148**, second finger upper solenoid **152**, third finger upper solenoid **156** (refer to Figure 5) thereby retracting the plungers **302**.
5. Activate first thumb solenoid **136** (thereby rotating the thumb **500** forward) and activate second thumb solenoid **138** (thereby bending the thumb **500** at the joint **352** over the first finger **502** and the second finger **504**).
6. Activate elbow solenoid **132** thereby moving forearm **102** to the right.

7. Deactivate wrist solenoid **134** thereby moving wrist **103** downwards.
8. Deactivate elbow solenoid **132** thereby moving forearm **102** to the left and back to a neutral position.
9. Read "J" from the memory **75**.
10. Send "J" to the display controller **54**; the display controller outputs "J" to the display **52**.
11. Read "J" from the memory **75**.
12. Send analog signals for "J" to the audio driver **62**.
13. Processor **76** waits for a short time, (2 seconds in the preferred embodiment).

In order to form the letter "Z", upon initiation of the sequence by the user activating switch **192**, the following series of principal steps will be followed:

1. The elbow **105** will return to neutral position.
2. The wrist **103** will return to neutral position.
3. The wrist **103** bends upwards.
4. Second finger **504**, third finger **506**, fourth finger **508** bend at the 1st and 2nd joints (first finger **502** remains vertical).
5. The thumb **500** bends at the thumb joint **352** across first finger **502** and second finger **504**.
6. The forearm **102** moves horizontally to the right.
7. The wrist **103** bends downwards simultaneously as the forearm **102** moves horizontally to the left.
8. The forearm **102** moves horizontally to the right.
9. The letter "Z" is displayed on the digital display **50**.
10. The sound "Z" is broadcast through the audio device **60**.

11. pause.

To achieve these high level steps, the controller **70** performs the following steps:

1. Deactivate elbow solenoid **132** thereby returning the plunger **302** into the housing **301**.
2. Deactivate wrist solenoid **134** thereby returning the plunger **302** into the housing **301**.
3. Activate wrist solenoid **134** to the extended position, thereby extending the wrist **103** upwards.
4. Activate second finger upper solenoid **152**, third finger upper solenoid **156**, fourth finger upper solenoid **160** (refer to Figure 5) thereby retracting the plungers **302** and bending the finger segments **309**.
5. Extend plunger **302** of elbow solenoid **132** fully thereby moving forearm **102** to the right.
6. Retract plunger **302** of wrist solenoid **134** thereby rotating wrist **103** downwards while simultaneously retracting plunger **302** of elbow solenoid **132** thereby moving forearm **102** to the left.
7. Extend plunger **302** of the elbow solenoid **132** thereby moving forearm **102** to the right.
8. Read "Z" from the memory **75**.
9. Send "Z" to the display controller **54**; the display controller outputs "A" to the display **52**.
10. Read "Z" from the memory **75**.
11. Send analog signals for "Z" to the audio driver **62**.
12. Processor **76** waits for a short time, (2 seconds in the preferred embodiment).

A similar series of steps will be followed for each of the letters "A" through "Z", adjusted for each letter.

In this manner the doll **10** concurrently demonstrates the AMA with electromechanical arm subsystem **100**, displays the Latin letter being signed on visual display **50**, and audibly outputs the letter being signed via audio device **60**. This provides a visual representation, an audible representation and the actual hand sign for each letter of the AMA. The concurrent output of the Latin letter, the corresponding vocalization of the letter and the AMA hand formation is

advantageous from a pedagogical standpoint as the user may learn more effectively from any one of the three media, or from a combination thereof, and can more effectively imitate and practise the AMA.

In a variation, finger segments **110** are hollow plastic cylinders and the solenoids **130** are disposed within the finger segments **110** and anchored to the interior surface.

Referring now to Figure **8**, a variation of the control section **72** is shown. The control section **72** is comprised of an external memory system **520** such as a flash memory, a processing system **522** comprised of discrete digital components (flip-flips **524**, logic gates **526**, and other components as required) for processing (commercially available), and an I/O section **528** comprised of discrete analog components **529** and discrete digital components **527**. In this variation, the discrete digital components, **524** and **526**, perform the function of the CPU in the preferred embodiment.

Referring now to Figure **9**, a further variation wherein the control section **72** is comprised of a programmable logic controller ("PLC") **530** is shown. The PLC **530** is connected to an external memory system **532** such as flash memory, and an I/O section **534** comprised of discrete analog components **535** and discrete digital components **533**. The PLC **530** is configured to provide the correct outputs to the various subcomponents.

Referring again to Figure **1**, in the preferred method, the doll **10** is viewed from the front. The arm subsystem **100** is shown slightly in front of the torso **16** and slightly above the waistline **17**. This is the most common signing position. The user activates the switch **192** (not shown) at the back of the doll **10** and thereby activates the doll **10**. The audio output **62** of the doll **10** then states, for instance "Hi, I'm Signing Sandy. Let's sing and sign the Alphabet Song." The traditional "ABC" song is then played through the audio output **62** and the doll's arm subsystem **100** then forms each of the 26 letters of the AMA, following the order of the alphabet, "A" through "Z". A brief pause is made between each finger and hand position. Additionally, the electronic display **52** displays the Latin letter being signed.

It is recommended that the user watch as the doll **10** signs the AMA, and initiates the finger

movements with his or her own hand. Once all letters of the alphabet have been demonstrated, the arm subsystem 100 will return to its neutral position and repeat the signing and singing process. The user terminates the activity of the doll 10 by deactivating the switch 192.

A child is the preferred user of the doll; however the doll could equally be used to educate adults or even animals, particularly primates.

In an alternative embodiment, the user may demand a particular sign language element be demonstrated via a verbal recognition interface in the doll 10, or by a sensor or touch pad. The doll 10 then demonstrates the particular sign language element which may be a letter, word or phrase.

As will be apparent to those skilled in the art in the light of the foregoing disclosure, many alterations and modifications are possible in the practice of this invention without departing from the spirit or scope thereof. Accordingly, the scope of the invention is to be construed in accordance with the substance defined by the following claims.

I claim:

1. An apparatus for a sign language element demonstrating doll comprising an electromechanical arm and hand, said hand being positionally adjustable in a manner operative to demonstrate said sign language elements.
2. An apparatus according to claim 1 which further comprises an audio system for vocalizing the verbal equivalent of said sign language elements.
3. An apparatus according to claim 1 which further comprises a display system for displaying the Latin alphabet equivalent of said sign language elements.
4. An apparatus according to claim 1 which further comprises a speaker and a display screen which simultaneously broadcast and display the equivalent of said sign language elements which are being demonstrated by said electromechanical hand of said doll.
5. An apparatus according to claim 4 wherein said sign language elements are the American Manual Alphabet ("AMA") signs corresponding to the characters of the Latin alphabet.
6. An apparatus according to claim 5 wherein said electromechanical hand displays said AMA signs in sequence, while simultaneously broadcasting the equivalent name of said sign in a spoken language and displaying the Latin alphabet equivalent of said sign on said display screen.

7. An apparatus according to claim 1 wherein said sign language element is a sign representing a single letter of an alphabet.
8. An apparatus according to claim 1 wherein said sign language element is a sign representing a word in a spoken language.
9. An apparatus according to claim 1 wherein said sign language element is a sign representing a phrase in a spoken language.
10. A doll for demonstrating sign language, comprising an electromechanical arm attached to a right shoulder having a forearm segment, a hand segment and finger segments.
11. The doll of claim 10 further comprising an electronic controller including circuit board, a processor, a memory and interface headers.
12. The doll of claim 11 further comprising an electronic display.
13. The doll of claim 11 further comprising an audio means disposed in said doll.
14. The doll of claim 11 further comprising an electronic display screen, an audio output and a power supply disposed in said doll.
15. The doll according to claim 11 wherein said hand is comprised of a plurality of joints, springs and solenoids wherein when said solenoids are activated, said finger segments are flexed about said joint and wherein when said solenoids are deactivated, said springs return said finger segments to a neutral extended position.

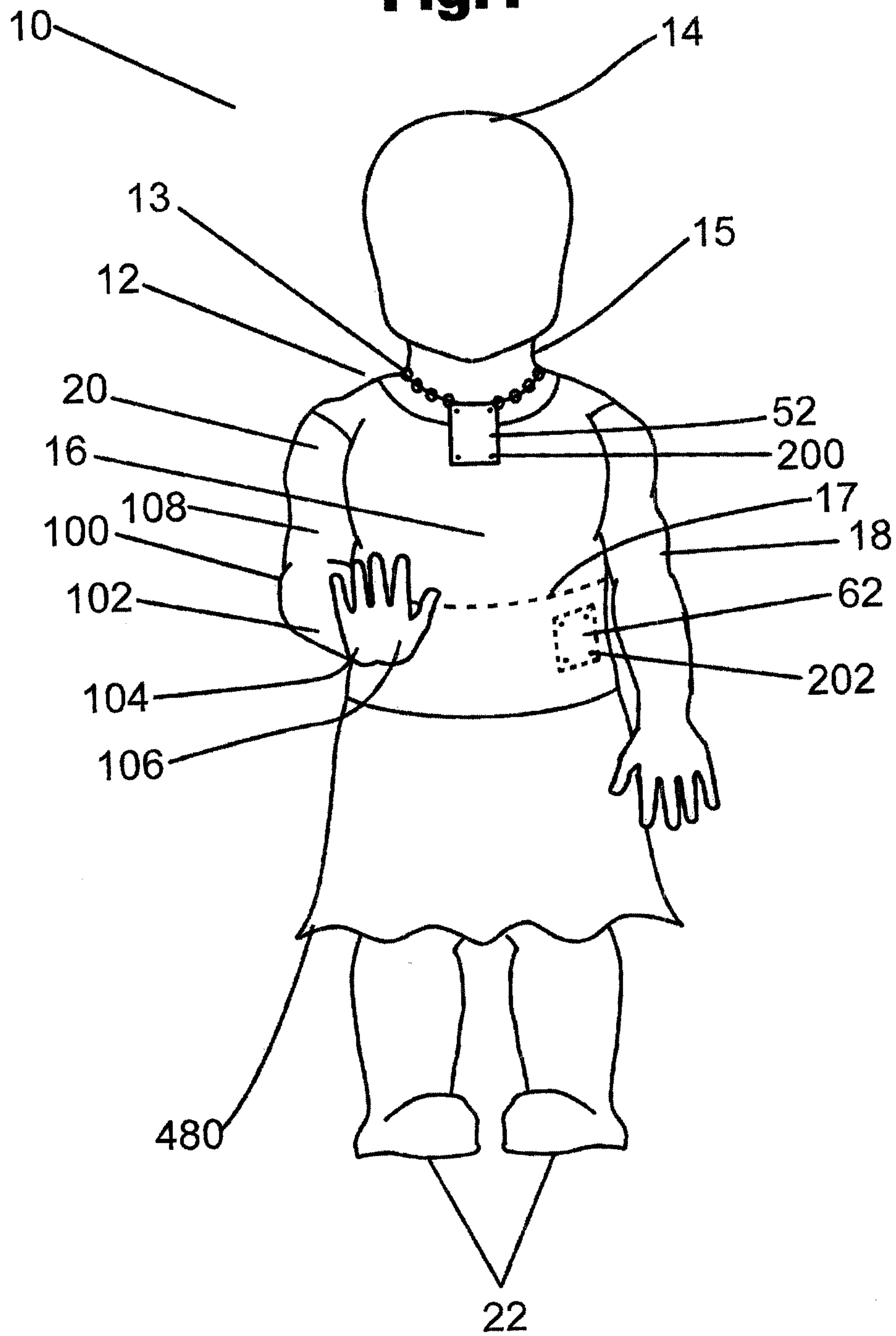
16. The doll according to claim 13 further comprising a wrist joint and an elbow joint.
17. The doll according to claim 16 wherein said wrist joint and said elbow joint each include a multi-position solenoid, operable in at least three positions.
18. The doll according to claim 12 wherein said electronic display is an alphanumeric light emitting diode display.
19. The doll according to claim 13 wherein said audio means is a piezo-electric speaker.
20. The doll according to claim 11 wherein said processor is a microcontroller.
21. The doll according to claim 14 wherein said power supply is a rechargeable battery.
22. The doll according to claim 21 wherein said power supply is a 6 volt battery.
23. An electromechanical hand having a hand segment and finger segments for demonstrating sign language comprised of:
 - a. four independently controllable fingers having at least one joint each and moveably attached to said hand segment by one said joint;
 - b. an independently controllable thumb having at least one joint and moveably attached to said hand segment by one said joint; and

- c. a controller having a processor and a memory and being attached to said hand.
24. The hand of claim 23 additionally comprising an electromechanical arm having a forearm segment, said hand being moveably attached at a distal end of said forearm segment, such that said forearm segment is moveable to demonstrate sign language.
25. The doll according to claim 24 wherein an electronic display is attached to said electromechanical arm.
26. The apparatus according to claim 25 wherein said electronic display is an alphanumeric light emitting diode.
27. The apparatus according to claim 25 wherein said electronic display means is a backlit liquid crystal display.
28. The apparatus according to claim 24 wherein an audio output is attached to said electromechanical arm.
29. The doll according to claim 28 wherein said audio output is a piezo-electric speaker.
30. The doll according to claim 23 wherein at least one spring and at least one electric solenoid is disposed at each said joint wherein when said solenoids are activated, said segments are flexed and wherein when said solenoids are deactivated, said springs extend said segments to a neutral anatomical position.

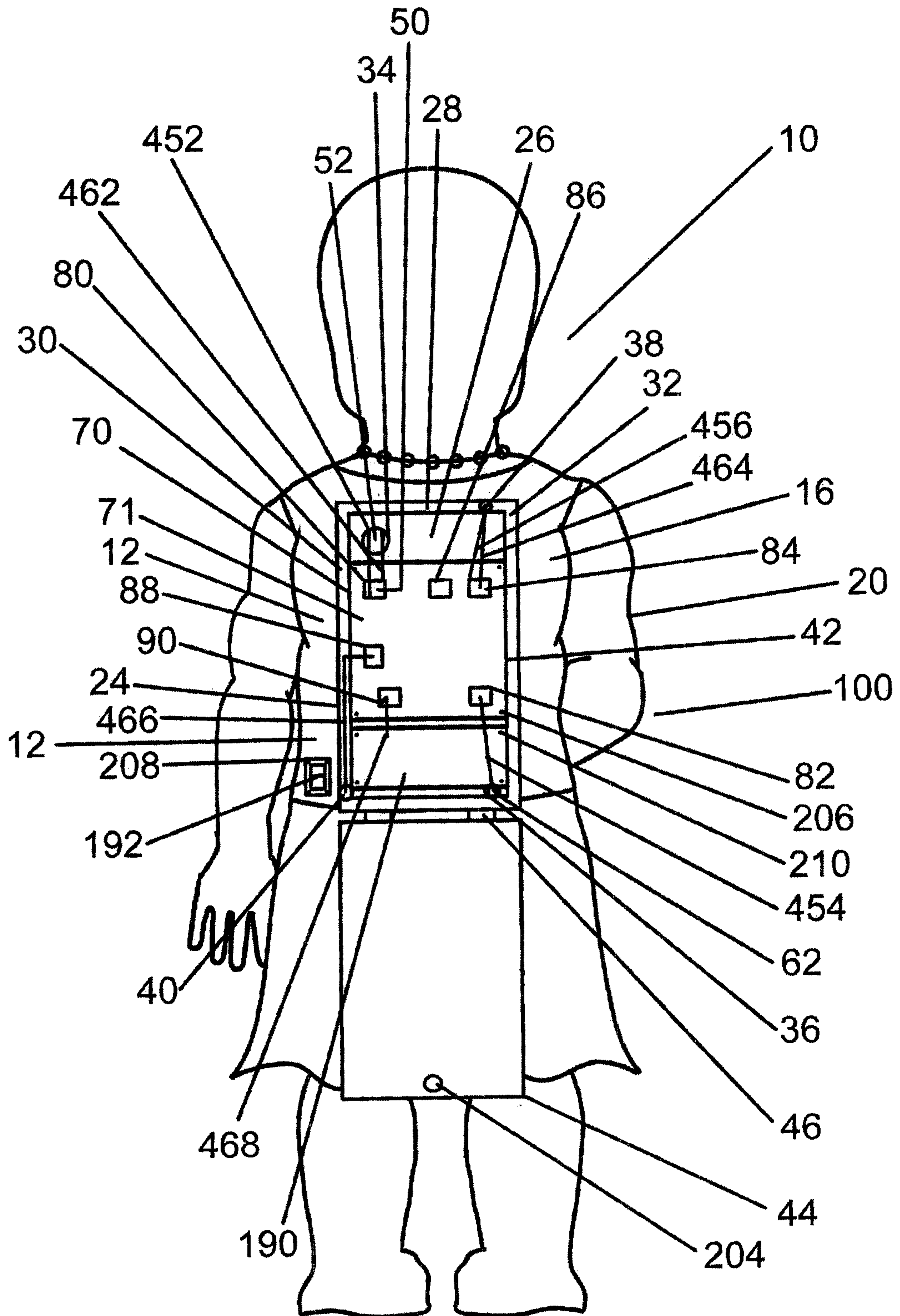
31. The doll according to claim 23 wherein said memory is an interchangeable memory card.
32. A method of sequentially demonstrating the hand and finger positions of the American Manual Alphabet using an electromechanical arm while concurrently displaying the letter being signed on a digital display and concurrently providing an audial representation of the letter being signed through an audio device.
33. A method of demonstrating sign language with an electromechanical doll providing the steps of:
 - a. turning a switch on the doll to an on position; and
 - b. controlling an electromechanical arm, hand, and fingers to form a physical representation of a sign language component.
34. The method of claim 33 further comprising the step of:
 - c. simultaneously controlling an audio output device to emit a sound corresponding to said sign language component.
35. The method of claim 34 further comprising the step of:
 - d. simultaneously controlling a display device to show the Latin character corresponding to said sign language component.
36. A method of demonstrating sign language with a doll having an electronic control device, an audio output device, a visual display device and a plurality of joints manipulatable by a flexional device comprising the steps of:

- a. controlling said manipulatable joints in at least one finger of said doll to form a sign language; and
 - b. simultaneously emitting the sound corresponding to said sign from said audio output device; and
 - c. simultaneously displaying the Latin letter equivalent of said sign on said visual display device.
37. The method of claim 36 wherein step a. further comprises controlling manipulatable joints in an elbow and wrist.
38. The method of claim 36 wherein said flexional devices are electrical solenoids, and further comprising the step of controlling said solenoids to flex said fingers, hand and wrist to form said sign character.
39. The method of claim 38 further comprising the steps of:
- d. deactivating said solenoids;
 - e. returning said fingers, hand and wrist to a neutral position by means of at least one spring under tension.

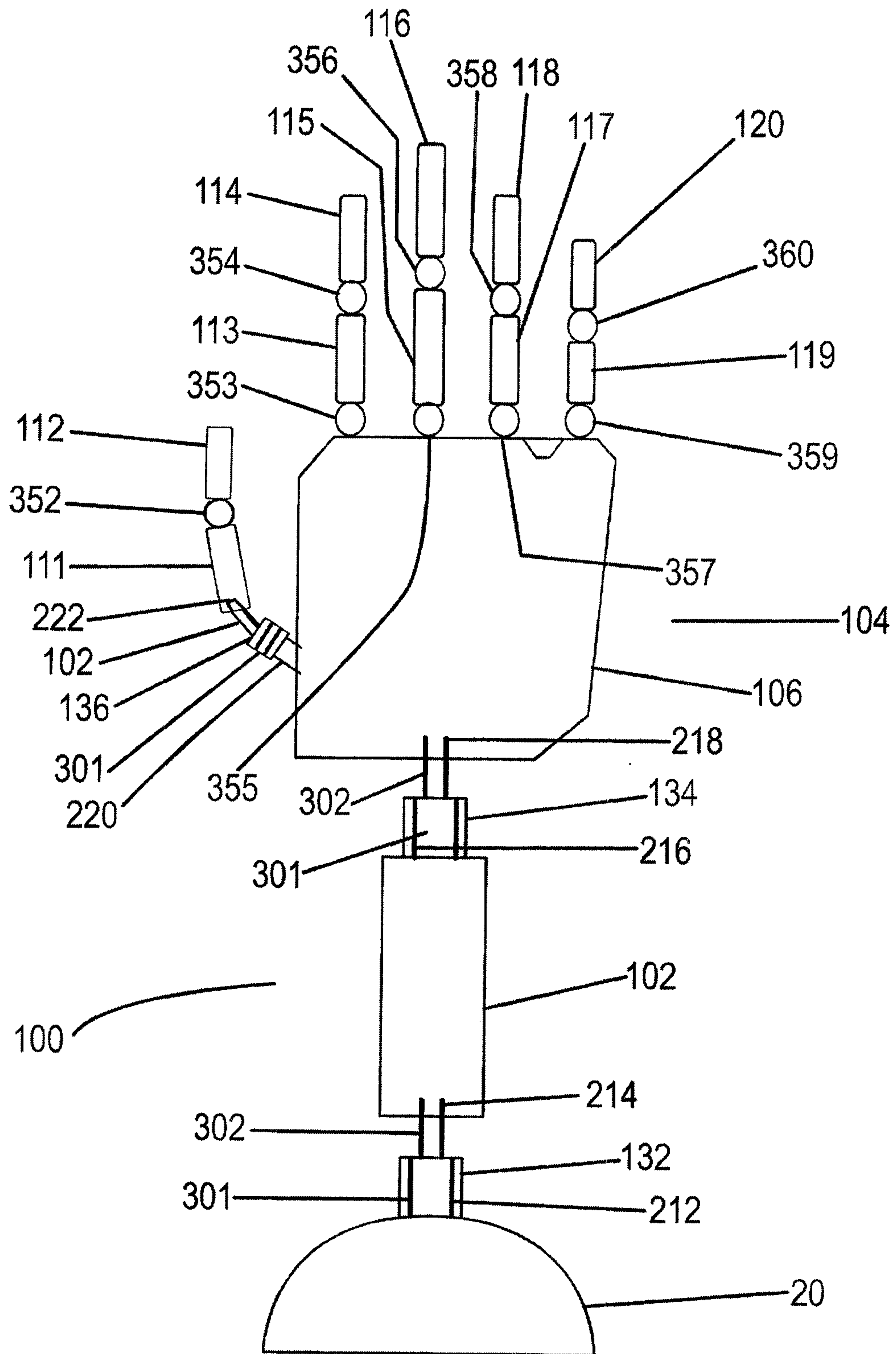
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Fig.1

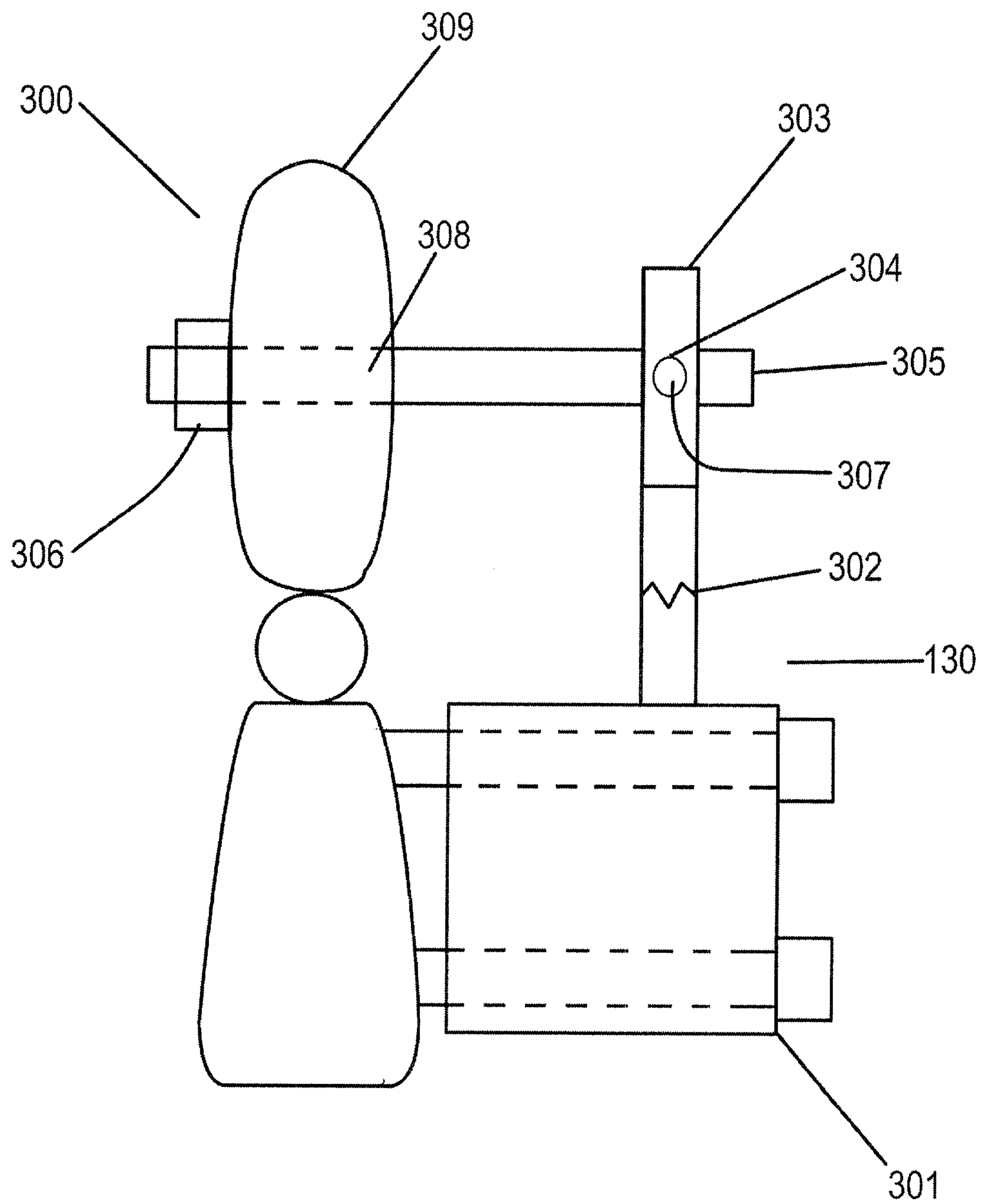
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Fig.2



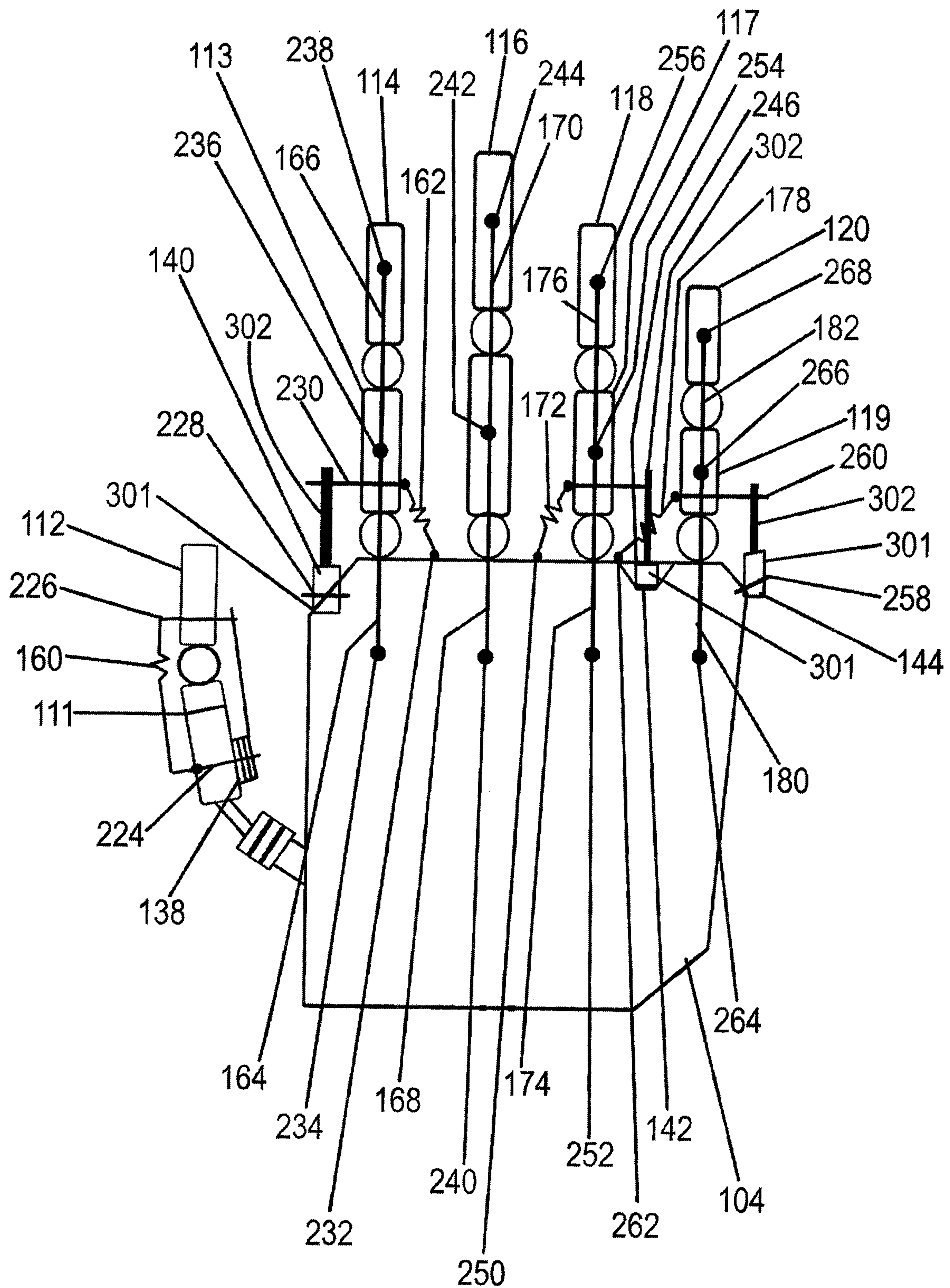
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Fig.3



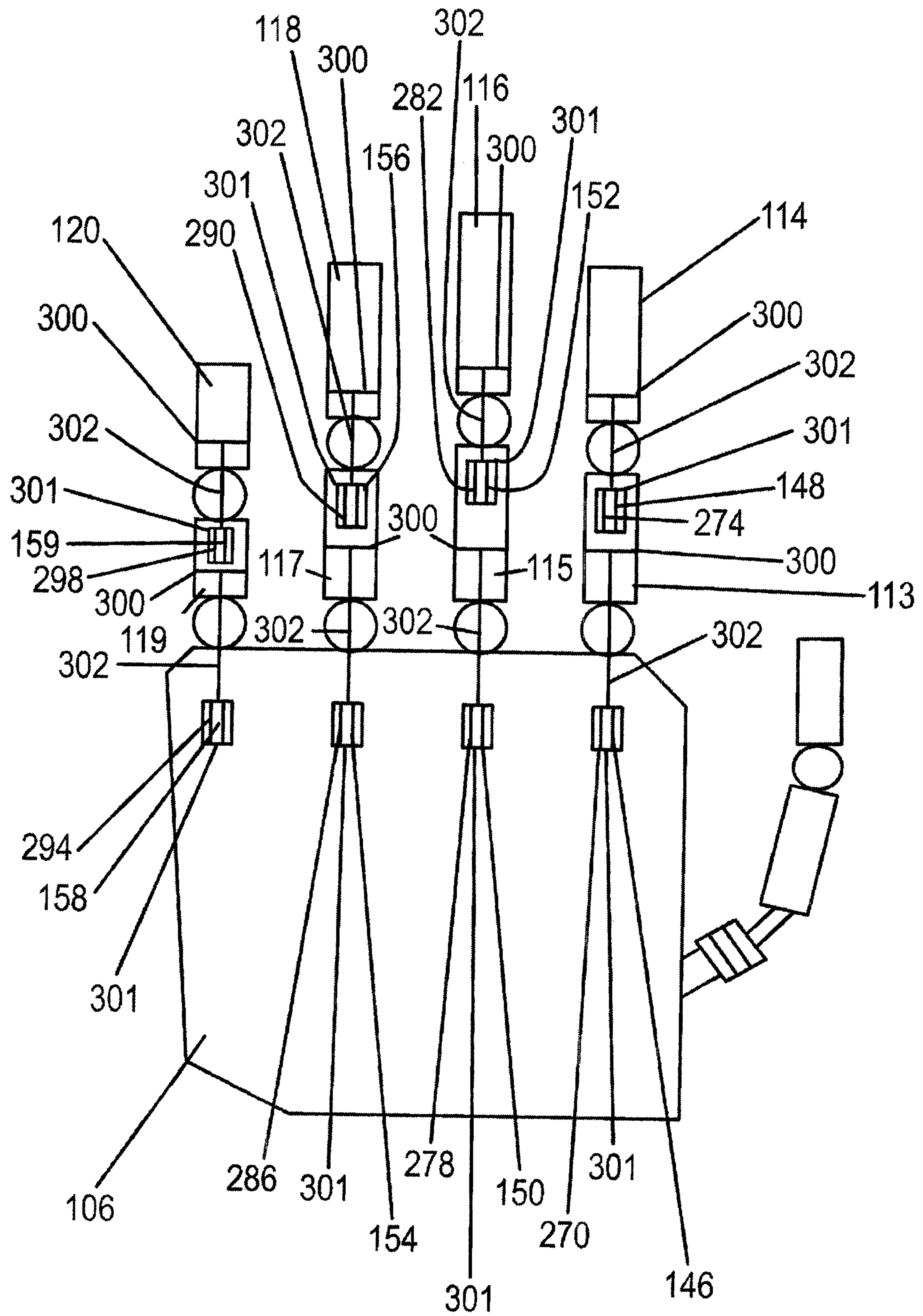
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Fig.4



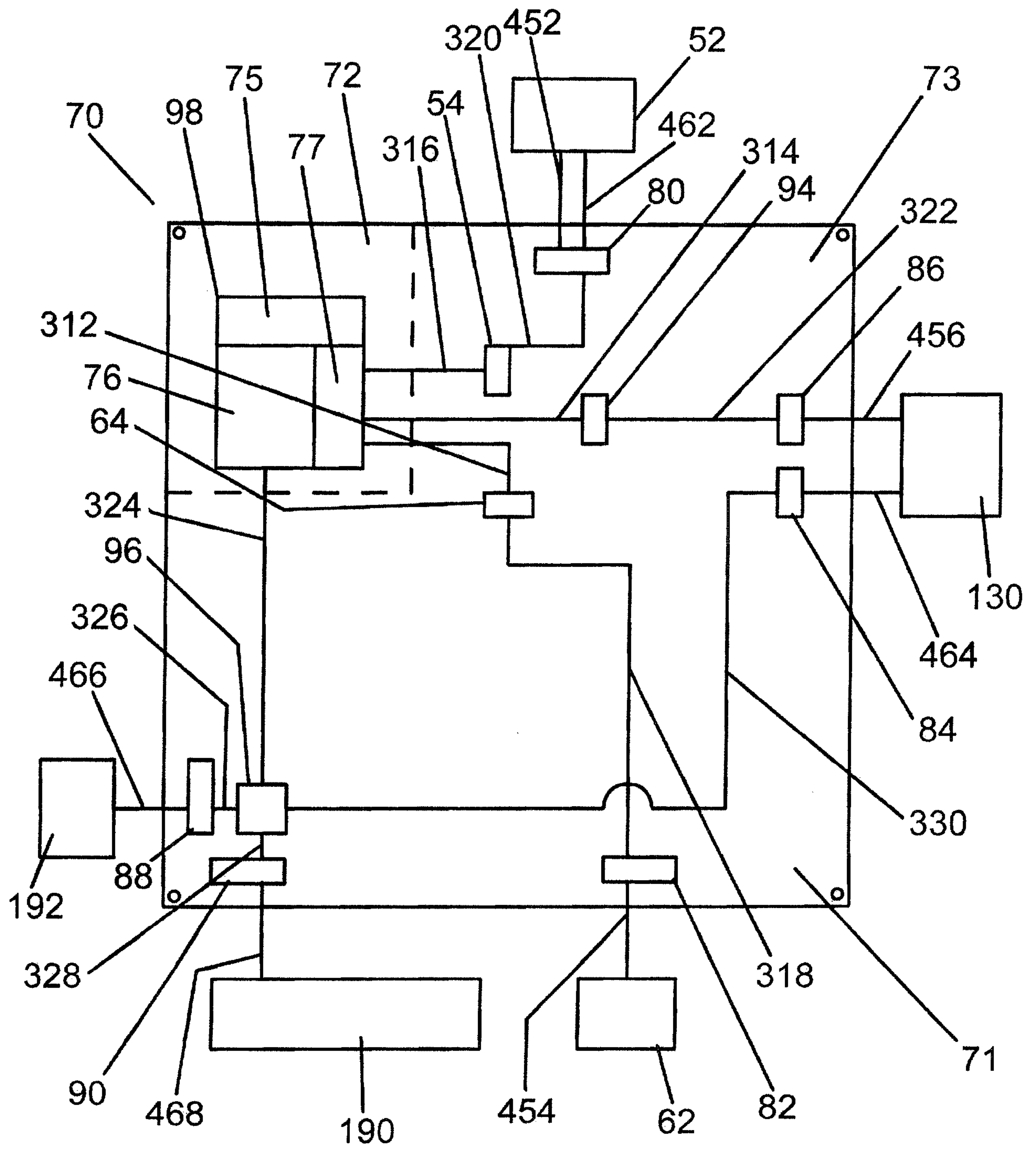
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Fig.5



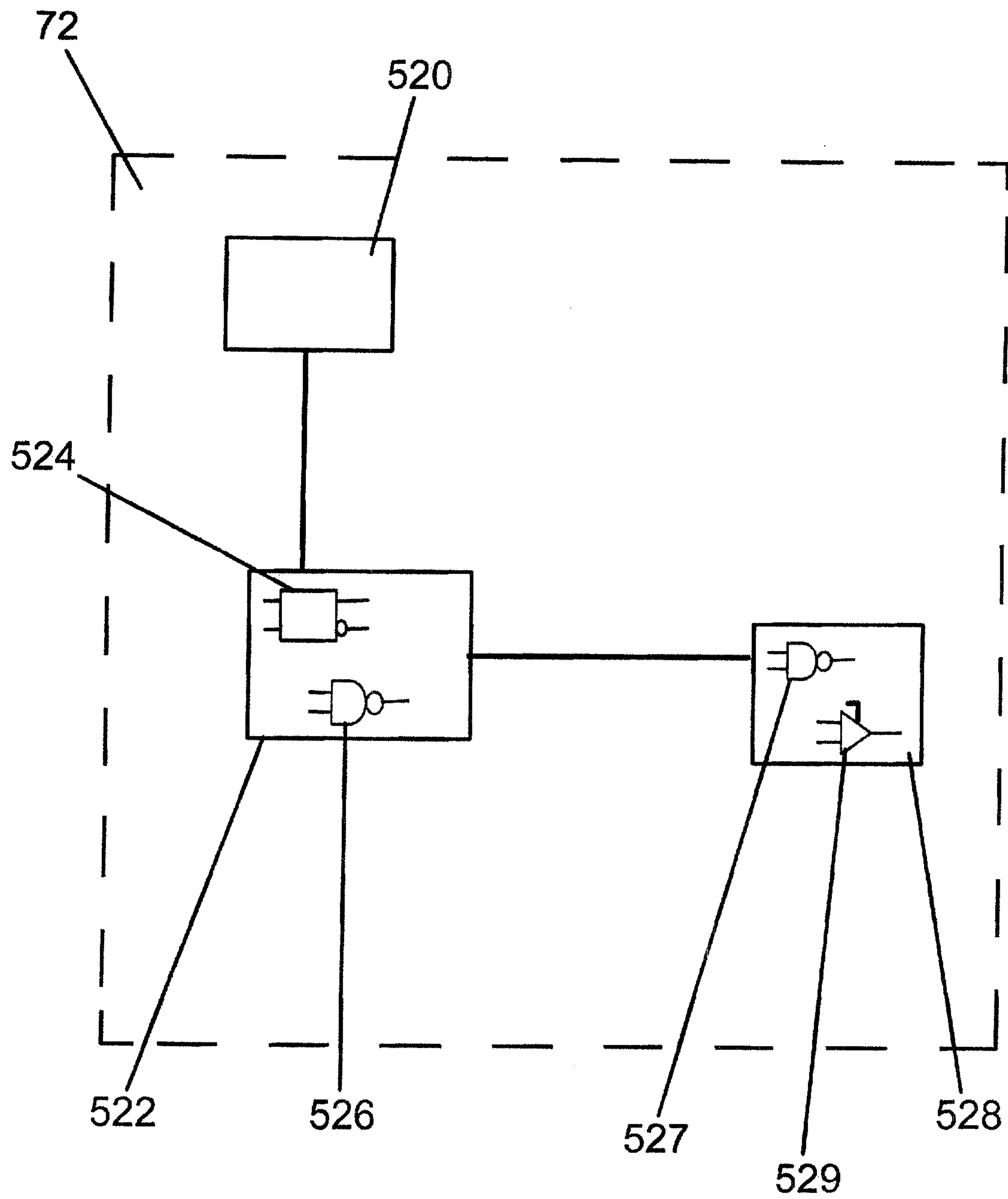
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Fig.6

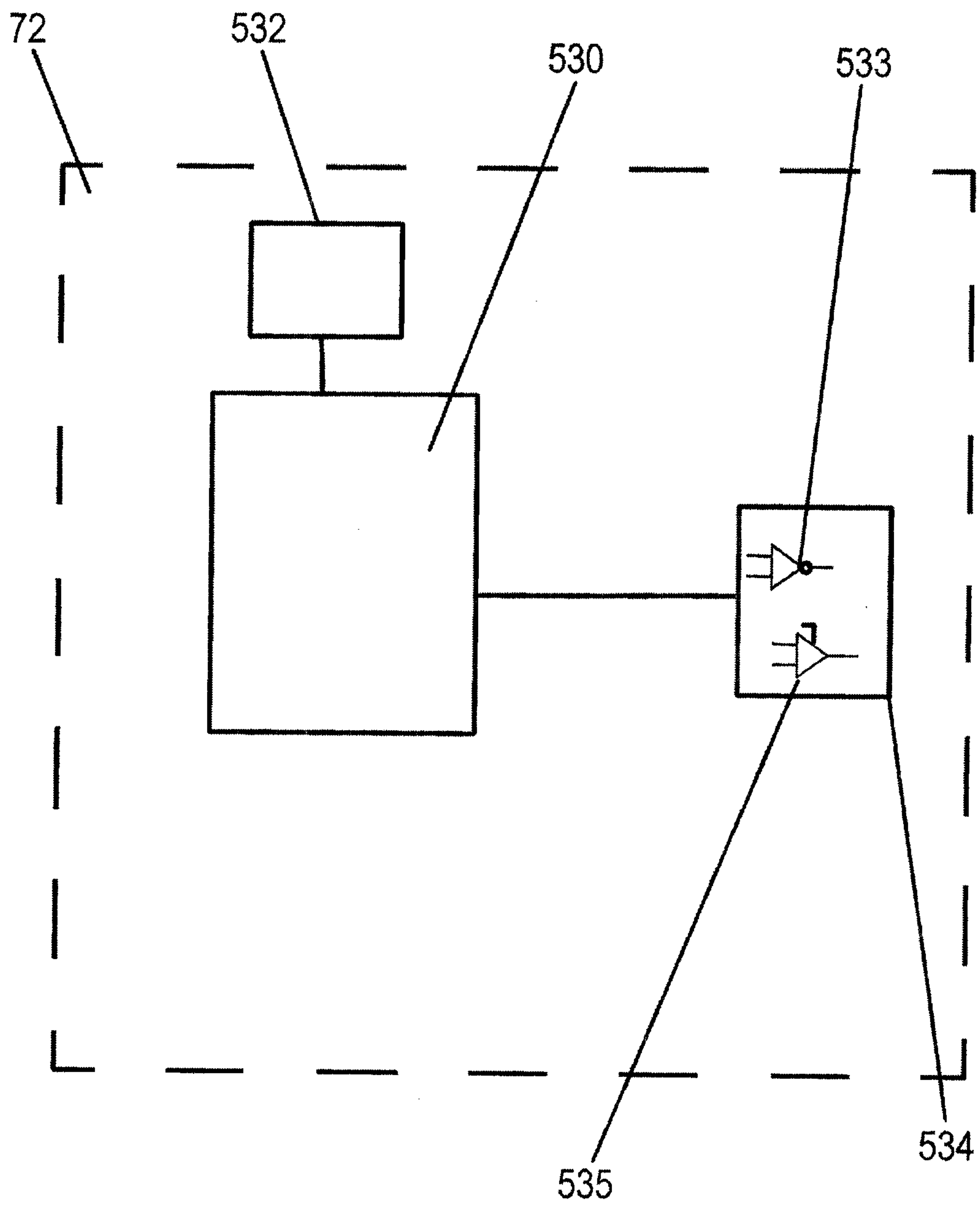
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Fig.7



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Fig.8



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Fig.9



10 Signing Apparatus	110 finger segments	200 audio fasteners	310 traces
12 body	111 lower thumb segment	202 display fasteners	312 traces
14 head	112 upper thumb segment	204 cover fastener	314 traces
16 torso	113 first finger lower segment	206 controller fasteners	316 traces
17 waistline	114 first finger upper segment	208 switch fasteners	318 traces
18 left arm	115 second finger lower segment	210 power supply fasteners	320 traces
20 hollow right upper arm	116 second finger upper segment	212 elbow solenoid fasteners	322 traces
22 legs	117 third finger lower segment	214 forearm fasteners	324 traces
24 cavity	118 third finger upper segment	216 wrist solenoid fasteners	326 traces
26 back wall	119 fourth finger lower segment	218 wrist fasteners	328 traces
28 top wall	120 fourth finger upper segment	220 thumb solenoid fasteners	330 traces
30 left wall		222 thumb segment fasteners	
32 right wall	130 solenoids	224 second thumb solenoid fastener	350 joint (general)
34 display opening	132 elbow solenoid	226 second thumb solenoid proximal fastener	351 joint (not assigned)
36 audio opening	134 wrist solenoid	228 first finger solenoid fastener	352 thumb joint
38 arm opening	136 first thumb solenoid	230 first finger solenoid proximal fastener	353 first finger first joint
40 power switch opening	138 second thumb solenoid	232 spring fastener	354 first finger second joint
42 cavity opening	140 first finger solenoid	234 spring fastener	355 second finger first joint
44 cover	142 third finger solenoid	236 spring fastener	356 second finger second joint
46 cover hinges	144 fourth finger solenoid	238 spring fastener	357 third finger first joint
	146 first finger lower solenoid	240 spring fastener	358 third finger second joint
50 display subsystem	148 first finger upper solenoid	242 spring fastener	359 fourth finger first joint
52 electronic letter display	150 second finger lower solenoid	244 spring fastener	360 fourth finger second joint
54 display controller	152 second finger upper solenoid	246 third finger solenoid fastener	
	154 third finger lower solenoid	248 third finger solenoid proximal fastener	450 control wires
60 audio subsystem	156 third finger upper solenoid	250 spring fastener	452 display control wires
62 audio output	158 fourth finger lower solenoid	252 spring fastener	454 audio output wires
64 audio driver	159 fourth finger upper solenoid	254 spring fastener	456 arm control wires
		256 spring fastener	
70 controller	160 springs	258 fourth finger solenoid fastener	460 power wires
71 circuit board	161 thumb spring	260 fourth finger solenoid proximal fastener	462 display power wires
72 control section	162 first finger side spring	262 spring fastener	464 arm power wires
75 memory	164 first finger lower spring	264 spring fastener	466 power switch wires
76 processor	166 first finger upper spring	266 spring fastener	468 controller power wires
77 input/output	168 second finger lower spring	268 spring fastener	
78 I/O section	170 second finger upper spring	270 first finger lower solenoid fasteners	480 clothes
	172 third finger side spring		
80 display header	174 third finger lower spring	274 first finger upper solenoid fasteners	500 thumb
82 audio header	176 third finger upper spring		502 first finger
84 arm power header	178 fourth finger side spring	278 second finger lower solenoid fasteners	504 second finger
86 arm control header	180 fourth finger lower spring		506 third finger
88 power switch header	182 fourth finger upper spring	282 second finger upper solenoid fasteners	508 fourth finger
90 power supply header			
	170 skin	286 third finger lower solenoid fasteners	520 external memory system
98 microcontroller			522 processing system
	190 power supply	290 third finger upper solenoid fasteners	524 flip-flops
100 arm subsystem	192 power switch		526 logic gates
102 forearm		294 fourth finger lower solenoid fasteners	527 digital components
103 wrist			528 i/o section
104 hand		298 fourth finger lower solenoid fasteners	529 analog components
105 elbow			
106 palm		300 plunger assembly	530 PLC
107 joint		301 housing	532 external memory system
108 arm covering		302 plunger	533 digital components
		303 fork	534 i/o section
		304 hole	535 analog components
		305 rod	
		306 nut	
		307 pin	
		308 hole	
		309 finger segment	

