An Emergency Fire Telephone System

by

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Design and Development of

an Emergency Fire Telephone System

for the
Cape Town City Council

by

Alister D van Tonder

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for the

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at

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Cape Town City Council
Electricity Department
Test and Metering Branch
Computer Section

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Declaration.

I declare that this thesis is my own, unaided work.
It is being submitted in partial fulfillment
of the requirement for
the Masters Diploma in Technology.
It has not been submitted before for any Diploma or
examination at this or any other Techikon.

Name of Candidate: Alister D. van Tonder.

Signed: Alister D. van Tonder.

Date: 29th February 1988.

Acknowledgements.

Without the guidance, support and assistance of the following persons, this thesis may never have materialised.

The Cape Town City Council, in particular Mr. M.J. van Rensburg, Assistant City Electrical Engineer (Test and Metering Branch), for giving me the opportunity to do this project.

The members of the Computer Section (test and Metering Branch), for their contribution, guidance and support.

A special word of appreciation to my wife Engela for her loving support.

Summary.

The project entails designing and installing an emergency fire telephone system (EFTS) for the 23 storey Cape Town Administrative Civic Centre.

The original system, with its mostly analogue circuitry, has no documentation available, is difficult to maintain and has become unreliable. After considering alternative systems the most economical option was to expand the original system by adding more extension telephones and to redesign the control section.

The new EFTS briefly operates as follows:

The status of ninety six extension telephones, installed at the emergency exits on each floor, are displayed on a mimic status display which both operators can monitor. Any emergency call can be identified by a green flashing LED and a distinctive bleep. The LED indicates the exact position and number of the telephone in the building, Each operator has a keypad and a two digit numeric display fitted his telephone.

The operator can immediately answer incoming calls by pressing the queue button. Calls queue on a first in first out basis. The number of the extension telephone will be displayed on a numeric display. The operator can also select the extension he wishes to contact, by dialling the extension number on the keypad.

The EFTS consists of nine rack mounted printed circuit boards. A Microcomputer

board, made up of a Motorola MC6809 microprocessor, six 6821 PIAs, 2 kilobyte RAM, up to 16 kilobyte ROM and a watchdog timer controls the EFTS.

Two Telephone Controller boards process voice signals and generate logic control signals for the CMOS voice switching circuitry on the Multiplexer Monitor boards.

Six Multiplexer Monitor boards switch the two operators to any of the ninety six extension telephones and continuously monitor the extension telephone lines for faults and handset statuses. Noise and over voltage line protection is provided.

The multiplexing of the 192 LEDs on the Mimic Status Display is controlled by the Microcomputer board.

An unusual principle used in this design is the combination of low frequency AM and audio to affect communication.

Two uninterruptable power supplies provide user independence from mains.

Software used for the EFTS is written in 6809 Assembly Language. A Real time interrupt controls the Mimic Status Display. Operator actions are interfaced with the program logic by means of hardware interrupts.

Opsomming.

Hierdie tesis behels die ontwerp en installasie van 'n telefoon noodkommunikasiestelsel in die 23 verdieping Kaapstad Administratiewe Burgersentrum.

Die oorspronklike stelsel, wat meestal analoog-stroombane gebruik, beskik oor weinige dokumentasie. As gevolg hiervan is stelselonderhoud moelik en is die stelsel onbetroubaar. Nadat verskeie alternatiewe stelsels ondersoek is met inagneming van verskeie faktore was die mees ekonomiese uitweg die uibreiding van bestaande stelsel deur die byvoeging van 42 addisionele telefoonuitbreidings en die vervanging en herontwerp van die beheerstelsel.

Die nuwe telefoon noodkommunikasiestelsel behels die volgende:

Ses en negentig telefoonuitbreidings is by die nooduitgange op elke vloer aangebring. Die stand van elke telefoon word aangedui op 'n paneel met die uitleg van die gebou daarop. 'n Flikkerende LED, wat die posisie van die telefoon in die gebou aandui op die stelseltoestandvertooneenheid, dui 'n noodoproep aan. Die alarm gebruik 'n kenmerkende klank om oproepe of fouttoestande aan te kondig. Die twee operateurs se telefone is elk toegerus met 'n 4 x 4 sleutelbord en tweesyfervertooneenheid.

Die operateur beantwoord inkomende oproepe deur die Q-sleutel te gebruik. Hierdie fasiliteit koppel inkomende oproepe out-

omaties in volgorde deur die eerste-in-eerste-uit metode. Die operateur kan ook kies met watter telefoonuitbreidings hy in verbinding wil tree deur die uitbreidingnommer te skakel op sy sleutelbord.

Die stelsel bestaan uit nege rakgemonteerde stroombaankaarte en word beheer deur 'n Motorola 6809 mikro-rekenaar. Die mikrorekenaarkaart bestaan uit ses randeenheid koppelstukke (E.PIAs), 2 kilogreep leesskryfgeheue, 2 tot 16 kilogreep elektries-programmeerbare-leesalleengeheue en 'n waaktydreëllaar.

Twee telefoonbeheerkaarte prosesseer die stemkseine vir die stelsel. Beheerseine, wat deur die skakelbordkaarte gebruik word, word ook hierop verwerk.

Ses telefoonvertakskakelkaarte skakel die twee operateurs deur na enige van die 96 telefoonuitbreidings. Die status van al die telefoonlyne word gedurigdeur gemonitor vir fouttoestande sowel as die status van telefoongehoorstukke (d.i. of die gehoorstuk opgelig is al dan nie).

Die telefoonstandvertoonpaneel se 192 LEDs word op 'n tyddeel beginsel aangedryf.

Die stelsel gebruik 'n ongewone modulasietegniek vir die klank. Beide lae frekwensie amplitudemodulasie en suiwer oudio word gebruik.

Twee nie-onderbreekbare kragbronne word gebruik vir kragvoorsiening.

Motorola 6809 saamsteltaal is gebuik om programmatuur vir die stelsel te ontwikkel. 'n Reëltyd onderbreeksein beheer die stelseltoestandvertooneenheid. Alle datakop-

pelling tussen gebruikeraksies en die stelselprogrammatuur geskied d.m.v. apparatuuronderbreekseine.

INDEX

Chapter I.

INTRODUCTION.

A practical solution to the problem of designing and selecting the most suitable emergency communication system can be obtained by the careful consideration of various factors of which only six will be discussed in this chapter.

I.1 The importance.

Fires in high rise buildings spread rapidly and can be very fierce especially when spreading via lift shafts and ducts which make perfect ventilators. Evacuating people from the building should be controlled to promote safety and to reduce panic situations, while fire fighting activity should be coordinated throughout different areas in the building.

Because public buildings are prime targets for sabotage and terrorism, the evacuation procedure should remain secret. Therefore appropriate in situ communication and instructions should be issued during evacuations or emergencies.

I.2 The Requirements.

In order to control emergency situations it stands to reason that the communication system should be reliable and uncomplicated with good audio quality.

The system should allow the operator to communicate clear instructions to different locations in the building, to give and receive regular reports of conditions at specific locations and the progress of specific events and to supplement information for improved overall security.

The efficiency of an emergency telephone system depends on its ease of use and on the proficiency of the operator. An uncomplicated system requires less intensive training and thereby saves time and cost while ensuring the effective operation of the system.

In order to keep system downtime to a minimum, the system design has to incorporate simple and easy maintenance. Full documentation has to be provided.

The users have to be consulted to determine desirable user features. Clearly defined and well understood user requirements will improve the quality and efficiency of the end product.

Security, evacuation and life support communication systems provide private communication which will help constrain panic situations.

I.3 The Location.

The EFTS is used in the 23 storey Cape Town Administrative Civic Centre. Fire telephone extensions are located at the emergency escapes on every floor. The Control Centre, located in the basement of the building, directs all communication to the various locations throughout the building.

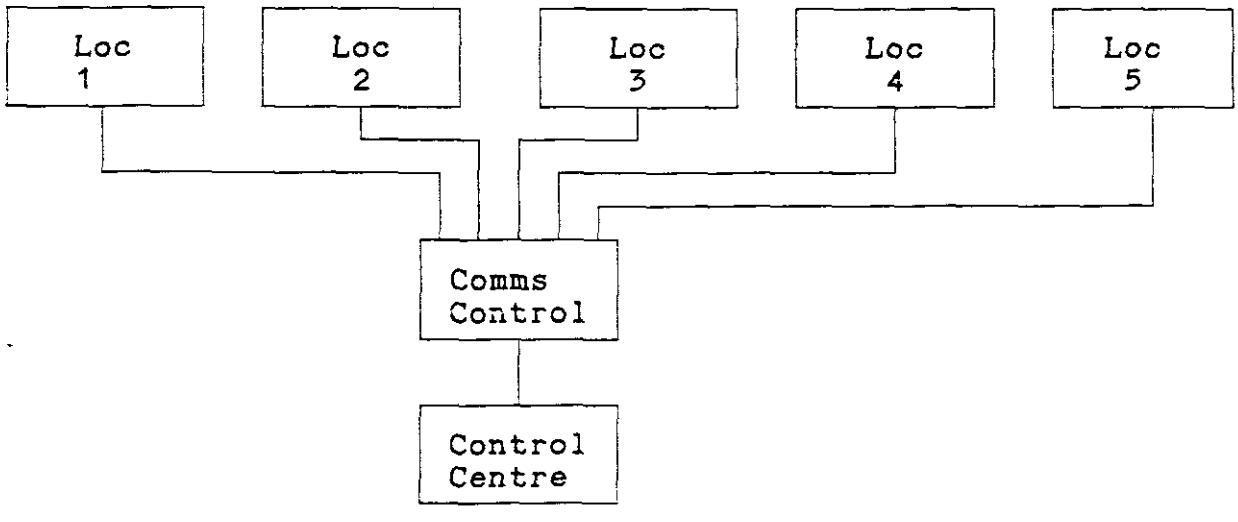


Fig.I.1. Functional Block Diagram.

I.4 Various communication systems available.

Use of **video and voice** provide the most elaborate communication. The visual and verbal contact ensure that the control centre is fully informed.

Video signals require a wide band transmission line. Suitable video equipment and transmission lines are very expensive.

Voice communication may be provided in different forms.

Two way communication can be realized in many different ways.

I.4.1. UHF radios provides full two way communication as well as mobility. Reliability is enhanced because of independence from use of cabling as transmission lines. Correct selection of operating frequency limits RF attenuation caused by the steel structure of the building.

Multiple channel radios allow simultaneous communication. Should secrecy be important the audio signals can be scrambled.

I.4.2. A standard **balanced telephone line system** provides good audio quality, is reliable and not expensive considering its performance.

In terms of transmission lines, a balanced line telephone would be the most suitable, since cabling is simple and relatively cheap. However cabling impose a reduced reliability during fires.

Depending on the communication control required (see block diagram, figure I.1), a suitable exchange can be implemented, whether digital, relay or standard switching techniques are used.

I.4.3. A high quality **intercom** system is another option. Either telephone handsets or loudspeakers can be used. A low cost system will use small 50 mm high impedance loudspeakers at all locations. Impedance matching transformers may be used as necessary. Relatively good voice quality is possible.

Low signal levels are associated with low impedance transducers. Amplification of both received and transmitted voice signals will therefore be required. Methods of powering these amplifiers via the two signal lines complicate the design. Additional cabling for power make the design more expensive than a balanced line telephone system.

Handsets provide for more private communication than loudspeakers.

I.4.4. **One way communication** will certainly be the cheapest option. This can be accomplished using voice communication or other means.

In fact the most common building evacuation systems are one way communication systems. A 100V PA amplifier would drive loudspeakers mounted at suitable locations throughout the building.

Since the earliest times visual (**nonverbal**) signals have been used for communication. A very basic form is to use strategically placed labelled indicator lamps. More elaborate communication using alpha numeric displays can be used to display text messages.

I.5. The operation of various systems.

I.5.1. UHF radio communication.

Handheld UHF two way radios provide a very effective communications network. See figure I.2 for a proposed system.

A base station will be installed at the Control Centre to provide not only communication control, but also a more powerful transmitter to effect communication to any point within the building and the near proximity. The base station can have an antenna mounted in a suitable area to provide full coverage of the building. A suitable emergency repeater station can provide the same features.

The Handheld radios are kept in suitable positions were security staff or those responsible for evacuation can obtain

them. These radios will remain on a trickle charge to keep them fully operational.

Spare battery packs can be used on a rotational basis. While security staff use the handheld radios daily, some batteries will be on charge while other are used in the radios. This ensures that radios are tested and operational and spare fully charged batteries are available at all times.

A suitably located repeater station will ensure good communication throughout the building between all radios. The additional cost of this will outweigh the improved performance of the radios. Also, lower powered radios may then be used.

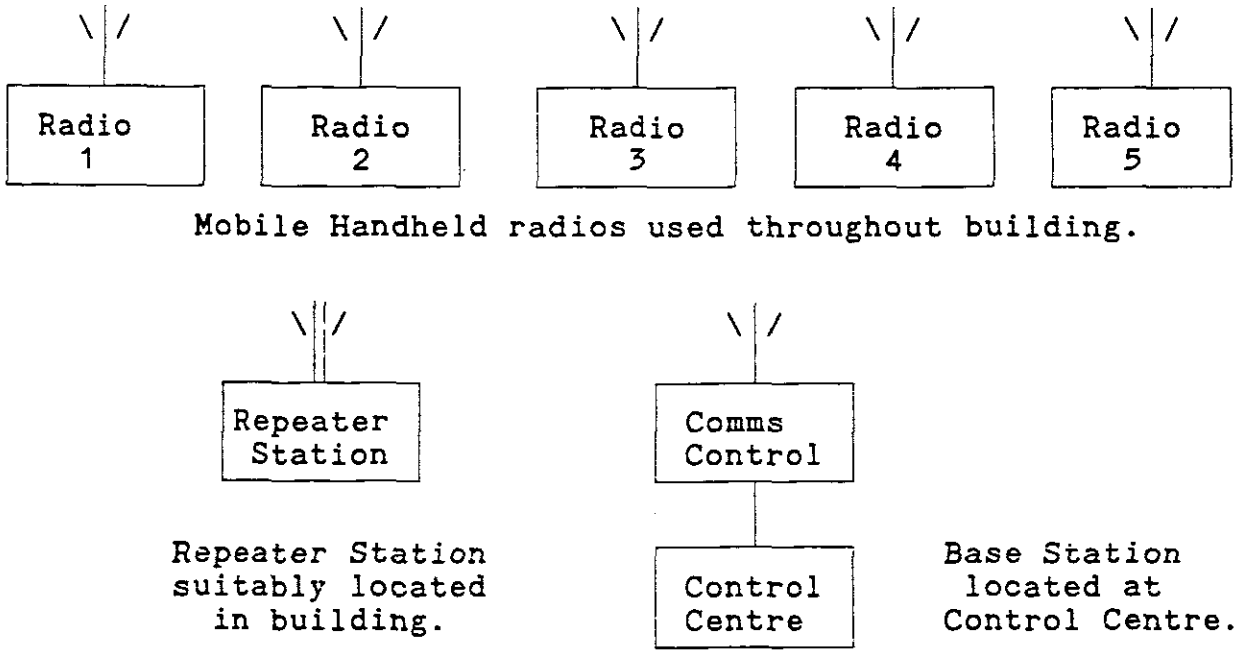


Fig.I.2. UHF radio communication.

I.5.2. A balanced line telephone system.

This system requires separate or its own cable paths but can serve as a backup to an existing PABX telephone system. If special care is taken in routing the cabling, the risk of fire damage to the cabling can be reduced substantially.

A telephone exchange which meets the system requirements will be installed in the Control Centre. The exchange operator controls the flow of communication manually.

I.5.3. An intercom system.

A two way intercom system will provide a similar service than that of a balanced line telephone system. Instead of using standard telephone units, a simple box with a small 50 mm loudspeaker and a line transformer is provided. A button on the box will provide a call facility.

The hardware cost of the intercom system is substantially less when using loudspeaker units instead of telephones. Cabling costs will be more or less the same for both systems.

Should an amplifier be required at each loudspeaker, this can be powered by providing DC on the lines. A hybrid network in the amplifier separates the DC from the audio signals.

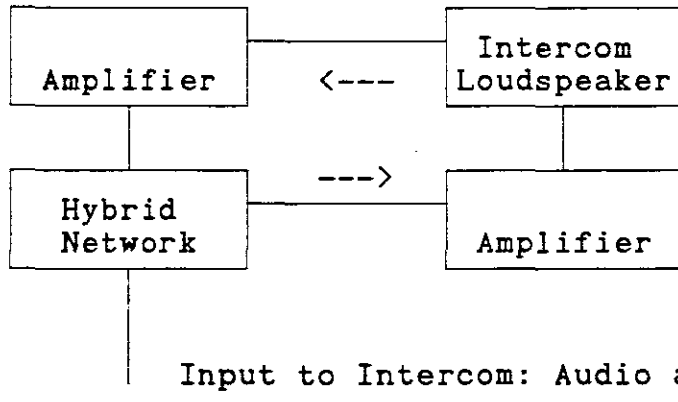


Fig.I.3. Intercom system.

Switching of intercoms at the Control Centre exchange may be done using switches, relays or electronic switching (i.e. CMOS analogue switches). Indication of selected intercoms is indicated by the switch position, i.e. switches remain in a centre position until activated. Incoming calls are indicated by a LED.

Should handsets instead of loudspeakers be required, the design remain basically the same.

I.6. Circumstantial and budget limitations.

I.6.1. The original system.

This system has been in use since the commissioning of the building. It requires only one operator to communicate with fifty four extension telephones.

Unique to the design of the original system is the special PYRO cabling used to provide telephone cabling which will withstand the high duct temperatures in cases of fire. This cabling has a solid copper outer core. The individual conductors are isolated from the outer core by means of a powdery substance which withstands very high temperatures before the isolation breaks down.

The high cost of the PYRO cabling has necessitated minimization of the number of wires per extension telephone. Therefore only one wire per extension telephone is used. The copper outer core, which forms an earth return path, is used as the second conductor. This forms an unbalanced line condition requiring more complex termination of the lines.

No documentation is presently available for the original system and therefore several design details are unknown. The modulation technique used for communication between the extension telephone and the Control Center is an unusual technique.

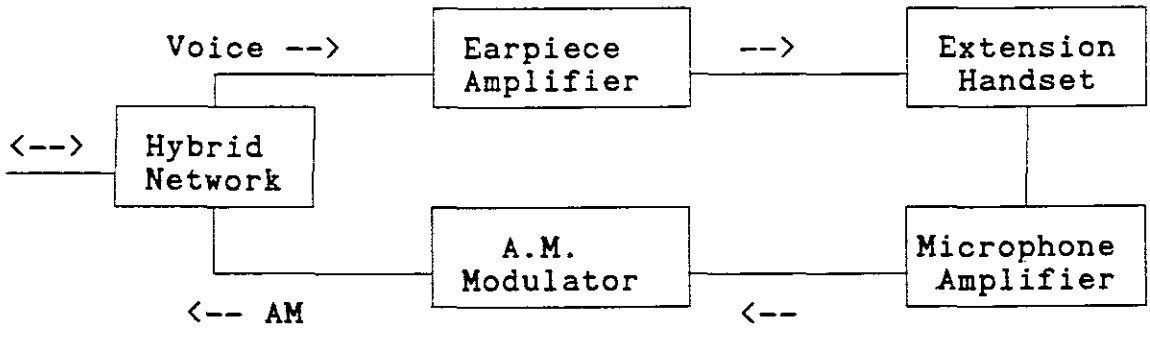


Fig.I.4. Extension Telephone Block Diagram.

The voice signal between the extension telephone and the Control Centre use amplitude modulation of which the carrier frequency is 14 kHz. The voice signal between the Control Centre and the extension telephone uses normal audio.

I.6.2. Existing cabling has to be used.

Since so much has been invested in the cabling of the original system, the new system will have to utilize the existing cabling which places many limitations on the new design.

The number of extension telephones have to be increased to ninety six. The additional extension telephones will use identical cabling in order to provide equivalent safety and performance.

I.6.3. Modulation technique used in existing system.

The low carrier frequency used causes several problems.

An audio bandwidth of 300 to 3400 Hz is used. With a carrier frequency of 14 kHz the lower side band will be at 10 600 Hz (14 000 - 3400). Very good filtering will be required if high gain amplifiers are required in the extension telephone.

From the extension telephone block diagram (figure I.4) it can be seen that a feedback loop is formed. The hybrid network, the earpiece and mouthpiece of the handset forms the feedback paths under non-ideal conditions. This will require careful attention.

I.6.4. Limited budget.

UHF radios: For an effective system a minimum of fifteen handheld radios will be required as well as a base station and a repeater station. This would be too expensive for a conservative budget.

Balanced telephone system: The replacement of at least fifty four existing telephones as well as the acquisition of new balanced line twisted pair cabling would be uneconomical.

Standard telephone equipment: A limited budget will not allow for the cost of a new system.

Intercom System: The cost of this system will be equal to the cost of a new EFTS installation. New telephone line cables will have to be installed and the present investment in cabling and extension telephones forfeited.

I.7. A practical solution.

Retaining the 54 existing extension telephones, adding 42 new extension telephones with the same cabling and redesigning and replacing obsolete control equipment would be the most viable and economical solution.

New features of the expanded system will be:

A second operator at the Control Centre.

First in first out (FIFO) queuing of extension telephones awaiting a response from the Control Centre.

Real time line proving of all the extension telephone lines.

A mimic display panel to indicate the status of the EFTS, i.e. both the status of all extension telephones and the condition of all the extension telephone lines.

An uninterruptable power supply.

Chapter II

DESIGN CONSIDERATIONS.

The philosophy of design of the EFTS is considered in this chapter. Technical design detail is discussed in a later chapter.

II.1 System Block Diagram.

The EFTS is divided into several functional blocks. These are:

1. Microcomputer Board.
2. Telephone Controller Board.
3. Multiplexer and Monitoring Boards.
4. Status Display.
5. Operator Telephones.
6. Power Supplies
7. Subrack and associated hardware.

A short description of some of the functional blocks are given.

The telephone controller board processes all audio signals, generates and controls the ring tone, and generates several logic control signals for the multiplexer monitor boards.

The primary function of the multiplexer monitor board is to switch the voice signal between an operator telephone and an extension telephone. It also monitors the extension telephone handset statuses and the extension telephone lines for faults.

The status display displays extension telephone handset and extension telephone line statuses. LEDs are used as indicators.

The operator telephones control the communication. The extension telephone is always the slave of the operator telephone. Each operator telephone consists of a handset, cradle switch, keypad and two digit 7 segment display.

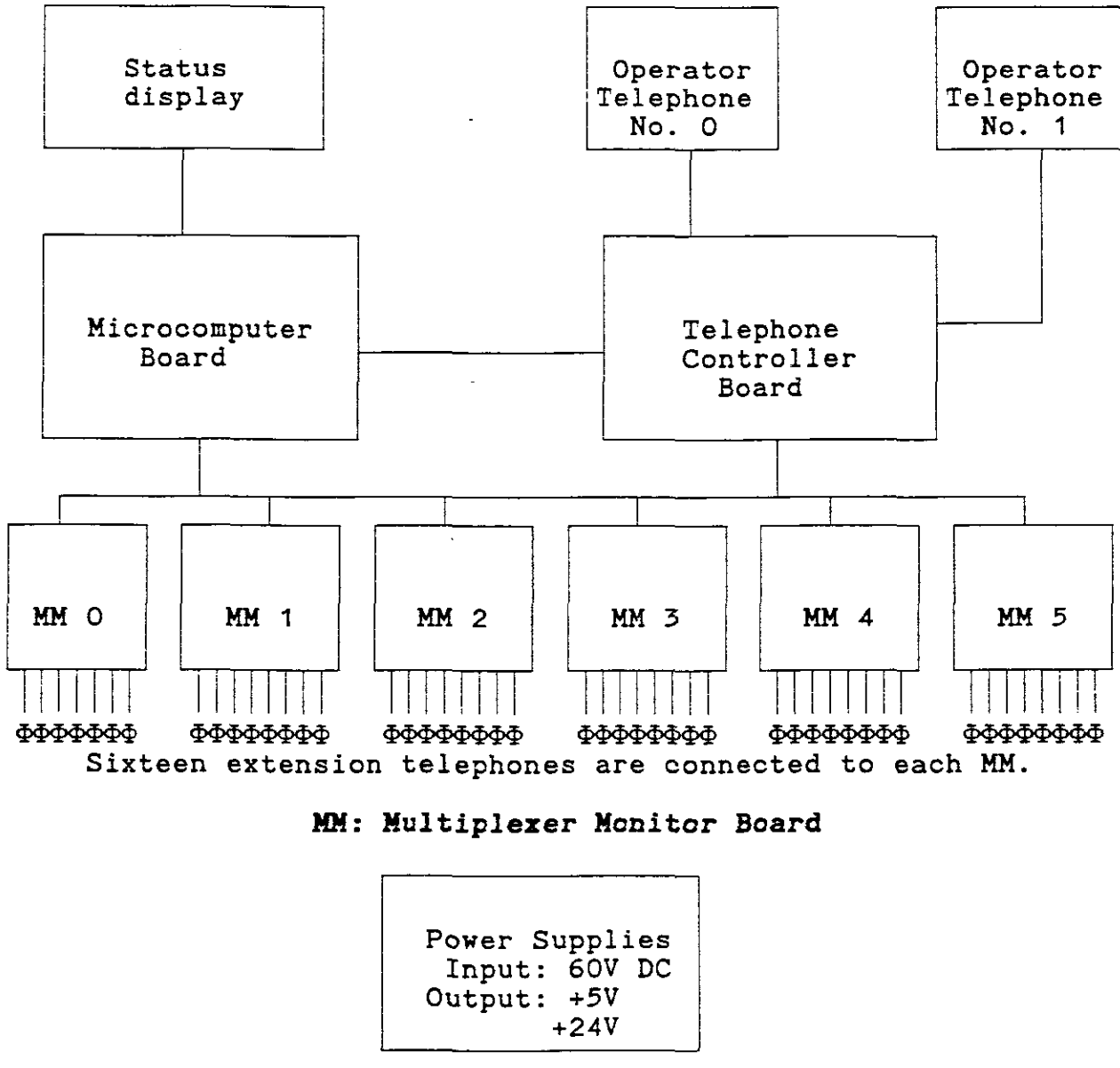


Fig. II.1. System Block Diagram.

II.2 Microcomputer Board.

A few years ago we were still amazed by the four function hand held calculator. The microcomputer is applied more than ever for sequential and logical control applications. Often it is cheaper to exploit the potential of the microcomputer than using discrete designs.

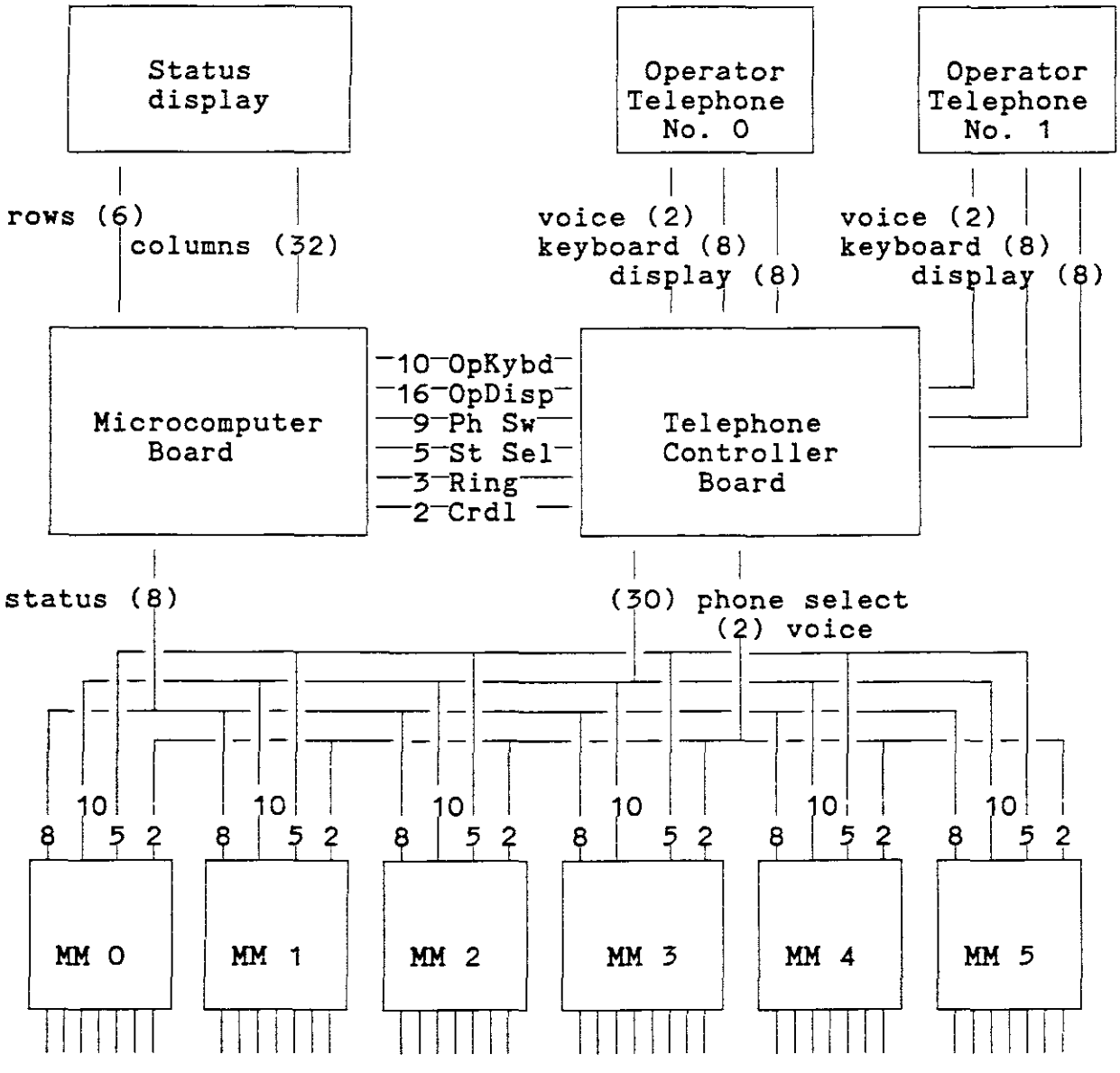
To provide the required control facilities for this project, a microcomputer offers an economical and versatile solution. A similar discrete logic EFTS design is more complex, the component count is much higher, and the system less reliable compared to moderate component count microprocessor controlled designs. Design time, constructional simplicity and operational flexibility of the microcomputer design far outweigh that of discrete designs.

Various tasks are controlled by the microprocessor:

Continuous monitoring of telephone lines for faults.
Continuous monitoring of telephone handset statuses.
Displaying the extension telephone handset and line statuses.
Executing of operator keyboard commands.
Controlling of the audio switching.
Ringing the extension telephones.
Queuing of incoming calls.
Testing the system.

A Motorola EXORCISER development system is available and consequently the powerful Motorola 6809 micro processor is used in the new design. MPL, a high level language developed for the Motorola, is well suited for development of the software. 6809 Assembler will only be used where necessary.

II.2.1 Microcomputer Input/Output Requirements.



Sixteen extension telephones are connected to each MM.

MM = Multiplexer Monitor Board

Fig. II.2. System Block Diagram with input/output lines.

II.2.1 Microcomputer Input/Output Requirements.

The block diagram shows the number of input/output lines required to control various tasks on the different boards. The input/output lines on the Microcomputer Board are utilized as follows:

(i)	6	-	Status display: ROW lines
(ii)	32	-	Status display: COLumns lines
(iii)	10	-	Operator Keyboard data and strobe lines
(iv)	16	-	Operator Displays
(v)	9	-	Phone switching control lines
(vi)	5	-	Status Selection control signals
(vii)	3	-	Ring tone control lines
(viii)	2	-	Cradle status lines
(ix)	8	-	Status data bus
	91		Total number of i/o lines

Since both software and hardware requirements determine the allocation of the input/output ports, the final grouping of the input/output lines is indicated in the Appendices.

Timing for the status display multiplexing is derived from the onboard real time interrupt. A multiplexing frequency greater than 30 Hz provide a flicker free status display. An interrupt period of 5 ms provide a 33 Hz display refresh frequency (6 columns x 5 ms = 30 ms).

(i). The mimic status display data is routed from the microcomputer board to the status display board on the ROW and (ii) COLumn lines.

(iii). The strobe lines of the operator keyboards are connected to the microprocessor interrupt lines. When an operator depress a key, an interrupt is generated which reads the keyboard data. (viii). Similarly, a change in operator handset status generates an interrupt which supervises continuing processes, e.g. when the handset is replaced all commands are cleared.

(iv). The operator keyboard and display data between the microcomputer board and the telephone controller board is routed via the Kybd and OpDsp lines.

(v). The Phone switching lines control the switching of the voice signals between the extension telephones and the operators.

(vii). Two of the ring lines are used to ring extension telephones. The third line controls the operator alarm.

(ix). The status data bus routes the telephone handset and line statuses to the microcomputer board. (vi).The status control lines control status data flow on the status data bus.

II.3 Telephone Controller Board.

The TCB processes all audio signals, generates and controls the ring tone, and generates several logic control signals for the multiplexer monitor boards.

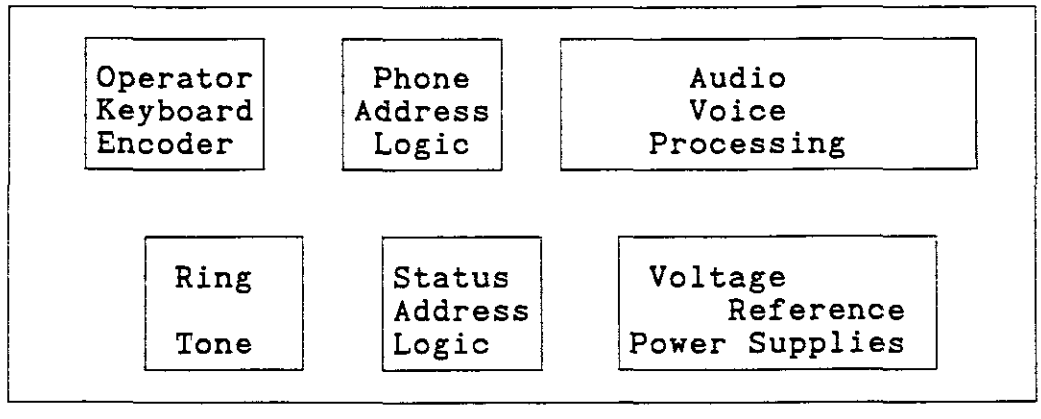


Fig. II.3. Telephone Controller Functional Block Diagram.

The main purpose of the audio section is to provide clear communication between the operators and the extension telephones.

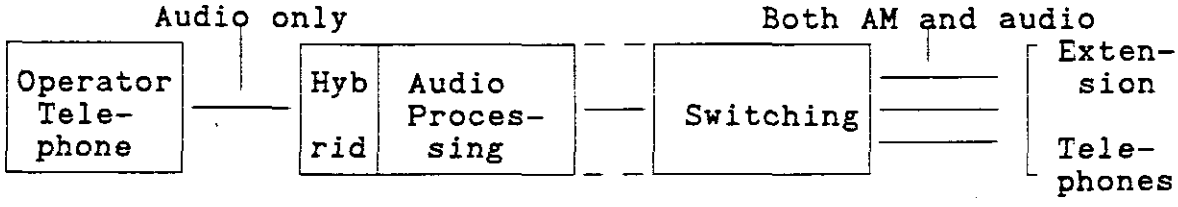


Fig. II.4. Basic Audio and Voice Switching Block Diagram.

Operator communication is explained by the above block diagram, figure II.4. Audio is amplified and processed in the Audio Processing block. Switching the voice signal between an operator and a selected extension telephone is controlled by the switching block. Both operators may be switched to any one of 96 extension telephones - totaling 192 switching nodes. Also see Fig. II.5.

The AM carrier frequency is 14 kHz. Reduction of the frequency spectrum is achieved by band limiting the audio to between 300 Hz and 3300 Hz. This frequency band is determined by the original extension telephones, and can therefore not be altered. See the chapter on the hardware for a full description.

The operator telephone is interfaced to the Audio Voice Processing block with a hybrid network. The hybrid network prevents the microphone signal reaching the earpiece and also blocks the DC supplied to the telephone handset from the audio circuitry.

Electrically standard telephone handsets are used for the extension telephones. The voice signal from the extension telephones to the operator telephones use amplitude modulation. Normal audio is used from the operator telephones to the extension telephones. Power to the extension telephones, each having an amplifier and modulator, is delivered via the same telephone lines.

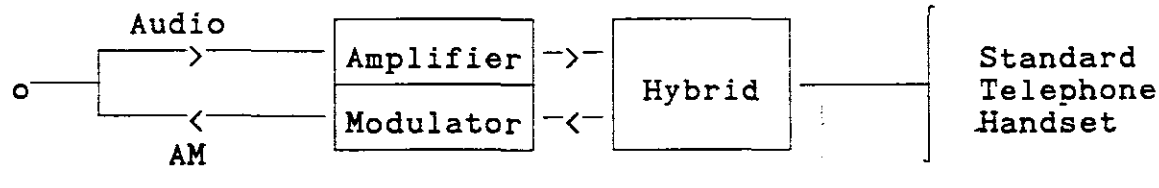


Fig II.5. Extension Telephone Block Diagram.

Inducement of noise into the audio circuitry was foreseen because of interference introduced by the monitoring of the status data lines. See section II.4 on the Multiplexer Monitor boards for a description of the status monitoring.

When the status of a data latch is read by the microcomputer the impedance of the corresponding window comparator circuitry changes minutely thereby introducing noise into the audio circuitry. The frequency of the noise introduced is proportional to the frequency at which the status is read.

The 96 extension telephone lines are effectively all paralleled at the 192 CMOS switches. This loading effectively reduces the input impedance of the analogue switches. The lower input impedance can generate a limited amount of crosstalk between the CMOS switches whilst in their "off" state. The high frequency of the AM signal, 14 kHz and the sidebands, introduce additional crosstalk.

The status of each extension telephone line is monitored by two window comparators. The high input impedance of the voltage comparators have negligible loading on the low impedance telephone lines.

The low "on" resistance of the analogue switches (150 Ohm) cause little signal degradation. The high "off" resistance of the analogue switches result in minimal cross talk between channels.

A ring tone is generated both for the operator and the extension telephone. To aid quick cognizance in the busy Control Room the ring tone differs entirely from that of the G.P.O. telephones. The ring tone is switched to:

the extension telephone operator 0 is ringing, or
the extension telephone operator 1 is ringing, or
the operator telephones/audible alarm.

Due to the common earth return path of unbalanced telephone lines merely one switch per extension telephone is required. CMOS analogue switches effect a compact and reliable switching arrangement.

Figure II.6 indicates the switching of the 96 voice signals to the two operators. Each operator may be connected to any one of the 96 extension telephones with one proviso: both the operators may never concurrently be connected to the same extension telephone. Excessive signal degradation will result from loading a line.

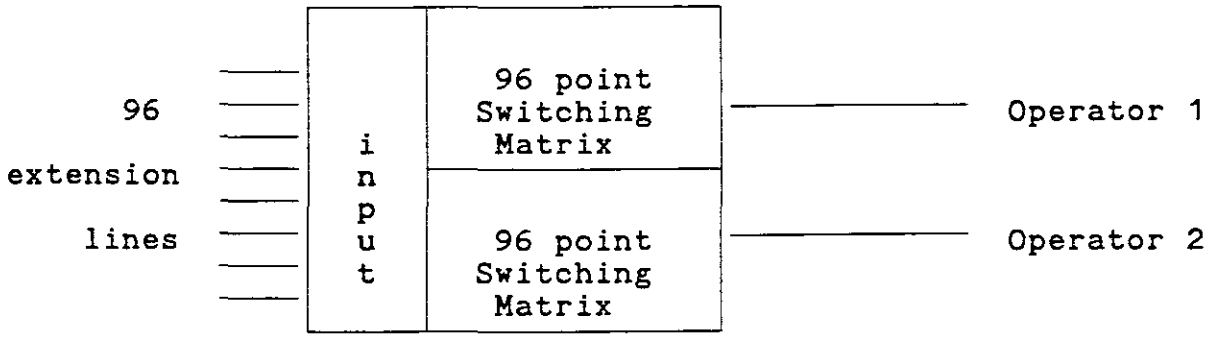


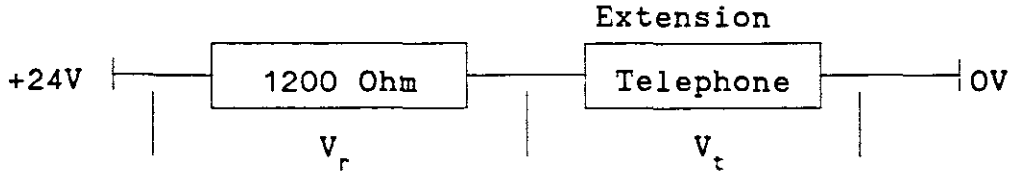
Fig. II.6. Audio switching matrix.

II.4 Multiplexer Monitor Boards.

The primary function of the multiplexer monitor board is to switch the voice signal between an operator telephone and an extension telephone. It also monitors the extension telephone handset statuses and the extension telephone lines for faults.

The power requirements of an extension telephone is such that with the extension telephone handset replaced, the power drawn is approximately 10 mA, and with the handset lifted approximately 7 mA.

The extension telephone is powered from a 24 volt source via 1200 Ohm series resistor. When a handset is lifted the line voltage is approximately 10V. With the handset replaced the line voltage rises to approximately 12V.



	I_t	V_r	V_t
Handset up	7mA	8,4V	15,6V
Handset replaced	10mA	12,0V	12,0V

Fig. II.7. Window Comparator Voltages.

The effect of the line resistance is not taken into consideration in above calculation.

Line voltages outside these parameters indicate the presence of line faults (figure II.8). Two voltage comparator windows are set up. The one window checks between 20 and 12 volt, the other between 12 and 8 volt. The selected window voltages give the most consistent and reliable results.

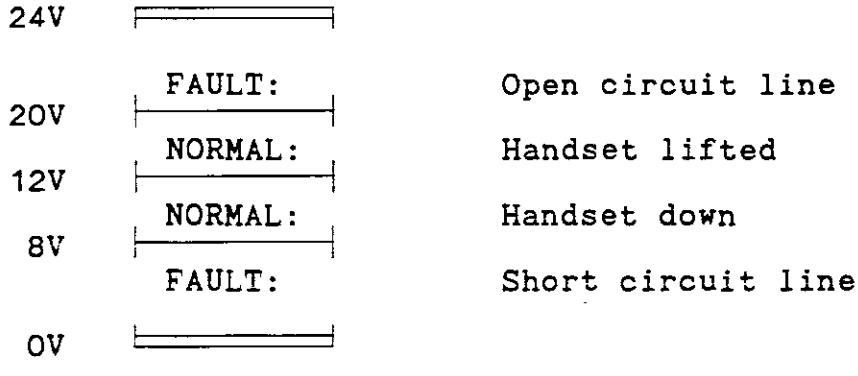


Fig. II.8. Status comparator window limits.

While ringing, the extension telephone power consumption rises and the line voltage drops to below 8V and fault status monitoring is disabled to inhibit false alarms.

II.5 Status Display.

Extension telephone line fault statuses and handset statuses are indicated on the Status Display using red and green LEDs respectively.

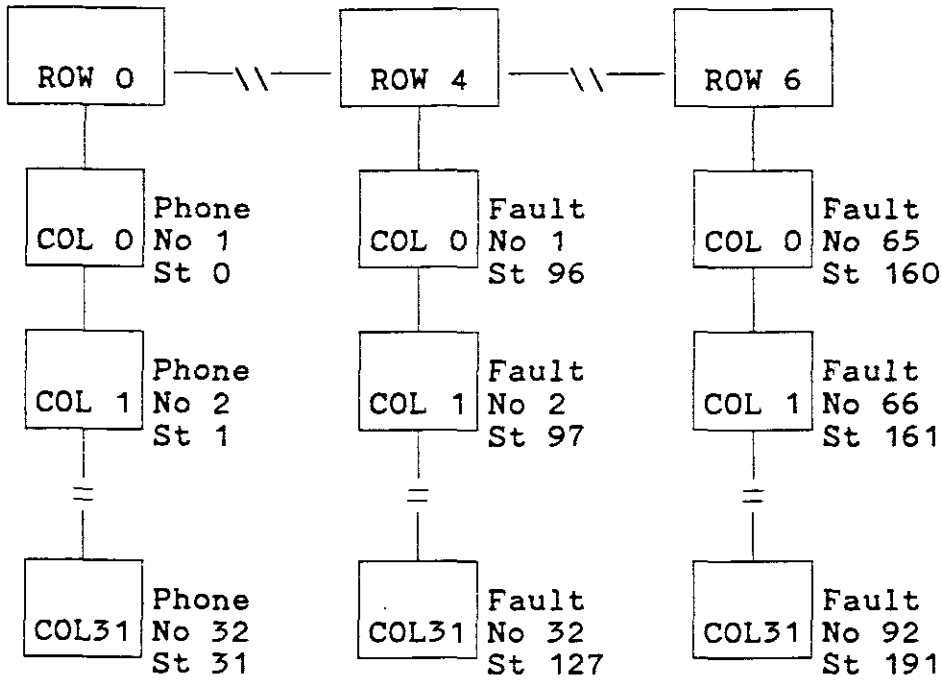
The display of 192 different statuses requires too many microcomputer input/output lines and therefore LEDs are multiplexed to conserve microcomputer i/o lines.

The 192 indicators are divided into six rows of thirty two columns each. Each extension telephone has two statuses associated with it, namely handset and fault statuses. The handset statuses are numbered from 0 to 95 and the fault statuses from 96 to 191. Also see figure II.9.

Telephone No	Handset status No	Fault status No
1 - 32	0 - 31	96 - 127
33 - 64	32 - 63	126 - 159
65 - 96	64 - 95	158 - 191

LEDs may be steady or they may blink. A flashing fault LED indicates a new extension telephone line fault which has not been acknowledged by the operator (the audible alarm is activated if both operator handsets are down). A fixed (non-flashing) fault LED indicates a fault which has been acknowledged by the operator (the audible alarm is de-activated by the acknowledgement made by the operator).

When an operator is connected to an extension telephone the corresponding LED is steady. The green LED flashes when the operator rings an extension telephone of which the handset is down. As soon as the extension telephone is lifted the green LED stops flashing. The corresponding green LED will also flash when an extension telephone is lifted to call the operator.



No - Extension Telephone number
St - Extension Telephone status number
Phone - Extension Telephone status indicator (green)
Fault - Extension Telephone fault status indicator (red)

Fig. II.9. Mimic numbering.

In the mimic status display each row transistor sources thirty two column transistors. A LED is enabled when the row transistor and the corresponding column transistor is enabled.

Whenever a row transistor and any of its associated column transistors are enabled, the corresponding LEDs are enabled. In this way, instead of using 192 row and column control lines, only 38 lines are used to control the 192 LEDs.

The row transistors are selected for worst case conditions. This occurs while executing a lamp test, then all the column transistors for each row are on. The maximum instantaneous current to a row is 32 x 25 mA = 800 mA.

The column transistors each enable only one LED, i.e. source a maximum of 25 mA. Row transistors therefore require a higher power rating than that of the column transistors.

Each row transistor is successively enabled for 1 ms every 6 ms. Switching transistors are used for this purpose. The optically less efficient green LEDs are driven harder than the red LEDs - 50 mA as opposed to 25 mA (instantaneous current).

II.6 Operator Telephone.

The operator telephones control the communication. The extension telephone is always the slave of the operator telephone. Each operator telephone consists of a handset, cradle switch, keypad and two digit 7 segment display.

The operator telephone two-digit-readout displays the extension telephone number entered by the operator on the keypad, or the number which he is ringing, or the number which he is connected to.

The operator telephone uses standard unmodified balanced line audio circuitry.

A 16 key keypad is used. The 4x4 keypad matrix (8 lines) is encoded on the TCB to four data lines in addition to a strobe line (5 lines). The encoded data (TCB) is connected to the Microcomputer Board. See figure II.2 for the I/O lines.

Sixteen data lines are used to output operator display data from the microcomputer to the operator numeric displays - eight lines per operator display. The operator display data is decoded by two BCD to seven segment decoder/drivers in the operator telephone housing.

A red operator telephone is used, making its use as emergency telephone more obvious.

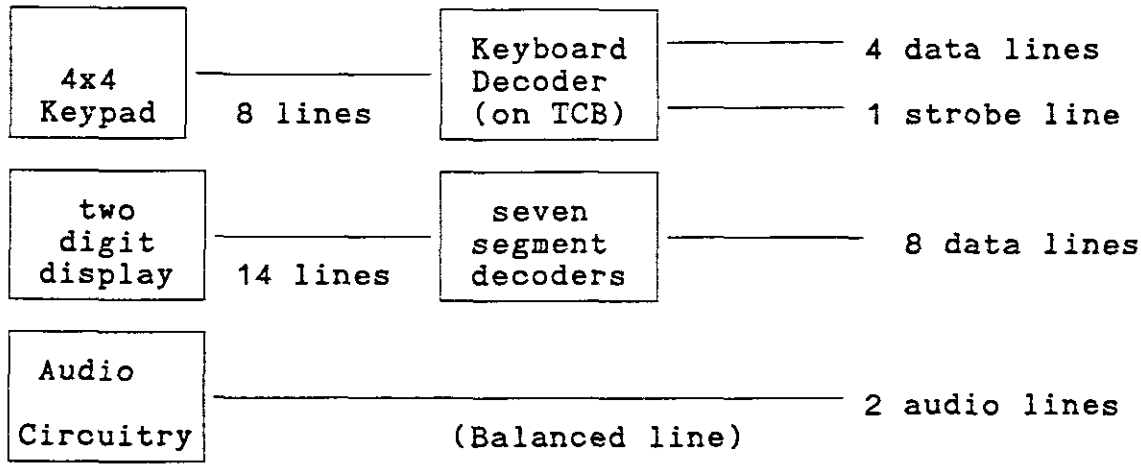


Fig. II.10. Operator Telephone Block Diagram.

II.7 Power Supplies.

The main power source is a 60V battery supply. The voltage may increase to some 72V when the batteries are charged. Switching power supplies are most suitable for such varying supply voltages.

The project specifications require all telephone circuitry to operate from a 24V source. Logic circuitry operates at 5 volt.

Fault status monitoring circuits require reference voltages for the window comparators. Three voltages (8V, 11V and 14V) are supplied with minimal current source.

II.8 Subrack and associated hardware.

Console equipment is made up of the operator telephones and the mimic status display. The subrack, including the rack mounting frame, Main Distribution Frame (MDF) and the cable termination, is separated from the console equipment and installed in a different location.

The operating environment influences operator efficiency. Ease and simplicity of use of the EFTS is of prime importance.

Therefore operator involvement should be as simple as possible. Only basic operations are required. Operator training is given to familiarize them with all operational features.

Similarly the status display is made simple and clear. Correlation of the telephone number with the telephone position within the building is facilitated by using a mimic display.

Care is taken to ensure that the operator position relative to the status display is such as to make viewing and operation most efficient. Unnecessary operator movement is minimized by correct placement of the operator telephone on the operator console.

Since the status display is legible and bright, changes in lighting conditions will not affect the visibility and clarity of the EFTS displays.

Frequent emergency exercises ascertain thorough testing of the system.

The particular rack equipment is selected for easy maintenance of the system and for its robust construction. The rack size is determined by the standard used for telephone equipment by the Cape Town City Council.

Chapter III

HARDWARE DESCRIPTION.

NOTE: Please refer to the detailed circuit diagrams in the Appendix.

Chapter III

HARDWARE DESCRIPTION.

III.1 MICROCOMPUTER BOARD.

Please refer to drawing SK3818, sheet 10, in the Appendix for the microcomputer board circuit diagram.

The Microcomputer Board is designed as a multipurpose single board computer (microcomputer board). Not all the possible options are utilized in the EFTS application. The microcomputer board is specifically designed to provide a large number of parallel input/output lines. No serial communication is provided. Two kilobytes of RAM is provided and two to sixteen kilobytes of EPROM.

Six PIAs provide 96 input/output lines. An additional 22 control lines are available. These lines are all connected to the edge connectors of the printed circuit board.

A real time interrupt can be obtained by connecting a divided clock signal to any one of the PIA CA0 lines. Additional timing signals may be derived from the same frequency divider.

A hardware watchdog circuit provides an automatic reset of the system should any software or hardware failures interfere with timing loops. The watchdog may be disabled if so required.

A reset switch provides a controlled restart for the microcomputer board.

III.1.1 6809 Microprocessor

Please refer to drawing SK3818, sheet 10, in the Appendix for the Microcomputer circuit diagram.

A Motorola MC6809 microprocessor (U3) controls the single board computer. A 4MHz ceramic resonator acts as external parallel resonator to an on-chip oscillator to generate the bus timing signals, E and Q. The ceramic resonator is used in preference to

the more expensive crystal. A 4MHz oscillator frequency provides an effective 1 MHz bus frequency. (The E bus timing signal is a quarter of the clock frequency).

The NMI, IRQ and FIRQ lines are tied high, but the IRQA and IRQB lines from each of the six PIAs can be wire-ORed to the desired interrupt line of the 6809. The PIA Allocation tables in the Appendices provide full detail on which interrupt lines are used.

III.1.2 EPROM (U4)

By making appropriate links, the user has the option of using a 2k, 4k, 8k or 16k EPROM in the U4 socket. In this application a 2732 EPROM is used. See the Microcomputer Board circuit diagram in the Appendices for which link to set to facilitate the use of the 2732.

III.1.3 RAM

Static RAM (U5) used is 2k x 8 at locations $0000 to $07FF.

III.1.4 Clock Divider

The CD4020 (U1) 14 bit binary counter divides the 1MHz system clock. One of the divider outputs may be connected to the CA1 line of PIA0A (U10) to generate a real time interrupt to the microprocessor. Connecting the divide by 2^{14} pin to CA1 will generate an approximately 16 ms interrupt. During the initialization PIA0 needs to be configured to generate an interrupt when CA1 is toggled.

PIA0 has to be initialized with the CA2 line as an input to generate an interrupt. See the RESET, PIA0A initialization routine in the Source Code Listing for more detail.

III.1.5 Address Decoding

Address decoding is accomplished by using a decoding PROM (U6) and a three-to-eight decoder (U7). The binary output from the decoding PROM is decoded by a three to eight decoder which selects the desired memory chip.

III.1.6 PIA's (U10 - U15)

Six 6821 PIA's are available to the user. Each PIA provides two 8 bit programmable i/o ports and four handshaking lines. The IRQA and IRQB lines of the PIA's may be wire-ORed to the microprocessor interrupt lines.

See the PIA Allocation table in the Appendices for the appropriate wire-ORed IRQ lines. The CA lines used as inputs to generate IRQ's are labeled: TIMER, KYSTRB0, KYSTRB1, CRADL0 and CRADL1.

The output of the divider (U1) is connected to CA1 of PIA0. PIA0 is programmed to generate an interrupt to the microprocessor (IRQA line) with the CA1 line. The interrupt service routine causes CA2 to be toggled in order to retrigger the watchdog timer.

All the PIA i/o lines are connected to the edge connector.

III.1.7 Watchdog (U9, U17)

The watchdog circuit consists of a dual monostable IC (U9) and a 555 (U7) set up as an astable multivibrator. At power-up, or after pressing the system RESET button, monostable B provides a 100 ms RESET pulse. The start-up routine takes CA2 (PIA0) low until a pulse is received from the divider circuit connected to CA1. The PIA is programmed so that CA2 goes high as well as generate an interrupt on IRQA when CA1 goes low. The interrupt service then cause CA2 to reset again (goes low).

Monostable A is continually re-triggered during normal operation of the system. Should a hardware or software fault occur and the interrupt is not serviced, monostable A times out and the astable (IC17) is activated which then provides a string of RESET pulses. The watchdog can be inhibited by strapping the RESET pin of monostable A to ground.

III.1.8 Edge Connector

Port A, Port B and the control lines of each of the six PIA's (CA1, CA2, CB1, CB2) are connected to the two 64 pin edge connectors (labelled A and B respectively). Each edge connector has two rows of 32 pins (a and c respectively e.g. PIA3, the eight bits of PA0 - PA7 are connected to pins B c9 - B c2 respectively).

The Microcomputer Board connector pinouts are tabled in the Appendices.

HARDWARE

III.2 TELEPHONE CONTROLLER BOARDS:

Please refer to drawing SK3818, sheet 1 and sheet 2, in the Appendix for the Telephone Controller Board circuit diagrams.

The Telephone Controller board consists build of:

Logic circuitry composed of:

- Keyboard encoder
- Status addressing
- Multiplexer addressing

and,

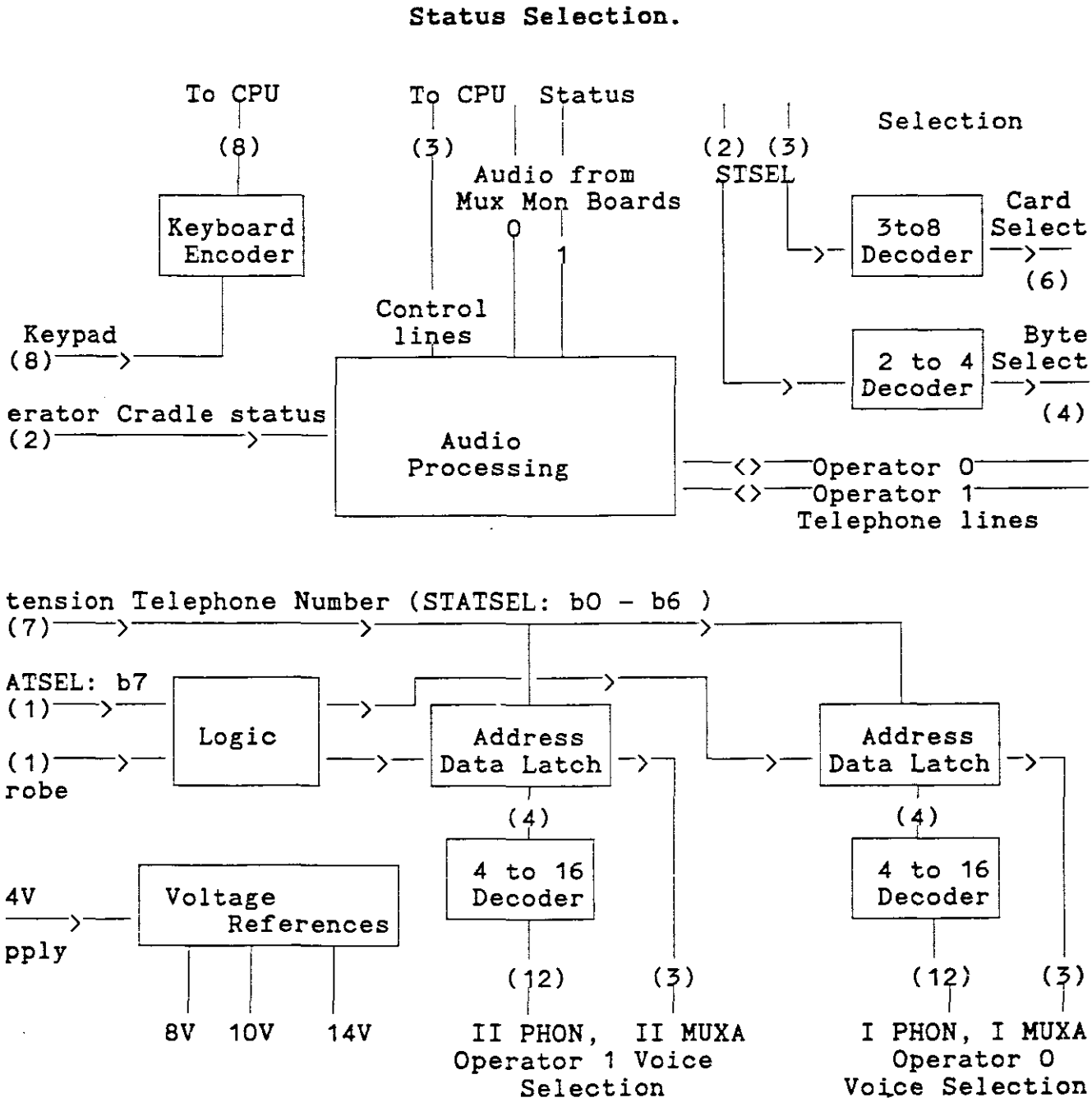
Analogue circuitry composed of:

- Audio circuitry; AM demodulator, filters and amplifier and Ring generator.
- Reference voltage power supplies

Initially it was attempted to design a single printed circuit board incorporating all the above functions which served both operators concurrently. This approach was prevented because too many control lines had to be connected to the edge connectors and could not be achieved using the available printed circuit board manufacturing equipment.

Each Telephone Controller Board (TCB) serves one operator. Two identical TCBs are used (i.e. TCB0 and TCB1) and duplicate logic and analogue circuitry exist. However, the reference voltage and ring tone generator on TCB1 are not used and not connected to the backplane.

Even though the TCB's are functionally identical, the boards may only be interchanged once links on the TCBs are correctly set up for the particular board position in the rack.



e bracketed numbers indicate the number of wires per function.

Fig. III.1. Telephone Controller Block Diagram.

Figure III.1 indicates the fundamental functions of the TCBs. An elementary description is given below.

The keyboard encoder encodes the operator 4x4 keyboard array. The data is output to the microcomputer board with the necessary control signals.

The majority of the logic control signals for the audio multiplexer I.C.s and the status data latches, situated on the Multiplexer Monitor cards (MM), is generated on the TCBs.

The line statuses of extension telephones are monitored on the multiplexer monitor boards. The status selection logic signals control data flow on the 8 bit status bus between the status data latches on the MMs and the microcomputer board. The CARD SELECT signals select one of the six MMs. The BYTE SELECT lines then selects one of four data latches on the selected MM. Status data may then be read by the microcomputer board.

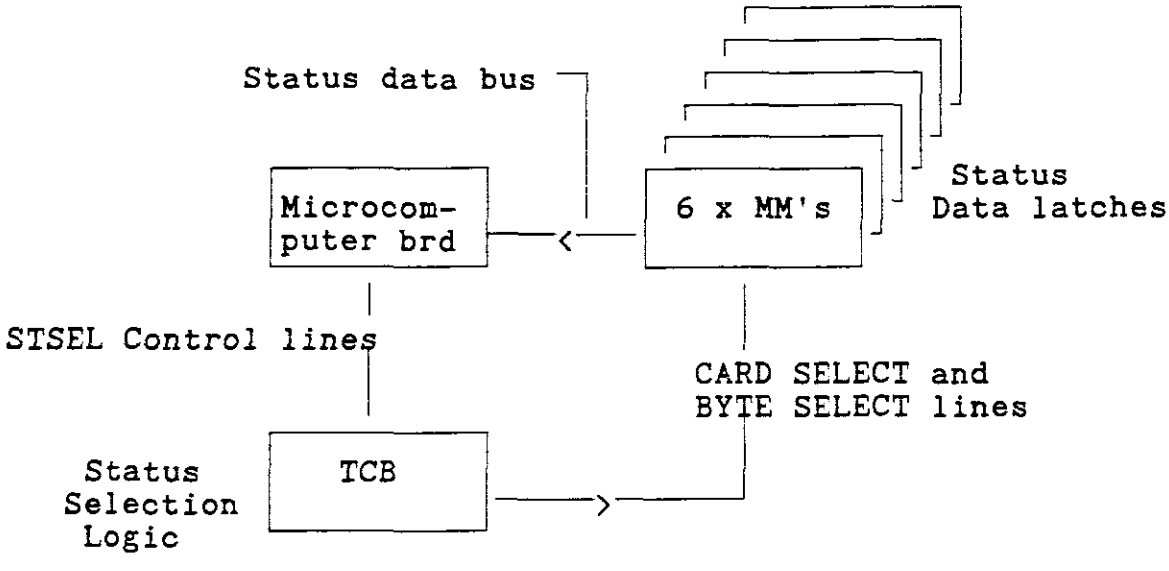


Fig.III.2. Status Selection.

Three logic signals are used for the audio processing. The three lines control the ringing of the two extension telephones selected by the operators and the operator audible alarm.

The control of the multiplexer I.C.s on the MM's is shown in the Audio Selection portion of figure III.1. Each operator's extension telephone is addressed separately by the microcomputer board. The address data for a particular extension telephone multiplexer I.C. is latched before the address data is further decoded by the 4-to-16 decoders. The MUX lines select a multiplexer IC on one of the MMs. The PHON lines connect the operator voice signals to a particular extension telephone on the selected multiplexer IC.

III.2.1 Keyboard Encoder

A 74C922 (U6) 16-Key keyboard encoder, used in a standard configuration, encodes the 4x4 keypad. The strobe line (KYSTRB) goes high with every key depression. Key debouncing is performed by the encoder chip. The auto-repeat facility is not used.

III.2.2 Status Addressing

The five status address lines output from STSEL (PIA4A) are grouped as follows:-

b0, b1 - STMXA - Status Mux Address

selects one of four data latches on the Multiplexer Monitor boards

b2, b2, b3 - STCRDSEL - Status Card Select

selects one of the six Multiplexer Monitor boards

Also see figure III.2.

Bits b2 - b4 are decoded by a 3-to-8 decoder (74LS138, U8) to obtain eight Status Card Select (STCRDSEL) lines. Only six of the eight Status Card Select lines are used, i.e. one STCRDSEL line per Multiplexer Monitor board.

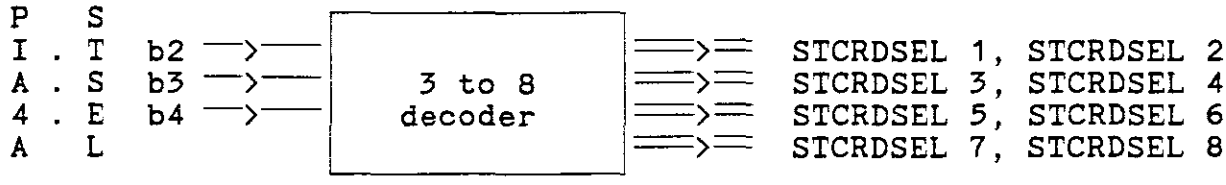


Fig. III.3. Status card select decoding.

The STCRDSEL line selects one of the six Multiplexer Monitor cards.

STATSEL control word bits b0 and b1 are decoded to obtain four chip select lines (STMXA, Status Multiplexer Address) by the 2-to-4 line decoders (74LS139, U7). The STMXA lines enable one of four status data latches on a Multiplexer Monitor board if the corresponding STCRDSEL is enabled. STMXA lines are bussed to all the Multiplexer Monitor boards.

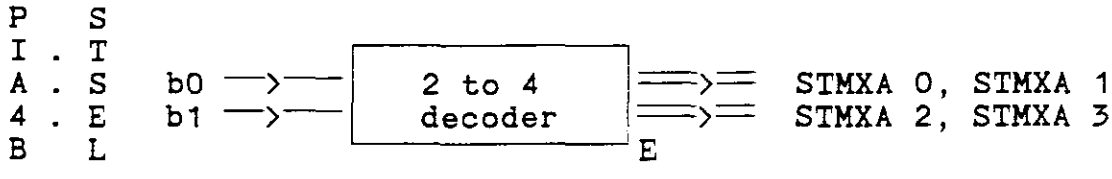


Fig. III.4. Status address multiplexer decoding.

Each of the STMXA lines selects one of the possible four multiplexer I.C.'s on the Multiplexer Monitor Board which are enabled by the STCRDSEL line.

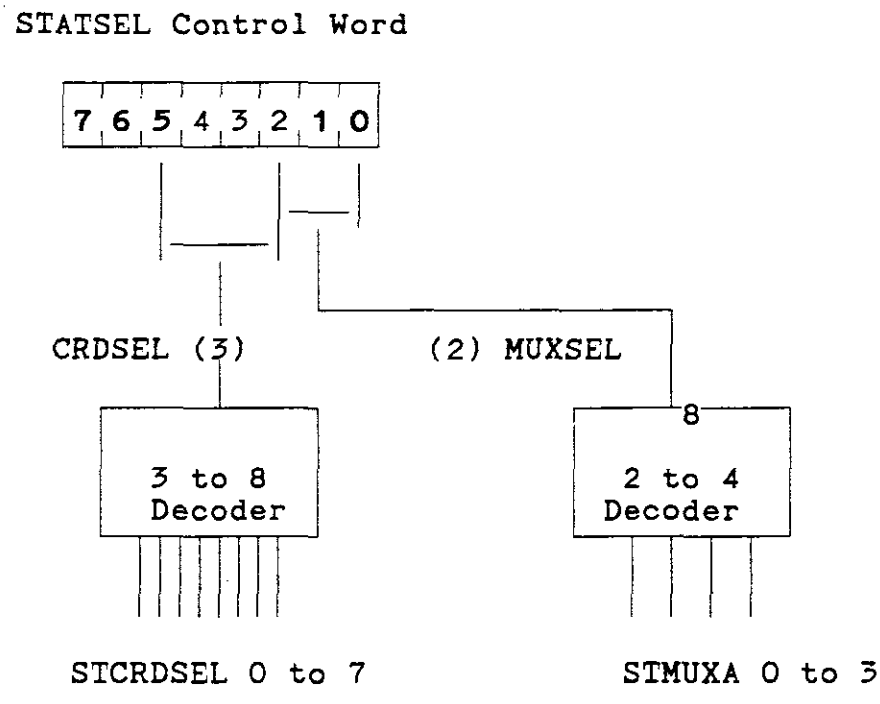


Fig. III.5. Status Decoding Block Diagram.

If STCRDSEL is enabled, STMUXA selects one of four tri-state data buffers.

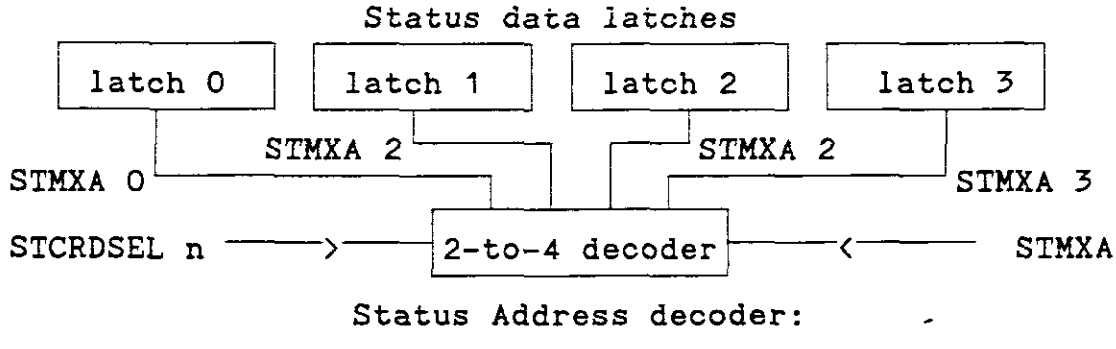


Fig. III.6. Addressing the Status data latches on the MM.

To summarize again, using figure III.6. The status data of a MM is selected by enabling the STCRDSEL (STCRDSEL n in the diagram for that card). STMXA selects one of the four data latches. The selected data latch routes the line statuses, established by the window comparators, to the single board computer via the status data bus.

III.2.3 Multiplexer Addressing

Extension telephone number data is output from PIA3B to the two Telephone Controller Boards. Each Telephone Controller Board latches the extension telephone number addressed to it. On each board the 74LS374 (U1) tri-state octal D-type flip flop latches the extension telephone number data. The latch enable line is controlled by the most significant bit of PIA3B (PSEL line).

The latch enable strobes for the two boards are generated on the first Telephone Controller Board by one of the 3-8 decoders of the 74LS139 (U9). By making the appropriate links on both Telephone Controller boards the latch enable signals are connected to the data latches.

Figure III.1 shows the relationship between the control lines of the MMs and TCBs. Also refer to the complete circuit diagram in the Appendices of the MM Board.

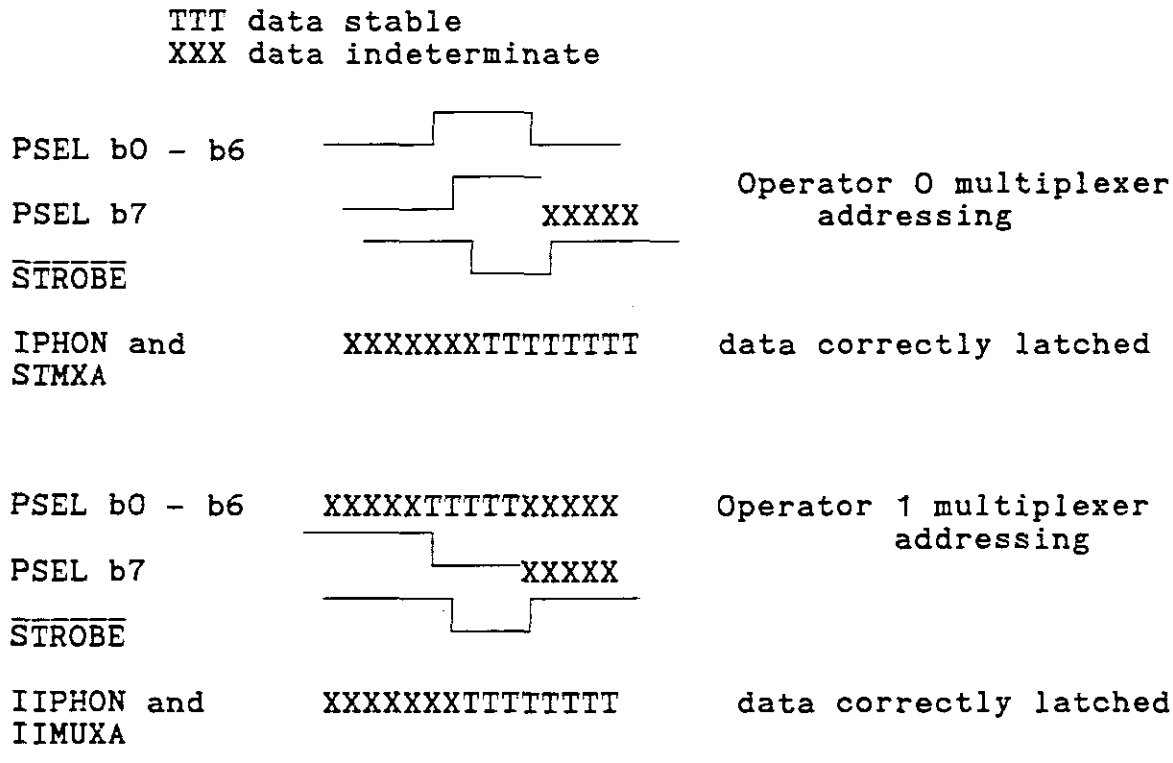


Fig. III.7. Multiplexer Control Timing Diagram.

The timing diagrams in figure III.7 reveal the relationship between the control signals. The PSEL b0 - b6 lines contain the telephone number data, whereas b7 determines to which the extension telephone is connected. Once the PSEL data has stabilized, the selected data latch is strobed (STROBE) to latch the data on the PSEL b0 - b7 lines.

III.2.4 Multiplexer Addressing and Control Word (CNNCT).

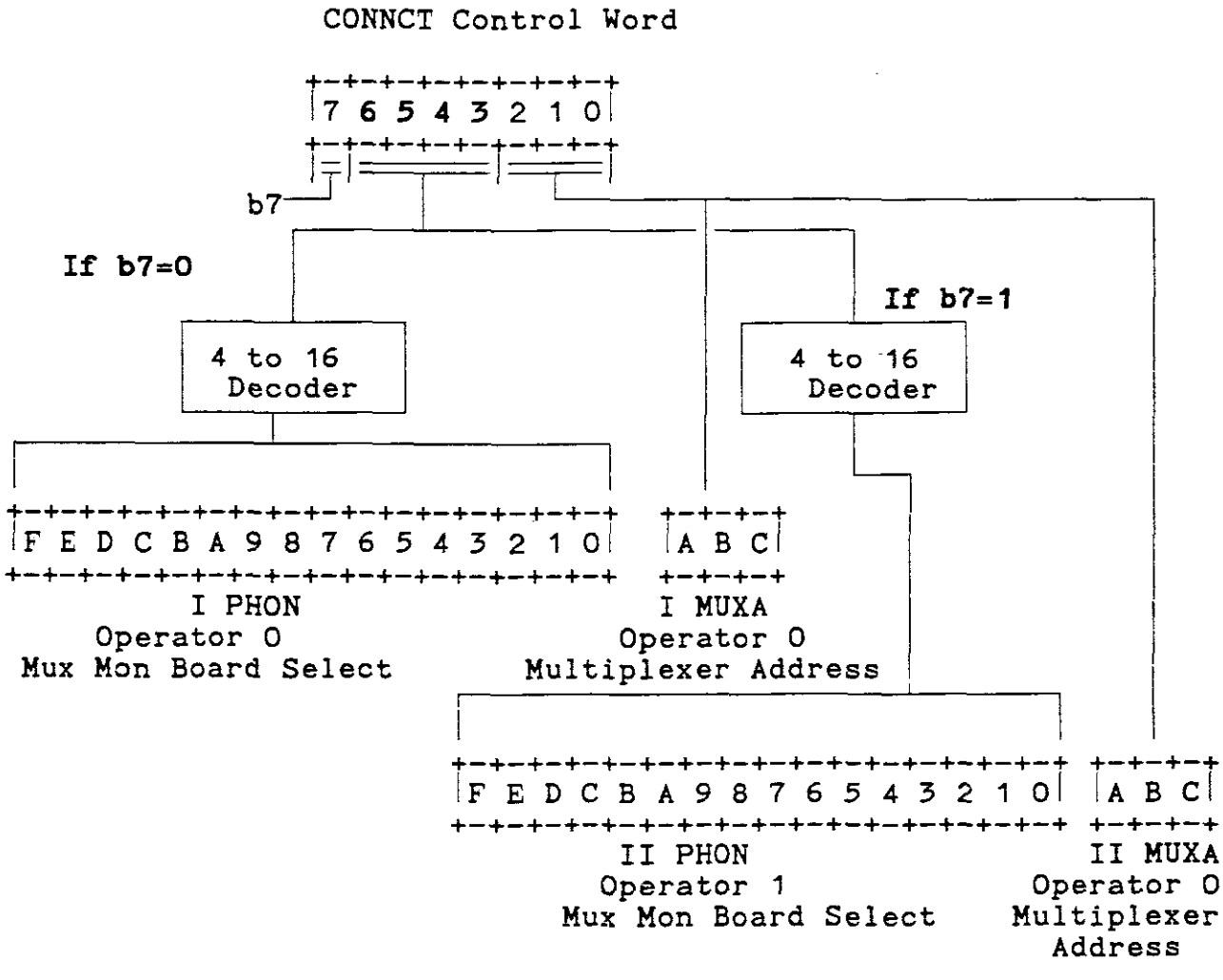


Fig. III.9. Multiplexer Addressing and Control Word (CNNCT).

If b7 of CNNCT is zero Operator 0 audio multiplexers are selected. When b7 is set, Operator 1 audio multiplexers are selected.

The I PHON line enables the Multiplexer Monitor Board's audio multiplexers for Operator 0. The multiplexers are addressed by the I MUXA lines.

III.2.5 Links

See the Telephone Controller Board circuit diagram.

First Telephone Controller Board: TCB0
Connect CS0 to CS
PSEL CS to CS1

Second Telephone Controller Board: TCB1
Connect PSEL CS to CS

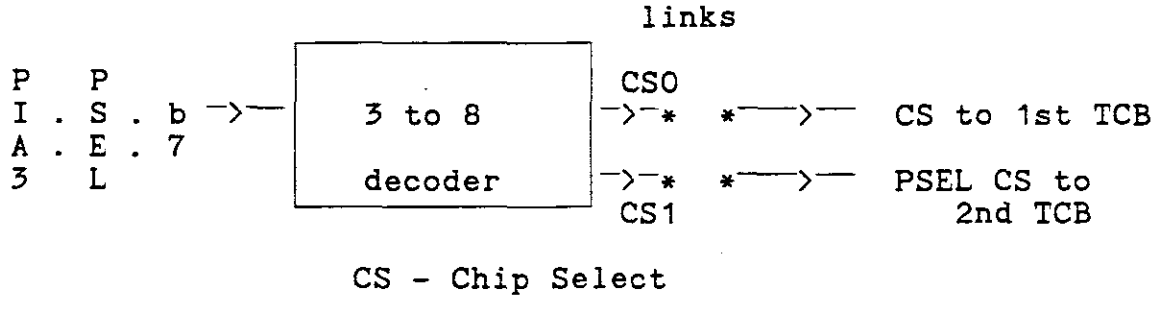


Fig. III.8. Phone select decoding.

III.2.6 Voltage Translators

The Multiplexer I.C.s operate from a 14V supply voltage. The logic control signals (IPHON, IIPHON and MUXA), which originate from 5V circuits, are translated to the higher voltage levels using 7407 open collector buffers (U3, U4, U5).

III.2.7 Audio Circuitry

Voice signals on the MUX audio line contains both audio and AM signals. AM is used from the extension telephone to the operator telephone. Normal audio is used from the operator to the extension telephone.

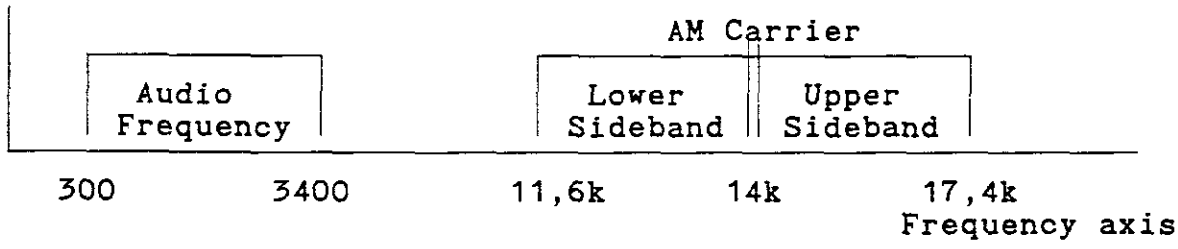


Fig. III.10. Voice and AM Frequency Spectrum.

The 14kHz AM signal is filtered by a high pass filter, U12, and then demodulated. The demodulator signal losses are minimized by applying a 0,6 V offset to the demodulation diode. The demodulated signal is filtered and amplified by a band limited audio amplifier (U11a). The 680pF capacitor of U11a shunts the internal pole-splitting capacitor of the LM381 to limit the frequency to 6kHz (See Bibliography for more detail). The band limited audio is output to the operator telephone via the hybrid circuit.

The audio from the operator telephone to the MUX line is amplified by an LM381 inverting frequency compensated AC amplifier, U11b, with a high frequency cutoff at 5kHz. The LM381 is used in the suggested special bias, low noise configuration.

The impedance matching of the hybrid network is adjusted with 1k cermet potentiometer. Proper adjustment of the hybrid impedance ensures minimal feedback between the operator microphone and earpiece.

III.2.8 Buzzer

A 556 dual timer circuit generates the ringing tone. Refer to the full circuit diagram of the TCB, SK3818 sheet 2, in the Appendix. Transistors T1, T2 and T3 switch mercury wetted relays to connect the ringing tone to MUX0, MUX1 and the operator audio alarm respectively. The operator alarm is mounted on mimic status display board.

Mercury wetted relays were used because of its high reliability.

The mercury wetted relays have internal back e.m.f. diodes.

III.2.9 Reference Power Supplies

Minimal current is supplied by the four reference power supplies since they are primarily reference voltages to the Multiplexer Monitor Boards. U12 (LF351, high pass filter) and the analogue multiplexer (CD4051, U17 to U20) I.C.s on the Multiplexer Monitor Boards are powered by the +14V supply.

Standard LM317 voltage regulator circuits are used. The voltages used are:

+8 volt - for short circuit faults
+12 volt - for extension telephone handset statuses
+20 volt - for open circuit faults

HARDWARE

III.3 MULTIPLEXER MONITOR BOARD

Please refer to drawing SK3818, sheet 3, in the Appendix for the detailed circuit diagram of the multiplexer monitor board.

Each Multiplexer Monitor board (MM) multiplexes voice signals and monitors telephone lines for sixteen extension telephones. Six MMs are used in the EFTS.

The voice signals of the 96 extension telephones can be switched to the two operators. There is one requirement: both operators may not simultaneously be connected to the same extension telephone.

The two Operator 0 multiplexers (U17. U19) are addressed by OP#0 BSEL and enabled by OP0 CS0 or OP1 CS1. Operator 1 multiplexers (U18, U20) are addressed by OP#1 BSEL and enabled by OP1 CS0 or OP1 CS1. These control signals are derived from the two Telephone Controller Boards.

One microfarad capacitors on each of the extension telephone lines block the DC on the extension telephone lines from the multiplexer I.C.s. The signal that is switched by the CMOS analogue switch contains no DC component.

The voltage of the line switched by the CMOS switch may not exceed the power supply voltages. Line protection is provided to clamp the extension telephone line voltages to ensure that these parameters are not exceeded.

Noise and voltage spikes on the extension telephone lines are clipped by clipping diodes on every line.

To simplify printed circuit board layout and to make maintenance easier all the voltage comparator circuits are physically identical. Consequently only three of the four comparators in each quad voltage comparator package (LM339) are used to promote efficient circuit board layout.

Each extension telephone line is monitored for open circuit and short circuit faults. The LEDs, mounted onboard the multiplexer

monitor board, display the extension telephone statuses. The on-board LEDs are provided as a maintenance aid. The outputs of the window comparators are buffered by four status data latches (74LS373, U22, U23, U24, U25).

The STATUS bus outputs the statuses, established by the window comparators, to the microcomputer board subsequent to STAT BYT and STCRDSEL lines being enabled. Refer to figure III.11.

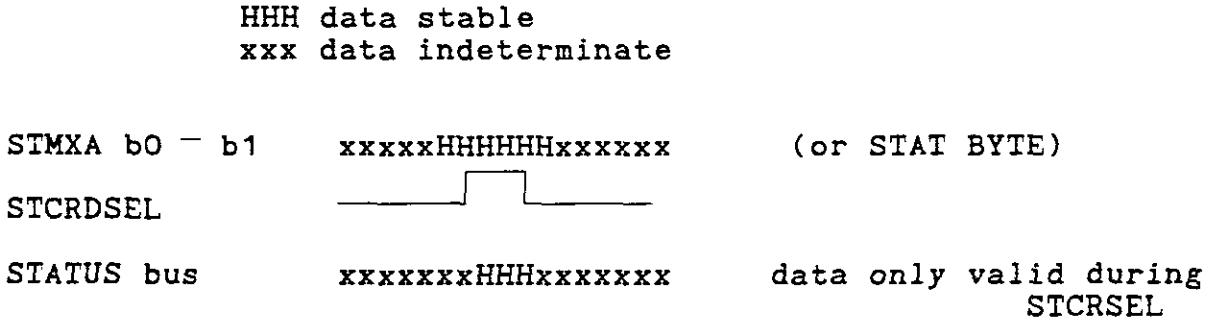
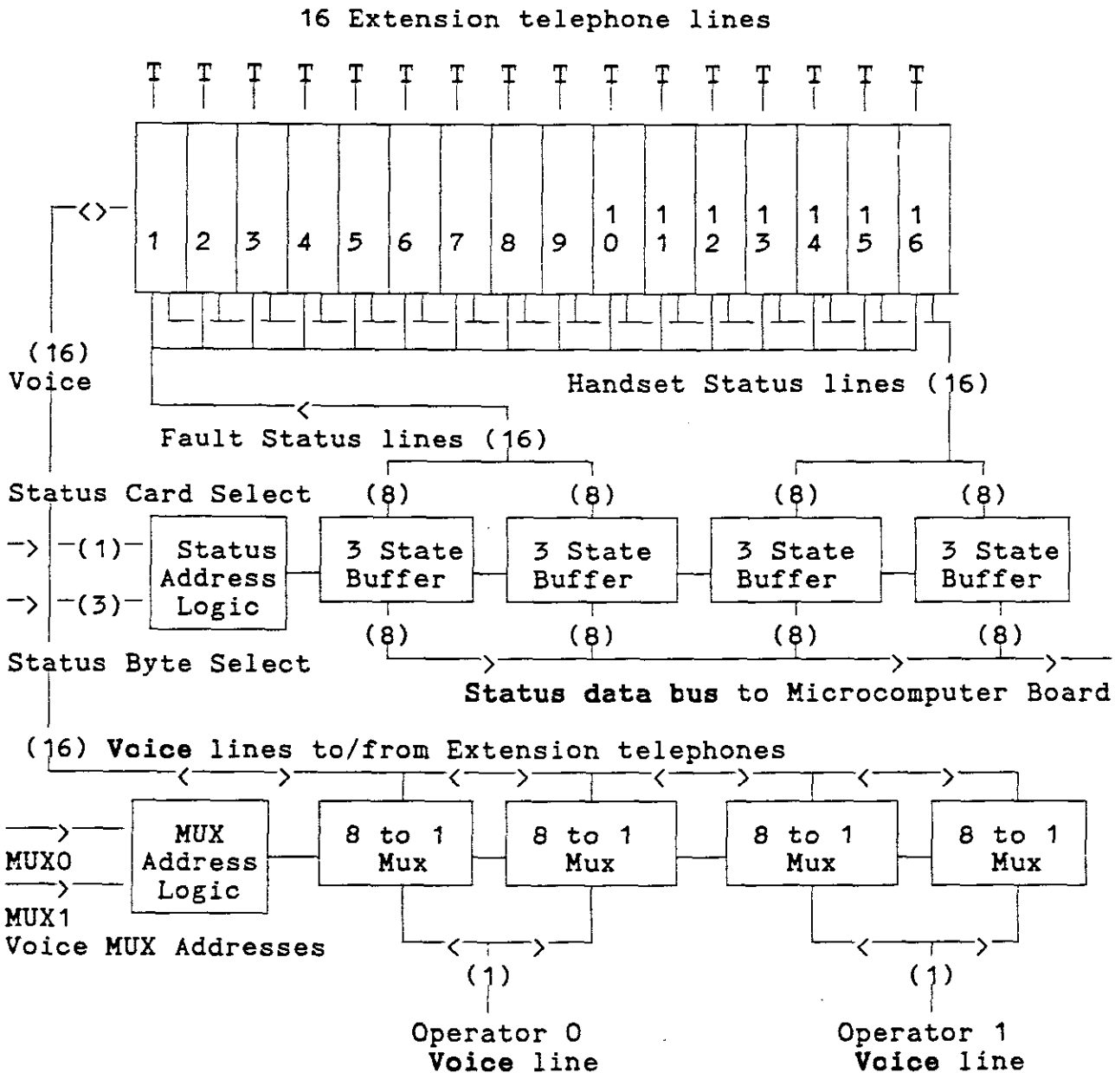


Fig. III.11. Status Control Timing Diagram.

The extension telephone handset status is determined by measuring the line voltage. When the handset is lifted the line voltage exceeds +12 V (green LED enabled). With the handset down the line voltage is less than +12 V (green LED disabled).



STCRDSEL - Status Card Select. STATBYT - Status Byte Select.

Fig. III.12. Multiplexer Monitor Board Block Diagram.

i

III.4 MIMIC DISPLAY

Positioning of LED's on the Mimic Display indicate the relative positions of the extension telephones throughout the CTACC. Only 74 extension telephone of a possible 96 are indicated on the present Mimic display.

The 192 LED's are grouped into six ROWs of thirty two COLumns each. Whenever a ROW is enabled, the corresponding 32 COLumns may be enabled to display the extension telephone statuses.

High efficiency LEDs are used for good legibility. The less bright green LEDs are driven at their maximum instantaneous current of 25 mA to compensate for their lower intensity.

> NOTE: LED's on the Mimic display should never be allowed to be switched on unless they are multiplexed. The LEDs dissipate maximum power while being multiplexed and will be destroyed if switched on perpetually.

The LEDs are continually multiplexed. Only when a fault occurs on the microcomputer board will the multiplexing be terminated. The fault may be cleared by resetting the Computer Board. Should this not restore the multiplexing the EFTS must be switched off and the Computer Board checked.

The operator audio alarm, mounted on the status display printed circuit board, is generated on Telephone Controller Board 0. The piezo electric buzzer is pulsed with a 5 V DC voltage to facilitate invoking the operator alarm.

Flashing red LED's indicate new faults. Steady (non flashing) red LED's indicate faults that have been accepted.

Green LED's indicate extension telephone statuses. When flashing it could mean:

> The extension telephone handset is replaced and the operator is ringing him.

The extension telephone handset has been lifted. The call will be queued and the operator connected to him at a later stage.

A steady green LED indicates that an operator is connected to an extension telephone.

Should both a red and green LED be on (flashing or steady), an open circuit fault condition exists on the line of the extension telephone.

The table given below may be used to obtain the ROW and COLumn numbers of the green and red LEDs.

Row and Column matrix of LEDs.

GREEN			
Column	Row 0	Row 1	Row 2
1	1	33	65
2	2	34	66
3	3	35	67
4	4	36	68
5	5	37	69
6	6	38	70
7	7	39	71
8	8	40	72
9	9	41	73
10	10	42	74
11	11	43	.
12	12	44	.
13	13	45	.
14	14	46	.
15	15	47	.
16	16	48	.
17	17	49	.
18	18	50	.
19	19	51	.
20	20	52	.
21	21	53	.
22	22	54	.
23	23	55	.
24	24	56	.
25	25	57	.
26	26	58	.
27	27	59	.
28	28	60	.
29	29	61	.
30	30	62	.
31	31	63	.
32	32	64	.

RED			
Column	Row 3	Row 4	Row 5
1	1	33	65
2	2	34	66
3	3	35	67
4	4	36	68
5	5	37	79
6	6	38	60
7	7	39	71
8	8	40	72
9	9	41	73
10	10	42	74
11	11	43	.
12	12	44	.
13	13	45	.
14	14	46	.
15	15	47	.
16	16	48	.
17	17	49	.
18	18	50	.
19	19	51	.
20	20	52	.
21	21	53	.
22	22	54	.
23	23	55	.
24	24	56	.
25	25	57	.
26	26	58	.
27	27	59	.
28	28	60	.
29	29	61	.
30	30	62	.
31	31	63	.
32	32	64	.

Telephone no. 56: the green LED is in ROW 1 and COLumn 2.
Telephone no. 38: the red LED is in ROW 4, and COLumn 6.

Fig. III.13. LED Row and Column Matrix Table.

III.5 OPERATOR TELEPHONES

Please refer to drawing SK3818, sheet 6, in the Appendix for the detailed circuit diagram of the operator telephone.

Standard Siemens Master 111 telephones are used for the operator telephones. The rotary dials are replaced with 4x4 keypads. The two digit seven-segment displays, with the associated driver circuitry, have been added to the units.

A D-25 connector terminates the operator display ribbon cable to the microcomputer board. Voice lines are connected to pins 24 and 25 of the same connector.

The operator telephone circuit diagram drawing SK2818 Sheet 6 is provided in the Appendix. A wiring schedule is also supplied, see: the "Operator Telephone to Telephone Controller Board" and "Backplane Wiring" wiring schedules.

III.6 EXTENSION TELEPHONE

Please refer to drawing SK3818, sheet 7, in the Appendix for the detailed circuit diagram of the operator telephone.

The audio design philosophy of the system has been largely determined by the original design of the extension telephones. Communication from the extension telephone to the operator telephone use AM. A 14 kHz carrier frequency is used.

Each extension telephone is powered by the single extension telephone line and the ground return telephone line provided by the PYRO cable (+24 V with 1 200 ohms series resistor). When the extension telephone handset is down, receiver gain is increased to facilitate the a loud ring tone. When the handset is down, power consumption is reduced such that the line voltage increases to approximately 13,5 V.

The microphone signal is amplified by IC2 (pin1). IC1 (pin 7) provides the carrier. The carrier signal is modulated with the audio signal of IC2 (pin 7) in the transformer (LT60). IC2 (pin 7) is configured in a low pass filter mode in order to reduce the

high frequency content of the audio signal. The microphone characteristics automatically reduce the low frequency content in the signal.

The received audio signal is buffered with the IC1 (pin1) audio amplifier. This has a low pass filter in its input stage to filter out the carrier frequency. When the handset is replaced, switch S2 increases the earpiece volume by increasing the feedback level.

The switch S1 determines the extension telephone filtering characteristics during the high gain operation.

III.7 POWER SUPPLIES

DC Power for the system is provided by two VERO MONOVOLT GK60 switching supplies which operates from a DC source which varies between 24 V and 72V.

The power supplies were selected for worst case operating conditions.

i. All LEDs are illuminated on the Status display and on the Multiplexer Monitor Boards. A Maximum of 32 LEDs are on at a time on the Status Display and 96 LEDs on the Multiplexer Monitor Boards.

ii. One operator display with all segments of the two digits illuminated.

iii. The audio alarm active.

iv. The normal power supply requirements of the eight boards in the rack.

Power requirements are:

Extension Telephones (96X)-	+24V	- 0,012A	= 1,200A
Operator Telephones (X2) -	+24V	- 0,020A	= 0,04A
Mimic Status display (32X)-	+5V	- 0,030A	= 0,960A
Multiplexer Monitor(x6) -	+12V	-	
	-12V	-	
	+5V	- 0,640A	= 3,2A
	+24V	- 0,200A	= 1,2A
Telephone Controller(x2) -	+12V	-	
	-12V	-	
	+5V	- 0,300A	= 0,6A
	+24V	- 0,040A	= 0,08A
Single Board Computer -	+5V	-	1,5A

Worst case total power requirements:

+5V	-	6,3A
+24V	-	2,6A

The +12V and -12V is derived from the +24V supply. It is used for the voltage comparator circuits.

The power supplies used are:
+ 5 V at 12 A, and
+24 V at 2,5 A.
Since these worst case considerations are not possible, the +24V @ 2,5A power supply power rating would not be exceeded.

III.8 BACKPLANE WIRING

The complete wiring schedule is given in the Appendix. Bussing is clearly indicated by the names given to all functions in the wiring schedule in the Appendices.

Point to point wire wrapping is used. A heavier gauge wire is used to make allowance for high currents of the power supply lines.

Chapter IV

SOFTWARE DESCRIPTION

Please refer to the 'Software module description' and the 'List of Variables' for a list of mnemonics used in the software.

Chapter IV

SOFTWARE DESCRIPTION

IV.1 Software Background

A high level language such as MPL is generally well suited for applications such as this one.

The Motorola EXORCISER compiles the MPL source code into 6809 Assembler modules. The object modules, whether originally Assembler or MPL, are linked together by the 6809 Linker to form the object code.

The available MPL compiler is an upgraded version of the 6800 Motorola MPL compiler. The advanced addressing modes of the 6809 microprocessor had not been implemented into this 6809 Motorola MPL Compiler. Some MPL routines compiled into very inefficient Assembler code because some powerful 6809 instructions were not exploited.

Since the mimic status display LEDs are multiplexed the software is time dependent. Data to the Status Display has to be updated every 5 ms in order to provide a flicker free display.

The Status display interrupt service routine interspaces normal processing. The Status display service call is the highest priority task, and is invoked by a 5 ms real time interrupt. The execution time of the Status display interrupt service routine (t_{mimic}) has to be as short as possible to allow the maximum time for other processing (t_x) to be done.

Figure VI.1 shows this concept graphically. If t_{mimic} is too long, insufficient time remains for normal processing.

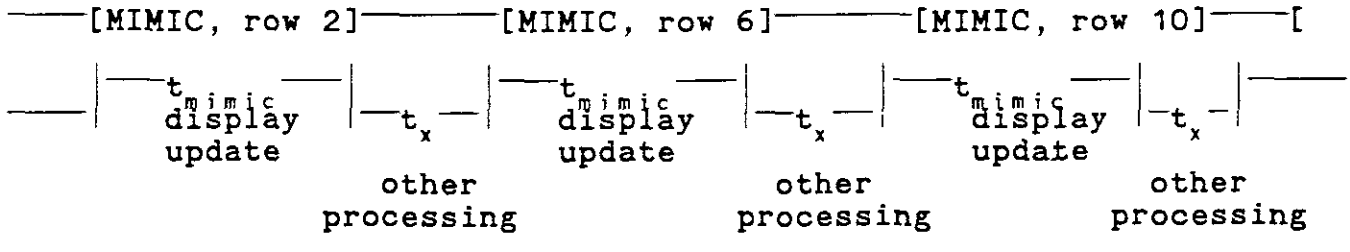


Fig. VI.1. Interrupt Timing.

I had completed most of the software using MPL before hardware became available to test the software interface efficiency. The display routine written in MPL executed in approximately 4000 clock cycles. Less than 1 ms remained for normal processing when the 5 ms interrupt is used - this was not acceptable.

Comparing the compiled MPL with the Assembler was easy since the compiler generates Assembler. From this compiled MPL it became clear that the available MPL was not optimized for the 6809 microprocessor. In the case of the Display service routines the optimized Assembly language code executed in only 400 clock cycles as compared with the 4000 of the MPL.

Assembler and MPL use different programming methods and philosophies. Parameter passing between Assembler and MPL routines proved to be difficult. Assembler counters decrement to zero and MPL counters, e.g. DO loops, where the count variable increments from the start to the stop parameter. It was decided to rewrite all software in assembly language.

IV.2 Introduction.

NassiShneiderman flow charts are used to document program logic. It's format aids structured programming and promotes more compact documentation than conventional flow charting.

The flow charts are included at the end of this chapter.

Included with the software listing in the Appendix is a pseudo high level language used to aid description of the program logic.

An overall perspective of the software is best obtained by studying both the IRQP and MAINP routines. IRQP is the main interrupt handler. MAINP is the main controlling routine subsequent to system initialization.

All data is input via interrupts. Operator and user action invoke IRQP which call the necessary interrupt service routines to pass data via system status flags (in SYSTAT, the system status word) to the main program, MAINP. The main program responds only to changes in the system status flags (or changes in the telephone statuses). The status flags are set or cleared by the interrupt service routines.

Subsequently the main program checks the system status flags and executes the appropriate service routines. Once the service routines have been completed the system status flags are checked again. The program flow of the MAINProgram is exclusively determined by the system status flags.

Figure IV.2 pictorially present the relationship between the interrupts, the extension telephone statuses and the main program (MAINP). Hardware interrupts interface the operator cradle statuses, operator keypads and the mimic status display with the software. If necessary the interrupt handling routines set or clear flags in the system status word (SYSTAT) during execution. Subsequently control is returned to the MAINP.

Each time MAINP is activated the extension telephone statuses are checked. The mimic status display data update, operator numeric displays, operator alarm and the ring tone are all controlled by MAINP.

The MAINP execution is interrupted only by the hardware interrupts. These interrupts interface to the MAINP only via the system status flags (SYSTAT, FNCST0 and FNCST1). The main program executes iteratively and the program flow is solely determined by the system status flags.

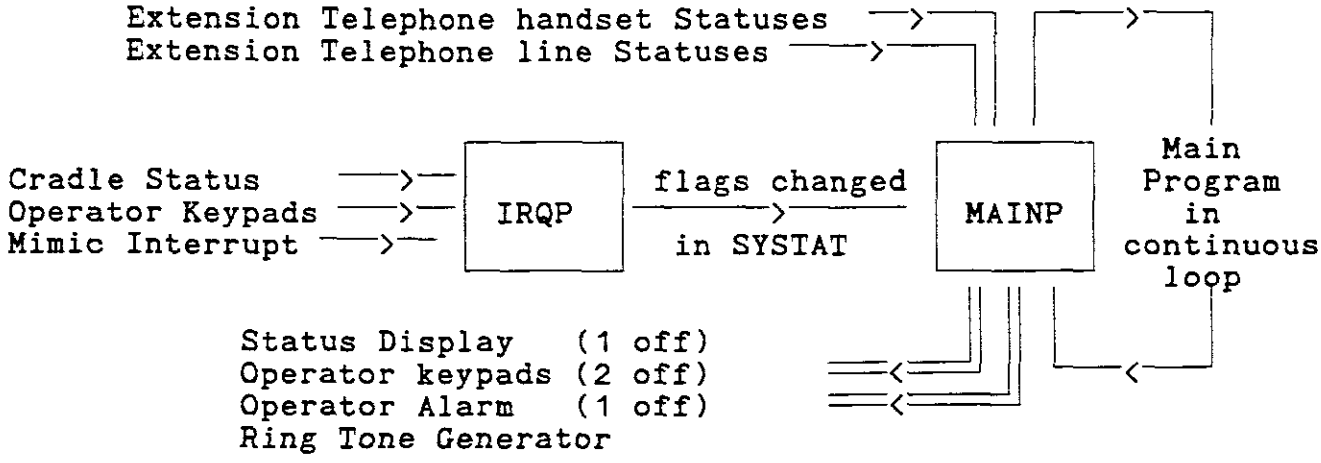


Fig. VI.2. Data flow Pictorial

The EFTS software can be divided into two main sections:

Interrupt driven routines, and
main program

All the software is written in 6809 assembly language and totals approximately 2100 bytes in length.

IV.3 Interrupt Driven Routines.

Hardware interrupts invoke IRQP, the main interrupt handler. The interrupt routine disables all further hardware interrupts. IRQP identifies the origin of the interrupt and then calls the appropriate interrupt service routines. Interrupts are re-enabled upon completion of the interrupt service routines, when program control is resumed by the main routines (MAINP).

When an interrupt is invoked by the onboard clock (5 ms), the two counters, MSEC and IRQCNT, are decremented. MSEC is a presettable counter and used by the DELAY-routine. IRQCNT determines the flashing period of the LEDs - when zero, IRQCNT is preset to FLSHTM.

The Cradle interrupt pass appropriate parameters to CRDLP, the cradle interrupt service routine. A keyboard interrupt invokes

the KYBX routine, the operator keyboard service routine, which read and then decodes keyboard data.

IV.3.1 Interrupt Priorities (IRQP)

The periodic real time interrupt (the interrupt period is selected by jumpers on the Computer Board) has the highest interrupt priority and the highest recurrence rate. The operator telephone cradle switches have the next highest priority because of their vital function: it cancels all system command modes. Keyboard action has the lowest priority.

highest priority	1 ms real time interrupt
	Operator 0 cradle interrupt
	Operator 1 cradle interrupt
	Operator 0 keypad interrupt
lowest priority	Operator 1 keypad interrupt

The interrupt flags are reset by their appropriate service routines.

IV.3.2 Mimic Status Display

The mimic status display is multiplexed at fixed regular intervals (IRQCNT) to provide a flicker free constant intensity display. The 192 LEDs are grouped into 32 columns of 6 rows. Data is output to one row at a time - each row has 32 LEDs. The 6 rows of 32 columns of LEDs therefore require 30 ms to refresh.

Flashing and steady (non flashing) LED statuses are stored in two 24-byte arrays: FLSH & COLBUF. The arrays respectively indicate flashing or steady LEDs. The first 12-bytes (96-bits) of each array represent handset statuses and the next 12-bytes represent fault statuses.

The MIMIC service routine is invoked only by the real time interrupt. Upon entry all ROW's are disabled. Before enabling the next row (one of six rows) the 32-bits (4-bytes, 4 PIA's) of column data is output to the columns.

Multiplexing is executed in one of two modes:

- Lamp test active, or
- Normal multiplexing

When the lamp test flag (LAMPM) in SYSFLG is set, all Columns are enabled to turn on all the LEDs.

The flash bit (FLASHB) in SYSFLG determine the status of the flashing LEDs. When set the flashing LEDs are on, and when cleared, the flashing LEDs are off. The flashing LEDs are turned on and off by negating the status of FLSHB at the flashing period (FLSHTM).

If the flash bit (FLASHB) is cleared, only COLBUF data is output to the COLUMNS. When the flash bit is set, COLBUF & FLASH data is logically ORed before outputting the data to the COLUMNS, thereby turning on the flashing LEDs as well as the steady LEDs.

IV.3.3 Keypad Routine (KYBX and KYBRDP)

Operator keypad activity invokes the IRQP main interrupt service routine which then calls the KYBX interrupt service routine. KYBX has lowest priority of the interrupt service routines. Upon completion of the keyboard service routine the interrupt flag is cleared enabling further interrupts.

Operator 0 keypad (KYBRD0) uses the least significant nibble (4 bits) of the keypad PIA (KYBRD), and the operator 1 keypad (KYBRD1) the most significant nibble. Depending on which keypad initiated the interrupt the KYBRD code is masked and the relevant keypad code stored in KYBINP buffer.

The keypad codes stored in KYBINP is decoded by the KYBRDP subroutine. Decoding by KYBRDP is accomplished on three levels.

Level 1

Unnumbered key	-	No action taken.
Lamp Test code	-	Set Lamp Test flag in SYSTAT.
Alarm Accept code	-	Set Alarm Accept flag in SYSTAT.
Clear code	-	Set the Clear flag in SYSTAT.

Level 2

If the Audio flag is set and the cradle is down all other codes are ignored.

If the operator telephone cradle is up, then:

Ring code	-	Set Ring flag in SYSTAT.
Queue code	-	Set Queue flag in SYSTAT.

Level 3

Decode the numeric keys and display the numbers on the operator numeric display.

Level 1 keypad codes are actioned irrespective of the operator telephone cradle status. Level 2 codes are executed only if the Audio flag (in FNCST) is set and the operator telephone cradle is up. Level 3 codes can only be executed if the keycode is not Level 1 or Level 2 code.

After this the program control is returned to IRQP.

Keypad decoding table:

Function	Code	Priority		Function	Code	Priority
1	1	6 lowest		9	A	6 lowest
2	5	6		0	7	6
3	9	6		L	3	1
4	0	6		A	B	2
5	4	6		C	F	5
6	8	6		Unmarked	E	0 highest
7	2	6		Q	D	4
8	6	6		R	C	3

Fig. VI.3. Keypad decoding table.

IV.3.4 Cradle Procedure (CRDLP)

The cradle procedure has the second highest priority of the interrupt service routines. Any change in operator cradle status invokes the CRDLP service routine.

First the operator telephone cradle status is determined. If the operator handset is lifted no further action is taken and program control is returned to IRQP.

If the operator handset is down, the AUDIOM and RINGM flags of the function status word are tested. When the AUDIOM flag is set the audio line between the operator and the extension telephone is disconnected. If the RINGM flag is set ringing of the extension telephone is stopped.

Consequently all status flags of that operator are cleared. Lastly, the operator numeric display is cleared. Program control is then returned to IRQP.

Note: When the cradle is down, the cradle status at PIAOB is low (logic 0).

IV.4 Main Programs

IV.4.1 Main Program (MAINP)

The Main Program (MAINP) executes in an iterative loop. It's execution is diverted only by the five hardware interrupts.

The status of a specific operator is represented by flags in the function status word (FNCST0 and FNCST1 for operator 0 and operator 1 respectively).

The program flow of MAINP is determined by the mode flags in the function status words (FNCST0 for operator 0 and FNCST1 for operator 1). When no mode flags are set, MAINP resets the watchdog and checks the extension telephone statuses for changes in status. MAINP invoke routines associated with the mode flags.

Mode flag	Description	Routine called
ACKM	Acknowledge	ACKP
LAMPM	Lamp Test	LAMPM
RINGM	Ring	RING
QM	Queue	QP
CLRM	Clear	CLRP
AUDIOM	Audio mode	Status only
RINGING	Ringing active	Status only

During execution of a procedure called by MAINP, flags in FNCST0 and FNCST1 may be set and/or cleared in order to invoke other appropriate procedures.

IV.4.2 Watchdog (WTCHDG)

At power up the Watchdog timer is disabled for approximately 4,5 seconds. During normal processing the watchdog timer has to be reset every 10 ms, otherwise the watchdog timer resets the system.

The watchdog timer is reset when the CA2 line of PIA0 is toggled by the watchdog routine, WTCHDG.

IV.4.3 Test for Status Changes (TSTCHNG)

This routine checks the handset and line statuses of the 96 extension telephones.

A change from low to high in extension telephone handset status sets the particular bit representing that extension telephone in the mimic data buffer (STBUF0 and STBUF1). The operator audio alarm is then activated to inform the operator of the incoming call.

A change from high to low in status clears the particular bit in both the FLSH and COLBUF data buffers. Both the flashing and steady LEDs are turned off.

When the handset status changed from low to high QPHON adds the telephone number to the queue. If the handset status changed from high to low QPHON deletes the telephone number from the queue.

IV.4.4 Make Buffer (MAKBUF)

This routine alternately buffers all the extension telephone statuses in one of the data buffers, STTBUF and STBUF1 (24 bytes each).

A change in extension telephone status is reflected by a difference between the two data buffers. This difference is detected by TSTCHG when it compares the two data bases.

Momentary open circuit faults on the lines necessitate debouncing of the fault statuses. The faults are caused when fumbling the extension telephones handsets when they are lifted or replaced.

IV.4.5 Ring Procedure (RINGP)

This routine rings an extension telephone when the ring mode flag (RINGM) is set.

When you ring an extension telephone an audio multiplexer connects the voice signal to the extension telephone. Should the extension telephone handset be lifted no ring tone is required. If the extension handset is down the ring tone is enabled and the ring tone can be heard at both the operator telephone and the extension telephone. When the handset is lifted the ringing is terminated.

The RINGM flag is cleared when the ringing is terminated.

Before ringing an extension telephone two tests are done:

> Two operators may never simultaneously be connected to the same extension telephone. Should the one operator dial the extension telephone the other operator is connected to, the other operator is disconnected from that extension telephone. The latter caller is connected to the extension telephone. The other operator's numeric readout is cleared to indicate that his call has been terminated.
>
> The second test executed checks that a valid extension telephone number is dialled, i.e. the number is zero or is not

greater than the maximum number allowed (96 for the present implementation). When an invalid number is dialled ringing is aborted and program control is immediately returned to MAINP after clearing the operator numeric readout.

A valid extension telephone number is decoded and stored in the ring buffer for the particular operator. The operator telephone voice circuit is connected to the dialled extension telephone and the audio flag is set in the function status word. If the extension telephone handset is not lifted the LED corresponding to the extension telephone number starts flashing. The operator telephone voice circuit is connected to the dialled extension telephone and the audio flag is set in the function status word. The ringing flag is set and the ring flag remains set in the function status word.

The dialled extension telephone is checked to see if the handset has been lifted. Until such time as the handset is lifted or the call is terminated, the extension telephone is disabled.

Replacing the operator handset or pressing the C-key will terminate the Ring function.

IV.4.6 Alarm Acknowledge (ACKP)

The ACKP routine servers two main functions:

The operator audio alarm is silenced

A new fault is acknowledged by turning the flashing fault LEDs on permanently until the fault is cleared and/or the system reset.

The fault LEDs stop flashing when the fault statuses in the FLSH data buffer are cleared. The fault LEDs turn on (steady) by logically ORing the FLSH fault data with the COLBUF column data. The ORed data is stored in the fault status section of COLBUF.

The acknowledged faults are indicated by steady red LEDs on the mimic status display. These LEDs are enabled via the normal MIMIC routine.

IV.4.7 Clear Function (CLRP)

This routine terminates all functions of the operator and is equivalent to replacing the operator handset.

The clear routine clears the Clear flag in the appropriate function status word (FNCST0 or FNCST1) and then branches to the cradle down routine (CRDLDW) which is part of the cradle procedure (CRDLP). The CRDLDW routine terminates all operator functions.

IV.4.8 Lamp Test (LAMPP)

The lamp test routine has two functions. All the LEDs on the Status display and all the operator readout segments are all turned on.

LAMPP indirectly control the LEDs by setting the lamp test flag in the appropriate function status word (FNCST0 or FNCST1). The LEDs are then enabled by the MIMIC interrupt service routine.

Before enabling all the segments on the operator readout the data displayed on the operator readout is buffered. All the segments are enabled for the lamp test by outputting "88" to the readout. Once the lamp test has been completed the lamp test flag is cleared and the operator readout data restored to its values prior to the lamp test.

The operator who invoked the lamp test may terminate the lamp test by lifting and replacing his handset. Replacing of the handset clears the function status flags and so terminate the Mimic lamp test.

IV.4.9 Queuing Routines

Queuing routines are subdivided into four routines:

Testing the presence of an extension telephone number in the queue.

Adding an extension telephone number to the queue.

Deleting an extension telephone number from the queue.

Ringing the extension telephone number at the top of the queue.

Queuing data is stored in a linked list. Each extension telephone number use two bytes. Therefore all linked list table offsets and pointer values are double that of the telephone number.

Each telephone number data element is made up of two bytes: "prev" and "next". The pointer value to the telephone number data element is therefore double the value of the telephone number. See figure VI.4.

When a telephone number is not in the queue both its pointer values are 00_{16}.

Queuing Example:

Refer to Figure VI.4. In this example the extension telephone at the top of the queue is number 9 (12_{16}). FRSTNO points to 12_{16} (double the value of number 9). The "prev"-byte of extension telephone number 9 points to 00_{16}, which means there is no telephone number prior to this one in the queue.

The 'next'-byte of extension telephone number 9 is 04_{16}, and points to extension telephone number 2.

The 'next'-byte of extension telephone number 2 is 18_{16}, and points to extension telephone number 12.

The "next"-byte of telephone number 12 (pointer value 18_{16}) is 00_{16}. This implies that there is no next telephone in the queue and that it is the last telephone in the queue.

Telephone number 12 is the last extension telephone number in the queue for two reasons. The pointer to the next location is 00_{16}, and LASTNO also points to it.

The "prev"-byte of telephone number 12 (pointer value 18_{16}) points to 04_{16}, or extension telephone number 2.

Telephone number 2 pointers indicate that the previous telephone number in the queue is at location 12_{16}, which is extension telephone number 9. The next extension telephone number in the queue is at location 18_{16}, which is telephone number 12 ($0C_{16}$).

tel. no.	pointer value	Linked list prev	Linked list next
	+ 0	00	00
1	+ 2	00	00
2	+ 4	12	18
3	+ 6	00	00
4	+ 8	00	00
5	+ A	00	00
6	+ C	00	00
7	+ E	00	00
8	+ 10	00	00
9	+ 12	00	04
10	+ 14	00	00
11	+ 16	00	00
12	+ 18	04	00
13	+ 1A	00	00
14	+ 1C	00	00

<— These two bytes are not used.

12	FRSTNO
18	LASTNO

Fig. VI.4. Example of queue in operation.

IV.4.10 Check Queue: (CHKQ)

The routine checks the Queue for the presence of a specified Telephone number. There are four possibilities:

i. The extension telephone number is not in the queue. On completion of the routine, the A-register contains $FF.

ii. The extension telephone number is in the queue and it is linked to other extension

telephone numbers. A test is made to see whether these pointers are present. If these are present, the A-register contains the extension telephone number on completion of this test. If the test fails, a third test is done.

iii. The number checked may be the only number in the queue. Such a number if not linked to any other numbers and is therefore both the first and last extension telephone number in the queue. FRSTNO, the pointer to the first extension telephone number in the queue, is tested for correspondence. If the test is true, the number is the FRSTNO and the A-register will contain the extension telephone number on exit. If false, the A-register will contain $FF.

iv. The extension telephone number is the last extension telephone number in the queue. The test in (ii) will locate this number. Since it is only linked to a previous extension telephone number in the queue, no numbers follow it. Test (iv) is a special case of test (ii).

IV.4.11 Add to Queue (ADDQ)

The routine adds an extension telephone number to the queue. There are two possibilities:

i. The queue is empty. The extension telephone number to be added will be the first extension telephone number in the queue.

FRSTNO points to the first extension telephone number entry in the queue.

ii. The queue is already in use. The extension telephone number is added to the end of the queue.

The last extension telephone number in the queue now becomes the second last in the queue by making its "next"-byte point to the new last entry.

The extension telephone number added to the queue becomes the LASTNO, and its "previous" byte points to the extension telephone number that has become the second last in the queue.

IV.4.12 Delete from Queue (DELFQ)

The routine deletes the selected extension telephone number from the queue. CHCKQ must be invoked before calling DELQ to ensure that the number to be deleted is present in the queue. Three possibilities exist for program control.

i. The extension telephone number to be deleted is the first number in the queue, i.e. FRSTNO. The second extension telephone number now becomes the FRSTNO, and the "previous" and "next"-bytes of the extension telephone number to be deleted is cleared.

ii. The extension telephone number to be deleted is somewhere in the queue, but not the FRSTNO or LASTNO. The "previous"-byte of the extension telephone number following the to-be-deleted extension telephone number is made the same as the "previous"-byte of the to-be-deleted extension telephone number. Also, the "next"-byte of the extension telephone number preceding the to-be-deleted extension telephone number is made the same as the "next"-byte of the to-be-deleted extension telephone number. Then the "previous" and "next"-bytes of the to-be-deleted number is deleted. The to-be-deleted extension telephone number are now deleted from the queue.

iii. The extension telephone number to be deleted is the LASTNO. The "next"-byte of the second last extension telephone number

in the queue is cleared. The "previous" and "next"-bytes of the last extension telephone number in the queue is cleared and LASTNO made to point at the second last entry in the queue. The old LASTNO is now deleted.

IV.4.13 Ring Top of Queue (QP)

This program rings the extension number at the top of the queue simply by pressing the Q-key.

If there are no telephone numbers are in the queue when the Q-key is pressed program, control is resumed by MAINP.

If the queue is in use, FRSTNO is decoded and displayed on the operator readout. The extension telephone number is further decoded and appropriate parameters passed to RINGP. RINGP is then executed i.e. RINGP rings the extension telephone as if the extension telephone number was dialled from an operator keypad.

IV.5 System Software Flow Charts

P

IF PERIODIC INTERRUPT THEN DO
DECREMENT MSEC COUNTER
DECREMENT IRQCNT COUNTER
IF IRQCNT ZERO THEN DO
EQUATE IRQCNT TO FLASHTIME (FLSHTM)
INVERT FLASH (FLSH) FLAG IN SYSTEM FLAG (SYSFLG)

IC:

IS LAMP TEST FLAG SET	
ELSE	THEN
IF FLASH FLAG SET	
ELSE	THEN
OUTPUT: COLBUF (NCOLM) TO COLO	COLO = COLBUF (NCOLM) OR FLSH (NCOLM)
DECREMENT NCOLM	DECREMENT NCOLM
COLBUF (NCOLM TO COL1	COL1 = COLBUF (NCOLM) OR FLSH (NCOLM)
DECREMENT NCOLM	DECREMENT NCOLM
COLBUF (NCOLM) TO COL2	COL2 = COLBUF (NCOLM) OR FLSH (NCOLM)
DECREMENT NCOLM	DECREMENT NCOLM
COLBUF (NCOLM) TO COL3	COL3 = COLBUF (NCOLM) OR FLSH (NCOLM)
IF NCOLM = 0 THEN NCOLM = 23	DECREMENT NCOLM IF NCOLM = 0 THEN NCOLM = 23

ENABLE ALL COLUMNS

ROW = MASK (NROW)
DECREMENT NROW
IF NROW 0 THEN
NROW = 5

LX:

IF ANY CRADLE IS SET THEN THEN

IF CRADLE 0 IS SET	
THEN	THEN
PASS PARAMETER = 0	PASS PARAMETER = 1

CALL CRADLP (CRADLE PROCEDURE)

X:

IF ANY KEYBOARD FLAG IS SET THEN

IF KYBO IS SET	
THEN	ELSE
GET KEYBOARD0 INPUT FROM KYBRD PIA & STORE IN KYBINP(0)	GET KEYBOARD 1 INPUT FROM KYBRD PIA & STORE IN KYBINP(1)

CALL KYBRDP (KEYBOARD PROC)

RETURN FROM INTERRUPT

NOTE: COLBUF (13) = FLASH (1)
COLBUF (23) = FLASH (11)

)LP:

IF NONE OF THE CRADLE'S HAVE BEEN PUT DOWN THEN
RETURN FROM SUBROUTINE
RESET CRADLE IRQ'S
IF AUDIO OR RING MODE FLAGS ARE SET THEN
DISABLE LED OR PHONO CONNECTED TO : JSR CHGLED
DISABLE OPERATOR RINGING : JSR BUZZR
DISCONNECT AUDIO FROM EXTENSION : JSR AUDIO
)SP: CLEAR KYBUF (OP#) (KEYBOARD BUFFER)
CLEAR OPERATOR DISPLAY : JSR LINKP
CLEAR FUNCTION STATUS FLAGS
RETURN FROM SUBROUTINE

)DP:

GET KYBINP (OP#) (KEYBOARD INPUT)					
DO CASE					
UNNUMBERED KEY	LAMP TEST	ALARM ACCEPT	CLEAR	RING	NUMBER 0 - 9
	SET LAMPM FLAG	SET ACKM FLAG	SET CLRM FLAG	SET RINGM FLAG	MAKE OLD LSD NEW MSD
					ADD NEW DIGIT
					DISPLAY DATA : LINKP
RETURN FROM SUBROUTINE					

P

DO FOREVER				
CLEAR IRQ MASK				
RESET WTCHDG				
DO CASE (FNCST (OPRN2))				
RINGM FLAG	ACKM FLAG	QM	CLRM	LAMPM
JSR RING	JSR ACKP	JSR QP	JSR CLRP	JSR LAMPP
RESET WTCHDG (WATCHDOG)				
INVERT OPRNO (OPERATOR NO. 0 OR 1)				
TEST FOR STATUS CHANGES : TSTCHG				

TCHG

CHANGE STATUS BUFFER NO.	
GET ACTIVE STATBUF ADDRESS	
JSR MAKEBUF MAKE NEW STATUS BUFFER	
DO MUXNO = 23 TO 0	
IF THERE IS A CHANGE IN STATUS THEN	
FIND BITNO OF CHANGED BIT	
FIND NEW STATUS OF CHANGED BIT	
IF NEW STATUS OF BIT = 1	
NO	YES
TURN FLASHING LED OFF	SET LED FLASHING
IF MUXNO ≤ 11 (PHONE) THEN	
GET PHONO NO 0 CHANGED STATUS	
HAS HANDSET BEEN LIFTED	
YES	NO
PUT PHONE IN Q	DELETE PHONE NO FROM Q

LAMPP

```
OUTPUT "88" TO OPERATOR DISPLAY
DELAY FOR TSTIME  (TEST TIME)
RESTORE OPERATOR DISPLAY
CLEAR LAMP TEST FLAG IN FNCST (OP#)
```

CLRP

```
CLEAR ALL FLAGS IN FNCST (OP#)
CLEAR OPERATOR DISPLAY
```

ACKP

```
MAKE ALL FLASHING 'FAULT' LED'S
                STEADY
STOP BUZZER RINGING
```

RINGP

```
IF SAME PHONO RUNG AS OTHER OP THEN
   RETURN
IF RNGNG FLAG IS NOT SET THEN
   SET RNGNG FLAG
   IF PHONO IS NOT VALID THEN
      RETURN
   FLASH GREEN LED
   CONNECT OP# PHONE TO PHONO
      JSR AUDIO
   RING  PHONO
IF PHONO HAS BEEN ANSWERED THEN
   STOP RINGING
   CLEAR RNGNG FLAG
   MAKE GREEN LED STEADY
RETURN
```

ARD CODING:-

KEYBOARD & LAYOUT:

1	2	3	Q
4	5	6	RING
7	8	9	DIAL
LAMP	0	ACK	CL

KEYBOARD CODES:

1	5	9	D
0	4	8	C
2	6	4	E
3	7	B	F

Chapter V

OPERATOR INSTRUCTIONS

V.1 CONTROL CENTRE

V.1.1 Incoming Calls

The audio alarm sounds and a flashing green LED on the Mimic indicates the calling Extension telephone.

The operator lifts a telephone handset. This cancels the audio alarm.

Press the Q-key to connect to the incoming call. The flashing green LED turns on permanently and the numeric readout displays the Extension telephone's number.

The operator telephone is now connected to the Extension telephone.

The operator terminates the call by either replacing the handset or pressing the C-key.

In the case of queued calls, first terminate the present call (C-key) before connecting to the next in the queue (Q-key).

Once a call is terminated, the operator may directly ring any Extension telephone or connect to the next Extension telephone in the queue.

NOTE: No audible alarm sounds when any one of the operator handsets have been lifted. Should the operator replace his handset before all the incoming calls have been answered, the audio alarm will NOT sound again, however the green LED will remain flashing as long as the Extension telephone handset remains lifted.

Once the audio alarm has been silenced and the operator handset replaced, the audio alarm will sound again until another Extension telephone handset is lifted.

V.1.2 Outgoing Calls

Lift the operator handset and enter the Extension telephone number on the keypad. Press the R-key (RING) to ring the Extension telephone.

The green LED, corresponding to the Extension telephone, will flash while the Extension telephone is ringing.

When the Extension telephone is answered, the green flashing LED stops flashing and becomes steady. Communication may now proceed.

The operator replaces his handset or presses the C-key to terminate the call. The green LED then turns off.

NOTE: Only the operator can terminate a call.

Replacing the Extension telephone handset will not terminate a call. After replacing the Extension telephone handset the operator telephone voice signals will be amplified to an extra high volume level until the operator terminates the call.

V.1.3 FAULT CONDITIONS

When a fault occurs the corresponding red LED flashes. If neither of the operator handsets are lifted the audio alarm sounds.

Press the A-key to acknowledge and silence the alarm. The flashing red LED stops flashing and turns on permanently.

The operator reports the fault to the Technical Staff.

NOTE: Intermittent audio alarms may be eliminated by lifting an operator handset off the cradle.

No audio alarms can sound with the operator handset lifted and incoming calls may so be missed.

V.2 EXTENSION TELEPHONE

V.2.1 To make a call.

The caller lifts the handset and waits for the Control Centre operator to answer. After conversing the handset is replaced.

V.2.2 To receive a call.

The Extension telephone will ring. When the handset is lifted the ringing terminates. The user may now converse with the Control Centre operator.

V.3 LAMP TEST

When the L-key is pressed all the LED's and the numeric readout of the one operator telephone are turned on.

The operator numeric readouts may be tested independent from the mimic status display by pressing the black button on the operator telephone.

V.4 GENERAL

When in doubt press the C-key. This has the same effect as replacing the handset which cancels all previous commands and keyboard entries.

The only two operator functions that can be executed with the handset on the cradle are the Lamp test and Alarm acknowledgement.

The two operators cannot simultaneously communicate with the same Extension telephone. The call may be interrupted by the second operator by him dialling the same extension telephone number. The first operator will then be cut off.

A lamp test is automatically executed after power up or after system reset.

Chapter VI.

SYNOPSIS.

It is good practice to determine whether the design attained the original objective.

The following factors restrained attainment of the original goal:

The restrictive budget curbed more ingenious solutions.

The modulation technique used restricted the remodeled design and the resulting audio quality.

Few failings have been found in the present design beyond those originating from the alluded restraints.

The modulation technique used, i.e. using both AM and audio, resulted in an inferior audio quality.

In order to obtain the required gain in the audio circuitry the audio and AM bandwidths had to be restricted regardless of the effect.

The hybrid network and amplifier circuit has been adjusted to operate marginally below the point of oscillation where positive feedback results. Even so, sometimes the volume has been found to be insufficient, or oscillations have resulted.

The use of dedicated filtering ICs is probably the most economical way to improve the audio quality. Superior filtering characteristics are possible with these devices. Research has found it to be relatively costly. One Chebychev filter IC costs approximately the same as the microcomputer board would cost to manufacture. At least three of these devices would be required - once again fluked by the budget.

A practical issue has been overlooked regarding the queuing of incoming calls. The person at the extension telephone has no indication that an operator has in fact received his call. Some discernible form of acknowledgment would be a distinct enhancement.

Substituting the red and green LEDs with single dual color LEDs will aesthetically enhance the Mimic display even though the dual colour LEDs are more expensive than two single colour LEDs.

Personally I would have preferred using standard balanced line telephones. This would have been a viable solution if the previous extension telephones were discarded. However, the previous system had to be expanded, and could not replaced.

Ultimately the EFTS can be regarded as economical, durable and reliable and uncomplicated with a reasonable audio quality.

APPENDICES.

A. APPENDICES.

A.1. Features of the Emergency Fire Telephone System.

The Emergency Fire Telephone System provides communication between various selected places, distributed throughout the Cape Town Administrative Centre (CTACC), i.e. from the tower block, the podium, and the foyer, to the Security Control Centre on the first floor in the podium block.

The system has the following facilities:

Communication from the control centre to an Extension telephone, with ring capability.

Communication from the Extension telephone to the control centre, also with ring facility.

Simultaneous two way communication is provided between one operator at the control centre and an Extension telephone.

Line monitoring of all Extension telephone lines for short circuit and open circuit detection.

Line status and fault status indication of all Extension telephones.

An operator can only communicate with one Extension telephone at any one time. An Extension telephone is selected by means of a two digit telephone number dialled on the Operator telephone.

Ring and Clear facilities are provided on the Operator keyboard.

The "ring" and "fault" statuses of all Extension telephones are displayed.

Telephone circuitry is designed to operate on a nominal 24V supply.

A.1.1 System Layout.

A.1.1.1 Extension Telephones.

The Extension telephone receives a normal audio signal from the Operator telephone and amplifies it. However, the signal from the Extension telephone to the Operator is an A.M. signal with a 14 kHz carrier frequency.

Each of the Extension telephones is provided with an unbalanced wire pair: one is the ground line, and the other carries the audio, the A.M. voice signals, and the 12V power.

A.1.1.2 Rack and Console.

The line monitoring boards multiplex the speech lines and monitor each of the Extension telephone lines. Each Extension telephone is addressed by a specific code which connects the Extension telephone to the Operator telephone. The line statuses are monitored and output to the status display boards.

Speech processing is accomplished by demodulating the A.M. voice signal from the Extension telephone and amplifying it to the Operator earpiece. The Operator microphone signal is amplified and directly output to the Extension telephone.

A.1.2 The Improvements.

The original system had become unreliable and no circuit diagrams or documentation were available for system maintenance.

The system required expansion for improved utilization. The original fifty four Extension telephones had to be increased to ninety six. With the additional Extension telephones a second operator decrease operator workload under emergency conditions.

Answering multiple calls on a FIFO basis necessitated a queueing facility. New incoming calls would be queued when the operator

was busy with a call, and he would then not be distracted by new calls.

A.2 Software Module Description.

RESET	System Initialization.
FMSB	Find most significant bit.
VALBIT	Determine value of specified bit within a byte.
SETBIT	Sets/Clears specified bit within a byte.
IRQP	Interrupt priority determining service routine.
MIMIC	Mimic display control: interrupt driven routine.
KYBRDP	Keyboard decoding procedure: Interrupt service routine.
CRDLP	Cradle procedure: Interrupt service routine.
LINKP	Operator readout procedure.
KYBX	Operator keyboard procedure.
MAINP	Main procedure.
WTCHDG	Watchdog reset routine.
TSTCHG	Tests for changes in Extension telephone statuses.
MAKBUF	Debounces and reads Extension telephone statuses into status buffers.
CHGLED	Changes/Sets mimic LED statuses: off/flash/on.
ACKP	Alarm acknowledge routine.
LAMPP	Lamp test procedure.
DELAYP	Delay procedure: real time interrupt.
DELAYR	Delay procedure: repetitive loop.
RINGP	Ring extension telephone procedure.
QP	Ring extension telephone at top of the queue.
AUDIO	Dis/connect an Extension telephone from/to an operator.
PHDCOD	BCD telephone no. to bit and byte code.
PHECOD	Phone number encode: Byte and bit code to BCD phone number.

STROBE	Strobes Extension telephone address into Telephone Controller Board data latch.
BUZZR	Operator and/or Extension telephone ring controller.
DECBIN	BCD to binary conversion.
CHKQ	Checks for Extension telephone in queue.
ADDQ	Adds Extension telephone to queue.
QPHON	Queueing control routine: section of TSTCHG.

A.3 List of Variables.

Name	Bytes	Description
SYSFLG	1	System Status Flag b1: FLASH-ON
FNCST0	1	Function Status Word, Operator 0.
FNCST1	1	Function Status Word, Operator 1. b7: ACKM b6: LAMPM b5: RINGM b4: not used b3: QM b2: CLRM b1: AUDIOM b0: RINGNG
BUFNO	1	Active Status Buffer number: 0 or 1, used as pointer.
BUFADD	2	Status Buffer Address: Contains address of STTBUF or STBUF1.
MSEC	1	Real Time Interrupt counter; max of $9999.
IRQCNT	2	Interrupt Counter; counts to FLSHTIM before reset.
KYBUF0	2	Keyboard 0 Data Buffer.
KYBUF1	2	Keyboard 1 Data Buffer.
NCOLM	1	Mimic COLumn counter.
NROW	1	Mimic ROW counter.
BYTNO	2	Extension Telephone decoder: byte pointer, BYTNO, BYTN1.
BITNO	2	Extension Telephone decoder: bit pointer, BITNO, BITN1.
STTPTR	2	Status pointer: STTPTR, STPTR1.
OPRNO	1	Operator number pointer; 0 or 1.
KYBINP	2	Keyboard input code.
STTBUF	1	Status Buffer 0.
STBUF1	1	Status Buffer 1.
COLBUF	24	Column data buffer for Mimic: Mimic LED status.
FLSH	24	Flash data buffer for Mimic: flashing LED status.
FRSTNO	1	First number in queue.
LASTNO	1	Last number in queue.
QUE	192	Queue tables.
TSTCNT	192	Debounce counter table.

A.4 PIA Allocation.

		Bit No	Name	Function	
PIA0A	$2000	7	Not used		
		6	ROW	O/P	
		5	ROW	O/P	
		4	ROW	O/P	
		3	ROW	O/P	
		2	ROW	O/P	
		1	ROW	O/P	
		0	ROW	O/P	
CR0A	$2001	7	TIMER:	IRQA1	I/P
		6	WTCHDG:	CA2	O/P

		Bit No	Name
PIA0B	$2002	7	CRDL0
		6	CRDL1
		5	not used
		4	not used
		3	not used
		2	OPX, BUZZR function
		1	MUX1, BUZZR function
		0	MUX0, BUZZR function
CR0B	$2003	7	not used
		6	not used
		7	CRDL0
		6	CRDL1
		5	not used
		4	not used
		3	not used
		2	OPX, BUZZR function
		1	MUX1, BUZZR function

		_0_	MUX0, BUZZR function	
CR0B	$2003	_7_	not used	
		_6_	not used	
PIA1A	$2004	Bit No	Name	Function
		_7_	COL0	O/P
		_6_	COL0	O/P
		_5_	COL0	O/P
		_4_	COL0	O/P
		_3_	COL0	O/P
		_2_	COL0	O/P
		_1_	COL0	O/P
		_0_	COL0	O/P
CR1A	$2005	_7_	Not used	
		_6_	Not used	
PIA2B	$200A	Bit No	Name	Function
		_7_	COL3	O/P
		_6_	COL3	O/P
		_5_	COL3	O/P
		_4_	COL3	O/P
		_3_	COL3	O/P
		_2_	COL3	O/P
		_1_	COL3	O/P
		_0_	COL3	O/P
CR2B	$200B	_7_	Not used	
		_6_	Not used	

PIA3A	$200C	Bit No	Name	Function
		7	KYBRD1: b3,	I/P
		6	KYBRD1: b2,	I/P
		5	KYBRD1: b1,	I/P
		4	KYBRD1: b0,	I/P
		3	KYBRD0: b3,	I/P
		2	KYBRD0: b2,	I/P
		1	KYBRD0: b1,	I/P
		0	KYBRD0: b0,	I/P
CR3A	$200D	7	KYSTRB0	I/P
		6	KYSTRB1	I/P

PIA3B	$200E	Bit No	Name	Function
		7	OPX	O/P
		6	PHONO	O/P
		5	PHONO	O/P
		4	PHONO	O/P
		3	PHONO	O/P
		2	PHONO	O/P
		1	PHONO	O/P
		0	PHONO	O/P
CR3B	$200F	7	Not used	
		6	Not used	

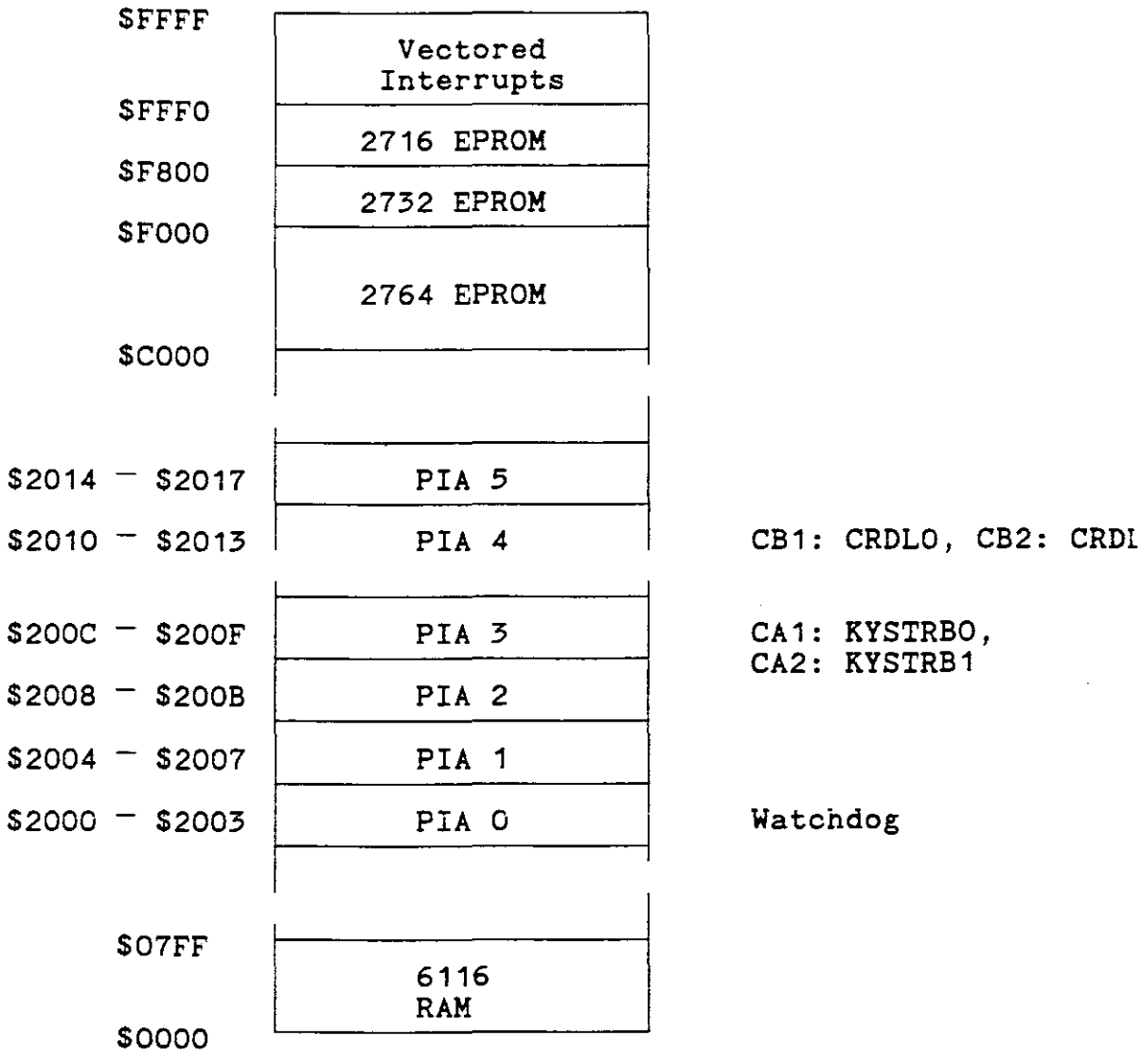
PIA4A	$2010	Bit No	Name	Function
		7	Not used	
		6	Not used	
		5	Not used	
		4	CRDSEL	O/P
		3	CRDSEL	O/P
		2	CRDSEL	O/P
		1	MUXSEL	O/P
		0	MUXSEL	O/P
CR4A	$2011	7	Not used	
		6	Not used	

PIA4B $2012	Bit No	Name	Function
	7	STATUS	O/P
	6	STATUS	O/P
	5	STATUS	O/P
	4	STATUS	O/P
	3	STATUS	O/P
	2	STATUS	O/P
	1	STATUS	O/P
	0	STATUS	O/P
CR4B $2013	7	CRADLO, IRQB1	I/P
	6	CRADL1, IRQB2,	I/P

PIA5A $2014	Bit No	Name	Function
	7	LINKO, DIG1A, MSD	O/P
	6	LINKO, DIG1A, MSD	O/P
	5	LINKO, DIG1A, MSD	O/P
	4	LINKO, DIG1A, MSD	O/P
	3	LINKO, DIG1B, MSD	O/P
	2	LINKO, DIG1B, MSD	O/P
	1	LINKO, DIG1B, MSD	O/P
	0	LINKO, DIG1B, MSD	O/P
CR5A $2015	7	Not used	
	6	Not used	

PIA5B $2016	Bit No	Name	Function
	7	LINK1, DIG2A, LSD	O/P
	6	LINK1, DIG2A, LSD	O/P
	5	LINK1, DIG2A, LSD	O/P
	4	LINK1, DIG2A, LSD	O/P
	3	LINK1, DIG2B, LSD	O/P
	2	LINK1, DIG2B, LSD	O/P
	1	LINK1, DIG2B, LSD	O/P
	0	LINK1, DIG2B, LSD	O/P
CR5B $2017	7	Not used	
	6	Not used	

A.5 Memory Map.



Memory Map of System.

A.6 Operator Command Summary.

R - Rings the Extension telephone number entered on the keyboard and displayed on the operator numeric readout.

- Cannot ring extensions 0, 97, 98, 99.
- Ringing the Extension telephone to which the other operator is connected to disconnects the Extension telephone from that operator and transfers the call to the other operator.

Q - Connects the operator to the Extension telephone at the top of the queue.

- Before making a new call to an Extension telephone the present call must be terminated.

A - Acknowledges a new alarm and silences the audio alarm.

- The flashing fault LED turns on permanently.

C - Clears the operator display and all functions.

L - Executes a lamp test of the Mimic display and operator readout.

A.7 Board Function Schedule.

A.7.1 Computer Board.

A Connector (Top)			B Connector (Bottom)	
a	**c**	**Pin No.**	**a**	**c**
+5V	+5V	1	N.C.	N.C.
CB2/1	CB2/0	2	PIA3A/7	PIA2A/7
CB1/1	CB1/0	3	PIA3A/6	PIA2A/6
PIA1B/7	PIA0B/7	4	PIA3A/5	PIA2A/5
PIA1B/6	PIA0B/6	5	PIA3A/4	PIA2A/4
PIA1B/5	PIA0B/5	6	PIA3A/3	PIA2A/3
PIA1B/4	PIA0B/4	7	PIA3A/2	PIA2A/2
PIA1B/3	PIA0B/3	8	PIA3A/1	PIA2A/1
PIA1B/2	PIA0B/2	9	PIA3A/0	PIA2A/0
PIA1B/1	PIA0B/1	10	CA2/3	CA2/2
PIA1B/0	PIA0B/0	11	CA1/3	CA1/2
PIA1A/7	PIA0A/7	12	CA2/5	CA2/4
PIA1A/6	PIA0A/6	13	CA1/5	CA1/4
PIA1A/5	PIA0A/5	14	CB2/5	CB2/4
PIA1A/4	PIA0A/4	15	CB1/5	CB1/4
PIA1A/3	PIA0A/3	16	PIA5B/7	PIA4B/7
a	**c**	**Pin No.**	**a**	**c**
PIA1A/2	PIA0A/2	17	PIA5B/6	PIA4B/6
PIA1A/1	PIA0A/1	18	PIA5B/5	PIA4B/5
PIA1A/0	PIA0A/0	19	PIA5B/4	PIA4B/4
CA2/1	CA2/0	20	PIA5B/3	PIA4B/3
CA1/1	CA1/0	21	PIA5B/2	PIA4B/2
CB2/3	CB2/2	22	PIA5B/1	PIA4B/1
CB1/3	CB1/2	23	PIA5B/0	PIA4B/0
PIA3B/7	PIA2B/7	24	PIA5A/7	PIA4A/7
PIA3B/6	PIA2B/6	25	PIA5A/6	PIA4A/6
PIA3B/5	PIA2B/5	26	PIA5A/5	PIA4A/5
PIA3B/4	PIA2B/4	27	PIA5A/4	PIA4A/4
PIA3B/3	PIA2B/3	28	PIA5A/3	PIA4A/3
PIA3B/2	PIA2B/2	29	PIA5A/2	PIA4A/2
PIA3B/1	PIA2B/1	30	PIA5A/1	PIA4A/1
PIA3B/0	PIA2B/0	31	PIA5A/0	PIA4A/0
N.C.	N.C.	32	OV	OV

A.7.2 Telephone Controller Board.

A Connector (Top)			B Connector (Bottom)	
a	**c**	**Pin No.**	**a**	**c**
+5V	+5V	1	STSEL0	STROBE
MUXA A	-	2	STSEL1	PSEL7
PHON3	-	3	STMXA1	STMXA0
MUXA B	-	4	STMXA3	STMXA2
PHON2	-	5	-	KYP0
MUXA C	-	6	KYBRDD	KYP1
-	-	7	KYBRDC	KYP2
PHON1	-	8	KYBRDB	KYP3
-	-	9	KYBRDA	-
+14V	+14V	10	-	-
-	-	11	KYSTRB	KYP4
PHON4	-	12	KYP7	KYP5
PHON9	-	13	KYP6	-
PHON5	-	14	STSEL2	-
PHON8	-	15	-	STSEL3
PHON6	-	16	-	STSEL4
PHON7	-	17	STCRDS1	-
-	-	18	STCRDS2	-
-	-	19	STCRDS3	-
-	-	20	STCRDS4	STCRDS7
PHON10	-	21	STCRDS5	-
PHON15	-	22	STCRDS6	-
PHON11	-	23	0V	0V
PHON14	-	24	+24V	+24V
PHON12	-	25	+10V	+14V
PHON13	-	26	+20V	RNGOP
-	-	27	RNGMX0	RNGMX1
-	-	28	OPRNG	-
PSEL4	PSEL3	29	MXRNG	-
PSEL5	PSEL2	30	OPX	-
PSEL6	PSEL1	31	OPX	-
PSEL0	PSELCS	32	+24V	MUX

A.7.3 Multiplexer Monitor Board.

A Connector (Top)			B Connector (Bottom)	
a	**c**	**Pin No.**	**a**	**c**
PSEL4	PSEL3	29	MXRNG	-
+5V	+5V	1	ZP7	ZP6
+24V	+24V	2	ZP9	ZP8
STAT0	STAT7	3	ZP11	ZP10
STAT1	STAT6	4	MUX1	-
STAT2	STAT5	5	-	-
-	-	6	-	-
-	-	7	-	-
STAT3	STAT4	8	-	-
-	-	9	OP1 CS0	-
-	-	10	OP#1 BSELA	-
-	-	11	OP#1 BSELB	OP#1 BSELC
-	-	12	-	-
-	-	13	OP0 CS1	-
-	-	14	+14V	+14V
ZP1	ZP2	15	+20V	+20V
ZP3	ZP4	16	+10V	+10V
ZP5	-	17	0V	0V
-	-	18	ZP12	ZP13
-	-	19	ZP14	ZP15
-	-	20	ZP16	-
-	-	21	-	-
MUX0	-	22	-	-
-	-	23	-	-
-	-	24	-	STAT7
OP0 CS0	-	25	STAT0	-
OP#0 BSELA	-	26	-	-
OP#0 BSELB	-	27	-	STAT6
OP#0 BSELC	-	28	STAT1	STAT5
OP1 CS1	-	29	STAT2	-
STCRDSEL	-	30	-	-
STBYT0	STBYT3	31	-	STAT4
STBYT1	STBYT2	32	STAT3	-

a	**c**	**Pin No.**	**a**	**c**
A Connector (Top)			B Connector (Bottom)	

A.7.4 Multiplexer Monitor Board Interconnections.

IC No	Edge Conn	PHON Addr.		FAULT	IC No /pin	MUX Addr	Voice: Phone No./ Mux No.
U1	A15c	24/3	0	22/3	U17/13 U19/13	0	1/0 17/2 33/4 49/6 65/8 81/A
U2	A15a	24/4	1	22/4	U17/14 U19/14	1	2/0 18/2 34/4 50/6 66/8 82/A
U3	A16c	24/7	2	22/7	U17/15 U19/15	2	3/0 19/2 35/4 51/6 67/8 83/A
U4	A16a	24/8	3	22/8	U17/12 U19/12	3	4/0 20/2 36/4 52/6 68/8 84/A
U5	A17c	24/13	4	22/13	U17/1 U19/1	4	5/0 21/2 37/4 53/6 69/8 85/A
U6	B1a	24/14	5	22/14	U17/4 U19/4	7	6/0 22/2 38/4 54/6 70/8 86/A
U7	B1c	24/17	6	22/17	U17/5 U19/5	5	7/0 23/2 39/4 55/6 71/8 87/A
U8	B2a	24/18	7	22/18	U17/2 U19/2	6	8/0 24/2 40/4 56/6 72/8 88/A

A.7.4 Multiplexer Monitor Board Interconnections. (Continued)

IC No	Edge Conn	PHON Addr.		FAULT	IC No /pin	MUX Addr	Voice: Phone No./ Mux No.
U9	B2c	25/3	0	23/3	U18/13 U20/13	0	9/1 25/3 41/5 57/7 73/9 89/B
U10	B3a	25/18	7	23/18	U18/14 U20/14	1	10/1 26/3 42/5 58/7 74/9 90/B
U11	B3c	25/4	1	23/4	U18/15 U20/15	2	11/1 27/3 43/5 59/7 75/9 91/B
U12	B18c	25/17	6	23/17	U20/12 U18/12	3	12/1 28/3 44/5 60/7 76/9 92/B
U13	B18a	25/7	2	23/7	U18/1 U20/1	4	13/1 29/3 45/5 61/7 77/9 93/B
U14	B19a	25/14	5	23/14	U18/5 U20/5	5	14/1 30/3 46/5 62/7 78/9 94/B
U15	B19a	25/8	3	23/8	U18/2 U20/2	6	15/1 31/3 47/5 63/7 79/9 95/B
U16	B20c	25/13	4	23/13	U18/4 U20/4	7	16/1 32/3 48/5 64/7 80/9 96/B

How to use this table:

Take Extension Telephone 72 as an example. This Extension telephone is monitored and multiplexed on Multiplexer Monitor Board M4. The 8 of the 72/8 is the mux no of the multiplexer chip; the total is 12, two per board. U17 and U19 are accessed with an address of 6 for telephone number 72.

The Extension telephone line is connected to pin B2a on the edge connector. Status monitoring is done by U8. Telephone handset status is input to data buffer U24 pin 18, and the fault status input at U22 pin 18.

The handset status of this telephone is bit 6 of the STATUS word and the fault status is b7 of that STATUS word. The voice signals are input to the multiplexer I.C.s on U17 pin 2 and U19 pin 2.

A.8. Back Plane Wiring Schedule.

A.8.1 Power Supplies.

Supply	+5V Supply Pin No.	+24V Supply Pin No.
Input:		
+60V (earthed)	28 30	28 30
0V	24 26	24 26
Outputs:		
Ground	32	32
System 0V	12 16	12 16
0V Sense	10	10
+5V	4 8	
+5V Sense	6	
+24V		4 8
+24V Sense		6

A.8.2 Operator Telephone and Readout. (LINK)

Operator Phone D-25	Cabinet Rear Panel	Function	
1	1	+5V	O
2	2	KYB COLO	P
3	3	LSD A	E
4	4	KYB COL1	R
5	5	LSD D	A
6	6	KYB COL2	T
7	7	LSD C	O
8	8	KYB COL3	R
9	9	LSD B	
10	10	KYB ROWO	O
11	11	MSD A	O
12	12	KYB ROW1	P
13	13	MSD D	E
14	14	KYB ROW2	R
15	15	MSD C	A
16	16	KYB ROW3	T
17	17	MSD B	O
18	18	CRADLEO	R
19	19	OV	
20	20	Not used	O

VOICE signals are connected to pins 24 and 25.

Operator Phone D-25	Cabinet Rear Panel	Function	
1	21	+5V	O
2	22	KYB COLO	P
3	23	LSD A	E
4	24	KYB COL1	R
5	25	LSD D	A
6	26	KYB COL2	T
7	27	LSD C	O
8	28	KYB COL3	R
9	29	LSD B	
10	30	KYB ROWO	1
11	31	MSD A	O
12	32	KYB ROW1	P
13	33	MSD D	E
14	34	KYB ROW2	R
15	35	MSD C	A
16	36	KYB ROW3	T
17	37	MSD B	O
18	38	CRADLE1	R
19	39	OV	
20	40	Not used	1

VOICE signals are connected to pins 24 and 25.

A.8.3 Operator Telephone to Telephone Controller Boards.

Operator 0:

	Function	Telephone Board 0	Controller LINK
KYBRD0:	KYB COL0/KYP0	B5a	2
	KYB COL1/KYP1	B6a	4
	KYB COL2/KYP2	B7a	6
	KYB COL3/KYP3	B8a	8
	KYB ROW0/KYP4	B11a	10
	KYB ROW1/KYP5	B12a	12
	KYB ROW2/KYP6	B13c	14
	KYB ROW3/KYP7	B12c	16

Operator 1:

	Function	Telephone Board 1	Controller LINK
KYBRD1:	KYB COL0/KYP0	B5a	22
	KYB COL1/KYP1	B6a	24
	KYB COL2/KYP2	B7a	26
	KYB COL3/KYP3	B8a	28
	KYB ROW0/KYP4	B11a	30
	KYB ROW1/KYP5	B12a	32
	KYB ROW2/KYP6	B13c	34
	KYB ROW3/KYP7	B12c	36

A.8.4 Mimic Wiring.

Column No.	Function
1	COL0
2	COL1
3	COL2
4	COL3
5	COL4
6	COL5
7	COL6
8	COL7
9	COL8
10	COL9
11	COL10
12	COL11
13	COL12
14	COL13
15	COL14
16	COL15
17	COL16
18	COL17
19	COL18
20	COL19
21	COL20
22	COL21
23	COL22
24	COL23
25	COL24
26	COL25
27	COL26
28	COL27
29	COL28
30	COL29
31	COL30
32	COL31
33	OP RNG: OV
34	OP RNG
35	ROW0
36	ROW1
37	ROW2
38	ROW3

39	ROW4
40	ROW5

A.8.4 Mimic Wiring. (Continued)

Function	Computer Board	Mimic Panel
+5V	A1a	
+5V	A1c	+5V
	B32a	
0V	B32c	0V
ROW0	A19a	35
ROW1	A18a	36
ROW2	A17a	37
ROW3	A16a	38
ROW4	A15a	39
ROW5	A14a	40
COL0	A19c	1
COL1	A18c	2
COL2	A17c	3
COL3	A16c	4
COL4	A15c	5
COL5	A14c	6
COL6	A13c	7
COL7	A12c	8
COL8	A11c	9
COL9	A10c	10
COL10	A9c	11
COL11	A8c	12
COL12	A7c	13
COL13	A6c	14
COL14	A5c	15
COL15	A4c	16

Function	Computer Board	Mimic Panel	
COL16	B9a	17	
COL17	B8a	18	
COL18	B7a	19	
COL19	B6a	20	
COL20	B5a	21	
COL21	B4a	22	
COL22	B3a	23	
COL23	B2a	24	
COL24	B2a	25	
COL25	A3a	26	
COL26	A29a	27	
COL27	A28a	28	
COL28	A27a	29	
COL29	A26a	30	
COL30	A25a	31	
COL31	A24a	32	
OP RNG:OV	-	33	
OP RNG	-	34	B28c on the Telephone Controller Board 1

A.8.5 Backlane Wiring.

	Computer Board	Telephone Controller		Multiplexer Monitor Boards					
		0	1	M0	M1	M2	M3	M4	M5
0 V	B32a B32c	B23a B23c	B23a B23c	B17a B17c	B17a B17c	B17a B17c	B17a B17c	B17a B17c	B17a B17c
+5 V	A1a A1c	A1a A1c	A1a A1c	A1a A1c	A1a A1c	A1a A1c	A1a A1c	A1a A1c	A1a A1c
+24 V	-	B24a B24c B32c	B24a B24c B32c	A2a A2c	A2a A2c	A2a A2c	A2a A2c	A2a A2c	A2a A2c
+10 V	-	B25c	-	B16a B16c	B16a B16c	B16a B16c	B16a B16c	B16a B16c	B16a B16c
+14 V	-	B25a	A25a	B14a B14c	B14a B14c	B14a B14c	B14a B14c	B14a B14c	B14a B14c
+20 V	-	B26c	-	B15a B15c	B15a B15c	B15a B15c	B15a B15c	B15a B15c	B15a B15c
PSEL0	A31c	A32c	A32c	-	-	-	-	-	-
PSEL1	A30c	A31a	A31a	-	-	-	-	-	-
PSEL2	A29c	A30a	A30a	-	-	-	-	-	-
PSEL3	A28c	A29a	A29a	-	-	-	-	-	-
PSEL4	A27c	A29c	A29c	-	-	-	-	-	-
PSEL5	A26c	A30c	A30c	-	-	-	-	-	-
PSEL6	A25c	A31c	A31c	-	-	-	-	-	-
PSEL7	A24c	B2a	-	-	-	-	-	-	-
STSEL0	B31a	B1c	-	-	-	-	-	-	-
STSEL1	B30a	B2c	-	-	-	-	-	-	-
STSEL2	B29a	B14c	-	-	-	-	-	-	-
STSEL3	B28a	B15a	-	-	-	-	-	-	-
STSEL4	B27a	B16a	-	-	-	-	-	-	-
STROBE	A22c	B1a	-	-	-	-	-	-	-

KYBRD0	B9c	B9c	-	-	-	-	-	-	-
KYBRD0B	B8c	B8c	-	-	-	-	-	-	-
KYBRD0C	B7c	B7c	-	-	-	-	-	-	-
KYBRD0D	B6c	B6c	-	-	-	-	-	-	-
PSEL CS	-	A32a	A32a	-	-	-	-	-	-

A.8.5 Backplane Wiring. (Continued)

	Computer Board	Telephone Controller 0	Telephone Controller 1	Multiplexer Monitor Boards M0	M1	M2	M3	M4	M5
STMXA0 & STBYT0	-	B3a	-	A31c	A31c	A31c	A31c	A31c	A31c
STMXA1 & STBYT1	-	B3c	-	A32c	A32c	A32c	A32c	A32c	A32c
STMXA2 & STBYT2	-	B4a	-	A32a	A32a	A32a	A32a	A32a	A32a
STMXA3 & STBYT3	-	B4c	-	A31a	A31a	A31a	A31a	A31a	A31a
KYBRD1A	B5c	-	B9c	-	-	-	-	-	-
KYBRD1B	B4c	-	B8c	-	-	-	-	-	-
KYBRD1C	B3c	-	B7c	-	-	-	-	-	-
KYBRD1D	B2c	-	B6c	-	-	-	-	-	-
KYSTRB0	B11c	B11c	-	-	-	-	-	-	-
KYSTRB1	B10c	-	B11c	-	-	-	-	-	-

A.8.5 Backplane Wiring. (Continued)

Function	Telephone Controller 0	Telephone Controller 1	Multiplexer Monitor Boards M0	M1	M2	M3	M4	M5
IMUXA A/OP0 BSELA	A2c	-	A26c	A26c	A26c	A26c	A26c	A26c
IMUXA B/OP0 BSELB	A4c	-	A27c	A27c	A27c	A27c	A27c	A27c
IMUXA C/OP0 BSELC	A6c	-	A28c	A28c	A28c	A28c	A28c	A28c
IIMUXA A/OP1 BSELA	-	A2c	B10c	B10c	B10c	B10c	B10c	B10c
IIMUXA B/OP1 BSELB	-	A4c	B11c	B11c	B11c	B11c	B11c	B11c
IIMUXA C/OP1 BSELC	-	A6c	B11a	B11a	B11a	B11a	B11a	B11a

Function	Computer Board	Telephone Controller 0	Telephone Controller 1	Multiplexer Monitor Boards M0	M1	M2	M3	M4	M5
RNG MX0	A10a	B27c	-	-	-	-	-	-	-
RNG MX1	A9a	B27a	-	-	-	-	-	-	-
RNG OP	A11a	B26a	-	-	-	-	-	-	-
OPX	-	B30c	B30c	-	-	-	-	-	-
OPX	-	B31c	B31c	-	-	-	-	-	-
MUX RNG/MUX1		B29c	B32a	-	-	-	-	-	-
STCRDSEL0	-	B16c	-	A30c	-	-	-	-	-
STCRDSEL1	-	B17c	-	-	A30c	-	-	-	-
STCRDSEL2	-	B18c	-	-	-	A30c	-	-	-
STCRDSEL3	-	B19c	-	-	-	-	A30c	-	-
STCRDSEL4	-	B20c	-	-	-	-	-	A30c	-
STCRDSEL5	-	B21c	-	-	-	-	-	-	A30c
STCRDSEL6	-	B22c	-	-	-	-	-	-	-
STCRDSEL7	-	B20a	-	-	-	-	-	-	-
MUX0	-	B32a	-	A22c	A22c	A22c	A22c	A22c	A22c
MUX1	-	-	B32a	B4c	B4c	B4c	B4c	B4c	B4c

A.8.5 Backplane Wiring. (Continued)

Function	Telephone Controller 0	Telephone Controller 1	Multiplexer Monitor Boards M0	M1	M2	M3	M4	M5
IPHON1/OP0 CS0	A8c	-	A25c	-	-	-	-	-
IPHON2/OP0 CS1	A5c	-	B13c	-	-	-	-	-
IPHON3/OP0 CS0	A3c	-	-	A25c	-	-	-	-
IPHON4/OP0 CS1	A12c	-	-	B13c	-	-	-	-
IPHON5/OP0 CS0	A14c	-	-	-	A25c	-	-	-
IPHON6/OP0 CS1	A16c	-	-	-	B13c	-	-	-
IPHON7/OP0 CS0	A17c	-	-	-	-	A25c	-	-
IPHON8/OP0 CS1	A15c	-	-	-	-	B13c	-	-
IPHON9/OP0 CS0	B13c	-	-	-	-	-	A25c	-
IPHON10/OP0 CS1	A21c	-	-	-	-	-	B13c	-
IPHON11/OP0 CS0	A23c	-	-	-	-	-	-	A25c
IPHON12/OP0 CS1	A25c	-	-	-	-	-	-	B13c
IPHON13/	A26c	-	-	-	-	-	-	-
IPHON14/	A24c	-	-	-	-	-	-	-
IPHON15/	A22c	-	-	-	-	-	-	-
IIPHON1/OP1 CS0	-	A8c	A29c	-	-	-	-	-
IIPHON2/OP1 CS1	-	A5c	B9c	-	-	-	-	-
IIPHON3/OP1 CS0	-	A3c	-	A29c	-	-	-	-
IIPHON4/OP1 CS1	-	A12c	-	B9c	-	-	-	-
IIPHON5/OP1 CS0	-	A14c	-	-	A29c	-	-	-
IIPHON6/OP1 CS1	-	A16c	-	-	B9c	-	-	-
IIPHON7/OP1 CS0	-	A17c	-	-	-	A29c	-	-
IIPHON8/OP1 CS1	-	A15c	-	-	-	B9c	-	-
IIPHON9/OP1 CS0	-	A13c	-	-	-	-	A29c	-
IIPHON10/OP1 CS1	-	A21c	-	-	-	-	B9c	-
IIPHON11/OP1 CS0	-	A23c	-	-	-	-	-	A29c
IIPHON12/OP1 CS1	-	A25c	-	-	-	-	-	B9c
IIPHON13/	-	A26c	-	-	-	-	-	-
IIPHON14/	-	A24c	-	-	-	-	-	-
IIPHON15/	-	A22c	-	-	-	-	-	-

A.8.5 Backplane Wiring. (Continued)

Function	Computer Board	Telephone Controller 0	1	MO	M1	Multiplexer Monitor Boards M2	M3	M4	M5
STATUS 0	B23c	-	-	A3c B25c	A3c B25c	A3c B25c	A3c B25c	A3c B25c	A3c B25c
STATUS 1	B22a	-	-	A4c B28c	A4c B28c	A4c B28c	A4c B28c	A4c B28c	A4c B28c
STATUS 2	B21a	-	-	A5c B29c	A5c B29c	A5c B29c	A5c B29c	A5c B29c	A5c B29c
STATUS 3	B20a	-	-	A8c B32c	A8c B32c	A8c B32c	A8c B32c	A8c B32c	A8c B32c
STATUS 4	B19a	-	-	A8a B31a	A8a B31a	A8a B31a	A8a B31a	A8a B31a	A8a B31a
STATUS 5	B18a	-	-	A5a B28a	A5a B28a	A5a B28a	A5a B28a	A5a B28a	A5a B28a
STATUS 6	B17a	-	-	A4a B27a	A4a B27a	A4a B27a	A4a B27a	A4a B27a	A4a B27a
STATUS 7	B16a	-	-	A3a B24a	A3a B24a	A3a B24a	A3a B24a	A3a B24a	A3a B24a

A.8.5 Backplane Wiring. (Continued)

Function	Computer Board	LINK
LINK0/0 /LSDA	B31c	3
LINK0/1 /LSDB	B30c	9
LINK0/2 /LSDC	B29c	7
LINK0/3 /LSDD	B28c	5
LINK0/4 /MSDA	B27c	11
LINK0/5 /MSDB	B26c	17
LINK0/6 /MSDC	B25c	15
LINK0/7 /MSDD	B24c	13
LINK1/0 /LSDA	B23c	23
LINK1/1 /LSDB	B22c	29
LINK1/2 /LSDC	B21c	27
LINK1/3 /LSDD	B20c	25
LINK1/4 /MSDA	B19c	31
LINK1/5 /MSDB	B18c	37
LINK1/6 /MSDC	B17c	35
LINK1/7 /MSDD	B16c	33

Function	Computer Board	LINK
CRDLO	B15a A4a	18
CRDL1	B14a A5a	38
0 V	-	19 39
+5 V	-	1 21

A.8.6 Extension Telephone Wiring.

Multiplexer Monitor Board	M0	M1	M2	M3	M4	M5
A15c	1	17	33	49	65	81
A15a	2	18	34	50	66	82
A16c	3	19	35	51	67	83
A16a	4	20	36	52	68	84
A17c	5	21	37	53	69	85
B1a	6	22	38	54	70	86
B1c	7	23	39	55	71	87
B2a	8	24	40	56	72	88
B2c	9	25	41	57	73	89
B3a	10	26	42	58	74	90
B3c	11	27	43	59	75	91
B18c	12	28	44	60	76	92
B18a	13	29	45	61	77	93
B19c	14	30	46	62	78	94
B19a	15	31	47	63	79	95
B20c	16	32	48	64	80	96

The above table indicates which Extension Telephones are connected to a particular Multiplexer Monitor Board. E.g. Extension Telephone 56 is connected to Pin B2a of the M3 Multiplexer Monitor Board.

REAR PANEL LAYOUT:-

COMPUTER BOARD

TELEPHONE CONTROLLER Ø

TELEPHONE CONTROLLER 1

MUX MON BOARD Ø

M1

M2

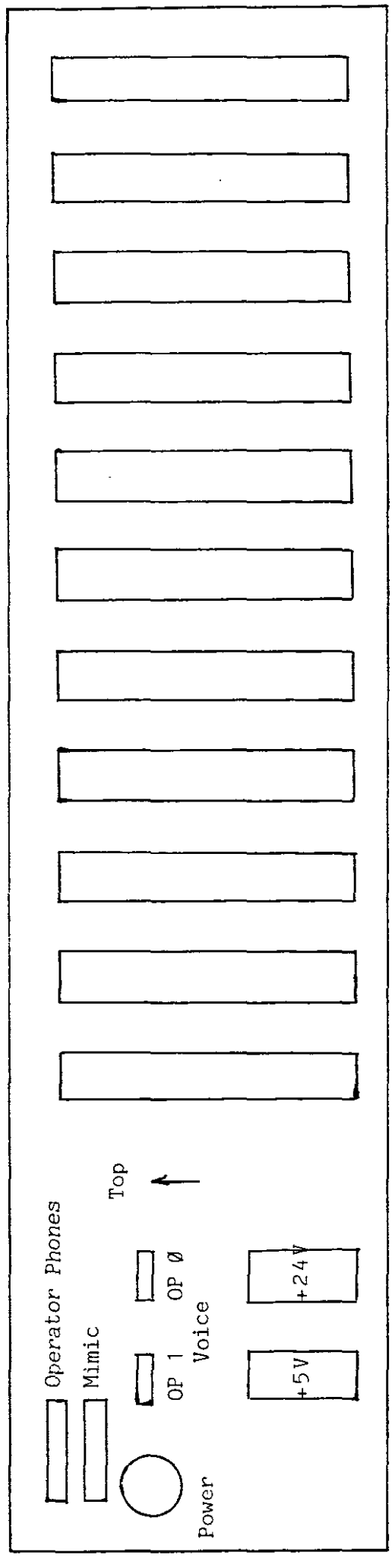
M3

M4

MUX MON BOARD 5

NOT USED

NOT USED



POWER SUPPLY

POWER SUPPLY

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«I1»

SOURCE CODE LISTING

```
BE  001  PREL     .SA:1  PREL   DATA PRELUDE FILE

001
002                    ************************************************
003                    ************************************************
004                    **       EMERGENCY TELEPHONE SYSTEM             *
005                    ************************************************
006                    * The following COMMAND FILES are available:
007                    *
008                    *    i. S.CF:1    Assembles and links all the
009                    *                  modules for the full system
010                    *                  and saves the object code in
011                    *                       PREL.LO:1.
012                    *   ii. SL.CF:1    Assembles and links all the
013                    *                  modules for the full system
014                    *                  and saves the object code in
015                    *                       PREL.LO:1
016                    *                  and the listing in
017                    *                       PREL.AL:1.
018                    *  iii. S.CF:1    Assembles and links all the
019                    *                  modules for the full system
020                    *                  and outputs the listing on
021                    *                  terminan screen
022                    *                  and saves the object code in
023                    *                       PREL.LO:1.
024                    *   iv. LP.CF:1    Assembles and links all the
025                    *                  modules for the full system.
026                    *                  The listing is output to
027                    *                    the line printer.
028                    *  These chain files will call other chain
029                    *    files during execution.
030                    ************************************************
031                    **                Alister van Tonder    86/02/25
032                    ************************************************
033
```

```
035                             OPT     REL
036                             NAM     PREL
037                             TTL     DATA PRELUDE FILE
038
039                     ********************************************************
040                     *              DATA PRELUDE FILE                       *
041                     ********************************************************
042                     * SYSTEM FLAGS: SYSFLG- B7 - Not used.                 *
043                     *                       B6 - Not used.                 *
044                     *                       B5 - Not used.                 *
045                     *                       B4 - Not used.                 *
046                     *                       B3 - Not used.                 *
047                     *                       B2 - Not used.                 *
048                     *                       B1 - FLASH-ON                  *
049                     *                       B0 - Not used.                 *
050                     *                                                      *
051                     *                                                      *
052                     * OPERATOR FUNCTION STATUS: FNCSTx-                    *
053                     *                       B7 - ACKM                      *
054                     *                       B6 - LAMPM                     *
055                     *                       B5 - RINGM                     *
056                     *                       B4 - Not used.                 *
057                     *                       B3 - QM                        *
058                     *                       B2 - CLRM                      *
059                     *                       B1 - AUDIOM                    *
060                     *                       B0 - RINGNG                    *
061                     *                                                      *
062                     ********************************************************
```

```
064              0002    A FLASHB EQU    $02
065              00DF    A NFLASB EQU    $DF
066              0080    A ACKM   EQU    $80
067              007F    A NACKM  EQU    $7F
068              0040    A LAMPM  EQU    $40
069              00BF    A NLAMPM EQU    $BF
070              0020    A RINGM  EQU    $20
071              00DF    A NRINGM EQU    $DF
072              0008    A QM     EQU    $08
073              00F7    A NQM    EQU    $F7
074              0004    A CLRM   EQU    $04
075              00FB    A NCLRM  EQU    $FB
076              0000    A CTRBLO EQU    $00
077              00F7    A NSTRBL EQU    $F7       B3=0
078              0038    A STRBHI EQU    $38       B3=1, ENABLE CB2 O/P
079              0022    A AUDRNG EQU    $22       AUDIOM + RINGM
080              0002    A AUDIOM EQU    $02
081              00FD    A NAUDIO EQU    $FD
082              0001    A RINGNG EQU    $01
083              00FE    A NRNGNG EQU    $FE
084              00DE    A NRGNGM EQU    $DE       NOT RINGING & NOT RING
085              1000    A TSTIME EQU    $1000     LAMP TEST TIME
086
087                        ***     KEYBOARD DECODE DATA    ***
088
089              000C    A LAMPK  EQU    $C        LAMP KEYCOD
090              000D    A ACKK   EQU    $D        ACK KEYCOD
091              0003    A QK     EQU    $3        Q KEYCOD
092              000B    A RINGK  EQU    $B        RING KEYCOD
093              000F    A CLRK   EQU    $F        CLEAR KEYCOD
094              0007    A NONO   EQU    $7        UNUSED KEY CODE
095
096
097              2000    A ROW    EQU    $2000     PIA0A
098              2001    A CRA0   EQU    $2001     CRA/0
099              2002    A RING   EQU    $2002     PIA0B
100              2002    A CRDLST EQU    $2002     PIA0B
101              2004    A COL0   EQU    $2004     PIA1A
102              2006    A COL1   EQU    $2006     PIA1B
103              2008    A COL2   EQU    $2008     PIA2A
104              200A    A COL3   EQU    $200A     PIA2B
105              200C    A KYBRD  EQU    $200C     PIA3A
106              200E    A CONNCT EQU    $200E     PIA3B
107              200F    A STRBPH EQU    $200F     CRB/3
108              2010    A STTSEL EQU    $2010     PIAA/4
109              2012    A STATUS EQU    $2012     PIA4B
110              2013    A CRDLCR EQU    $2013     CRB/4
111              2014    A LINK0  EQU    $2014     PIA5A
112              2016    A LINK1  EQU    $2016     PIA5B
113              200D    A KYBCR  EQU    $200D     CRA/3
114              0180    A FLSHTM EQU    $0180     FLASHING PERIOD
115
```

```
                        ********************************************************
                        *                  DATA SECTION                        *
                        ********************************************************

0000                            DSCT
                                XDEF    SYSFLG    SYSTEM FLAGS
0000        0001    A SYSFLG    RMB     1
                                XDEF    FNCST0    OP#0 FUNC STAT FLGS
0001        0001    A FNCST0    RMB     1
0002        0001    A FNCST1    RMB     1
0003        0001    A BUFNO     RMB     1         STAT BUF NO: 1/0
0004        0002    A BUFADD    RMB     2         STAT BUF ADDRESS
                      *                           . STTBUF OR STBUF1
                                XDEF    MSEC
0006        0002    A MSEC      RMB     2
                                XDEF    IRQCNT
0008        0002    A IRQCNT    RMB     2
                                XDEF    KYBUF
000A        0001    A KYBUF     RMB     1
                                XDEF    KYBUF1
000B        0001    A KYBUF1    RMB     1
000C        0001    A NCOLM     RMB     1
000D        0001    A NROW      RMB     1
                                XDEF    BYTNO
000E        0001    A BYTNO     RMB     1
000F        0001    A BYTN1     RMB     1
                                XDEF    BITNO
0010        0001    A BITNO     RMB     1
0011        0001    A BITN1     RMB     1
                                XDEF    OPRNO
0012        0001    A OPRNO     RMB     1         OPERATOR NO
0013        0001    A KYBINP    RMB     1         KYB0 INPUT COD
0014        0001    A           RMB     1         KYB1 INPUT COD
                                XDEF    FRSTNO
0015        0002    A FRSTNO    RMB     2         PTR TO FIRST NO IN Q
0017        0002    A LASTNO    RMB     2
```

```
                                ********************************************************
                                *                  DATA ARRAYS                         *
                                ********************************************************

                                         XDEF    STTBUF    STAT BUF0
0019       0018    A STTBUF      RMB     24        STATUS BUFFER 0
                                         XDEF    STBUF1    STAT BUF1
0031       0018    A STBUF1      RMB     24        STATUS BUFFER 1
                                         XDEF    COLBUF
0049       0018    A COLBUF      RMB     24        COLUMN BUFFER: STEADY
                                         XDEF    FLSH
0061       0018    A FLSH        RMB     24        FLASH BUFFER: FLASHING
                                         XDEF    QUE
0079       00C0    A QUE         RMB     192       QUEUEING LINKED LISTS
                                         XDEF    TSTCNT
0139       00C0    A TSTCNT      RMB     192       STATUS LINE DEBOUNCE C

                                ********************************************************
                                *          PROGRAM SECTION: CONSTANTS                  *
                                ********************************************************

0000                                     PSCT
                                         XDEF    MASK
0000       01      A MASK        FCB     1,2,4,8,16,32,64,128
                                         XDEF    CRDLFL
0008       80      A CRDLFL      FCB     $80,$40   CRADLE FLAGS
                                         XDEF    STDCOD    MUX ADDR DECODER
000A       02      A STDCOD      FCB     $02,$03,$06,$07 PHONE STAT: M0,
000E       0A      A             FCB     $0A,$0B,$0E,$0F PHONE STAT: M2,
0012       12      A             FCB     $12,$13,$16,$17 PHONE STAT: M4,
0016       00      A             FCB     $00,$01,$04,$05 FAULT STAT: M0,
001A       08      A             FCB     $08,$09,$0C,$0D FAULT STAT: M2,
001E       10      A             FCB     $10,$11,$14,$15 FAULT STAT: M4,
                                         XDEF    NOSCOD    KEYBOARD CODES 1 TO 0
0022       0E      A NOSCOD      FCB     $E,0,2,1,8,$A,9,4,6,5
                                         XDEF    VOICE     MUX DECOD ARRAY
002C       00      A VOICE       FCB     $00,$10,$20,$30,$40,$70,$50,$60
0034       01      A             FCB     $01,$11,$21,$31,$41,$51,$61,$71
003C       02      A             FCB     $02,$12,$22,$32,$42,$72,$52,$62
0044       03      A             FCB     $03,$13,$23,$33,$43,$53,$63,$73
004C       04      A             FCB     $04,$14,$24,$34,$44,$74,$54,$64
0054       05      A             FCB     $05,$15,$25,$35,$45,$55,$65,$75
005C       06      A             FCB     $06,$16,$26,$36,$46,$76,$56,$66
0064       07      A             FCB     $07,$17,$27,$37,$47,$57,$67,$77
006C       08      A             FCB     $08,$18,$28,$38,$48,$78,$58,$68
0074       09      A             FCB     $09,$19,$29,$39,$49,$59,$69,$79
007C       0A      A             FCB     $0A,$1A,$2A,$3A,$4A,$7A,$5A,$6A
0084       0B      A             FCB     $0B,$1B,$2B,$3B,$4B,$5B,$6B,$7B

                                * MSD:  BYTE ADDR AT MUX
                                * LSD:  MUX ADDRESS: TOTAL OF 12 MUX'S PER OP
                                * VOICE IS MODIFIED TO CORRECT FOR HARDWARE E
```

```
209P 008C       FF       A BLIND  FCB     $FF       1 TO 18 - HANDSETS
210P 008D       FF       A        FCB     $FF       19 TO 16 - HANDSETS
211P 008E       FF       A        FCB     $FF       17 TO 24 - HANDSETS
212P 008F       FF       A        FCB     $FF       25 TO 32 - HANDSETS
213P 0090       FF       A        FCB     $FF       33 TO 40 - HANDSETS
214P 0091       FF       A        FCB     $FF       41 TO 48 - HANDSETS
215P 0092       FF       A        FCB     $FF       49 TO 56 - HANDSETS
216P 0093       FF       A        FCB     $FF       57 TO 64 - HANDSETS
217P 0094       FF       A        FCB     $FF       65 TO 72 - HANDSETS
218P 0095       03       A        FCB     $03       73 TO 80 - HANDSETS  -
219P 0096       00       A        FCB     $00       81 TO 88 - HANDSETS  -
220P 0097       00       A        FCB     $00       89 TO 96 - HANDSETS  -
221P 0098       FF       A        FCB     $FF       1 TO  8 - FAULTS
222P 0099       FF       A        FCB     $FF       9 TO 16 - FAULTS
223P 009A       FF       A        FCB     $FF       17 TO 24 - FAULTS
224P 009B       FF       A        FCB     $FF       25 TO 32 - FAULTS
225P 009C       FF       A        FCB     $FF       33 TO 40 - FAULTS
226P 009D       FF       A        FCB     $FF       41 TO 48 - FAULTS
227P 009E       FF       A        FCB     $FF       49 TO 56 - FAULTS
228P 009F       FF       A        FCB     $FF       57 TO 64 - FAULTS
229P 00A0       FF       A        FCB     $FF       65 TO 72 - FAULTS
230P 00A1       03       A        FCB     $03       73 TO 80 - FAULTS   -B
231P 00A2       00       A        FCB     $00       81 TO 88 - FAULTS   -
232P 00A3       00       A        FCB     $00       89 TO 96 - FAULTS   -
```

```
)234P 00A4                              PSCT
)235                                    NAM     RESET
)236                                    TTL     INITIALISATION ROUTINE
)237
)238                            ********************************************************
)239                            *                       RESET
)240                            ********************************************************
)241
)242                                    XDEF    RESET
)243P 00A4 1A    10       A RESET  ORCC    #$10       SET IRQ MASK FOR EMULA
)244P 00A6 10CE 07FE      A        LDS     #$7FE      INIT S
)245P 00AA CE   07FE      A        LDU     #$7FE      INIT U
)246
)247P 00AD 8E   2000      A CLRALL LDX     #$2000     PIA 0
)248P 00B0 4F                      CLRA
)249P 00B1 C6   17        A        LDB     #$17
)250P 00B3 A7   85        A CRINIT STA     B,X        PIA(B)
)251P 00B5 5A                      DECB
)252P 00B6 26   FB    00B3        BNE     CRINIT
)253
)254P 00B8 86   7F        A PIAOA  LDA     #$7F
)255P 00BA B7   2000      A        STA     $2000      B6-B0 O/P'S
)256P 00BD 86   07        A        LDA     #$07
)257P 00BF B7   2001      A        STA     $2001      CA1 IRQ, ENBL DR'S
)258P 00C2 86   FF        A        LDA     #$FF
)259P 00C4 B7   00B8      P        STA     PIAOA      DISABLE ALL ROWS
)260
)261P 00C7 86   0F        A PIAOB  LDA     #$0F
)262P 00C9 B7   2002      A        STA     $2002
)263P 00CC C6   04        A        LDB     #4
)264P 00CE F7   2003      A        STB     $2003
)265
)266P 00D1 86   FF        A COLMS  LDA     #$FF
)267P 00D3 8E   2004      A        LDX     #$2004
)268P 00D6 A7   81        A        STA     X++        COLO ALL O/P'S
)269P 00D8 A7   81        A        STA     X++        COL1 ALL O/P'S
)270P 00DA A7   81        A        STA     X++        COL2 ALL O/P'S
)271P 00DC A7   84        A        STA     X          COL3 ALL O/P'S
)272P 00DE 30   1B        A        LEAX    -5,X       RESET X=$2005
)273P 00E0 E7   81        A        STB     X++        COLO DR ENBL
)274P 00E2 E7   81        A        STB     X++        COL1 DR ENBL
)275P 00E4 E7   81        A        STB     X++        COL2 DR ENBL
)276P 00E6 E7   84        A        STB     X          COL3 DR ENBL
)277
```

```
)279P 00E8 7F   200C     A PIA3A  CLR    $200C     ALL I/P'S
)280P 00EB 86   1F       A        LDA    #$1F      CA1 & CA2 POS GOING IR
)281P 00ED B7   200D     A        STA    $200D     ENBL DR
)282
)283P 00F0 86   FF       A PIA3B  LDA    #$FF      ALL O/P'S
)284P 00F2 B7   200E     A        STA    $200E
)285P 00F5 86   34       A        LDA    #$34      CB2/3 OP, ENBL DR
)286P 00F7 B7   200F     A        STA    $200F
)287
)288P 00FA 86   1F       A PIA4A  LDA    #$1F      B4-B0 O/P'S
)289P 00FC B7   2010     A        STA    $2010
)290P 00FF F7   2011     A        STB    $2011     ENBL DR
)291
)292P 0102 7F   2012     A PIA4B  CLR    $2012     ALL I/P'S
)293P 0105 86   1F       A        LDA    #$1F
)294P 0107 B7   2013     A        STA    $2013     CB1 & CB2 POS GOING IR
)295
)296P 010A 86   FF       A PIA5A  LDA    #$FF      ALL O/P'S
)297P 010C B7   2014     A        STA    $2014
)298P 010F F7   2015     A        STB    $2015     ENBL DR
)299
)300P 0112 B7   2016     A PIA5B  STA    $2016     ALL O/P'S
)301P 0115 F7   2017     A        STB    $2017     ENBL DR
)302
)303
)304P 0118 CC   0000     A        LDD    #0
)305P 011B 8E   0801     A        LDX    #$801     RAM TOP
)306P 011E ED   83       A CLRMEM STD    ,--X
)307P 0120 8C   0000     A        CPX    #0
)308P 0123 2E   F9    011E       BGT    CLRMEM
)309
)310P 0125 86   40       A LNKTS  LDA    #LAMPM
)311P 0127 B7   0001     D        STA    FNCSTO    SET LAMP TEST FLAG
)312
)313
)314P 012A 8E   0019     D CONST  LDX    #STTBUF
)315P 012D BF   0004     D        STX    BUFADD    SET BUFADDR FOR MAKBUF
)316P 0130 17   0341  0474        LBSR   MAKBUF    MAKE STATUS BUFFER
)317
)318P 0133 86   17       A        LDA    #23
)319P 0135 B7   000C     D        STA    NCOLM     INIT NCOLM
)320P 0138 86   05       A        LDA    #5
)321P 013A B7   000D     D        STA    NROW      INIT NROW
)322P 013D 8E   0180     A        LDX    #FLSHTM
)323P 0140 BF   0008     D        STX    IRQCNT
)324
)325P 0143 86   FF       A        LDA    #$FF
)326P 0145 B7   200E     A        STA    CONNCT
)327P 0148 17   05E0  072B        LBSR   STROBE    INIT MUX/MON BOARDS
)328P 014B 84   7F       A        ANDA   #$7F
)329P 014D B7   200E     A        STA    CONNCT
)330P 0150 17   05D8  072B        LBSR   STROBE
)331
)332P 0153 16   0214  036A        LBRA   MAINP     START
)333
)334
)335                    ********************************************
)336                    *            END OF RESET ROUTINE
)337                    ********************************************
)338
)339
340
```

```
342                                     TTL     SHORT ROUTINES
343                                 ********************************************
344                                 *                DELAY ROUTINE
345                                 ********************************************
346                                     XDEF    DELAYR
347P 0156 17   0282 03DB DELAYR LBSR   WTCHDG   RESET WTCHDG
348P 0159 30   1F      A       LEAX   -1,X
349P 015B 26   F9   0156       BNE    DELAYR
350P 015D 39                   RTS
351
352
353                                 ********************************************
354                                 *         FIND MOST SIGNIFICANT BIT          *
355                                 ********************************************
356                                 * FINDS MOST SIGNIFICANT SET BIT IN A BYTE   *
357                                 * -- INPUT PARAM'S: X - DATA POINTER         *
358                                 * - OUTPUT PARAM'S: A - SET BIT'S NO         *
0                                * ---      CHANGED:   X                       *
361                                 * ---    UNCHANGED:  Y,DP,U,S               *
362                                 ********************************************
363                                     XDEF    FMSB
364P 015E A6   84       A FMSB   LDA    X       DATA
365P 0160 27   0F   0171       BEQ    NOSB    NO SET BIT
366P 0162 8E   0008    P       LDX    #MASK+8
367P 0165 A5   82       A BITAGN BITA  -X
368P 0167 27   FC   0165       BEQ    BITAGN  BIT NOT SET
369P 0169 1F   10       A      TFR    X,D
370P 016B 83   0000    P       SUBD   #MASK
371P 016E 1F   98       A      TFR    B,A
372P 0170 39                   RTS
373P 0171 86   FF       A NOSB   LDA    #$FF
374P 0173 39                   RTS
375
376                                 ********************************************
377                                     XDEF    VALBIT
378                                 ********************************************
379                                 * TESTS STATUS OF SPECIFIED BIT IN BYTE.     *
380                                 * -- INPUT PARAM'S: X - DATA POINTER         *
381                                 *                   A - BITNO                *
382                                 * - OUTPUT PARAM'S: A - BIT STATUS          *
383                                 *                   B - MASK(BITNO)          *
384                                 *                   Y - #MASK                *
385                                 *                   X - #DATA                *
386                                 * ---   UNCHANGED:  DP,U,S                   *
387                                 ********************************************
388
389P 0174 108E 0000    P VALBIT LDY    #MASK
390P 0178 E6   A6       A      LDB    A,Y     MASK(BITNO)
391P 017A 4F                   CLRA
392P 017B E5   84       A      BITB   X
393P 017D 27   01   0180       BEQ    BITCLR
394P 017F 4C                   INCA
395P 0180 39              BITCLR RTS
396
```

```
                                ********************************************
                                        XDEF    SETBIT
                                ********************************************
                                * SETS/CLEARS THE SPECIFIED BIT WITHIN A     *
                                *    SPECIFIED BYTE.                         *
                                * -- INPUT PARAM'S: X - DATA POINTER         *
                                *                   A - BIT STATUS           *
                                *                   B - BITNO                *
                                *                                            *
                                * - OUTPUT PARAM'S: A - NEW DATA BYTE        *
                                *                   B - BITNO                *
                                *                   X - #DATA                *
                                *                   Y - #MASK                *
                                * ---     UNCHANGED: DP,U,S                  *
                                ********************************************

0181 108E 0000     P SETBIT LDY     #MASK
0185 4D                     TSTA                BIT STATUS
0186 27   07   018F         BEQ     SETOFF
0188 A6   84       A SETON  LDA     ,X         DATA
018A AA   A5       A        ORA     B,Y        MASK(BITNO)
018C A7   84       A        STA     ,X         NEW DATA
018E 39                     RTS
018F A6   A5       A SETOFF LDA     B,Y        MASK(BITNO)
0191 43                     COMA
0192 A4   84       A        ANDA    ,X
0194 A7   84       A        STA     ,X         NEW DATA
0196 39                     RTS


                                ********************************************
                                        XDEF    BINDEC
                                ********************************************
                                * -- INPUT PARAM'S: A -  BIN NO              *
                                * - OUTPUT PARAM'S: A -  DEC NO              *
                                *   ---     CHANGED: A,B,DP,S                *
                                *   ---  UNCHANGED: X,Y,U                    *
                                *   NOTE: MAX NO: $63 OR 99                  *
                                ********************************************
0197 1F   8B       A BINDEC TFR     A,DP
0199 1F   89       A        TFR     A,B
019B 4F                     CLRA
019C C4   F0       A        ANDB    #$F0       MSD
019E 27   07   01A7         BEQ     NOTENS
01A0 8B   16       A ADD16  ADDA    #$16
01A2 19                     DAA
01A3 C0   10       A        SUBB    #$10
01A5 26   F9   01A0         BNE     ADD16

01A7 1F   B9       A NOTENS TFR     DP,B
01A9 C4   0F       A        ANDB    #$0F       LSD

01AB C1   0A       A        CMPB    #10
01AD 2D   04   01B3         BLT     ONEPLS
01AF 8B   10       A        ADDA    #$10
01B1 C0   0A       A        SUBB    #10

01B3 34   04       A ONEPLS PSHS    B

01B5 AB   E0       A        ADDA    ,S+
01B7 19                     DAA
01B8 39                     RTS

                            NAM     IRQ
```

```
1464                        ********************************************************
1465                        *        INTERRUPT DRIVEN ROUTINES                     *
1466                        ********************************************************
1467
1468
1469                        ********************************************************
1470                        *         INTERRUPT CONTROL ROUTINE                    *
1471                        ********************************************************
1472                        *  -- ENTRY PARAM'S: NONE                              *
1473                        ********************************************************
1474
1475
1476                                          XDEF   IRQP
1477P 01B9 B6   2001     A IRQP    LDA    CRA0
1478P 01BC 85   80       A         BITA   #$80       TIMER IRQ B
1479P 01BE 27   22   01E2          BEQ    QCRDL      NOT TIMER IRQ
1480P 01C0 B6   2000     A TIMERP  LDA    CRA0-1     RESET TIMER IRQ
1481P 01C3 BE   0006     D         LDX    MSEC
1482P 01C6 30   1F       A         LEAX   -1,X       DECREMENT MSEC
1483P 01C8 BF   0006     D         STX    MSEC
1484P 01CB BE   0008     D         LDX    IRQCNT
1485P 01CE 30   1F       A         LEAX   -1,X       DECREMENT IRQCNT
1486P 01D0 26   0B   01DD          BNE    STRCNT
1487P 01D2 8E   0180     A         LDX    #FLSHTM    RESTORE TO FLSHTIME
1488P 01D5 86   02       A         LDA    #$02
1489P 01D7 B8   0000     D         EORA   SYSFLG     INVERT FLASH-ON BIT
1490P 01DA B7   0000     D         STA    SYSFLG
1491P 01DD BF   0008     D STRCNT  STX    IRQCNT     RESTORE IRQCNT
1492P 01E0 8D   35   0217          BSR    MIMIC      DISPLAY INFO
1493
1494P 01E2 F6   2013     A QCRDL   LDB    CRDLCR     CRADLE IRQ'S
1495P 01E5 C5   C0       A         BITB   #$C0       CRDL 0 & 1  IRQ B
1496P 01E7 27   09   01F2          BEQ    QKYB       NOT CRADLE IRQ
1497P 01E9 4F                  CRDLX  CLRA
1498P 01EA C5   80       A         BITB   #$80       CRDL0
1499P 01EC 26   01   01EF          BNE    CRLX
1500P 01EE 4C                      INCA               CRDL1 IRQ
1501P 01EF 17   0394 0586  CRLX    LBSR   CRDLP
1502
1503P 01F2 F6   200D     A QKYB    LDB    KYBCR
1504P 01F5 C5   C0       A         BITB   #$C0       KYBRD IRQ FLAGS
1505P 01F7 26   01   01FA          BNE    KYBX
1506P 01F9 3B                      RTI                RETURN TO MAIN PROGRAM
1507
```

```
0509                        ************************************************
0510                        *         KEYBOARD DECODING ROUTINE.           *
0511                        ************************************************
0512                        *                                              *
0513                        *      STORES KEYBOARD ENTRY IN KYBINP.        *
0514                        *      THEN BRANCHES TO KYBRDP TO DISPLAY      *
0515                        *        KEYBOARD INPUT.                       *
0516                        * -- INPUT PARAM'S: A - OPERATOR NO            *
0517                        *                   - GLOBAL: KYBRD            *
0518                        * - OUTPUT PARAM'S:   - GLOBAL: KYBINP         *
0519                        ************************************************
0520                                  XDEF   KYBX
0521P 01FA 4F               KYBX      CLRA
0522P 01FB C5   80       A            BITB   #$80
0523P 01FD 26   01   0200             BNE    KYBO        KYBRD 0 IRQ
0524P 01FF 4C                         INCA               KYBRD 1 IRQ
0525P 0200 F6   200C     A KYBO       LDB    KYBRD       READ KYBRD/RESET IRQ
0526P 0203 8E   0013     D            LDX    #KYBINP
0527P 0206 4D                         TSTA
0528P 0207 27   06   020F             BEQ    KYBDO
0529P 0209 54                         LSRB
0530P 020A 54                         LSRB
0531P 020B 54                         LSRB
0532P 020C 54                         LSRB               NEW LSD: KYBRD1
0533P 020D 20   02   0211             BRA    ADDIG
0534
0535P 020F C4   0F       A KYBDO      ANDB   #$0F        KYBRDO
0536
0537P 0211 E7   86       A ADDIG      STB    A,X         NEW KEYBRD INPT COD
0538P 0213 17   0099 02AF             LBSR   KYBRDP      DISPLAY KB I/P
0539
0540                              *      LSD    = NEW ENTRY
0541
0542P 0216 3B                         RTI                RETURN TO MAIN PRGM
0543
```

```
1545                            ************************************************
1546                            *         MIMIC CONTROL ROUTINE                *
1547                            ************************************************
1548                            *                                              *
1549                            *       ENTRY PARAMS: NONE                     *
1550                            *         GLOBAL DATA USED FOR PARAMETERS      *
1551                            ************************************************
1552
1553P 0217                                  PSCT
1554                                    XDEF    MIMIC
1555P 0217 86   FF       A MIMIC     LDA     #$FF
1556P 0219 B7   2000     A           STA     ROW         DISABLE ALL ROWS
1557
1558P 021C 86   40       A           LDA     #LAMPM
1559P 021E B5   0001     D           BITA    FNCSTO      LAMPM0
1560P 0221 26   67   028A           BNE     MIMTST
1561P 0223 B5   0002     D           BITA    FNCST1      LAMPM1
1562P 0226 26   62   028A           BNE     MIMTST
1563
1564P 0228 8E   0049     D           LDX     #COLBUF
1565P 022B 86   02       A           LDA     #FLASHB
1566P 022D B5   0000     D           BITA    SYSFLG      FLASH-ON FLAG
1567P 0230 26   28   025A           BNE     MIMFLS
1568P 0232 B6   000C     D STEADY    LDA     NCOLM
1569P 0235 E6   86       A           LDB     A,X         COLBUF(A)
1570P 0237 F7   200A     A           STB     COL3
1571P 023A 4A                       DECA
1572P 023B E6   86       A           LDB     A,X         COLBUF(A)
1573P 023D F7   2008     A           STB     COL2
1574P 0240 4A                       DECA
1575P 0241 E6   86       A           LDB     A,X         COLBUF(A)
1576P 0243 F7   2006     A           STB     COL1
1577P 0246 4A                       DECA
1578P 0247 E6   86       A           LDB     A,X         COLBUF(A)
1579P 0249 F7   2004     A           STB     COL0
1580P 024C 4A                       DECA
1581
1582P 024D 2E   06   0255           BGT     FROM24
1583P 024F 4F                       CLRA
1584P 0250 B7   000D     D          STA     NROW        P/RESET NROW
1585P 0253 86   17       A          LDA     #23
1586P 0255 B7   000C     D FROM24   STA     NCOLM
1587P 0258 20   3E   0298           BRA     XROWS
1588
1589P 025A B6   000C     D MIMFLS   LDA     NCOLM       COLUMN COUNTER
1590P 025D 108E 0061     D          LDY     #FLSH
1591P 0261 E6   86       A          LDB     A,X         COLBUF(A)
1592P 0263 EA   A6       A          ORB     A,Y         FLSH(A)
1593P 0265 4A                       DECA
1594P 0266 F7   200A     A          STB     COL3
1595P 0269 E6   86       A          LDB     A,X         COLBUF(A)
1596P 026B EA   A6       A          ORB     A,Y         FLSH(A)
1597P 026D F7   2008     A          STB     COL2
1598P 0270 4A                       DECA
1599P 0271 E6   86       A          LDB     A,X         COLBUF(A)
1600P 0273 EA   A6       A          ORB     A,Y         FLSH(A)
1601P 0275 F7   2006     A          STB     COL1
1602P 0278 4A                       DECA
1603P 0279 E6   86       A          LDB     A,X         COLBUF(A)
1604P 027B EA   A6       A          ORB     A,Y         FLSH(A)
1605P 027D F7   2004     A          STB     COL0
1606P 0280 4A                       DECA
1607
1608
```

```
   15  IRQ      .SA:1  IRQ     INTERRUPT DRIVEN ROUTINES

   0281 2E   02   0285          BGT     FROM23
   0283 86   17      A          LDA     #23
   0285 B7   000C    D FROM23   STA     NCOLM
   0288 20   0E   0298          BRA     XROWS

 ? 028A 86   FF      A MIMTST   LDA     #$FF
 P 028C B7   200A    A          STA     COL3
 P 028F B7   2008    A          STA     COL2
 P 0292 B7   2006    A          STA     COL1
 3P 0295 B7   2004    A          STA     COL0      ENABLE ALL LEDS
 9
 0P 0298 B6   000D    D XROWS    LDA     NROW
 1P 029B 8E   0000    P          LDX     #MASK
 2P 029E A6   86      A          LDA     A,X       MASK(NROW)
 3P 02A0 43                      COMA              INVERT ROWS
 4P 02A1 B7   2000    A          STA     ROW       ENABLE A ROW
 5P 02A4 7A   000D    D          DEC     NROW      DECREMENT ROW COUNTER
 6P 02A7 2C   05   02AE          BGE     RTNIRQ
 7P 02A9 86   05      A          LDA     #5        SIX ROWS
 8P 02AB B7   000D    D          STA     NROW
 629
 630P 02AE 39             RTNIRQ RTS
 631
```

```
0633                        ************************************************
0634                        *          KEYBOARD PROCEDURE                  *
0635                        ************************************************
0636                        *                                              *
0637                        *    FUNCTION KEYS SET APPROPRIATE FLAGS IN *
0638                        *     FUNCTION STATUS. NUMERIC KEYS DISPLAY-*
0639                        *     ED ON NUMERIC READOUT AND STORED IN    *
0640                        *     KEYBUF.                                  *
0641                        * -- INPUT PARAM'S: A - OPERATOR NO           *
0642                        *                   - GLOBAL: KYBINP         *
0643                        * - OUTPUT PARAM'S:   - NONE                   *
0644                        ************************************************
0645
0646                                      XDEF   KYBRDP
0647P 02AF 1F   8B       A KYBRDP TFR    A,DP       OP#,MUX NO
0648P 02B1 8E   0013     D        LDX    #KYBINP    KEYBOARD INPUT
0649P 02B4 E6   86       A        LDB    A,X        KEYBOARD(A) INPUT
0650P 02B6 C4   0F       A        ANDB   #$0F       LSD: NEW I/P
0651
0652P 02B8 8E   0001     D        LDX    #FNCST0
0653P 02BB C1   07       A        CMPB   #NONO      NOP KEY
0654P 02BD 26   01   02C0         BNE    LPMACT
0655P 02BF 39                     RTS               DISREGARD THIS KEY
0656
0657P 02C0 34   06       A LPMACT PSHS   A,B        0- OP#, 1- KYBRD I/P
0658P 02C2 C6   40       A        LDB    #LAMPM
0659P 02C4 F5   0001     D        BITB   FNCST0
0660P 02C7 26   05   02CE         BNE    DISRGD
0661P 02C9 F5   0002     D        BITB   FNCST1
0662P 02CC 27   03   02D1         BEQ    LAMP
0663P 02CE 32   62       A DISRGD LEAS   2,S        RESSTOR S
0664P 02D0 39                     RTS
0665
0666P 02D1 35   06       A LAMP   PULS   A,B        A- OP#, B-KYRD I/P
0667P 02D3 C1   0C       A        CMPB   #LAMPK
0668P 02D5 26   07   02DE         BNE    ACK
0669P 02D7 C6   40       A        LDB    #LAMPM
0670P 02D9 EA   86       A        ORB    A,X
0671P 02DB E7   86       A        STB    A,X        SET LAMPM FLAG
0672P 02DD 39                     RTS
0673
0674P 02DE C1   0D       A ACK    CMPB   #ACKK
0675P 02E0 26   07   02E9         BNE    CLR
0676P 02E2 C6   80       A        LDB    #ACKM
0677P 02E4 EA   86       A        ORB    A,X
0678P 02E6 E7   86       A        STB    A,X        SET ACK FLAG
0679P 02E8 39                     RTS
0680
0681P 02E9 C1   0F       A CLR    CMPB   #CLRK
0682P 02EB 26   07   02F4         BNE    AUDFLG
0683P 02ED C6   04       A        LDB    #CLRM
0684P 02EF EA   86       A        ORB    A,X
0685P 02F1 E7   86       A        STB    A,X        SET CLEAR MODE FLAG
0686P 02F3 39                     RTS
0687
0688P 02F4 C6   02       A AUDFLG LDB    #AUDIOM
0689P 02F6 E5   86       A        BITB   A,X
0690P 02F8 27   01   02FB         BEQ    CRDLS
0691P 02FA 39                     RTS               AUDIO ACTIV, DISREGARD
0692
0693P 02FB 8E   0008     P CRDLS  LDX    #CRDLFL    CRADLE STATUS
0694P 02FE F6   2002     A        LDB    RING       PIA
0695P 0301 E5   86       A        BITB   A,X        CRDLFL(CRDL NO)
0696P 0303 27   01   0306         BEQ    CRDLUP     CRADLE UP
```

```
0697P 0305 39                          RTS             CRDL DWN, DISREGARD
0698P 0306 8E   0013    D CRDLUP LDX    #KYBINP
0699P 0309 E6   86      A        LDB    A,X             KYBINP(OP#)
0700P 030B C4   0F      A        ANDB   #$0F            LSD: NEW I/P
0701
0702P 030D 8E   0001    D RINGF  LDX    #FNCSTO
0703P 0310 C1   0B      A        CMPB   #RINGK
0704P 0312 26   07   031B        BNE    Q
0705P 0314 C6   20      A        LDB    #RINGM
0706P 0316 EA   86      A        ORB    A,X
0707P 0318 E7   86      A        STB    A,X             SET RING MODE FLAG
0708P 031A 39                    RTS
0709
0710P 031B C1   03      A Q      CMPB   #QK
0711P 031D 26   07   0326        BNE    AUDACT
0712P 031F C6   08      A        LDB    #QM
0713P 0321 EA   86      A        ORB    A,X
0714P 0323 E7   86      A        STB    A,X             SET QUEUE MODE FLAG
0715P 0325 39                    RTS
0716
0717P 0326 34   04      A AUDACT PSHS   B               COPY KYBINP
0718P 0328 8E   0001    D        LDX    #FNCSTO
0719P 032B C6   02      A        LDB    #AUDIOM
0720P 032D E5   86      A        BITB   A,X             FNCST(OP#)
0721P 032F 27   03   0334        BEQ    NOS
0722P 0331 32   61      A        LEAS   1,S             RESTOR S
0723P 0333 39                    RTS                    DISREGARD NUMERIC I/P
0724
0725P 0334 35   04      A NOS    PULS   B               KYB I/P
0726P 0336 1F   8B      A        TFR    A,DP            OP#
0727P 0338 8E   0022    P        LDX    #NOSCOD
0728P 033B E1   80      A NOTNO  CMPB   X+
0729P 033D 26   FC   033B        BNE    NOTNO
0730P 033F 1F   10      A        TFR    X,D             A&B DSTROYD
0731P 0341 83   0023    P        SUBD   #NOSCOD+1
0732P 0344 34   04      A        PSHS   B               COPY NO
0733P 0346 8E   000A    D        LDX    #KYBUF          KYBRD DATA BUFFER
0734P 0349 1F   B8      A        TFR    DP,A            OP#
0735P 034B E6   86      A        LDB    A,X             KYBUF(OP#)
0736P 034D 58                    LSLB
0737P 034E 58                    LSLB
0738P 034F 58                    LSLB
0739P 0350 58                    LSLB                   LSD NOW MSD
0740
0741P 0351 EA   E0      A        ORB    ,S+             ADD NEW DATA
0742P 0353 E7   86      A        STB    A,X             KYBUF(OP#)
0743                      *                             NOW DISPLAY DATA
0744
```

```
0746                            ********************************************************
0747                            *  DATA STORED IN KEYBUF() IS  DISPAYED ON  *
0748                            *     OPERATOR NUMERIC READOUT.             *
0749                            *                                           *
0750                            * -- INPUT PARAM'S: A - OPERATOR NO         *
0751                            * - OUTPUT PARAM'S:   - NONE                *
0752                            ********************************************************
0753
0754                                        XDEF    LINKP
0755P 0355 8E   000A     D LINKP  LDX     #KYBUF
0756P 0358 E6   86       A        LDB     A,X        KYBUF(A)
0757P 035A 8E   2014     A        LDX     #LINKO
0758P 035D 4D                     TSTA
0759P 035E 27   01   0361         BEQ     DSPX       LINKO
0760P 0360 4C                     INCA                LINK1: A=2
0761P 0361 C5   F0       A DSPX   BITB    #$F0       MSD=0?
0762P 0363 26   02   0367         BNE     DISPL
0763P 0365 CA   F0       A        ORB     #$F0       MASK LEADING ZERO
0764P 0367 E7   86       A DISPL  STB     A,X        KYBUF(A) TO LINK(A)
0765P 0369 39                     RTS
0766
```

```
0768                                    NAM     MO
0769                                    TTL     MAIN PROGRAM ROUTINES
0770                                ********************************************
0771                                *              MAIN PROGRAM                *
0772                                ********************************************
0773                                *    ROUTINE ACTIVE WHEN CPU IS NOT        *
0774                                *      INTERRUPTED.                        *
0775                                * -- INPUT PARAM'S: NONE                   *
0776                                * -- ROUTINES CALLED: WTCHDG, QP, RINGP,   *
0777                                *                     ACKP, CLRP, LAMPP,   *
0778                                *                     TSTCHNG, CDLUP       *
0779                                ********************************************
0780
0781                                    XDEF    MAINP
0782P 036A 8E   0001    D MAINP  LDX     #FNCST0
0783P 036D 1C   EF      A        ANDCC   #$EF        CLEAR IRQ MASK
0784P 036F 8D   6A   03DB        BSR     WTCHDG     RESET WTCHDG
0785P 0371 B6   0012    D        LDA     OPRNO      OPERATOR NO
0786P 0374 E6   86      A        LDB     A,X
0787P 0376 34   06      A        PSHS    A,B        0-OP#,1-FNCST(A)
0788
0789P 0378 C6   08      A        LDB     #QM
0790P 037A E5   61      A        BITB    1,S        FNCST(A)
0791P 037C 27   0F   038D        BEQ     NQ
0792P 037E B6   0012    D        LDA     OPRNO      OP#
0793P 0381 8E   0001    D        LDX     #FNCST0
0794P 0384 C6   DF      A        LDB     #NRINGM
0795P 0386 E4   86      A        ANDB    A,X
0796P 0388 E7   86      A        STB     A,X        CLEAR RINGM & RINGNG F
0797                            * CANNOT RING WHILE QUEUEING
0798P 038A 17   04E5 0872       LBSR    QP
0799
0800P 038D C6   80      A NQ     LDB     #ACKM
0801P 038F E5   61      A        BITB    1,S        FNCST(A)
0802P 0391 27   06   0399        BEQ     NA         ACK NOT SELCTD
0803P 0393 B6   0012    D        LDA     OPRNO      OP#
0804P 0396 17   0247 05E0       LBSR    ACKP
0805
0806P 0399 C6   20      A NA     LDB     #RINGM
0807P 039B E5   61      A        BITB    1,S
0808P 039D 27   06   03A5        BEQ     NR         RING NOT SELCTD
0809P 039F B6   0012    D        LDA     OPRNO      OP#
0810P 03A2 17   02A3 0648        LBSR    RINGP
0811
0812P 03A5 C6   04      A NR     LDB     #CLRM
0813P 03A7 E5   61      A        BITB    1,S        FNCST(A)
0814P 03A9 27   06   03B1        BEQ     NC
0815P 03AB B6   0012    D        LDA     OPRNO      OP#
0816P 03AE 17   027A 062B        LBSR    CLRP
0817
0818P 03B1 C6   40      A NC     LDB     #LAMPM
0819P 03B3 E5   61      A        BITB    1,S        FNCST(A)
0820P 03B5 27   06   03BD        BEQ     NL
0821P 03B7 B6   0012    D        LDA     OPRNO      OP#
0822P 03BA 17   024B 0608        LBSR    LAMPP
0823
0824P 03BD 32   62      A NL     LEAS    2,S        A-OP#, RESTOR S
0825P 03BF B6   0012    D        LDA     OPRNO      OP#
0826P 03C2 88   01      A        EORA    #1
0827P 03C4 B7   0012    D        STA     OPRNO      OTHER OP NXT TIM
0828P 03C7 26   10   03D9        BNE     GOMNP
0829P 03C9 8D   10   03DB        BSR     WTCHDG     RESET WATCHDOG TIMER
0830P 03CB 8D   1F   03EC        BSR     TSTCHG     CHCK CHNG IN STATUS
0831
```

```
0832P 03CD F6   2002    A         LDB    RING
0833P 03D0 C4   C0      A         ANDB   #$C0      CRDL0, CRDL1 STATUS ON
0834P 03D2 C1   C0      A         CMPB   #$C0
0835P 03D4 27   03   03D9         BEQ    GOMNP     A HANDSET LIFTED
0836P 03D6 17   01B9 0592         LBSR   CRLUP     TURN BUZZR OFF
0837
0838P 03D9 20   8F   036A GOMNP   BRA    MAINP
0839
0840                     ********************************************************
0841                              XDEF   WTCHDG
0842                     ********************************************************
0843P 03DB 86   F7      A WTCHDG  LDA    #$F7
0844P 03DD B4   2001    A         ANDA   CRA0
0845P 03E0 B7   2001    A         STA    CRA0      SET CA2/1 OP LO
0846P 03E3 86   38      A         LDA    #$38
0847P 03E5 BA   2001    A         ORA    CRA0
0848P 03E8 B7   2001    A         STA    CRA0      SET CA2/1 OP HI
0849P 03EB 39                     RTS
0850
```

```
0852                            ********************************************************
0853                            *                  TEST CHANGE                         *
0854                            ********************************************************
0855                            *    TESTS FOR CHANGES IN ZONE TELEPHONE               *
0856                            *      STATUSES: HANDSETS & FAULTS.                    *
0857                            *    DATA BUFFERS USED ARE: COLBUF & FLASH             *
0858                            *                                                      *
0859                            * -- INPUT PARAM'S: NONE                               *
0860                            * -- OTHER PARAM'S: BUFNO                              *
0861                            *                   BUFADD                             *
0862                            *                   STBUF0 & STBUF1                    *
0863                            * -- ROUTINES CALLED: MAKBUF, FMSB, VALBIT,            *
0864                            *                     SETBIT, BUZZR                    *
0865                            ********************************************************
0866
0867                                                XDEF    TSTCHG
0868P 03EC B6    0003     D TSTCHG  LDA     BUFNO     0 OR 1
0869P 03EF 88    01       A         EORA    #$01      INVERT B0
0870P 03F1 8E    0019     D         LDX     #STTBUF
0871P 03F4 B7    0003     D         STA     BUFNO     CHANGE BUF NO
0872P 03F7 27    03   03FC         BEQ     BUFR      STATUS BUF 0
0873P 03F9 8E    0031     D         LDX     #STBUF1   STATUS BUF 1
0874P 03FC BF    0004     D BUFR    STX     BUFADD
0875P 03FF 8D    73   0474         BSR     MAKBUF    MAK NEW BUFFER
0876                            *                      BUFNO 0: STTBUF
0877                            *                      BUFNO 1: STBUF1
0878
0879P 0401 86    17       A         LDA     #23
0880P 0403 8E    0019     D         LDX     #STTBUF
0881P 0406 108E  0031     D         LDY     #STBUF1   STBUF1 ADDR
0882
0883P 040A E6    86       A CHK     LDB     A,X       A- PORT NO, BYNO
0884P 040C E8    A6       A         EORB    A,Y
0885P 040E 26    04   0414         BNE     ACHNG     CHANGE IN FAULTS
0886P 0410 4A                   CHK1  DECA
0887P 0411 2C    F7   040A         BGE     CHK       DO ALL FAULTS
0888P 0413 39                     RTS               RTN TO MAIN PRGM
0889
0890P 0414 34    06       A ACHNG   PSHS    A,B       0-PRT, 1-CHNGBUF
0891P 0416 30    61       A MORCHG  LEAX    1,S       CHNGBUF PTR
0892P 0418 17    FD43 015E         LBSR    FMSB      A- MSB THAT IS SET
0893P 041B 34    02       A         PSHS    A         0- BITNO, 1- PRT, 2- C
0894
0895P 041D E6    61       A         LDB     1,S       PRT
0896P 041F BE    0004     D         LDX     BUFADD
0897P 0422 30    85       A         LEAX    B,X       BUFADD(PRT)
0898
0899P 0424 A6    E4       A         LDA     ,S        BITNO
0900P 0426 17    FD4B 0174         LBSR    VALBIT    A- BINO, X- PTR
0901P 0429 88    01       A         EORA    #$01      STATUS INVERSION
0902P 042B 1F    8B       A         TFR     A,DP      STATUS OF CHANGED BIT
0903P 042D 27    0B   043A         BEQ     NOTNEW    NOT CHANGE TO ACTICE S
0904P 042F C6    01       A         LDB     #1        ON
0905P 0431 86    02       A         LDA     #2        OPX BUZZR
0906P 0433 34    06       A         PSHS    A,B
0907P 0435 17    0310 0748         LBSR    BUZZR     ENABLE OPX BUZZR
0908P 0438 32    62       A         LEAS    2,S       RESTOR S
0909
```

```
0911P 043A 8E   0061    D NOTNEW LDX   #FLSH
0912P 043D E6   61      A        LDB   1,S       PRT
0913
0914P 043F C1   0B      A        CMPB  #11       HANDSET OR FAULT
0915P 0441 2F   05   0448        BLE   OKSTAT    HANDSET STAT, NOT FAUL
0916P 0443 1F   B8      A        TFR   DP,A      IN/ACTIV STAT
0917P 0445 4D                    TSTA            *
0918P 0446 27   07   044F        BEQ   ONESHT    ENABLED ALARM LED CANN
0919
0920P 0448 30   85      A OKSTAT LEAX  B,X       FLSH(PRT)
0921P 044A E6   E4      A        LDB   ,S        BITNO
0922
0923P 044C 17   FD32 0181 ENBLED LBSR  SETBIT   A-ON/OFF, B-BITNO, X-D
0924
0925P 044F 30   62      A ONESHT LEAX  2,S       CHNGBUF
0926P 0451 E6   E4      A        LDB   ,S        BITNO
0927P 0453 4F                    CLRA
0928P 0454 17   FD2A 0181        LBSR  SETBIT    CLEAR SET MSB IN CHGBU
0929
0930P 0457 A6   61      A        LDA   1,S       PRT
0931P 0459 81   0B      A        CMPA  #11
0932P 045B 102F 00D5 0534        LBLE  QPHON     CHNGS IN PHON STAT
0933
0934P 045F 6D   62      A TSTACH TST   2,S       ANY MORE CHANGES
0935P 0461 27   04   0467        BEQ   NOCHG
0936P 0463 32   61      A        LEAS  1,S       0- PRT, 1- CHGBUF
0937P 0465 20   AF   0416        BRA   MORCHG    MORE CHANGES
0938
0939P 0467 A6   61      A NOCHG  LDA   1,S       PRT
0940P 0469 32   63      A        LEAS  3,S       RESTOR S
0941P 046B 8E   0019    D        LDX   #STTBUF
0942P 046E 108E 0031    D        LDY   #STBUF1
0943P 0472 20   9C   0410        BRA   CHK1      NEXT PORT
0944
```

```
0946                    ************************************************
0947                    *                MAKE BUFFER                   *
0948                    ************************************************
0949                    *    MAKES DATA BUFFER OF TELEPHONE            *
0950                    *      STATUSES.                               *
0951                    *    CHANGES IN STATUS IS DEBOUNCED.           *
0952                    *    MAKBUF DOES NOT SEE STATUS LINES THAT     *
0953                    *      IS MASKED BY BLIND().                   *
0954                    *    A HARDWARE FAULT IS CORRECTED BY          *
0955                    *      SHIFTING OF BITS.                       *
0956                    *                                              *
0957                    * -- INPUT PARAM'S: NONE                       *
0958                    * - GLOBAL PARAM'S: STTBUF & STBUF1            *
0959                    *                   STATUS                     *
0960                    *                   TSTCNT                     *
0961                    *                   BUFADD                     *
0962                    * - OUTPUT PARAM'S: NONE                       *
0963                    * - ROUTINES CALLED:WTCHDG                     *
0964                    ************************************************
0965
0966                                        XDEF    MAKBUF
0967P 0474 17   FF64 03DB MAKBUF LBSR    WTCHDG   *** REQIURED WHEN SYST
0968P 0477 BE   0004    D        LDX     BUFADD
0969P 047A 108E 000A    P        LDY     #STDCOD
0970
0971P 047E CE   0031    D        LDU     #STBUF1
0972P 0481 B6   0003    D        LDA     BUFNO
0973P 0484 27   03   0489        BEQ     ABX0
0974P 0486 CE   0019    D        LDU     #STTBUF
0975P 0489 32   7E      A ABX0   LEAS    -2,S
0976P 048B EF   E4      A        STU     ,S       OTHER BUFFER
0977
0978P 048D 86   17      A        LDA     #23
0979
0980P 048F E6   A6      A ADSTAT LDB     A,Y      DECOD MUXNO
0981P 0491 EE   E4      A        LDU     ,S       OTHER BUFFER
0982P 0493 F7   2010    A        STB     STTSEL   ADDR. CARD & MUX
0983
0984P 0496 34   36      A        PSHS    A,B,X,Y
0985P 0498 35   36      A        PULS    A,B,X,Y  DELAY: SETLING TIME
0986
0987P 049A F6   2012    A        LDB     STATUS   READ STATUS
0988
```

```
0990                        ************************************************
0991                        *       HARDWARE WIRING CORRECTION !!          *
0992                        ************************************************
0993
0994                                    XDEF    SAVCOD
0995P 049D 34   02      A SAVCOD PSHS   A
0996P 049F 4F                   CLRA
0997
0998P 04A0 C5   02      A       BITB    #$02
0999P 04A2 27   02  04A6        BEQ     XX2
1000P 04A4 8A   04      A       ORA     #$04
1001
1002P 04A6 C5   04      A XX2   BITB    #$04
1003P 04A8 27   02  04AC        BEQ     XX3
1004P 04AA 8A   10      A       ORA     #$10
1005
1006P 04AC C5   08      A XX3   BITB    #$08
1007P 04AE 27   02  04B2        BEQ     XX4
1008P 04B0 8A   40      A       ORA     #$40
1009
1010P 04B2 C5   10      A XX4   BITB    #$10
1011P 04B4 27   02  04B8        BEQ     XX6
1012P 04B6 8A   80      A       ORA     #$80
1013
1014P 04B8 C5   40      A XX6   BITB    #$40
1015P 04BA 27   02  04BE        BEQ     XX7
1016P 04BC 8A   08      A       ORA     #$08
1017
1018P 04BE C5   80      A XX7   BITB    #$80
1019P 04C0 27   02  04C4        BEQ     X21
1020P 04C2 8A   02      A       ORA     #$02
1021
1022P 04C4 C4   21      A X21   ANDB    #$21
1023P 04C6 34   02      A       PSHS    A
1024P 04C8 EA   E0      A       ORB     ,S+
1025
1026P 04CA 35   02      A       PULS    A
1027
1028                        ************************************************
1029                        *         END OF CORRECTION ROUTINE              *
1030                        ************************************************
```

This routine corrects wiring errors on the backplane.

Corrections of the status data input from the Multiplexer Monitor boards are done interchanging bits.

It is simpler to correct the error using software than to rewire the entire wire wrapped back plane.

```
1032
1033P 04CC 8E   008C    P        LDX    #BLIND    *** ZONE TELEPHONE MAS
1034P 04CF E4   86      A        ANDB   A,X       *** ZONE TELEPHONE MAS
1035P 04D1 BE   0004    D        LDX    BUFADD    *** RESTORE X ***
1036                        ***  ONLY LOOKS  AT TELEPHONE EXTENSIONS  1 T
1037
1038P 04D4 E1   C6      A        CMPB   A,U       STBUF1 & STTBUF
1039P 04D6 26   35   050D        BNE    DBNCR
1040P 04D8 CE   0139    D        LDU    #TSTCNT
1041P 04DB 6F   C6      A        CLR    A,U
1042P 04DD BE   0004    D        LDX    BUFADD
1043
1044P 04E0 E7   86      A ABX2   STB    A,X       STOR IN BUFFR
1045P 04E2 4A                    DECA
1046
1047P 04E3 E6   A6      A        LDB    A,Y       DECOD MUXNO
1048P 04E5 F7   2010    A        STB    STTSEL    ADDR. CARD & MUX
1049
1050P 04E8 34   36      A        PSHS   A,B,X,Y
1051P 04EA 35   36      A        PULS   A,B,X,Y   DELAY: SETLING TIME
1052
1053P 04EC F6   2012    A        LDB    STATUS    READ STATUS
1054
1055P 04EF 8E   008C    P        LDX    #BLIND    *** ZONE TELEPHONE_MAS
1056P 04F2 E4   86      A        ANDB   A,X       *** ZONE TELEPHONE MAS
1057P 04F4 BE   0004    D        LDX    BUFADD    *** RESTORE X ***
1058                        ***  ONLY LOOKS  AT TELEPHONE EXTENSIONS  1 T
1059
1060P 04F7 EE   E4      A        LDU    ,S        OTHER BUFFER
1061P 04F9 E1   C6      A        CMPB   A,U       STBUF1 & STTBUF
1062P 04FB 26   10   050D        BNE    DBNCR
1063P 04FD CE   0139    D        LDU    #TSTCNT
1064P 0500 6F   C6      A        CLR    A,U
1065P 0502 BE   0004    D        LDX    BUFADD
1066
1067P 0505 E7   86      A ABX3   STB    A,X       STOR IN BUFFR
1068P 0507 4A                    DECA
1069
1070P 0508 2C   85   048F        BGE    ADSTAT    ALL 24
1071P 050A 32   62      A        LEAS   2,S
1072P 050C 39                    RTS
1073
1074P 050D CE   0139    D DBNCR  LDU    #TSTCNT
1075P 0510 6D   C6      A        TST    A,U
1076P 0512 27   0D   0521        BEQ    INITCT
1077P 0514 6A   C6      A        DEC    A,U       TSTCNT(A)
1078P 0516 26   17   052F        BNE    ABX1
1079P 0518 BE   0004    D ABX8   LDX    BUFADD
1080P 051B 85   01      A ABX6   BITA   #$01
1081P 051D 26   C1   04E0        BNE    ABX2
1082P 051F 20   E4   0505        BRA    ABX3
1083
1084P 0521 34   04      A INITCT PSHS   B
1085P 0523 C6   0A      A        LDB    #10
1086P 0525 81   0B      A        CMPA   #11
1087P 0527 2F   02   052B        BLE    ABX7
1088P 0529 C6   FF      A        LDB    #$FF
1089P 052B E7   C6      A ABX7   STB    A,U       TSTCNT(A)
1090P 052D 35   04      A        PULS   B
1091P 052F 8E   1000    A ABX1   LDX    #$1000    NONEXISTENT ADDR
1092P 0532 20   E7   051B        BRA    ABX6
1093
1094
1095
```

```
1097                    ************************************************
1098                    *                QUEUE PHONE                   *
1099                    ************************************************
1100                    *    CHECKS WHETHER ZONE TELEPHONE HANDSET     *
1101                    *      IS LIFTED OR NOT.                       *
1102                    *    IF HANDSET IS LIFTED: ADDS TEL TO         *
1103                    *      QUEUE IF NOT IN QUEUE.                  *
1104                    *    IF HANDSET IS DOWN: DELETES TEL FROM      *
1105                    *      QUEUE IF IN QUEUE.                      *
1106                    *                                              *
1107                    * -- INPUT PARAM'S: DP- CHANGED BIT STAT       *
1108                    * - GLOBAL PARAM'S: FRSTNO                     *
1109                    * - ROUTINES CALLED :                          *
1110                    *                   PHECOD, BINDEC, CHKQ,      *
1111                    *                   DELFQ, ADDQ                *
1112                    ************************************************
1113
1114                                        XDEF    QPHON
1115P 0534 34   08       A QPHON  PSHS    DP          CHANGED BIT STATUS
1116P 0536 E6   62       A        LDB     2,S         PRT: BYNO
1117P 0538 A6   61       A        LDA     1,S         BINO
1118P 053A 17   0203 0740         LBSR    PHECOD
1119P 053D 17   FC57 0197         LBSR    BINDEC
1120P 0540 8B   01       A        ADDA    #1          1ST COUNT=1
1121P 0542 19                     DAA
1122P 0543 34   02       A        PSHS    A           BCD PHONO
1123P 0545 1F   89       A        TFR     A,B
1124P 0547 17   02AB 07F5         LBSR    CHKQ
1125
1126P 054A E6   61       A        LDB     1,S         CHANGED BIT STATUS
1127P 054C 27   0C    055A        BEQ     DELFQ
1128P 054E 81   FF       A        CMPA    #$FF
1129P 0550 26   03    0555        BNE     ENDQP       ALREADY IN Q
1130P 0552 17   025D 07B2         LBSR    ADDQ
1131
1132P 0555 32   62       A ENDQP  LEAS    2,S         RESTOR S
1133P 0557 16   FF05 045F         LBRA    TSTACH      TST FOT MOR CHGES
1134
```

```
1097                    ************************************************
1098                    *                QUEUE PHONE                   *
1099                    ************************************************
1100                    *    CHECKS WHETHER ZONE TELEPHONE HANDSET     *
1101                    *      IS LIFTED OR NOT.                       *
1102                    *    IF HANDSET IS LIFTED: ADDS TEL TO         *
1103                    *      QUEUE IF NOT IN QUEUE.                  *
1104                    *    IF HANDSET IS DOWN: DELETES TEL FROM      *
1105                    *      QUEUE IF IN QUEUE.                      *
1106                    *                                              *
1107                    * -- INPUT PARAM'S: DP- CHANGED BIT STAT       *
1108                    * - GLOBAL PARAM'S: FRSTNO                     *
1109                    * - ROUTINES CALLED :                          *
1110                    *                    PHECOD, BINDEC, CHKQ,     *
1111                    *                    DELFQ, ADDQ               *
1112                    ************************************************
1113
1114                                        XDEF    QPHON
1115P 0534 34    08       A QPHON  PSHS    DP          CHANGED BIT STATUS
1116P 0536 E6    62       A        LDB     2,S         PRT: BYNO
1117P 0538 A6    61       A        LDA     1,S         BINO
1118P 053A 17    0203 0740         LBSR    PHECOD
1119P 053D 17    FC57 C197         LBSR    BINDEC
1120P 0540 8B    01       A        ADDA    #1          1ST COUNT=1
1121P 0542 19                      DAA
1122P 0543 34    02       A        PSHS    A           BCD PHONO
1123P 0545 1F    89       A        TFR     A,B
1124P 0547 17    02AB 07F5         LBSR    CHKQ
1125
1126P 054A E6    61       A        LDB     1,S         CHANGED BIT STATUS
1127P 054C 27    0C    055A        BEQ     DELFQ
1128P 054E 81    FF       A        CMPA    #$FF
1129P 0550 26    03    0555        BNE     ENDQP       ALREADY IN Q
1130P 0552 17    025D 07B2         LBSR    ADDQ
1131
1132P 0555 32    62       A ENDQP  LEAS    2,S         RESTOR S
1133P 0557 16    FF05 045F         LBRA    TSTACH      TST FOT MOR CHGES
1134
```

```
01136                          ************************************************
01137                          *              DELETE FROM QUEUE               *
01138                          ************************************************
01139                          *     DELETES TELEPHONE NUMBER FROM QUEUE      *
01140                          *       IF IN QUEUE & CORRECTS ALL POINTERS.   *
01141                          *                                              *
01142                          * -- INPUT PARAM'S: A - PASSED FROM CHKQ       *
01143                          * -- GLOBAL PARAM'S: FRSTNO                    *
01144                          * - ROUTINES CALLED: DELQ, CDLUP,              *
01145                          ************************************************
01146
01147                                  XDEF    DELFQ
01148P 055A 81   FF       A DELFQ   CMPA    #$FF
01149P 055C 27   F7   0555         BEQ     ENDQP       Q INACTIVE
01150P 055E A6   E4       A        LDA     ,S          BCD PHONO
01151P 0560 17   02BA 081D         LBSR    DELQ
01152P 0563 FC   0015     D        LDD     FRSTNO
01153P 0566 26   ED   0555         BNE     ENDQP       Q STILL ACTIVE
01154P 0568 8D   28   0592         BSR     CRLUP       Q INACTIV, STOP RINGNG
01155P 056A 20   E9   0555         BRA     ENDQP
01156
01157
01158                          ************************************************
01159                          *                 CHANGE LED                   *
01160                          ************************************************
01161                          *     CHANGES LED STATUS ON MIMIC              *
01162                          * -- INPUT PARAM'S: All param's on stack.      *
01163                          *                 S + 0: RTS address           *
01164                          *                     2: ON/OFF                *
01165                          *                     3: Base Address of data  *
01166                          *                     5: OP#                   *
01167                          *  ---   CHANGED: A,B,X,DP                     *
01168                          ************************************************
01169                                  XDEF    CHGLED
01170P 056C A6   65       A CHGLED  LDA     5,S         OP#
01171P 056E 8E   0010     D         LDX     #BITNO
01172P 0571 E6   86       A         LDB     A,X         BITN(OP#)
01173P 0573 1F   9B       A         TFR     B,DP
01174
01175P 0575 8E   000E     D         LDX     #BYTNO
01176P 0578 E6   86       A         LDB     A,X         BYTN(OP#)
01177P 057A AE   63       A         LDX     3,S         BASE ADDR
01178P 057C 30   85       A         LEAX    B,X         BASE ADDR + BYTNO(OP#)
01179
01180P 057E 1F   B9       A         TFR     DP,B        BITNO
01181P 0580 A6   62       A         LDA     2,S         ON/OFF
01182P 0582 17   FBFC 0181         LBSR    SETBIT
01183
01184P 0585 39                     RTS
01185
01186
```

```
1188                                ***************************************************
1189                                *                CRADLE PROCEDURE                 *
1190                                ***************************************************
1191                                *       CRDL UP: LO   ::   CRDL DWN HI            *
1192                                ***************************************************
1193                                        XDEF    CRDLP
1194P 0586 1F   8B       A CRDLP  TFR     A,DP       COPY OP#
1195P 0588 8E   0008     P        LDX     #CRDLFL    CRADLE FLAG
1196P 058B E6   86       A        LDB     A,X        CRADLE(A) FLAG
1197P 058D F5   2013     A        BITB    CRDLCR     CRADLE IRQ'CNTRL REG
1198P 0590 26   0E   05A0         BNE     CRDLDW
1199
1200                                        XDEF    CRLUP
1201P 0592 F6   2012     A CRLUP  LDB     CRDLCR-1   CLR CRDL IRQ
1202P 0595 5F                     CLRB
1203P 0596 86   02       A        LDA     #2         OPX
1204P 0598 34   06       A        PSHS    A,B        0-OPX, 1-OFF
1205P 059A 17   01AB 0748         LBSR    BUZZR      OPX BUZZR OFF
1206P 059D 32   62       A        LEAS    2,S
1207P 059F 39                     RTS
1208
1209                                        XDEF    CRDLDW
1210P 05A0 F6   2012     A CRDLDW LDB     CRDLCR-1   RESET CRDL IRQ'S
1211P 05A3 8E   0001     D        LDX     #FNCST0
1212P 05A6 34   02       A        PSHS    A          COPY OP#: 0-OP#
1213P 05A8 E6   86       A        LDB     A,X        FNCST(OP#)
1214P 05AA C5   22       A        BITB    #AUDRNG    AUDIOM OR RINGM
1215P 05AC 27   1E   05CC         BEQ     CLRDSP     NOT RINGING/ NO AUDIO
1216P 05AE 5F                     CLRB               OFF
1217P 05AF 8E   0061     D        LDX     #FLSH
1218P 05B2 34   14       A        PSHS    B,X        0- ON/OFF, 2- ADDR, 3-
1219P 05B4 8D   B6   056C         BSR     CHGLED     S+2: 0-ON/OFF,2-FLSHDP
1220P 05B6 8E   0049     D        LDX     #COLBUF
1221P 05B9 AF   61       A        STX     1,S        NEW PTR
1222P 05BB 8D   AF   056C         BSR     CHGLED     0-ON/OFF,2-COLBUF PTR,
1223P 05BD 32   63       A        LEAS    3,S        RESTOR S
1224
1225P 05BF A6   E4       A        LDA     ,S         OP#
1226P 05C1 5F                     CLRB               OFF
1227P 05C2 34   06       A        PSHS    A,B        0- OP#, 1-OFF
1228P 05C4 17   012F 06F6         LBSR    AUDIO      DISCONNECT AUD
1229P 05C7 17   017E 0748         LBSR    BUZZR      STOP RINGNG
1230P 05CA 32   62       A        LEAS    2,S        RESTOR S
1231
1232P 05CC A6   E4       A CLRDSP LDA     ,S         OP#
1233P 05CE 8E   000A     D        LDX     #KYBUF
1234P 05D1 6F   86       A        CLR     A,X        CLR KYBUF(OP#)
1235P 05D3 17   FD7F 0355         LBSR    LINKP      CLEAR DISPLAY(OP#)
1236
1237P 05D6 A6   E4       A        LDA     ,S         OP#
1238P 05D8 8E   0001     D        LDX     #FNCST0
1239P 05DB 6F   86       A        CLR     A,X        CLEAR ALL MODES(OP#)
1240P 05DD 32   61       A        LEAS    1,S        RESTOR S
1241
1242P 05DF 39                     RTS
1243
```

```
1245                            ********************************************************
1246                            *          ACKNOWLEDGE ALARM ROUTINE                   *
1247                            ********************************************************
1248                            *    ACKNOWLEDGE ALARM ROUTINE.                        *
1249                            *    SILENCES AUDIO ALARM & STOPS FLASHING             *
1250                            *      FAULT LED & TURNS IT ON PERMANENTLY.            *
1251                            *                                                      *
1252                            * -- INPUT PARAM'S: A - OPRNO                          *
1253                            * - GLOBAL PARAM'S: FLSH, COLBUF                       *
1254                            *                   FNCSTO & FNCST1                    *
1255                            * - ROUTINES CALLED: BUZZR                             *
1256                            *                                                      *
1257                            ********************************************************
1258
1259                                              XDEF    ACKP
1260P 05E0 8E   0001      D ACKP    LDX     #FNCSTO
1261P 05E3 C6   7F        A         LDB     #NACKM
1262P 05E5 E4   84        A         ANDB    A,X         CLEAR ACKM FLAG
1263P 05E7 E7   84        A         STB     A,X
1264
1265P 05E9 8E   006D      D         LDX     #FLSH+12
1266P 05EC 108E 0055      D         LDY     #COLBUF+12
1267P 05F0 86   0B        A         LDA     #11
1268
1269P 05F2 E6   84        A XCHNG   LDB     A,X       FLSH(A)
1270P 05F4 EA   A6        A         ORB     A,Y       FLSH(A) OR COLBUF(A)
1271P 05F6 E7   A6        A         STB     A,Y       NEW COLBUF(A)
1272P 05F8 6F   84        A         CLR     A,X       CLEAR FLSH(A)
1273P 05FA 4A                       DECA
1274P 05FB 2C   F5    05F2          BGE     XCHNG
1275
1276P 05FD 86   02        A         LDA     #2
1277P 05FF 5F                       CLRB
1278P 0600 34   06        A         PSHS    A,B         0- MIM BUZZR, 1- OFF
1279P 0602 17   0143 0748          LBSR    BUZZR       STOP OPERATOR BUZZER
1280P 0605 32   62        A         LEAS    2,S         RESTOR S
1281
1282P 0607 39                       RTS
1283
```

```
01285                          ********************************************************
01286                          *              LAMP TEST ROUTINE                       *
01287                          ********************************************************
01288                          *    ILLUMINATES ALL LED'S ON MIMIC AND ALL            *
01289                          *      SEGMENTS ON THE OPERATOR DISPLAY.               *
01290                          *                                                      *
01291                          * -- INPUT PARAM'S: A - OPRNO                          *
01292                          * - GLOBAL PARAM'S: LINK0 & LINK1                      *
01293                          *                   FNCST0 & FNCST1                    *
01294                          * -- ROUTINES CALLED: LINKP, DELAYP,                   *
01295                          ********************************************************
01296
01297                                            XDEF    LAMPP
01298P 0608 34   02       A LAMPP  PSHS    A          OP#
01299P 060A C6   88       A        LDB     #$88
01300P 060C 8E   2014     A        LDX     #LINK0
01301P 060F 4D                     TSTA
01302P 0610 27   01   0613        BEQ     DX         A=0
01303P 0612 4C                     INCA               A=2
01304P 0613 E7   86       A DX     STB     A,X        ENBLE ALL SEGMENTS
01305
01306P 0615 8E   1000     A        LDX     #TSTIME
01307P 0618 8D   1F   0639        BSR     DELAYP
01308
01309P 061A A6   E4       A        LDA     ,S         OP#
01310P 061C 17   FD36 0355        LBSR    LINKP      RESTOR LINK(OP#)
01311
01312P 061F C6   BF       A        LDB     #NLAMPM
01313P 0621 8E   0001     D        LDX     #FNCST0
01314P 0624 A6   E0       A        LDA     ,S+
01315P 0626 E4   86       A        ANDB    A,X
01316P 0628 E7   86       A        STB     A,X
01317P 062A 39                     RTS
01318
01319                          ********************************************************
01320                          *           CLEAR FUNCTION PROCEDURE                   *
01321                          ********************************************************
01322                          * CLEARS OPERATOR DISPLAY AND ALL FUNCTION             *
01323                          *   MODES.                                             *
01324                          * -- INPUT PARAM'S: A - OPRNO                          *
01325                          * - GLOBAL PARAM'S: FNCST0 & FNCST1                    *
01326                          ********************************************************
01327
01328                                            XDEF    CLRP
01329P 062B C6   FB       A CLRP   LDB     #NCLRM
01330P 062D 8E   0001     D        LDX     #FNCST0
01331P 0630 E4   86       A        ANDB    A,X
01332P 0632 E7   86       A        STB     A,X        CLEAR CLRM FLG
01333P 0634 1F   8B       A        TFR     A,DP
01334P 0636 16   FF67 05A0        LBRA    CRDLDW
```

```
01336                                   NAM     M1
01337                                   TTL     MAIN PROGRAM ROUTINES
01338                           ********************************************************
01339                           *     DELAY PROCEDURE USING REAL TIME IRQ              *
01340                           ********************************************************
01341                           * -- INPUT PARAM'S: NONE                               *
01342                           * - GLOBAL PARAM'S: MSEC                               *
01343                           * - ROUTINES CALLED: WTCHDG                            *
01344                           ********************************************************
01345                                   XDEF    DELAYP
01346P 0639 BF    0006     D DELAYP STX     MSEC      PRESET COUNTER
01347P 063C 17    FD9C 03DB WAIT    LBSR    WTCHDG    RESET WATCHDOG
01348P 063F BE    0006     D        LDX     MSEC      READ NEW TIME
01349P 0642 26    F8   063C        BNE     WAIT      WAIT MOR
01350P 0644 39                     RTS
01351
01352                                   XDEF    RINGR
01353P 0645       01       A RINGR  FCB     $01       MUXO
01354P 0646       02       A        FCB     $02       MUX1
01355P 0647       04       A        FCB     $04       OP#
01356
01357
01358                           ********************************************************
01359                           *                RING ROUTINE                          *
01360                           ********************************************************
01361                           * -- INPUT PARAM'S: A - OPRNO                          *
01362                           * - GLOBAL PARAM'S: KYBUF, BYTNO, BITNO,               *
01363                           *                   BUFADD, FNCSTO & FNCST1            *
01364                           * - ROUTINES CALLED: DECBIN, PHDCOD, CHGLED,           *
01365                           *                    AUDIO, BUZZR, VALBIT,             *
01366                           *                                                      *
01367                           ********************************************************
01368
01369                                   XDEF    RINGP
01370P 0648 8E    000A     D RINGP  LDX     #KYBUF
01371P 064B E6    86       A        LDB     A,X       PHONO
01372P 064D 88    01       A        EORA    #1        CHANGE OP#
01373P 064F E1    86       A        CMPB    A,X       OTHER PHONO
01374P 0651 1027  FF4B 05A0        LBEQ    CRDLDW    CANNOT RING SAME NO
01375
01376P 0655 88    01       A        EORA    #1        RESTOR OP#
01377P 0657 34    02       A        PSHS    A         O- OP#
01378P 0659 8E    0001     D        LDX     #FNCSTO
01379P 065C E6    86       A        LDB     A,X       FNCST(OP#)
01380P 065E C5    01       A        BITB    #RINGNG
01381P 0660 26    4E   06B0        BNE     QPHUP     PHON RINGNG, HAS
01382                           *                      IT BEEN ANSWERED
01383P 0662 CA    01       A        ORB     #RINGNG
01384P 0664 E7    86       A        STB     A,X       SET RINGNG FLAG
01385
01386
01387P 0666 8E    000A     D        LDX     #KYBUF
01388P 0669 E6    86       A        LDB     A,X       KYBUF(OP#)
01389P 066B 1027  0084 06F3        LBEQ    RTNRNG    INVALID PHONO
01390
01391P 066F C1    96       A        CMPB    #$96
01392P 0671 1022  FF57 05CC        LBHI    CLRDSP    INVALID PHONO
01393P 0675 1F    98       A        TFR     B,A       DEC PHONO
01394P 0677 17    0112 078C        LBSR    DECBIN
01395P 067A 17    012B 07A8        LBSR    PHDCOD    A- BITN, B- BYTN
01396P 067D 1F    8B       A        TFR     A,DP      COPY BITN
01397P 067F A6    E4       A        LDA     ,S        OP#
01398P 0681 8E    000E     D        LDX     #BYTNO
01399P 0684 E7    86       A        STB     A,X       SET UP BYTN(OP#)
```

```
01400P 0686 8E   0010    D        LDX   #BITNO
01401P 0689 1F   B9      A        TFR   DP,B      BITN
01402P 068B E7   86      A        STB   A,X       SET UP BITN(OP#)
01403
01404P 068D 86   01      A        LDA   #1        ON
01405P 068F 8E   0061    D        LDX   #FLSH
01406P 0692 34   12      A        PSHS  A,X       0- ON, 1- PTR: FLSH, 3
01407P 0694 17   FED5 056C        LBSR  CHGLED    FLASH LED
01408P 0697 32   63      A        LEAS  3,S       RESTOR S
01409P 0699 A6   E4      A        LDA   ,S        OP#
01410P 069B C6   01      A        LDB   #1        CONNECT
01411P 069D 34   06      A        PSHS  A,B       0- OP#, 2- CONNCT, 3-
01412P 069F 8D   55   06F6        BSR   AUDIO
01413P 06A1 32   62      A        LEAS  2,S       RESTOR S: 0- OP#
01414
01415P 06A3 A6   E4      A        LDA   ,S        OP#
01416P 06A5 C6   01      A        LDB   #1        ON
01417P 06A7 34   06      A        PSHS  A,B       0- OP#,1- ON,3- OP#
01418P 06A9 17   009C 0748        LBSR  BUZZR     RING MUX1 OR MUX2
01419P 06AC 32   62      A        LEAS  2,S       RESTOR S
01420P 06AE A6   E4      A        LDA   ,S        OP#
01421
01422P 06B0 8E   000E    D OPHUP  LDX   #BYTNO
01423P 06B3 E6   86      A        LDB   A,X       BYTN(OP#)
01424P 06B5 BE   0004    D        LDX   BUFADD
01425P 06B8 30   85      A        LEAX  B,X       BYTNO(OP#) + BUFADD
01426
01427P 06BA 108E 0010    D        LDY   #BITNO
01428P 06BE A6   E4      A        LDA   ,S        OP#
01429P 06C0 A6   A6      A        LDA   A,Y       BITN(OP)
01430
01431P 06C2 17   FAAF 0174        LBSR  VALBIT    X- PTR, A- BITN
01432P 06C5 4D                    TSTA
01433P 06C6 26   2B   06F3        BNE   RTNRNG
01434
01435P 06C8 A6   E4      A        LDA   ,S        OP#
01436P 06CA 5F                    CLRB            STOP RINGNG
01437P 06CB 34   06      A        PSHS  A,B       0- OP#,1- STOP
01438P 06CD 8D   79   0748        BSR   BUZZR
01439P 06CF 32   62      A        LEAS  2,S       RESTOR S
01440
01441P 06D1 E6   E4      A        LDB   ,S        OP#
01442P 06D3 8E   0001    D        LDX   #FNCSTO
01443P 06D6 A6   85      A        LDA   B,X       FNCST(OP#)
01444P 06D8 84   DE      A        ANDA  #NRGNGM   NOT RINGING & NOT RING
01445P 06DA A7   85      A        STA   B,X       CLR RINGNG FLG
01446
01447P 06DC 4F                    CLRA
01448P 06DD 8E   0061    D        LDX   #FLSH
01449P 06E0 34   12      A        PSHS  A,X       0- OFF, 1-PTR: FLSH, 3
01450P 06E2 17   FE87 056C        LBSR  CHGLED
01451
01452P 06E5 8E   0049    D        LDX   #COLBUF
01453P 06E8 AF   61      A        STX   1,S
01454P 06EA 86   01      A        LDA   #1
01455P 06EC A7   E4      A        STA   ,S
01456P 06EE 17   FE7B 056C        LBSR  CHGLED    0- ON, 1-PTR: COLBUF,
01457P 06F1 32   63      A        LEAS  3,S       RESTOR S
01458
01459P 06F3 32   61      A RTNRNG LEAS  1,S       RESTOR S
01460P 06F5 39                    RTS
01461
01462
01463
```

```
01465                                   XDEF    AUDIO
01466                           ********************************************************
01467                           *     AUDIO SWITCHING ROUTINE                          *
01468                           ********************************************************
01469                           * -- Input param's on Stack:                           *
01470                           *                  S + 0 = RTS ADDR.                   *
01471                           *                      2 - MUXNO, OP#                  *
01472                           *                      3 - DIS/CONNECT                 *
01473                           *                                                      *
01474                           *    ---     CHANGED: A,B,X,S                          *
01475                           *    ---   UNCHANGED: DP,Y,U                          *
01476                           *    --  Routines called: PHECOD                       *
01477                           ********************************************************
01478
01479P 06F6 8E   0001     D AUDIO  LDX     #FNCSTO
01480P 06F9 6D   63         A     TST     3,S       DIS/CONNECT
01481P 06FB 26   0C   0709        BNE     CNNCT
01482
01483P 06FD C6   FD         A DIS    LDB     #NAUDIO
01484P 06FF A6   62         A     LDA     2,S       OP#
01485P 0701 E4   86         A     ANDB    A,X
01486P 0703 E7   86         A     STB     A,X       CLR AUDIO FLG
01487
01488P 0705 86   7F         A     LDA     #$7F      IMAGINARY NO
01489P 0707 20   19   0722        BRA     QMUXNO
01490
01491P 0709 A6   62         A CNNCT  LDA     2,S       OP#
01492P 070B C6   02         A     LDB     #AUDIOM
01493P 070D EA   86         A     ORB     A,X
01494P 070F E7   86         A     STB     A,X       SET AUDIO FLG
01495
01496P 0711 8E   000E       D     LDX     #BYTNO
01497P 0714 E6   86         A     LDB     A,X       BYTN(OP#)
01498P 0716 8E   0010       D     LDX     #BITNO
01499P 0719 A6   86         A     LDA     A,X       BITN(OP#)
01500
01501P 071B 8D   23   0740        BSR     PHECOD
01502
01503P 071D 8E   002C       P     LDX     #VOICE
01504P 0720 A6   86         A     LDA     A,X       VOICE(PHONNO)
01505P 0722 E6   62         A QMUXNO LDB     2,S       OP#
01506P 0724 26   02   0728        BNE     OP1
01507P 0726 8A   80         A OP0    ORA     #$80      B7= 1 FOR OP#0
01508P 0728 B7   200E       A OP1    STA     CONNCT    B7= 0 FOR OP#1
01509
```

```
01511                          ********************************************************
01512                          *       STROBE ROUTINE.                                *
01513                          ********************************************************
01514                          *       STROBES DATA INTO DATA LATCH.                  *
01515                          ********************************************************
01516                                  XDEF    STROBE
01517P 072B 86   F7      A STROBE LDA    #NSTRBL  NOT STROBE LO
01518P 072D B4   200F    A        ANDA   STRBPH
01519P 0730 B7   200F    A        STA    STRBPH   STROBE LO
01520
01521                          *       ENABLE B7 OF CONNCT TO BE DECODED
01522                          *           BY 74LS139.
01523
01524P 0733 34   36      A        PSHS   A,B,X,Y
01525P 0735 35   36      A        PULS   A,B,X,Y  DELAY
01526
01527P 0737 86   38      A        LDA    #STRBHI
01528P 0739 BA   200F    A        ORA    STRBPH
01529P 073C B7   200F    A        STA    STRBPH   STROBE HI
01530
01531                          *       DISABLE DECODING BY 74LS139. ALL O/P'S
01532                          *          GO HI, IF NOT HI ALREADY.
01533
01534P 073F 39                   RTS
01535
01536                          ********************************************************
01537                          *      PHONE NUMBER ENCODE ROUTINE.                    *
01538                          ********************************************************
01539                          ********************************************************
01540                          * - GLOBAL PARAM'S: A - BITNO                           *
01541                          *                   B - BYTNO                           *
01542                          *                                                       *
01543                          * - OUTPUT PARAM'S: A - BINARY PHONO                    *
01544                          *                   B - BYTNO                           *
01545                          *    ---     CHANGED: A,B                               *
01546                          *    ---   UNCHANGED: X,Y,S,U,DP                       *
01547                          ********************************************************
01548
01549                                  XDEF    PHECOD
01550P 0740 58                PHECOD LSLB
01551P 0741 58                       LSLB
01552P 0742 58                       LSLB
01553P 0743 34   04      A        PSHS   B
01554P 0745 AA   E0      A        ORA    ,S+
01555P 0747 39                   RTS
01556
01557
01558
```

```
01560                                   XDEF    BUZZR
01561                           ********************************************************
01562                           * -- Input param's on stack:                           *
01563                           *                 s + 0 - RTN ADDR                     *
01564                           *                     2 - FUNCTION                     *
01565                           *                         0: MUX0                      *
01566                           *                         1: MUX1                      *
01567                           *                         2: OP#                       *
01568                           *                     3 - ONOFF                        *
01569                           *    ---     CHANGED: A,B,X,Y,S                       *
01570                           *    ---   UNCHANGED: DP,U                            *
01571                           *                                                      *
01572                           *       CRDL UP: LO  :: CRDL DWN: HI                   *
01573                           ********************************************************
01574P 0748 108E 2002     A BUZZR  LDY     #RING     PIAOB
01575P 074C 8E   0645     P        LDX     #RINGR
01576
01577P 074F 86   02       A        LDA     #2
01578P 0751 A1   62       A        CMPA    2,S       FUNCTION
01579P 0753 26   24   0779         BNE     NMIMIC
01580
01581P 0755 6D   63       A        TST     3,S       ON/OFF
01582P 0757 27   14   076D         BEQ     OFFMIM    TURN MIM BUZZR OFF
01583
01584P 0759 F6   2002     A        LDB     RING      PIAOB
01585P 075C C4   C0       A        ANDB    #$C0      CRDL0, CRDL1 STAT ONLY
01586P 075E C1   C0       A        CMPB    #$C0
01587P 0760 26   0A   076C         BNE     NORNG     BOTH HANDSETS NOT DOWN
01588
01589P 0762 A6   62       A        LDA     2,S       FUNCTION: OPX
01590P 0764 E6   86       A        LDB     A,X       RINGER(A)
01591P 0766 FA   2002     A        ORB     RING
01592P 0769 F7   2002     A        STB     RING      ENABLE OPX BUZZR
01593P 076C 39                NORNG  RTS
01594
01595P 076D A6   62       A OFFMIM LDA     2,S       FUNCTION: OPX
01596P 076F E6   86       A        LDB     A,X
01597P 0771 53                    COMB
01598P 0772 F4   2002     A        ANDB    RING
01599P 0775 F7   2002     A        STB     RING      TURN MIM BUZZR OFF
01600P 0778 39                    RTS
01601
01602P 0779 A6   62       A NMIMIC LDA     2,S       FUNCTION
01603P 077B A6   86       A        LDA     A,X       DECOD FUNCTION
01604P 077D 6D   63       A        TST     3,S       ON/OFF
01605P 077F 27   05   0786         BEQ     STPRNG    STOP RNGNG
01606P 0781 AA   A4       A        ORA     Y
01607P 0783 A7   A4       A        STA     Y         SET BITS
01608P 0785 39                    RTS
01609
01610P 0786 43                STPRNG COMA             NOT RINGR
01611P 0787 A4   A4       A        ANDA    Y
01612P 0789 A7   A4       A        STA     Y         STOP RINGNG
01613P 078B 39                    RTS
01614
01615
```

```
01617                          *       ****************************************
01618                          *       * DECBIN CONVERTS A DECIMAL NO.      *
01619                          *       *   TO A BINARY NO.                  *
01620                          *       *                                    *
01621                          *       *  -- CHANGED:  A,B,S,DPR            *
01622                          *       *  -UNCHANGED:  X,Y                  *
01623                          *       *                                    *
01624                          *       *  -- INPUT PARAM'S:                 *
01625                          *       *     A - DECIMAL NO. UPON ENTRY.    *
01626                          *       *  -- OUTPUT PARAM'S:                *
01627                          *       *     A - BINARY NO. UPON EXIT.      *
01628                          *       *  NOTE:-  16 = $0F                  *
01629                          *       *          1 = $00                   *
01630                          *       ****************************************
01631                          *
01632                                  XDEF    DECBIN
01633P 078C 1F   8B       A DECBIN    TFR     A,DP        COPY PHONNO
01634P 078E 84   F0       A           ANDA    #$F0        MSD
01635P 0790 27   0C   079E            BEQ     ONEDIG      MSD = 0
01636P 0792 1F   89       A           TFR     A,B         B- MSD
01637P 0794 54                        LSRB
01638P 0795 54                        LSRB
01639P 0796 54                        LSRB
01640P 0797 54                        LSRB                MSD NOW LSD
01641P 0798 4F                        CLRA                SUM
01642P 0799 8B   0A       A TEN       ADDA    #10
01643P 079B 5A                        DECB                DECREMENT TENS COUNTER
01644P 079C 26   FB   0799            BNE     TEN
01645
01646P 079E 1F   B9       A ONEDIG    TFR     DP,B        PHONNO
01647P 07A0 C4   0F       A           ANDB    #$0F        LSD
01648P 07A2 34   04       A           PSHS    B
01649P 07A4 AB   E0       A           ADDA    0,S+
01650P 07A6 4A                        DECA                PHONO 16 = $0F
01651                          *                            PHONO  1 = $00
01652P 07A7 39                        RTS
01653
01654                                  XDEF    PHDCOD
01655
01656                          *       ****************************************
01657                          *       * DECODES PHONE NO. TO CARD NO. (B)  *
01658                          *       *    AND MUX NO. (A).                *
01659                          *       * --  CHANGED:  A,B                   *
01660                          *       * - UNCHANGED:  X,Y                   *
01661                          *       *                                     *
01662                          *       * --  INPUT PARAM'S: A - BIN PHONO    *
01663                          *       * -- OUTPUT PARAM'S: A - MUX ADDR     *
01664                          *       *                     B - CARD ADDR   *
01665                          *       ****************************************
01666
01667P 07A8 1F   89       A PHDCOD    TFR     A,B         COPY OF A
01668P 07AA 84   07       A           ANDA    #$07        MUX ADDR
01669P 07AC C4   78       A           ANDB    #$78        CRD ADDR
01670P 07AE 54                        LSRB
01671P 07AF 54                        LSRB
01672P 07B0 54                        LSRB
01673P 07B1 39                        RTS
01674
01675
```

```
01677                                XDEF   ADDQ
01678                          ***************************************************
01679                          * -- INPUT PARAM'S: S - BCD PHONO, 1BYTE          *
01680                          *                                                 *
01681                          * - OUTPUT PARAM'S: X - #QUE                      *
01682                          *   ---     CHANGED: A,B,X,U                      *
01683                          *   ---   UNCHANGED: X,DP,S                       *
01684                          *                                                 *
01685                          * NOTE:   UNUSED ELEMENTS = 0                     *
01686                          *         LAST ELMNT:NXT  = 0                     *
01687                          *         FIRST ELMNT:PREV = 0                    *
01688                          ***************************************************
01689P 07B2 A6   62       A ADDQ   LDA    2,S       BCD PHONO
01690P 07B4 8D   D6   07BC         BSR    DECBIN    CONVERT TO BIN
01691P 07B6 4C                     INCA             CORRECTION
01692P 07B7 A7   62       A       STA    2,S
01693
01694P 07B9 8E   0079     D       LDX    #QUE
01695P 07BC FC   0017     D       LDD    LASTNO
01696P 07BF 1F   02       A       TFR    D,Y       Y- LASTNO
01697
01698P 07C1 EC   8B       A       LDD    D,X       LAST ELEMENT
01699P 07C3 E6   62       A       LDB    2,S       PHONO
01700P 07C5 58                     LSLB             PTR TO NEW PHONO
01701P 07C6 1F   03       A       TFR    D,U       OLD LASTNO: PREV# NEW
01702P 07C8 1F   20       A       TFR    Y,D       LASTNO
01703P 07CA EF   8B       A       STU    D,X       OLD LAST ELEMENT UPDAT
01704
01705P 07CC 1F   20       A       TFR    Y,D       LASTNO
01706P 07CE 1F   98       A       TFR    B,A       LASTNO#LASTNO
01707P 07D0 5F                     CLRB             CLR NXT
01708P 07D1 1F   03       A       TFR    D,U       COPY
01709P 07D3 4F                     CLRA
01710P 07D4 E6   62       A       LDB    2,S       NEW PHONO IN Q
01711P 07D6 58                     LSLB             PHONO NOW PTR
01712P 07D7 EF   8B       A       STU    D,X       NEW LAST ELEMENT
01713
01714P 07D9 4F                     CLRA
01715P 07DA E6   62       A       LDB    2,S       PHONO
01716P 07DC 58                     LSLB             LASTNO PTR
01717P 07DD FD   0017     D       STD    LASTNO
01718
01719P 07E0 4F                     CLRA
01720P 07E1 5F                     CLRB
01721P 07E2 10B3 0015     D       CMPD   FRSTNO    QUE NOT IN USE
01722P 07E6 26   0C   07F4        BNE    NTNEW     NOT 1ST NO IN NEW Q
01723P 07E8 CE   0000     A       LDU    #$0
01724P 07EB EF   84       A       STU    ,X        CLR UNUSED BYTES
01725P 07ED E6   62       A       LDB    2,S       NEW PHONO
01726P 07EF 58                     LSLB             NOW PTR
01727P 07F0 4F                     CLRA
01728P 07F1 FD   0015     D       STD    FRSTNO    NEW FIRSTNO: 1ST ELMNT
01729
01730P 07F4 39           NTNEW    RTS
01731
```

```
01733                                   XDEF    CHKQ
01734                                  ***************************************************
01735                                  * -- INPUT PARAM'S: B - BCD PHONO                 *
01736                                  *                                                 *
01737                                  * - OUTPUT PARAM'S: A - ENTRY NO                  *
01738                                  *                   X - #QUE                      *
01739                                  *   ---     CHANGED: A,B,X,Y,U                    *
01740                                  *   ---   UNCHANGED: S,DP                         *
01741                                  *                                                 *
01742                                  * NOTE:   UNUSED ELEMENTS = 0                     *
01743                                  *         LAST ELMNT:NXT  = 0                     *
01744                                  *         FIRST ELMNT:PREV = 0                    *
01745                                  ***************************************************
01746
01747P 07F5 1F   98       A CHKQ    TFR     B,A       BCD PHONO
01748P 07F7 8D   93   078C          BSR     DECBIN    CONVERT TO BIN
01749P 07F9 4C                      INCA              CORRECTION
01750P 07FA 1F   89       A         TFR     A,B
01751
01752P 07FC 4F                      CLRA
01753P 07FD 8E   0079     D         LDX     #QUE
01754P 0800 6D   8B       A         TST     D,X
01755P 0802 27   04   0808          BEQ     NFOUND
01756P 0804 1F   98       A         TFR     B,A
01757P 0806 58                      LSLB              PTR TO PHONO
01758P 0807 39                      RTS
01759P 0808 34   06       A NFOUND  PSHS    D
01760P 080A FC   0015     D         LDD     FRSTNO
01761P 080D 10A3 E4       A         CMPD    ,S        IS IT FRSTNO
01762P 0810 26   06   0818          BNE     NOQ       NOT FRSTNO
01763P 0812 35   06       A         PULS    D
01764P 0814 54                      LSRB              PTR TO PHONO
01765P 0815 1F   98       A         TFR     B,A
01766P 0817 39                      RTS
01767
01768P 0818 32   62       A NOQ     LEAS    2,S       RESTOR S
01769P 081A 86   FF       A         LDA     #$FF      NO NOT IN Q
01770P 081C 39                      RTS
01771
```

```
01773                                   XDEF    DELQ
01774
01775                           ********************************************
01776                           * -- INPUT PARAM'S: A - ENTRY NO: BCD      *
01777                           *                                          *
01778                           * - OUTPUT PARAM'S: X - #QUE              *
01779                           *   ---     CHANGED: A,B,DP,X,Y,U          *
01780                           *   ---   UNCHANGED:                       *
01781                           *                                          *
01782                           * NOTE:  UNUSED ELEMENTS = 0               *
01783                           *        LAST ELMNT:NXT  = 0               *
01784                           *        FIRST ELMNT:PREV = 0              *
01785                           ********************************************
01786
01787P 081D 17    FF6C 078C DELQ   LBSR   DECBIN   CONVERT PHONO TO BIN
01788P 0820 4C                    INCA             CORRECTION
01789
01790P 0821 1F    89        A     TFR    A,B
01791P 0823 4F                    CLRA
01792P 0824 58                    LSLB
01793P 0825 34    06        A     PSHS   D         0- PTR TO DEL PHONO
01794P 0827 8E    0079      D     LDX    #QUE
01795P 082A EC    8B        A     LDD    D,X       PHONO ELMNT: PREV#NXT
01796P 082C 34    06        A     PSHS   D         0-PHONO EMNT, 2- PHONO
01797
01798P 082E 4F                    CLRA
01799P 082F EC    8B        A     LDD    D,X       NXT ELEMENT
01800P 0831 A6    E4        A     LDA    0,S       PTR TO NEW PREV
01801P 0833 1F    03        A     TFR    D,U
01802P 0835 EC    E4        A     LDD    0,S       DEL PHONO ELMNT
01803P 0837 4F                    CLRA
01804P 0838 EF    8B        A     STU    D,X       NEW NXT ELEMENT
01805
01806P 083A EC    E4        A     LDD    0,S
01807P 083C 1F    89        A     TFR    A,B
01808P 083E 4F                    CLRA
01809P 083F EC    8B        A     LDD    D,X       PREV ELEMENT
01810P 0841 E6    61        A     LDB    1,S       PTR TO NEW NXT
01811P 0843 1F    03        A     TFR    D,U
01812P 0845 EC    E4        A     LDD    0,S
01813P 0847 1F    89        A     TFR    A,B
01814P 0849 4F                    CLRA
01815P 084A EF    8B        A     STU    D,X       NEW PREV ELEMENT
01816
01817P 084C EC    62        A     LDD    2,S       PTR TO DEL PHONO
01818P 084E CE    0000      A     LDU    #0
01819P 0851 EF    8B        A     STU    D,X       CLR DEL PHONO
01820
01821P 0853 10B3  0017      D     CMPD   LASTNO
01822P 0857 26    08    0861      BNE    NOTLST    NOT LAST NO IN Q
01823P 0859 EC    E4        A     LDD    0,S       DEL PHONO ELMNT
01824P 085B 1F    89        A     TFR    A,B
01825P 085D 4F                    CLRA             PTS TO PREV ELEMENT
01826P 085E FD    0017      D     STD    LASTNO    NEW LASTNO
01827
01828P 0861 EC    62        A NOTLST LDD   2,S       PTR TO DEL PHONO
01829P 0863 10B3  0015      D     CMPD   FRSTNO
01830P 0867 26    06    086F      BNE    NTFRST    NOT FIRST NO IN Q
01831P 0869 EC    E4        A     LDD    ,S        DEL PHONO ELMNT
01832P 086B 4F                    CLRA             D PTR TO NEW FRSTNO
01833P 086C FD    0015      D     STD    FRSTNO    NEW FRSTNO
01834P 086F 32    64        A NTFRST LEAS  4,S       RESTOR S
01835P 0871 39                    RTS
01836
```

```
01838                          ********************************************************
01839                          *              QUEUEING PROCEDURE                      *
01840                          ********************************************************
01841
01842                                        XDEF    QP
01843P 0872 108E 0001     D QP      LDY     #FNCSTO
01844P 0876 34   02       A         PSHS    A           O-OP#
01845P 0878 C6   F7       A         LDB     #NQM
01846P 087A E4   A6       A         ANDB    A,Y         CLEAR Q FLAG
01847P 087C E7   A6       A         STB     A,Y
01848
01849P 087E FC   0015     D         LDD     FRSTNQ      PTR TO TOQ: TOP OF Q
01850P 0881 26   0D   0890         BNE     CONTNQ      VALID Q
01851P 0883 C6   00       A         LDB     #0
01852P 0885 8E   000A     D         LDX     #KYBUF
01853P 0888 35   02       A         PULS    A           OP#
01854P 088A E7   86       A         STB     A,X         SET ZERO
01855P 088C 17   FAC6 0355          LBSR    LINKP       DISPLAY ZERO
01856P 088F 39                      RTS
01857
01858P 0890 A6   E4       A CONTNQ  LDA     ,S          OP#
01859P 0892 C6   20       A         LDB     #RINGM
01860P 0894 EA   A6       A         ORB     A,Y
01861P 0896 E7   A6       A         STB     A,Y         SET RING MODE
01862
01863P 0898 FC   0015     D         LDD     FRSTNQ      TOQ PHONQ: PTR
01864P 089B 54                      LSRB                NOW PHONQ
01865P 089C 1F   98       A         TFR     B,A
01866
01867P 089E 17   F8F6 0197          LBSR    BINDEC      BCD PHONQ
01868P 08A1 34   02       A         PSHS    A           Q-PHONQ, 1-OP#
01869P 08A3 1F   89       A         TFR     A,B         PHONQ
01870P 08A5 A6   61       A         LDA     1,S         OP#
01871P 08A7 8E   000A     D         LDX     #KYBUF
01872P 08AA E7   86       A         STB     A,X         PUT TOQ PHONQ IN KEYBU
01873P 08AC 17   FAA6 0355          LBSR    LINKP       DSPLY T.O.Q
01874
01875P 08AF 35   02       A         PULS    A           BCD PHONQ
01876P 08B1 17   FF69 081D          LBSR    DELQ        DEL PHONQ FROM TOQ
01877
01878P 08B4 35   02       A         PULS    A           OP#
01879P 08B6 17   FD8F 0648          LBSR    RINGP
01880P 08B9 39                      RTS                 RETURN TO MAINP
01881
01882
01883                               END
TOTAL ERRORS 00000--00000
TOTAL WARNINGS 00000--00000


P 0489 ABXQ    00973 00975*
P 052F ABX1    01078 01091*
P 04EQ ABX2    01044*01081
P 0505 ABX3    01067*01082
P 051B ABX6    01080*01092
P 052B ABX7    01087 01089*
P 0518 ABXS    01079*
P 0414 ACHNG   00885 00890*
P 02DE ACK     00668 00674*
  000D ACKK    00090*00674
  0080 ACKM    00066*00676 00800
P 05EQ ACKP    00804 01259 01260*
P 01AQ ADD16   00442*00445
```

```
P 0211 ADDIG  00533 00537*
P 07B2 ADDQ   01130 01677 01689*
P 048F ADSTAT 00980*01070
P 0326 AUDACT 00711 00717*
P 02F4 AUDFLG 00682 00688*
P 06F6 AUDIO  01228 01412 01465 01479*
  0002 AUDIOM 00080*00688 00719 01492
  0022 AUDRNG 00079*01214
P 0197 BINDEC 00429 00437*01119 01867
P 0165 BITAGN 00367*00368
P 0180 BITCLR 00393 00395*
D 0010 BITNO  00143 00144*01171 01400 01427 01498
D 0011 BITN1  00145*
P 008C BLIND  00209*01033 01055
D 0004 BUFADD 00128*00315 00874 00896 00968 01035 01042 01057 01065
                01079 01424
D 0003 BUFNO  00127*00868 00871 00972
P 03FC BUFR   00872 00874*
P 0748 BUZZR  00907 01205 01229 01279 01418 01438 01560 01574*
D 000E BYTNO  00140 00141*01175 01398 01422 01496
D 000F BYTN1  00142*
P 056C CHGLED 01169 01170*01219 01222 01407 01450 01456
P 040A CHK    00883*00887
P 0410 CHK1   00886*00943
P 07F5 CHKQ   01124 01733 01747*
P 02E9 CLR    00675 00681*
P 00AD CLRALL 00247*
P 05CC CLRDSP 01215 01232*01392
  000F CLRK   00093*00681
  0004 CLRM   00074*00683 00812
P 011E CLRMEM 00306*00308
P 062B CLRP   00816 01328 01329*
P 0709 CNNCT  01481 01491*
  2004 COL0   00101*00579 00605 00618
  2006 COL1   00102*00576 00601 00617
  2008 COL2   00103*00573 00597 00616
  200A COL3   00104*00570 00594 00615
D 0049 COLBUF 00163 00164*00564 01220 01266 01452
P 00D1 COLMS  00266*
  200E CONNCT 00106*00326 00329 01508
P 012A CONST  00314*
P 0890 CONTNQ 01850 01858*
  2001 CRA0   00098*00477 00480 00844 00845 00847 00848
  2013 CRDLCR 00110*00494 01197 01201 01210
P 05A0 CRDLDW 01198 01209 01210*01334 01374
P 0008 CRDLFL 00179 00180*00693 01195
P 0586 CRDLP  00501 01193 01194*
P 02FB CRDLS  00690 00693*
  2002 CRDLST 00100*
P 0306 CRDLUP 00696 00698*
P 01E9 CRDLX  00497*
P 00B3 CRINIT 00250*00252
P 0592 CRLUP  00836 01154 01200 01201*
P 01EF CRLX   00499 00501*
  0000 CTRBLO 00076*
P 050D DBNCR  01039 01062 01074*
P 078C DECBIN 01394 01632 01633*01690 01748 01787
P 0639 DELAYP 01307 01345 01346*
P 0156 DELAYR 00346 00347*00349
P 055A DELFQ  01127 01147 01148*
P 081D DELQ   01151 01773 01787*01876
P 06FD DIS    01483*
P 0367 DISPL  00762 00764*
P 02CE DISRGD 00660 00663*
```

```
P 0361 DSPX    00759 00761*
P 0613 DX      01302 01304*
P 044C ENBLED  00923*
P 0555 ENDOP   01129 01132*01149 01153 01155
  0002 FLASHB  00064*00565
D 0061 FLSH    00165 00166*00590 00911 01217 01265 01405 01448
  0180 FLSHTM  00114*00322 00487
P 015E FMSB    00363 00364*00892
D 0001 FNCSTO  00124 00125*00311 00559 00652 00659 00702 00718 00782
               00793 01211 01238 01260 01313 01330 01378 01442 01479
               01843
D 0002 FNCST1  00126*00561 00661
P 0285 FROM23  00609 00611*
P 0255 FROM24  00582 00586*
D 0015 FRSTNO  00150 00151*01152 01721 01728 01760 01829 01833 01849
               01863
P 03D9 GOMNP   00828 00835 00838*
P 0521 INITCT  01076 01084*
D 0008 IRQCNT  00132 00133*00323 00484 00491
P 01B9 IRQP    00476 00477*
P 0200 KYBO    00523 00525*
  200D KYBCR   00113*00503
P 020F KYBDO   00528 00535*
D 0013 KYBINP  00148*00526 00648 00698
  200C KYBRD   00105*00525
P 02AF KYBRDP  00538 00646 00647*
D 000A KYBUF   00134 00135*00733 00755 01233 01370 01387 01852 01871
D 000B KYBUF1  00136 00137*
P 01FA KYBX    00505 00520 00521*
P 02D1 LAMP    00662 00666*
  000C LAMPK   00089*00667
  0040 LAMPM   00068*00310 00558 00658 00669 00818
P 0608 LAMPP   00822 01297 01298*
D 0017 LASTNO  00152*01695 01717 01821 01826
  2014 LINKO   00111*00757 01300
  2016 LINK1   00112*
P 0355 LINKP   00754 00755*01235 01310 01855 01873
P 0125 LNKTS   00310*
P 02C0 LPMACT  00654 00657*
P 036A MAINP   00332 00781 00782*00838
P 0474 MAKBUF  00316 00875 00966 00967*
P 0000 MASK    00177 00178*00366 00370 00389 00414 00621
P 025A MIMFLS  00567 00589*
P 0217 MIMIC   00492 00554 00555*
P 028A MIMTST  00560 00562 00614*
P 0416 MORCHG  00891*00937
D 0006 MSEC    00130 00131*00481 00483 01346 01348
P 0399 NA      00802 00806*
  007F NACKM   00067*01261
  00FD NAUDIO  00081*01483
P 03B1 NC      00814 00818*
  00FB NCLRM   00075*01329
D 000C NCOLM   00138*00319 00568 00586 00589 00611
  00DF NFLASB  00065*
P 0808 NFOUND  01755 01759*
P 03BD NL      00820 00824*
  00BF NLAMPM  00069*01312
P 0779 NMIMIC  01579 01602*
P 0467 NOCHG   00935 00939*
  0007 NONO    00094*00653
P 0818 NOQ     01762 01768*
P 076C NORNG   01587 01593*
P 0334 NOS     00721 00725*
P 0171 NOSB    00365 00373*
```

```
P 0022 NOSCOD 00188 00189*00727 00731
P 01A7 NOTENS 00441 00447*
P 0861 NOTLST 01822 01828*
P 043A NOTNEW 00903 00911*
P 033B NOTNO  00728*00729
P 038D NQ     00791 00800*
  00F7 NQM    00073*01845
P 03A5 NR     00808 00812*
  00DE NRGNGM 00084*01444
  00DF NRINGM 00071*00794
  00FE NRNGNG 00083*
D 000D NROW   00139*00321 00584 00620 00625 00628
  00F7 NSTRBL 00077*01517
P 086F NTFRST 01830 01834*
P 07F4 NTNEW  01722 01730*
P 076D OFFMIM 01582 01595*
P 0448 OKSTAT 00915 00920*
P 079E ONEDIG 01635 01646*
P 01B3 ONEPLS 00451 00455*
P 044F ONESHT 00918 00925*
P 0726 OP0    01507*
P 0728 OP1    01506 01508*
D 0012 OPRNO  00146 00147*00785 00792 00803 00809 00815 00821 00825
              00827
P 07A8 PHDCOD 01395 01654 01667*
P 0740 PHECOD 01118 01501 01549 01550*
P 00B8 PIA0A  00254*00259
P 00C7 PIA0B  00261*
P 00E8 PIA3A  00279*
P 00F0 PIA3B  00283*
P 00FA PIA4A  00288*
P 0102 PIA4B  00292*
P 010A PIA5A  00296*
P 0112 PIA5B  00300*
P 031B Q      00704 00710*
P 01E2 QCRDL  00479 00494*
  0003 QK     00091*00710
P 01F2 QKYB   00496 00503*
  0008 QM     00072*00712 00789
P 0722 QMUXNO 01489 01505*
P 0872 QP     00798 01842 01843*
P 0534 QPHON  00932 01114 01115*
P 06B0 QPHUP  01381 01422*
D 0079 QUE    00167 00168*01694 01753 01794
P 00A4 RESET  00242 00243*
  2002 RING   00099*00694 00832 01574 01584 01591 01592 01598 01599
P 030D RINGF  00702*
  000B RINGK  00092*00703
  0020 RINGM  00070*00705 00806 01859
  0001 RINGNG 00082*01380 01383
P 0648 RINGP  00810 01369 01370*01879
P 0645 RINGR  01352 01353*01575
  2000 ROW    00097*00556 00624
P 02AE RTNIRQ 00626 00630*
P 06F3 RTNRNG 01389 01433 01459*
P 049D SAVCOD 00994 00995*
P 0181 SETBIT 00399 00414*00923 00928 01182
P 018F SETOFF 00416 00421*
P 0188 SETON  00417*
  2012 STATUS 00109*00987 01053
D 0031 STBUF1 00161 00162*00873 00881 00942 00971
P 000A STDCOD 00181 00182*00969
P 0232 STEADY 00568*
P 0786 STPRNG 01605 01610*
```

```
  0038 STRBHI 00078*01527
  200F STRBPH 00107*01518 01519 01528 01529
P 01DD STRCNT 00486 00491*
P 072B STROBE 00327 00330 01516 01517*
D 0019 STTBUF 00159 00160*00314 00870 00880 00941 00974
  2010 STTSEL 00108*00982 01048
D 0000 SYSFLG 00122 00123*00489 00490 00566
P 0799 TEN    01642*01644
P 01C0 TIMERP 00480*
P 045F TSTACH 00934*01133
P 03EC TSTCHG 00830 00867 00868*
D 0139 TSTCNT 00169 00170*01040 01063 01074
  1000 TSTIME 00085*01306
P 0174 VALBIT 00377 00389*00900 01431
P 002C VOICE  00190 00191*01503
P 063C WAIT   01347*01349
P 03DB WTCHDG 00347 00784 00829 00841 00843*00967 01347
P 04C4 X21    01019 01022*
P 05F2 XCHNG  01269*01274
P 0298 XROWS  00587 00612 00620*
P 04A6 XX2    00999 01002*
P 04AC XX3    01003 01006*
P 04B2 XX4    01007 01010*
P 04B8 XX6    01011 01014*
P 04BE XX7    01015 01018*
```

Program Logic

Pseudo Code

Note: This psuedo code is not a programming language.
It was used to complement the flow charts.
The pseudo code is virtually equivalent to
MPL coding.

Interrupt Procedures.

```
IRQP:       IF real time interrupt THEN
                  DECREMENT (MSEC) timing counter
                  DECREMENT (IRQCNT) interrupt  counter
                  IF IRQCNT zero THEN
                        Equate IRQCNT to LED flash time (FLSHTM)
                        Invert LED flash status by inverting FLASH-ON in SYSFLG

MIMIC:                  IF Lamp test flag is set in SYSTAT THEN
                              Enable all LEDs. Turn on all COLUMNs.
                        ELSE
                              IF FLASH-ON flag is set THEN
                                    Enable four LED columns and flashing
                                    COL=COLBUF(NCOLM) OR FLSH(NCOLM) }
                                    NCOLM=NCOLM-1                    }x4

                                    IF NCOLM = 0 THEN NCOLM = 23
                              ELSE
                                    Enable four LED columns
                                    COL=COLBUF(NCOLM) }
                                    NCOLM=NCOLM-1     } x4
                                    IF NCOLM=0 THEN NCOLM=23
XROWS:      Enable next Row
            ROW=NOT(MASK(NROW))
            NROW=NROW-1
            IF NROW=0 THEN NROW=5

            IF any Operator CRADL flag SET THEN
                  IF CRADL0 THEN Pass parameter 0
                  IF CRADL1 THEN Pass parameter 1
                  CALL Cradle Procedure (CRDLP)

            IF any Keyboard flag is set THEN
                  IF KEYBRD0 THEN
                        Get KYBRD data
                        Mask data
                        Store data in KYBINP(0)
                  ELSE
                        Get KYBRD data
                        Mask data
                        Store data in KYBINP(0)
                  CALL Keyboard Procedure (KYBRDP)

            RETURN FROM INTERRUPT
```

Main Procedures.

```
MAINP:      DO FOREVER
                  RESET Watchdog
                  DO CASE FNCST(OPRNO).
                  Execute routines as per set flags in Function Status.
                        RINGP, ACKP, QP, CLRP, LAMPP
                  RESET Watchdog
                  INVERT Operator No (OPRNO)
                  Test for Changes in Extention Telephone Statuses. CALL TSTCHG.
            END DO
```

Operator Cradle Procedure.

```
CRADLP:     IF Cradle is up THEN RETURN
            Reset Cradle IRQs
            IF AUDIO OR RINGMN flags are set THEN
                  Disable connection between operator and extension
                  Disable Operator Audio Alarm
                  Disable LED indicating connection
CLRDSP:     Clear Operator Keyboard buffer
            Clear Operator display
            Clear FNCST(OPRNO), Operator function status
            RETURN
                              NOTE: If Operator Handset is up: Status high
                                    If Operator Handset is down: Status is low.

KYBRDP:     Read Keyboard Input
            DO CASE
                  UNNAMED KEY, LAMP TEST, ACKN, CLEAR, RING, Numerals
            Display keyboard entry on readout
            Set Mode flag in FNCST, Function Status
            RETURN
```

Test Extension Telephone Status Changes.

```
TSTCHG:     Invert Status Buffer No
            IF BUFNO=0 THEN
                  BUFADD=STTBUF. Set Database address
            ELSE
                  BUFAD=STBUF1. Set Database address
            CALL MAKBUF. Read all Telephone statuses
            DO PORT=24 TO 1
                  IF STTBUF(PORT) <> STBUF1(PORT) THEN
                        Find Phone No of changed status
                        IF Status change active THEN
                              Flash appropriate green LED flashing
                        ELSE
                              Disable flashing or steady LED
                              Disable Operator Audio alarm
                        IF PORT < 11 THEN, i.e. Phone Status, not Fault
                              IF Active change THEN
                                    IF PHONO not in Queue THEN
                                          Add PHONO to Queue
                              ELSE
                                    IF PHONO in Queue THEN
                                          Delete PHONO from Queue
            END DO
            RETURN
```

Lamp Test.

```
LAMPP:      Output $88 to Operator readout
            CALL DELAY(TSTIME)
            Restore Operator readout
            Clear Lamp Test flag in FNCST(OPRNO)
            RETURN
```

Clear Procedure.

```
CLRP:       Clear all flags in FNCST(OPRNO), Function status
            Clear Operator readout
            RETURN
```

Ring Procedure.

```
RINGP:      IF same PHONO as other Operator THEN RETURN
            IF RINGM not set THEN
                  Set RINGM flag (Ring Mode flag in FNCST(OPRNO))
                  IF PHONO invalid THEN RETURN
                  Flash PHONOs LED
                  Connect Operator to Extension
                  Ring Extension
            IF Extension telephone handset is lifted THEN
                  Disable Ringing
                  Clear RINGM flag
                  Flashing LED turned on
            RETURN
```

Acknowledge Procedure.

```
ACKP:       Turn flashing LEDs on permanently
            Disable Operator Audio Alarm
            RETURN
```

Queue Procedure

```
QP:         Clear QM (Queue Mode) flag in FNCST(OPRNO)
            Display Phone nuber at top of QUE on Operator readout
            GOTO RINPG with PHONO as parameter
```

Add Extension Telephone number to Queue.

```
ADDQ:       IF QUE > one entry THEN
                  Add BCD Phone No to end of QUE
                  Correct all linked list pointers
            ELSE
                  FIRSTNO=PHONO
      RETURN
```

Keyboard Procedure.

```
KYBRDP:    BUF=KYBINP(OPRNO). Get appropriate keyboard data
             IF BUF=Unmarked key THEN RETURN
             IF BUF=Lamp Test code THEN set LAMPM flag in FNCTST(OPRNO)
             IF BUF=Ackn code THEN set ACKM flag in FNCST(OPRNO)

             IF Cradle is down THEN RETURN
             IF BUF=Ring code THEN set RINGM in FNCST(OPRNO)
             IF BUF=Queue code then set QM in FNCST(OPRNO)

             DO NO=1 TO 0
                   IF BUF=NOS(NO) THEN GOTO X
             ENDDO
X:           Shift KEYBUF(OPRNO) LSD to MSD
             LSD=BUF, New data no the LSD
             GOTO LINKP
```

Operator Readout routine.

```
LINKP:     Output KEYBUF(OPRNO) to Operator readout
             RETURN
```

CHAIN FILES.

These command files were written to save the user much repetitively keyboard entry during assembly and linking.

The assembly and linking of source code modules is controlled by A.CF and L.CF respectively. Parameters used during execution of the chain files are passed on by the calling chain file to both A.CF and L.CF. Four calling chain files are available and are described on page C1.

Page C51 is a screen dump showing the user prompt when an error occurs during assembly. Execution of the chain file is terminated by pressing the '**Break**' key.

A screen dump of the complete assembly and linking process is shown on pages C52 to C54. The single line S.CF invokes A.CF. Parameters are passed from S.CF to A.CF and are dispayed on the screen by the latter. Run time errors or assembler errors will terminate execution of the chain file and prompt the user.

If no assembler errors are detected, A.CF calls the linker chain file L.CF and pass parameters to the it. L.CF links up to four relocatable object modules and stores the object code in a specified loadable object file.

A full listing of the command files are given on pages C56 to C61.

```
CHAIN SL.CF:1

Assembles and links the EMERGENCY TELEPHONE SYSTEM and then
      outputs the listing to the file: PREL.AL:1

CHAIN A.CF:1:F%PREL%,F1%RESET%,F2%IRQ%,F3%M0%,F4%M1%,LI%L%
                        **********************
                        Assembler Chain file.
                        **********************

F  - PREL
F1 - RESET
F2 - IRQ
F3 - M0
F4 - M1
LI - L : Listing saved in file: PREL.AL:1
LP -   : Listing output to line printer.
SS -   : Listing to terminal screen.
OR -   : ORG'D. Used for absolute file creation.
SET FOFF 0800
*
KILL PREL.AL:1,PREL.RO:1,PREL.LX:1
KILL     .AL:1 DOES NOT EXIST
KILL     .RO:1 DELETED
KILL     .LX:1 DOES NOT EXIST
ASM09 PREL:1,RESET:1,IRQ:1,M0:1,M1:1:N=120,L=PREL:1,O=PREL:1,XS
6809 MACROASSEMBLER  3.02
COPYRIGHT BY MOTOROLA 1978



*PROM I/O ERROR-STATUS=33 AT 08F6 ON DRIVE 1-PSN 042B
JMP 86FB
TST,F000 0000 0027
JMP 8706
*
*              ************************************************
*           --- Assembler error!  Press BREAK to exit.
.              ************************************************

LBL 8712

* 08 CHAIN ABORTED BY BREAK KEY
```

```
HAIN S.CF:1

Assembles and links the EMERGENCY TELEPHONE SYSTEM.
     No Listing is given.
     --------------------

HAIN A.CF:1;F%PREL%,F1%RESET%,F2%IRQ%,F3%M0%,F4%M1%
                        **********************
                        Assembler Chain file.
                        **********************

F  - PREL
F1 - RESET
F2 - IRQ
F3 - M0
F4 - M1
LI -  : Listing saved in file: PREL.AL:1
LP -  : Listing output to line printer.
SS -  : Listing to terminal screen.
OR -  : ORG'D. Used for absolute file creation.
SET F0FF 0800
*
EL PREL.AL:1,PREL.R0:1,PREL.LX:1
REL     .AL:1 DELETED
REL     .R0:1 DOES NOT EXIST
REL     .LX:1 DOES NOT EXIST
ASM09 PREL:1,RESET:1,IRQ:1,M0:1,M1:1;O=PREL:1
6809 MACROASSEMBLER  3.02
OPYRIGHT BY MOTOROLA 1978


JMP 86FB
TST,F000 0000 0027
JMP 8712
*
*      ********************************************************
* --- BREAK if you do not want to link: PREL, VECTOR.
*      ********************************************************
*
HAIN L.CF:1;F%PREL%,F1%VECTOR%,XR%X%,SP%$F000%
                         ***********************
                          Linking chain file.
                         ***********************

- Do not specify File Type or Drive No
- Links relocatable object files and load them into user memory.

-- The loader file has name of the first linked .R0 file.

    F = PREL
   F1 = VECTOR
   F2 =
   F3 =
   SB =   :  Start Base addr.
   EB =   :  End Base addr.
   SD =   :  Start Data addr.
   ED =   :  End Data addr.
   SP = $F000 :  Start Program addr.
   EP =   :  End Program addr.
   XR = X :  Cross Reference Table.
   LB =   :  MPL Cross Reference Library File.
```

```
@SET FOFF 0800
DEL TEMP.IF:0
TEMP     .IF:0 DELETED
DEL PREL.LO:1
PREL     .LO:1 DELETED
RLOAD
MDOS LINKING LOADER REV 03.00
COPYRIGHT BY MOTOROLA 1977
?IF=TEMP
?BASE=0
?STRB=0
?STRC=0
?STRD=0
?ENDD=$7FF
?STRP=$F000
?LOAD=PREL:1
?LOAD=VECTOR:1
?@*
@* -- MAPF following.
MAPF
  NO UNDEFINED SYMBOLS

MEMORY MAP

  S SIZE  STR  END COMN
  A 0010 FFF0 FFFF
  B 0000 0000 0000 0000
  C 0000 0000 0000 0000
  D 01F9 0000 07FF 0000
  P 08BA F000 F8B9 0000

MODULE NAME BSCT DSCT PSCT
  PREL      0000 0000 F000
  VECTOR    0000 01F9 F8BA

DEFINED SYMBOLS


MODULE NAME: PREL
  ACKP   P F5E0    ADDQ   P F7B2    AUDIO  P F6F6    BINDEC P F197
  BITNO  D 0010    BUZZR  P F748    BYTNO  D 000E    CHGLED P F56C
  CHKQ   P F7F5    CLRP   P F62B    COLBUF D 0049    CRDLDW P F5A0
  CRDLFL P F008    CRDLP  P F586    CRLUP  P F592    DECBIN P F78C
  DELAYP P F639    DELAYR P F156    DELFQ  P F55A    DELQ   P F81D
  FLSH   D 0061    FMSB   P F15E    FNCSTO D 0001    FRSTNO D 0015
  IRQCNT D 0008    IRQP   P F1B9    KYBRDP P F2AF    KYBUF  D 000A
  KYBUF1 D 000B    KYBX   P F1FA    LAMPP  P F608    LINKP  P F355
  MAINP  P F36A    MAKBUF P F474    MASK   P F000    MIMIC  P F217
  MSEC   D 0006    NOSCOD P F022    OPRND  D 0012    PHDCOD P F7A8
  PHECOD P F740    QP     P F872    QPHON  P F534    QUE    D 0079
  RESET  P F0A4    RINGP  P F648    RINGR  P F645    SAVCOD P F49D
  SETBIT P F181    STBUF1 D 0031    STDCOD P F00A    STROBE P F72B
  STTBUF D 0019    SYSFLG D 0000    TSTCHG P F3EC    TSTCNT D 0139
  VALBIT P F174    VOICE  P F02C    WTCHDG P F3DB

MODULE NAME: VECTOR
  FIRQV  A FFF6    IRQV   A FFF8    NMIV   A FFFC    RSRVD  A FFF0
  RSTV   A FFFE    SWI2V  A FFF4    SWI3V  A FFF2    SWIV   A FFFA

?MO=#LP
?OBJA=PREL.LO:1
```

```
   NO UNDEFINED SYMBOLS

MEMORY MAP

   S SIZE  STR  END COMN
   A 0010 FFF0 FFFF
   B 0000 0000 0000 0000
   C 0000 0000 0000 0000
   D 0800 0000 07FF 0000
   P 08BA F000 F8B9 0000

MODULE NAME BSCT DSCT PSCT
  PREL      0000 0000 F000
  VECTOR    0000 01F9 F8BA

DEFINED SYMBOLS


MODULE NAME: PREL
  ACKP   P F5E0    ADDQ   P F7B2    AUDIO  P F6F6    BINDEC P F197
  BITNO  D 0010    BUZZR  P F748    BYTNO  D 000E    CHGLED P F56C
  CHKQ   P F7F5    CLRP   P F62B    COLBUF D 0049    CRDLDW P F5A0
  CRDLFL P F008    CRDLP  P F586    CRLUP  P F592    DECBIN P F78C
  DELAYP P F639    DELAYR P F156    DELFQ  P F55A    DELQ   P F81D
  FLSH   D 0061    FMSB   P F15E    FNCSTO D 0001    FRSTNO D 0015
  IRQCNT D 0008    IRQP   P F1B9    KYBRDP P F2AF    KYBUF  D 000A
  KYBUF1 D 000B    KYBX   P F1FA    LAMPP  P F608    LINKP  P F355
  MAINP  P F36A    MAKBUF P F474    MASK   P F000    MIMIC  P F217
  MSEC   D 0006    NOSCOD P F022    OPRNO  D 0012    PHDCOD P F7A8
  PHECOD P F740    QP     P F872    QPHON  P F534    QUE    D 0079
  RESET  P F0A4    RINGP  P F648    RINGR  P F645    SAVCOD P F49D
  SETBIT P F181    STBUF1 D 0031    STDCOD P F00A    STROBE P F72B
  STTBUF D 0019    SYSFLG D 0000    TSTCHG P F3EC    TSTCNT D 0139
  VALBIT P F174    VOICE  P F02C    WTCHDG P F3DB

MODULE NAME: VECTOR
  FIRQV  A FFF6    IRQV   A FFF8    NMIV   A FFFC    RSRVD  A FFF0
  RSTV   A FFFE    SWI2V  A FFF4    SWI3V  A FFF2    SWIV   A FFFA

?EXIT


@*
@*  ****************************************
@* - Load Object file into user memory.
@*  ****************************************
@*
@. - Press BREAK if you do not want to load .LO file into user memory.

LOAD PREL.LO:1:U

** 08 CHAIN ABORTED BY BREAK KEY
```

Listing of Chain Files.

```
PAGE 001  S        .CF:1

/*
/* Assembles and links the EMERGENCY TELEPHONE SYSTEM.
/*       No Listing is given.
/*       --------------------
/*
CHAIN A.CF:1;F\%PREL\%,F1\%RESET\%,F2\%IRQ\%,F3\%M0\%,F4\%M1\%
```

```
PAGE 001  SL       .CF:1

/*
/* Assembles and links the EMERGENCY TELEPHONE SYSTEM and then
/*        outputs the listing to the file: PREL.AL:1
/*
CHAIN A.CF:1;F\%PREL\%,F1\%RESET\%,F2\%IRQ\%,F3\%M0\%,F4\%M1\%,LI\%L\%
```

```
PAGE 001  LP       .CF:1

/*
/* Assembles and links EMERGENCY TELEPHONE SYSTEM source code.
/*       Outputs the listing to the line printer. Page length = 64 lines.
/*
CHAIN A.CF:1;F\%PREL\%,F1\%RESET\%,F2\%IRQ\%,F3\%M0\%,F4\%M1\%,LP\%LP\%
```

```
/*                          **********************
/*                          Assembler Chain file.
/*                          **********************
/*
@SET,M 8
/* F  - %F%
/* F1 - %F1%
/* F2 - %F2%
/* F3 - %F3%
/* F4 - %F4%
/* LI - %LI% : Listing saved in file: %F%.AL:1
/* LP - %LP% : Listing output to line printer.
/* SS - %SS% : Listing to terminal screen.
/* OR - %OR% : ORG'D. Used for absolute file creation.
@*
DEL %F%.AL:1,%F%.RO:1,%F%.LX:1
/IFS F4
/IFS LI
RASM09 %F%:1,%F1%:1,%F2%:1,%F3%:1,%F4%:1;N=120,L=%F%:1,O=%F%:1,XS
/ELSE
/IFS SS
RASM09 %F%:1,%F1%:1,%F2%:1,%F3%:1,%F4%:1;O=%F%:1,L=#CN,-P
/ELSE
/IFS LP
RASM09 %F%:1,%F1%:1,%F2%:1,%F3%:1,%F4%:1;P=64,LXS
/ELSE
RASM09 %F%:1,%F1%:1,%F2%:1,%F3%:1,%F4%:1;O=%F%:1
/XIF
/XIF
/XIF
@JMP FIN
/XIF
/IFS F3
/IFS LI
RASM09 %F%:1,%F1%:1,%F2%:1,%F3%:1;N=120,L=%F%:1,O=%F%:1,XS
/ELSE
/IFS SS
RASM09 %F%:1,%F1%:1,%F2%:1,%F3%:1;O=%F%:1,L=#CN,-P
/ELSE
/IFS LP
RASM09 %F%:1,%F1%:1,%F2%:1,%F3%:1:1;P=64,LXS
/ELSE
RASM09 %F%:1,%F1%:1,%F2%:1,%F3%:1:1;O=%F%:1
/XIF
/XIF
/XIF
@JMP FIN
/XIF
/IFS F2
/IFS LI
RASM09 %F%:1,%F1%:1,%F2%:1;N=120,L=%F%:1,O=%F%:1,XS
/ELSE
/IFS SS
RASM09 %F%:1,%F1%:1,%F2%:1;O=%F%:1,L=#CN,-P
/ELSE
/IFS LP
RASM09 %F%:1,%F1%:1,%F2%:1;P=64,LXS
/ELSE
RASM09 %F%:1,%F1%:1,%F2%:1;O=%F%:1
/XIF
/XIF
/XIF
@JMP FIN
/XIF
```

```
PAGE 002  H          .CF:1

/IFS F1
/IFS LI
RASM09 %F%:1,%F1%:1:N=120,L=%F%:1,O=%F%:1,XS
/ELSE
/IFS SS
RASM09 %F%:1,%F1%:1:O=%F%:1,L=#CN,-P
/ELSE
/IFS LP
RASM09 %F%:1,%F1%:1:P=64,LXS
/ELSE
RASM09 %F%:1,%F1%:1:O=%F%:1
/XIF
/XIF
/XIF
@JMP FIN
/XIF
/IFS LI
RASM09 %F%:1:N=120,L=%F%:1,O=%F%:1,XS
/ELSE
/IFS SS
RASM09 %F%:1:O=%F%:1,L=#CN,-P
/ELSE
/IFS LP
RASM09 %F%:1:P=64,L
/ELSE
RASM09 %F%:1:O=%F%:1
/XIF
/XIF
/XIF
@LBL FIN
@TST,S EQ
@JMP ERROR
/IFS OR
EXBIN %F%:1
DEL %F%.LX:1
/XIF
@JMP THEEND
@LBL ERROR
@*
@*              ********************************************
@*          --- Assembler error!  Press BREAK to exit.
@.              ********************************************
@LBL THEEND
@*
@*      ******************************************************
@* --- BREAK if you do not want to link: %F%, VECTOR.
@*      ******************************************************
@*
CHAIN L.CF:1:F\%F%\%,F1\%VECTOR\%,XR\%X\%,SP\%$FOOO\%
```

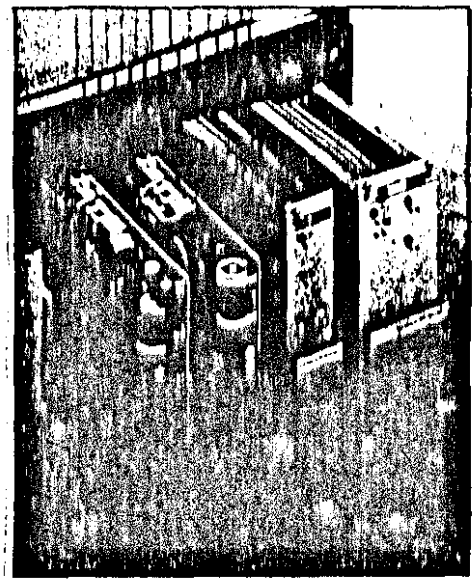
```
@SET,M 8
/*                          **********************
/*                           Linking chain file.
/*                          **********************
/*
/* - Do not specify File Type or Drive No
/* - Links relocatable object files and load them into user memory.
/*
/* -- The loader file has name of the first linked .RO file.
/*
/*      F = %F%
/*     F1 = %F1%
/*     F2 = %F2%
/*     F3 = %F3%
/*     SB = %SB% :  Start Base addr.
/*     EB = %EB% :  End Base addr.
/*     SD = %SD% :  Start Data addr.
/*     ED = %ED% :  End Data addr.
/*     SP = %SP% :  Start Program addr.
/*     EP = %EP% :  End Program addr.
/*     XR = %XR% :  Cross Reference Table.
/*     LB = %LB% :  MPL Cross Reference Library File.
/*
DEL TEMP.IF:0
DEL %F%.LO:1
RLOAD
IF=TEMP
BASE=0
/IFS SB
STRB=%SB%
/ELSE
STRB=0
/XIF
/IFS EB
ENDB=%EB%
/XIF
/IFS SC
STRC=%SC%
/ELSE
STRC=0
/XIF
/*
/IFC SD
STRD=0
/ELSE
STRD=%SD%
/XIF
/IFS ED
ENDD=%ED%
/ELSE
ENDD=$7FF
/XIF
/*
/IFC SP
STRP=$F000
/ELSE
STRP=%SP%
/XIF
/*
/IFS EP
ENDP=%EP%
/XIF
/*
LOAD=%F%:1
```

```
PAGE 002  L        .CF:1

/IFS F1
LOAD=%F1%:1
/XIF
/IFS F2
LOAD=%F2%:1
/XIF
/IFS F3
LOAD=%F3%:1
/XIF
/IFS LB
LIB=MPLSLIB
/XIF
@*
@* -- MAPF following.
MAPF
/IFS XR
MO=#LP
/XIF
OBJA=%F%.LO:1
EXIT
@*
@*  ****************************************
@* - Load Object file into user memory.
@*  ****************************************
@*
@. - Press BREAK if you do not want to load .LO file into user memory.
LOAD %F%.LO:1:U
```

Switching Power Supplies.

VERO Monovolt GK60



Stromversorgungen für die 19"-Technik

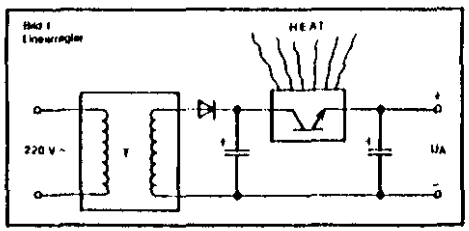
Seit Jahren entwickelt BICC-VERO ELECTRONICS Stromversorgungen für die 19"-Technik, die sich in vielfältigen Industrieanwendungen bewährt haben.

Ausgereifte Entwicklungen, hochwertige Bauelemente, kontrollierte Fertigung und uP-gestützte Testverfahren sichern eine optimale Qualität und Zuverlässigkeit unserer Geräte.

Linear geregelte Netzteile

Diese Stromversorgungen verwenden einen 50 Hz-(60 Hz-)Transformator, dem sich ein Gleichrichter und ein als Längsregler arbeitender Transistor anschließen. Bei diesem Schaltungsprinzip wird ein großer Teil der Leistung in Wärme umgewandelt, dementsprechend liegt der Wirkungsgrad nur zwischen 30 und 50%. Die eingesetzten Bauteile (Transformator, Kühlkörper u.a.) bewirken, daß linear geregelte Netzteile größer und schwerer ausfallen als z.B. Schaltnetzteile.

BICC-VERO Linearregler werden überwiegend dort eingesetzt, wo kleine Leistungen benötigt werden und das Volumen unberücksichtigt bleiben kann.

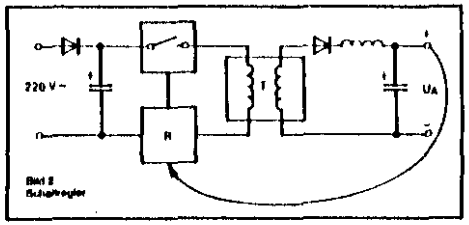


Primär getaktete Netzteile (Schaltnetzteile)

Hier wird die gleichgerichtete und geglättete Netzspannung durch einen mit hoher Frequenz arbeitenden Transistorschalter auf die Primärseite eines Übertragers geschaltet. Diese Technologie erlaubt den Einsatz von kleinen Ferrit-Transformatoren für die Netztrennung. Neben der Erhöhung des Wirkungsgrades und einer wesentlichen Verbesserung des Leistungsvolumens ergibt sich eine deutliche Gewichtseinsparung.

Die wesentlichen Vorteile von Schaltnetzteilen zusammengefaßt:

- Hoher Wirkungsgrad ≥ 75%
- Volumenleistung ca. 100 W/dm³
- Kompakt durch Gewicht- und Volumeneinsparung um den Faktor 5 gegenüber Linearreglern



Schaltnetzteile von BICC-VERO sind voll steckbare Stromversorgungen, speziell für den Einsatz in Baugruppenträger und Kartenmagazinen nach der 19"-Norm, DIN 41494, Teil 5. Die Führungshöhe der Kassette beträgt 100 mm (233,40 mm bei 6 HE). Der Steckverbinder nach DIN 41 612, Bauform H11 oder H15 besitzt einen voreilenden Schutzkontakt. VDE 0804 und die Schutzklasse I nach VDE 0100 werden erfüllt.

Um eine hohe Zuverlässigkeit und Lebensdauer zu erreichen, konstruierte BICC-VERO eine spezielle schwarz-eloxierte Profil-Kassette mit rückwärtigen Kühlkörperausschnitt. Zusammen mit den großflächigen Belüftungsfeldern in den Seitenteilen gewährleistet diese Konstruktion eine optimierte Wärmeableitung.

Wirkungsvolle Schutz- und Kontrolleinrichtungen sorgen darüber hinaus für ein Höchstmaß an Funktionsbereitschaft.

Schaltnetzteile von BICC-VERO sind durchdachte Entwicklungen von der Elektronik bis zur Mechanik. Für einen reibungslosen Betrieb empfehlen wir dem Anwender auch die Anwendungshinweise für Schaltnetzteile zu beachten.

Primär-getaktete Schaltnetzteile (SNT) von BICC-VERO ELECTRONICS sind kompakte, zukunftsorientierte Stromversorgungen mit hohen Anforderungen an die Qualität der Funktionsbereitschaft. Für einen reibungslosen Betrieb empfehlen wir die Beachtung folgender Hinweise:

Sense-Leitungen

Wenn die Verbindungsleitungen zwischen SNT und Verbraucher lang sind und über diese Leitungen große Ströme fließen, empfiehlt sich der Betrieb mit Sense-Leitungen, die Spannungsabfälle auf der Zuführung kompensieren.

Hierbei ist folgendes zu beachten:

1.1 Zuleitungslänge und -querschnitt sind so zu bemessen, daß höchstens 10% der Ausgangsspannung daran abfallen kann, das bedeutet, bei 5 V am Verbraucher müssen maximal 5,5 V vom Netzteil geliefert werden.

1.2 Ein Überlasten des Netzteils ist nicht zulässig. Bei einem 5 V/10 A-Netzteil dürfen bei 5,5 V Ausgangsspannung und einem angenommenen Spannungsabfall von 0,5 V auf den Versorgungsleitungen nur 9,1 A auf Dauer entnommen werden.

1.3 Bei einer Unterbrechung der Führerleitungen steuert der eingebaute Regler das Netzteil voll aus, was die Ausgangsspannung hochlaufen läßt und damit die angeschlossene Elektronik gefährdet, wenn nicht gar zerstören würde. Dagegen schützt der eingebaute Überspannungsschutz (OVP), der das Netzteil abschaltet.

1.4 Die Sensoranschlüsse müssen immer direkt oder über Führerleitungen mit den Ausgangsklemmen entsprechender Polarität verbunden bleiben und dürfen nicht durch Schalter o. ä. abgetrennt werden. Soll eine Last durch einen Schalter abschaltbar sein, muß dies hinter den Verbindungen der Fühlerleitungen mit den Ausgangsklemmen geschehen.

1.5 Durch die nicht unerheblichen Induktivitäten, besonders bei längeren Zuleitungen zum Verbraucher, kann es bei Lastsprüngen zu unliebsamen Spikes kommen. Diese können mit einem Elektrolytkondensator (ca. 1000 uF) direkt am Verbraucher abgeblockt werden.

1.6 Kompaktnetzteile von BICC-VERO dürfen parallel geschaltet werden. Bei gleichzeitigem Sensorbetrieb ist die Parallelschaltung erst nach dem Verbindungspunkt der Sensorleitungen mit den Ausgangsleitungen durchzuführen, da sonst vermaschte Systeme entstehen und sich die Regler gegenseitig beeinflussen. Vor der Parallelschaltung sind die Ausgangsspannungen der einzelnen Netzteile auf gleiche Werte einzustellen.

Überspannungsschutz (OVP)

Der OVP schützt die angeschlossene Elektronik vor Überspannungen, die infolge interner oder externer Fehlfunktion auftreten können. Je nach Modell wirkt der OVP wie folgt:

PK 25, PK 55

Mit einer Brücke zwischen PIN 2 und PIN 4 (H11) ist der OVP aktiv. Überschreitet die Ausgangsspannung einen Wert von ca. 6.3 V, schaltet ein Thyristor die Ausgänge kurz. Wiederanlauf durch Netztrennung oder Unterbrechung der Verbindung PIN 2 - PIN 14.

PK 50, PK 100, PK 110

Erreicht die Ausgangsspannung die einstellbare OVP-Schwelle, schaltet der Regler ab, ohne den Ausgang kurzzuschließen. Automatischer Wiederanlauf nach Abklingen der Überspannung. Die Einstellung der OVP soll bei max. Ausgangsstrom erfolgen, um ausgeregelte Spannungsabfälle an den Zuleitungen zu berücksichtigen.

Überstromschutz (OCP)

Der OCP schützt das SNT und den angeschlossenen Verbraucher vor unzulässig hohen Ausgangsströmen. Nach Aufhebung des Überstromes/Kurzschlußstromes erfolgt automatischer Wiederanlauf.

Schutzleiter

Alle SNT von BICC-VERO sind nach Schutzklasse I ausgelegt. Die Metall-Kassette ist mit dem voreilenden Schutzleiter-Kontakt 32 des Steckverbinders galvanisch verbunden, der vom Anwender an das Schutzleitersystem angeschlossen werden **muß.**

Sollten die Sicherheitsmaßnahmen nach Schutzklasse I nicht genutzt werden (z.B. im Laborbereich) liegt an der Kassette, bedingt durch die eingebauten Entstörkondensatoren eine Spannung gegen Erde an. Der damit ermöglichte Ableitstrom (max. 0,75 mA) ist jedoch gemäß VDE 0875 zulässig.

Power-fail-Signal (PFS)

Das PFS ist ein TTL-kompatibles 'open-collector'-Signal, das bei Netzausfall von ‚Low' auf ‚High' schaltet und zur rechtzeitigen Einleitung geeigneter Maßnahmen genutzt werden kann, ehe die Ausgangsspannung zusammenbricht.

Thermische Beanspruchung

Die thermische Verlustleistung von SNT ist wegen des hohen Wirkungsgrades relativ klein.

Unsere kompakten SNT sind konstruktiv nach Gesichtspunkten konzipiert worden, die eine optimale Wärmeabfuhr ermöglichen. Dies wird z. B. durch großflächige Durchbrüche in der Metall-Kassette und durch einen rückseitig angeordneten Kühlkörper erreicht, der die Wärme erst gar nicht ins Innere der Kassette leitet.

Der Anwender hat einen großen Einfluß auf die Lebensdauer seines Produktes, wenn er z. B. bei mehreren wärmeproduzierenden Baugruppen/SNT dafür sorgt, daß ausreichend freie Luftkonvektion ermöglicht wird und die Betriebstemperaturen der elektronischen Komponenten somit minimal gehalten werden.

Parallel-/Serien-Schaltung

Bei Parallelbetrieb ist darauf zu achten, daß die Ausgangsspannungen so exakt wie möglich auf gleiche Werte eingestellt werden, um eine gleichmäßige Stromaufteilung in den Geräten zu ermöglichen.

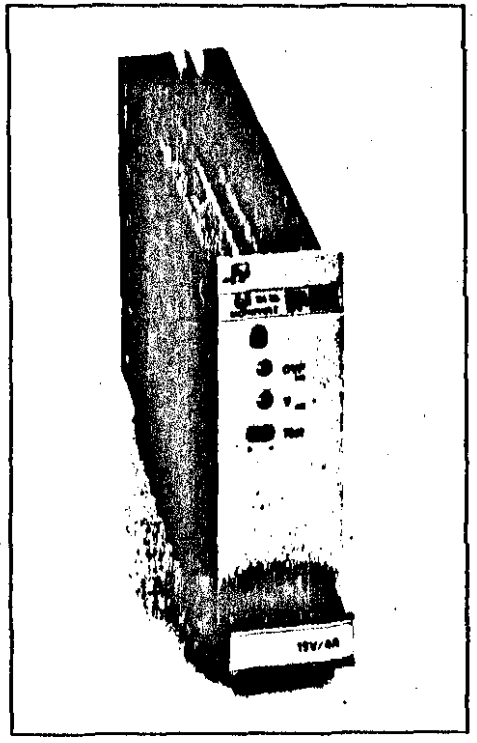
Bei Serienschaltung muß damit gerechnet werden, daß sich die den Ausgleichsspannungen überlagerten Restwelligkeiten addieren.

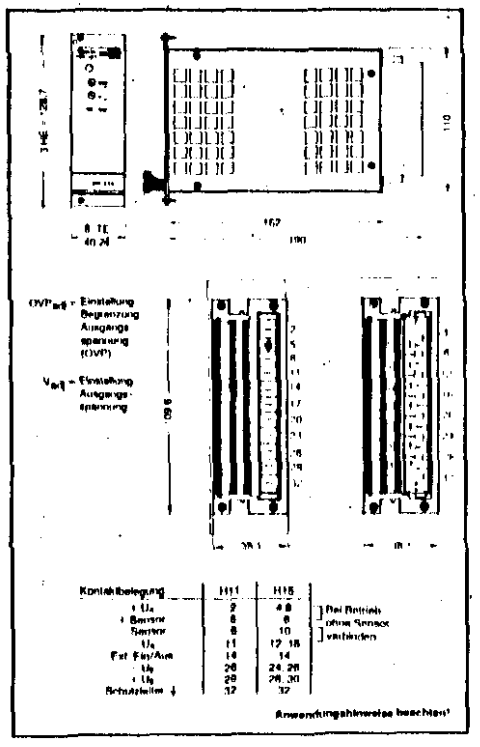
Lastregelung

Zum Messen der im Datenblatt spezifizierten Werte für eine Laständerung von 10%...90% Ausgangsstrom sollte der Einfluß von Übergangswiderständen im Steckerbereich berücksichtigt werden.

MONOVOLT GK 60
DC-DC-Wandler, 15 V/4 A, 24 V/2,5 A

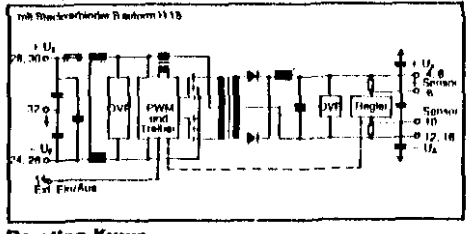
Schaltnetzteil in MOS-Technologie für den Einsatz in 19"-Baugruppenträger nach DIN 41494 Teil 5



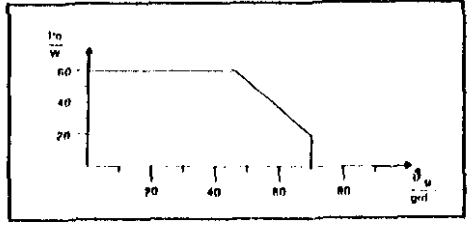


- Primär getaktete Stromversorgung auf Europakarte 100 x 160 mm
- Entwickelt in fortschrittlicher 100 kHz MOSFET-Technik
- Eingangsspannung 24 V DC (10 – 36 V) oder 48 V DC (24 – 72 V)
- Überspannungs- und Verpolungsschutz der Eingangsspannung
- Dauerkurzschluß- und Leerlauffest
- Parallel und seriell schaltbar
- Sicherheit nach VDE 0804/0110
- Funkentstört nach VDE 0871, Kurve B
- Sense-Betrieb
- Kontroll- und Steuersignale
- Wirkungsvolle Schutzeinrichtungen
- Externes Ein-/Ausschalten mit TTL-Signal möglich
- Erstklassiges Design mit optimaler Wärmeabführung
- Frontseitige Meßbuchsen (Test)

Prinzipschaltbild



Derating-Kurve



Eingangsgrößen

Eingangsgleichspannung		24 V DC (10 – 36 V) bzw. 48 V DC (24 – 72 V)
Wirkungsgrad (bei Vollast):		≥ 75 %

Ausgangsgrößen

Ausgangsgleichspannung, einstellbar:		**15 V ± 1 V**	**24 V ± 2 V**
Ausgangsgleichstrom:		4 A	2,5 A
Ripple (bei Vollast):		≤ 40 mV_{ss}	≤ 40 mV_{ss}

Regelgrößen

Netzregelung (V_{IN} ± 50 %, 100 % I_{OUT}):	ΔV_{OUT}	≤ 0,1 %	≤ 0,1 %
Lastregelung (10...90 % I_{OUT}, statisch):	ΔV_{OUT}	≤ 0,1 %	≤ 0,1 %
Regelzeit (10...90 % I_{OUT}):		0,2 ms	
Spannungsausregelung mit Sense-Leitungen:		0,5 V	

Schutz- und Kontrolleinrichtungen

Begrenzung Ausgangsstrom:	> 4,3 A	> 2,7 A
Begrenzung Ausgangsspannung (OVP), einstellbar:	16,5 – 18 V	26,4 – 30 V
Begrenzung Einschaltstrom:	–	
Begrenzung Eingangsspannung:	36,5 V ± 1,5 V bzw. 77 V ± 3 V, Verpolungsschutz	
Netzausfallüberbrückung ($V_{IN\ NENN}$, 100 % I_{OUT}):	≥ 3 ms	
Powerfail-Signal (bei Vollast):	–	

Sicherheit

Isolationsspannungsfestigkeit nach VDE 0804:	Primär	– Sekundär	2,5 kV_{eff}
	Primär	– Erde	1,5 kV_{eff}
	Sekundär	– Erde	0,5 kV_{eff}
Schutzklasse I nach VDE 0100:	Steckverbinder mit voreilendem Kontakt		

Funkentstörung

Funkentstört nach VDE 0871, Kurve B (150 kHz – 30 MHz)

Betriebsgrößen

Max. Umgebungstemperatur:	70° C (siehe Derating Kurve)
Leistungsderating nach Diagramm:	1,6 W/K ab 45°
Lagertemperatur:	– 25° ... + 85° C

Mechanik

Stabile schwarz eloxierte Profil-Kassette mit rückwärtigem Kühlkörper und großflächigen Belüftungsausschnitte
Kompatibel zu 19" Einschubtechnik nach DIN 41494, Teil 5
Gewicht: ca. 850 g

Lieferung

Bezeichnung	Beschreibung	Bestell-Code 15 V/4 A	Bestell-Code 24 V/2,5 A	VE
MONOVOLT GK 60/24 V DC	mit Steckverbinder Bauform H15*	*116-33393L	*116-33394H	ST
MONOVOLT GK 60/48 V DC	mit Steckverbinder Bauform H15*	*116-33397K	*116-33396G	ST
Federleiste	DIN 41 612 Bauform H15		*017-144091	ST

*Lagervorzugstype

*Lieferung mit Steckverbinder Bauform H11 auf Anfra

Switching Power Supplies.

VERO Monovolt GK60

- C64 -

MIMIC

+5 V

ROW(6)

COLUMN (32)

COMPUTER BOARD

KYSTRB Ø (1)

KYBRD Ø (4)

STSEL(5)

+5 V

STATUS(8)

KYSTRB 1(1)

KYBRD 1 (4)

PSEL(8)

OPERATOR Ø PHONE

OPERATOR 1 PHONE

OP#Ø

KEYPAD (8)

VOICE (2)

TELEPHONE CONTROLLER

+5 V

+24V

TELEPHONE CONTROLLER

KEYPAD(8)

OP#1

VOICE (2)

OP# Ø BSEL (3)
OP# 1 BSEL (3)
ST MXA (3)
STATUS (8)

STMXA (2)

(12) Ø PHON

(6) STCROSEL

IMUX (3)

1 PHON(12)

IMUX (3)

STATUS

STCROSEL Ø

Ø PHON 1

1 PHON 1

M Ø

STCROSEL 1

Ø PHON 2

1 PHON 2

M 1

STCROSEL 2

Ø PHON 3

1 PHON 3

M 2

STCROSEL 3

Ø PHON 4

1 PHON 4

M 3

STCROSEL 4

Ø PHON 5

1 PHON 5

M 4

STCROSEL 5

Ø PHON 6

1 PHON 6

M 5

T

16 X

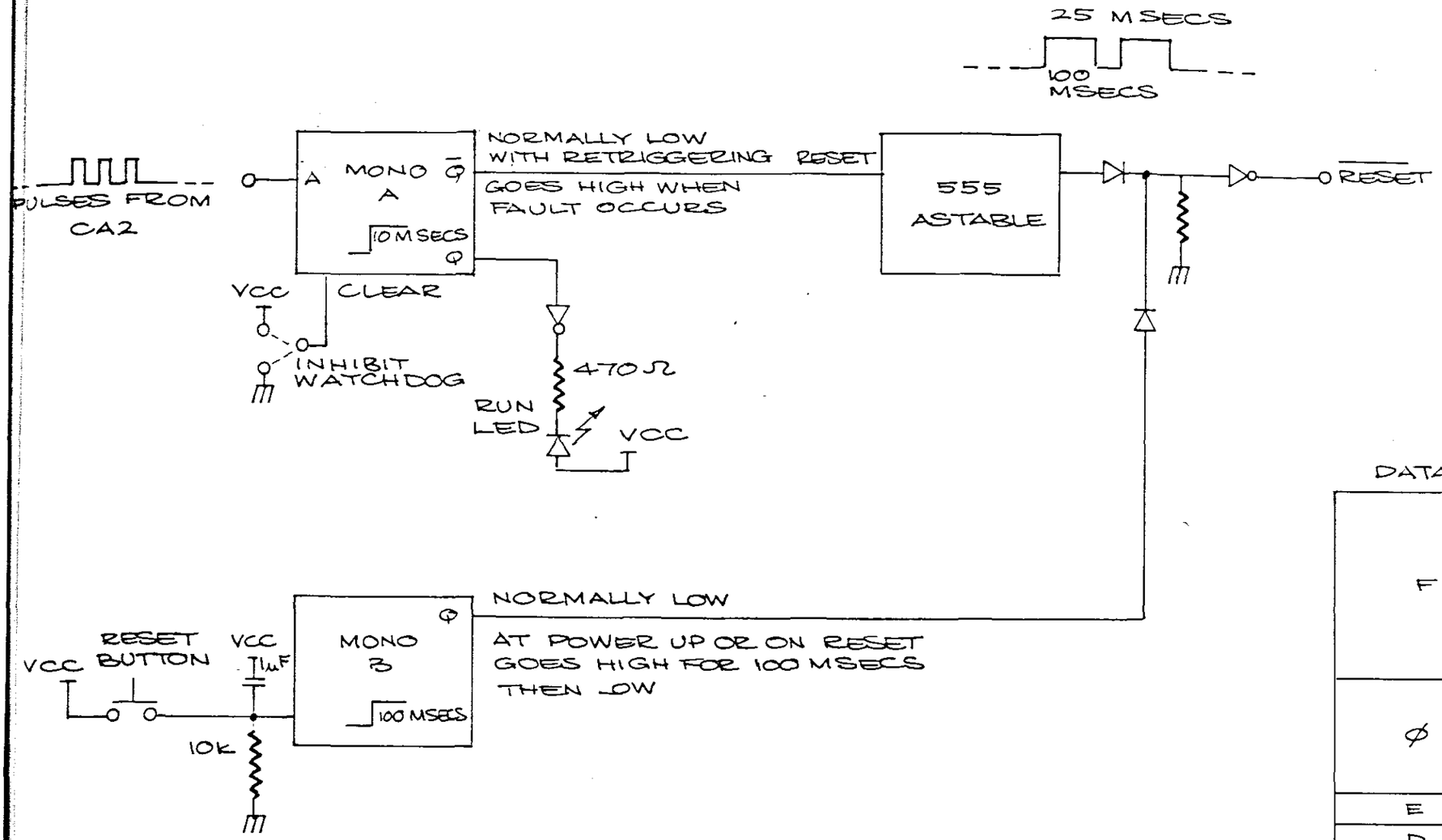
EMERGENCY TELEPHONE SYSTEM

SYSTEM BLOCK DIAGRAM

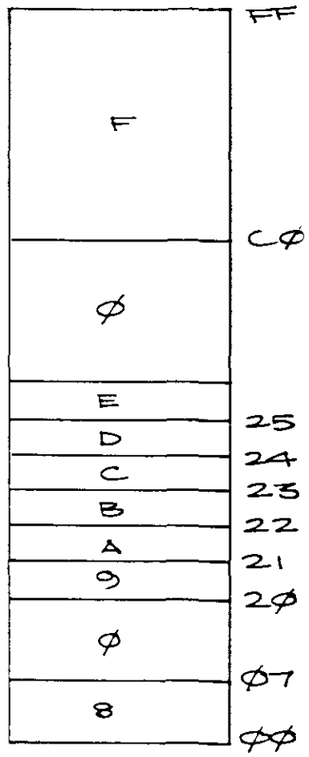
CITY OF CAPE TOWN ELECTRICITY DEPT.	DRAWN	C. RIX	SCALE	REV
DRAWING OFFICE MANAGER M. L. Richard	TRACED	C. RIX	SHEET 8	
CEE DC PALSER	INFO	A.Van Tonder	SK 3818	
	CHECKED			

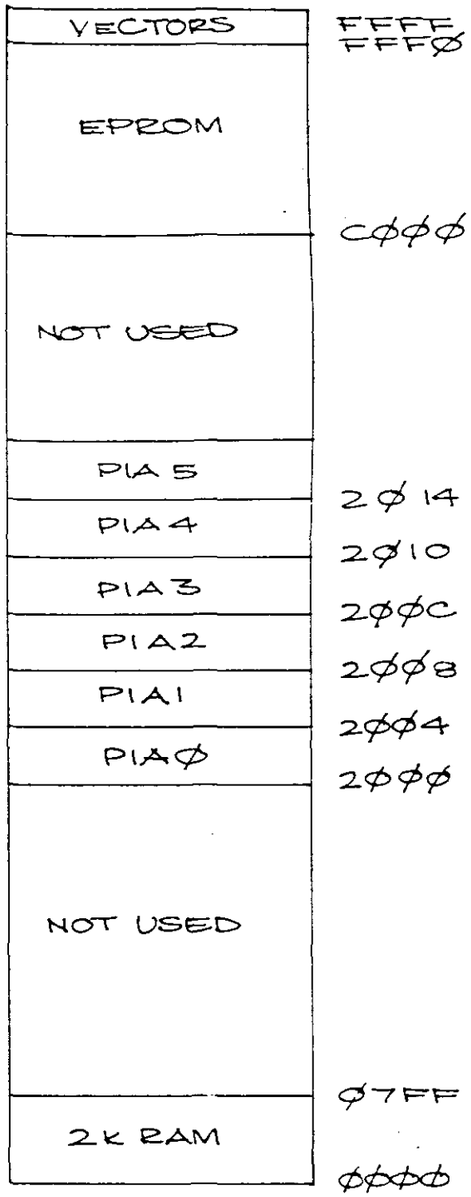
SINGLE BOARD COMPUTER. FIG 1.

CITY OF CAPE TOWN ELECTRICITY DEPT	DRAWN	A HALL	85 04 23	SCALE	REV
	TRACED	A HALL	86 04 25	~	
D/O MANAGER N. DE STADLER	INFO	FULLER			
C.E.E. D.C. PALSER				SK 3818 sh10	



WATCHDOG CIRCUIT





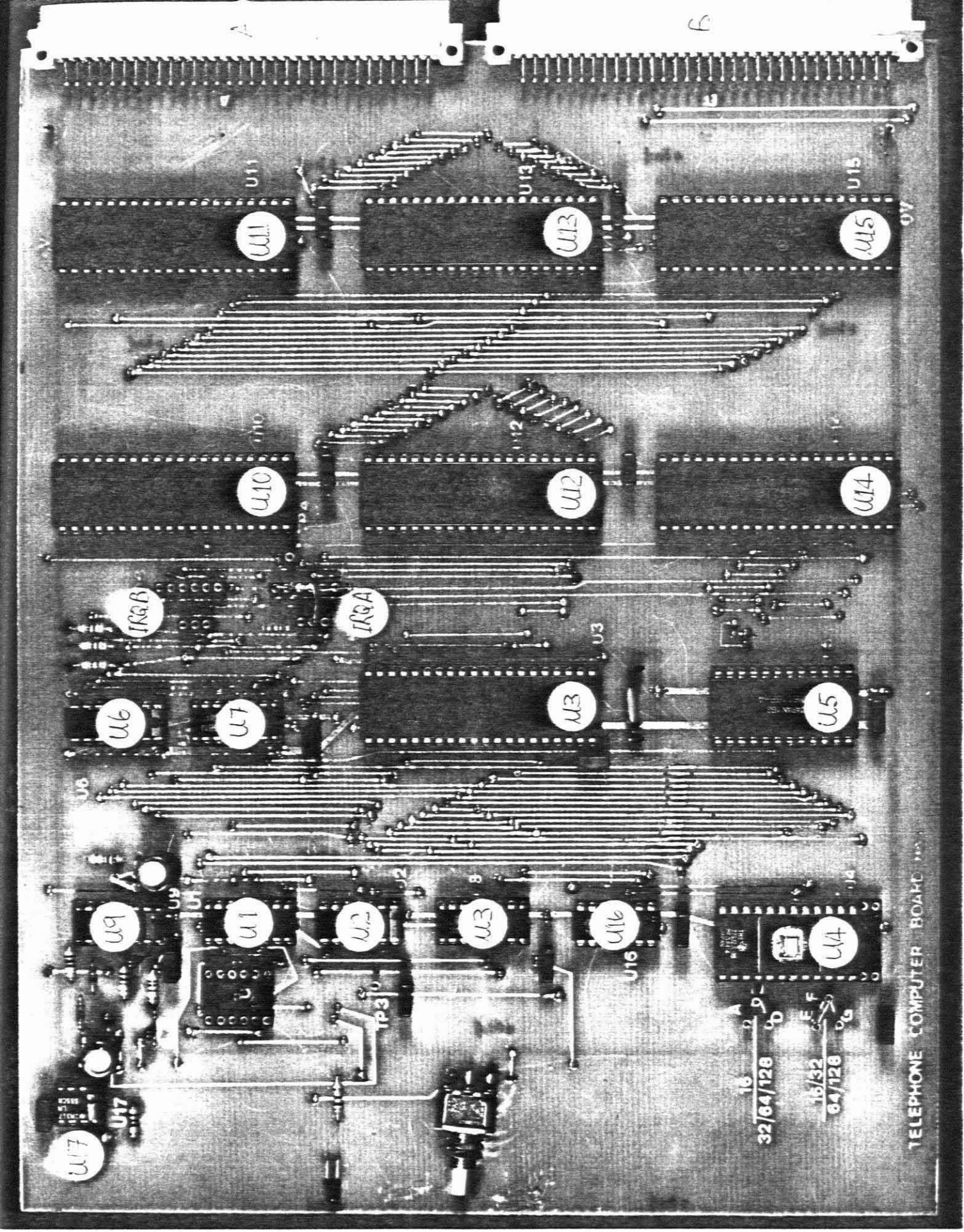
MEMORY MAP

DECODING PROM

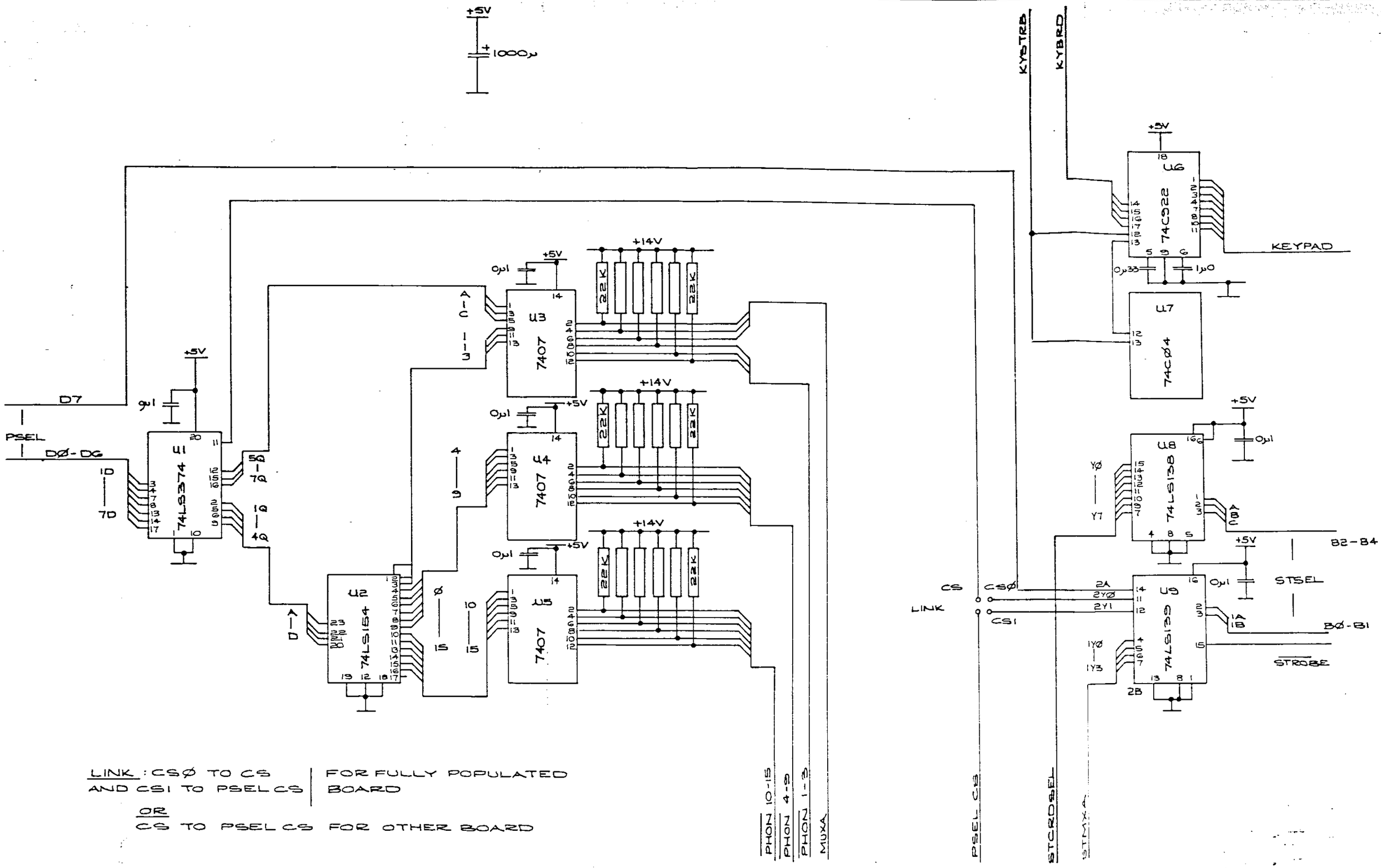
MEMORY & DECODING MAPS

TELEPHONE CONTROLLER

CITY OF CAPE TOWN ELECTRICITY DEPT	DRAWN	S.J.R	86.06.17	SCALE ~	REV
	TRACED	S.J.R	86.06.17	SHEET 9	
D/O MANAGER N. DE STADLER	INFO	R FULLER	86.04 24	SK 3818	
C.E.E. D.C. PALSER	CHECKED				



Single Board Computer Component Layout



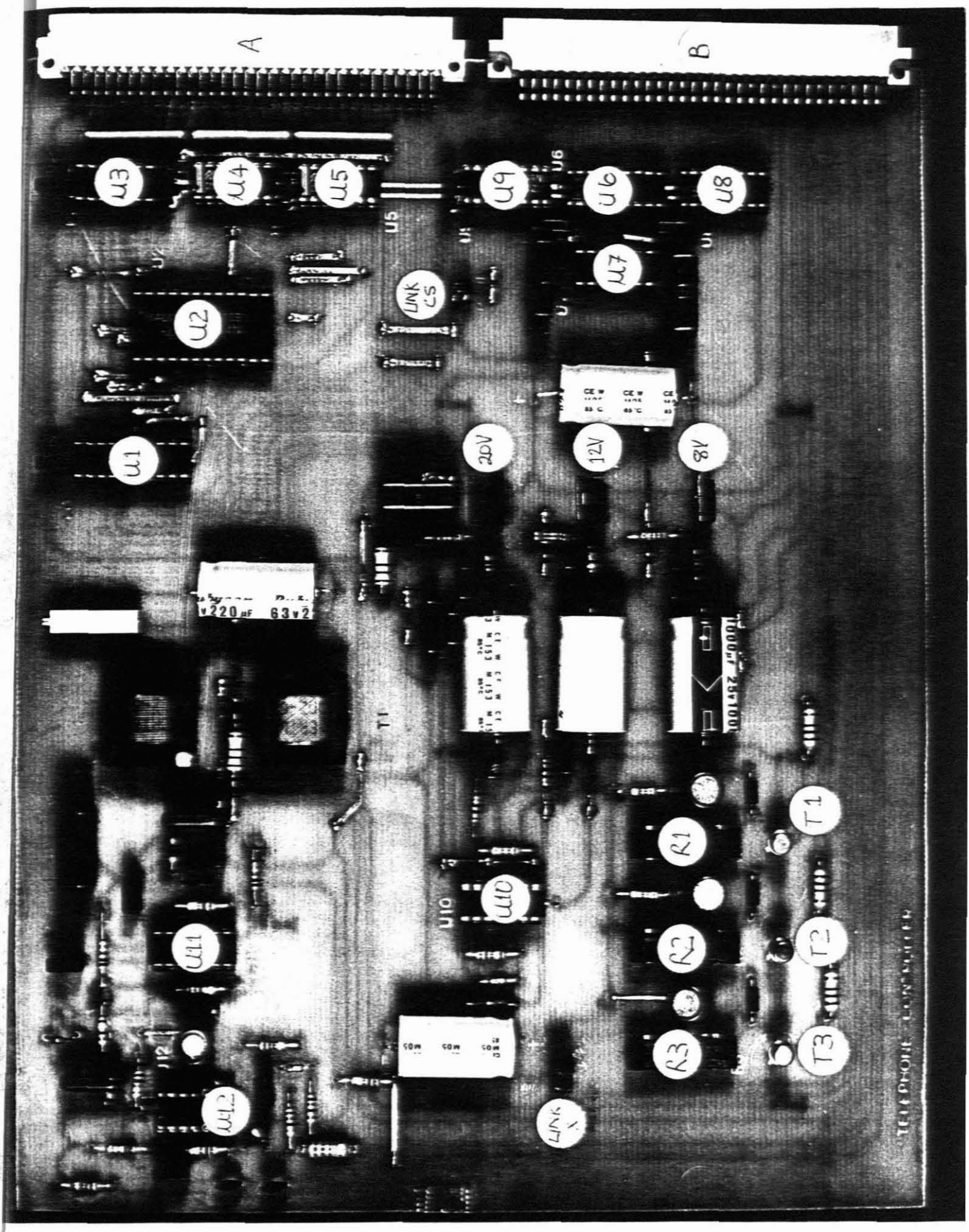
LINK : CSØ TO CS AND CS1 TO PSEL CS | FOR FULLY POPULATED BOARD

OR

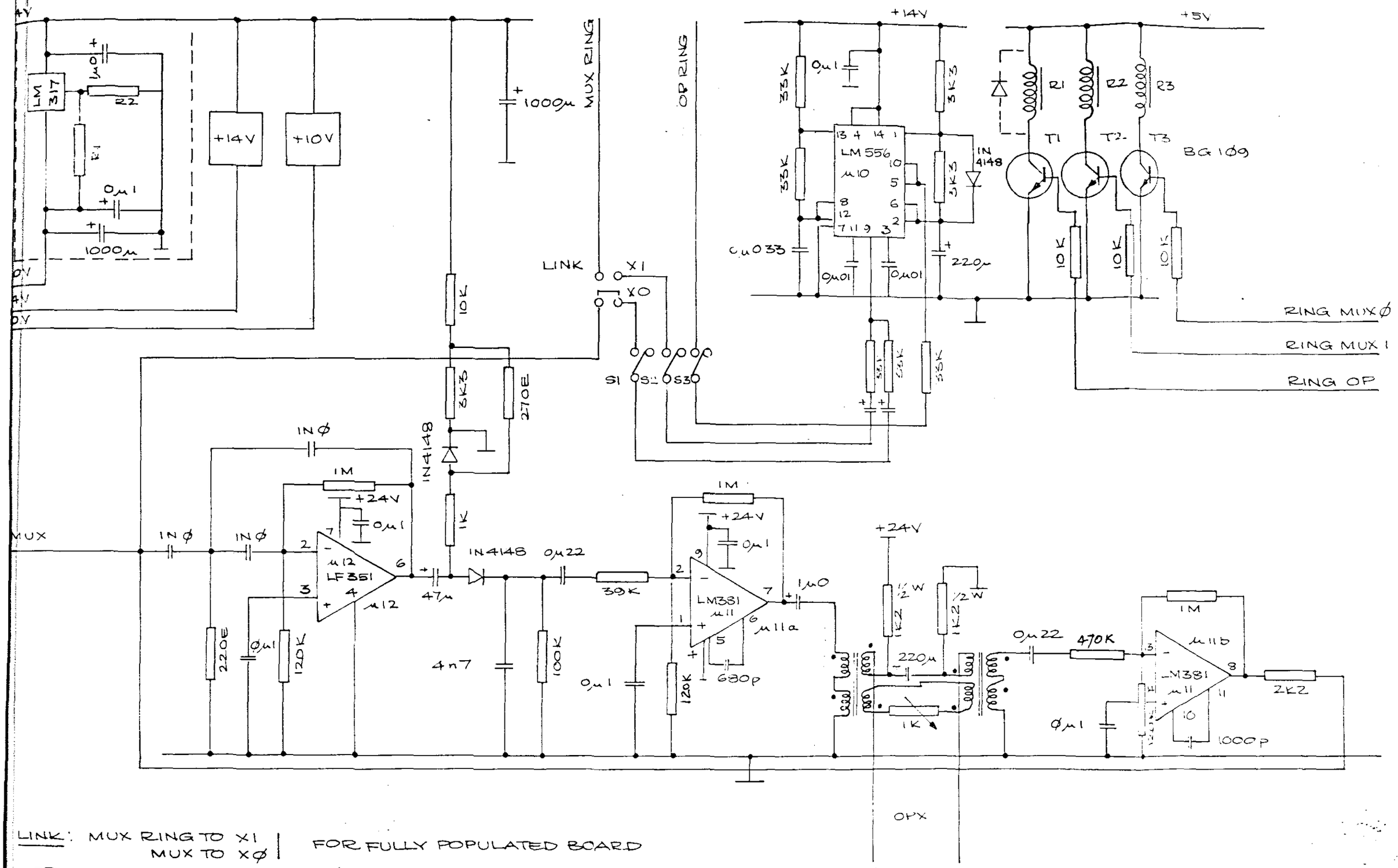
CS TO PSEL CS FOR OTHER BOARD

EMERGENCY TELEPHONE SYSTEM
TELEPHONE CONTROLLER (LOGIC CCTS.)

CITY OF CAPE TOWN ELECTRICITY DEPT	DRAWN	A.HALL	86·01·13	SCALE :- NTS	REV
D/O MANAGER	TRACED	A.HALL	86·01·14	SHT 1	
	INFO	A.v.T.		SK 3818Sh.1	
C.E.E D.C. PALSER					



Telephone Controller Board Component Layout



LINK: MUX RING TO X1
MUX TO XØ | FOR FULLY POPULATED BOARD

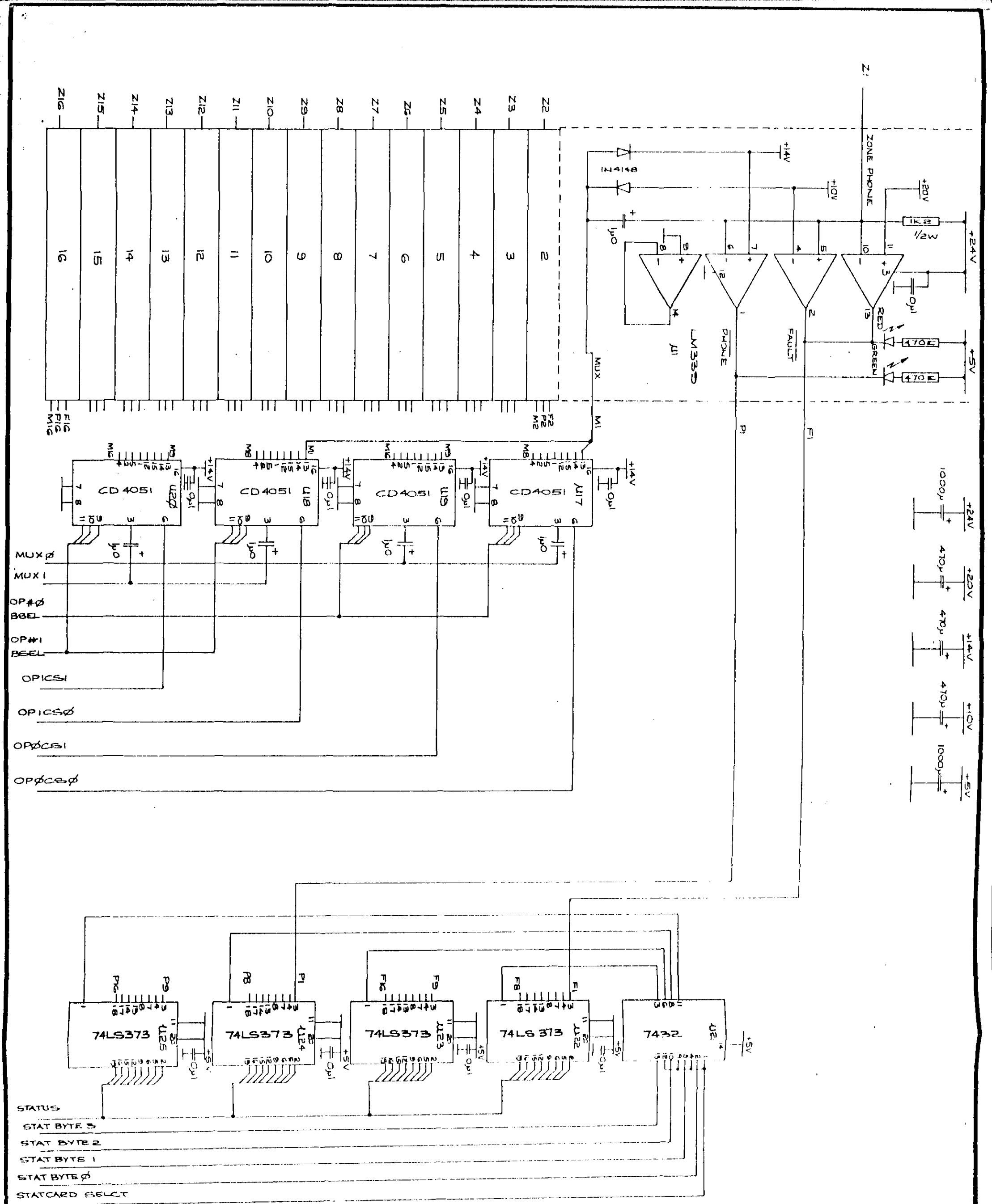
OR

MUX RING TO MUX

EMERGENCY TELEPHONE SYSTEM

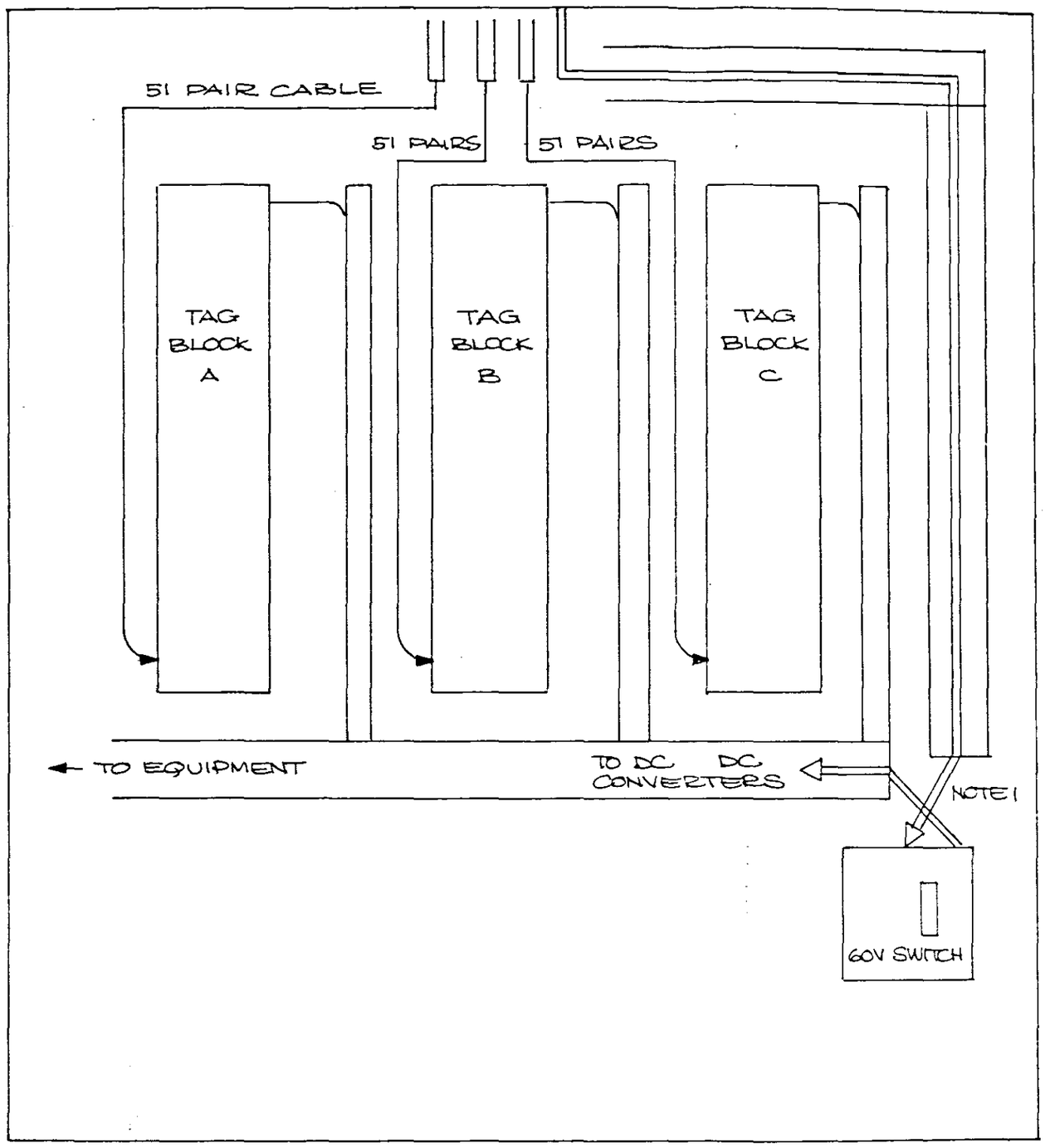
TELEPHONE CONTROLLER (ANALOGUE)

CITY OF CAPE TOWN ELECTRICITY DEPT	DRAWN	S.T.R.	86.01.14	SCALE	REV
D/O MANAGER: N. DE STADLER	INFO	A.Y.T.	86.01.14	~	
C.E.E: D.C. PALSER				SK 3818 Sh 2	



MUX MON BOARD.

CITY OF CAPE TOWN ELECTRICITY DEPT	DRAWN	A. HALL	86-01-14	SCALE - NTS	REV
D/O MANAGER	TRACED	A HALL	86-01-15	SHEET 3	
	INFO	A. VT		SK 3818	



TAG BLOCK A TO CONSOLE:
CARRIES MIMIC, OPERATOR TELEPHONE CONNECTIONS AND +5V & 0V FOR MIMIC

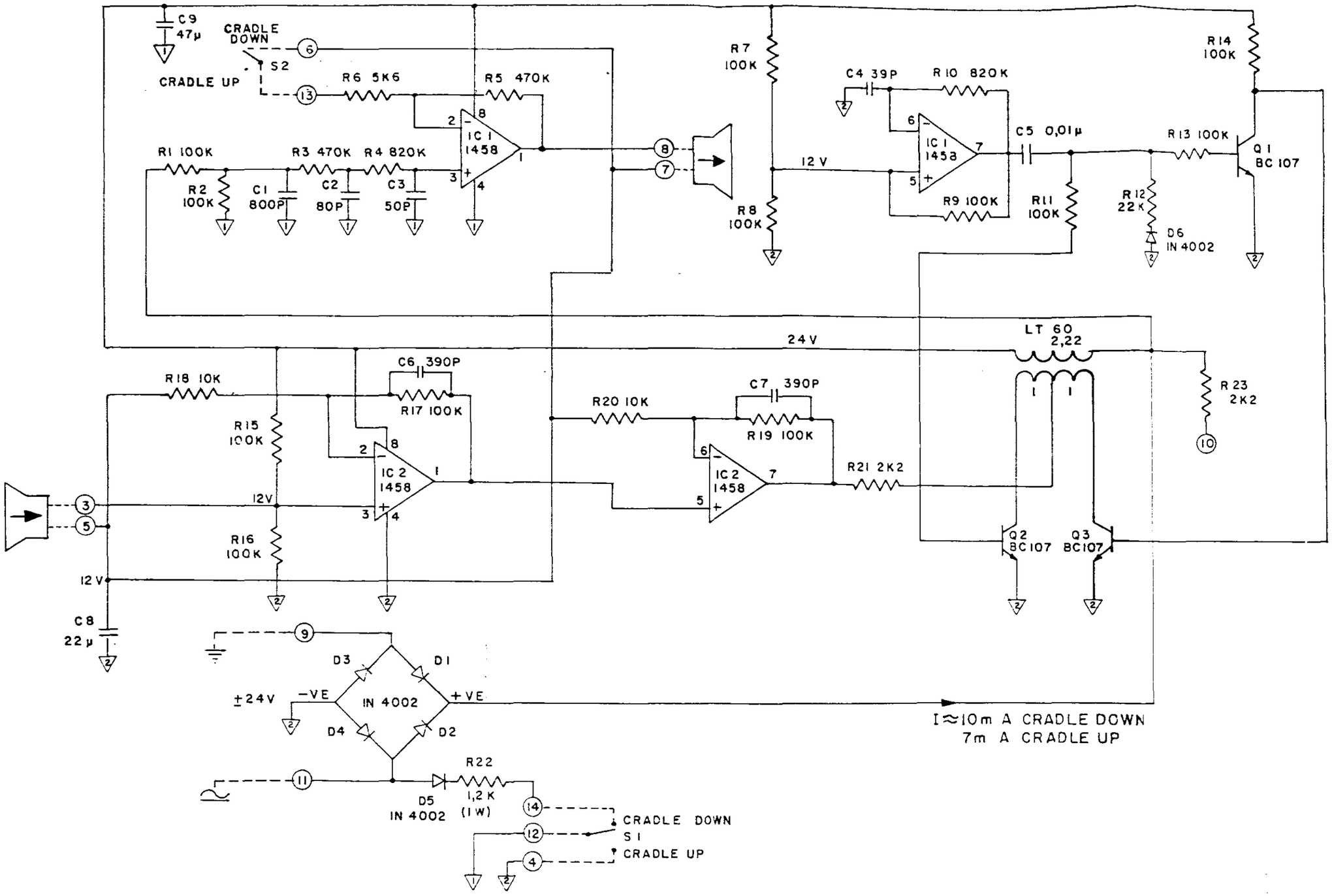
TAG BLOCK B TO DISTRIBUTION BOARD:
FOR ALL TELEPHONES TO ALL FLOORS OF MAIN & PODIUM TOWER BLOCKS.

TAG BLOCK C SPARE

NOTE 1: POWER CABLE TO PAX; 60V FUSE ON MC RACK 2 IN PABX

EMERGENCY TELEPHONE SYSTEM
CABINET TAG BLOCK INFORMATION

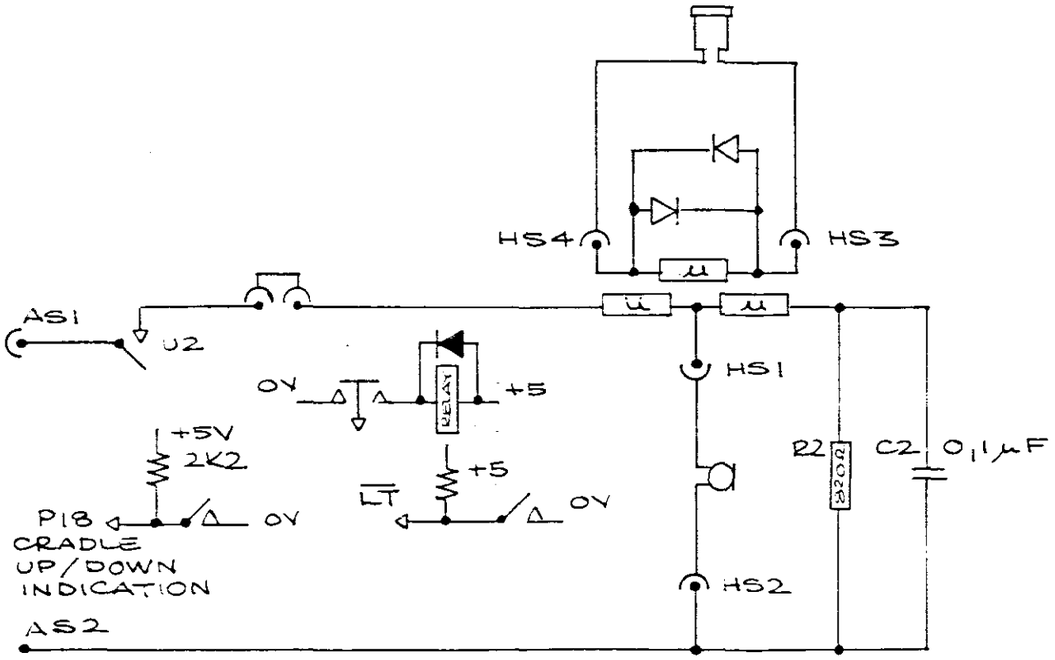
CITY OF CAPE TOWN ELECTRICITY DEPT.	DRAWN	S.T.R	86.02.19	SCALE	REV
D/O MANAGER: N. DE STADLER	INFO	C.S.	86 02 19	~	
C.E.E.: D.C. PALSER				SK 3818 Sh.5	

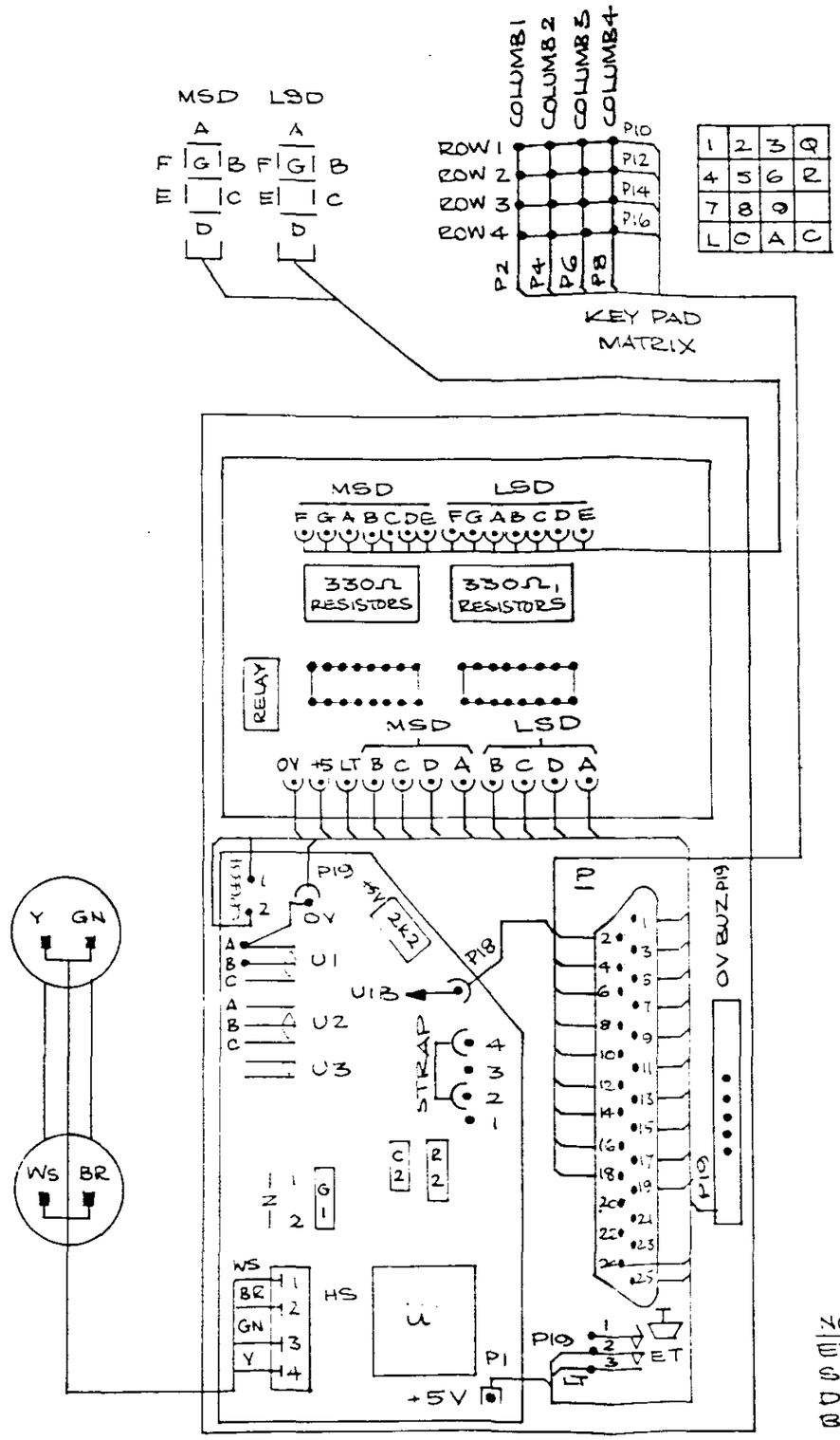


EMERGENCY TELEPHONE SYSTEM

ZONE TELEPHONE

CITY OF CAPE TOWN ELECTRICITY DEPT.	DRAWN	C. RIX	SCALE	REV
DRAWING OFFICE MANAGER M. G. Ridgard	TRACED	C. RIX	SHEET 7	
CEE DC PALSER	INFO	A. Van Tonder	SK 3818	
	CHECKED			



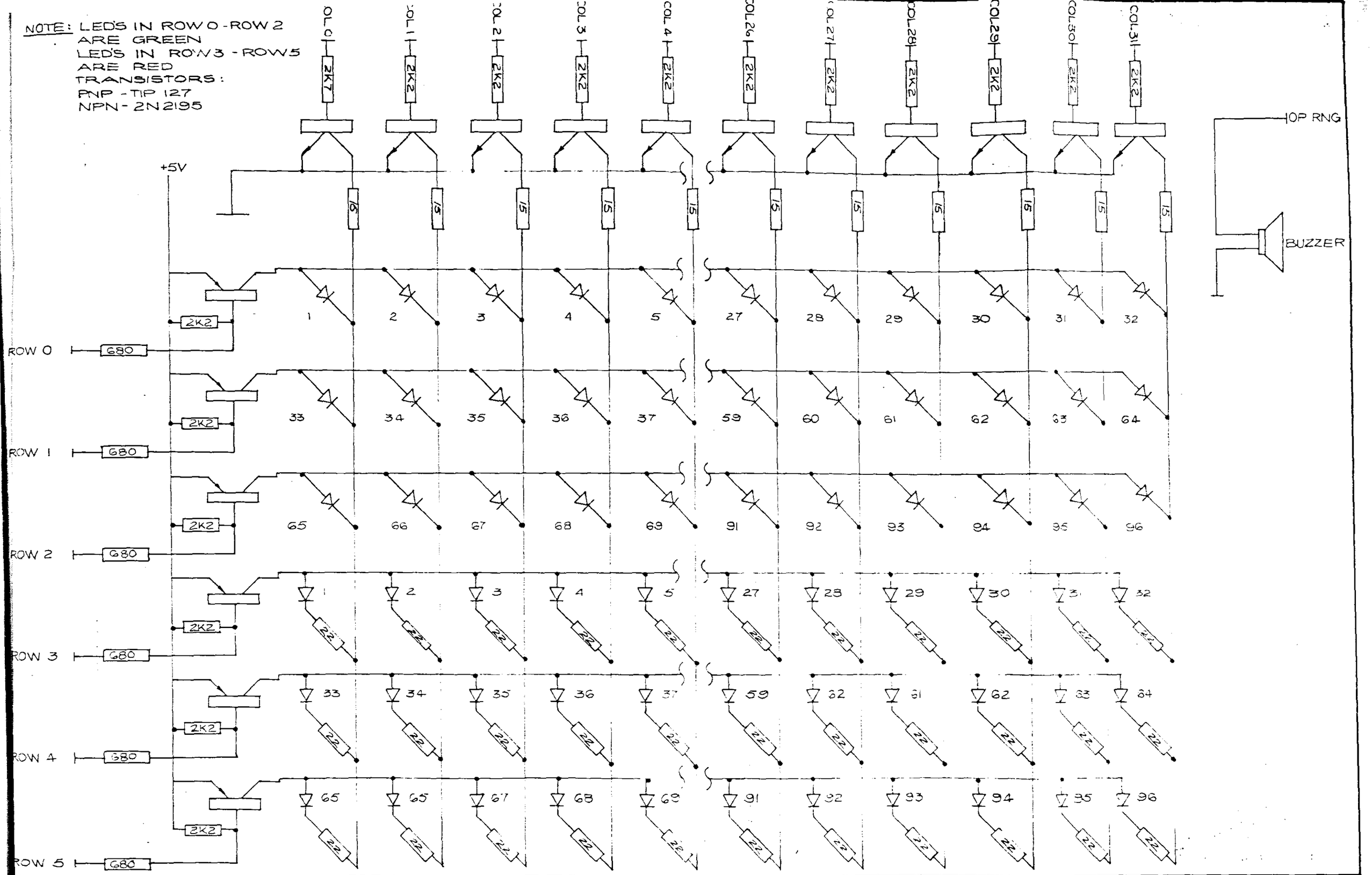


NOTE:
ET TO TEST
SEVEN SEGMENT
DISPLAY ONLY
BY OV TO $\overline{LT}$ PIN

EMERGENCY TELEPHONE SYSTEM
OPERATOR'S TELEPHONE

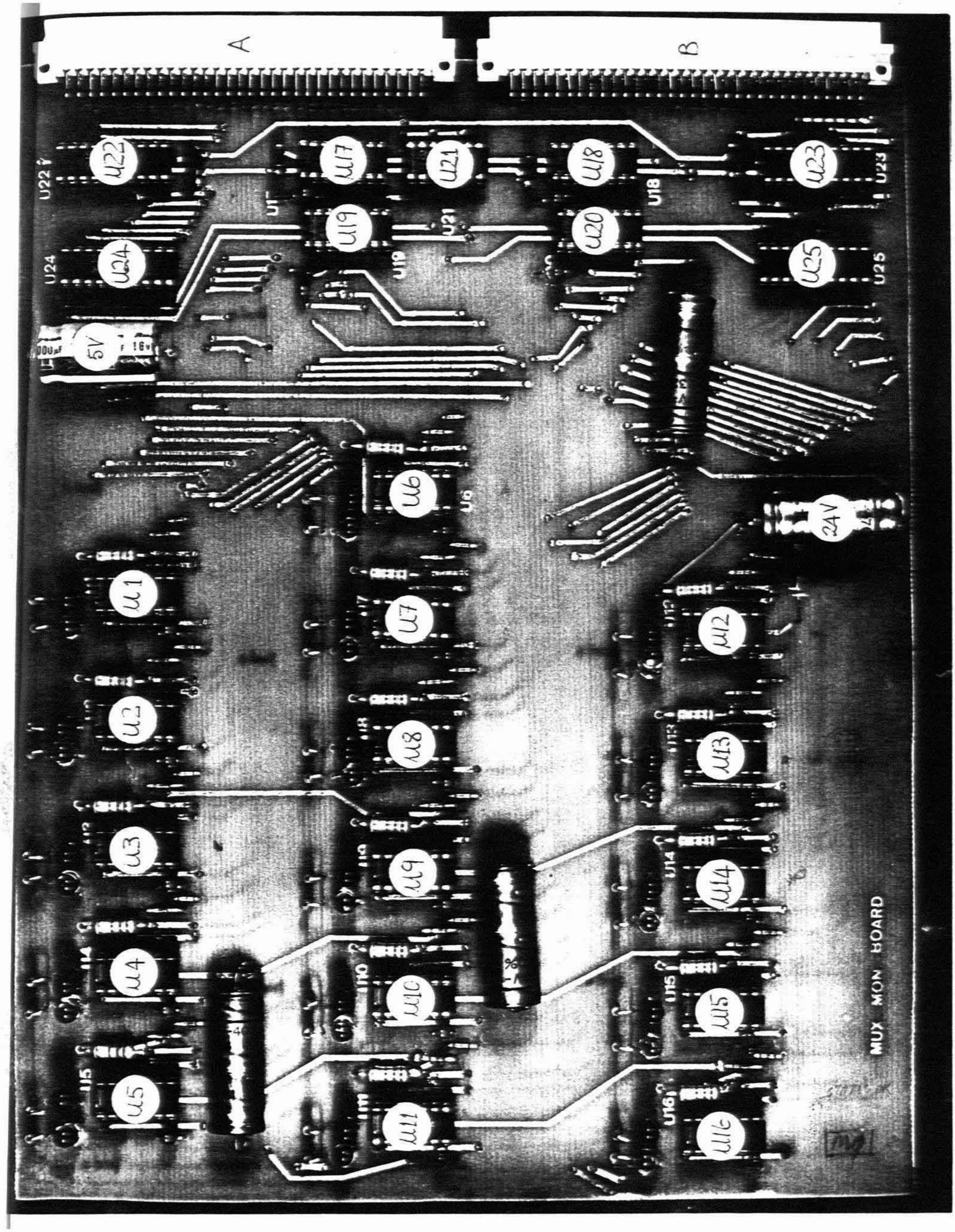
CITY OF CAPE TOWN ELECTRICITY DEPT	DRAWN	S.J.R	86 02 25	SCALE	REV
D/O MANAGER. N. DE STADLER	INFO	C.S.	86 02 25	~	
C.E.E: D.C. PALSER				SK 3818 Sh6	

NOTE: LED'S IN ROW 0 - ROW 2
ARE GREEN
LED'S IN ROW 3 - ROW 5
ARE RED
TRANSISTORS:
PNP - TIP 127
NPN - 2N2195



MIMIC

CITY OF CAPE TOWN ELECTRICITY DEPT	DRAWN	D.A.	860110	SCALE: N.T.S.	REV.
	TRACED			SHEET 4	
D/O MANAGER	INFO	A.v.T.		SK 3818	
C.E.E. D.C. PALSER	CHECKED				



Multiplexer Monitor Board Component Layout