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JOINT ENTERPRISE UNDERTAKEN BETWEEN TWO CENTERS FOR DEVELOPMENT AND EVALUATION OF A TACTILE COMMUNICATION AID FOR DEAF-BLIND PERSONS

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I. INTRODUCTION

A unique joint enterprise is presently in progress by the National Center for Deaf-Blind Youths and Adults (operated by The Industrial Home for the Blind under an agreement with the United States Department of Health, Education, and Welfare) and the MIT Sensory Aids Evaluation and Development Center. Prior to the creation of the National Center, the Anne Sullivan Macy Service for Deaf-Blind Persons of The Industrial Home for the Blind, a research and demonstration program conducted with the help of grants from the United States Social and Rehabilitation Service of the Department of Health, Education, and Welfare, recognized an urgent need for a tactile communication system for deaf-blind persons. This need was apparent in home, industrial, and residential environments.

Deaf-blind persons use many contrivances for doorbells and other simple communication devices. Some doorbell accouterments, for example, consist of fans and heavy tactile buzzers strategically located throughout a dwelling or residence that are attached to an ordinary doorbell system. With the new telegraph devices currently being attached to telephones which allow coded communication between deaf-blind people, a tactile telephone ring indicator is needed.

To our knowledge, no electronic communication systems for deaf-blind workers exist in industrial settings. A deaf-blind person must be contacted in person by another worker or supervisor if a message is to be delivered. Loud speakers or traditional call

systems are of no value to a deaf-blind worker. In case of fire or fire drill, deaf-blind persons must be contacted personally, which ordinarily presents no real problem except where the flames or smoke might isolate the deaf-blind worker.

Deaf-blind clerical and professional people have expressed a need for "end of line indicators" on braillers and typewriters. The bell is of no help, whereas a vibratory message would eliminate the need for tactually experiencing with the hand the end of a braille or typed line. This group of professional and clerical deaf-blind persons also expressed a need for an office call system that could be used to announce a visitor or colleague.

Mobility instructors working with deaf-blind clients who are learning to commute in urban areas have wanted for many years a signal device that would allow them to follow their client on heavily travelled streets beyond the range of physical contact in order to direct them in the process of teaching maximum independent travel skills. Problems such as these, dictated that development and evaluation of a remote-control tactile communication system be established as a first priority for aid research projects.

With the establishment of the National Center on June 24, 1969, funds were made available for research in evaluating systems such as the one discussed in this paper. After soliciting proposals from several development centers, the National Center awarded a contract of evaluating the tactile communication system, hereafter referred to as TAC-COM, developed by the MIT Sensory Aids Evaluation

and Development Center. Jointly, the needs and problems of a tactile communication system were explored. As these concerns became clarified, the Sensory Aids Evaluation and Development Center developed, proposed, and demonstrated a prototype system devised to meet the specified needs. The immediate feedback to the engineers at periodic intervals during the evaluation of the prototype system has furthered its development.

Discussion of the technical aspects and the evaluation of TAC-COM along the following parameters is considered in the balance of this paper:

1. Technical Development of the System
2. Fire Alarm System
3. Doorbell System
4. End of Line Indicator
5. Mobility Aid System
6. General Communication Systems
    a. Time Clock
    b. Office Call
    c. Telephone Ring

II. TECHNICAL DEVELOPMENT

The Center for Sensory Aids Evaluation and Development (SAEDC) has been responsible, with the help of its consultant staff, for the design and development of a vibro-tactile communication system, known as TAC-COM. The system was then demonstrated to members of the staff of The Industrial Home for the Blind to be considered as a potential solution to some of the communication problems of the deaf-blind.

The initially proposed program for TAC-COM was to investigate and evaluate the system as a doorbell and fire alarm communication device in environments which house deaf-blind persons.

Preliminary investigations were conducted at SAEDC prior to the demonstration at the National Center to determine the coverage field and effectiveness of the system in a confined location. Rectangular induction loops were erected in a location set aside for this purpose and field test measurements were made to determine the field strength throughout the environment. It was found and verified that the minimum loops required to adequately cover a small location such as a room, were two loops erected on perpendicular and adjacent walls. Large locations required the installation of a number of loops to assure complete coverage. To demonstrate this, an office area 20 ft. x 20 ft. was tested with two perpendicular rectangular loops and then a larger environment covering an area of 40 ft. x 80 ft., was tested to determine field coverage requirements with respect to the number of loops needed. A single loop did create nulls in some locations and was considered an inadequate installation.

An important parameter to determine coverage and to assure communication is the height of the loop, the higher the loop the greater the coverage.

The TAC-COM system consists of a sender and a receiver and utilizes induction field principles as the communication link. The receiver is worn on the person in a convenient pocket, or if necessary, a holder and vibrates when it receives a signal from the induction

field. The length of signals or vibrations can be varied according to a code pre-selected by the operator of the transmitter. The receiver is a battery-operated device which is approximately the size of a pack of cigarettes and weighs about six ounces. In order to maintain reliable operation, the receiver should be recharged every twenty-four hours or at shorter intervals depending on the usage. The transmitter is an amplifier-transmitting system which is connected directly to the tuned induction loops.

The reasons for selecting a system which utilized induction field principles can be summarized as follows:

1. Interference due to external source and extraneous systems is considerably reduced,
2. Transmission of signal is confined to small locations and will not infringe on FCC regulations,
3. Low powers are required to transmit the signal in desired locations, and
4. The system can easily be constructed and requires no exotic engineering techniques and circuitry.

III. EVALUATION OF TAC-COM AS A FIRE ALARM SYSTEM IN A REHABILITATION CENTER.

TAC-COM was installed in the temporary headquarters of the National Center, measuring approximately 150 ft. long and 75 ft. wide. Five loops of number 12 wire, 18 ft. high were placed in the building, one loop on each of four walls, and one loop erected in the center of the building. Lead wires from each loop were then connected to the transmitter. Ten clients in training during the evaluation period were asked to wear a TAC-COM receiver and were

instructed that its vibratory message was a fire alarm signal.

In the first phase of this study the TAC-COM system as a fire alarm was compared to the traditional method used by The Industrial Home for the Blind, which consists of a supervisor or fellow worker tracing an "x" with the finger on the back of the deaf-blind worker. Time from beginning of first alert to total evacuation was recorded on 26 fire drills over a period of 4 months, 13 of which were TAC-COM and 13 "x" method drills. No statistically significant differences were found between the two methods. However, needless to say, these were only fire drills, and the hazard of a deaf-blind person being isolated by fire and smoke were not investigated. TAC-COM could be invaluable if such isolation were the case.

The second phase of the fire alarm evaluation consisted of comparing the "x" procedure with the TAC-COM system from time of first signal to the first purposeful movement of individual clients which indicated an awareness of the fire drill. Differences were found with this approach of measurement with TAC-COM proving better. These findings were expected because of the time needed for a helper to trace "x's" on the back of each client with the traditional method.

Phase three of the evaluation pertained to client attitudes toward TAC-COM. Interviews with each client who had enough language facility to express his ideas about the instrument were conducted. Four out of nine clients with communication ability thought well of the TAC-COM, two complained about not having a pocket to put it in, two said the clip was unreliable, and one client said it was too heavy. These attitudes about TAC-COM were sent to the Sensory Aids

Evaluation and Development Center for consideration. As a result, all of the clips on the receivers were replaced and fastened more securely to the units. The idea of enclosing each TAC-COM receiver in a shoulder or belt holster was also considered and these holders are now being developed.

A final phase of the National Center TAC-COM fire alarm evaluation consisted of isolating difficulties with the system as a whole. The center loop presented a tripping hazard as it crossed the floor of the building in a heavily travelled section of the National Center. It was later found that the system was still reliable with the center loop disconnected and consequently it was removed. The engineers at MIT also found that a metal strip cemented to the floor in place of the wire worked adequately for buildings in which central loops might be mandatory. As a fire alarm system the TAC-COM is reliable and functions as expected.

IV. TAC-COM AS A FIRE ALARM SYSTEM AT A LIGHT INDUSTRY ESTABLISHMENT

Currently, a TAC-COM system is being readied for installation at one of the departments of the sheltered workshop of The Industrial Home for the Blind. The primary function of this department is the construction, packing and shipping of mops. Eight deaf-blind persons are currently working in this department. Preliminary surveys of the shop in question highlighted several problems:

1. Several doorways and one elevator shaft create a problem due to the necessity of wiring across openings.
2. It is a large area, measuring 175 ft. x 60 ft. and filled with much heavy electrical equipment. For these reasons the consulting and developing engineers thought

at least one and possibly three central wires might be necessary to effectively cover the entire area. These central loops would dictate crossing heavily travelled work lanes with a number of wires, once again creating a tripping hazard.

When the Sensory Aids Evaluation and Development Center was confronted with these problems, alternatives were suggested as to how the center loop might be installed. Again, a suggestion made by engineers at SAEDC was that a metal strip be cemented to the concrete floor to substitute for the bottom portion of the rectangular loop. This might eliminate the hazard of tripping and stumbling of clients and workers. However, it was found upon further investigation that it would be difficult to install a metal tape to substitute for the wire since the floor surface did not lend itself to the solution.

An alternative to the solution of installing vertical wire loops was carefully investigated at SAEDC. After several tests and careful measurements were completed, a recommendation was made that the vertical loops could be replaced by a single horizontal loop in the workshop area. A single horizontal loop would encompass the entire workshop area. This would require that the receivers be maintained horizontally as compared to the vertical position in a pocket since the induction field would be altered 90 degrees. A further change required to accomplish this would be that all receivers be placed in holders and supported by belts. This recommended system will be installed in the light industry establishment, and an evaluation program will be conducted to determine its effectiveness as a fire alarm warning system.

V. TAC-COM EVALUATED AS A DOORBELL

TAC-COM was installed in the two-bedroom apartment of Dr. Robert Smithdas who is deaf-blind and is Director of Community Education at the National Center. Original plans were to place loops on all four sides of the entire apartment but because of the numerous wires that this would involve, it was decided to loop only the centrally located kitchen to see if the system had power enough to cover the entire apartment. At the time of this report, the doorbell was working as expected with only two very slight nulls in remote areas of the apartment due to the experimental reduction of the loops. Because of their location at the extreme ends of the apartment, the probability of these nulls creating any functional problems is highly limited. The system sends a strong dependable signal as anticipated.

The New York City Electrical Wiring Code prohibits tying extraneous electrical equipment into the feeder lines of apartment houses. Therefore, SAEDC developed a sound switch (a microphonelike device). The sound switch was placed at close proximity to the existing apartment buzzer which was used to activate the TAC-COM transmitter. The sound switch has been found to be a highly reliable and efficient device. It can be used to convert many auditory cues to tactile responses. The doorbell hookup in Dr. Robert Smithdas' apartment was not affected by extraneous noise present in the environment.

After using the doorbell for a period of two weeks, Dr. Smithdas reports that the system is reliable, sends strong messages and has allowed his friends to signal with individualized, predetermined codes

from the street entrance. Dr. Smithdas also recommended that stronger, more reliable clips be put on the receivers. Consequently, this was done.

VI. TAC-COM USED AS A MOBILITY TRAINING DEVICE

A study is presently being considered for testing a hypothesis that immediate feedback about veering behavior using a vibratory signal is superior to traditional delayed feedback or physical contact methods. To help test this hypothesis, the SAEDC developed a portable wireless version of TAC-COM. This instrument utilizes the same receivers previously described. The transmitter, however, is portable and is operated by a rechargeable battery with an operational range of five ft. This will make it possible to give trainees different remote-control signals with TAC-COM for right and left veering behavior as they walk on a mobility training grid.

VII. END OF LINE INDICATOR

The success of technically innovative communication devices is related to the number of applications which can be applied to the system and to its utility and efficiency of operation in the respective functional areas. It is felt at MIT SAEDC that TAC-COM has many useful applications which will help bridge the communication gap with deaf-blind people. The system has a simple vibro-tactile display which can be coded as to length of vibration.

An initial investigation examined the TAC-COM system to substitute for bells, i.e., a vibration would correspond to a bell

ringing. An excellent example of this is an end of line indicator for the braille-writer and typewriter.

VIII. EXTENDED APPLICATIONS AND OTHER PROJECTED USES FOR TAC-COM

It has been suggested at SAEDC that other applications exist for the TAC-COM system and plans are currently underway to investigate other uses for TAC-COM.

SAEDC has installed in its present on-campus MIT facility a complete TAC-COM system. The entire center has been wired for total coverage in order that the system can be tested for various purposes. Members of the staff carry TAC-COM receivers which are presently used as a calling or annunciator system. Each staff member is given a code in order that the administrative assistant can communicate with each person. The TAC-COM transmitter is also connected to the telephone ringing circuit to inform members of the staff that the telephone is ringing via the corresponding vibro-tactile sensations.

A sound switch (or microphone) has also been incorporated in the TAC-COM system for experimental reasons. The sound switch sensitivity can be varied or adjusted to indicate or detect various levels of sound cues. For example, noises, whistles, bells, claps, taps, and general environmental noises can be detected. Experiments are being conducted to determine the usefulness of this accessory device to the TAC-COM system for deaf-blind persons.

Other projects will evaluate TAC-COM at the National Center for Deaf-Blind Youths and Adults to convert a time clock and bell ringing system to indicate class changes, coffee breaks, lunch periods and end of day, using the vibro-tactile display as a substitute for the bell.

IX. SUMMARY AND CONCLUSIONS

The joint enterprise undertaken between the Sensory Aids Evaluation and Development Center and the National Center for Deaf-Blind Youths and Adults has led to the creation of a promising vibratory communication aid for use by deaf-blind people. This system has proven effective thus far as a:

(1) doorbell,

(2) fire alarm, and

(3) as the basis for building a tactile display system that promises to have many uses for not only the deaf-blind but the deaf community as well.

This project also demonstrated that two agencies, one rehabilatative, the other technical, could cooperate closely in a complex project and that an important aid for the handicapped could result from this cooperation. As this paper is being prepared, other cooperative ventures are being considered.