UTAH ARM 2: NEW TECHNOLOGIES APPLIED TO ELECTRIC ELBOW AND HAND SYSTEMS

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The Utah Artificial Arm, since 1981, introduced a high level of electronic sophistication, using hybrid electronic circuit technology, with a modular design, which allowed for miniaturization of many automatic functions within the limited space of the electric elbow. The original Utah Artificial Arm has been successfully used throughout North America and Europe, but suffered the problems of a product which pushed the limits of available manufacturing technology, i.e., difficult-to-find components, non-standard connectors, and electronic circuits (called "hybrids") demanding very high precision, and a high level of hand assembly.

In 1985 Motion Control embarked upon a reengineering project to bring the technology used in the Utah Arm to the state-of -the-art, to achieve the goals of :

#1, High dependable electronics, which also are more easily manufactured.

#2, User-friendly design, especially in the connectors, battery and charger system, and the labeling.

As shown below, in Figure 1, elements throughout the Utah Arm 2 are reengineered.

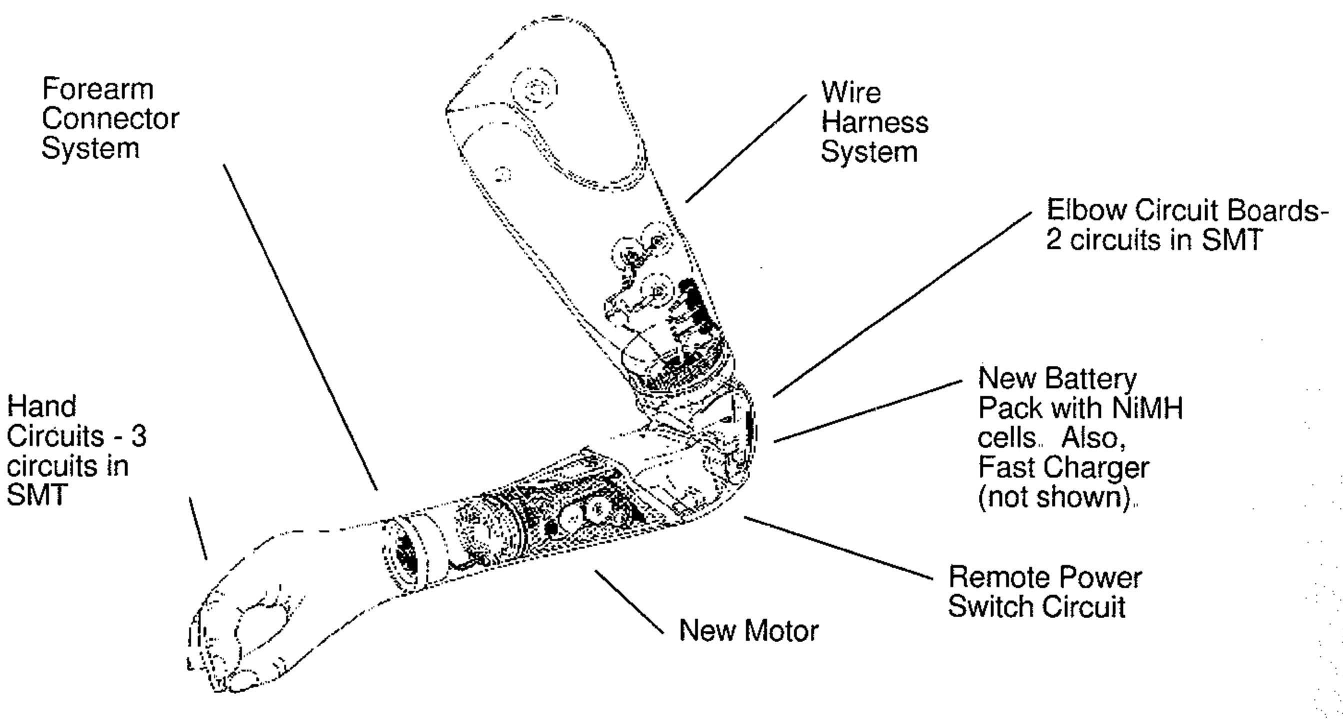

Figure 1
Elements reengineered in the Utah Arm 2.

Specifically, the areas of change include:

· New Circuit Board Technology

Nine circuits in the Arm are reengineered in Surface Mount Technology (SMT), a modern, very widely used method for circuit board manufacturing. Its features are a very high level of dependability, ease of manufacturability, and availability of the basic electronic components.

· New Conector Systems

State of the Art components available from modern connector manufacturers have been used wherever possible. Micro-D-subminiature (MDM) connectors are now widely used in the computer industry, especially where small size and high dependability are important, which are of high priority in prosthetics as well. For instance, one of the new MDM connectors used in Utah Arm 2 has a connector density of 21 pins in 0.16 sq. in of surface area, four times the density of connectors, and with the dependability of a MIL-STD connector (approved for military applications).

Connections to the Humeral Section of the Utah Arm 2 are now utilizing the 21 pin MDM connector, which connects to either a 5-wire, 3-wire, or 1-wire harness, depending upon the prosthetist's need for control options, and the space available in the socket.

Internal connections within the Utah Arm have always been made via a Flexible Circuit, which makes approximately 100 connections between Elbow Circuits, Hand Circuit, and Elbow Drive. Although the Flexible Circuit system is still substantially the same, with new connectors and routing design, 40 solder connections have now been replaced with pre-installed connectors, which are more dependable and easier to manufacture.

Connections in the Forearm Section, linking the Hand Control Circuit to the Terminal Device, Wrist, and Servo Sensors (if installed), are now made via a 9-pin MDM connector, which self-aligns in the Forearm Cover, eliminating several loose, dangling wires, formerly necessary in the original Utah Arm. A unique Ring Mechanism is installed in the Forearm Cover, which precisely locates the distal connector so it self-aligns whenever the Cover is installed. Only one connector is now necessary, for all necessary forearm connectors.

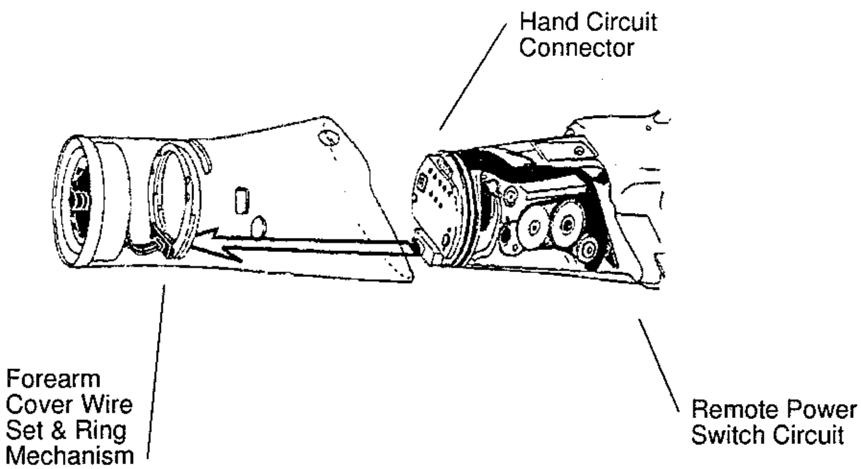

Figure 2
The Forearm Section connection system, featuring a self-aligning 9-pin MDM connector, linking the Utah Arm 2 with all Hand, Wrist, and Servo sensors.

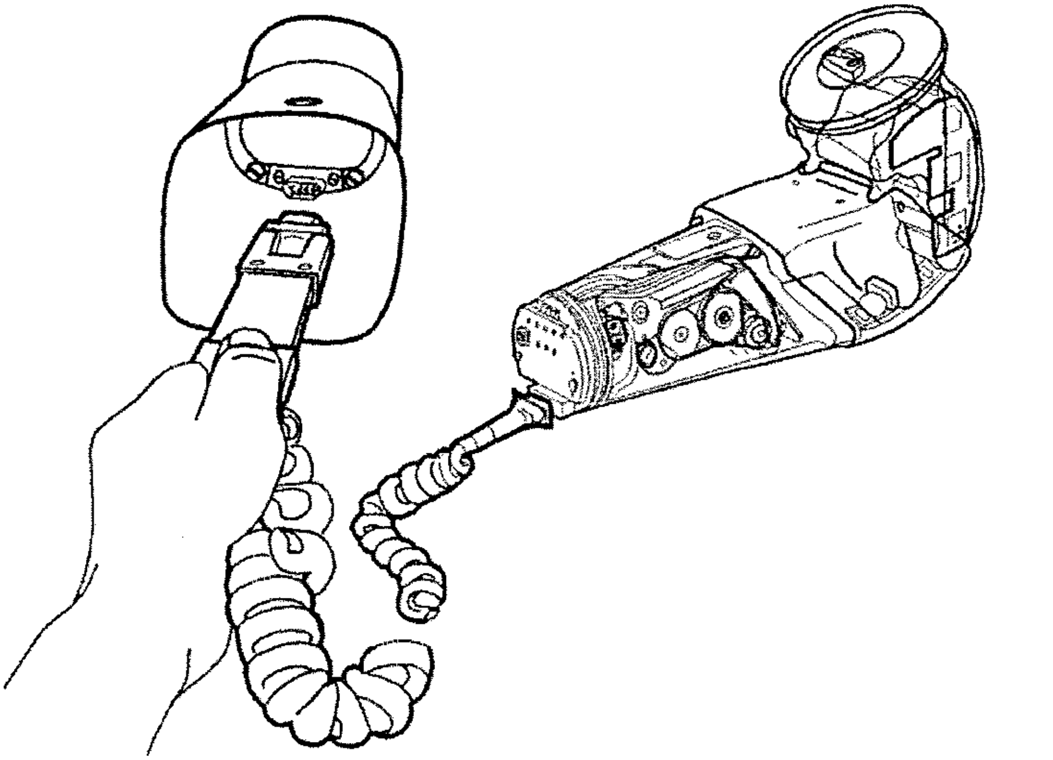

Figure 3
Installation of the Access Cable, which allows operation of the Hand with the Forearm Cover detached.

Remote Power Switch capability is introduced in the Utah Arm 2 also. As shown in Figure 2, a built-in circuit is installed in the Forearm, which can be enabled with a simple DIP switch. Once enabled, a switch or even a simple electrode, can be connected to the Humeral Section, which will cycle the power ON or OFF, when touched for three seconds.

A new high-temperature motor will also be implemented, in the second phase of the Utah Arm 2 introduction, later in 1997. Laboratory testing, and field trials, have shown the new motor to last many times longer than the original motor, under the same conditions.

A new nickel-metal-hydride (NiMH) cell will be implemented in the Utah Arm 2 battery pack, also in the second phase. Along with the elimination of the "memory effect" of earlier NiCad cells, the NiMH technology will increase battery capacity by 50% (increasing from 600 ma.hr to 900 ma.hr) allowing Utah Arm wearers to use one battery for as long as several days of regular use.

A new microprocessor-controlled battery charger will allow fast-charge of the new NiMH battery pack in approximately two hours. The new charger will be useable with an automobile charging adaptor, i.e., a "cigarette lighter" plug-in. All previously-manufactured Utah Arm battery packs will be chargeable with the new charger, as well.

The labeling of the new circuits also has implemented "User Friendly" instructions, to simplify and demystify the fine-tuning process of the Utah Arm. As shown in Figure 4, below, initial settings are written on the label, and the potentiometers are visibly arranged in two rows. Also note the DIP switch for selecting the "A" or "B" option for Wrist Control as well as for selection of the "R" or "T" option for elbow unlock. Two terminals are also provided for "Jump Starting", i.e., unlocking the elbow in the case when the battery is dead and cannot be removed. A 9 -volt size battery, conveniently available for consumers, is simply touched to these terminals, without any other connector being required.

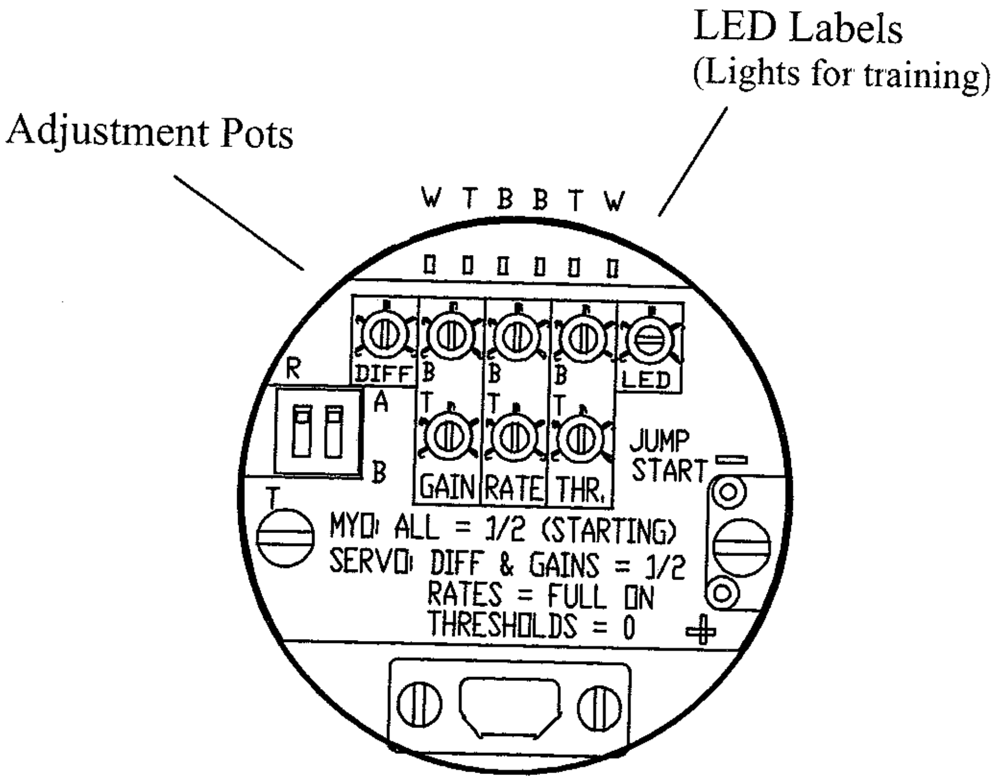

Figure 4

Hand Circuit - The labeled circles represent adjust potentiometers for fine-tuning the Utah Arm 2 to an individual patient.

Conclusions:

The Utah Arm has always represented a high degree of technical sophistication, relative to other prosthetic products. Now, by applying technologies which have evolved in other industries, such as computers, etc., technical sophistication is companioned with dependability, and ease of use. We hope and expect that other prosthetic devices will also benefit from this example.