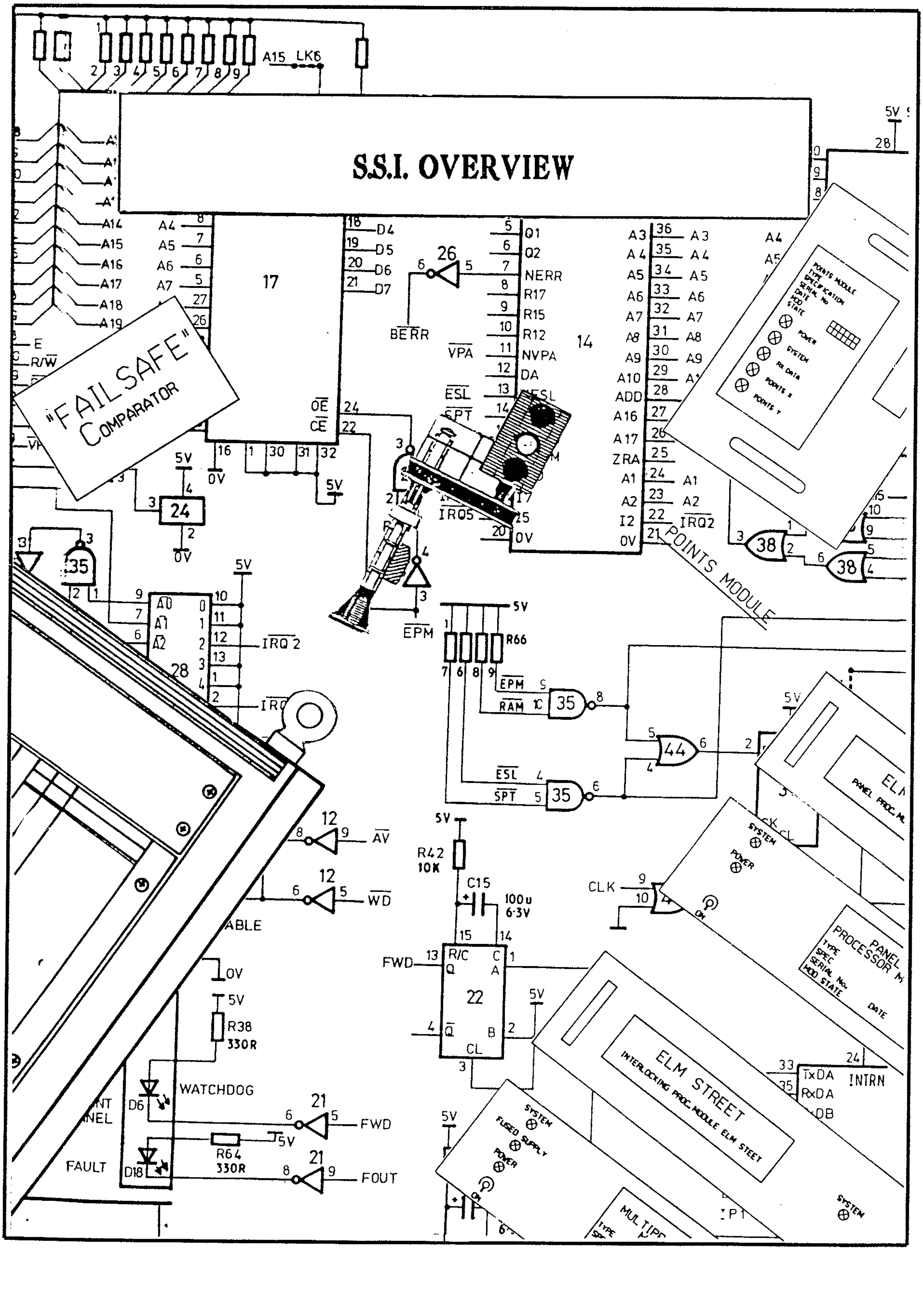
CENTRAL SERVICES
SIGNALLING PROJECTS GROUP

S.S.I. OVERVIEW



INTRODUCTION

WHAT IS SSI?

Solid State Interlocking (SSI) is a system which has been developed as a replacement for present day relay signalling with a microprocessor.

It is important to note at this stage, that the term SSI refers to"**the complete signalling system, from signal box panel (or VDU) to the tail cables running to the equipment on the ground".** Therefore, it can be said that SSI is not just an electronic replacement for the relay based interlockings we use presently, but a replacement for multi-core lineside cables.

BASIC SYSTEM DESIGN

The majority of railway signalling in use on British Rail today is relay based. This is due to the fact that designers can produce circuitry using relays that will remain safe under any failure condition ie , **"fail safe".** This is due to the highly predictable failure modes of relays we use today. The same cannot be said for the electronic devices we use in SSI. Therefore, to insure the safe operation of an electronic system a fresh approach was required, and is referred to as **"HARDWARE REDUNDANCY"**

HARDWARE REDUNDANCY PRINCIPLE

As we already know an SSI system employs microprocessors to carry out all the necessary functions. The basic principle behind Hardware Redundancy is the duplication of micro-processors associated with particular parts of the system (Figure 1). The same results (output) should be provided by each microprocessor working independently under normal circumstances. In addition to this, some means of comparing the outputs is required to ensure that they are in fact in agreement. In the event of a failure occurring in either of the microprocessors they would not reach an agreement, ie., their outputs would not coincide. The "fail-safe" comparator would detect a disagreement but as it cannot tell which micro-processor is providing a correct output, the system would then cause itself to shut down the disagreeing part of the system.

Due to the highly unlikely situation where both processors fail in the same way at the same time, and so maintaining an agreement, the safety element is provided.

This practice is adopted for the part of the SSI system which connects directly to external equipment, Track-side Functional Modules, where the effect of any fault would only cause localised interruption.

continued

MAJORITY VOTING

If the Hardware Redundancy System was adopted for the central interlocking, any disagreements between the two would result in a complete shutdown of the area controlled by the SSI system. This is obviously not desirable as it would lead to total disruption of the SSI signal boxes' control area. So another method had to be found.

PRINCIPLES OF MAJORITY VOTING

The method used to overcome the problem highlighted previously is the triplication of the interlocking microprocessors (Figure 2). Again comparing outputs if a failure occurred in one of the three interlockings its output would not coincide with the other two. The failed microprocessor would then be voted out by the other two microprocessor's agreement. This then causes the failed microprocessor to shut itself down. The interlocking will then continue to run providing the two remaining interlockings remain in agreement. During this time relevant action can be taken to restore the interlocking to its normal operational state. If the two remaining interlockings were to disagree the interlocking would shut down.

PRACTICAL APPROACH TO MAJORITY VOTING

The arrangement in Figure 2 for the majority voting system suggests the use of an inherently safe voting circuit which would point towards the use of safety relays. This is clearly not an ideal solution as we are trying to remove costly relays from the system. In practice the system is arranged so that all three interlockings compare their own outputs with the other two interlockings (Figure 3).

In the event of a disagreement, the processor which does not agree with the other two can blow an internal "security" fuse, disconnecting itself permanently from the system. Should the faulty microprocessor module be unable to blow its own fuse the other two can jointly blow the fuse of the faulty multiprocessor Module.

BASIC STRUCTURE OF SSI CONTROLLED SCHEME

This basic structure of an SSI controlled scheme is shown in Figure 4 and will consist of :-

1) An operating panel - Standard entrance/exit or VDU which will contain a panel multiplexer.

2) One or more microprocessor controlled central interlockings. The number being dependent on the size and complexity of the scheme.

3) Technicians Terminal providing fault diagrams, event logging and certain control facilities.

4) A duplicated internal data link to provide communication between interlockings where more than one is required.

continued

5) A duplicated external data-link between each interlocking and each of its locations.

6) A number of trackside modules (TFM's):

   a). Points module
   b). Signal module
   c). Data link module (DLM)

THE OPERATING PANEL

There are basically two different mediums that the signalman can use to regulate the trains,

1) Standard Entrance-Exit panel and,

2) V.D.U. with roller ball

The standard unit that will be connected to the entrance exit panel is the Panel Processor Module (P.P.M.). The central interlocking would go straight to a VDU and also to the Train Desribers etc. The purpose of the PPM of which there are two in each system (if a standard panel is used), is to relieve the interlocking modules of the non-vital task of servicing the signalmans panel.

THE MICROPROCESSORS

These are the controlling element of the central interlocking and are known as the multi-processor modules (M.P.M.'s). Each of these three modules are designed to carry out the safe execution of the interlocking process and, therefore, to issue the correct instructions to the lineside equipment. They also control the management of the majority voting, of which they all form a part.

Another one of these modules is used to monitor the flow of data from the interlocking to site and to communicate with the technicians terminal.

TECHNICIANS TERMINAL

The main reason for the provision of a technicians terminal is as a diagnostic aid to fault finding and should be considered an essential part of the SSI system. Its function is to listen to and interrupt the various messages from all around the system and thus replaces the job of "tracing a fault".

Another job the technicians terminal can do is to place "a block" on an item of equipment ie. stop the movement of a set of points, but not only can you stop them , you can make them move. You can also drop and pick track circuits, but obviously this has to be done under the correct circumstances.

continued

When the technician does anything with the terminal or there is a fault a hard copy is printed out. The most useful function the technicians terminal performs though, is its connection to the magnetic tape recorder. This keeps a log of all changes in the system including signalling inputs, panel requests, faults and control alterations from the keyboard.

This can then be used if an accident occurs in the signalbox's area, because it can be played back to tell you what people and equipment were doing before the incident.

THE EXTERNAL DATA LINK

The track side data link cable's consist of two screened twisted pair cables (usually red and blue cores), which are run in separate cable routes to avoid both cables being cut or damaged in any way at the same time. The cables carry the same information from interlocking to equipment, so maintenance work could be carried out on link "A" while link "B" is continuing to carrying the information.

TRACKSIDE FUNCTIONAL MODULES

The S.S.I. system controls the equipment on the trackside by means of Track-side Functional Modules (T.F.M's), of which two types are presently available, the Point module and the Signal module. These two modules are then connected to the S.S.I. system via Data Link Modules (D.L.M's).

DATA LINK MODULE (D.L.M.)

The D.L.M. connects the interlocking and the T.F.M's to the the data link. As we already know we run two data link cables so we must therefore have two D.L.M.'s wherever we have any T.F.M.'s. Data link modules are found at the central interlocking and the trackside apparatus cases. Each D.L.M. has six outputs and because of this can only interface to six T.F.M.'s. A neon lamp indicates a 110v power supply to the module. (Figure 6.)

POINTS MODULE

This module is designed to drive clamp lock points directly from the module without the need for relays. Although other types of point machine can be controlled via a relay interface. Up to four point ends can be controlled by one module, but a maximum of two point control numbers can only be allocated to each module. ie.

Two x Double Ended
One x Double Ended + One x Single Ended
or Two x Single Ended

The points module also has the provision for point detection plus other signalling functions.

continued

The points module contains five indication lamps (Figure 6):

Power - Module Energised
System - Module Operational (security fuse intact)
Rx data - Own Data Recieved
Points X - Module Outputs Operational
Points Y - Module outputs Operational

SIGNAL MODULE

The signal module is designed to directly feed colour light signals and is sufficiently durable to cope with all other signalling functions other than points. The module has four indications similar to those in the Points module but only one output lamp is required to monitor the state of the module outputs. (Figure 6).

DESIGN OF AN S.S.I.SCHEME

An S.S.I. uses a microprocessor as its central interlocking , but the question is, how does the interlocking know what it can allow the signalman to do **SAFELY**. The answer to this question is a computer program or "data"

Below is a section of data:

if S11 set stick , TACc , TADc, TAEc , TAFc , TAGc ,
P103 cdn , P105 cdn , S17 set lp\

At first glance it looks an incoherent jumble of letters and numbers but if we look at it logically it may not be as difficult as it first appeared.

The section of data mentioned previously tells the interlocking what controls it needs to set a route. But what controls do we need ?

For this we can refer to the document called " **Regulations for Train Signalling by the Track Circuit Block System** " **(BR30062/1)** which says

> **"Track Circuit Block signalling permits a signal to exhibit a Proceed aspect when all track circuits in the line ahead are clear up to and including the overlap beyond the next stop signal and all necessary points within that distance are set in the proper position for the safe passage of the train".**

Now look at Figure 7 and we will consider the data more closely.

To do this we will look at each piece of data highlighted in bold as follows with **S11**:-

if **S11** set stick,TACc, TADc, TAEc,TAFc,TAGc,P103cdn,P105cdn,
S17 set lp\

continued

S11 - simply stands for signal 11

> if S11 **set stick**, TACc, TADc, TAEc, TAFc, TAGc,
> P103cdn, P105cdn, S17 set lp\

set stick - is the GR/GSR as previously explained in the module called "FREE WIRED INTERLOCKING (A Simple Route)"

> if S11 set stick,**TACc, TADc, TAEc, TAFc, TAGc,**
> P103cdn, P105cdn, S17 set lp\

TACc, TADc, TAEc, TAFc, TAGc, - checks that TAC to TAG are unoccupied/clear

> if S11 set stick, TACc, TADc, TAEc, TAFc, TAGc,
> **P103cdn, P105cdn**, S17 set lp\

P103cdn - 103 points are locked and detected in the required position which in this case is the normal position.

> if S11 set stick, TACc, TADc, TAEc, TAFc, TAGc,
> P103cdn, P105cdn,**S17 set lp**\

S17 set lp - makes sure signal 17 has a lamp alight

So there is what might be called to some, a "**SIMPLE**" piece of data but beware in the "real world" it is not all as easy as is shown here.

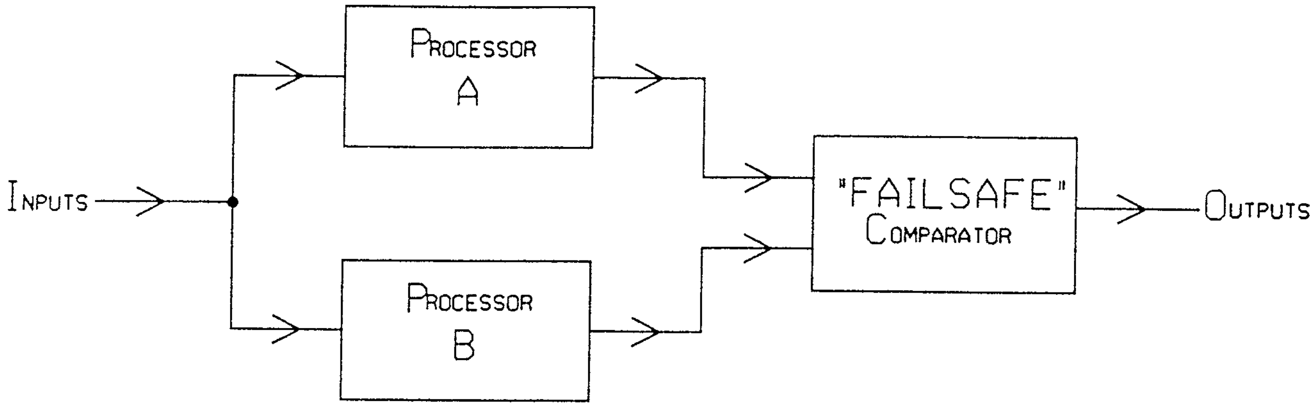
As the title suggests this unit is only a brief overview of SSI.

For more information see :-

Railway Control Systems by I.R.S.E. Published A&C Black.
SSI Green Booklet No.29. Published by I.R.S.E.
SSI Appreciation Course , Railway Engineering School, Derby.

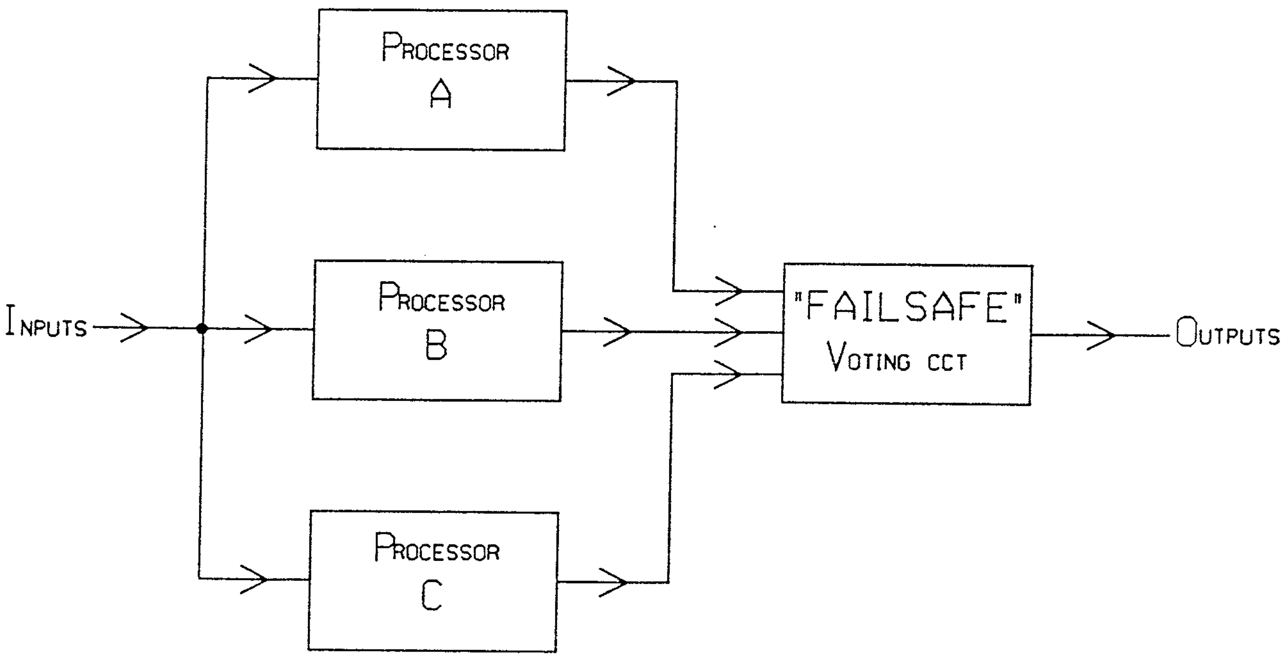
continued

SSI OVERVIEW



Basic Principle of Safety By Duplication

FIGURE 1



Basic Principle of Triplicated System

Employing Majority Voting

FIGURE 2

continued

SSI OVERVIEW

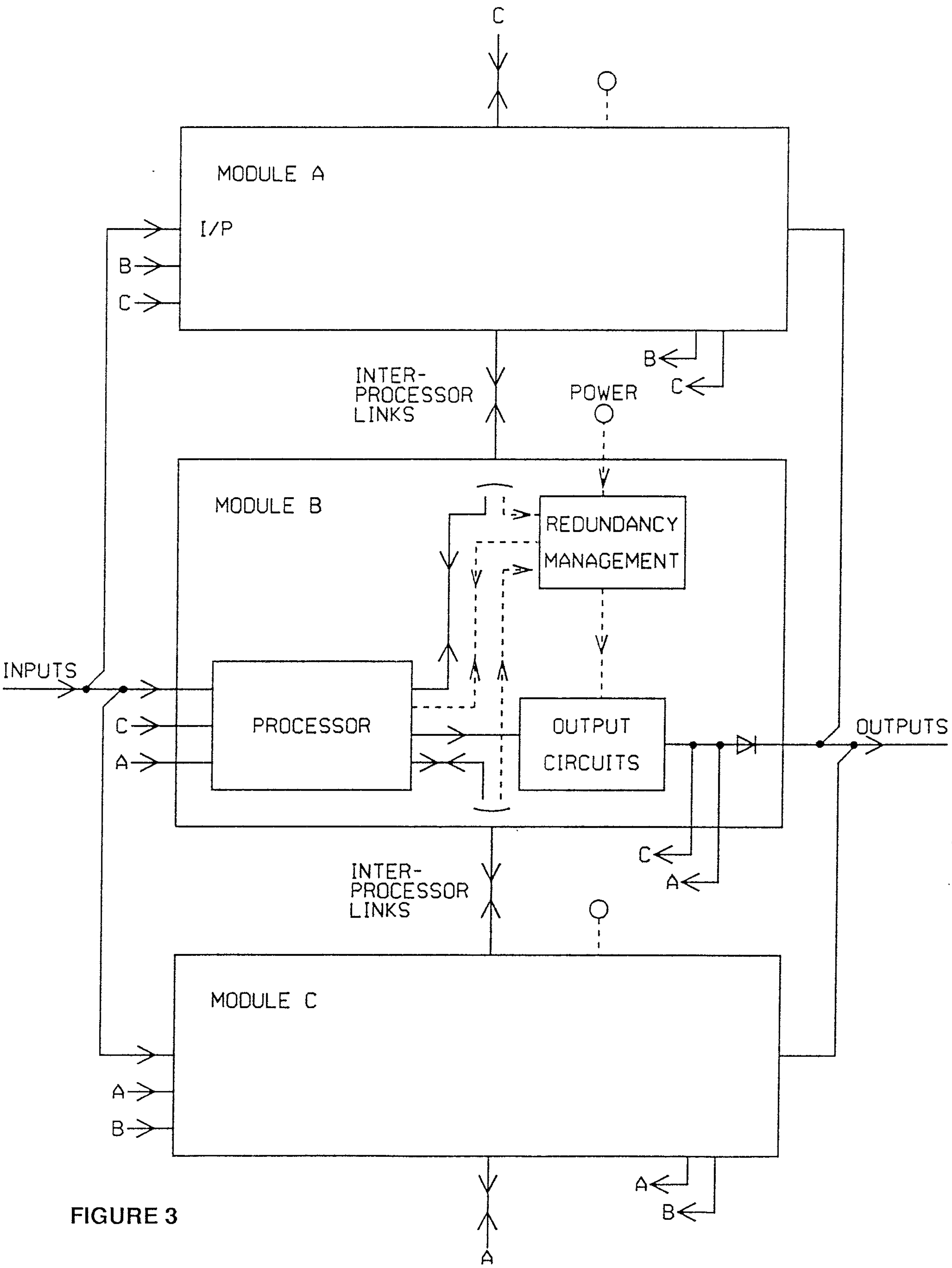


FIGURE 3

TRIPLICATED MAJORITY VOTING -PRACTICAL SYSTEM

continued

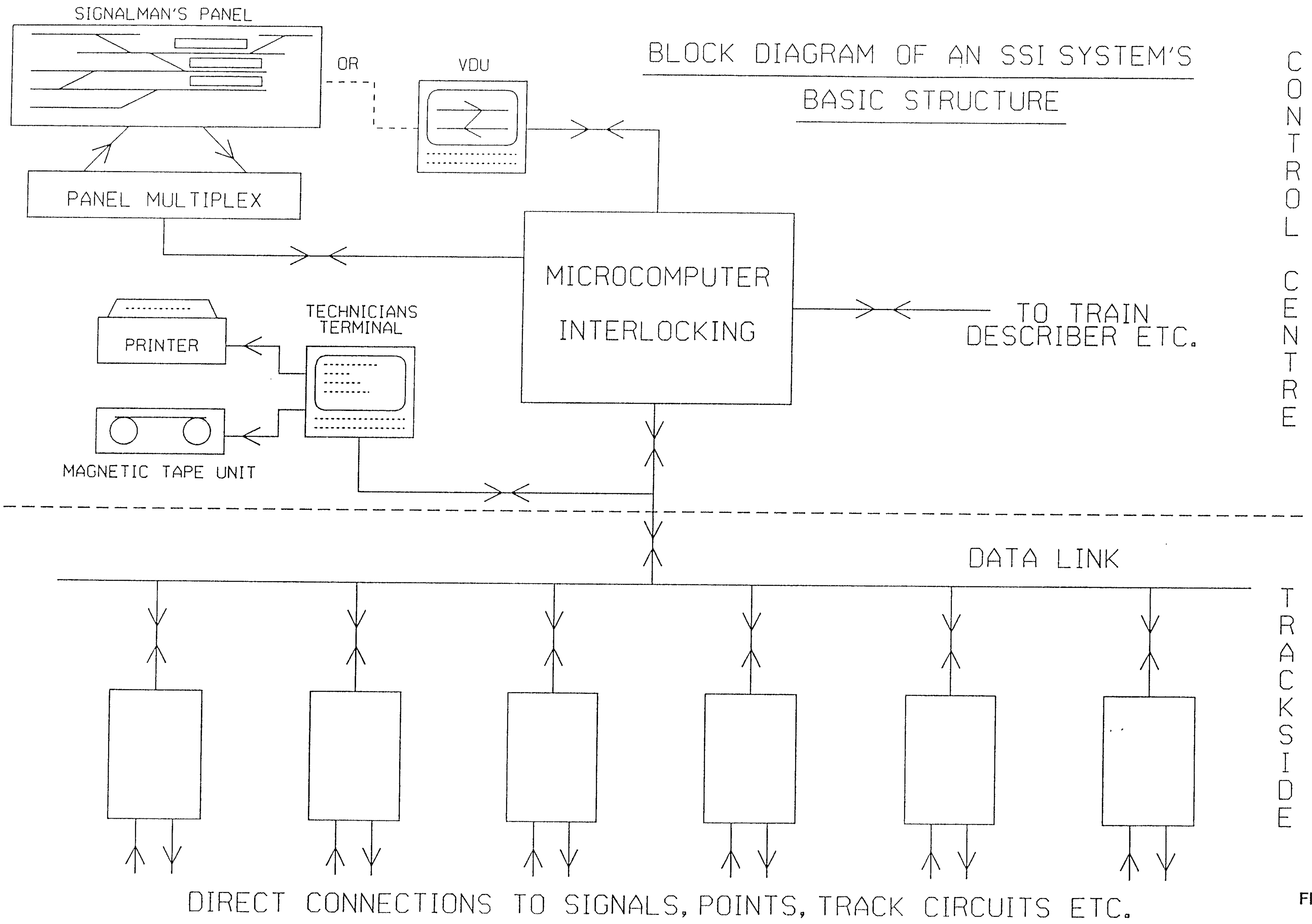
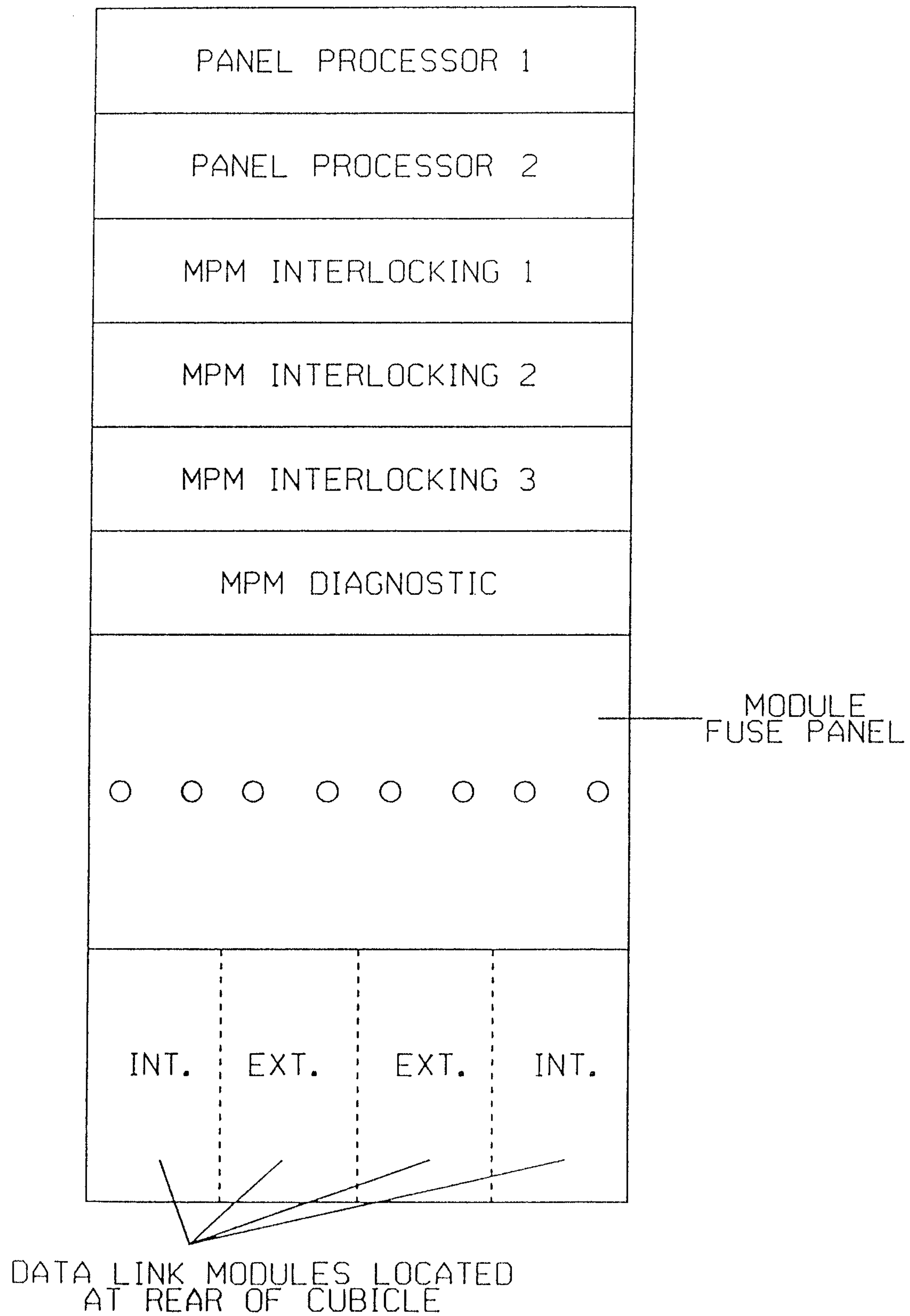


FIGURE 4

continued

SSI OVERVIEW



CENTRAL INTERLOCKING CUBICLE

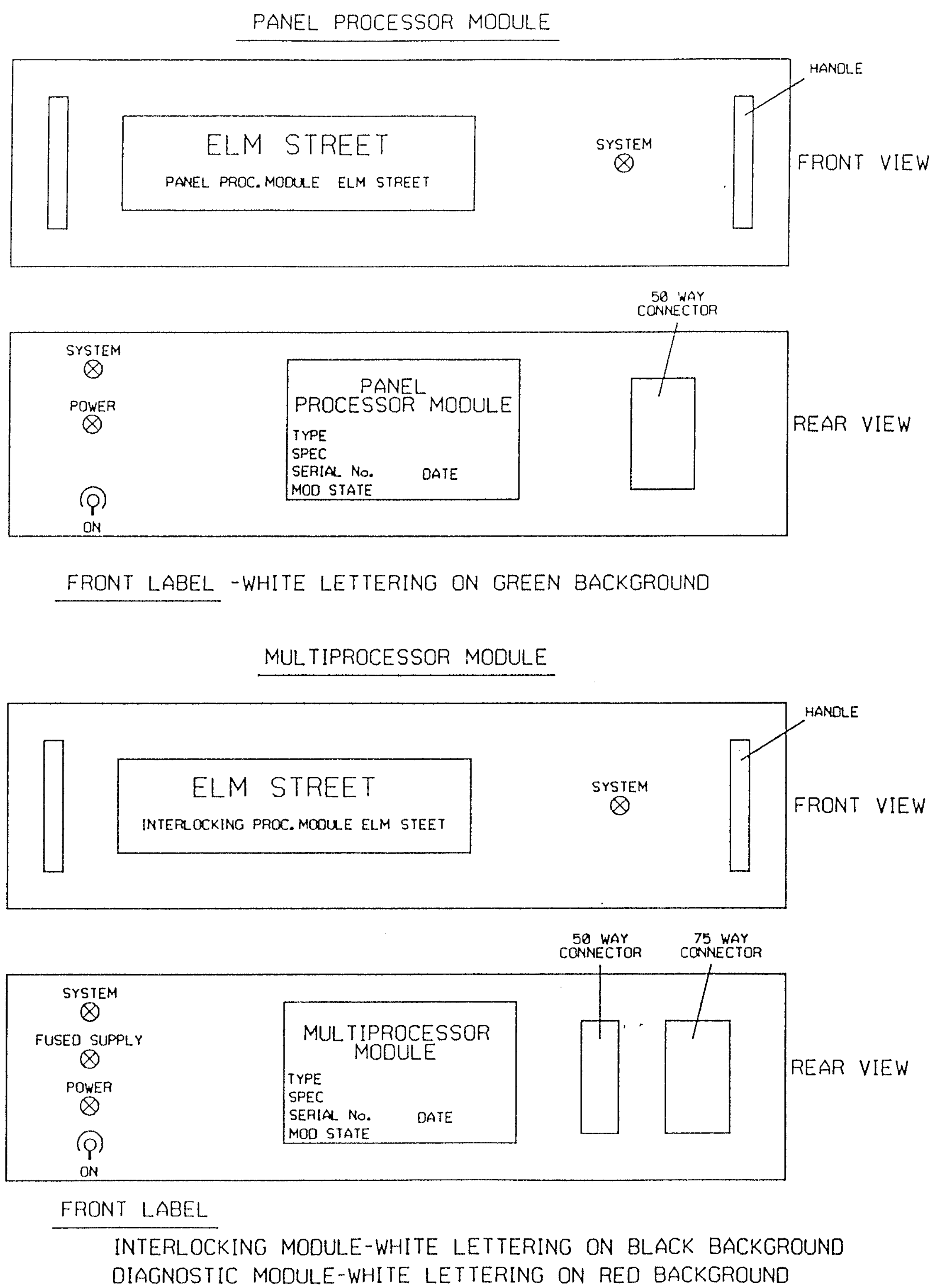


FIGURE 5

continued

SSI OVERVIEW

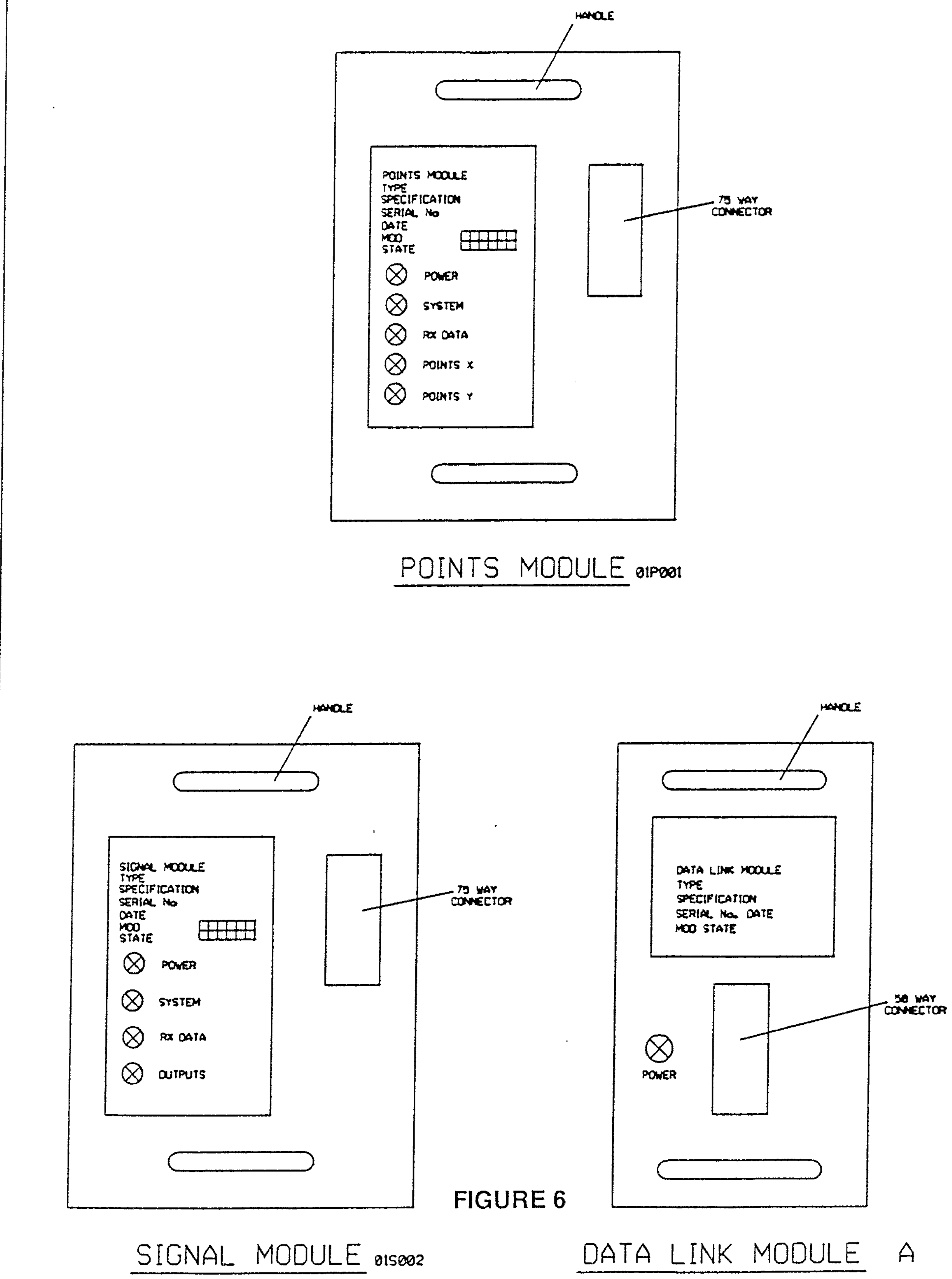
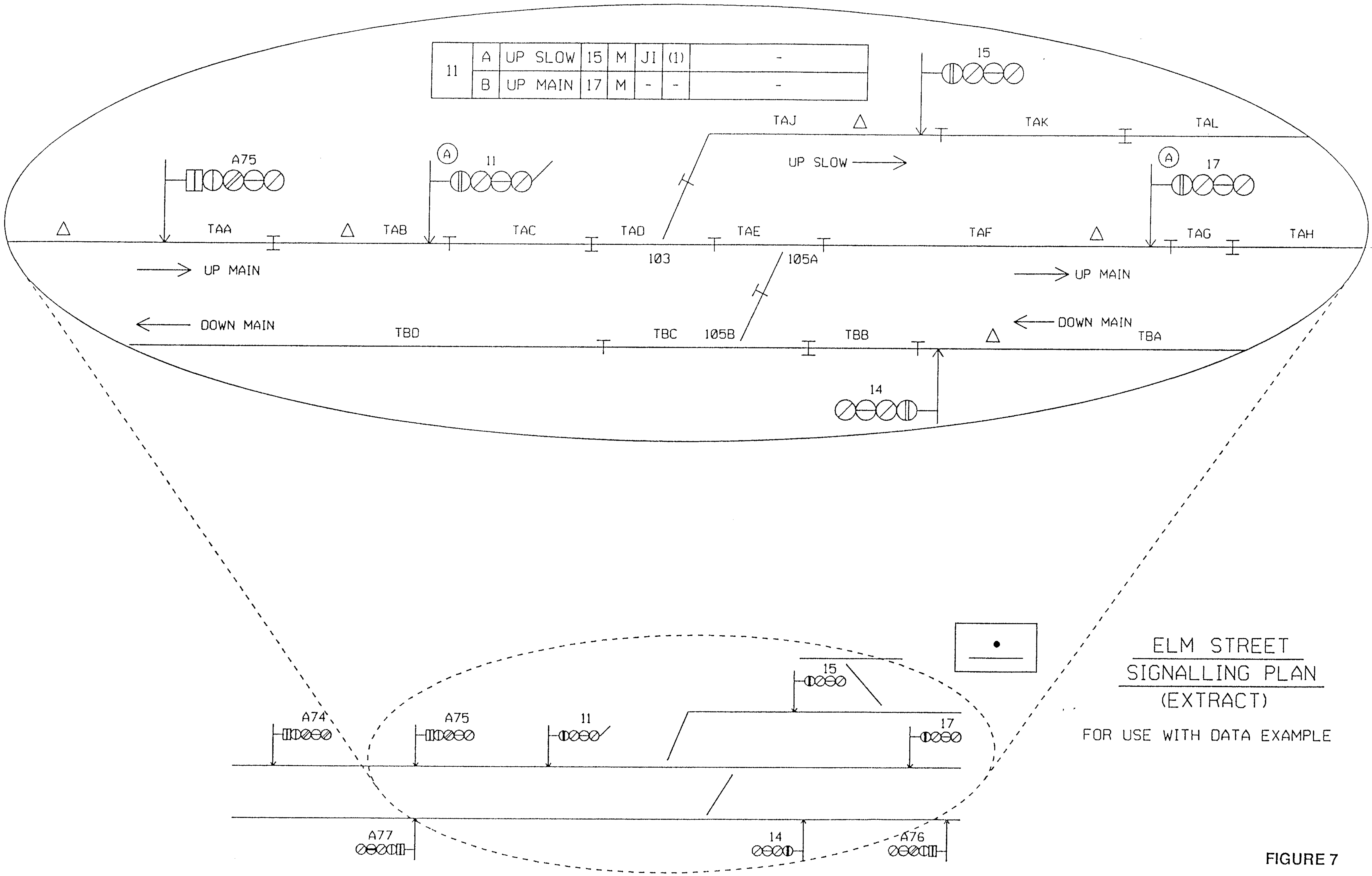


FIGURE 6

continued



ELM STREET
SIGNALLING PLAN
(EXTRACT)

FOR USE WITH DATA EXAMPLE

FIGURE 7

end