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DEVELOPMENT AND EVALUATION OF ADAPTIVE COMMUNICATION DEVICES FOR THE SEVERELY HANDICAPPED CHILD. FINAL REPORT.

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A SAMPLE OF THIRTEEN, SEVERELY INVOLVED, CEREBRAL PALSIED CLIENTS (12 CHILDREN, ONE ADULT) PARTICIPATED IN THIS STUDY. DEGREE OF NEUROMOTOR DISABILITY WAS DETERMINED BY A SCALE BASED ON ACTIVITIES OF DAILY LIVING. A PSYCHOLOGICAL EVALUATION WAS MADE OF ALL SUBJECTS IN THE STUDY. SUBJECTS WERE EVALUATED IN THEIR USE OF ELECTRONIC SWITCHES CONNECTED TO VARIOUS OUTPUT DEVICES RANGING IN COMPLEXITY FROM A SIMPLE SERIES OF LIGHTS TO A SPECIALLY MODIFIED ELECTRIC TYPEWRITER. SUCCESSFUL USE OF THESE DEVICES HAS IMPLICATIONS FOR RECREATION, EDUCATION, COMMUNICATION, AND THERAPY. SWITCH CONTROLS THAT WERE DEVELOPED INCLUDED A JOYSTICK, A SET OF MERCURY SWITCHES MOUNTED ON A HAT, A MINIATURE JOYSTICK HELD BETWEEN THE TEETH AND OPERATED BY THE TONGUE, A PNEUMATIC CONTROL HEMISPHERICAL JOYSTICK FOR A PALMAR SURFACE CONTROL, SEVERAL MAGNETICALLY ACTIVATED DEVICES, AND A HORN BUTTON SWITCH. OUTPUT DEVICES INCLUDED A DISPLAY BOARD WITH FOUR LIGHTBULBS, ETCH-A-SKETCH DRAWING TOY, STRIP PROJECTOR AND ELECTRIC TYPEWRITER CONTROL DEVICE. SUBJECTS WERE EVALUATED ON TIME LAPSE BETWEEN REQUEST FOR RESPONSE AND RESPONSE AND ADEQUACY OF RESPONSE. THE APPENDIXES INCLUDE ACTIVITIES OF DAILY LIVING EVALUATION FORM, INFORMATION ON SUBJECTS TESTED, AND PHOTOGRAPHS OF THE INPUT AND OUTPUT DEVICES TESTED. (GB)

FINAL REPORT

DEVELOPMENT AND EVALUATION OF ADAPTIVE COMMUNICATION DEVICES FOR THE SEVERELY HANDICAPPED CHILD.

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SUMMARY

This report summarizes a year's work - January to December, 1965. A project was designed in which selected patients with cerebral palsy were evaluated as to their ability to manipulate and control reliably a series of switches connected to various output devices. The evaluation involved rather exact observation of the child's residual motor abilities. The child was then matched with the most appropriate control.

A measure of success in this attempt was the patient's ability to control reliably one or more of a series of outputs, varying in complexity from a simple series of light bulbs, to a specially modified and adapted electric typewriter.

Results of this experience indicated the value of exploring to the maximum all available motor function in the child with cerebral palsy, in the expectation that we can identify at least one sufficiently reliable motor function that may then be used to control a variety of possible specially engineered outputs. It is conceivable that with further development and more sophistication of device operation and more accurate analysis of control function, some prospect of improved communication exists for the more severely handicapped, cerebral palsied child.

RATIONALE FOR STUDY

The most severely physically handicapped children with cerebral palsy sorely tax the limits of our present rehabilitation treatment resources. In the larger therapeutic centers, we may expose the child to as many as six professional disciplines daily, all directed at teaching maximum function. When such intensive efforts fail to improve the child's function, after a reasonable trial, there has heretofore been little left to offer such a patient or his family, other than psychological supportive help.

The provision of electronic devices to provide possible function to such a handicapped child was the basic purpose of the study. Help of this type to the totally disabled patient might be expected to provide him:

(1) Some control of his environment;
(2) Some means of communication with the outside world;
(3) It might give him some control over machinery that could lead to a means of livelihood; and
(4) It might afford sufficient "success" at a task as to allow that task to take on meaning and hence to motivate continued practice on the child's "own time" and pace.

During the course of the year's study, the following specific applications were apparent:

A. Recreation

The severely involved quadriplegic child has little opportunity to experience play or recreational activities; particularly to manipulate or control toys. Design of a system of controls within his competence that in turn could be linked with toys or other pleasant output would have immediate application.

B. Education

Special Education will continue to be a major consideration in the total management of the child with cerebral palsy. Well-designed special classes, notwithstanding the child with a severe speech intelligibility problem with a little useful function in his hands for writing or typing, pose a very individual problem for the teacher. The provision of controls and devices that would enable the child to participate in and contribute to classroom interplay was estimated to have considerable implication.

C. Communication

The severely involved child who is anarthric requires a method of communication if he is to experience anything approaching normal developmental experience. Sufficient hand function may be present to allow writing or typing. In the majority of cases, however, severe speech involvement goes hand-in-hand with severe upper extremity disability. Such a child has then a multiple problem in communication. He can neither communicate verbally, nor by graphic methods. The provision of a prototype communication based on an electric typewriter was, therefore, one of the prime objectives in this project.

D. Therapy

Attempts to devise therapeutic avenues to improve muscle efficiency in strength and coordination in patients of this type are frustrating. The child has little function to start with, and motivation is difficult to achieve. Time-honored conventional therapeutic exercises have disappointing results.

The use of stimulating, entertaining output displays controlled by the child through a simple mechanism matched to his limited neuromotor function offered possibilities of arranging the geometry of the control function in such a way that graded improvement in extremity range, increased speed and reliability of control might be made possible by such manipulation of devices within the O.T. environment.

PROJECT DESIGN AND DEVELOPMENT

The project was developed in the following phases:

I. Patient selection and evaluation.
II. Switch and control design.
III. Patient/Device interface: matching switch and patient.
IV. Output characteristics.

I. Patient Selection and Evaluation

During the year covered by the study, a total of 104 children were admitted to the Children's Unit of the Rehabilitation Center. Of this total, 77 suffered from cerebral palsy. It was from this group that the project sample was drawn. The types, degree of involvement, and age distribution of the project subjects are summarized in Table I. One patient admitted to the Adult Unit, age 23, was used in the study. She was wheelchair dependent, with severe dysarthria, and severe upper extremity involvement.

Degree of Neuromotor Disability

Terminology to indicate degree of disability in the patient with cerebral palsy is subject to misinterpretation. Associated disabilities of mental retardation or convulsive disorders may be profound in a patient who from the neuromotor standpoint is but mildly handicapped. Degree of involvement in this study refers to the neuromotor aspects of the disability. The most meaningful measure or degree of disability probably is the Activities of Daily Living summary. All children in the study were evaluated on the A.D.L. scale attached (Appendix A). As would be expected, there is a high degree of correlation between self-care functions involving skilled hand use, advanced dressing skills, and hand functions such as writing. Children evaluated on the device controls were, for the most part, dependent in self-care in the areas of dressing. Some were independent or partially independent in the more basic skill of feeding. All patients dependent in eating and dressing would be classified as "severe involvement". Under this classification, children in the study were distributed as per Table I.

Psychological

Psychological evaluation was performed on all children in the study, and the findings were summarized in Table I. The patient must have sufficient intelligence to learn basic reading, spelling and understand the basic operation of the device. IQ ratings were not of themselves employed as a major criterion in our selection, as the majority of those selected showed brain damage with very erratic performance on IQ scales. Each patient who by reason of his disability seemed likely to benefit from the device was tried in the use of the switches.

By trial methods it rapidly became apparent that mental maturity of six to seven years or first grade level is necessary to maintain interest and attention span.

Perceptual Status

Problems of visual perceptual function, or visuo-motor perceptual difficulties would undoubtedly be a factor in final performance, especially in the use of the typewriter output device with its demands on figure-ground discrimination and selection of appropriate letters and symbols. Measures of perceptual function in the form of the Ayres and Frostig tests, were applied when appropriate.

Language and Speech Development or Involvement

The subjects of the study were evaluated by the speech pathologist and audiologist. Presence of a central language disorder adds a further dimension to the disability pattern that was beyond the scope of this study to follow. One patient (M.B.) with language disorder and hearing loss was included in the early stage of the study. Not all children were tested on the typing device, which was delivered toward the end of the project period. During the phase of the study devoted to switch analysis and control ability, there were children tested who had the ability to communicate, but who suffered from severe motor disability. This group was tested for two reasons:

(a) They could benefit from the use of the switches to operate other devices (book, movie projector, toys, teaching devices); and

(b) The likelihood that a similar type disability might later be encountered in a child lacking communication.

II. Switch and Control Design

Theory:

In a study involving patient control of output devices, the design theory of the switch or control was of basic and major concern. Two considerations were kept in mind. Obviously, to be effective, the switch design must allow a severely handicapped individual some prospect and assurance of control. On the contrary, however, there was the hope that we might gain insight and information on learning and skill training if we can develop skill in the individual during the process. The sophisticated machine is useless unless those whom it is designed to assist can be trained to control it.

The most basic design possibility considered was an on-off switch. Muscle action leading to triggering a device, a relaxation resulting in the switch-off or the use of some other muscle action to switch off, demands that a pre-determined program is activated. It might be as simple as activating an electric train, and stopping it. It might be complicated, as in activating a computerized programmed arm activity, as in feeding. Project staff had explored this avenue in a basic way in a prior device study (Ref. 1) which evaluated one type of communication board, based on the simple operation of controlling an on-off switch.

It was decided to concentrate on a control form that was two-dimensional. The view that all forms of non-verbal communication reveal the common property of two-dimensionality, was the basis for this decision. Drawing, painting, writing, music-making, pointing with the finger playing "board" games; all have a two-dimensional nature; and it is the ability to specify at a given time a position or direction in two dimensions that is necessary in order to participate in the language at hand. The most human approach to specifying the position of an object is to point at it, but this requires the measurement of angles by a control device; and, in any case, a handicapped individual is limited in his ability to point accurately. The next most natural specification of position, and certainly the method of choice when position must be verbalized, takes the form of a statement of the up-down, and left-right properties of that position. Hereupon we are led to the form of the proposed devices and controls.

Every physical movement, however small, implies also the opposite or return action so that if one can detect a movement at all, one is in a position to operate a device in one dimension. Micro-switches and other sensitive switching devices may be employed in such a fashion that almost any repeatable movement may be used to control the on-off function of two switches and allow the electrical control of two events in one dimension with a neutral or OFF condition assumed at the mid-position. Pairing two such movements together provides the facility for the desired two-dimensional controls. The pairs chosen do not have to be associated with the same limb or extremity; although it will be seen later that the operator's appreciation of the up-down and left-right properties of the control is improved if the pair of movements have a common origin of coordinates.

The advantage of switches over other forms of motion pickup is that they all have the common property electrically speaking of open-close, rather than a graded response of some sort. The use of switches as a control allows one to control relatively large power outputs without intermediate amplification or buffering and also allows the control to be used to operate devices run at high or low voltage, and on line current or battery power. Thus, standardization of the controlling function is assured.

<u>Controls Developed</u>

A number of switch controls were developed:

(1) A "joystick", to be operated by the fingertips or hand represented the most basic application of the design. This type of control concept has been applied to motorized wheelchair control, and has been found effective.

(2) A set of mercury switches, mounted on a hat, sensitive to the tilt of the head in two planes.

(3) A miniaturized joystick control, small enough to be held between the teeth and operated by the tongue.

(4) Pneumatic control requiring blowing-sucking action on two tubes. This device offered possibilities of adjusting air leak rate and required operating pressures.

(5) Hemispherical joystick (for palmar surface control).

(6) Control board with spatially dispersed controls of a magnetic type, activated by the patient bringing a magnet within a "trigger area" of the switch.

(6-A) The magnet activator in this variation was attached to an extended rod with a T-shaped dowel handle at the end, allowing a secure grip, utilizing finger flexion and being adaptable for different size hands.

(6-B) Activator of simple dowel shape.

(6-C) A 1"x2" magnet was taped in the palm or on the dorsum of the hand. This was practical for testing. For permanent use, one would use a glove with appropriate small pocket, or an attached splint holder. In one child the magnet was attached to the foot.

(6-D) A rod-shaped magnet was attached to the end of a mouth stick.

The switch elements themselves were made movable by attaching them to Velcro, and a board covered with Velcro, allowing infinite positioning possibilities to adapt to a given child.

(7) Control board on which the 4 elements of the switch are separated and can be activated by a punch or direct pressure contact ("horn-button").

Summary of the Advantages of the Proposed Devices

(1) All controls were of a 4-switch type; hence standardization was possible. Standardization allowed:

(a) Device and control characteristics to be specified before development, making for minimal expense of unfruitful development efforts.
(b) All devices and controls interconnectible.
(c) Other researchers may use the same standard connection form and try their devices or controls with the ones developed on this project.

(2) All controlling functions are of the form: up, down, left, right - except where the election has been made to separate control components.

(3) Many available devices, games, and toys may be operated by means of one to four switch closures.

(4) Training of skill with a given control may be programmed, starting with a clear demonstration of the control function, proceeding through the use of a device with a highly motivating property, leading to the employment of the skill on a "verbal" communication device with increasing sophistication.

III. Patient/Device Interface: Matching Switch and Patient

As a general procedure, all patients in the study were evaluated in their ability to manipulate and control all the switches, unless it was obvious from clinical knowledge and observation of the subject that he could not conceivably operate a given switch. If there was any doubt, the switch was tried. In making these judgements, experience of the therapist played a part. Factors, such as grasp, both gross and fine, ability to center the arm and move the extremity grossly over the area encompassed by the control boards of devices 6 & 7, were the first consideration. Head control in all axes, particularly head tilting, was observed; breathing control, tongue control, lip control, all were measures that were evaluated in considering switch No. 4.

Positioning of the switch control in relation to the patient's trunk repeatedly proved a critical detail, in order to place the patient in the most advantageous position to control the device. For the most part, children were tested in whatever was their usual sitting or resting posture. This might be in a wheelchair or walker. In certain cases we positioned the subject specially by placing prone on a stretcher to explore the effect of posture on relaxation and motor control.

The table used to support the device was adjustable in height, to offer the most advantageous working position for the child being tested.

Switch No. 4 (air pressure) was adjusted in height to meet the needs of the individual child.

In switches 6 & 7 the elements were placed in varying spatial relationships to one another, to adjust to the pattern or useful range of motion of the subject.

Lapboard was used if the subject's need called for this proximity and working height.

Control Testing - Summary

Information collected and summarized from this phase of the study was as described in Table II, Attached.

TABLE II

Output Device in All Cases - The 4 Lights

Switch No. 1, Large Joystick

Child's Initials	TIME Average of 24 requests for "Left, Right, Up, Down" given randomly - Seconds*	Errors per 24 requests**
S.N.	1.1	0
T.O.	1.2	3 7/8
B.A.	1.9	2 11/12
	Switch No. 2, Mercury Head Switch	
T.O.	3.2	7
S.N.	1.7	3
B.A.	1.7	8
	Switch No. 3, Tiny Joystick	
S.N.	2.9	7
B.A.	4.8	5
	Switch No. 4, Suck-Blow Switch	
No one was able to operate reliably.		
	Switch No. 5 - Bell Shaped, Red	
S.N.	1.25	0
B.A.	2.2	3
	Switch No. 6 & 6A - Magnetic with T-shape Flat Activator	
S.N.	1.1	0
P.W.	9.4	3
L.S.	5.0	4
T.O.	1.9	0
J.C.	5.0	1
B.A.	1.8	0
	Switch No. 6 & 6B - Magnetic With Dowel-shaped Activator	
S.N.	1.3	0
P.W.	4.0	4
L.S.	6.0	0
T.O.	2.5	0
J.C.	4.3	0
B.A.	3.3	0

*Time is the time elapsing between the request for "left, right, up, down" and the response.

**Errors are those the child made in 24 tries. But these are variable. Some days more--others less. We would need 100 or so tries, or an average of 5 days (24 a day) for accuracy.

Switch No. 6 & 6C - Magnetic with Bar Magnet Taped to Child's Hand as Activator.

S.N.	1.6	0
P.W.	2.5	6
L.S.		
J.P.	3.7	1
T.O.	1.4	1
J.C.	4.3	5
B.T.	3.0	3
B.A.	2.1	0

Switch No. 7 - The 4 Horn Buttons Switch

S.N.	1.1	0
P.W.	6.0	1
L.S.	2.9	1
T.O.	1.2	0
J.C.	6.1	1
B.T.	5.0	2
B.A.	4.3	0

Special Set-up Switch - No. 6 (Magnetic) With 6C (Bar Magnet) taped to foot.

P.W.	1.3	1

Special Set-up Switch - No. 6 (Magnetic) with Rod-shaped Magnet Attached to Mouthstick

P.W.	1.3	2

Switch No.	Number of Children Tested	Average Time Seconds	Average Errors
1.	3	1.3	1.3
2.	2	2.2	6.0
3.	2	3.9	6.0
4.	We tried 3-4 children but no one could operate it reliably enough to make testing practical		
5.	2	1.7	1.5
6. & 6A	6	4.0	1.3
6. & 6B	6	3.6	0.7
6. & 6C	7	2.6	2.3
7.	7	3.8	0.7

COMMENTS ON SWITCHES

1. Joystick: This control proved very efficient for a certain type of child. The subject without gross athetoid involvement of the proximal arm segments, who could center or maintain static arm position reasonably well, found it possible to manipulate this switch; some by grasping the joystick handle, by a nudge of the thumb or other motion. For the grossly athetoid child, the control proved too sensitive, even when the handle was enlarged to five-inch length to allow more gross control.

2. Mercury Head Switch: This control has great flexibility of sensitivity control. Lateral bending motions of the head proved more difficult for the subjects than the nodding movement in an anterior plane. It is planned to design if possible a switch control sensitive to rotation movements. The potential of this switch has not yet been fully realized.

3. Miniature Joystick: This switch was too sensitive and too small an excursion for hand control. Despite the theoretical possibilities of tongue control, we were unsuccessful in our attempts to prove the practicability of this particular type of control.

4. Pneumatic Control: No child in our study had sufficient control to operate this switch reliably. We used the switch constantly, however, to train lip closure and sucking control, using mouth pieces of different diameters, working from a large to a smaller one in a progressive scale.

The use of air pressure offers possibilities of adaptation to bulbs, syringes, and the ability to grade the sensitivity of the control by air-release, valve adjustment, alteration of the tube bore, suggests the need for further exploration of this control.

5. Hemispherical Joystick: Two subjects only could operate this control successfully. The fine tilting motinn necessary was too difficult for the majority of subjects.

6. Magnetic Switch: Using the various adaptations described, this switch proved the most adaptable for the majority of athetoid children. The possibility of wide and variable separation of the four switch elements proved a very valuable compensation feature for the athetoid child with involuntary and often gross movements. The bar magnet taped in the child's hand (6-C) proved to be the best activating mechanism. The child did not need to concentrate on holding the activator, and involuntary supination did not prove a problem. A difficulty occurred, when in traveling from one switch position to the next, the child might accidentally trigger an unintended switch by passing too closely with the magnetic field. To avoid this required a pattern of elevating the outstretched arm, a movement pattern many found difficult to perform. Variations 6-A and 6-B proved more demanding of hand and forearm control.

7. Horn Button: This switch proved balky and did not perform as well as was hoped for. The button control will require further refinement.

Cases of failure in controlling switches in many cases was due to short attention span and/or insufficient motivation or intelligence.

IV. Output Devices

The original proposal conceived of a series of outputs, starting on a relavitely simple level, and proceeding to greater degrees of sophistication, while retaining the basic two-dimensional control concept. The following outputs were constructed and evaluated.

1. Display Board with Four Lightbulbs:

This simple device allowed a very graphical demonstration of the immediate output consequency of a control movement. A basic hypothesis was tested from the earliest phases of the study, through this display device. The concepts of up-down, left-right often proved most difficult to test in the young, non-verbal, severely handicapped child. It was possible to establish with accuracy in the majority of children the understanding or lack of understanding of this concept, by appropriate manipulation of the display board. The use of the board as a teaching device was demonstrated in the special education setting, by placing symbols, letters, pictures in relation to the various bulbs and allowing the child to choose from four alternatives by appropriate switch control. The use of such a display light board as a teaching device in the classroom may have considerable promise, and is worthy of continued study. This display board was the measure used in all of the tests of the switch control. Technique used was to request at random that the child light a specific bulb, "up", "down", "left", or "right". Inserting bulb of different color provided more motivation and also served in an educational setting where color recognition could be tested, when we were certain of the child's reliablity in switch control.

2. Etch-A-Sketch, Drawing Toy:

A specially wired pair of motors was designed, capable of being easily placed over the control knobs of this commercially available item. The motors were reversible, and were controlled by the switch control, making possible control of the stylus in the directions up, down, left, right. It provided an opportunity for the first time to make a line drawing.

Patterns of movement to be followed by the patient could be placed on the surface of the Etch-A-Sketch, enabling an element of skill and training to be introduced into the control process.

3. Strip-Projector:

A strip-projector belonging to one of the study patients was modified so as to be adaptable to the project switches, and proved controllable by the patient B.T., a severely involved athetoid patient. In this instance, reading material had been transferred to film page by page, and brought this activity within the scope of a patient who was quite unable to read a book; and this seemed worth consideration as an alternative to the commercially available page-turners.

4. Electric Typewriter Control Device:

Ultimately an electric typewriter control device was design and built, in which 32 characters are displayed on a 4 x 8 matrix with a light behind each. Any symbol position in such an array may be specified uniquely by five binary choices (yes/no, on/off, etc.). One asks first, let us say, whether the desired character is right or left of center; then whether it is in the upper or lower half, and so on. An "M", for example, might be the lower right-hand character in the left half of the upper left-hand quadrant and would therefore be specified as "left, up, left, down, right". As each directional choice is made, half of the remaining lights go out so that the sequence terminates with only the one desired being lit. Further motions cause print or reset, etc. Eventually the code would be learned well enough so that the display board would be unnecessary. The advantage over Morse Code is that the proposed code is self-teaching and requires no special timing skills. A fast, experienced operator may use the same "decoder" as a slow first-timer. The advantage of immediate feedback and observation of errors made before print-out is a big advantage over Morse Code.

In addition, the circuitry is very simple and the "decoder" is the display device itself. (See attached diagram)

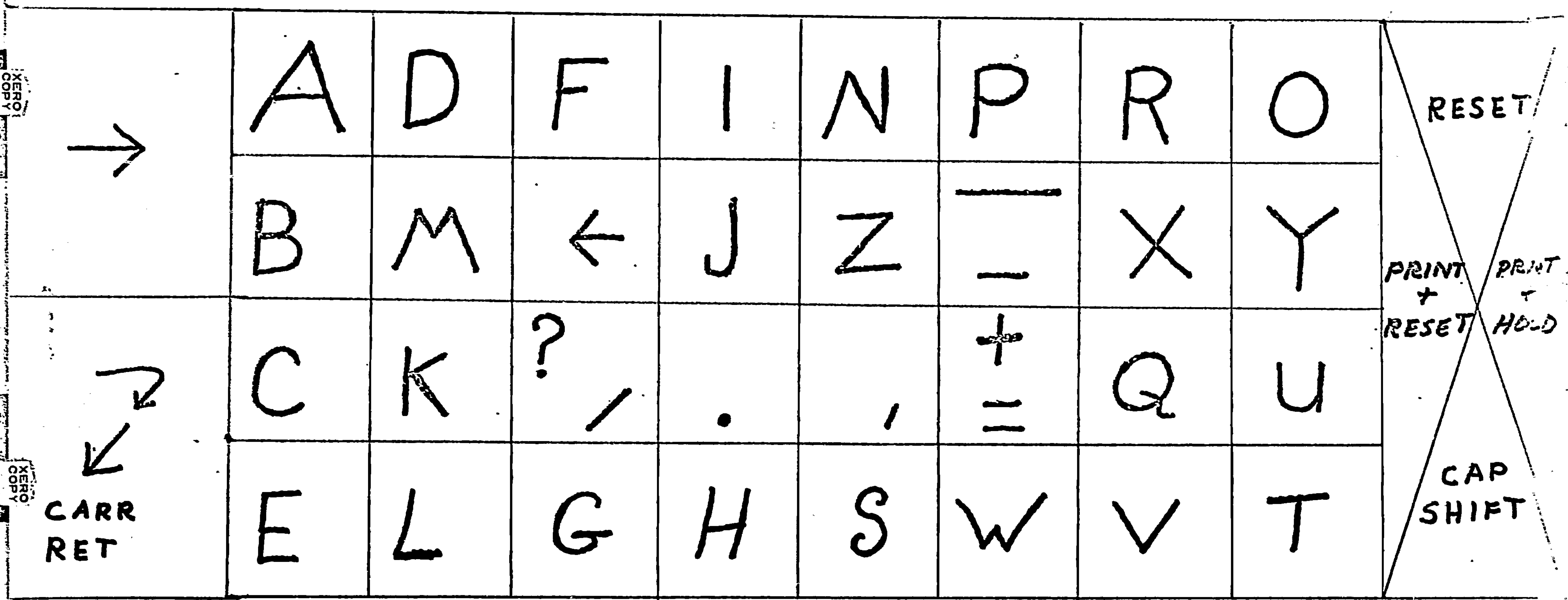
Once the skills of operation of the controls have been acquired through use of one or more of the output devices, they may be applied to the operation of anything which may be controlled by one to four switch closures. The four output closures need not have a common effect but may be used separately, as in controlling a tape recorder suitably equipped. The ultimate universality of communication skills becomes evident once they are developed.

This device was completed and delivered toward the end of the project period, and a total of four subjects were tested on the unit by the termination date of the project.

B.A.: This subject after two hours practice was tried on length of time needed to print one letter (five motinns for letter selection, plus one to print) -average time per letter - 11.0 seconds.

P.W.: This severely handicapped boy suffering from deafness in addition to his motor difficulties, was found not to have reliable concepts of up/down, left/right. He will be repeatedly exposed to the device during his special deaf education residence in the Rehabilitation Center.

ELECTRIC TYPEWRITER CONTROL DEVICE



J.C.: A total of 4 hours concentrated effort failed to result in reliable grasp of the principle of operation of the typing device; this despite the fact that in preliminary evaluation and training on switch control and light bulb display he learned this concept.

L.S.: 7½ hours concentrated individual practice. Best time on an individual letter was 19 seconds. Slowest time was 40 seconds. Average time on a trial of 15 letters was 22.9 seconds.

CONCLUSIONS:

A detailed experience was obtained in a clinical setting, of a group of 12 children and one adult. The abilities of the severely handicapped athetoid child to control mechanical devices was studied. There was indication that continued study of switch control and careful analysis of the severely handicapped child's residual motor skills may offer more hope to the severely handicapped individual of controlling his environment to the point that he may communicate better, profit more in the special classroom, enjoy more of recreational activities by controlling toys. For the physician or therapist or teacher there is the opportunity to work with a child in a meaningful way, in that simple therapeutic contact can be made even in the profoundly handicapped child, using special controls and motivating outputs.

More study will be needed to assess more accurately the influences of attention span, mental maturity, on the process of exposing a child to gadgetry of this type. Ingenuity will be required to probe for a variety of outputs that will be stimulating and meaningful for such a child. Recreational devices were not explored in any depth during the project. Very valuable insight was gained in this place however, by a convenient study in conjunction with Thayer School of Engineering in Dartmouth College, which explored the design of recreational devices suitable for the handicapped child.

The experience gained by the project staff was invaluable. Basic information has been obtained and documented that may be of use to future observers in this field.

Ref 1- Miller, John, OTR -Electronics for Communication, The American Journal of Occupational Therapy, January/February, 1964, vol. XVIII, No. 1.

APPENDED NOTE - from Project Engineer, Avery R. Johnson, Ph.D.

A retrospective view of the project in its more mechanical and functional aspects reveals a shift in teleology that could not have been anticipated because of the presumed specificity of function of the proposed devices. Recently published papers* in the fields of experimental psychology and neurophysiology necessitate a renewed appraisal of the methods of training handicapped children in concept formation and language development.

With reference to this project in particular it is apparent for a number of reasons that the typewriter-controller is far too ambitious and complex a device for the purposes it was intended to subserve. Not only was the required amount of time for development and component cost sorely underestimated at the outset, and the continuing problem of maintenance unforeseen or ignored, but it is in form and function too sophisticated in some senses and not enough so in others. The funds and time would have far better been spent on more, simpler controls and instruments. However, a number of the separate circuits and compenents show promise of being quite useful in the future, and the apparatus as a whole does operate as intended even though the emphasis on its use is attenuated. The designer and builder, instead of writing a detailed use and repair manual, finds it more practical to make periodical visits to Crotched Mountain for repair and modification of the machine.

One modification that is suggested and will probably be effected this year is a change in the first-step protocol of the operation. Immediately after RESET the user is presented with the four choices: UP means Space; DOWN means Carriage Return; LEFT and RIGHT are the first choice in a character search and shift the operation to the next four binary choices of character position. For a subject with imprecise or spastic control of the switches available to him, there is the ever-present danger of an unintended space or carriage return before each letter. A spacing error can be corrected by the laborious specification of a back-space while the carriage-return error cannot be corrected in any way without physical intervention on the typewriter. Therefore it would seem wiser to make space the result of a unique up-down sequence, so that unintentional operation is improbable but repetition is not difficult, and relegate Carriage Return to the character board where it is fairly safe from misuse. Backspace could easily be sacrified --- in fact, the easiest change is just to interchange to two.

The motorized Etch-A-Sketch board is still a potentially good recreational device but the line made by the stylus should be broader for better visibility and the motors should be adjustable in speed. The stylus modification is not one the manufacturer is likely to make on a limited quantity of boards and customer disassembly of them is potentially disastrous because of the quantity of fine powder inside. However, a technique might be attempted whereby the stylus is cranked off to an extreme corner position, a small access hole drilled just distal from it, and a small wad of felt placed on the stylus from there, after which the hole could be sealed with wax or glue.

As for the control switches themselves, the original intent was to make them operable with a minimum of effort or movement. However, as the project progressed, requests were made for switch arrangements requiring more movement and less precision. In view of the overall purposes of the project, the latter requests appear now to be quite valid. At the outset of training users on the switches, it was apparent that the directional concepts were poorly established in them and since the main idea seemed to be to elicit correct and rapid operation of the devices in achieving their output functions, the best instructional procedure appeared to be that of requesting that this lightbulb be lit rather than saying "push the switch Left". The latter command would direct the subject's attention to the switch where little motion was evident, the former to the lightbulb where the desired result was to arise. It is now apparent, however, that the reflexology involved in geometrical concept-formation and in the development of language skills is so important to promote in the subject, that his use of a control requiring large movements under his own observation is indicated. Further development of switch combinations should be made in this direction and provision included where possible for the adjustment of the precision of movement required for switch activation.

*Held, R., Plasticity in Sensory-Motor Systems, Scientific American, 1965, Vol. 213, No. 5, Pp. 84-94.

Geschwind, N., Disconnexion Syndromes in Animals and Man, Brain, Vol. 88, Parts II and III, 1965, Pp. 237-294, 585-644.

COMMUNICATION PROJECT REPORT INFORMATION
-ADDITION TO CHILDREN'S TIME SCORES ON EACH SWITCH

No.	CHILD		TIME SPENT WITH EACH CHILD
1.	B. Tesone		1½ hours
2.	B.A.		8½ "
3.	K.A.		1 "
4.	M.B.		½ "
5.	J.P.		4½ "
6.	J. Coleman		¼ "
7.	L.S.		18 "
8.	P.W.		6 "
9.	T.O.		4½ "
10.	J. Cohen		6 "
11.	S.N.		2 "
12.	S.T.		2 "
13.	B. Taylor		4 "
		Total:	58,3/4 Hours

CROTCHED MOUNTAIN REHABILITATION CENTER

ACTIVITIES OF DAILY LIVING

ADL EVALUATION

Name	B.D.	Age	Adm.Date
Address	Diagnosis		
Vocation			
Contraindications to activities			

CODE:

X - independent
O - dependent
P - physical assistance
P^1 - moderate physical assistance
P^2 - maximum physical assistance
V - verbal assistance
V^1 - moderate verbal assistance
V^2 - maximum verbal assistance
S - with supervision
L.Ex. - lack of experience
N.A. - not applicable
N.P.T.- not practical length of time
D - dressing
UD - undressing
$\bar{c}$ - $\bar{s}$ - specify $\bar{c}$ or $\bar{s}$ braces (with or without)
(circle) - circle, if more than one activity listed

I. Bed Activities:	Adm.Ev.Date	Re.Ev. Date	Disch. Date
1) Roll side to side			
2) Prone to supine			
3) Supine to prone			
4) Sit erect on bed			
5) Procure objects on night stand . . .			
6) Assume long sitting position			
7) Maintain long sitting position			
8) Come to sitting position with feet off bed			
9) Manage pillows and blanket			
10)			
11)			
12)			

Comments:

APPENDIX A

II. Wheelchair Activities:

	Adm.Ev.Date	Re.Ev. Date	Disch. Date
1) Propel: forward, backward, turn . . .			
2) Open: go through and close door . . .			
3) Up, down ramp			
4) Turn to left and right			
5) Lock brakes			
6) Unlock brakes			
7) Swing out footrests			
8) Swing in footrests			
9) Put on armrests			
10) Manage pushups			
11)			
12)			
13)			
14)			
15)			
16)			

Comments:

SELF CARE ACTIVITIES:

A. Eating: Dependent:__________ Independent:__________

	Adm.Ev. Date	ReEv. Date	Disch. Date
1) Sucking (type of straw).			
2) Drinking Cup (glass)			
3) Open jaw on command			
4) Close jaw, retain food			
5) Close jaw, retain liquid			
6) Bite			
7) Chew			
8) Jaw motion only			
9) Swallow solid food			
10) Swallow semi-liquid			
11) Use knife, fork and spoon			
12) Get food to mouth			
13) Scoop c̄ spoon			
14) Cut meat			
15) Use knife for spreading			
16) Jaw-tongue co-ordination			
17)			
18)			
19)			
20)			
21)			

Comments:

ADL EVALUATION - 3

PERSONAL HYGIENE AND GROOMING (Toilet Activities)   Independent ________ Dependent ________

	Adm.Ev.Date	Reev. Date	Disch. Date
1) Comb, brush hair			
2) Brush teeth			
3) Manage toothpaste			
4) Manage cup			
5) Turn faucet			
6) Wash and dry face and hands			
7) Wash & dry extremities & body			
8) Take bath			
9) Take shower			
10) Wash hair			
11) Apply cosmetics (make-up)			
12) Shave			
13) Rinse mouth			
14) Use urinal			
15) Clean self after BM			

Comments:

TRANSFERRING

	Adm.Ev. Date	Reev. Date	Disch. Date
1) (Bed to wheelchair			
(Wheelchair to bed			
2) (Straight chair to wheelchair			
(Wheelchair to straight chair			
3) (Soft chair to wheelchair			
(Wheelchair to soft chair			
4) (Toilet to wheelchair			
(Wheelchair to toilet			
(Adjust clothing before & after			
5) (Tub to wheelchair			
(Wheelchair to tub			
6) (Shower to wheelchair			
(Wheelchair to shower			
7) (Mat to wheelchair			
(Wheelchair to mat			
8) (Wheelchair to car			
(Car to wheelchair			
9) (Wheelchair in car			
(Wheelchair out of car			
10) (			
(			
11) (			
(			
12) (			
(			

Comments:

ADL EVALUATION - 4

DRESSING SKILLS: Dependent__________ Independent__________

Dressing & Undressing (specify)	Adm.Ev. Date	Reev. Date	Disch. Date
1) Dress . . . . . Slacks			
2) Skirt			
3) Slip-over garment			
4) Shirt . . . . Blouse			
5) Bra . . . . . Undershirt			
6) Panties . . . Undershorts			
7) Stockings . . . . . Socks			
8) Bow . . . . . tie necktie			
9) Shoes, lace, buckle, slipon			
10) Coat . . . . jacket			
11) Braces			
12)			
13)			
14)			

Comments:

FASTENINGS: Independent__________ Dependent__________

	Adm.Ev.Date	Reev. Date	Disch. Date
1) Buttons			
2) Zippers			
3) Snaps			
4) Hooks			
5) Buckles			
6) Velcro			
7) Back of clothing			
8) Adaptations - adjustments			
9)			
10)			
11)			

Comments:

ADL EVALUATION - 5

BRACING:

Type

Independent____________ Dependent____________

A. Unbuckle and Buckle:

	Adm.Ev.Date	Reev. Date	Disch. Date
1) Pelvic band			
2) Thigh band (pads)			
3) Knee pads			
4) Ankle strap			
5) Calf band			
6)			
7)			

Can remove

How?

Can get into braces

How?

8) Lock - unlock			
9) Attach to shoes			

Comments:

KNIGHT SPINAL

	Adm.Ev. Date	Reev. Date	Disch. Date
1) unlace & lace corset			
2) unhook & hook strap			

Comments:

BACK CORSET:

	Adm.Ev.Date	Reev. Date	Disch. Date
1) place properly			
2) hook - unhook			
3) tighten straps			
4) remove corset			

Comments:

EQUIPMENT USED:

Braces:

1) Short leg - double
2) Long leg - double
3) Pelvic band
4) Knight spinal
5) Other --
6)

Crutches:
1. Axillary
2. Lofstrand
3. Canes
4. None
5. Other
6.

Gait:
1. Swing-to
2. Swing-through
3. Four-point
4. Other
5. Hemi
6. Quad.
7. Para.
8.

Devices:

Other:

Comments:

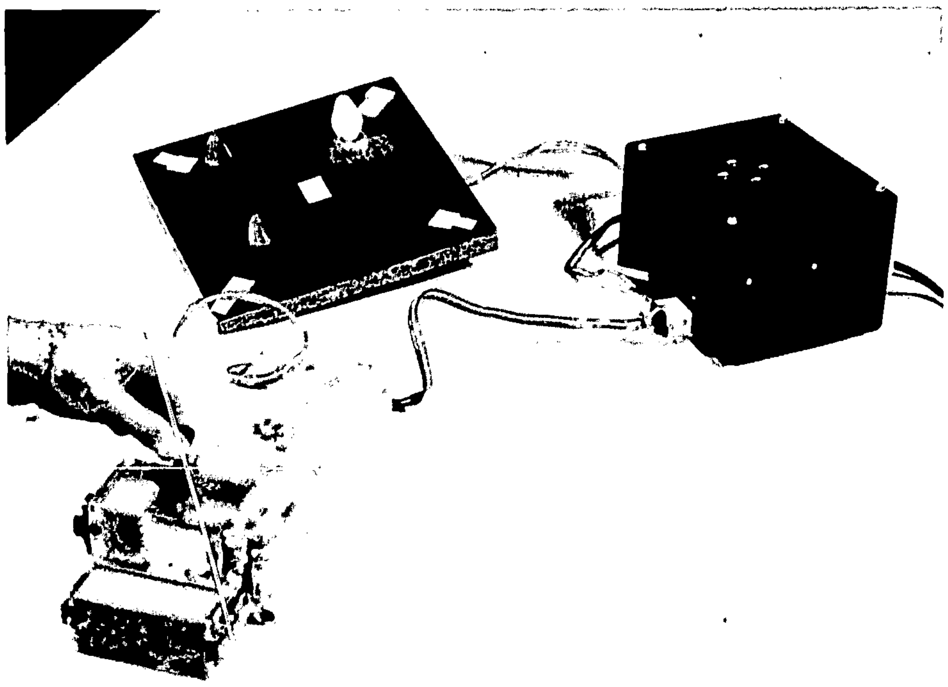
NO.	INIT	DIAGNOSIS	D.O.B.	SPEECH INVOLVEMENT	L.E. FUNCTION	U.E. FUNCTION	HEAD CONTROL	I.Q.
1.	B.T.	C.P. Athetoid	6/30/42	Intelligible speech with an effort on her part.	Wheelchair dependent, cannot walk, can wheel chair with left foot with impractical amount of effort.	Can type on an elec. typewriter accurately. Needs assistance to feed self. Prefers to paint with mouth stick. Involvement moderate to severe.	Can nod "yes", and shake "no". If she is upright, her head is usually hyperextended.	90
2.	B.A.	C.P. Spastic Athetoid	12/9/51	Intelligibility low on most words. Tongue movement difficult, uses communication board on wheelchair.	Cannot walk.	Feeds self with adaptive equipment, can type on elec. typewriter with rt. thumb, 2 sec. per letter. Cannot write, cannot wheel chair.	No serious problem, but enough so that he could not operate switch #2 - the mercury head switch.	Probably 102 or average
3.	K.A.	C.P. Tension Athetoid	2/14/61	Language retardation, speech infantile and frequently unintelligible, mild involvement of speech muscles. Makes omissions and substitutions.	Not 100% independent even with braces and crutches. P.T. reports have optimistic tone for future locomotion.	Grasp and release not fully voluntary, no hand preference. Feeds self with built-up spoon. Can unbutton large buttons. Pinch abnormal.	Good	Mental age 3-0 I.Q. 78 Very wide scatter, I.Q. probably well above average score--in actuality.

TABLE I

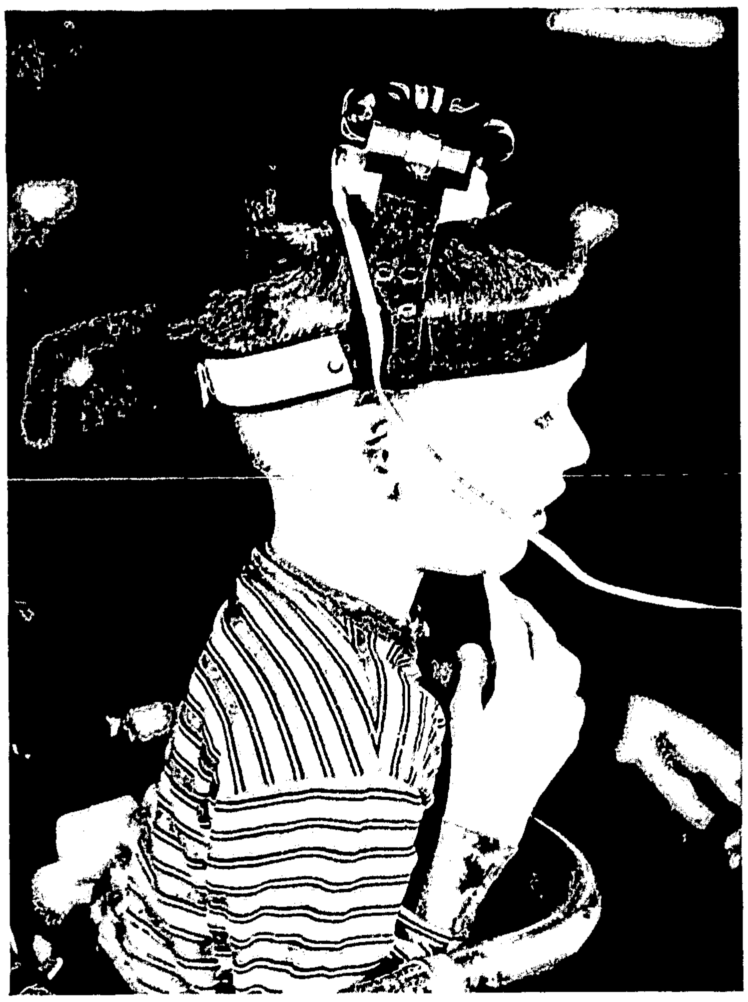
NO.	INIT	DIAGNOSIS	D.O.B.	SPEECH INVOLVEMENT	L.E. FUNCTION	U.E. FUNCTION	HEAD CONTROL	I.Q.
4.	M.B.	Central language disorder definite visual form perception deficit.	3/31/58	Could grunt and produce M,N,L,P, B, also ball and bye-bye, combines consonants and vowels, no recognizable speech.	Some advanced motor skill incoordination --mild, not seriously in need of physical therapy.	If any involvement, mild.	No indication there is any involvement.	No I.Q. assigned by psychologist, performance widely spread out, interested and motivated, routines close to age level, aphasic for symbols and communication. M.A. sufficient for language instruction.
5.	J.P.	C.P. Athetoid Quad.	10/1/61	Speech frequently unintelligible using phrases and incomplete sentences, omits final consonants.	Unable to walk even with braces. Able with braces to balance up to 2 minutes in parallel bars.	Difficulty with any motions. Cannot effectively pick up a 2" round bead, does somewhat better with smaller objects, release often involuntary and often difficult as well.	No significant problem.	Average, or possibly above average intellectual ability. Defects not in intellectual functioning but in performance. Should show good progress.
6.	J.C.	Spina Bifida Hydrocephalus	4/22/59	None	LDUP with pelvic band, hop-to gait. In wheelchair most of the time.	Insignificant involvement, if any.	Normal	I.Q. 94 low average

NO.	INIT	DIAGNOSIS	D.O.B.	SPEECH INVOLVEMENT	L.E. FUNCTION	U.E. FUNCTION	HEAD CONTROL	I.Q.
7.	L.S.	C.P. Athetoid Spastic	3/28/47	No intelligible speech.	Cannot walk even with equipment. Can move wheel chair with feet --this is practical.	Severe athetoid involvement. See performance on switch #6 (magnetic). It is slow and laborious. Could not operate other switches. Must be fed.	Very poor.	Unquestionably of sound intellect beneath physical problems.
8.	P.W.	C.P. Tension Athetoid Quad. Deafness	12/13/56	Some lipreading. Just a few words. Responds to speech at about 50 db.	Unable to walk or crawl. Braces and wheelchair or walker. Ambulates in walker. Left foot good in control of switch #6 with magnet taped to foot.	Severely involved in uppers. Operates switch #6 and 6C (magnet taped to hand) but very laborious and impractical. Mouth stick and foot with magnets more efficient.	Insufficient for accurate operation of switch #2 (mercury head switch) but sufficient to allow him to get mouth on tubes of switch #4.	Alert, probably fully educable in School for Deaf, poor performance psychologically, due to physical limitations.
9.	T.O.	C.P. Athetoid Quad.	11/1/55	Speech unintelligible and limited.	Could walk independently but needed guarding due to lack of concentration. If concentrates can go 50 ft. unguarded. Can clump around well on all fours.	Severe. Nothing fine possible. can only scribble with pencil, can't stabilize sheet of paper No success with bimanual activities.	Good. Probably not enough, however, for mercury switch (#2).	Severe retardation in intellectual growth, attention and effort at 6-7 year level. I.Q. figure unreliable.

NO.	INIT	DIAGNOSIS	D.O.B.	SPEECH INVOLVEMENT	L.E. FUNCTION	U.E. FUNCTION	HEAD CONTROL	I.Q.
10.	J.C.	C.P. Athetoid Quad.	12/18/53	No intelligible speech to any practical extent. A few people can understand a few words if he (JC) really tries.	Full support required for ambulation even in braces. Moderate scissoring and equinus without braces.	Unable to type whatsoever with any practicality, on any typewriter. Involvement severe, has to be fed. See performance with magnetic switch #6 --slow and laborious.	Fair to good if reminded, often JC would let head droop.	I.Q. 72 Normal basic endowment intellectually. Retarded by physical limitations. Retention and comprehension normal in some areas.
11.	S.N.	C.P. Acquired Rt. Hemiplegia	12/12/53	Total expressive aphasia.	Can walk independently but gait is not cosmetic and cannot do advanced gross coordination skills.	Mild involvement on right, left side OK. He could even operate switch #3. Stereognostic loss on right documented.	Normal.	I.Q.--variable results: 104-Full Scale 81-Full Scale 61-Performance
12.	S.T.	C.P. Tension Athetoid Quad.	6/23/61	Severe involvement, no intelligible speech, not even babbling.	Can't walk, has braces, physical therapy is mostly mat work, can bring right leg through in stabilizer.	Very severe involvement. Cannot feed or do any dressing or wheel chair. Unable to do more than move large joystick laterally with difficulty(switch #1).	Good	No. I.Q. figure available. In 16 months growth progressed only 3-4 on psychological test.
13.	B.T.	C.P. Athetoid Quad.	3/21/57	Speech usually unintelligible, a little less so to a few who get to know him. Unintelligibility in spite of therapy.	Unable to walk. No braces at this time. Mat program in physical therapy.	Severe involvement due to tension athetosis. Cannot dress or feed self or wheel chair even with his arms.	Head control poor, especially in sitting position.	Near average native intellectual endowment, but abilities scattered.



Switch # 1



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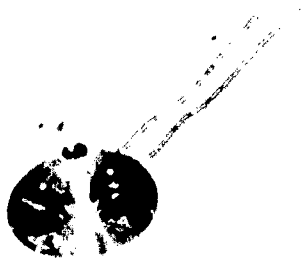
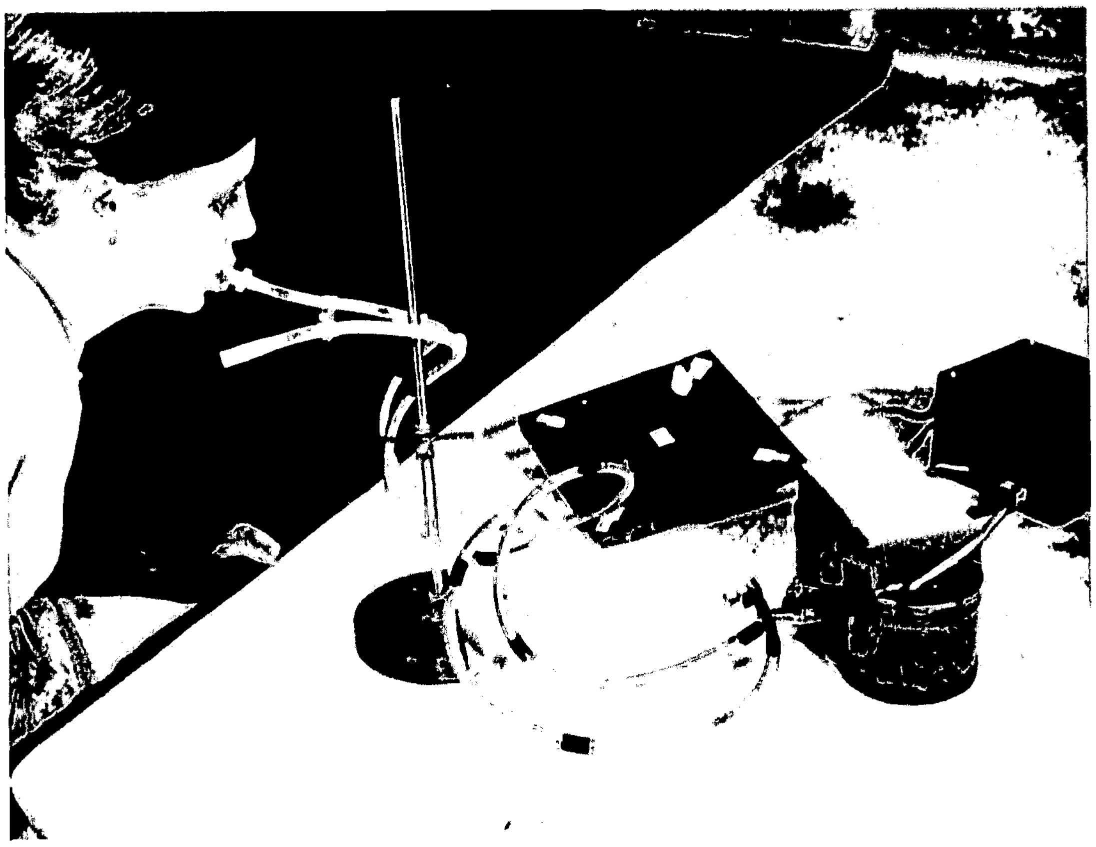


INPUT DEVICES

Switch # 3



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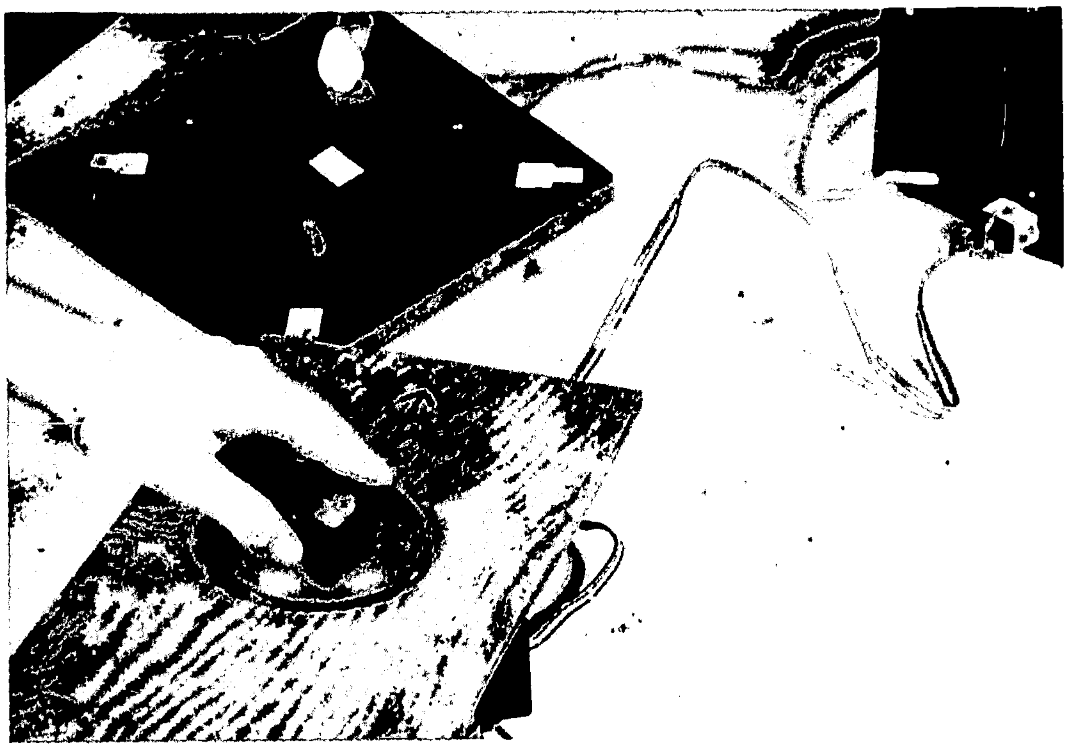

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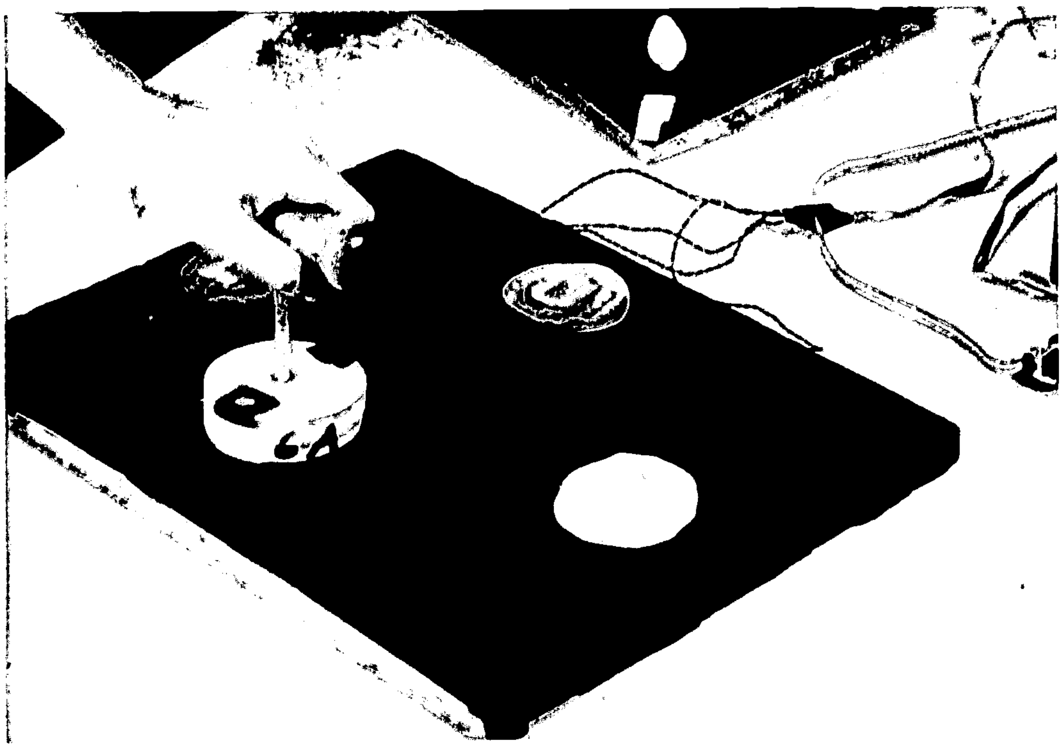
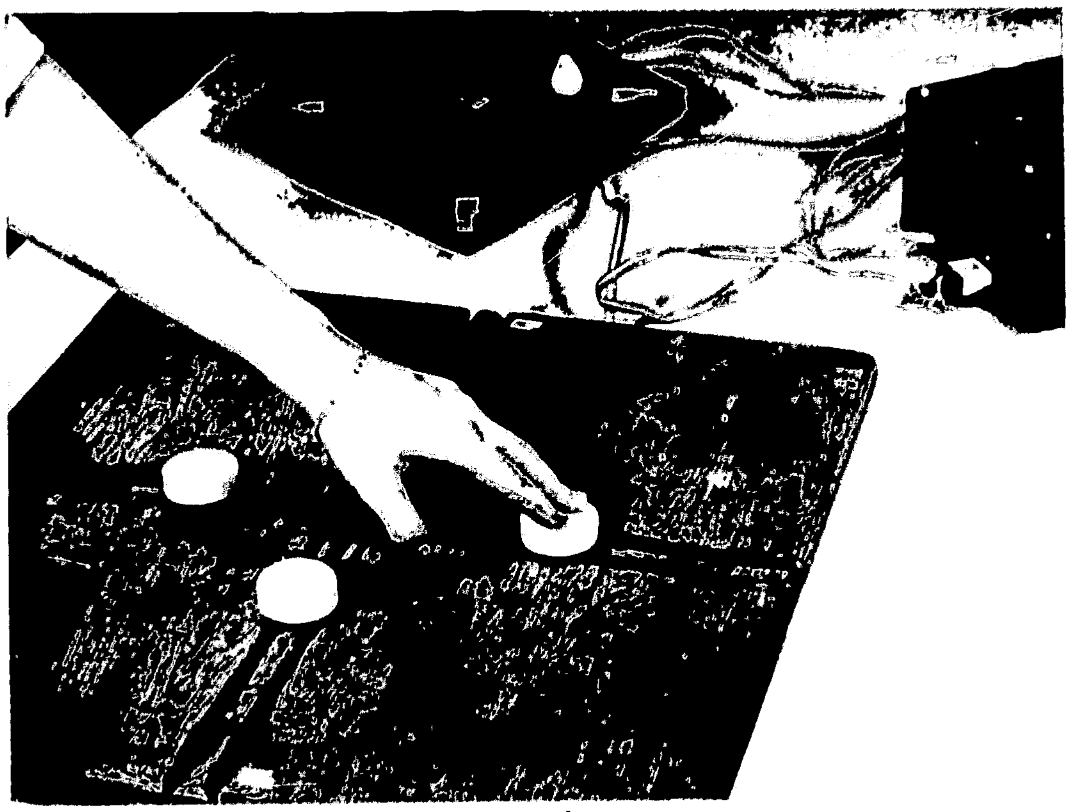
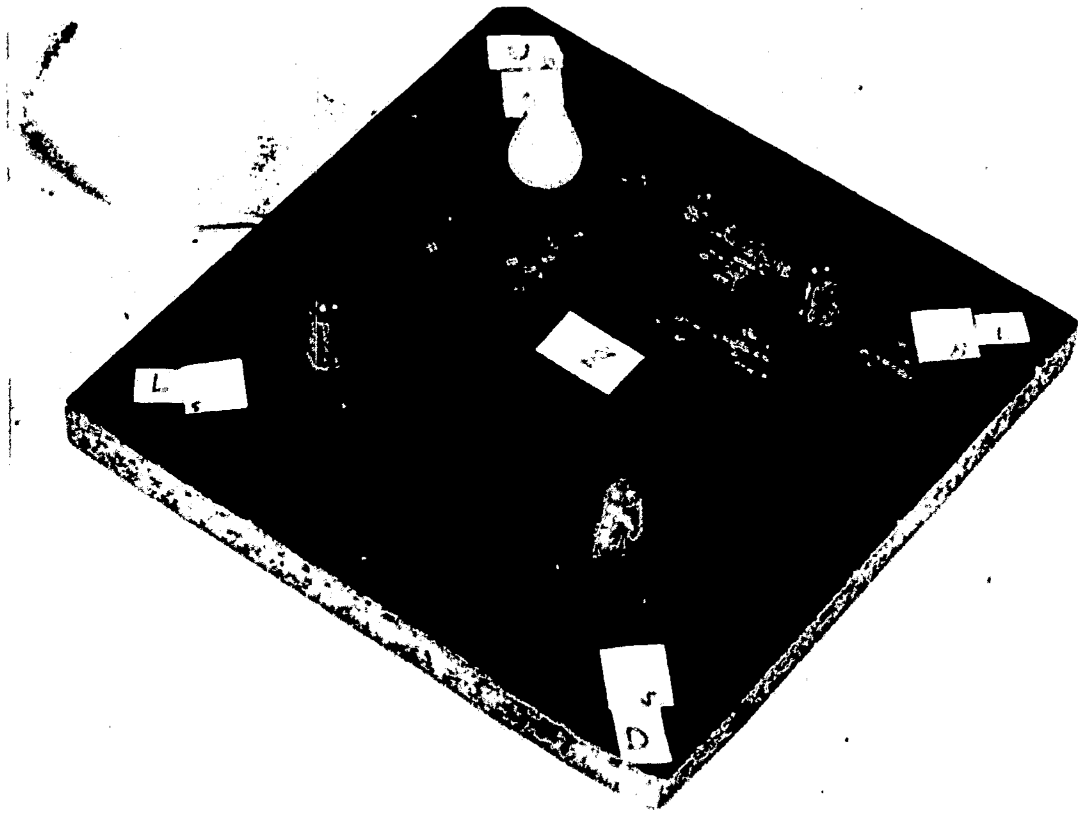


Switch # 6

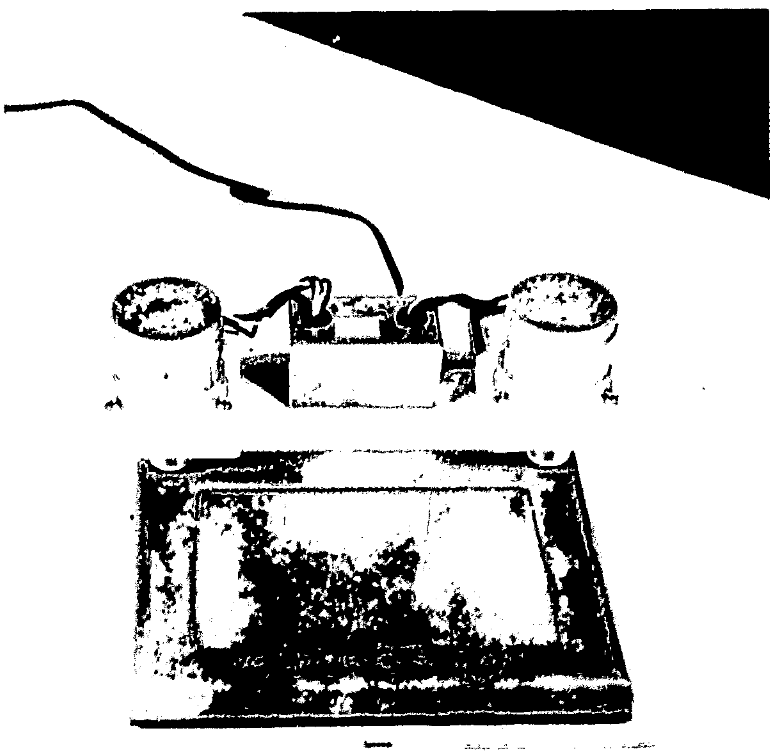


Switch # 7

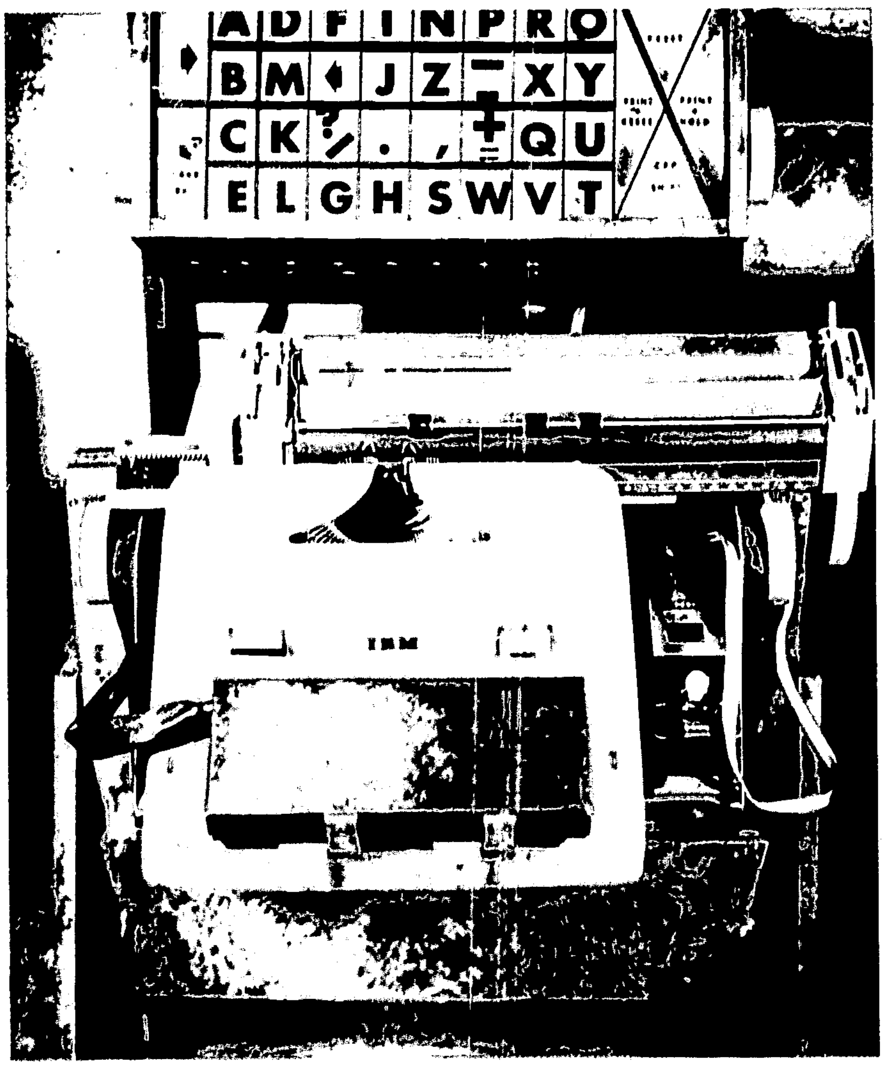
OUTPUT DEVICES



Display Board Output



"Etch-a-sketch" Output



Typewritter - Output