A COST-EFFECTIVE REMOTE MONITORING AND COMMUNICATION SYSTEM

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ABSTRACT

Remote monitoring of elevators is one of the most important features of elevator systems. The issue was addressed in CIBSE Guide D 1993 and it will be discussed in details again in the coming revision of Guide D 1998/99. The benefits of elevator monitoring are obvious but there is a danger of collecting so much data that it cannot be assessed and therefore will not be acted upon. Furthermore, the new standards and guidelines for remote monitoring very much rely on the availability of advanced microprocessor-based elevator controllers. A cost-effective system was developed, which can be applied to both new and existing installations, even the relay-logic type of controllers. Besides the monitoring of fundamental parameters and status, the system allows verbal communication between the emergency centre and the trapped passengers without the need to modify or replace the existing intercommunication system. The most distinctive feature of the system is the low cost of production.

1 INTRODUCTION

In accordance with CIBSE Guide D 1993, a study published by the National Economic Development Office in 1990 on the views of customers on lifts and escalators presented a depressing picture of the vertical transportation industry in Britain and clearly demonstrated the need for all-round improvements in performance.

In Hong Kong, more than 99% of elevator installations are still relying on the manual mode of fault reporting. When there is something wrong with a lift, the caretaker of the building can identify the problem either visually or by some means of local indicating panel. Or when some passengers are being trapped inside the lift, the passengers will normally press the emergency alarm button to make the caretaker alert of the case. Both incidents lead to the same result that the caretaker makes a phone call to the 24-hour emergency centre of the elevator maintenance contractor. The shift duty staff inside the emergency centre will contact the appropriate district maintenance team to send technical staff to attend the fault and carry out repair work. The delay in fault attendance will vary from tens of minutes to few hours, depending on the terms laid down in the relevant maintenance contract. This approach has been the most conventional practice in Hong Kong.

However, the caretaker is not always available. Furthermore, the message relayed to the emergency centre is often very brief, i.e. a breakdown either in exaggeration or under-estimation. From a technical point of view, a high priority should always be given when passengers are trapped inside a failed car whereas, a relatively longer delay in fault attendance can be tolerated when the car just breaks down and fails to serve landing calls. Therefore, the procedure of fault attendance must be improved so that the emergency centre will automatically be notified whenever a lift fails to operate and the shift duty staff must be able to judge whether any passenger is trapped inside the car. The district maintenance staff will then be informed immediately to attend the fault. The reliance on human reporting by the caretaker can be greatly reduced. Such an automatic procedure will enable automatic data logging and statistical trend analysis in the long-run.

Remote monitoring and interfacing with the elevator system is not new. But, it is still not popular in Hong Kong. The reason is twofold. First, most remote monitoring systems available in the market are designed for new installations that are microprocessor based while it will be a very major renovation work if they are to be installed in existing old-version lifts. Secondly, they are very often very expensive so that owners of lifts are reluctant to pay extra money to purchase them with the view to the seemingly satisfactory fault attending procedures at the present moment. In this paper, we describe our development of a cost-effective remote elevator monitoring and alarming system (REMAS) that can fit to any existing installations, even the relay-logic controllers installed in the 60's and 70's.

2 FEATURES AND BENEFITS OF REMOTE LIFT MONITORING

2.1 Features of remote lift monitoring

A standard lift monitoring system, in accordance with CIBSE Guide D 1993 is shown in Figure 1. The general features include:

i) indication of lift-in-service status
ii) trapped passenger alarms
iii) inoperable lift alarms
iv) performance malfunction (alarms)
v) early transmission of alarms and status to the lift maintenance contractor's monitoring control centre
vi) automatic collection of lift performance data
vii) two-way voice communication with trapped passengers
viii) remote configuration of field units
ix) ability to conduct 'on-line' investigation and analysis of lift activity
x) optional measurement of levelling performance
xi) data analysis

2.2 Benefits of lift monitoring

In accordance with CIBSE Guide D 1993, there is always a danger of collecting so much data that it cannot be assessed and therefore will not be acted upon. A clearly defined management approach is necessary if this is to be avoided. The benefits of remote monitoring to passengers include:

i) increased safety
ii) increased reliability
iii) faster response times
iv) quicker action in the event of breakdown
v) quicker action in the event of complaints

The benefits to the building owner include:

i) increased safety
ii) increased availability and reliability
iii) faster response to callbacks
iv) elimination of repetitive breakdowns
v) anticipation of breakdown
vi) achievement of maximum performance
vii) establishment of condition maintenance programmes
viii) 24-hour protection against accidental or deliberate damage
ix) 24-hour assistance for trapped passengers
x) direct contact with lift maintenance contractor's monitoring control centre

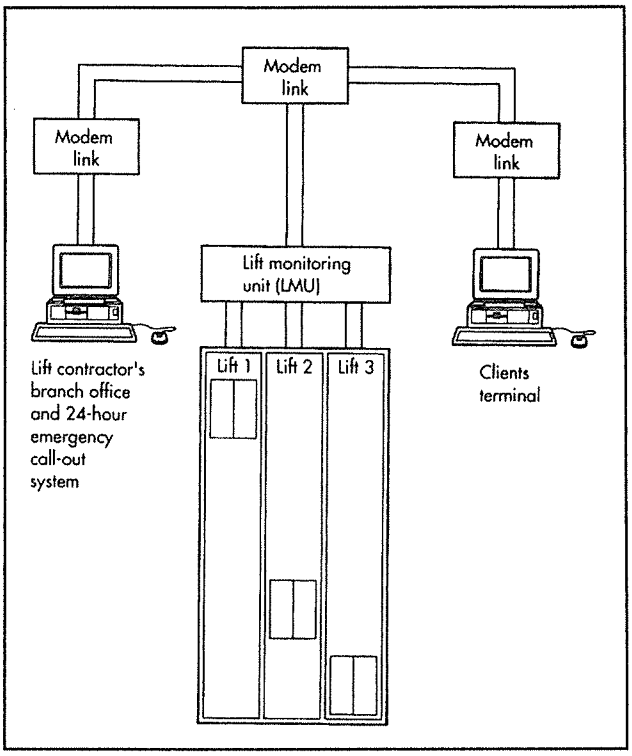

Figure 1

The benefits to the lift contractor include:

i) provides protection to service base
ii) provides information to enable field engineers to correct faults more quickly
iii) faster response to problems
iv) assistance in identifying genuine call-backs where a performance related contract is in operation
v) improved fault detection and monitoring of maintenance procedures

The benefits to the manufacturer include:

i) provision of feedback from the field to assist with future development
ii) provision of feedback from the field to improve and develop computer-based traffic analysis programs and simulation software

Although there are so many benefits for remote lift monitoring, the major criteria are convenience of installation and cost effectiveness. Therefore, the design objective for existing lift installations should be the provision of minimum features that can achieve the basic requirements of the owner and the maintenance contractor. For new lift installations, the system can be more fancy that includes all the eleven items detailed in section 2.1.

3 REMOTE ELEVATOR MONITORING AND ALARMING SYSTEM

3.1 The design requirements

In order to keep a reasonable cost for the developed system and to avoid the danger of collecting so much data that it cannot be usefully assessed, we have rigorously evaluated the eleven required features as detailed in section 2.1. In Hong Kong, a lift can be switched off anytime during off-peak hours by the management office of the building and the lift maintenance contractor has no interest in it. Thus, item 2.1 (i) needs no reporting. Item 2.1 (ii) is important and it should be reported to the emergency centre. Items 2.1 (iii), (iv), (v) are similar and they are combined together to form one common alarm signal. Items (vi), (viii), (ix), (x) and (xi) are advanced features that are not important from an operational point of view. They should be included for new lift installations. For improvement on existing installations, they are not necessary. Item (vii) is important as the trapped passengers are very often very concerning about their lives and are in panic. Some verbal communication between them and the emergency centre will make them feel comfortable psychologically. At least, they can get have the faith that somebody will be coming to save them and under this situation, they are very often willing to wait for a longer period of time.

3.2 The design specifications

The REMAS can detect the following six incidents:

i) door lock fault: the landing door or car door is open abnormally for more than 50 seconds
ii) controller electric power supply fault: the 110 V d.c. supply to the controller fails
iii) controller fault: a general failure of the controller when the relevant safety relay trips
iv) battery supply failure: an undervoltage with the 24 V battery on the car top is detected
v) emergency call alarm: the alarm is triggered by a trapped passenger for a period of more than 3 seconds
vi) 220 V a.c. power supply failure to the REMAS

The REMAS has a built-in 12 V battery and it can sustain normal operation of the REMAS for a period of more than 2 hours. Under normal circumstances, the built-in charger of the REMAS continuously float charges the battery from the 220 V a.c. supply. Hence, in case of failure of the city mains, REMAS will inform the emergency centre immediately. The REMAS is installed inside the lift machine room because all signals from the car will be wired back to the controller via the travelling cables.

The size of the REMAS is 20 cm (width) x 26 cm (depth) x 13 cm (height), weighing 2.8 kg, as shown in Figure 2. It is of simple design philosophy so that all skilful or semi-skilful lift workers in Hong Kong are able to install it by the side of the lift controller. One REMAS is designed to monitor most four lifts. For monitoring one or

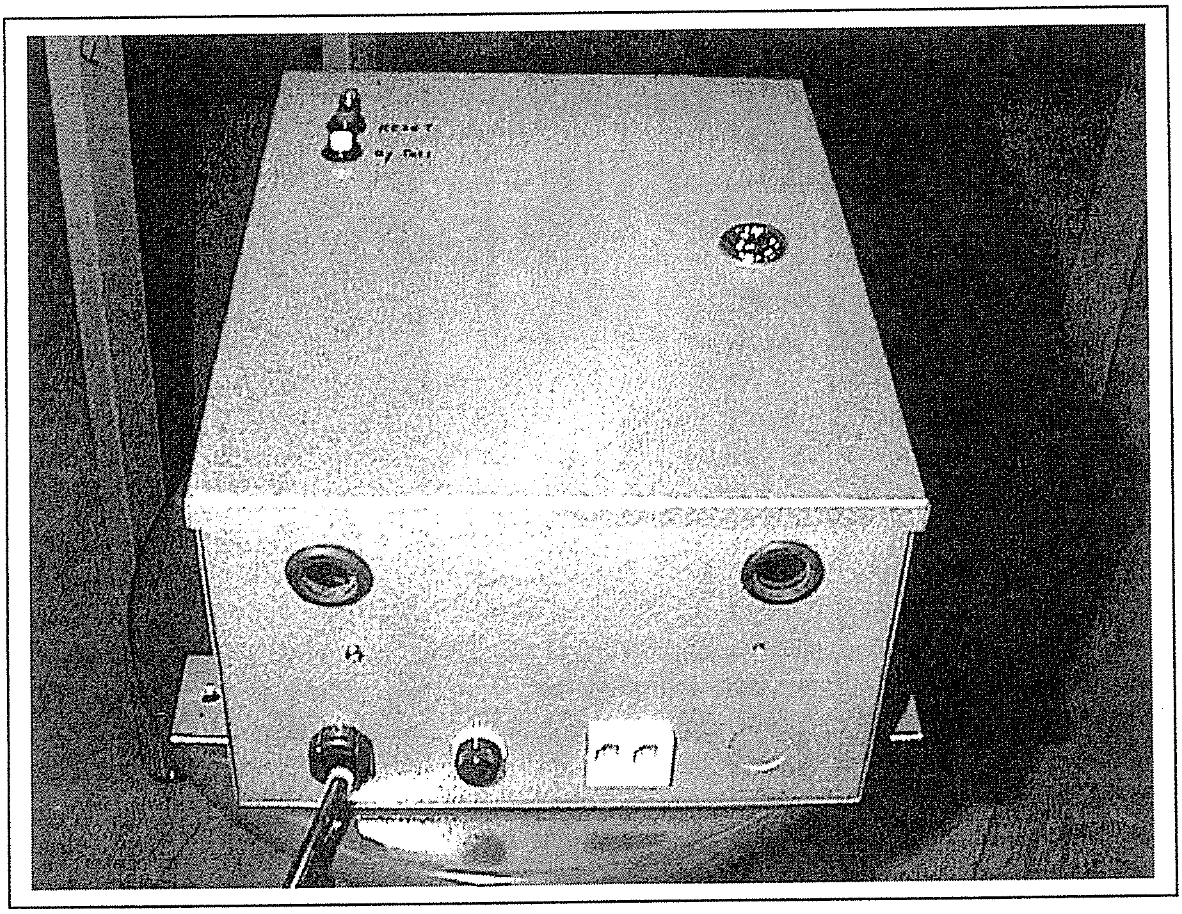

Figure 2

two lifts, a REMAS of even lower cost is available with less electronic components inside. From Figure 2, it can be seen that there are two cable inlets for the interfaces between the REMAS and the lift controllers. The black cable towards the bottom-left corner of the chassis is the 220 V city mains supply. Next to it is the fuse holder while the white socket is the standard dual telephone jacks, in and out. The REMAS has built-in communication modem chip for connection to the ISTN and one telephone line is adequate enough to serve a maximum of four REMASs, i.e. a maximum of 16 lift controllers within a machine room and it is good enough for most applications.

There are one LED and two push-buttons on the panel of the REMAS, as shown in Figure 3. The LED indicates the real-time status of the REMAS to the maintenance staff. Under normal operation, the LED flashes at a frequency of 5 Hz, with mark-space ratio of 1:1. When the LED is either permanent "on" or "off", the REMAS fails to operate. Besides normal operation, there are two more modes of operation, namely the holding mode and the by-pass mode. Under the holding mode, the LED flashes at a frequency of 1 Hz and that indicates the REMAS has received an alarming signal from the interfacing wires and the emergency centre is being accessed or has been accessed. Under the by-pass mode, the LED flashes at a frequency of 0.2 Hz. According to the statutory regulations in Hong Kong, every lift needs regular maintenance at a rate of once per fortnight. When the maintenance staff arrives at the machine room, the by-pass button will be pressed and the REMAS will go into the by-pass mode. Under this mode, the REMAS will not respond to any alarming signal from the lift controllers. This action ensures that the emergency centre will not receive any false alarm due to routine

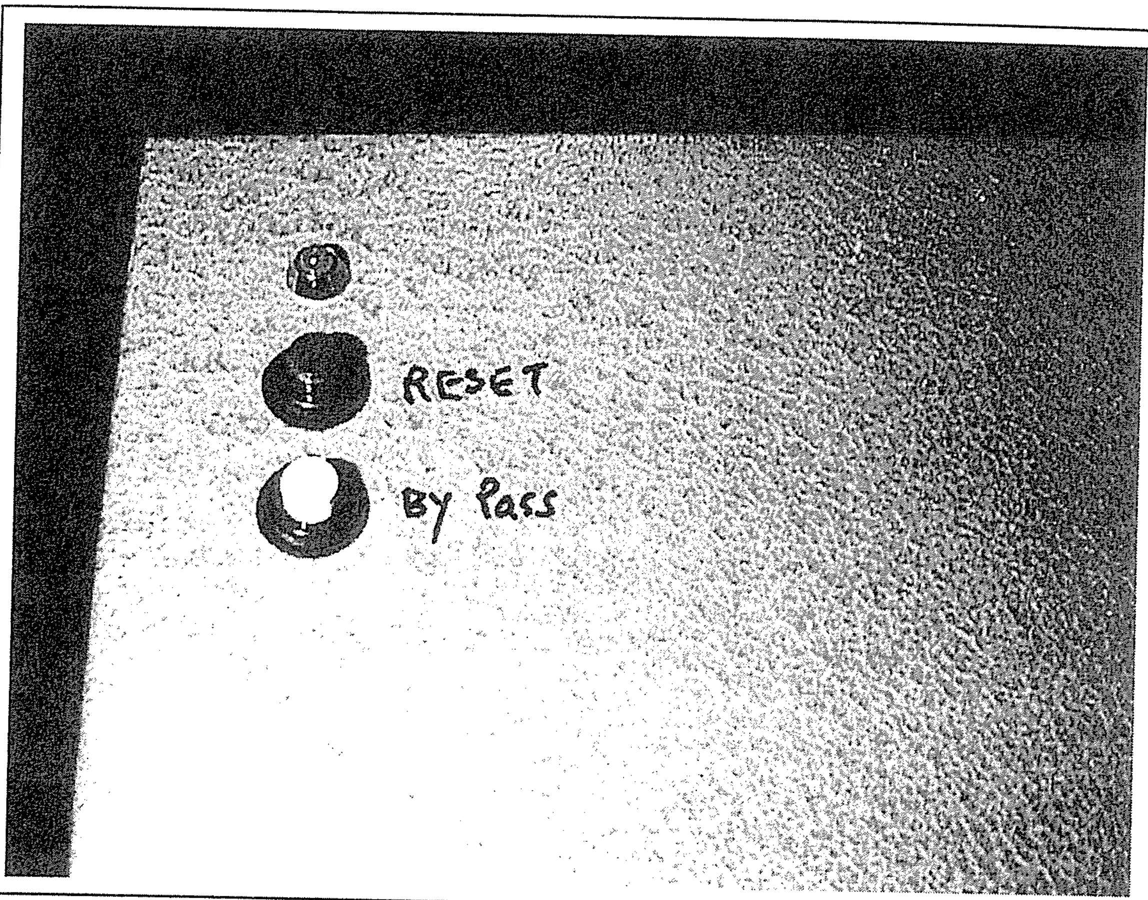

Figure 3

maintenance. After the maintenance staff has completed the work, the reset button will be pressed and the REMAS will go back to the normal mode with the LED flashing at a rate of 5 Hz.

A repeating lamp bulb is installed at the lift lobby of the main terminal so that the caretaker will notice a failure with the REMAS when the lamp bulb is not flashing.

3.3 The operation of REMAS

As mentioned in the last section, there are six binary inputs for each lift. The alarm button pressed by the passengers is assigned the top priority. When REMAS detects any problem, it will wait for the specific period of delayed time and confirm that it is a genuine problem. Then, it will dial up the 24-hour emergency centre, which is basically a PC with a voice modem. Once connected, it will transmit a string of bytes to it, message including the identification number of the car and the problem code. It will be very expensive if a full-scale modem is used. Hence, a telephone communication chip has been built on the PCB using tone coding. The PC inside the emergency centre will display the relevant information on the screen. If the problem is related to the trapping of passengers, the PC will give a discontinuous beeping signal and the staff inside the emergency centre will pick up the handset and talk to the trapped passengers inside the car. After the conversation has been completed, the REMAS will dial up the caretaker so that the trapped passengers have the chance to talk to the caretaker as well. After that, the REMAS will dial up the caretaker every time when that group of trapped passengers presses the alarm button again.

Since a manual alarm is of highest priority, the REMAS will dial up the emergency centre or the caretaker every time when such a alarm is triggered. However, for other alarms such as door-lock fault or power supply fault etc., the REMAS will only report once for every lift until the REMAS is reset. The philosophy here is to minimise the number of phone calls received by the emergency centre. Once the REMAS has reported a fault with a lift, the emergency centre has already informed the district maintenance staff to attend the fault. And after the maintenance staff has rectified the fault, the REMAS will be reset manually. Therefore, there is no meaning to report to the emergency centre another fault before the arrival of the maintenance staff. It should be kept in mind that the PC is manually attended in the emergency centre and we are talking about thousands of REMASs operating in the city.

3.4 The internal structure of REMAS

There are basically two PCBs inside the REMAS, the interfacing terminal blocks and

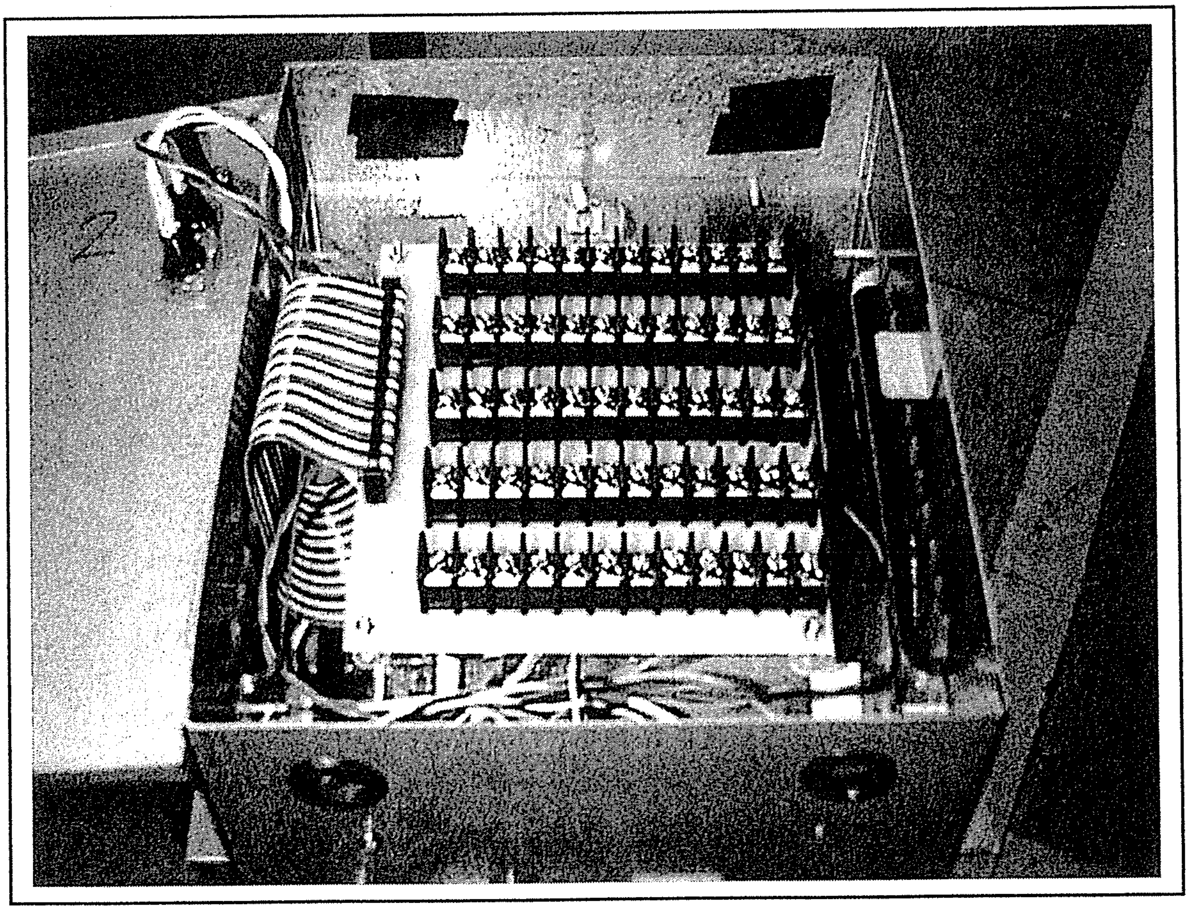

Figure 4

the micro-controller card. Figure 4 shows the terminal blocks. When the two interfacing cables enter the REMAS, the individual cord will be terminated on each screw terminal. There are totally 60 screw terminals available, in five blocks, adequate enough for interfacing at most four lift controllers. All these terminals are connected to the micro-controller card via the flat cable by the side. The advantage of this design is that the micro-controller card will not be disturbed during on-site installation. The workers only need to disconnect the flat cable and carry out the connection of the interfacing cables. After that, the flat cable is fixed and the system will start to operate.

Figure 5 shows the micro-controller card with the terminal blocks removed. There are, in general, seven major parts on the micro-controller card. "A" are reed switches for

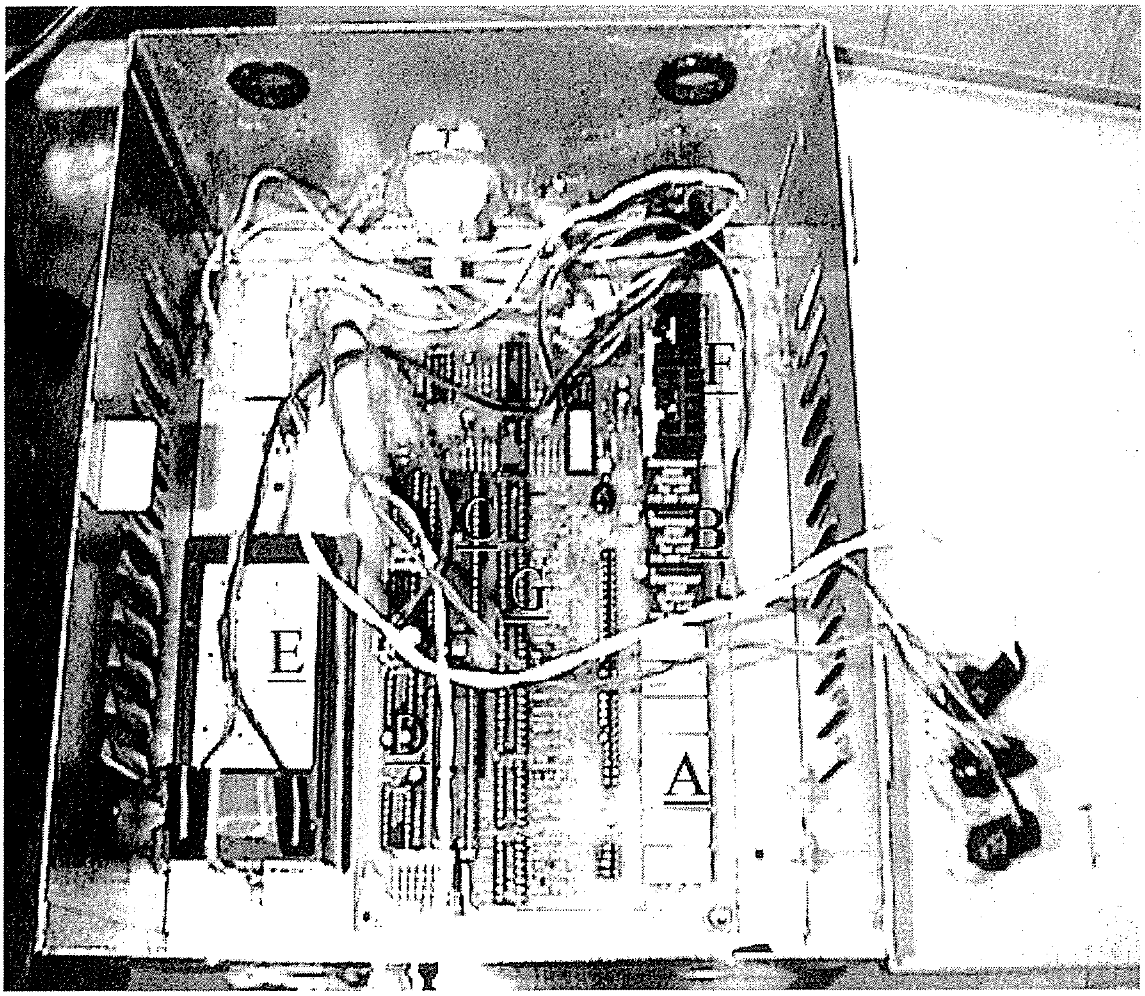

Figure 5

circuit diversion. It is better to use electro-mechanical devices rather than purely electronic devices to serve the functions because our experiments revealed that noise could be reduced in this way. The circuit diversion is to make a switching between the built-in intercommunication system of each lift car and the modem chip. "B" are the isolation transformers which are used to match the d.c. levels between the micro-controller board and the PSTN line. "C" is the microprocessor with built-in RAM and input/output ports, which is responsible for the major control functions of the REMAS. One microprocessor is good enough to serve two lifts and therefore, if four lifts are to be served by one BEPSA, a parallel microprocessor arrangement is needed. The socket below "C" is reserved for the second microprocessor. "D" are the modem chip and watchdog devices. "E" is the battery that allows continuous operation of the BEPSA for two hours under a major failure with the city mains. "F" is the charger and voltage regulator that supply electric power to the micro-controller board and the battery. "G" are the opto-couplers for complete isolation between the raw signals from the flat cable and the input/output ports of the microprocessors.

It can be seen that the whole design is module-based with two PCBs only. The chance of a fault with the interfacing terminal blocks is very remote because there is no active device there. If there is any fault with the micro-controller card, the watchdog system will try to reset the microprocessor every 15 seconds. The indicator LED will be kept "on" or "off" continuously for the 15 seconds and a flash for just 0.5 second. This is good enough for the caretaker to notice that there is a fault with the BEPSA. Under this situation, the whole BEPSA will be taken down and replaced by a new one. The maintenance staff only needs to disconnect the interfacing terminal blocks from the flat cable and connect it to the flat cable of the replaced BEPSA. The whole exercise is around ten minutes. As a supplement, the watchdog system not only monitors the operation of the microprocessor continuously but it also monitors the modem chip as well. As one telephone line can serve at most four BEPSA, infinite theoretically, the microprocessor inside the BEPSA is able to detect whether the PSTN line is "on-hook" by another BEPSA or not. If the line is "on-hook", the BEPSA will wait for 15 seconds and repeat its attempt to get the telephone line.

It has been mentioned before that the emergency centre will need to serve thousands of BEPSAs around Hong Kong. The chance of a busy line at the side of the emergency centre is quite high. When the BEPSA detects a fault, it will turn itself into holding mode with a lower flashing rate of the indicating LED and dials up the emergency centre. If it fails, it will wait for 10 seconds and re-dial two more times. If it fails to communicate with the emergency centre after the three attempts, it will dial up the caretaker first and afterwards re-dial up the emergency centre.

4 FACILITIES IN THE EMERGENCY CENTRE

Inside the emergency centre, there is a PC with an external voice model and a standard telephone. When a call is received, the PC will communicate with the calling BEPSA first. If the alarm code reveals that there is a hardware fault, the lift number, the contract number, the address of the lift (in Chinese and English), the description of the fault (in Chinese), the telephone number of the district maintenance office and the telephone number of the caretaker will be displayed on the screen. Furthermore, the time, correct to seconds, of the receipt of the call and the time when the shift duty staff acknowledges the call will be registered and displayed on the screen. All the information will be saved in the harddisk for analysis in the future. If the alarm code reveals that there are trapped passengers, the relevant problem description will be displayed on the screen and the PC will beep to make the shift duty staff alert. The shift duty staff then picks up the handset of the telephone and talk to the trapped passengers. A maximum time period of one minute is programmed for the verbal communication. Of course, the shift duty staff can terminate the call before the end of the allocated period of time. Once the verbal communication is completed, the shift duty staff should contact the district maintenance team for action. If the shift duty staff is not available, the PC will terminate the call after 20 seconds and all information displayed on the screen related to that particular call will be turned to red colour so that the staff will notice that after his return. All saved information on the harddisk is "Microsoft Excel" compatible for easy retrieval.

5 CONCLUSION

In this paper, we have described the importance of remote monitoring and data logging of elevator systems in accordance with CIBSE Guide D 1993. Actually, that chapter will be improved and modified in the coming CIBSE Guide D 1998/99. For new installations, the monitoring system can be very sophisticated. However, we have got almost 45,000 existing installations in Hong Kong. It will be too expensive for the owners to accept if the sophisticated model is adopted for upgrading the safety standards of all these existing installations. The modern remote monitoring model often requires a microprocessor based lift controller and the associated digital intercommunication system of the lift car. We have developed a cost effective remote monitoring and alarming system that serves most important features of the modern model. It can be installed to any existing lift installation even a relay logic based controller is used. The time for installation is minimal, around two hours, with two skilful or semi-skilful lift workers. The cost of each BEPSA, including both digital and analog features, is less than US$1,000, i.e. US$250 per lift, excluding labour cost, if the BEPSA is serving four lifts. A lower cost model for two lifts is also available. What is inside the emergency centre is a PC with monitor, a printer, a voice modem and a telephone set, costing less than US$1,000, excluding the salary of the shift duty staff who are required even without the introduction of BEPSA.

6 ACKNOWLEDGEMENT

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