ENVIRONMENTAL CONTROL SYSTEMS IN THE U.K.

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ABSTRACT:

People with severe long term physical disabilities who live at home or in institutional care may need special equipment to enable them to switch on electrical appliances, use a telephone or sound an alarm system in an emergency.

In the U.K. environmental control equipment is supplied free of charge to disabled people who meet the medical criteria laid down by the Department of Health and Social Security (D.H.S.S.)

Because of the degree of disability of the patients the equipment provided has to be controlled by a single operating switch.

This paper looks at the development of the most recently designed environmental control system and loudspeaking telephone that is available for supply from the D.H.S.S. It covers the experience of installing approximately 500 sets of this equipment since it was first introduced in 1983. Particular emphasis is placed on the users interface and various new techniques will be introduced. The expansion of the basic machine to enable the disabled person to use a word processor will be discussed.

The principal conclusions are that a dedicated machine of this type must be designed to be modified easily or expanded to suit the needs of the individual and, most important of all, must be simple to operate and understand.

KEYWORDS:
Environmental Control,
Single Switch Operating,
Loudspeaking Telephone.

BACKGROUND

The design of any environmental control system for use by people with severe long term physical disability will always be a compromise between the disabled persons requirements from the machine, the cost of providing it and the technology available. Equipment designed specifically for the individual user, in theory should produce the best results. The cost of implementing this approach however, is usually prohibitive. The Steeper Environmental Control System, which was adopted for supply by the D.H.S.S. in 1983, was the end result of a number of individually

designed units, which utilised simple selection techniques.

STEEPER ENVIRONMENTAL CONTROL EQUIPMENT DESIGNED FOR THE INDIVIDUAL USER (PRIOR TO 1983).

These systems were individually designed to control a small number of items which usually included an intercom system to the front door, an electrically controlled door lock, an alarm system and on/off control of several mains powered appliances. The control of a loudspeaking telephone, with the facility of auto dialling one telephone number could also be provided.

Other facilities, for example the control of an electric bed or a TV channel changer, were sometimes added.

In some cases, if the disabled person could successfully operate a number of actuator switches mounted next to each other, a keyboard was produced. The operation of a keyboard switch would produce one of the following outputs:

1) The output would latch "high", turning the device being controlled on. Subsequent operation of the switch would take the output "low", turning the device off. This "toggle" operation of the switch could be used to operate a relay, switching for example a 240 volt mains appliance on or off.

2) The output would operate as a monostable timer, resetting itself without a further operation of the switch. This could be used for control of an electric door lock, where the lock is only required to remain energised for a period of about 10 seconds, or for a page turner where a 1 second contact closure is required.

3) The output would remain in the "high" state for as long as the switch was operated, and be taken "low" again as soon as the switch was cancelled. This would be appropriate for the control of an electric bed. For bed control it was also necessary to ensure that two separately controlled motions could not be activated at the same time.

If the degree of patient disability necessitated the use of a single patient operating switch, a simple indicator board was provided. This usually comprised a display of light emitting diodes. Continuous or momentary operation of the patient switch would initiate the illumination of these LED's in sequence. Release of the switch, or if preferred a further momentary operation of the switch, when the LED indicating the required item was illuminated, would operate the appropriate output.

A number of systems using either keyboards or single switch control were installed going back to the late 1960's. Almost without exception they proved to be very successful. The reason for this was clearly because they were individually "tailored" to the requirements of the user.

FIG. 1 shows a simplified schematic diagram for a single switch operated environmental control. A system of this type was designed for a high level spinal injury patient, who

PATIENT ACTUATOR SWITCHES

The actuator switch used by the patient is of critical importance to the successful operation of the control equipment. It is frequently possible to use a hand, foot or pneumatic switch, suitably mounted to perform this function.

In some cases however, the degree of physical disability means that special actuators are necessary. Actuators sometimes used include:-

1. Myoelectric control
2. Switches built into specially made hand or foot splints.
3. Chin switches.
4. Voice control switch.
5. Eye movement switches.
6. Blink switches.
7. Proximity switches
8. Light beam interrupter switches.

Proximity/eye blink switch

We are currently carrying out trials with a switch that utilizes a small infrared reflective assembly. (See fig 6.) This device contains a light emitting diode and a photo transistor. Infrared light transmitted by an LED is reflected when an object that reflects infrared is placed in front of it. The reflected light is detected by the photo transistor.

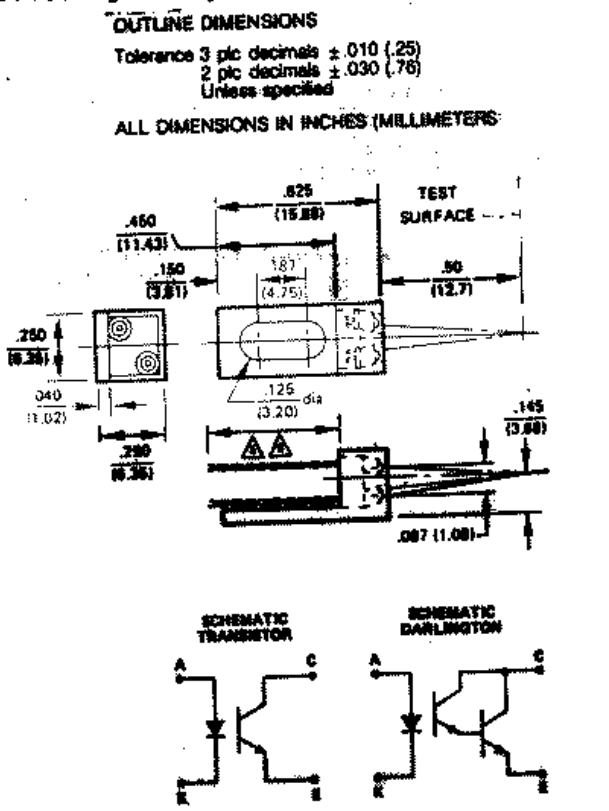


FIG 6

There is always a temptation to provide too many features thus making the resulting machine too complex to use.

The last 10 years has seen a revolution in the U.K. and worldwide with the introduction of the home computer on a wide scale. Some of these machines, with suitable software, would be capable of carrying out all of the computing tasks required by an Environmental Control System, and it would seem sensible to base any new design for a system around one of these units. There are however, a number of drawbacks to using machines of this type.

These may be summarised as follows:-

1) In the U.K., the D.H.S.S. insist that the equipment should be approved to BS 5724-1 the medical electrical safety standard. This is technically identical with IEC 601-1 the harmonised document adopted by the European Committee of Electro Technical Standardisation (CENELEC). This rules out the use of standard home computers. An important footnote to this is that in 1985 the European Community agreed to adopt new consumer protection legislation. Member States have until June 1988 to implement this legislation in their own countries. In the light of this, it is essential that equipment designed for the disabled user meets the requirements of the specified safety standard.

2) An emergency for a disabled person could arise if the house electrical supply fails. The D.H.S.S. require that,should this happen a standby battery inside the environmental control unit guarantees 4 hours use of the emergency functions (i.e. the telephone, alarm bell, door lock and intercom system.) The standby battery must be recharged automatically as soon as the house electricity supply is restored.

3) The equipment must be capable of operating in more than one room with the minimum of disruption.

4) Because the equipment is never switched off careful consideration needs to be given to the display. A lamp indicator board may well be preferable to a video monitor for many patients who may have an inbuilt fear of computers. The need for the equipment to operate under emergency battery power also has to be considered. Also prolonged use of VDU's can lead to eye strain, nausia etc.

5) The equipment must be capable of controlling a loud-speaking telephone. This would require additional hardware if a home computer were used.

6) Although a home computer would be well suited to carry out all of the computing requirements of the system, this is only half the story. The system requires intercoms, relay drivers, alarm bells and other peripherals, all of which have to meet the relevant safety standards.

7) Because a disabled person frequently relies totally on the equipment to call for help in an emergency, reliability

becomes extremely important. In the U.K. emergency repairs have to be carried out within 48 hours of a breakdown. If home computers were used a similar degree of reliability and service would be expected.

THE DESIGN SOLUTION ADOPTED

See figs 2,3 & 4.

A dedicated control system has been designed. The equipment is approved to BS5724:1(IEC601:1) and has the following features:-

1) The machine can be controlled by a single input actuator which acts as a normally open switch.
Operation and release of this switch initiates a selection process, and subsequent operations complete the selection. The actuator is connected directly to a selection indicator board.

2) Control of the following basic facilities are provided:-
a) Emergency alarm.
b) A simplex intercom to communicate to another room.
c) Door release and simplex intercom to external door.
d) ON/OFF control of 5 domestic appliances. These can be mains or battery powered.
e) Control of a loudspeaking telephone with a repertory store of up to ten telephone numbers with up to 15 digits In addition provision for the compiling of telephone numbers not held in the repertory store, by using the single input actuator.

3. Provision has been made for the use of the equipment in more than one room.

4. Although the control requirements of the system are relatively simple and could possibly be achieved using standard CMOS logic circuits, a CMOS 8-bit microprocessor with 8K of memory has been used giving a more flexible solution. In addition, 1K of random access memory (RAM) with battery backup is provided for the storing of telephone numbers.

5. A main control box is provided consisting of the incoming mains transformer, a standby emergency battery, power supply board, the microprocessor board and various other interface boards to connect to the different parts of the system. See fig 2 for schematic diagram.

6. An expansion port has been provided on the rear of the main control box to enable direct access to the processor. This enables the control capabilities of the machine to be modified or increased.

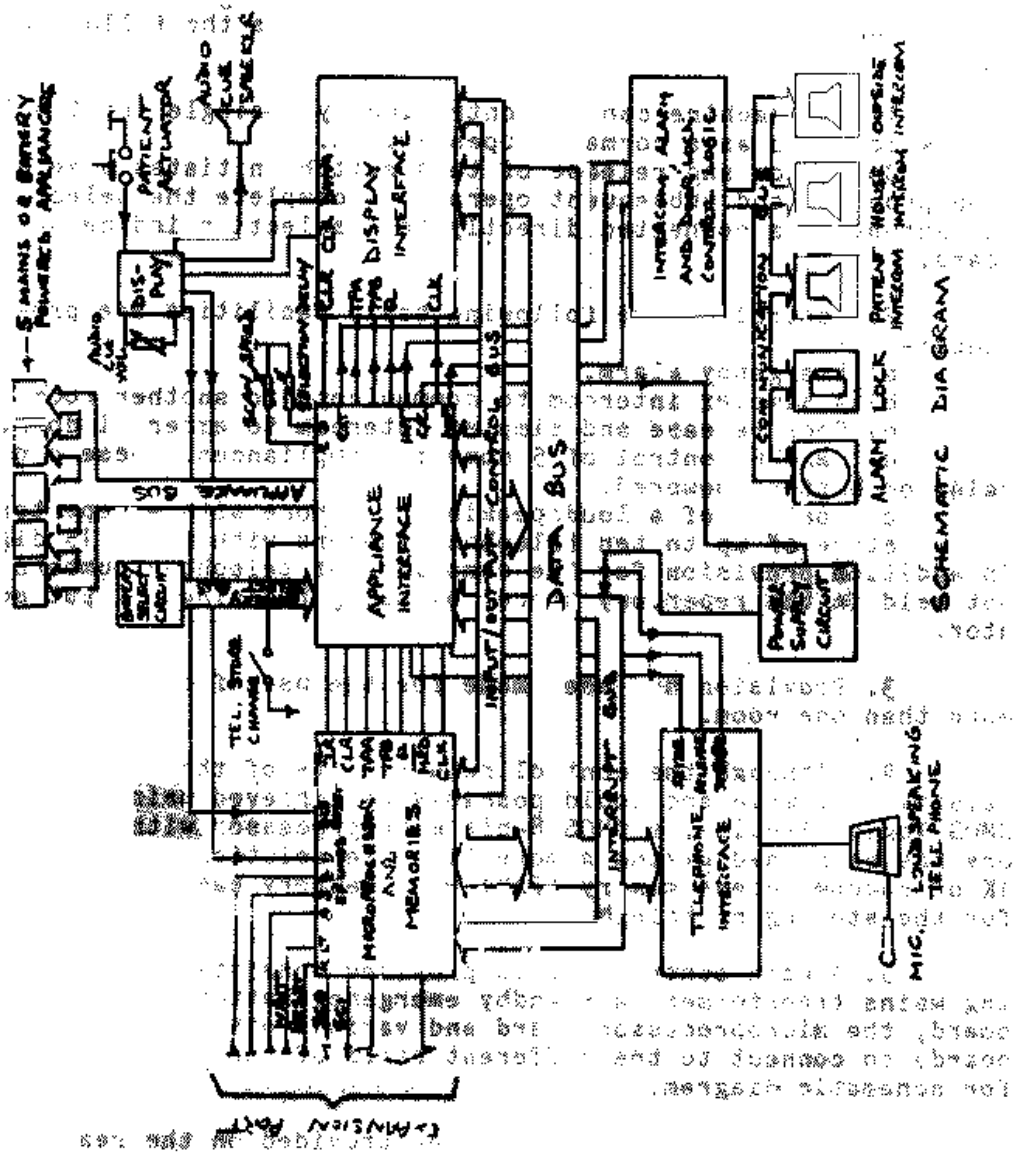
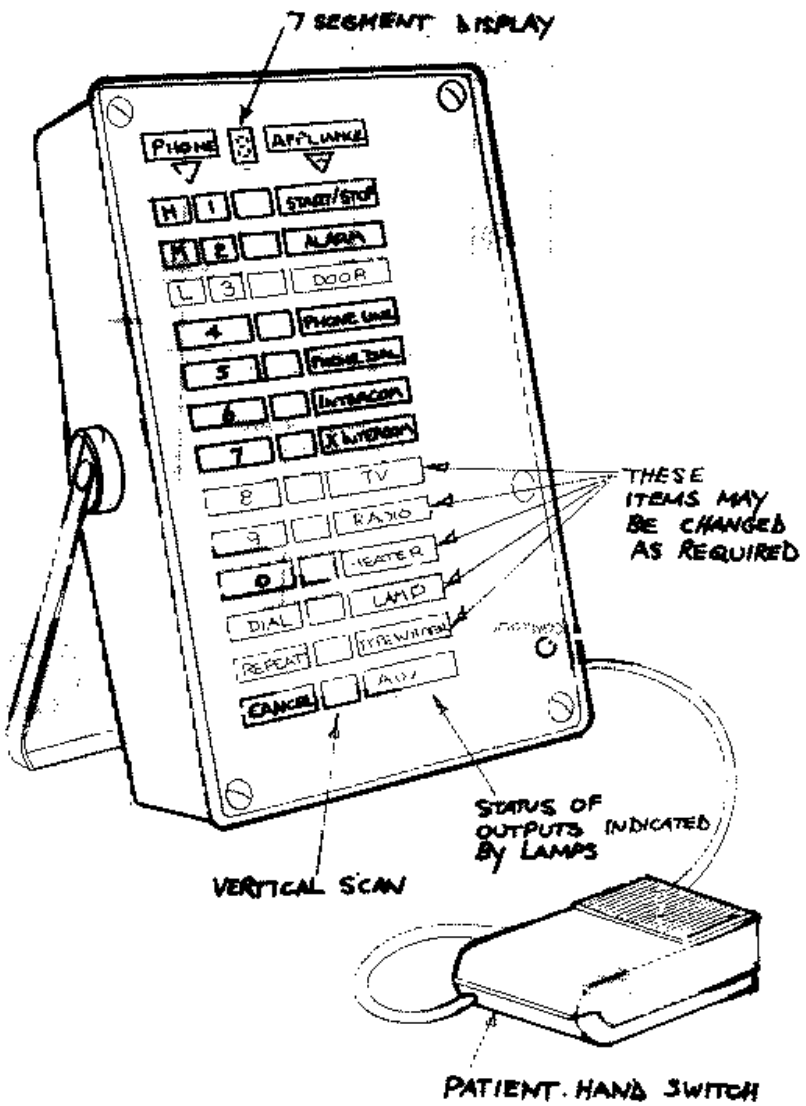

APPLIANCE INTERFACE
DISPLAY INTERFACE
DATA BUS
ADDRESS BUS
INPUT/OUTPUT CONTROL BUS
INTERRUPT BUS
TELEPHONE INTERFACE
AND MEMORIES
ALARM LOCK
PATIENT HOUSE
SCHEMATIC DIAGRAM

FIG 2

7. An indicator board is provided to be connected to the main control box. (See fig 3.) This comprises a single vertical scan of 13 filament lamps. Operation of the actuator switch whilst one of these lamps is illuminated selects the corresponding output. The status of each output is clearly indicated using additional lamps. Selection of telephone "DIAL" enables prestored telephone numbers to be dialled by use of the same vertical scan. The use of a seven segment display to make selections is not considered by the D.H.S.S.to be a reliable method, although a display of this type is included to facilitate the storing of telephone numbers and for interrogating the buffer store prior to dialling.

FIG 3



8. To assist patients with poor eyesight, the indicator board uses standard filament lamps as opposed to light emitting diodes (LED's). The size of the display is made large enough to be clearly legible with normal eyesight at a distance of 5m. The brilliance of the filament bulbs reduces automatically in the dark. An audible indication of the scan position is included.

9. The indicator board is easily disconnected from the main control box and can be readily transported into another room for reconnection to the system via an extension cable from the control box.

10. The indicator board is capable of being mounted in a variety of different ways. Provision for table top, floor stand, wall or even ceiling mounting have been made.

TYPICAL LAYOUT OF BASIC SYSTEM

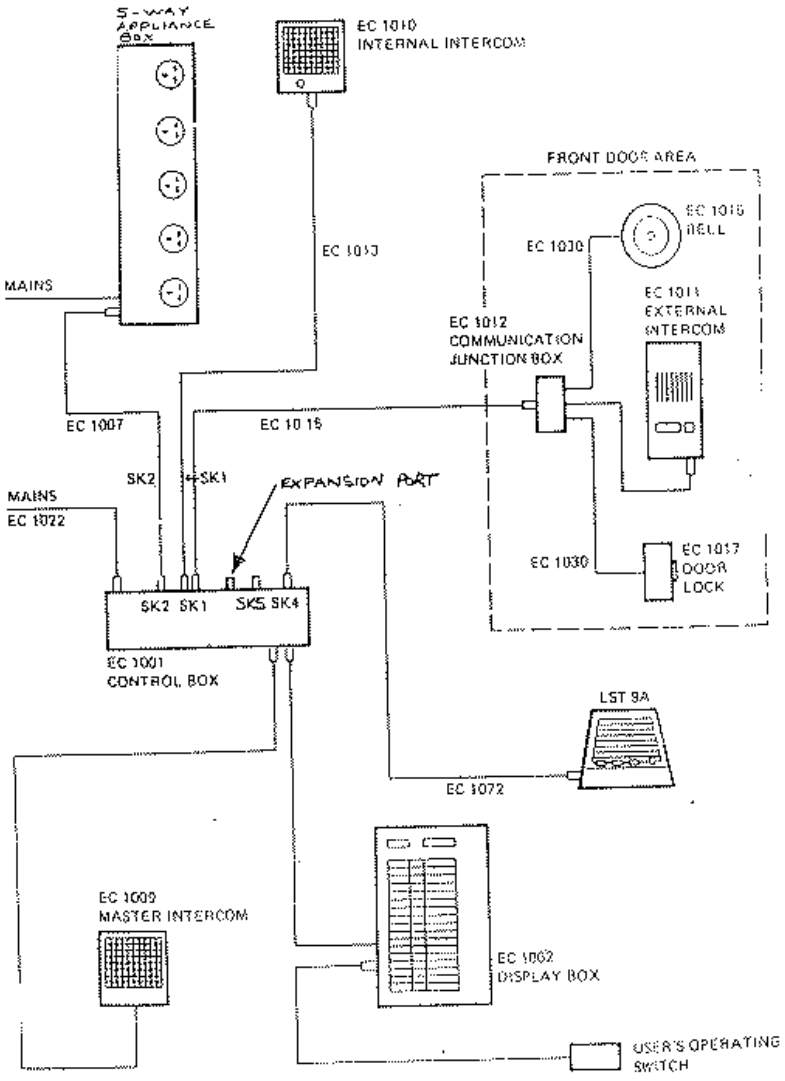


FIG 4

11. Because the machine has to operate reliably in any private dwelling place or institution, different parts of the system are wired directly to the main control box. The use of other forms of remote switching (infra-red or radio control) or utilizing existing power line wiring to transmit coded signals, does not offer the same degree of reliability and in certain situations may not even work. Note: See section on Patient Actuator Switches, where remote control is used.

Wiring of different parts of the system together is achieved using leads with pre-wired plugs. This makes it impossible incorrectly to connect the system together. Fig 4 shows a typical layout of the basic system.

12. Output sockets are provided at the rear of the control box (See fig.4) These connect the signals from the control box,via the appropriate cable to the peripheral device. The following output sockets are provided:-

a) Appliance output socket (SK2). This provides connection to special relay boxes for the switching of mains or battery powered appliances. Mains relay boxes are designed to include an opto triac device to provide 4kV isolation between the A.C. mains supply and the 12 volt output from SK2.

b) Communication output sockets (SK1). This socket provides the necessary signals for the intercoms, door lock and alarm bell.

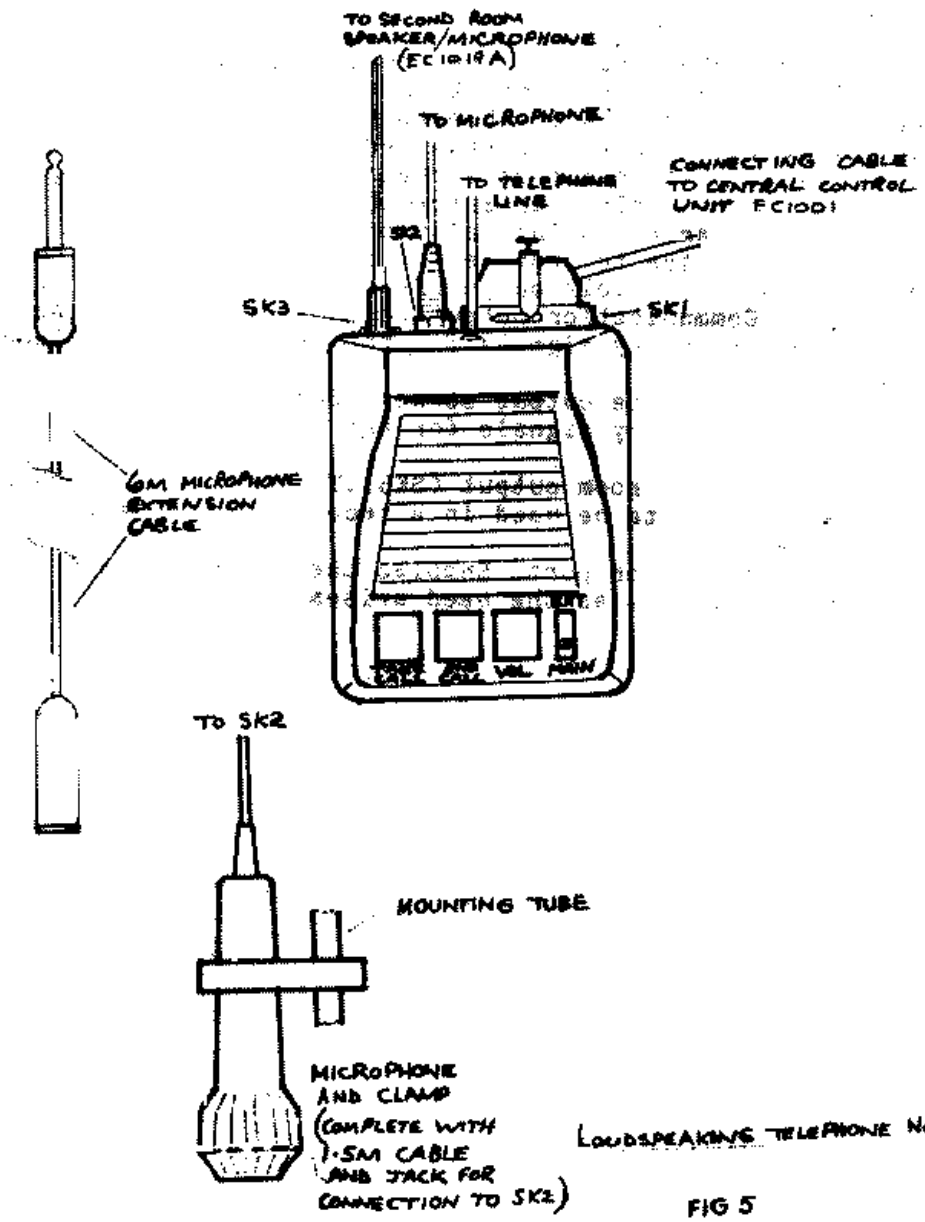
c) Telephone output socket (SK4). A 25 way connector provides the necessary signals for the operation of the loudspeaking telephone.

d) Second room output (SK5).This socket enables another indicator board to be used in a second room by means of a suitable extension

e) Expansion port. Enables the machine to control other peripheral devices as the need arises.

LOUDSPEAKING TELEPHONE

In 1984 work began on the design of a loudspeaking tele phone for use with the environmental control equipment. This unit was to replace a dated design of loudspeaking telephone which was being used at the time.



LOUDSPEAKING TELEPHONE No.9A

FIG 5

The telephone has the following features:-
(see fig 5)

1. A single enclosure houses the loudspeaker, dialling, ringing and audio input and output circuitry.

A jack socket is be provided for the connection of an external microphone.

2. A multi-way connector provides for connection to the main control box of the environmental control equipment. No dialling facility is provided on the telephone itself. All dialling is carried out by the environmental control equipment. Control of the volume giving two pre set levels is provided.

3. A 4-way connector to enable a second speaker and microphone to be used in another room is provided. A switch on the telephone determines which speaker and microphone are in use.

4. Three buttons are provided on the telephone. These are:-

a) "Take Call". Pressing this button answers the telephone.
b) "End Call". Pressing this button cancels the telephone.
c) "Vol". Pressing this button alters the volume.

5. The telephone is a 2 wire connected full duplex (not voice switched) unit with loop disconnect signalling. It is powered from the telephone line.

6. The telephone meets the requirements of BS6305 *.

7. Connection of the telephone to the environmental equipment does not to infringe BS5724:1 (IEC601:1) for that equipment. An opto-isolating barrier giving 4kV isolation between the telephone line and the environmental control equipment has been built into the telephone.

The telephone was approved for connection to the British Telephone Network in Nov. 1984 and to date approximately 600 units have been installed with disabled people.

*BS6305:1982 General requirements for apparatus for connection to the British Telecommunications public switched telephone network.

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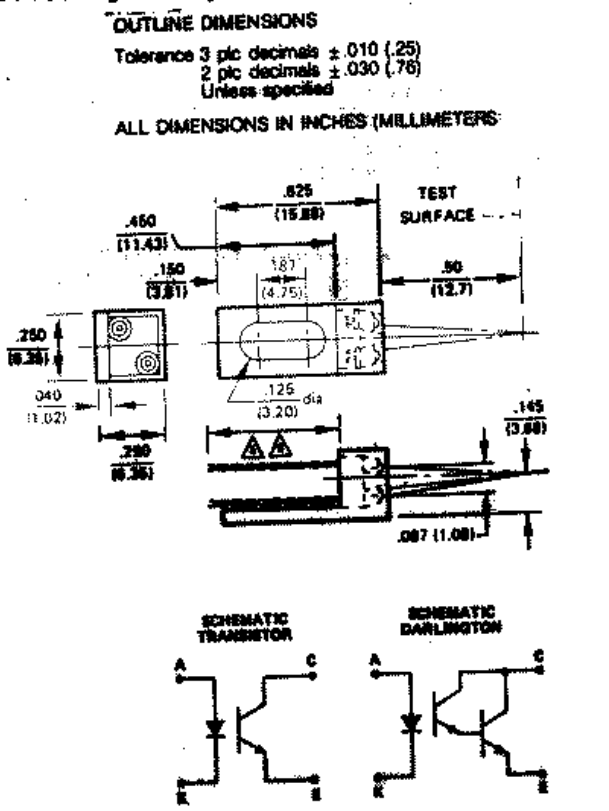

FIG 6

Because human skin is a good reflector of infrared light, the photo transistor will turn on when the device is brought into close proximity to the skin.

The device can be used as a blink detector. Because the reflective assembly is small, it can be mounted onto the arm of a spectacle frame, with the reflective assembly pointing at the eye. The sensitivity of the receiver circuit can be adjusted so that the photo transistor turns on when the eyelid is closed.

The design of the adjustable mounting for the spectacle frame is not simple. It is particularly important to make sure that no part of the assembly can cause physical harm to the wearer by actually touching the eye. Various prototypes are being tried.

Another very important design consideration is the maintenance of safe levels of infrared radiation directed at the eye. In the current design the mean level of radiated infrared emitted from the device is about 1/10m W at an approximate wavelength of 800nM. The accepted safe limit of continuous mean power for the eye is 10mW.

The proximity/eye switch has been designed for direct connection to the actuator switch input on the environmental control indicator board. It is powered from the 12 volt D.C. supply provided at the actuator socket.

The control logic for the device utilizes a programmable logic array. For use as a blink detector with the environmental control, the array is programmed to operate in the following manner:-

1. A blink of less than 200mS will be ignored.

2. A blink of 200mS or more will operate the environmental control.

3. An eye closure of more than 1 second will be interpreted as the wearer having gone to sleep and will cancel the scan light on the environmental control without a selection being made.

Remote control transmitter/receiver

The environmental control equipment was originally designed with the intention of directly wiring the actuator switch to the indicator display. For a patient who is not in a motorised wheel chair this arrangement is usually satisfactory. For many users in wheel chairs however, there is a clear need for remote control actuators.

We have designed an infrared transmitter/receiver which can be used with the majority of patient actuator switches.
The system comprises:

1. A battery powered infrared transmitter unit.
Size: 165mm x 80mm x 25mm.
Weight: 212 grams (complete with PP3 battery).
It has the following features:-
a) A pressure sensitive switch on the top of the transmitter. The area of the switch is approximately 50 x 50mm.
b) A 'battery voltage low' warning device.
When the transmitter switch is operated an audible "bleep" will be heard if the transmitter battery needs to be changed. When this occurs there is still plenty of time left before the battery is completely discharged. There will however be a gradual reduction in the operating range of the system.
c) A miniature jack socket is fitted on the side of the transmitter. This enables any normally open switch to be used to operate the transmitter.
d) An internal adjustment to the transmitter enables up to 6 different transmitters and receivers to be operated independently of each other in the same room. Each transmitter will only activate the receiver unit set
to receive its own unique infrared code.
e) The transmitter can be mounted in a variety of ways to suit individual needs.

2. An infrared receiver unit.
Size: 90mm x 55mm x 30mm.
Weight: 220 grams.
It has the following features:-
a) A 3 meter lead with 7 way d.i.n. plug enables direct connection to the environmental control equipment indicator board. The lead provides power to the receiver. It also connects the output control signal from the receiver to the control equipment.
b) If 2nd room operation is required a second receiver unit may be connected, via an extension cable, to the first receiver. A 7 way d.i.n. socket is provided at the rear of each receiver for this purpose. Up to six receivers could be connected together in this way. The 7 way d.i.n. socket can also be used to provide a non-remote actuator switch input to the environmental control equipment.

EXPANSION OF THE BASIC ENVIRONMENTAL CONTROL

The equipment was designed with the capability of being modified or expanded. As a result we have been able to respond to the majority of requests for the control of special items. Some of these items include:-

1) Page turners
2) 2 Movement bed and chair controls.
3) Curtain control
4) Talking books.
5) Special alarm systems.

We have found that control of only 5 mains or battery powered appliances is usually sufficient. Areas for further development are:-

1) The need for TV and possibly radio channel change units.

2) Tape recorder control.

3) Improved bed/chair control.

4) The use of synthetic speech with the telephone and intercoms.

Word Processor

A prototype word processing system to work in conjunction with the environmental control equipment has been produced. The selection of 'computer', on the indicator board automatically enables the actuator switch to control the word processor. The computer used is the BBC Microcomputer System produced by Acorn. The software developed so far requires the use of two monitors. One monitor for the display of a letter selection grid and the other for displaying the text. The eventual intention is to combine the selection grip and text on to a single large screen. The word processor will be available for use in various languages.

An important requirement of the environmental control/computer interface is that the user is always able to regain the control of the environmental system even in the event of a computer malfunction.

CONCLUSIONS

Opinions differ as to the most effective use of the technology available when designing an environmental control system for the profoundly physically disabled. The design emphasis in the U.K. has been for simplicity of use, safety and reliability. The equipment described in this paper has been developed as a direct result of these requirements.

For reasons of reliability and safety standard home computers have not been used in significant numbers in the U.K. for adaption as environmental control equipment.

This is also why special techniques to reduce the complexity of the wiring between component parts of a system have not been used on a wider scale. Nevertheless, the obvious advantages of simplifying the wiring is an attractive prospect for future developments if reliability can be guaranteed.

Experience has shown that the majority of people using our equipment have fairly basic needs in terms of a control system.

It is frequently an advantage to reduce the number of selections available or slightly to modify the way a particular item functions. The flexible design approach used in the Steeper system make this possible. It has also made it possible to respond to the majority of requests for special adaptions, and in the future will provide more sophisticated requirements such as the use of a word processor.