THE

Institution of Railway Signal Engineers

INCORPORATED 1912

FOR THE

Advancement of the Science of Railway Signalling

Proceedings 1986/87

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Contents

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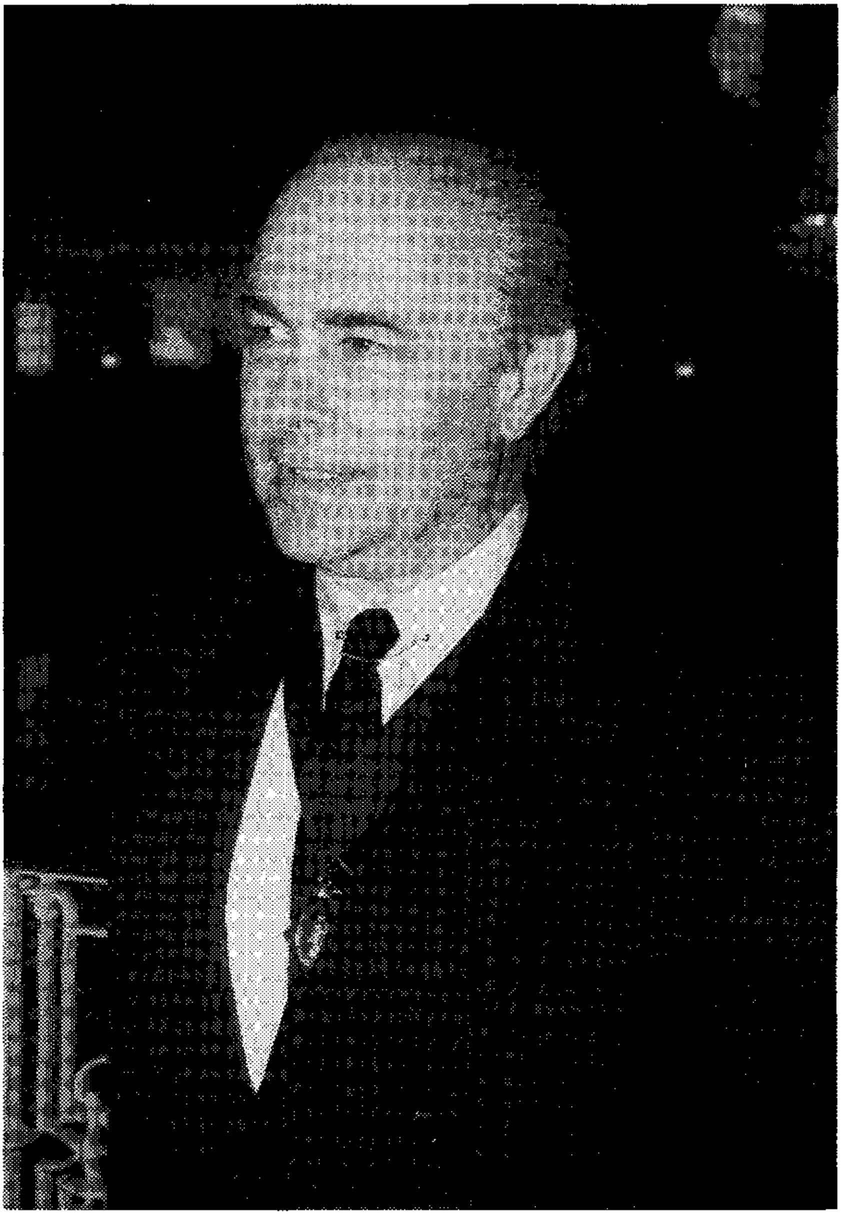

JÜRG GUSTAV OEHLER, Dipl. Ing. E.T.H., S.I.A., F.I.R.S.E.

JÜRG GUSTAV OEHLER, Dipl. Ing. E.T.H., S.I.A., F.I.R.S.E.

Jurg Gustav Oehler was born in Zurich in 1935, and received his education at the Federal Institute of Technology (ETH) in Zurich and was awarded his Diploma in Electrical Engineering in 1959. After a period as an Assistant Engineer with the Minneapoli's Honeywell Corporation, Datamatic Division in Newton, Mass., he joined the Integra Company in Wallisellen, Zurich in 1962 as a Project Engineer. In 1971 he was appointed Director and Member of the Board and became President of the Company in 1978. Jurg Oehler's management training was essentially gained in the Swiss Army where as is the custom in Switzerland he is still active in the rank of Colonel on the General Staff.

He joined the Institution in 1969 and was elected to the Council in 1979.

THE

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SESSION 1986/87

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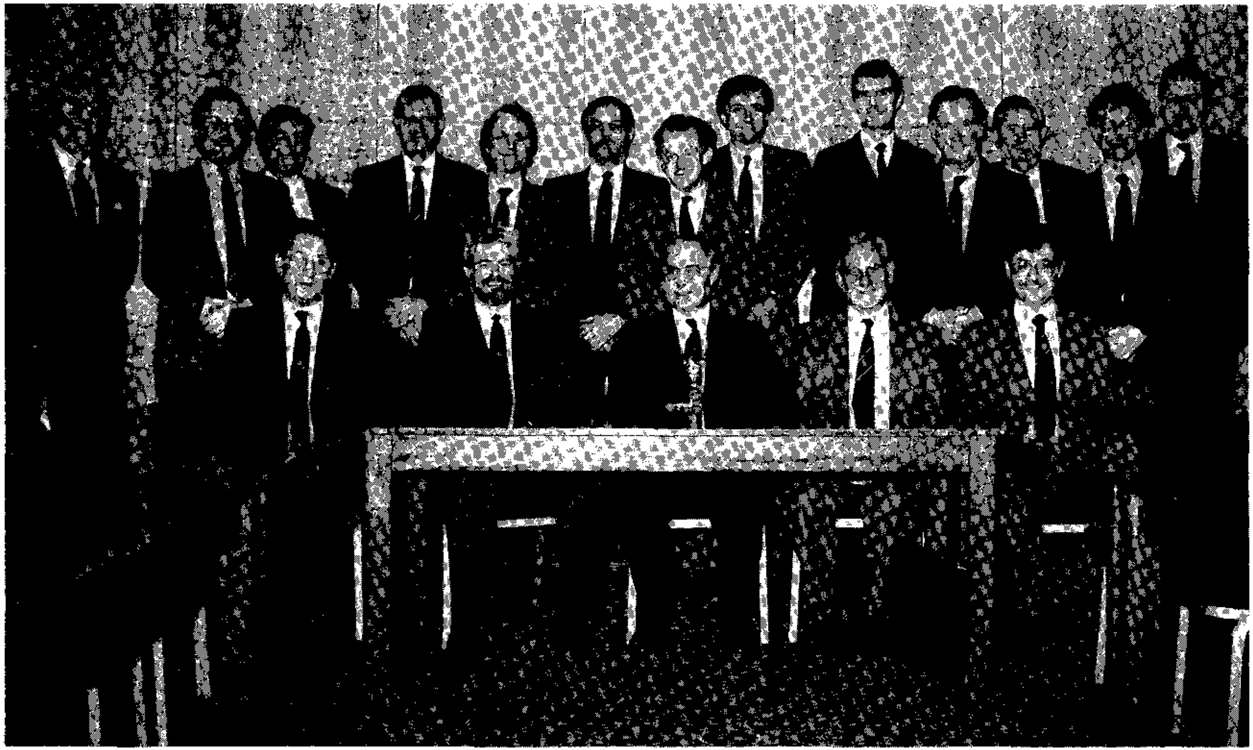

Standing, left to right: Messrs. D. M. Robertson, A. P. Harvey, F. G. Rayers, J. Catrain, M. G. Hewlett, W. G. Boddy, D. J. Wittamore, R. L. Wilkinson, C. A. Porter, D. J. Norton, N. S. Hurford, D. A. Edney, F. P. Wiltshire.

Seated, left to right: Messrs. R. L. Weedon, C. Hale, J. G. Oehler, T. S. Howard, C. H. Porter.

Institution Announcements

(The prices and subscription rates and other information given in these announcements are current at the date of publication - December 1989)

CHANGE OF ADDRESS

Considerable inconvenience is created by members failing to notify changes of address. Will members please inform the General Secretary immediately of any such alteration and so ensure prompt delivery to themselves of notices, etc.

THORROWGOOD SCHOLARSHIP

The Institution's Thorrowgood Scholarship is awarded annually, normally to the Student Member considered by the Council to have attained that highest commendation in the Institution's Examination, the Award being regarded as a prize for his achievment. The Award takes the form of assistance in the study of signalling installations either in the United Kingdom or abroad, under the sponsorship of the Institution.

TRANSFER TO HIGHER CLASS OF MEMBERSHIP

Members sometimes remain in one class of membership when their professional standing has become such as to entitle them to transfer to a higher one. The Council invites any such person to make application for transfer, for which purpose a form can be obtained from the General Secretary, and so take a position in the Institution consonant with his attainments and responsibilities.

TECHNICAL PAPERS

The Council invites members of all classes to submit papers for presentation at technical meetings in London or at Provincial meetings in the United Kingdom.

Papers should consist of between four thousand and six thousand words and while no limit is placed on the number of illustrations an author uses during his reading of his paper, the number printed as a part of the advance copy and published in the Journal of Proceedings must not exceed twelve.

The General Secretary will be pleased to provide full particulars upon application.

ADVANCE COPIES OF TECHNICAL PAPERS

Advance copies of papers will be available from 7 to 10 days before a meeting by application, including a stamped addressed foolscap envelope, to the General Secretary. Alternatively, members can register for the dispatch to them of each Advance Copy as it is issued. The fee for registration is £3.50 paid preferably with the Annual Subscription and will ensure the supply of Advance Copies for the calendar year, January to December.

SUBSCRIPTIONS AND REMITTANCES

The annual subscription rates are: Fellows, £27.00; Associates, £27.00; Members, £19.00; Technician Engineers, £15.00; Graduates, £14.00; Students (25 and over), £14.00; Students (under 25), £9.00; Technicians, £9.00.

Members are reminded that in accordance with the Articles of Association subscriptions are payable on election or on January 1st each year and should in any case be paid before June 30th. The Treasurer is obliged to send out notices of arrear to members who have not paid by that date.

The payment of subscriptions is facilitated by the use of a Banker's Order. The Treasurer will be pleased to supply forms for this purpose upon application. The use of these orders is of considerable assistance in easing the workload of the Treasurer.

All monies should be sent to the Treasurer, 16 Milebush, Leighton Buzzard, Beds. LU7 7UB.

Monies sent to the General Secretary will be dealt with, but it is possible that acknowledgements may be delayed in consequence.

All cheques and money orders, especially those from overseas, should be crossed, as the Post Office staff have instructions not to divulge the name of the remitter of the money order unless this is done. Transmission of the sender's receipt is in these circumstances rendered difficult if not impossible.

The attention of members is directed to the clauses in the Articles of Association under which neither notices nor copies of Proceedings may be sent to those who are in arrears with their subscriptions beyond a certain time.

Income Tax—the annual subscription to the Institution of Railway Signal Engineers is treated as an allowable expense under Section 16 Finance Act 1958 and should be included in your Tax Return in the section headed "Expenses in Employment — Fees or subscriptions to professional bodies".

Members of the Institution who have retired from business by reason of age or ill-health, and who have paid at least ten consecutive years annual subscriptions, may retain their membership of the Institution at half the rate of annual subscription applicable to their class of membership.

LIBRARY

The Institution Library is incorporated with the Library of the Institution of Electrical Engineers, by kindness of the Council of the latter body. It is situated at the Institution of Electrical Engineers building at Savoy Place, Victoria Embankment, W.C.2. Members of the Institution of Railway Signal Engineers have been granted the same privileges with respect to it as those enjoyed by members of the Institution of Electrical Engineers, and the entire collection is open to them on equal terms.

The Reference Library, which contains a Reading Room in which a great number of technical periodicals are always available, as well as a large general collection, is open as follows:

Monday to Friday, 9.30 a.m. to 5.30 p.m.; Tuesdays and Thursdays (from 1st October to 31st May), 9.30 a.m. to 7.30 p.m.

Any member of the Institution of Railway Signal Engineers entering the Library must sign his name in the book provided for that purpose.

The use of the Lending Library, which is open during the same hours as the Reference Library and which contains the principal works relating to electrical engineering, its applications, and allied subjects including, of course, railway signalling, is governed by the following rules, which must be strictly adhered to:

When applying for a book by post a member of the Institution of Railway Signal Engineers must state his class of membership. All communications should be addressed to the Secretary, Institution of Electrical Engineers, at the address already given.

Anyone desirous of making a presentation to the collection should forward it to the same address, when its receipt will be suitably acknowledged.

INSTITUTION TIE

An Institution tie bearing a single motif of the Institution crest in silver on green, wine or navy backgrounds is available from the General Secretary, price £3.50.

TEXT BOOK

A Railway Signalling Text Book is available from the General Secretary, price £15.00, inclusive of postage.

This book is a well-produced volume of 312 pages covering most aspects of British Railways signalling practice.

TECHNICAL BOOKLETS

Of the technical booklets published some years ago, the following are still available at reduced prices. Details may be obtained from the General Secretary:-

No. 3 — Mechanical and Electrical Interlocking (£1.90).
No. 6 — Signalling Relays (£2.15).
No. 7 — Typical Signal Control Circuits (1.70).
No. 10 — Mechanical Signalling (1.55).
No. 18 — Principles of Relay Interlocking and Control Panels (1.95).
No. 27 — Signalling the Layout (2.15).
No. 28 — Route Control Systems (L.T. Practice) (2.15).
No. 29 — Solid State Interlocking (2.50).

I.E.E. PERIODICALS AT REDUCED RATES

Arrangements have been made with the Institution of Electrical Engineers for the supply of periodicals to members of the I.R.S.E. at reduced subscription rates. Details can be obtained from the General Secretary.

TECHNICAL BRIEF

A technical brief on Remote Control Systems (L.T. Practice)- 1981 is available from the General Secretary, price £4.00.

SIGNAL AND TELEGRAPH TECHNICAL SOCIETIES

The following S. & T. Technical Societies are affilliated to the Institution:—

Birmingham—
Hon. Sec.: P. H. Dibden,
Area Signal and Telecomm. Engineer's Dept., British Railways,
Quayside Tower, Birmingham.

Carlisle—
Hon. Sec.: J. Coulthard,
c/o Area Engineer (Signalling),
St. Nicholas Bridges, Carlisle.

London Underground—
Hon. Sec.: J. L. C. Kelland,
10A Wood Lane,
London W12 7DT.

Manchester—
Hon. Sec.: J. Eccles,
Room 114, Station Buildings,
Victoria Station,
MANCHESTER.

Reading—
Hon. Sec.: P. J. Fortey,
Regional S. & T. Engineer's Office,
B.R. W.R., CP12
Western Tower,
Reading.

Southern Region—
Hon. Sec.: L. H. Heard,
Regional S. & T. Engineer's Office,
British Railways (S.R.), Southern House, Wellesley Grove, Croydon.

Leicester—
Hon. Sec.: D. C. Muddimer,
B.R. L.M. Region,
c/o Area Engineer (Signalling),
Fox Street,
Leicester.

THORROWGOOD SCHOLARSHIP

The Scholarship, awarded annually to a student member excelling in the Institution's Examination, assists the holder to undertake a study of Railway Signalling usually in a foreign administration.

The Scholarship was originally funded entirely from the Thorrowgood Bequest Fund, but the ravages of inflation devalued the interest from the fund, and any award to be of significant assistance requires to be subsidised by Institution funds.

However, an IRSE Scholarship Fund made up of members' donations and some of the profit from the 1984 International Conference now supplements the Bequest Fund. The interest from these combined funds maintains the capital in real terms and still enables the award to be in the region of £500.

Attention Student Members. There is considerable personal satisfaction to be gained from passing the Institution's Examination and even more from winning £500!

THORROWGOOD SCHOLARSHIP TOUR TO NORTH AMERICA

by M. J. Spencer

The objective of my tour was to see something of North American methods of employing microprocessor-based technologies in signalling systems. The sixteen day itinerary that was assembled for me was well balanced, enabling me to look at both present day techniques employed by railroad operators, and future products under development by signalling equipment manufacturers.

On arrival at Philadelphia, I was met by Mr. H. Gudenrath (US&S), who had arranged for me to ride the "head-end" of an AMTRAK express on the North-East corridor to Baltimore. Of interest here was the way the alternating current track circuits were "coded", to provide cab signalling aspects. We returned to Philadelphia by road, to look at some wayside installations.

At Pittsburgh, Mr. E. Callender (US&S) was able to show me around his company's head office, before the commencement of the Association of American Railroads Communication and Signal Division Annual Meeting. As well as being a three-day conference, this meeting also incorporated a trade exhibition attended by some fifty manufacturers, displaying goods worth a total of $3 million. Microprocessors were in evidence in many of the products on show. The meeting included reports from various AAR committee chairmen, as well as papers on technical matters.

I was able to visit the premises of GRS at Rochester, New York, where I enjoyed some discussions with design engineers employed on the development of "VPI" and "Spacerail". "VPI" is the GRS single processor based interlocking system, and "Spacerail" is a system of signal control by radio. "Spacerail" would be suitable as an ATCS level 30 system.

Mr. D. Walkington (Canadian Pacific), who had played a large part in the organisation of my tour, met me in Montreal. As well as demonstrating some rather older signalling equipment (in Canada's National Railway Museum), he was able to arrange a meeting with Mr. P. Detmold, one of the co-ordinators at the ATCS project.

The final leg of my tour included a second "head-end" ride, on a VIA express to Toronto. It was interesting to note that on this train, there was no in-cab signalling equipment at all (save the radio), but there were two drivers, for increased vigilance. In Toronto, I was able to spend some time with signal engineers from Canadian National and Canadian Pacific Railways, and to visit "old and new" installations on the Toronto Transit Commission.

It was interesting to compare and contrast the American techniques I saw, with the British practice - some items were similar, some different. Of these differences, some but not all could be explained by the dissimilar nature of railroad operations in America.

Presidential Address

of

J. G. OEHLER

It is a great moment for me to stand here, for the first time as President of this Institution under the stern eyes of Volta, Ohm, Faraday and Ampère who have looked down like this on many Presidents as they nervously face the assembled experts!

Am I - your elected President - an expert? A railway signal engineer? I doubt it, for my real activity is management. I am responsible for a company in Switzerland, which develops, manufactures and partly assembles on site railway signalling installations for Swiss Federal and private railways. In my early years as an engineer, I, too, was active in the development and engineering of signalling installations.

Today, however, my principal endeavour is to bring the long term business objectives into line with the ever changing economic and technical environment. IF the company is making profit, THEN the shareholders are happy - this is my BASIC knowledge!

With this in mind, I have not chosen a technical subject for my address tonight - others will do this much more accurately. I would like to convey to you some thoughts on the present objectives of our Institution and the consequential measures to be taken for the future. For this purpose I have searched in the Memorandum of Association for the aims of our Institution, which are defined as follows:-

First, let me quote article 3 of the Memorandum:

"The objects for which the Association is established are:

The advancement of the science and practice of signalling by

- discussion
- enquiry
- research
- experiment

and other means; the diffusion of knowledge regarding signalling by means of

- lectures
- publications
- the exchange of information and otherwise;

the expression "signalling" in this Memorandum of Association is employed in its most comprehensive sense as including

- the whole of the apparatus (electrical, mechanical and otherwise)
- methods
- regulations
- and principles

whereby the movement of railway or other traffic is controlled."

These aims are to be interpreted and formulated as a basis for the activities of committees, the Council and its President. They are open to broad definition. Our present activities fit perfectly within this framework. At first sight, we just have to continue as in the past, but we must take into account the fact that organisations like ours are slow-moving and require considerable foresight if we are to properly manage the future of our industry.

Looking to this future, I see some problems, three of which merit special comment:

The first problem:

- The professional profile of the signal engineer is changing rapidly. Who will in future be entitled to become a member of our Institution? I shall call this part, **"Management of the Profession".**

The second problem:

- Due to the use of modern technologies in the signalling field, costs for research and development will increase to such an extent that close co-operation between contractors and railway administrators will be essential. How can our Institution support this co-operation? **"Management of the Objectives"** will be the title of this issue.

The third problem:

- The strain on the staff members of railway administrations and industry is constantly increasing. It is getting more and more difficult to find members who, in addition to their increasing professional load, wish and are able to take over voluntary tasks within the Council and Committees of our Institution. How will it be possible in the future to carry out these increasingly demanding tasks, let alone pay for them?

This part will be elaborated under the heading **"Management of the Resources".**

Let's start by looking at the first issue, the

Management of the Profession

Most railway administrations have put the two disciplines "Signalling" and "Telecommunication" together in one department. I say "most", because Switzerland, for instance, has not, or not yet done so. The early decision to combine these two disciplines was singularly far-sighted and not as logical then as it may seem today, for it is only the transmission medium which is common. As far as equipment is concerned, analogue technology was used for voice-transmission. Digital technology was used for data transmission. Taking into account the limited confidence that the signal engineer had in the spoken word it is encouraging that he accepted "telecommunication" at such an early stage.

Today, as we all know, information processing is becoming omnipresent in railway signalling. The profession of the signal engineer is no longer aimed solely at safeguarding railway traffic; optimal efficiency of railway operation is his main objective. Even the Memorandum of Association defines the word "signalling" in a very broad sense, namely: "the whole of the apparatus, methods, regulations and principles whereby the movement of railways or other traffic is controlled". Today we would rather call this a System. This system consists of components like;

- data acquisition
- data transmission
- data processing
- process control

and differs only slightly from other information systems. There is, however, the requirement that **part** of the system must be fail-safe. I emphasise the word "part" to remind you that the pure information processing component is becoming more and more important.

Based on a wider definition of the word "signalling" it should be possible to describe more accurately the word "profession". The definition according to the Articles of Association reads: "The PROFESSION means the profession of signalling as defined in the Memorandum of Association and including all branches of Railway Signalling and Telecommunication work."

I consider this interpretation to be insufficient. The modern signal engineer must also have specific knowledge in the application of computer technology to **fail-safe process control systems** for the efficient operation of railways. This definition embraces a variety of professions, such as:

- the mechanical engineer:
  (one of the most famous pictures of Conventions is the group of members standing around an open point machine!)
- the electrical engineer:
  (track circuits will go on being a subject for discussion as long as we have railways!)
- the optical engineer:
  (even if some railway systems do work without lineside signals nowadays, the problem of visual signal transmission to the driver will still remain)
- the telecommunication engineer
- the computer engineer, which includes: the hardware engineer; the software engineer; the systems engineer

and finally

- the economist.

It may surprise you that I include this non-technical profession in the definition of the signal engineer. But we must be aware that the limits of technology are increasingly determined by economic considerations rather than by technology itself. The responsible and successful signal engineer must constantly answer the question: "Will my technical solution be economical at the time of its realization in 1, 3 or 5 years?" - I shall revert to this problem later.

This wider profile of the signal engineer proves that he is not born as such! He becomes a signal engineer through continued training and advanced education. The IRSE has always made a significant contribution to this education and will go on doing so. We must, however, consider the fact that the future signal engineer could be recruited from a multitude of professions. If the IRSE wishes in future to achieve its avowed aims it must follow a less restrictive trend in its admission policy. Maybe the definition in the Articles of Association has to be altered, replacing the word "Telecommunication" by "Information processing". If we acknowledge this principle, we must also accept the possibility that due to the wider definition of the Profession, the character of our Institution may change. It is up to all of us to control this change so as to bring positive advantage to our industry and the IRSE.

I now proceed to the part

Management of the Objectives

I begin with a rather provocative question: "How much signalling does a railway need?" "Too much" would normally be the answer of the General Manager of a railway administration who must justify his deficit account. "More" will probably be the comment of the politician who has to take official responsibility for the victims of a railway accident.

As long as signalling installations were only used for the prevention of casualties, it was practically impossible to establish a profitability study.

It has been proved, at least in Switzerland - and it probably will not be different in other countries - that every major railway accident resulted in financial resources being made more readily available for safety purposes. Surprisingly enough, this is still the case at the present time, despite the fact that the advantage of modern interlocking systems lies mainly in an improved efficiency and less in the safety aspects of railway operation. Can this advantage be substantiated economically? I would say, only to a limited extent, because as long as the control centres include the very costly elements of safety, such a calculation would be inaccurate.

Whilst, normally, the creativity, imagination and perfectionism of the engineer encounters limits set by economic considerations for his non-signalling product, the railway signal engineer might be tempted to misinterpret his responsibility by setting an excessive quality and safety standard on his product, regardless of the cost, and nobody can or would wish to give him proof that a lower standard may be good enough.

A signal engineer feels bound to ensure safety. His task is to protect human life. We must, however, accept the fact that despite this noble aim, a level of absolute safety cannot be reached. Even if the means at our disposal allow us to go ever further along the asymptotic way to absolute safety, we arrive at limits set by economic considerations.

There are other limits which are to be considered; the safety factor in a system can be in conflict with the reliability factor. In the case of a system failure, for instance, we are prepared to take the risk of running the railway operation at a lower safety level during the repair period of the system. Therefore, reliability is a major factor in the safety of railway operation. But the meantime between failures decreases by increasing safety.

It would exceed the scope of my lecture to enter into the detailed relationship between safety and reliability which is a very complex one. It is however, essential to acknowledge that there are conflicting aims between the factors;

safety — reliability — economy

which are insurmountable, and therefore represent a problem of optimization. It would be fine, though perhaps somewhat boring for our profession, if this problem of optimization could be solved by a mathematical model. This will, however, not be possible; the variables of this model are so intricate and their evaluation so controversial that this optimization process could become a never ending definition process.

This leads us to another fact which we have to accept: Although all railway administrations have the same target, which is to transport passengers and goods in the most rapid, safe and economic way from one place to another, the individual requirements are not the same. For example, it is quite impossible to treat the Southern Region in England, the TGV line in France or the Gotthard Line in Switzerland all alike.

The optimization process by each company will produce different results. Different solutions which are all well founded tend to lead to discussions of a near-philosophical nature. We may all remember this from the relay era, when endless arguments for and against the silver-silver contact or the silver-carbon-contact were exchanged. Another example is the problem which Switzerland is presently facing with ATC. The three neighbouring countries, Italy, France and Germany each have a different ATC system. Switzerland is about to introduce a fourth-one, which makes it difficult for international through traffic to reach our cities in the centre of Switzerland. There are good reasons for Swiss Federal Railways to introduce a different system and there are technical means to overcome the problems. For example, some TGV's will be equipped with our ATC receivers. The question is whether this individualism with adaptations is an economically, technically and operationally reasonable solution for the future.

Well, it is not up to me to answer this question; however, I foresee another economical problem which will face us: We all know, and no signal engineer with foresight would doubt it, that the computer is now accepted as fail-safe technology and will take over the functions of our beloved fail-safe relays!

In various countries, railway administrations and industry have made great efforts to develop solid state interlocking systems. England, Sweden and Germany already have such systems in operation, under construction or in the testing stage. All concerned agree that the costs for the development of these very complex systems, which all basically differ from each other in their technical concept, are enormous. It seems that the hardware cost of the computer interlocking system will be lower than for conventional interlocking. However, we have no figures available yet as to the overall life time costs of these new systems. Without wanting to anticipate the result of such calculations yet to come, I wish to put the following question to you:

Is it reasonable that each European country chooses its own solution, regardless of the tremendous costs upon the railways and in many cases, the taxpayer?

Please, do not misunderstand me. I am not suggesting abolishing competition. Competition is the basic condition for a free market. (Quite apart from the fact that it makes our professional life interesting and keeps us busy).

However, I do believe that despite our national variety and interests, it should be possible for European industries and railway administrations to co-operate in a way that the national interests and independence are safeguarded, but that the development could be shared and kept on a lower, more economical level.

This is another optimization problem for which there is no simple mathematical solution available. In both cases, the problem of the conflicting aims between safety, reliability and economy and the one just mentioned, we have to find the optimal solution by proceeding empirically, that means by:

doing — analysing — improving

It is a difficult task which can however be facilitated and accelerated by communicating with each other, by discussion and by getting to know the problems of others.

It cannot be the IRSE's business to initiate European co-operation. It is up to the initiative and willingness of us engineers and managers from the railways and contractors, to define the common interests and objectives and to propose solutions for a reasonable co-operation.

The IRSE is however perfectly suited to be the forum for such contacts and discussions. This task is indeed in line with the aims of the Memorandum of Association and, I would say we are not doing too badly, as the organisation of the 1984 International Conference has shown. The trend to internationalize our Institution, the trend to relax our admission policy and our endeavour to organize a high standard of technical meetings and visits in the UK and elsewhere must be furthered and intensified.

Here too, it is in our hands and to the common good that we actively participate in expanding the scope of our tasks within the framework of our objectives.

Whether it really is in our hands to do so and who would or should act, is another question which leads me to the third part of my lecture:

Management of the Resources

In this part I mention a problem which has already been brought up several times at our general meetings, the last time by David Norton. As I consider it vital to find a solution, I want to mention it once more.

Our Institution has at present rather more than 2000 members. This is a very modest number if we compare it with the 82,000 members of the Institution of Electrical Engineers. We do not have a big building with a magnificent lecture hall like this, in which we are but grateful guests, nor do we have a permanent office. All the work which is required for the administration of our Institution and for the organization of our events is done voluntarily by members alongside their regular job. We are dependent on the tolerant attitude of British managers who allow their staff members to use part of their time to do work for the Institution.

On the other hand, we should be proud of the high percentage of members who attend lectures, conventions and social functions. We may say that we have only active and no passive members, which proves that the motivation of our members is high. The great number of overseas members further indicates the importance of our Institution outside Great Britain. The expectation of our overseas members grows as they recognize that our organisation has become an important forum for contacts beyond national and economic borders and they wish this growth to continue.

The organisation and administration of an international conference like the one we had in 1984 requires an enormous expenditure of effort. Its success has proved, however, that such events are highly appreciated and should be continued. As mentioned before, all this work is done by members of British Rail or of British contractors on a voluntary basis.

I am all in favour of this type of voluntary system as it guarantees a rational procedure, there are no overhead costs and no unnecessary administrative efforts. However, if the range of our tasks and services needs to be extended in the projected sense, and if our activities, particularly on an international level, should be intensified, we must ask ourselves whether this workload can still be carried on the same basis, with the same means as up to the present.

Already certain weaknesses are perceptible. We are all aware of the very slow distribution of the Proceedings in the past years, sometimes with delays of one or more years. This is a most regrettable state, because, in our fast-moving industry, technical discussions, questions and answers are only of interest if the record is made available in good time.

I know and can assure you that those responsible for editing and distribution of the proceedings do their utmost to improve the situation and that the delay is in fact due to reasons beyond their control. We are hopeful that in the course of this and next year we can make up for lost time.

My opinion is that we have to review critically the question as to whether and how the workload on the home members can be reduced.

Such considerations of course automatically lead to the question of financing. We are not a wealthy organisation and have no intention of becoming one. Our membership fees must be kept as low as possible in order to allow any interested candidate to apply for membership. It should be possible, however, to finance our improved services by means outside the regular contributions. Those who actually need and use these services certainly ought to be prepared to pay for them. This seems to me another problem which has to be solved in the near future if we want to keep up the standard to which we have become accustomed.

Before I come to the end of my address, I would like to comment on our

Programme 1986/87

The Summer Convention will take place in Vienna from the 20th to the 23rd May. Thanks to the support of the Oesterreichische Bundesbahnen, the Wiener Stadtwerke, ITT Austria and Siemens Austria, as well as the Elektrotechnische and Maschinebautechnische Institute of the Arsenal in Vienna, we will have the opportunity to see a variety of most interesting installations.

The season of technical meetings in London will start on October 14th with papers and discussions about modern technologies in Germany and USA.

On 10th November, a paper on "Video and Display operating units" will be presented by ITT Austria.

A technical visit to France on 21st and 22nd November will show us the remote control centre in Tours.

In December, Swiss Federal Railways will present a paper on "New Systems for speed signalling and ATC".

Westinghouse will present a paper "Continuous automatic train control with mini-computers" in January 1987.

In February, we can expect from GEC a presentation on "The application of Solid State Signalling Systems".

At the last technical meeting on 9th March, a paper on the "Yoker Integrated Electronic Control Centre" will be presented by ScotRail.

The season will be terminated by the Annual General Meeting on 15th April, 1987.

Many decades ago, you decided to admit overseas members, primarily thinking of railway signal engineers of Commonwealth countries. After the Second World War, the Institution gradually accepted also, members of other countries, mainly European, and of the United States. Finally, a few years ago, overseas members were admitted to the Council and even to Presidency.

The Institution of Railway Signal Engineers has become a British based international organisation. With the home members' open minded and future oriented policy, the Institution has gained vital importance in the professional life of a signal engineer in large areas of the world. Behind this development stands a lot of work, and by accepting an overseas President you increased your burden once more as he needs all the support he can get from the British members in order to perform his duties successfully. In this context, I would particularly mention our Honorary Secretary, Ray Weedon who helps me enormously, with his advice, his readiness to supply me promptly with information, and with his patience in answering all my questions.

There is also a friend of mine I want to mention. He has been, and still is, my tutor since I came to London as a member of the Council. He tells me how to behave in British society, and believe me, I still have to learn quite a lot. I thank you, Jim Waller, also for helping me to improve the English of this Presidential Address.

Finally, I must say that without the tremendous support of the Council, the committees and the many friends I have had the good fortune to make, it wouldn't have been possible for me to take over the duty of a President.

Let me close my address by saying that I am happy to live in a time of fascinating technical evolution in the signalling world; I am proud to be the President of this Institution, and I am glad to have the opportunity to thank you all for the support you have given me and, so I trust, will go on giving me during my Presidential year!

TWENTY-SECOND ANNUAL MEMBERS' DINNER

The Institution's Members Dinner held on 21st April, 1986 at the I.E.E. Refectory, Savoy Place, London was attended by 163 members and guests.

The dinner was preceded by a reception for members in the I.E.E. bar and the President's reception was held in the Refectory bar.

A five course dinner was served with Braised Sirloin Steak in Red Wine as the main course.

The principle guest was Mr. Hans Eisenring, General Manager, S.B.B. Technical Department.

Other guests included:- Sir Robert Reid, C.B.E., Chairman, British Railways Board; G. H. Halter, O.B.E., Chairman, Railway Division of the Institute of Mechanical Engineers; Mr. E. J. Harris, Managing Director, Westinghouse Signals Ltd.; Mr. M. L. Boden, Managing Director, GEC Signals Ltd.; Mr. F. Rayers, Director of ML Engineering, Plymouth Ltd. and Mr. W. H. Whitehouse, B.Sc., Director of S. & T. Engineering, British Railways.

TECHNICAL VISIT TO THE EAST ANGLIA LINE

The rural railway from Ipswich to Lowestoft in East Suffolk was the venue for 138 members attending the winter Technical Visit on Saturday, 21st February, 1987, a cold but fine day. After splitting into small groups at Ipswich, members left by train or road vehicle to several locations in Woodbridge and Saxmundham where staff from BR Eastern Region and GEC-General Signal Ltd. explained the methods of working this basic railway along with the technical detail of the Radio Electronic Block (RETB), Solid State Interlocking, the radio system, Automatic Open Level Crossings (AOCL) and the train worked hydro-pneumatic points.

A short visit was also possible for each group to the control centre at Saxmundham.

Lunch was taken at the Brudenell Hotel in Aldeburgh where the President thanked those responsible for making the visit possible and expressed his pleasure with the way the organisation had coped with the programme of events.

The Institution is extremely grateful to the General Manager, BR Eastern Region for allowing the visit, the Area Manager, Norwich whose staff throughout the visit performed admirably, and to the Regional Signal and Telecomms Engineer, York for his support.

Special thanks to GEC-General Signal Ltd for their financial assistance both with technical displays and facilities, also their generous support towards lunch.

ANNUAL DINNER AND DANCE

The Annual Dinner and Dance was held on Friday, 24th October, for the second time in the Metropole Hotel, Edgware Road, London.

The principal guests on the occasion was the Swiss Ambassador to the United Kingdom Mr. F. C. Pictet and Mrs. Pictet.

The President, J. Oehler and Mrs. Oehler were supported by the Vice-Presidents, Mr. C. Hale and Mr. T. S. Howard and their ladies.

The President and Madam President received members and guests, individually as announced by the Toastmaster, at the reception prior to dinner.

The reception, in the London Room of the Hotel, was by courtesy of Clough Smith (Civil Engineers) of Crawley, Sussex.

The dinner was in the Westminster Suite of the Hotel and prior to the President saying grace, he and the Senior Vice-President presented bouquets to Mrs. Pictet and Madam President respectively.

The President and the Ambassador gave after dinner speeches and then the President and his lady led the members and guests onto the dance floor for the Vienese Waltz, the first dance of the evening.

The music for the evening was provided by the Michael Sparks Quartet, who have provided their services for many years and likewise the Toastmaster, Mr. Harry Somerville.

The number of members and guests who attended was 129, which was a little below last years attendance.

The event was a social success with all those attending having an enjoyable evening.

OVERSEAS TECHNICAL VISIT TO PARIS

On Friday, 21st November, a party of 74 members from eight countries, led by the President, met in Paris to hear a technical paper, "The New S.N.C.F. Electronic Interlocking at Tours" presented by Messrs. R. Retiveau (S.N.C.F.) and J. Pore (Jeumont Schneider). Mr. Retiveau described the system in general terms whilst Mr. Pore dealt with technical detail.

Both authors replied to several questions from the members before the meeting was concluded.

The following morning Members met at Gare d'Austerlitz for an early start and a journey to Tours, some 235 km South West of Paris.

After splitting into groups Members were shown the hardware of the system, the control centre and other items of interest, mainly telecommunications orientated.

Also included was a coach trip to view the earthworks for the new TGV Alantique line which will pass close to Tours.

The visit concluded with lunch and farewells from the President, Mr. Roumegiere (S.N.C.F.) and Mr. Catrain (Jeumont Schneider).

The Institution is extremely grateful to S.N.C.F., Jeumont Schneider, Alsthom, C.S.E.E. and Silec for their help and financial assistance with the successful and happy meeting.

SUMMER CONVENTION

The Summer Convention was held in Austria, based on Vienna from 20th to 23rd May inclusive and was made possible with the generous assistance and support of ITT Austria Gesellschaft mbH and Siemens Atkiengessellschaft Osterreich. The generous support of Integra (Zurich) Ltd., Clough Smith Ltd., GEC-General Signal Ltd., ML Engineering (Plymouth) Ltd. and Westinghouse Signals Ltd. is also acknowledged.

131 members, 57 of whom were from overseas, and 86 ladies representing 13 nations participated in the Convention. A full and interesting technical programme, including visits to U-Bahn and S-Bahn installations, together with trips to a marshalling yard and research laboratories, were supplemented by a number of enjoyable social events, the highlight of which was a visit by members and ladies to Mariazell.

The Institution is indebted to the Austrian State Railways and the Vienna Arsenal for allowing their operations to be viewed.

Technical Meeting of the Institution

held at

The Institution of Electrical Engineers

Tuesday, 14th October, 1986

The President (Mr. J. G. Oehler) in the Chair

The Minutes of the Technical Meeting held in London on 3rd March, 1986, were taken as read and signed by the President as a correct record.

The President then introduced two papers. The first by Mr. K. H. Wobig (Siemens Braunschweig, West Germany) entitled "Modern Technologies in Fail-Safe Systems" and the second by Mr. C. G. Shook (G.R.S. Rochester, USA) entitled "Microprocessors in Fail-Safe Systems".

Paper 1:

Modern Technologies in Fail-Safe Systems

*By Mr. K. H. Wobig**

INTRODUCTION

From the very beginning, it was clear that railway signalling equipment should possess **two important features:**

— it must fully and reliably perform the assigned tasks, and;

— it must react in a specific way in the event of failures, assuming the status of a "right-side failure".

The first mentioned requirement should really be a matter of course for **all** technical equipment, whereas the second one is an exceptional feature especially in railway signalling. However, the demand for "fail-safe behaviour" is increasing in other fields of modern technology too; one has only to think of reactor technology.

The introduction of electronics - in particular, microcomputers - has raised new problems in railway signal engineering. No longer is the **avoidance** of failures, by means of special constructions and appropriate dimensioning, to the fore (in general, this is no longer possible), but the prompt disclosure of failure and the equipments safe reaction to it, in other words: the control over failures. This had led to a whole series of different concepts, some of which have been put into effect over the past few years (Ref. 1,2,3,4,5). Prototype microcomputer interlockings are to be found in various countries (Ref. 6,7,8,9) and by means of these interlockings, the correct choice of the respective concept adopted should be verified.

There are many reasons why there are differences in interpreting and solving one and the same problem. Firstly, from the very beginning, different countries developed their own version of railway signalling and, consequently, the rules, regulations and laws drawn up for this also varied. This in turn has led to variations when carrying out fail-safe analysis. In the German Federal Republic, there are a number of state authorities who are appointed to assess and certify the safety of railway signalling systems. In the case of the German Federal Railway, this is the "Bundesbahn-Zentralamt, Munich". This authority has issued its own guidelines which, of course, are binding on all German manufacturers of signalling equipment. As a result, the proving of a system's fail-safety has been

*Siemens Braunschweig, West Germany

found to be an expensive and time-consuming activity (especially when different authorities are simultaneously involved for various customers). To a greater or lesser degree, the manufacturer has to add these costs to the product concerned. This was a reason for our decision to concentrate on the development of just one type of safe but universal microcomputer.

Finally, it should be borne in mind that all the technical solutions discussed here are always compromises between many factors of mutual influence for there is no possibility of achieving 100% safety. The tendency to favour the one or the other solution will depend upon the opinion formed during the planning stage of the electronic signalling equipment as to which of these many factors is of most importance.

BASIC DESIGN OF THE FAIL-SAFE COMPUTER

A single computer with no backing (i.e. no redundancy), is not able to recognize a failure and the resulting consequences with a sufficient degree of safety and because of this, a dangerous situation can arise. Consequently, the reactions of a computer must be monitored or controlled. Basically, this can be achieved in different ways:

— by cyclic execution of a self-checking program in a single computer (see Fig. 1a).
— by repeating the entire data processing in a single computer but using a different program. Results are then compared (see Fig. 1b).
— by parallel operation of two computers (see Fig. 1c);
  (a) with the same programs or
  (b) with different programs (diversity) and comparison of results.
— by parallel operation of three computers with majority-voting of results (see Fig. 1d).

All of these possibilities have certain advantages and disadvantages both with respect to their feasibility and to the safety level achieved. Nevertheless, nearly all have been put into practical application, with the exception of the first-mentioned method.

REQUIREMENTS ARISING FROM SAFETY

The recognition of single failures

The essence of all fail-safe engineering is: **A single failure must never result in a dangerous situation.** This requirement can be met only if every single failure can be **recognized** with certainty. All redundant aids which serve to detect single failures must, therefore, fulfil **three requirements:**

— they must be in a position to detect **every** single failure.
— their **own failures** must be just as detectable as those of the element under surveillance.
— the situation must never arise whereby the fault to be detected also appears in the redundant unit, thus impairing its function, in other words: its **independance** must be guaranteed.

The first two requirements can be best fulfilled when fault detection is by means of processing the data twice and finally comparing the results (and, if possible, also the intermediate results). With regard to the demand for independance, this should be performed in two separate devices, for example, two computers working in parallel. If, on the other hand, faults are to be detected just by using the same hardware for the second program, then it is extremely difficult to prove that both programs will never be corrupted in the same way due to a certain hardware fault.

Whether the **comparison** of results is performed in one separate hardware device - the fail-safe behaviour of which, however, must also be proven - or by using software to carry out individual comparisons in two computers, is of no significance for this purpose. However, in each case it should be guaranteed that when a discrepancy is disclosed, the output of any faulty information is prevented with absolute certainty.

Conclusion: The two-computer arrangement is an effective means of sure detection of single faults. These computers work in parallel and each compares its results with the other.

Of course, care must be taken that the two computers are not able to influence one another when a failure occurs. Moreover, it is not only the possibility of electrical or electromagnetic influences which must be considered, a thermal influence can also occur, for

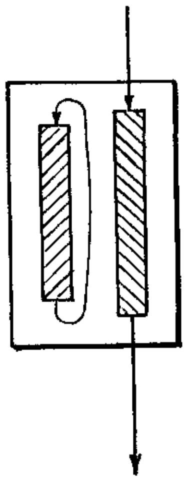

Fig. 1a: One computer,
one program + check program

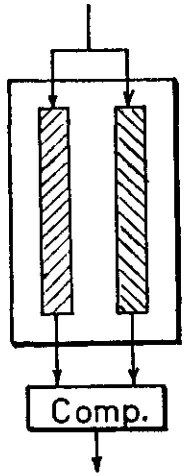

Fig. 1b: One computer,
two (diverse) programs

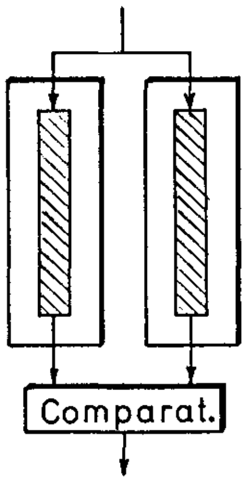

Fig. 1c: Two computers
(2-out-of-2 system)

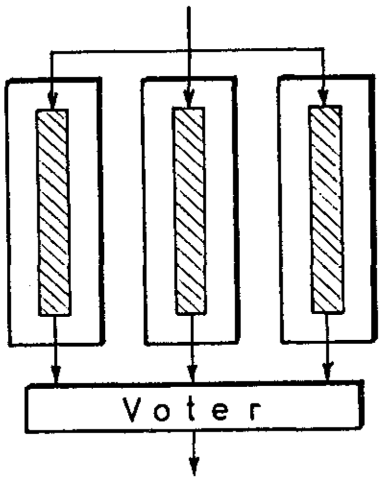

Fig. 1d: Three computers
(2-out-of-3 system)

Fig. 1. Basic concepts of fail-safe microcomputer systems.

example, when local temperatures increase considerably as a result of a failure. For this purpose, intensive investigations of all kinds of possible mutual influences were carried out in our laboratories in order to determine the conditions under which optimal independence can be guaranteed.

Conclusion: Suitable measures must be adopted to ensure that the two computers of a double computer system are not able to influence one another in a negative way even during a failure (mutual independence).

However, protection against **influences from the environment** is of no less importance for they could also cause both computers to make the same error (the cause being one and the same). To provide protection against outside interferences, certain measures have to be taken, like separate power supplies for both computers protected by suppressor filters, well-screened cables, earthing performed carefully, electrically decoupled interfaces, with high dielectric strength, to the outside equipment.

In this connection, the question whether the two computers function synchronously or not, would appear to be of less importance. Asynchronous computers are also prone to outside interferences if specific measures are not taken to keep them at bay. Namely, such interferences not only have an influence on the processing currently being carried out in the computers but also are able to falsify the information stored in the registers and memories. Such a danger cannot be eliminated, however, just by a higher or lower degree of asynchronism of both computers.

Conclusion: The entire dual computer system must be sufficiently screened from all conceivable environmental influences.

The avoidance of multiple failures

Should a single failure in a dual computer system remain undetected for too long, or not react as a "right-side failure", the probability of a chance second failure occurring increases. Double failures always present a potential danger for they could lead to the same incorrect results being produced in both channels of such a system, and these would remain undetected during a comparison.

One of the main problems of safe computer systems is therefore, the **prompt detection of single faults.** Thus, the following requirements have to be fulfilled:

— all conceivable failures must be detectable.
— each failure must be detected as quickly as possible, and
— this procedure shall cause as little hindrance as possible to the execution of user programs.

The first requirement can be fulfilled only by using **test programs** to check all functions of the CPU and of the memory at the shortest possible intervals. As it cannot be ruled out that some malfunctions are perceptible only during the processing of certain bit combinations, one comes to the conclusion that the tests of individual commands of a CPU or storage location also must be performed **using all possible bit combinations.** This results in a large number of individual tests.

Conclusion: Single failures must be detected as fully and as quickly as possible. To achieve this, it is absolutely essential that effective on-line test programs are performed.

If a check were to be carried out on each individual test result by using software, this would involve the transfer of one computer's result to the other for purposes of comparison. As this would take up considerable computer time, the execution of the user program would be impaired, which is in direct conflict with the last two requirements given above.

This disadvantage can be avoided if a **hardware circuit** is used for the comparison of test program results and, of course, those of user programs. In this case, too, care should also be taken that the amount of software involved is kept to the minimum. One possibility is the direct connection of the comparators to the bus system which links the individual components of the microcomputer with one another. Then, a comparison can be made almost at any time, e.g. within the span of each operating cycle. However, a prerequisite for this is that the computers run in strict synchronism; at the very outside, they could run slightly staggered. Such a degree of synchronism can be achieved by means of a common clock generator. The question as to whether strict synchronism of both computers presents a disadvantage with regard to possible outside interferences has already been answered in the negative.

In our opinion, the use of comparators, in hardware form, offers a whole series of advantages:

- comparison of data can be made at any time, that is at each stage of processing
- comparison is made of all data sent via the bus, for example all instructions fetched from the memory
- comparisons are made as frequently as possible
- comparisons are executed at maximum speed
- comparisons can be carried out without employing user software.

However, for this concept too, special test programs are indispensable as only the data which appears on the bus can be compared. These test programs have "only" to ensure that the information to be checked is also transmitted via the data bus.

An example to illustrate how well these hardware comparators simplify a test sequence is given in the test of a ROM for intactness of content. For this, the test program needs to read the entire contents just once, proceeding from storage location to storage location (without depositing it anywhere). During the process, the memory contents, which are sent via the data bus, are automatically and without further aid, compared with the contents of the neighbouring channel. (Should differences occur, the comparator blocks further execution of the computer programs; in addition, the connections to the peripheral in the output direction can be interrupted, for example by switching off the power supplies).

The advantages of quick testing without having to have frequent, software-controlled data exchange with the neighbouring computer will play an important role in the planning of future systems. 16-bit computers with large memory capacities and extensive instruction sets will require considerably more tests than is the case for the traditional 8-bit computer, in order to be able to detect all conceivable faults within an adequately short time. To carry out the numerous comparison operations just by means of software would result in either the failure detection time being increased or the number of tests considerably reduced. Both of these would have an adverse effect on the task set, namely, to prevent dangerous double failures from occurring; consequently, the system's level of safety would be reduced.

Conclusion: Single failures must be quickly and fully recognized. Comparisons carried out by hardware in conjunction with test programs offer advantages over comparisons by software of the two computers.

Retention of the safe status after safety shutdown

After detection of a failure in the actual core of a fail-safe double computer system, i.e. in the CPU's, the memories and the comparators (if being used), it is no longer possible to continue processing safely because:

- it is not possible to determine in which of the two channels the fault has occurred, and
- it would not be permitted in any case to continue operations with just one computer, for reasons of safety.

In such a situation, safety shutdown must be carried out immediately, i.e. processing has to be stopped. An additional method which can be applied is to separate the connection to the peripherals or to disconnect power. This status must remain unaltered until the fault has been rectified. Even if further failures should occur in the meantime, this must not effect a cancellation of the shutdown. This fact has to be taken into account when designing the safety shutdown.

The conditions in respect of a failure in the input/output PC-boards are somewhat different. These boards must also be of two-channel design to facilitate detection of failure; every item of information relevant to fail safety proceeds along two independent paths into (or out of) the fail-safe microcomputer system. The latter then serves as a safe, software controlled comparator for information passing into the system. In this case, comparison by hardware is neither reasonable nor practical. Firstly, the number of functions or information items to be compared is considerably less than that in both microcomputers and memories; secondly, a strict synchronization of the incoming data in the two input channels would be difficult to implement. Finally, there are many occasions when it would serve little purpose to close down the entire system when the failure concerns one specific peripheral PC-board. In this case, contrary to the fail-safe computer core, it is quite conceivable that operations will continue, safely but with reduced performance. The input or output path concerned would simply be inhibited by the microcomputers. Here, too, this status must be maintained until the fault is eliminated, which usually means the replacement of the defective PC-board.

Conclusion: When failures occur within the microcomputers, a safety shutdown must be executed. The resulting safe status must remain even if there are further failures in the meantime.

Absence of faults during commissioning

One of the most important points, which up until now has hardly been touched upon, is the guarantee that signalling equipment is free from errors at the time of commissioning. Then, should errors already exist during the design or production stage of a system (in hardware or software), it cannot be expected that the system afterwards functions so as to meet signalling requirements. We are talking here of **systematic** errors as opposed to random component failures occurring during current operation. The possibilities (or impossibilities) of preventing such errors, or at least of rectifying them before commissioning, can be discussed forevermore. During such discussions, the group usually divides into **two parties:**

— the **optimistic** work on the basis that it must be possible to track down and eliminate all crucial systematic errors before equipment is put into service, and

— the **pessimistic** are of the opinion that this is not possible and, therefore, strive to find methods which permit detection and appropriate handling of these errors **after** commissioning, similar to chance component failures.

The recognition of double errors during operations in a two-channel system is, however, only possible if the two errors are sufficiently different in their effect. A proposed solution for this is to provide **diversity** both for hardware and particularly for software, i.e. to use different hardware and software in both channels, although with the same function.

Although, at first glance, this would seem to be a reasonable solution, it has, in our opinion, two **serious disadvantages:**

— the expectation that errors which are not detectable during software testing will reveal themselves after commissioning cannot be sufficiently substantiated

— this procedure is rather too expensive for implementation on a large scale.

For these reasons, those who are confronted with its feasibility, e.g. German Federal Railway, British Rail and various railway signalling manufacturers, are not in favour of the principle of diversity. Its advocates are mostly to be found amongst the safety theorists in universities and similar institutions.

Conclusion: Signalling equipment must be free of systematic errors at the time of commissioning. Later detection of such errors by means of diversity appears to be problematic in many respects.

Just as a passing remark, diversity is, of course, a "must" when a concept is applied in which two programs run consecutively in **one** CPU. The two programs have to be as dissimilar as possible in order to detect the effects of a hardware failure in the CPU and to deal with this.

Maintenance Problems

This is not the occasion to discuss in detail the maintenance of fail-safe microcomputers, although this activity is also closely linked with the question of safety. After a restart-up following a repair, the system must be in the same faultless state as at the time of commissioning. Here, reference should be made only to the facts of the case, which will depend upon some special characteristics of the electronic components, on the one hand, and the use of a two-channel structure, on the other hand, the fact that electronic components can fail even when not in use, means that under certain circumstances, formerly tested replacement PC-boards could be faulty again. This could lead to the situation in which a complete dual computer module is replaced by another one which, as a result of too long a period of storage, has already sustained a double failure that is no longer detectable during subsequent test programs. Although such a possibility should not be overrated, it should also not be completely dismissed.

Conclusion: The fact that even unused replacement PC-boards can experience failures as a result of being stored too long, must be taken into account in the concept for performing repairs.

Availability of fail-safe microcomputer systems

A typical feature of systems with fail-safe behaviour is the adoption of a safe shutdown status in the event of failure. This safe shutdown involves a complete or, at least partial degradation of operations. **Fault tolerance** must be provided for cases where such hindrances, occurring at intervals given by the MTBF of the system, cannot be tolerated. A measure which is often proposed for this is the use of a three-computer system with majority voting (2-out-of-3-system), which after failure of one computer permits operations to be continued safely with the remaining two computers. Such a concept **can** be successfully applied if two pre-conditions are met (but **only** then!):

— It must be possible (with justifiable expenditure) to isolate and repair the faulty computer and to reintroduce the fully loaded computer into the system without impairing the operation of the two remaining computers

— Not only must the microcomputers themselves be provided with fault tolerance, but the input/output channels must also be protected to the same degree against failure if availability of the entire system is really to increase. This is particularly important because input/output channels very often have a higher failure rate than microcomputers, on account of the quantity of hardware involved.

As an alternative to the 2-out-of-3-system, there are the complete **standby systems** (as cold or hot reserve) to which a switchover is made when failures occur. In spite of the apparent larger hardware expenditure, this solution is preferred by our firm because technically it is simpler to implement.

Conclusion: 2-out-of-3-systems are a suitable means for increasing availability only when fault tolerance is also consistently carried into the interface system itself. Often, 2-out-of-2-systems with complete hot reserve systems are easier to implement.

SUMMARY

A number of ideas have been presented all over the world for the use of microcomputers in fail-safe signalling systems. These concepts differ not only in regard to their universality, cost and availability but also with respect to required safety and the way to prove this safety by analysis. Why is it that different concepts have been formed? Firstly, there is the historical reason, that is, in different countries, railways and their administrations have developed along their own lines. Secondly, there are no worldwide-established and uniform basic principles concerning the requirements to be met by safe electronic controls. This is why the required safety level (and the assumptions concerning the probability of certain failures or combinations of failures) varies and, therefore, determines the technical resources to be invested in such equipment.

The railway signalling division of Siemens has decided in favour of a fail-safe computer system comprising two parallel functioning microcomputers (2-out-of-2-system), based on the 8080 microprocessor. This system was chosen so as to conform with the operational guidelines of the German Federal Railway (see Fig. 2). Both computers function synchronously and compare their results by means of hardware comparators, supplemented by a sophisticated on-line test program. Hardware and software in both channels are identical. The principle of 2-channel operation with comparison of information is carried right through to the input/output channels and the peripheral equipment.

EXAMPLE OF APPLICATION

The above-mentioned fail-safe computer system has been checked by the Bundesbahn-Zentralamt and other supervisory bodies and authorized for application in railway signalling systems. It has already been in use for several years, about 150 such systems performing various tasks. Thus, we already have experience drawn from approx. 500 computer-operating years.

One of the main applications is the **electronic interlocking.** Siemens have developed a basic concept for this which uses the same fail-safe (2-out-of-2) computer in a compound system for a whole number of different tasks (see Fig. 3.). This microcomputer-controlled interlocking has a 3-level hierarchy:

— the input and display level

— the section computer level and

— the element control computer level.

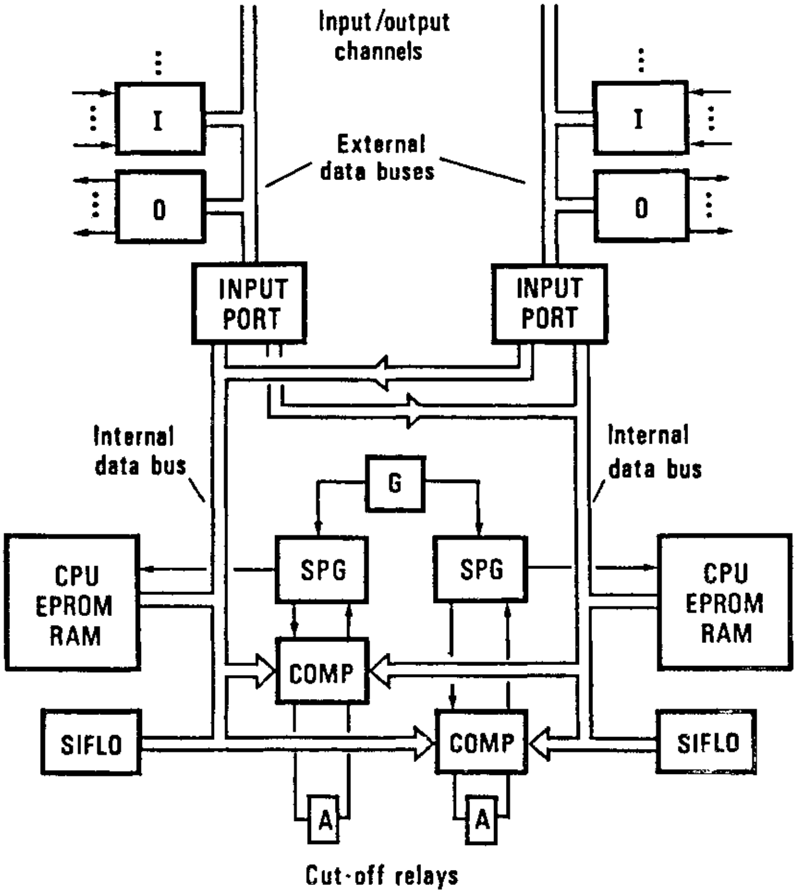

Fig. 2. Dual channel fail-safe microcomputer system with comparator device (COMP) and common clock generator (G/SPG).

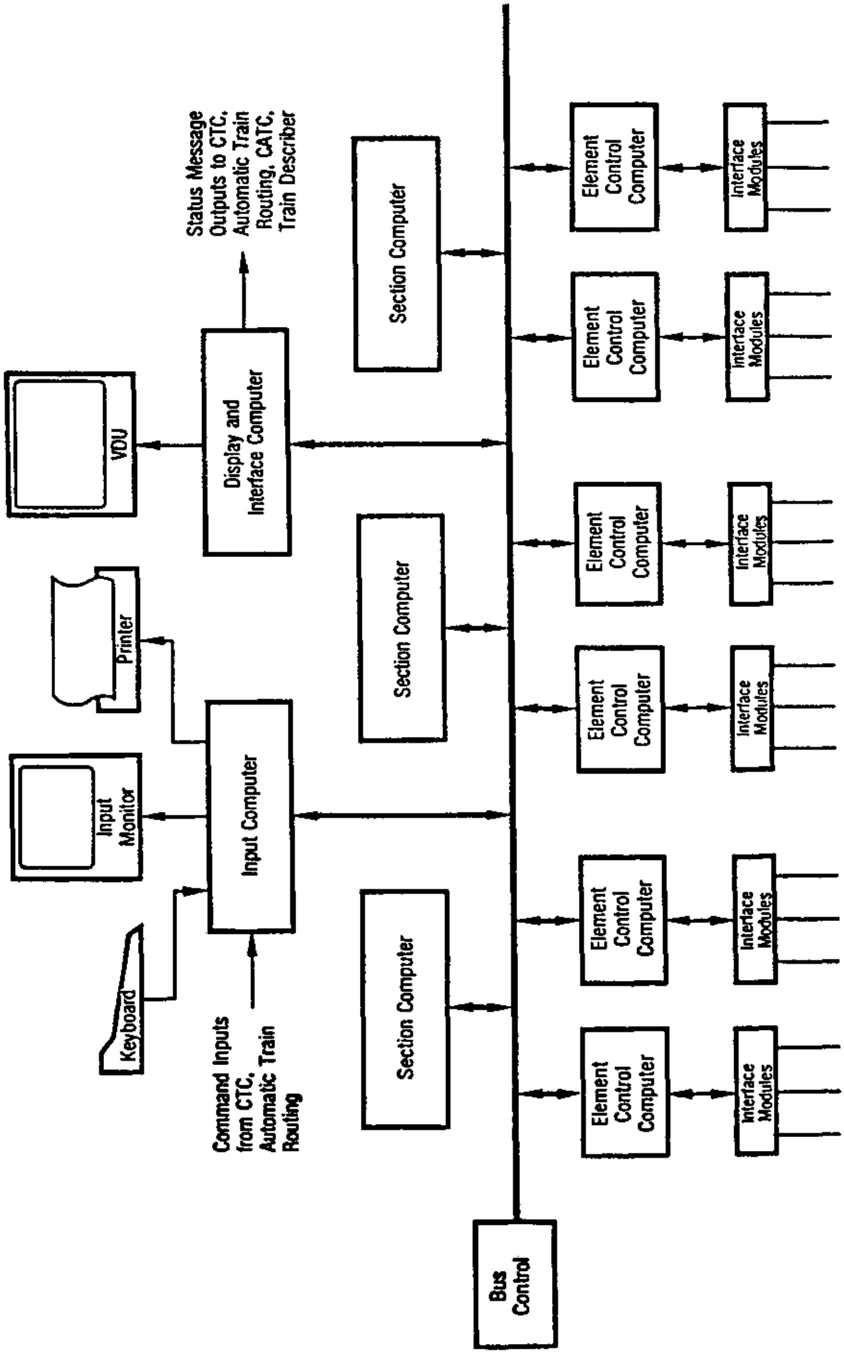

Fig. 3. Microcomputer controlled interlocking, based on a linked system of fail-safe microcomputers acc. Fig. 2.

One of the functions of the **input and display computers** is to provide the interface between the operator and the interlocking itself. All inputs into the system are performed via a keyboard and all displays are shown on a VDU screen, which replaces the traditional display panel.

The **section computers,** as the name implies, are responsible for a certain section of a railway station and contain the actual interlocking logic. They accept route setting commands from the input computer, establish operations to be performed and transmit these control commands to the linked element control computers.

Finally, the **element control computers** convert the received instructions into control commands for the linked trackside elements and monitor their execution. In addition, the status data of all trackside elements is transmitted cyclically to the corresponding section computer. Data exchange between all computers is carried out via an internal bus system, the **interlocking bus.**

All section computers - even those for different stations - have the same programs. After commissioning, the input computer transfers station-specific data, in the form of lists, to the section computers. This concept allows the use of only **one** reserve computer, as hot standby, for the section computers of a station. The same applies to the element control computers. All of these are provided with the same basic programs and only after system start-up do they receive the required additional information from the input computer, for example type and number of connected track elements, such as signals, points and track circuits.

We hope to have shown by these examples that work in the field of fail-safe microcomputers has reached the stage whereby their application is possible even where safety requirements are particularly high, and though requirements differ from country to country - at least at the present time.

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Paper 2:

Microprocessors in Fail-Safe Systems

*By Mr. C. G. Shook**

INTRODUCTION

In the creation of fail-safe railway control systems, the designer is confronted with a myriad of choices. This is perhaps especially true when applying a new technology, such as microprocessors, where standards of acceptance are as yet unestablished.

The current point of debate is the choice of hardware and software configurations involved in the implementation of fail-safe railroad control functions using microprocessors. We have chosen to pursue the single processor approach. We are aware, of course, that other companies (mainly European) follow the multiple processor approach to achieve safety. These appear at first sight to be distinctly different approaches. However, we note that the major design techniques used in the two cases to achieve safety are not that different.

We hold the belief, shared by many, that it is possible to implement safe systems with either single or multiple processor hardware configurations. We further believe that in many circumstances there are distinct advantages to the single processor approach.

The terminology, single processor, as used herein means the employment of a single microprocessor to achieve fail-safe design. While it is possible that such a system may include more than one processor, the reason for inclusion of other processors is not to create a fail-safe system by having two or more processors perform the same tasks and then checking them against one another. Rather the reason for using multiple processors in our systems will be to allow partitioning of functions, to control the overall system response time, or to improve system availability. This concept is illustrated in Fig. 1.

For contrast, the general multiple processor approach is illustrated in Fig. 2. Here, two or more processors are involved with executing the control logic. Some form of cross-checking is included to determine whether the processing is free from errors. If more than two processors are included, increased availability can also be achieved.

This paper will outline the technical and marketing environment that led to the choices made as well as enumerate the design challenges that had to be met in the creation of fail-safe systems employing microprocessors. It will also give some insight into our choices of solutions, although details of the design techniques used are not included here. These can be found in other papers presented to this Institution and elsewhere.

ENVIRONMENT

There has, for many years, been a fundamental difference between European and North American approaches to safety in railway signalling. North American approaches have, for the most part, been based on devices with intrinsic fail-safe characteristics such as the K and B relays of GRS and the Type P relay of US&S. European approaches by contrast have tended to use non-vital devices such as metal-to-metal contact relays.

*G.R.S. Rochester U.S.A.

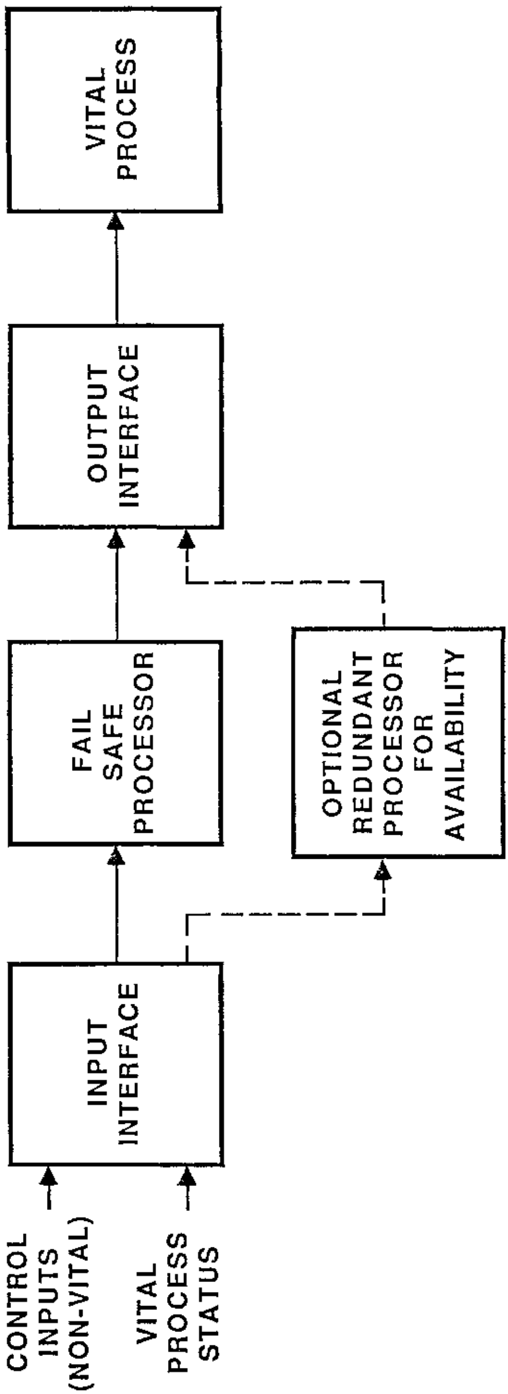

Fig. 1. Single Processor.

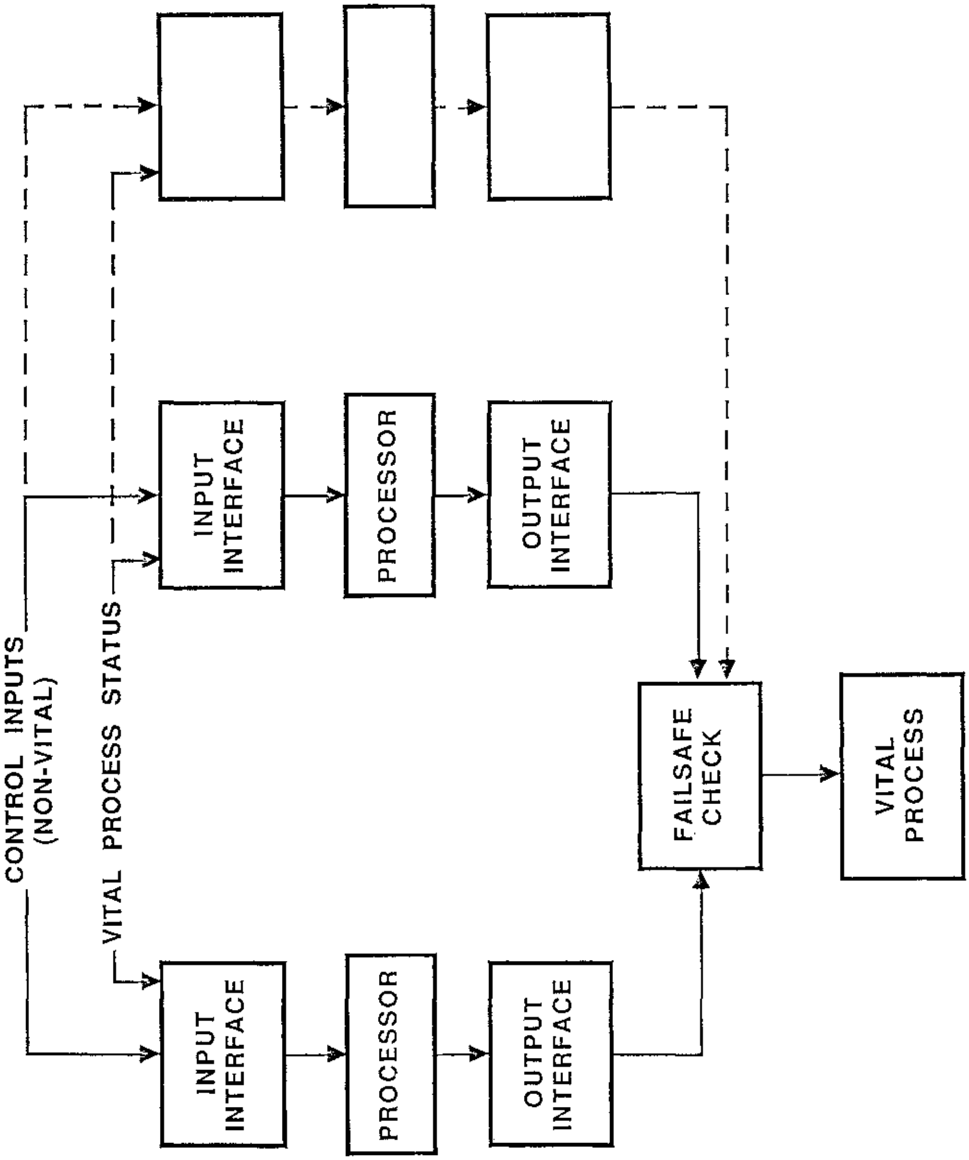

Fig. 2. Multiple Processor.

Safety is then assured by design techniques such as redundancy, back checking, cross checking etc.

Given these fundamental differences that have existed for decades, it is not too surprising that European suppliers would approach microprocessor safety system design using checked-redundancy, cross checking and other techniques borrowed from the predecessor relay systems. By the same token, it is hardly surprising that North American suppliers would choose the techniques familiar to them, such as diversity, cycle checking, etc., to build intrinsic safety into a single processor system.

With the recent exceptions of Conrail and Amtrak (passenger service), U.S. railroads have been privately rather than state owned. There have always been no less than two, and frequently more, major signal industry suppliers in the U.S. Thus there is inherent competition in the U.S. marketplace with the resulting drive to produce a product which provides the lowest cost/benefit ratio and simultaneously satisfies industry, the individual railroad's, and the supplier's own standards.

There are estimated to be more than 2700 multiple crossover interlockings in North America as well as a substantially larger number of single end-of-siding locations. Large complex interlockings, however, are relatively few in number, being located in and around the larger cities. This track configuration is of course directly related to the large distances spanned by the North American railroads and to the fact that the traffic is and has for many years, been dominated by freight rather than passenger service.

This track configuration has further led to the North American practice of vital interlocking logic being housed in wayside locations close to the devices being controlled. Remote control (ctc) is provided from central locations by communication of non-vital information over multiplexed communication facilities.

Much of this is in contrast to the European situation where distances are shorter, traffic density is greater, and passenger traffic represents a much greater proportion of the total. Interlockings are larger with the resulting larger concentrations of controlled devices. Prudent system design in these circumstances has led to larger, centrally located interlocking logic plants, with transmission of vital signals to and from the trackside.

HISTORY

GRS has been involved with and thinking about the use of processors for executing vital logic for more than twenty years. In 1965-66 we carried out a mainline railroad, radio cab signal experiment called Zone Control. At the time we were not satisfied with the degree of safety provided by the purpos-built digital processor. However, we felt the time was not too far distant when we would be able to satisfactorily use processors for such purposes.

In 1971, we committed to the design and supply of a control system for the Rohr Monocab, a people mover to be demonstrated at Transpo '72, the transportation exhibition held at Dulles Airport near Washington D.C. This control system provided all the features of automatic train supervision (ATS), automatic train operation (ATO) and automatic train protection (ATP). The vital train protection function (ATP) was implemented in dual minicomputers, each executing the same program. A fail-safe comparator allowed the vehicles to proceed only if the two computers produced identical results. At the time we were not totally satisfied with this approach but had no better solution to offer.

During the exposition in May and June of 1972, the Monocab PRT system under the control of this multiple processor safety system carried more than 10,000 people. Two separate vehicles, operating simultaneously on the same guideway, and three guideway switches represented the potential hazards against which the safety system provided the needed protection.

In 1974, we began work as a subcontractor on a control system for the Advanced Group Rapid Transit (AGRT) program of the U.S. Department of Transportation. This control system, based on the Monocab demonstration system, also used dual minicomputers for achieving safety.

In November 1977, at an AGRT meeting, much concern was expressed over how to assure the correctness of two complex, identical software programs such as were being designed for the AGRT project. No conclusion was drawn, leaving the uneasy feeling that this would always be an area of risk.

When the primary contractor of the AGRT program decided in 1978, to drop the line of business, our only active connection with multiple-processor safety applications was terminated. From that day on, GRS has never seen fit to resume vital multiple-processor activity, believing that single-processor methods are preferable.

The use of processors in vital signalling applications is, of course, not necessarily limited to interlocking or train protection logic. There are a number of safety devices in use in conventional signalling systems which are expensive and difficult to manufacture. These, and other devices, can be vastly improved in performance by digital techniques, if the logic can be made fail-safe and cost competitive.

One such device is the motor-driven, vital timer. In 1979 we designed a single microprocessor based vital timer which was introduced to the market in 1981.

Another such device is the mechanical rate code generator used for the generation of coded signals in track circuits and cab signal systems. We undertook the development of a single microprocessor based device for this purpose in 1977.

In July of 1978, a single microprocessor based vital speed enforcement governor was field tested on the Airtrans people mover system at the Dallas-Fort Worth Airport.

Trakode II, our vital microprocessor based track communication system was introduced in 1981, to replace the older all relay version.

None of these small, microprocessor based safety devices could be made cost effective and competitive with their predecessors if multiple processors were required to be used in their implementation.

DESIGN CONSIDERATIONS

The use of microprocessors, in any configuration, in safety applications, involves generating task logic that is primordially correct and a hardware/software system that will either faithfully execute the task logic or will revert to a known safe state if hardware failures result in execution faults. An additional requirement is the ability to check the hardware I/O ports for proper functioning. A further very desirable feature would be the ability to predict, with confidence, the rate at which wrong side failures could be expected to occur.

The fundamental design approach taken today does not differ significantly from that in use for over a century. Namely, one must determine what can go wrong, design in such a way that when the possible faults occur the result is no less safe than if the system were functioning properly.

There are those who argue that microprocessors cannot be adequately analyzed in safety applications. This is said to be due to the fact that the component level failures within the microprocessor can neither be accurately predicted nor simulated. While this statement may be true, it is also true that such an approach is not necessary. For any failure that may occur internal to the processor hardware, it is possible to identify the complete set of undesirable outcomes. The task then is to design the system in such a way as to protect against these undesirable results of failure.

Approaching the problem from this perspective, one determines that the design must provide adequate assurance that:

- the inputs to the processor are correct
- the program has executed correctly
- the program has not changed in memory
- data tables have not changed
- inputs and variable data are current
- no program segments have been skipped
- the outputs are correct
- the outputs have not been changed by device failures.

A major application of microprocessor safety systems is interlocking control. Fig. 3 illustrates the general control process for an interlocking. In this application we conclude that three things are necessary in order to have a safe processor-based system. First we must have a set of logic expressions that completely describe what we wish the interlocking to do. Second, we must have a means to accurately translate the interlocking logic expressions into software to be run by the processor. Finally, we must have a logic processor that can be relied upon to either process the program exactly as intended, or revert to a known safe state if the processing is in any way flawed.

Fig. 4 illustrates the fulfillment of these necessities. For the first part, the primordially safe interlocking logic, we must still rely on the signal engineer. He must do what he has done since interlockings first came into being, that is describe how the interlocking is intended to operate under all foresseeable circumstances. His output is a logic expression set.

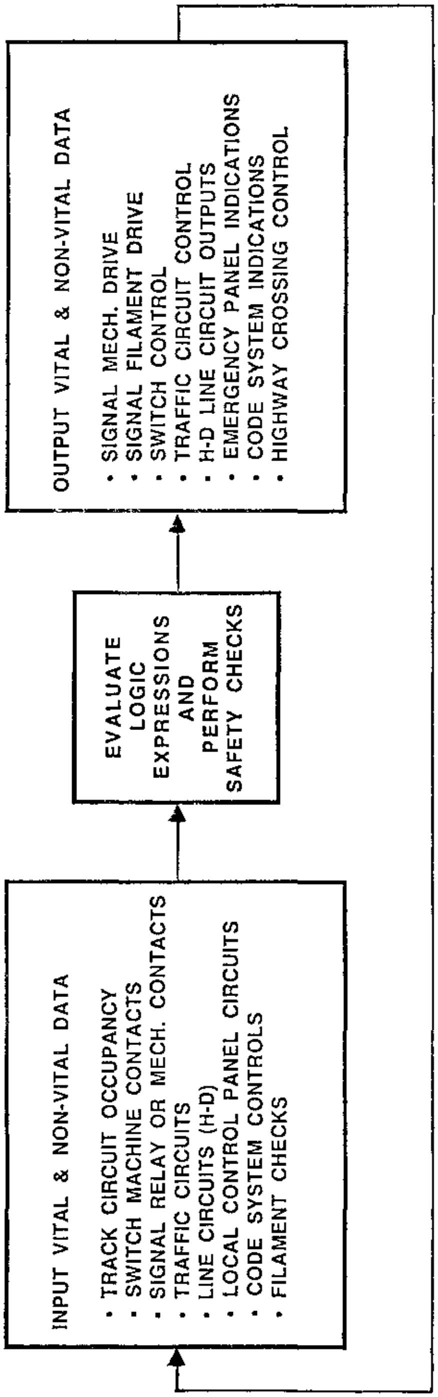

Fig. 3. Interlocking Control Process.

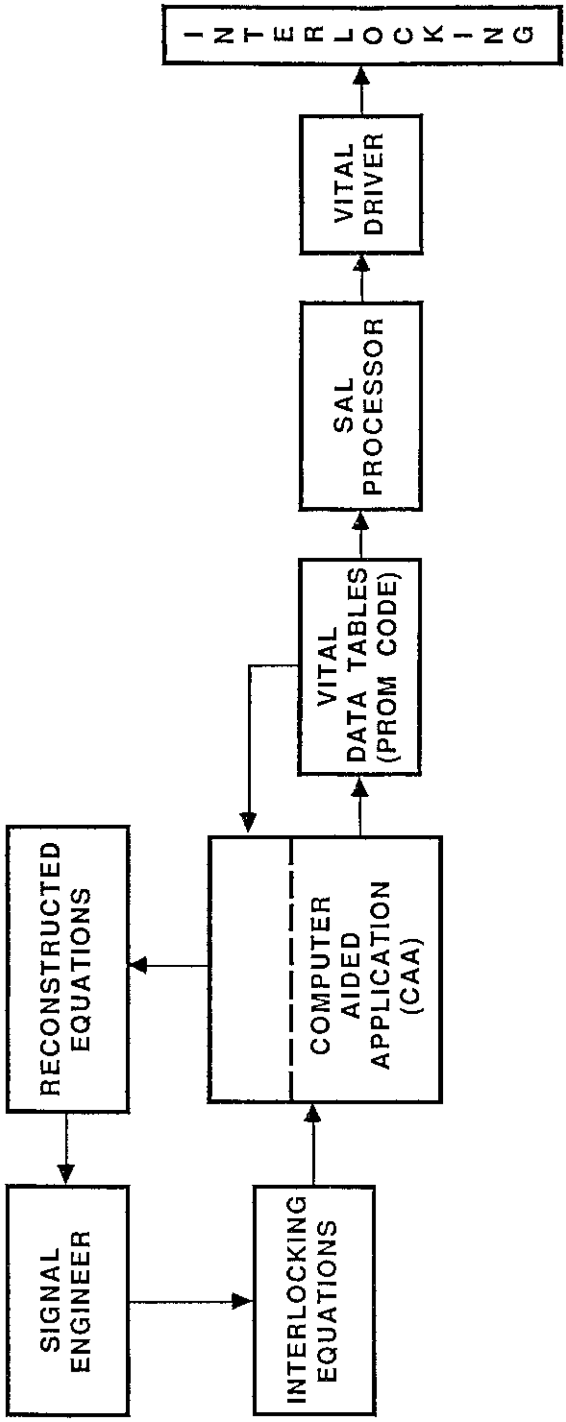

Fig. 4. Interlocking Processor Application.

For the second part, a computer-aided assembly (CAA) package has been designed to assist the application engineer in configuring the system. The CAA program constructs, in two independent diverse channels, the vital data base from the interlocking logic expression set. It encodes testword values, memory location assignments, and expression product term data definitions into PROM code.

To ensure integrity of the vital data base, the CAA check program reconstructs two logic expression sets, one from each of the two independent channels, using only the PROM code as source. These reconstructed expression sets are then checked against each other and against the original by the application engineer to ensure that the CAA's interpretation of the logic expression set is correct.

For the third requirement, we have developed Safety Assurance Logic (SAL) which proves that the primary logic has been processed correctly, or it does not allow an output to be delivered.

The Safety Assurance Logic verifies the performance of the primary logic by making prescribed tests. These tests are designed to reveal any failures that could result in an incorrect output. The mechanism employed is the generation of checkwords. Each checkword certifies the accurate completion of a group of steps. Correct checkwords are not permanently stored in processor memory. All tests must be completed on every processor cycle and new checkwords must be generated. Therefore, a complete and correct set of checkwords is assurance that all vital tests were made and passed.

The checkwords generated during the processing cycle are passed to an independent arbiter, known as a vital driver. This device is designed so that the output is allowed to be delivered only if a prescribed dynamic output is maintained. Only a full and correct complement of checkwords, periodically delivered and destroyed after each cycle will allow the correct dynamic output to be maintained.

In essence then, the processor contains two logic systems: the primary logic to perform the interlocking logic, and the Safety Assurance Logic to vitally assure that the primary logic is accurately executed.

A recent variation on the SAL concept is referred to as NISAL or Numerically Integrated Safety Assurance Logic. NISAL is similar to basic Safety Assurance Logic in that it uses checkwords to prove the processes have all been performed, the data used is current, the outputs have not been corrupted, etc. NISAL differs from SAL in that the checkwords and data are integrated. Each parameter is represented by a multi-bit word which identifies not only the state of the parameter, but also its unique identity. Therefore, for a Boolean parameter there are two applicable words, one for its true state and the other for its false state.

The system is arranged so that the parameter representations are affected by every operation that must be checked. A set of correct values of the parameter representations therefore is proof of correct system performance and that permissive outputs may be allowed to exist.

The probability of erroneously allowing the existence of a permissive output is related to the lengths of the words that represent the parameters. The longer they are, the less likely it is that they will, by chance, turn out to be one of the applicable words when a failure has occured.

With basic SAL the checkwords can be thought of as generated separately from the data representations, whereas with NISAL the checks are carried within the data representations.

While basic design techniques used in dealing with fail-safe microprocessor systems remain very similar to those which have been used for decades, there is now one more design factor which must be dealt with. Digital and microprocessor systems lend themselves readily to statistical failure prediction. Formal failure analysis techniques which were developed in conjunction with military and aerospace programs are now being applied to railway signal systems. One of the advantages of NISAL over SAL is that the probability of wrong side failure is more easily predicted and controlled. The ability to predict numerical rates of wrong side failure now adds this new dimension to safety design, that of deciding, in quantitative terms, what rate of wrong side failure is acceptable.

In the past, judgement was made as to the likelihood of each failure possibility and those deemed to be sufficiently unlikely to occur were dismissed from further consideration. Those deemed unacceptable were designed away. The judgement was made on the basis of intuition and experience. This more subjective judgement of the past was easier in many respects to deal with.

CONCLUSION

I hope I have conveyed the message that the GRS preference for the single microprocessor method of implementing vital logic functions did not develop without some understanding of and experience with the multiple processor alternative.

I also hope to have conveyed the message that the final choice of hardware and software configuration can be, and often is, significantly influenced by factors other than just the technical ones.

Finally, I reiterate my opening statement that we believe safety can be achieved in either single or multiple processor configurations.

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DISCUSSION

Opening the discussion, Mr. R. E. B. Barnard congratulated the authors on their exposition of the various safety philosophies used by their companies.

He commented that there seemed to be a trend in the civil aircraft industry towards diversity of software and hardware, possibly going to 'two-out-of-three' in each case, for flight control systems.

The nature of modern chip design, using CAD packages, might mean that there were hidden, possibly pattern sensitive, common failure modes. It was accepted that it was impossible to fully test the more complex processors. How did the authors take account of this?

Electrical noise could have the same effect on both of the Siemens synchronised processors, leading to an undetected error. The GRS approach gained some degree of safety from processing different forms of the data at different times. How was the adequacy of the interference immunity of any new system established?

It had always been possible to decide on an acceptable level of wrong-side failures, but people had shied away from doing it. Prediction of wrong-side failure rate achievement by a system was still difficult. Unexpected factors, such as carelessness in design and checking, poor quality control in manufacture, insufficient testing and poor maintenance were probably more significant than the potential failures known to the designer. Constant vigilance was required to prevent the unexpected happening.

Mr. Wobig replied that diversity, however it was defined, had been suggested as the remedy for common mode failures and the uncontrolled factors mentioned. Similar processors from different manufacturers might not be sufficiently different, whereas different types of processor were unlikely to show common errors.

Half of software errors have been found to be due to faulty specification. Diversity should start at the specification level. Different programming teams would not resolve specification errors.

There was a need to know what benefits were obtained by diversity, and at what cost. The initial investment was high and there was a need for assurance that replacements for hardware components would be available over a period of many years, up to 30 or more. There was always a need for a second source and the problem was compounded, if hardware diversity was used. Duplicate programming was very expensive and there were difficulties with independent maintenance when there were changes in the field.

Mr. Shook felt that there was a problem of semantics over the question of diversity. GRS claimed to use diversity in designs and systems, but it was different from what Siemens termed diversity. GRS felt that the same degree of safety can be achieved with a single processor. Storing inverse representations of data, in different memory locations, was a form of diversity that guarded against certain faults in the processor and in the memory. Independent processors and software, as a means of diversity, falls down when the system needs to be debugged to make it operate. Diversity meant different things to different people.

The engineer was frequently frightened by the fact that it was now possible to do an analysis and determine the probability of occurrence of a wrong-side failure. Knowing the number made it more real than judging that something was not significant. In the USA, and possibly elsewhere, the operating department tended to have more influence than the signal engineers so far as safety matters were concerned. Major causes of fatalities and injuries were not signalling systems but lifts, escalators and similar situations. The railway signal industry was, therefore, often accused of over designing systems when money could be better spent in other areas.

Estimates for wrong-side failure rates often did not agree to within an order of magnitude.

Mr. Wobig stated that neither DB nor Siemens thought that exact calculation of the probability of dangerous failures was possible. A sound knowledge of the different types and rates of failure that might occur in the computers was required. This was not available at the present time.

In a dual channel system the failure rate was dependant upon the individual failure detection times. The longer a failure in one channel remained undetected, the greater was the probability of a failure in the second channel occurring. Even so, only if the failures were more or less identical would a dangerous system failure occur. It was extremely difficult to produce accurate figures.

Mr. Shook commented that, from experience, attempting to do these calculations, which at best were only estimates, was very expensive.

Mr. J. Catrain asked if Siemens were satisfied that safety could be achieved with a single processor. This was not yet acceptable in France.

Although calculation of the wrong-side failure rate might be difficult, it was essential for the supplier to convince the customer that adequate security had been achieved. This had been the case with relays. What tests had the authors carried out to this end.

Mr. Wobig was not convinced that one computer was as safe as a two computer system. The GRS system used one computer with several processors, with safety assurance logic. It was difficult to show that failure in the one processor could not affect both the safety logic and the safety assurance logic in the same way. The same CPU was being used in a similar way, employing a real dual channel system and a reliable fail-safe comparator, there must be two independent but more or less identical failures before a wrong-side system failure could occur.

In Germany, DB had set up standards for electronic equipment for safe use in signalling installations. In particular, there were requirements for maximum failure detection times in a dual channel system. It had been accepted that, with extensive checking of the hardware and software production processes, the system would be adequately safe. Several other customers had also accepted this approach. For new developments, such as electronic interlockings, there had to be a long period of testing under very abnormal adverse electrical and environmental conditions.

Mr. Shook remarked that GRS did not have the same arrangement with their customer as Siemens, hence the need to attempt to calculate wrong-side failure rates. Some customers were willing to accept the assurance of the supplier that the equipment was safe. Others required some kind of proof, which had been found to be more difficult and expensive than designing and delivering the system.

The real question, which applied to all systems, was how the possible failure modes had been addressed and was the safety level acceptable.

There was a feeling that all new techniques and devices should be demonstrably satisfactory by field testing. In fact, a reasonably acceptable failure rate cannot be demonstrated in a reasonable testing time. All that testing did was to show that no unacceptable failures had occurred in that time. It did not demonstrate that the system was adequately safe, but it did give the customer some confidence.

Mr. J. D. Corrie pointed out a problem in availability. When parallel systems were used, there could be a problem on first failure and changeover to the second channel. An interlocking had to remember the sequence by which the system state was arrived at, as in approach locking particularly of opposing routes. He suggested that a 'two-out-of-three' system provided continuous safety throughout the changeover.

Mr. Shook responded that one group of users in the USA felt that if there was a processor, then there must also be a standby. This might mean an unacceptable increase in cost.

There were three approaches to availability. Small installations were assumed to be fairly reliable. When they did fail, then technician attendance was required for repair. Large installations required a cold or a hot standby. In the former case, there would be some time period when the system was out of operation while the new processor catches up. With a hot standby, whichever fail-safe processor was felt to be healthy was qualified to provide control, without a break.

Mr. Wobig agreed. Siemens had provided a number of hot standby systems. In the case of the section computers there was one standby for the group, because the programs were the same. There had been no problems over the changeover.

Mr. P. Barker suggested that there were differences between North American and European practice. The Siemens dual channel system had comparators on each input and output channel and could tolerate a single channel failure. The GRS single channel system would shut down on an input or output channel failure. The lower passenger traffic density in the USA might affect the design of fail-safe systems.

Mr. Wobig pointed out that Siemens had duplicated the input and output channels in order to be able to check the channel electronic equipment. If there was a disagreement there was no point in processing doubtful data. The redundancy was not for availability but for failure detection in the input ports. Failures in the output ports were a matter for concern.

Mr. Shook stated that, in the GRS system, an input port failure removed only those output ports affected.

The relatively low passenger traffic density in the USA affected the size of interlockings and the frequency of trains, hence the acceptance of lower system availability.

Mr. Wobig pointed out that the Ericsonn company in Europe also favoured the one computer concept for its interlockings. There might be little to choose between the overall hardware requirements of single and dual processor systems. There were difficulties in showing to the differing assessing authorities that the approach offered was acceptably safe.

Mr. C. Brown pointed out that both approaches described in the paper relied on one set of safe software. How was this prepared. How was it ensured to be correct and would not lead to wrong-side conditions.

He also asked if the synchronised dual processor system could suffer from a common mode failure due to outside interference.

Mr. Wobig noted that not all dual channel systems used synchronised channels. Siemens had used this solution for simplicity in the hardware comparator. All systems should be protected against external electrical and electromagnetic influences because much information of vital importance was stored in registers and memories. Special precautions were needed against the effects of lightning. Siemens had been able to satisfy their customers that there were no effects from such outside influences, so the synchronous dual channel system was acceptable.

Mr. Shook said that there had always been a requirement, since the first mechanical interlocking, that safe operation would occur if the system operated as intended. The need for ensuring the safety of the primordial logic was as valid today as it had always been.

Given a set of equations that described how the interlocking should operate, assurance was required that the system executed properly. It was assumed that hardware might fail but the software would not, provided that the code correctly reflected the designed logic.

Mr. Wobig said that the correctness of software was a very difficult matter. Systematic documentation of the programming steps and measures to develop, test and validate the software were needed. At all stages, a second independent programmer checked for agreement with the specification. This applied to the separate modules as well as to the complete system combined with the hardware. The real problem was of failures hidden in the original specification.

Proposing a vote of thanks to the authors, Mr. D. Glyde said that it was always a pleasure to listen to a speaker expert in his subject. Tonight there had been a double measure of such pleasure. He was grateful to the authors for addressing in their paper, and in the discussion, the very fundamentals of the application of microprocessors to fail-safe duties. He thanked the President for arranging such an interesting double act.

Technical Meeting of the Institution

held at

The Institution of Electrical Engineers

Monday, 10th November, 1986

The President (Mr. J. G. Oehler) in the Chair

The Minutes of the Technical Meeting held in London on 14th October, 1986, were taken as read and signed by the President as a correct record.

The President then introduced Mr. H. Steinbrecher (I.T.T. Vienna, Austria) and requested him to present his paper entitled "Videopult. A Video Display Control and Management System for Interlockings".

Videopult. A Video Display Control and Management System for Interlockings

*By Mr. H. Steinbrecher**

INTRODUCTION

In large railway stations with conventional relay interlocking systems, e.g. geographic interlocking systems, for the display of points, signals, tracks and train-numbers and used for their control, a panoramic display is available.

In Austria, the operation of a large route interlocking system was not in general controlled by pushbuttons on the display but through a command keyboard at the signalman's workstation. Each pushbutton on the panoramic display was allocated a three-digit number. These numbers were selected, as required, by the signalman and entered into the route interlocking system via function keys on the command keyboard.

The Videopult system has been developed by ITT Austria and the OBB (Austrian Federal Railways) as an alternative to the conventional command keyboard.

Today, in conventional interlocking systems the Videopult is the standardized operator man-machine-interface in Austria. The interface between operator and equipment was at the heart of the designsystem. Not only the classic indication and operating functions for the route interlocking facilities, analogous to the conventional command keyboard, were to be taken into account, but operation of the system was considered as a general task which was required in an integrated management system. The station management has been assisted by the Videopult system but retains its role as a decision maker, particularly for complex decisions. At the same time, human error was to be largely prevented by the system.

It was important for the indication and operation equipment to be independent of both the technology and make of the equipment that was to be controlled. To achieve this objective, the latest communication technologies and ergonomic principles were to be employed during design.

* I.T.T. Vienna Austria

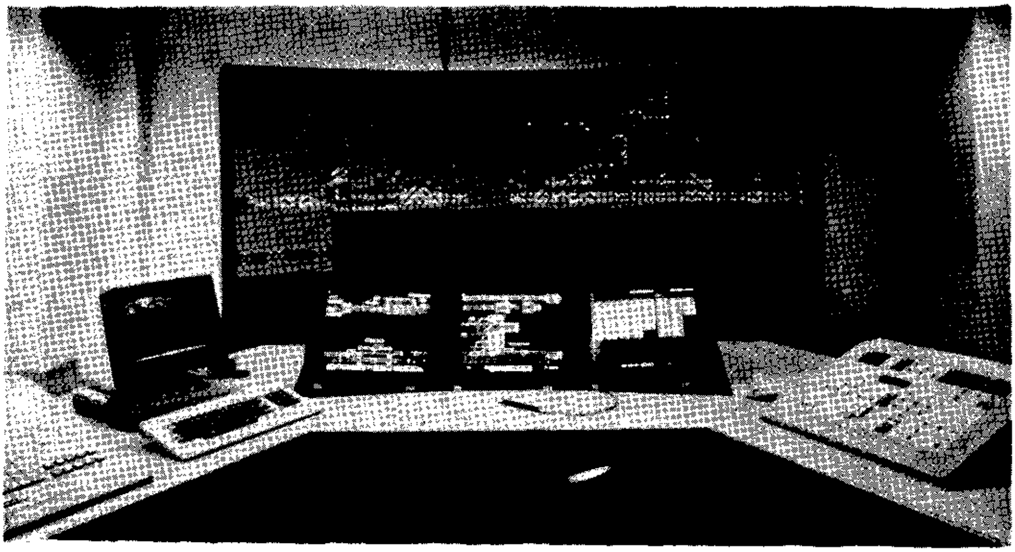

Fig. 1. Typical control post.

STRUCTURE OF THE VIDEOPULT SYSTEM

Basic Considerations

The objectives of the Videopult required the design of an equipment layout for the indication and operation functions that had to be clear, logical and provide the necessary operational flexibility.

A cathode ray tube was the natural choice as a display for the indication function since it had been proved valuable in train control centres for many years. The decision to use a colour screen followed because of the complexity of the tasks to be performed. A colour display makes it easier for the operator to rapidly assimilate a wide variety of information. A solution to the problem of entering instructions was, however, more difficult to achieve.

From the outset it was clear that integration of the operation of all technical facilities would only be acceptable to operating personnel if the system allowed associative interactive operation.

After careful analysis, a light-sensing pen was chosen for feeding in instructions to the indicating monitors.

Symbol Design

Special attention was given to the design of symbols for illustrating the wide range of rail operations. Basically the aim was to use a representation based on symbolic association; this means the choice of simple symbols that were familiar to and easily interpreted by the operating personnel. As an example, a main signal in the stop position is symbolized by a red bar across the track. When the signal condition changes to "go", a green arrow replaces the red bar. A shunting signal which is in the clear position is represented by a blue arrow in a white frame, analogous to the old mechanical shunting signal in Austria, which was a blue board with a white frame.

Human factors were used when considering the possible combinations of background colour with symbol colour; this made an important contribution to achieving the aim of

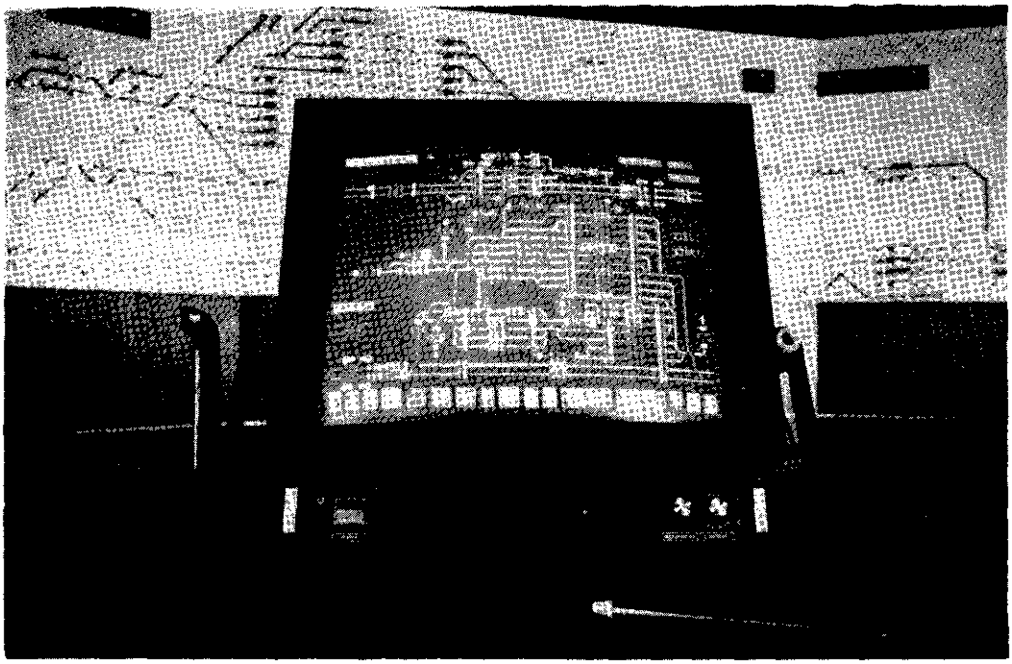

Fig. 2. Visual display with light sensitive pen.

symbolic association for the operating condition symbols.

Input of Commands

In the Videopult system, commands are fed in using a light-sensing pen. The light-sensing pen will be placed on the desired symbol (e.g. signal or switch) on the surface of the cathode ray tube and gently pressed. Pressing the light-sensing pen operates a contact which will switch on the phototransistor in the tip of the light-sensing pen, thereby generating the corresponding signalling command for the master computer.

The system confirms input of the command by flashing the appropriate symbol. Commands from the master computer are only passed to the interlocking system when the appropriate enabling key at the lower edge of the picture is pressed.

These enabling keys correspond to the group buttons of the panoramic display; in this way the proven operation method of the panoramic display has been retained. For example, when the operator wants to reverse a switch by using the panoramic display board, he has to press the push button of the respective switch and the so-called "switch group" - push button. If the operator wants to do the same actions by using the light-sensing pen via the screen, he has to press the light-sensing pen on the symbol of the respective switch and subsequently on the symbol called "switch group field".

Past experience has shown that command input using a light-sensing pen is quicker than using other input media, e.g. an alphanumeric keyboard. Nevertheless, a numeric keyboard is available for additional functions and to provide a back-up in the event of a monitor failure.

Hardware Configuration

The Videopult, in its basic configuration, consists of a master computer, a scanner and a semi-graphic process video system with input possibilities through a light-sensing pen or a numeric keyboard.

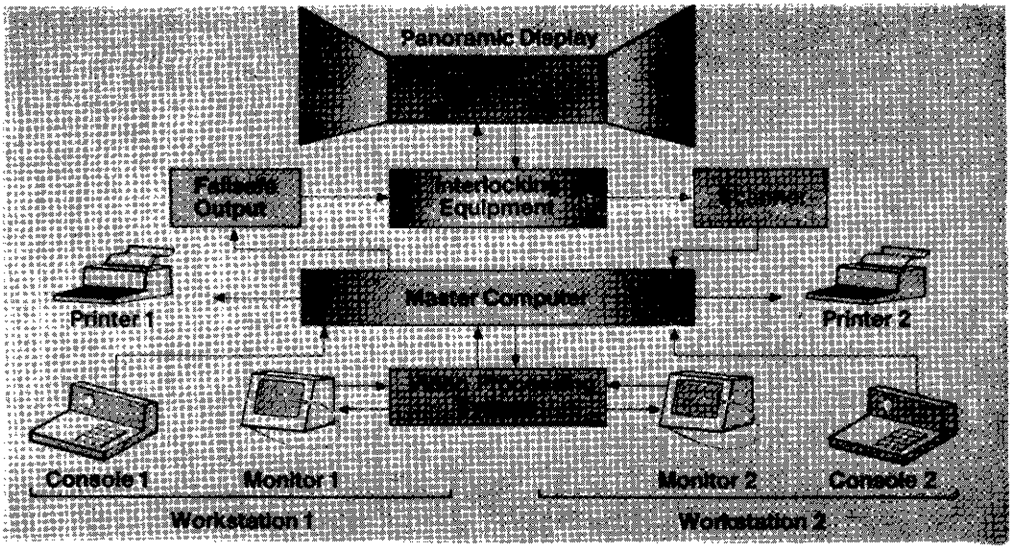

Fig. 3. Hardware structure.

The scanner, which is part of the ITT 0802 microcomputer family developed by ITT-Austria, is connected with the panoramic display or the interlocking system. Depending on availability, free contacts are used for scanning. If no contacts are available, scanning is carried out at the lamps of the panoramic display via suitable interface equipment. This scanning flexibility makes it possible to connect the Videopult system to any type of system available. All input signals are cyclically interrogated. A digital filter suppresses transients caused by contact bounce.

Sufficient logic switching is provided in the scanner for the logical evaluation of signals. At medium-sized stations with approximately seventy switches on an average, 1400 signal inputs are connected to the scanner. To one scanner 1024 input signals can be connected. So normally two scanners are provided in a station. The memory requirement necessary for scanning and processing is approximately 64 kbyte.

After evaluation, information from the scanner is passed to the master computer, which also belongs to the ITT 0802 microcomputer family. The master computer provides the central signalling function for the Videopult system. The 580 kbyte memory stores all constant and variable data relating to the connected facilities. Essential data for display on the monitors is passed in serial format to the video process system. In turn, the master computer receives commands which have been fed in using the light-sensing pen. The numeric keyboards (consoles) are connected directly via particular inputs to the master computer. The output of signalling commands from the master computer to the interlocking equipment is via compulsive guided relays ITT 65E (printed board-qualified relays used for fail-safe circuits in railway signalling). The contacts of these relays are switched in parallel with the corresponding buttons on the panoramic display board.

For the video processing system, a Process Video System made by Krupp-Atlas-Electronics is used. This semi-graphic system met all requirements with its 2048 screen fields and 256 freely definable symbols per picture. With one light-sensing pen up to four monitors can be handled. The simple, rapid creation and programming of process pictures by a light-sensing pen had a major influence on the choice of system.

To the basic configuration of the Videopult system additional operational modules and interfaces can be connected if used in a

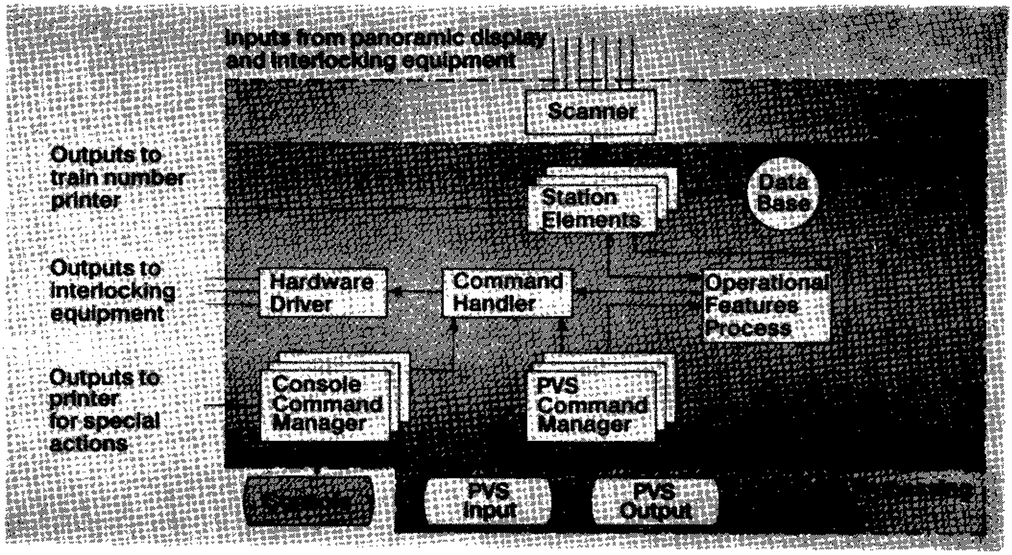

Fig. 4 Software structure.

station. The configuration can be enlarged to more operator positions, if e.g. more than one signalman for lining up of train movements or an additional operator for shunting movements are needed. Also the number of monitors used for an operator position can be varied according to the size of the station, e.g. two monitors for a medium-sized station, three or even four monitors for large and very large stations.

Software Structure

The software of the Videopult system is provided in CHILL, a real-time programming language for processor controlled switching systems. The static language properties of CHILL reflect today's state of engineering by providing PASCAL-like constructs for structured programming and user definable data types. The real-time multitasking capability of CHILL, which supports concurrent execution of processes, is essential to its use in control and switching systems. The main features supporting concurrent execution of processes are dynamic process management, process synchronization and communication, and mutual exclusion. The Videopult system is based upon a complete CHILL environment, including compiler, operating system and test tools.

The tasking capabilities of CHILL were enhanced by introducing features such as time-out handling, special input/output operations and database access. The additional tasking features are implemented without changing or extending the CHILL syntax, by using the concept of operating system primitives - built-in procedures with a pre-defined parameter and exception list.

In the Videopult system the master computer is the heart of the control software. This software consists of the following management components:

- the "station elements" to indicate the state of station elements on the monitors. For each type of station element (e.g. departure signals, home signals, switches, tracks with or without train number indication) one process type is provided. The main tasks of these processes are:
  - (i) receiving of element changes from the scanner;
  - (ii) storing the new state of the elements;
  - (iii) sending the specific messages to the Process Video System.

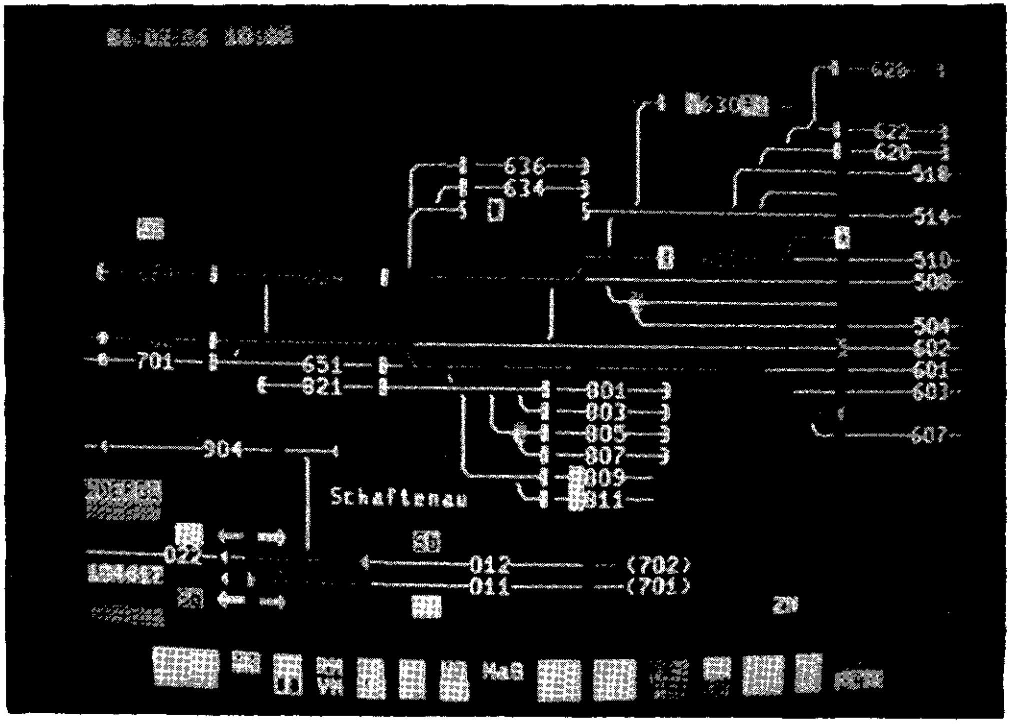

Fig. 5. Track diagram.

- Signal processes, switch processes and track processes are additionally responsible for the automatic train number movement in a station.
- the "command input management" which consists of the "console command manager" and the "PVS command manager" to work up the commands which are transmitted from the Process Video System or the console in serial format.
  The main tasks of these modules are:
  (i) Checking whether the inputs from the light-sensing pen or from a console are correct commands or not;
  (ii) sending the system indications back to the Process Video System (e.g. start flashing to the activated symbol or input error indication) or to the console;
  (iii) sending of complete commands to the "command handler".
- the "command handler" is responsible for issuing the commands, the setting of the output relays and executing the commands one after the other.
- the "operational features management" for automatic functions.

The application software of the Videopult system is independent of the specific station. All data which are necessary to project the station are stored in a database of the master computer.

In the database are stored:

(i) data which describes the geography of the station (e.g. needed for train number switching);
(ii) data for updating the pictures on the VDU's;
(iii) data for carrying-out commands to the interlocking equipment (e.g. the port/bit-information, which is necessary for the "command handler" to set the output relays).

OPERATIONAL FEATURES OF THE VIDEOPULT

Track Diagram

- display of track diagram based on previously proven diagrams;
- status of the fail-safe facilities is continuously scanned, and the results are displayed on the VDU's;

- display of date and time are on the VDU's. This data can be entered or changed by the operator via the numeric keyboard;
- Names of the destination stations are displayed on a coloured background. Train numbers are displayed with the same background colours as the designated destination stations, thus facilitating co-ordination of the destination and train number by the operator;
- Track memories allow rapid setting up of frequently used routes;
- "registered actions" are initiated in a similar way using the light-sensing pen on the monitor. If, for example, a substitution signal is set (e.g. in Austria needed should a green lamp of a main signal fail), then the associated symbol of the main signal is activated using the light-sensing pen. The number of the track section before the main signal begins to flash as soon as the main signal associated signal relay at the output of the master computer is activated. This relay reports back the number of the track to the operator in a fail-safe indicator on the numeric keyboard. However, the signalling command is only passed on to the interlocking equipment after the operator is satisfied with the correctness of the track number and has pressed the enable and group buttons on the console;
- passages through the station can be entered by the operator with one command via the light-sensing pen. The several routes of the passage are automatically activated one after the other by the master computer. The passages are freely programmable by the operator in a similar way by using the light-sensing pen;
- The function key area on the screen includes not only group keys for the fail-safe facilities but also labels (e.g. working group, track locking) that can be placed on the desired track section using the light-sensing pen. Up to four different labels can possibly be placed in one track section at the same time.

Switch Tabulation

For normal operations (e.g. route setting) the information of the positions of the switches in the track diagram are sufficient.

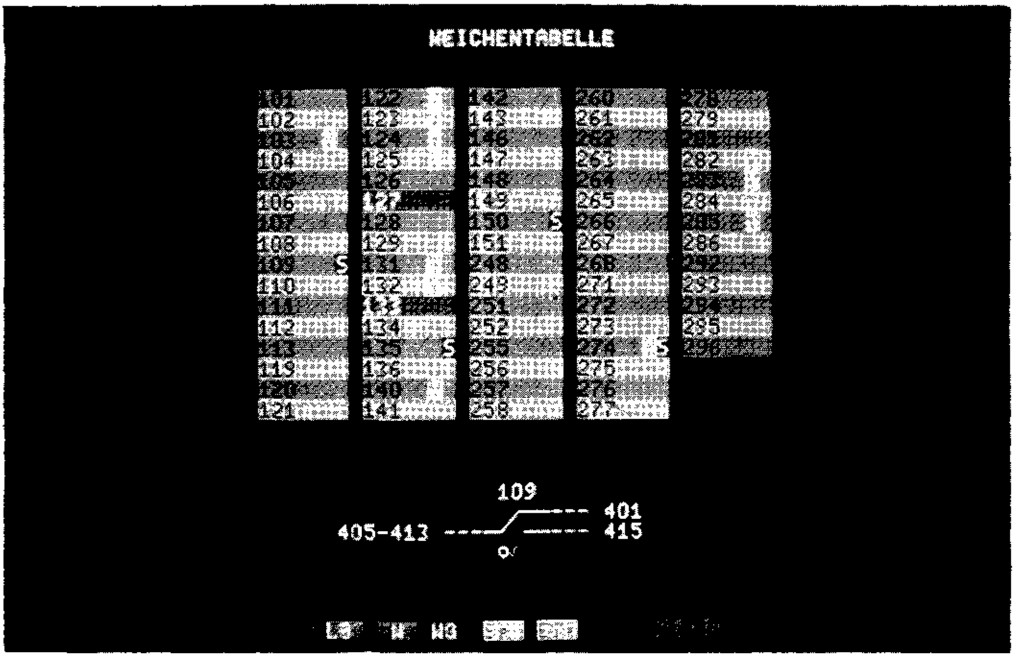

Fig. 6. Switch tabulation.

Additional information (e.g. number of the switch, manual locking) are necessary in case of maintenance or disturbance. For that purpose the picture on the monitor can be switched over to the so-called "switch tabulation".

This picture shows a table including all switches of the station ordered by their numbers. Using the light-sensing pen, rapid switchover of the pictures is practicable. With the "switch-tabulation" the operator can manipulate a switch, when he knows only the number of the switch and not its position in the track diagram. In addition to the approved display in the track diagram, an enlarged display is provided that can show the switch requested by the operator, including detailed information in the familiar form of a panoramic display.

Train number functions

The indication and the movement of train numbers is a feature needed in all modern large stations. Therefore it is completely integrated in the Videopult system. The input of a new train number is normally transmitted from a neighbour station using its own complete train number indication system or a numeric keyboard. If trains are generated in stations with Videopult the train number is set and handled with the light-sensing pen.

The first digit of the train number is normally used to indicate the desired destination of the train. Derived from this first digit an automatic lining up of routes to the defined destination can be done. The operator himself can define the individual route through the station and handle and fix it with the light-sensing pen. He can also change the input with the light-sensing pen very simply, if it is necessary.

The routes of all trains with train numbers beginning with this digit will be lined up automatically without an input from the signalman, as soon as the train approaches.

Suitable fault indications are provided for the automatic lining up of routes. So, for example, the operator's attention is called by the system when a train approaches and the system cannot immediately line up the route because another train is crossing. Or a signal did not change to "go" in time after the system had given the operating instruction to the interlocking equipment.

Another two additional features are included in the Videopult system for train number indication and train movement. One of them is the possibility to inform other station staff (e.g. the platform signal man) about the actual train movements in the station. If necessary, a simplified track diagram can be shown on a black-and-white monitor. This picture indicates train numbers, the position of the main signals and track occupations. Also, the Videopult system is provided for delivering information (e.g. train number movements) to a central train despatching system. The information can be transmitted by a separate serial data link channel.

Automatic Lining Up of Shunting Routes

In the Videopult system, shunting routes can be lined up automatically. The operator can immediately store a desired sequence of shunting movements by touching the symbols of the desired tracks on the monitor screens with the light-sensing pen.

The complete block of shunting routes can be started by one single command with the light-sensing pen. All subsequent routes are lined up automatically at the earliest possible moment, that means as soon as the last common track section of two consecutive routes is free. In this way, the operator is relieved of a routing activity, the tracks are signalled earliest and the dead time required for human action is eliminated.

Two different types of shunting routes can be handled in this way:

- fly shunting movements, pushing cars from one track into a series of other tracks;
- changeover movements, changing trains from track to track.

Three different shunting movements can be stored and worked out by the system at the same time.

Normally this feature is operated by an additional operator for shunting movements, but if necessary the stored blocks and function keys can be switched over to the workstation of the signalman.

Catenary Group Switching

Apart from the interlocking facilities, the switching of traction current is another of the signalman's management responsibilities.

Without Videopult, catenary groups are handled by means of switch elements totally separated from the signalling installation. This

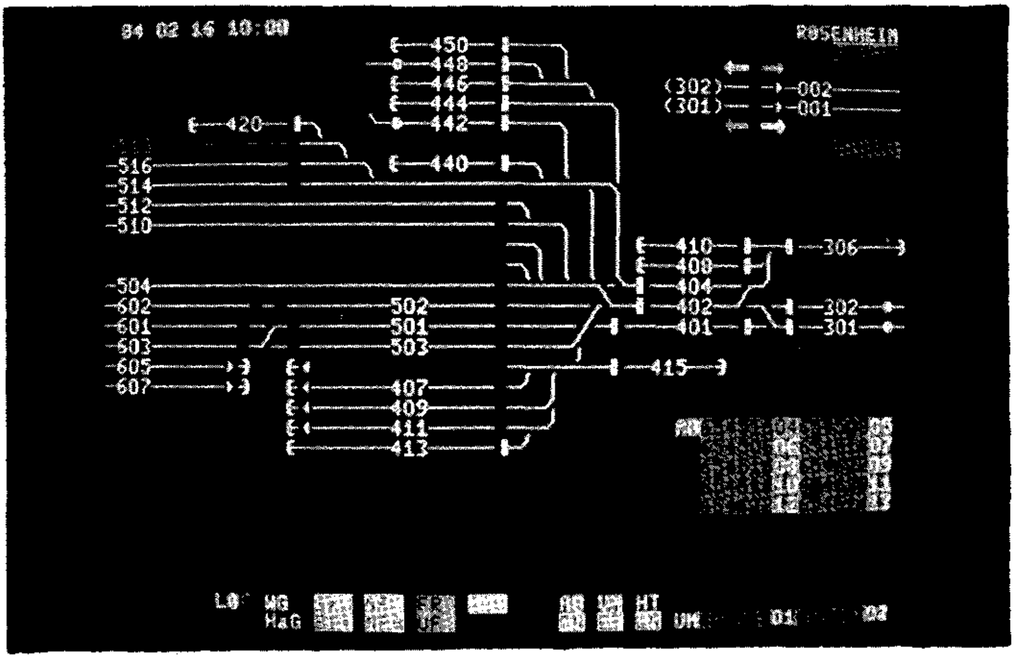

Fig. 7. Lining up of shunting routes.

can be integrated in the Videopult system, displaying the status of the catenary groups on the same monitors as those for the indication of track elements.

The change of pictures on the monitors is done by the light-sensing pen. The catenary picture on the VDU indicates the states of the catenary groups and of the catenary switches.

The update of the catenary picture takes place in the same way as that of the track diagram. Input signals from the catenary equipment are cyclically interrogated by the scanner and messages are sent via the master computer to the Process Video System.

For operations, the light-sensing pen is used. Two operational modes are provided:

- the catenary of the station is remote controlled by the line powerstation. In this mode the catenary picture is used like a memo-book. The operator can make notes by using the light-sensing pen, catenary groups will be switched off in a short time;
- the catenary of the station is locally controlled. In this mode, catenary groups can be switched off or on by the operator directly with the light-sensing pen via the screen.

If a catenary group is switched off or if there is a note about switching off in a short time, this state is automatically indicated in the picture of the track elements for all affected tracks. In this way, all operations ordered by the signalman are concentrated in the Videopult - an integrated management system.

Reporting Procedures

In a railway station, quite a lot has to be documented. This means that the signalman has to write into different books, and this needs a lot of time.

The Videopult system offers computer assisted reporting procedures which could replace all existing manual reporting books written by the signalman or by the maintenance man such as:

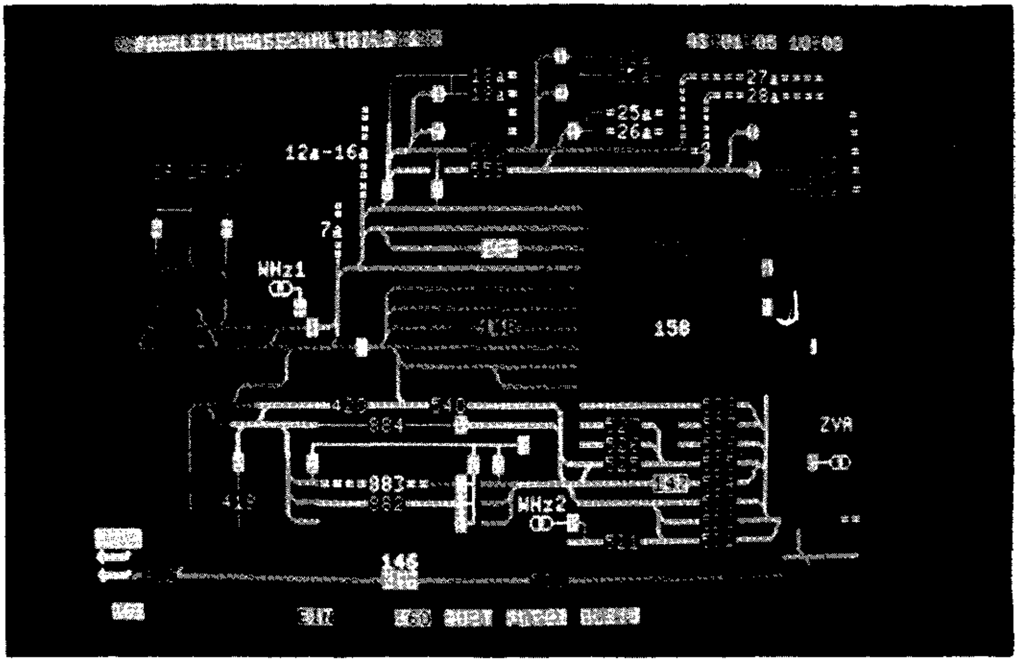

Fig. 8. Catenary diagram.

documentation of emergency commands which must be given in case of disturbances. These special actions by the operator which could lead to a dangerous situation by overriding the fail-safe equipment are printed out on the so-called "fault printer". The documented actions are necessary in order to move rail traffic as smoothly as possible should faults occur in the fail-safe equipment; this function is intrinsically dangerous since the safety of rail traffic is ensured exclusively by the attention of the signalman;

- documentation of "station management" procedures. For example, it can happen that the block installations between two stations are disturbed, so that all train movements must be handled by telephone calls. On the one hand the "station management" feature helps the signalman not to forget a telephone call, which could cause a dangerous situation, and on the other, it documents the telephone calls on a printer, on a separate monitor and in the non-volatile memories of the "station management processor" (a part of the master computer module) as soon as the signalman confirms the call with the light-sensing pen by touching the respective symbol on the monitor. The documentation is combined with the train number. Another example is the cover of a working group working in a track section. If the operator places the label "working group" in the desired track section on the screen using the light-sensing pen, a fail-safe circuit prevents the setting of a signal for a train movement into this track section. After pre-announcing a train by telephone and after advising the working group, the operator confirms the call with the light-sensing pen by touching the respective symbol on the screen. This handling will be documented and subsequently the signal will be set in the clear position automatically. After departure of the train, the track section will be locked automatically for the next train. Once a day, a complete list of the events of the day, including all train movements with train numbers, is printed out in a train-relevant order;

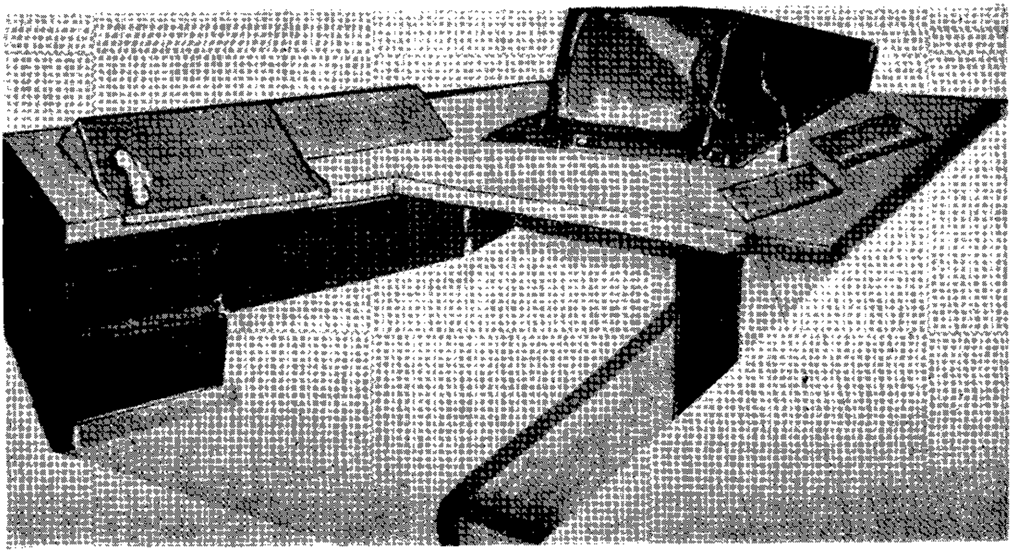

Fig. 9. The operating position.

- information available in the master computer is also used to detect faults in the interlocking equipment. Fault detection for all essential equipment (e.g. switches, signal lamps, axle counters) is integrated in the Videopult system, thereby achieving a higher availability of interlocking equipment.

OPERATOR POSITION

Considerable importance is attached to human factors in the design of the operator position. All statutory and medical regulations and guidelines have been taken into account during the design phase. This refers to the monitors as well as to all equipment necessary for the management of a station.

In a modular way, the size of the operator position can be built up optionally with the required number of equipments and monitors for smaller or larger stations.

CONCLUSION

The Videopult system makes an essential contribution to the management of railway station operations in which the interactive operational control using a light-sensing pen has proved excellent.

The Videopult system was originally installed for field trials at the Wolfurt freight station in Austria in 1981, the aim being to test the concept of an integrated facility for controlling train movements and shunting operations. The man-machine-interface between the operator and the route interlocking system was made the cornerstone of the development.

Training of operating and maintenance personnel did not present any problems, and there were no technical problems.

Finally, the stipulated cost target was met; the system offers a better cost/utilization ratio than any conventional system has achieved for the OBB.

Today, in Austria, four railway stations with Videopult are in operation. In one of the largest stations, the main station of Linz, Videopult is being installed.

Most of the features of the Videopult system will also be applied in the man-machine-interface of the future electronic interlocking system made by ITT Austria.

The mentioned features of the Videopult system show the status of today, but there are no obstacles preventing the inclusion of new requirements in order to combine station operation, station management and train disposition as efficiently as possible.

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DISCUSSION

Opening the discussion, Mr. E. O. Goddard thanked the author for his very interesting paper. He asked why the light-pen had been chosen for inputting information, rather than a tracker ball or touch sensitive screen.

Was a disk used to log data or was a printer alone relied upon?

Auto route setting was used for running and shunting movements. Did one type of movement have priority over another type or was it a case of first come first served?

How was train identification achieved for trains entering the system from outside?

How was the fail-safe output mentioned in fig 3 achieved?

In response, Mr. Steinbrecher stated that the reason for choosing the light-pen was for speed of operation by the signalman. The light-pen was quicker than using other media.

The disk was used only for the video display system. EPROMs are used for the master computer and scanner memory.

The registered commands and actions are recorded on a fault printer in a fail-safe manner. This is necessary in Austria because reliance is placed upon the signalman to perform correctly.

Under automatic route setting, running movements have priority over shunting movements, determined by the first digit of the train number. There is no distinction in the interlocking itself. Train number information is input from a keyboard at each fringe station.

The fail-safe output from the computer was required to enable the signalman to check that the proposed system action agreed with his intentions.

Mr. K. E. Hodgson asked what were the considerations involved in obtaining a better cost/utilisation ratio than with a conventional system. Were equipment lives taken into account.

How accurate was the pointing requirement for the light-pen?

In response, Mr. Steinbrecher stated that the basic Videopult configuration was cheaper than the conventional command keyboard and train number display. The integrated management features naturally cost more, because they were not realised in conventional systems.

The light-pen target area was about 1cm square, so it was simple to feed in commands, as with push buttons. Consideration had to be given to ambient lighting level and the operator position.

Mr. G. J. W. Meecham asked how frequently the push buttons on the panoramic display panel were used.

Did use of the light-pen interupt the major system scan, to provide minimum delay?

Could different sections of track be displayed on one screen or were a number of screens required to obtain an overview?

Was the signalling interlocked with the traction supply, to prevent trains becoming section-gapped?

Was there any system duplication, to avoid complete failure?

Mr. Steinbrecher stated that Videopult was an alternative to the command keyboard for controlling the panoramic display. The panel push buttons were a back-up.

A scanner dealt with 1024 inputs in a cycle time of 250 milliseconds. The system response to light-pen input was about three seconds.

The number of monitors provided depended upon the size of the station layout. Each could be used for light-pen input.

In Austria, the signalman controlled both the signalling interlocking and the overhead line equipment, therefore the customer did not require any other connection between the two systems, reliance being with the operator.

In medium sized stations there was no duplication of the Videopult system. At Linz, duplication was being developed,, whether it would be hot, warm or cold standby was to be decided by the customer on cost and operational grounds.

Mr. F. W. Harris asked if the system would be appropriate for a mass transit railway, with few points and automatic train regulation.

Mr. Steinbrecher stated that the goal for Videopult was to develop and automate an alternative to the command keyboard with the panoramic display. This was not required for a small station, but there was still a need to input data for supervision. It was still true that conventional push button keyboards were cheaper than an equivalent screen based system. There was a need to balance costs against the benefit derived.

Mr. C. H. Porter asked if control of signalling and power supply had always been carried out by the signalman in Austria. Was the catenery control equipment provided by another supplier?

Had combination of telephone and signalling functions been considered?

Mr. Steinbrecher stated that the overhead line control equipment was stand alone, from a different supplier. Inputs from the signalman were combined, for the first time, in one integrated management system.

The telephone equipment was provided by yet another supplier. It was intended to combine the telephone and signalling in the future, as part of the integrated management system.

Mr. R. C. Nelson asked if it was intended to use the system to drive a passenger information system, using the data that was already available. Mr. Steinbrecher replied that again there was a different supplier for passenger information system. It was politically not acceptable to integrate the two systems, although technically possible.

Mr. F. M. Hewlett commented that the Austrian philosophy appeared to differ from standard BR-NX panels. There was a possibility of pressing two buttons simultaneously to give an unambiguous request to the system, with some simplification. Use of the light-pen forced a sequential set of push button operations.

He felt, from personal experience, that the light-pen was easier to use than the tracker ball, particularly with the large screen target areas provided.

Mr. Steinbrecher pointed out that parallel button pushing on a large panoramic display might not be possible. Sequential input was quite common.

He agreed that the light-pen was much quicker than the tracker ball and seemed a more natural operation.

Mr. R. G. Fenge felt that one advantage of the CRT display over the panoramic panel was the speed at which it could be upgraded, with a ROM database. Was this electrically reprogrammable or more permanent? Were changes carried out by the supplier or by the user.

Mr. Steinbrecher stated that the video pictures were stored on disc. After system failure it took two or three minutes to normalise the video system. Detailed updating took only a matter of seconds.

Alteration of the EPROM database was performed by ITT whenever a layout was changed, at the request of the customer.

Mr. R. S. Wickenden asked how the Videopult system was related to the timetable.

Mr. Steinbrecher responded that, in Austria, stations used a despatcher system. The Videopult was not a despatching system. Automatic train movements were handled in response to the first digit of the train number, without any reference to a timetable.

Technical Meeting of the Institution

held in Paris

Friday, 21st November, 1986

The President (Mr. J. G. Oehler) in the Chair

New S.N.C.F. Electronic Interlocking at Tours

Part 1: Introduction

by Mr. R. Retiveau (S.N.C.F.)

GENERAL

The ORLEANS (LES AUBRAIS) line to TOURS (ST. PIERRE DES CORPS) is located on the PARIS to BORDEAUX route.

The double track line is travelled by an average of 160 trains each day. Traffic can achieve 180 trains on Fridays and 195 trains on some peak days of the year.

On average, normal traffic includes 30 passenger trains, non-stop travelling between ORLEANS and TOURS, 14 trains travelling at 200 km/h and 16 at 160 km/h, 40 passenger trains travelling at 160 km/h or 140 km/h, with one or several stops between ORLEANS and TOURS, most of the stops in this case on the main track, while 90 goods trains travel at 80 or 100 km/h.

Figure 1 shows a detail of the traffic graph for this line.

The amount of this mixed traffic, with trains operating at such a diversity of speeds (200 km/h on the one hand, and 80 km/h on the other), with such different assignments (direct non-stop trains and local trains stopping at all the stations) meant that the line had to be equipped with bypass tracks, i.e. tracks ranging between 1200 and 1800 metres in length, with fast access points from the main track to allow slow or local stopping trains to be parked, under optimum conditions of speed, while it is passed by a fast express train. Four bypass tracks on the odd side and five bypass tracks on the even side have been installed in this way.

In addition, the requirements for maintaining fixed installations (tracks, catenaries, etc.), with current maintenance methods, involve the implementation of machinery running on rails (tampers, catenary maintenance machines) causing stoppage in the circulation of commercial trains on the track being maintained, during the period of maintenance.

To deal with these constraints, the tracks had to be provided with signals allowing easy circulation in both directions and junction installations for two main track sections, 7 to 15 km apart (Fig. 2.).

For these installations to be efficient, a centralized control post was needed, referred to as the regulation and switching post*, to be informed in real time (1) on the traffic situation, and capable of controlling, again in real time (1), switch manoeuvres so that the trains can use the routes decided upon by the controller, with the least lost time possible.

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* Poste d'Aiguillage et de Régulation (P.A.R.)

(1) The term real time relates to being informed of an event or to being able to carry out an order within a period of a few seconds.

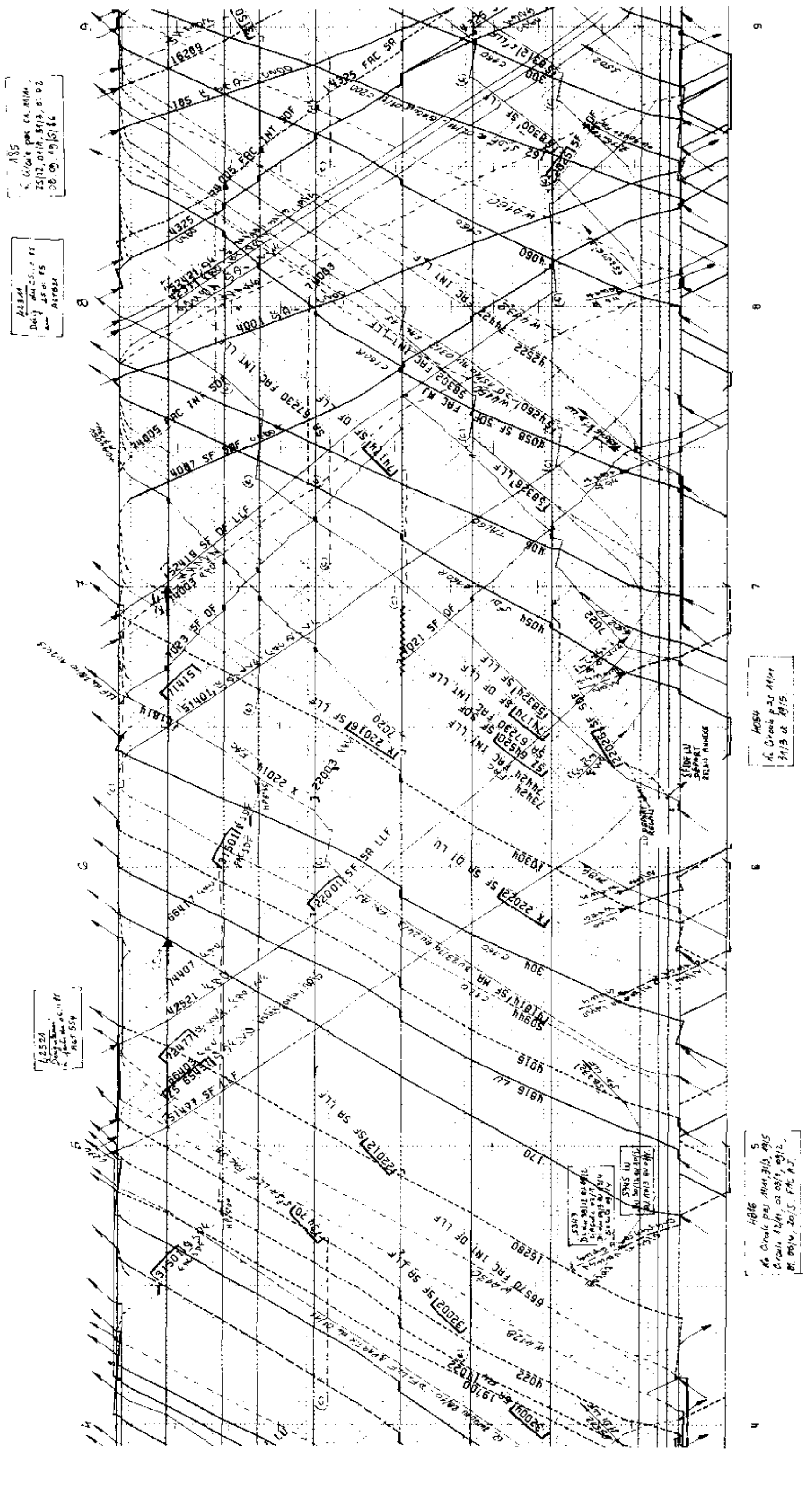


Fig. 1. Detail from the traffic graph for the line.

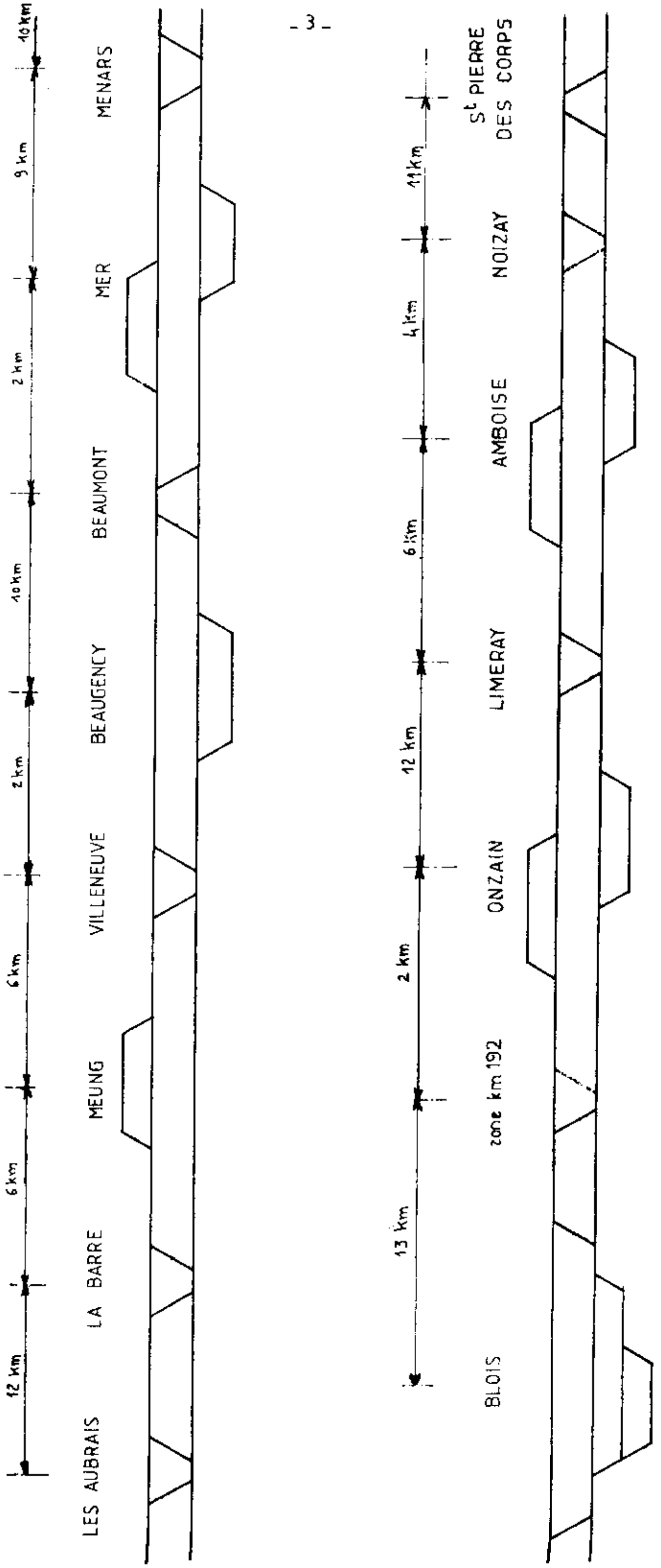


Fig. 2. Diagram of the dual track beteween Orleans and Tours.

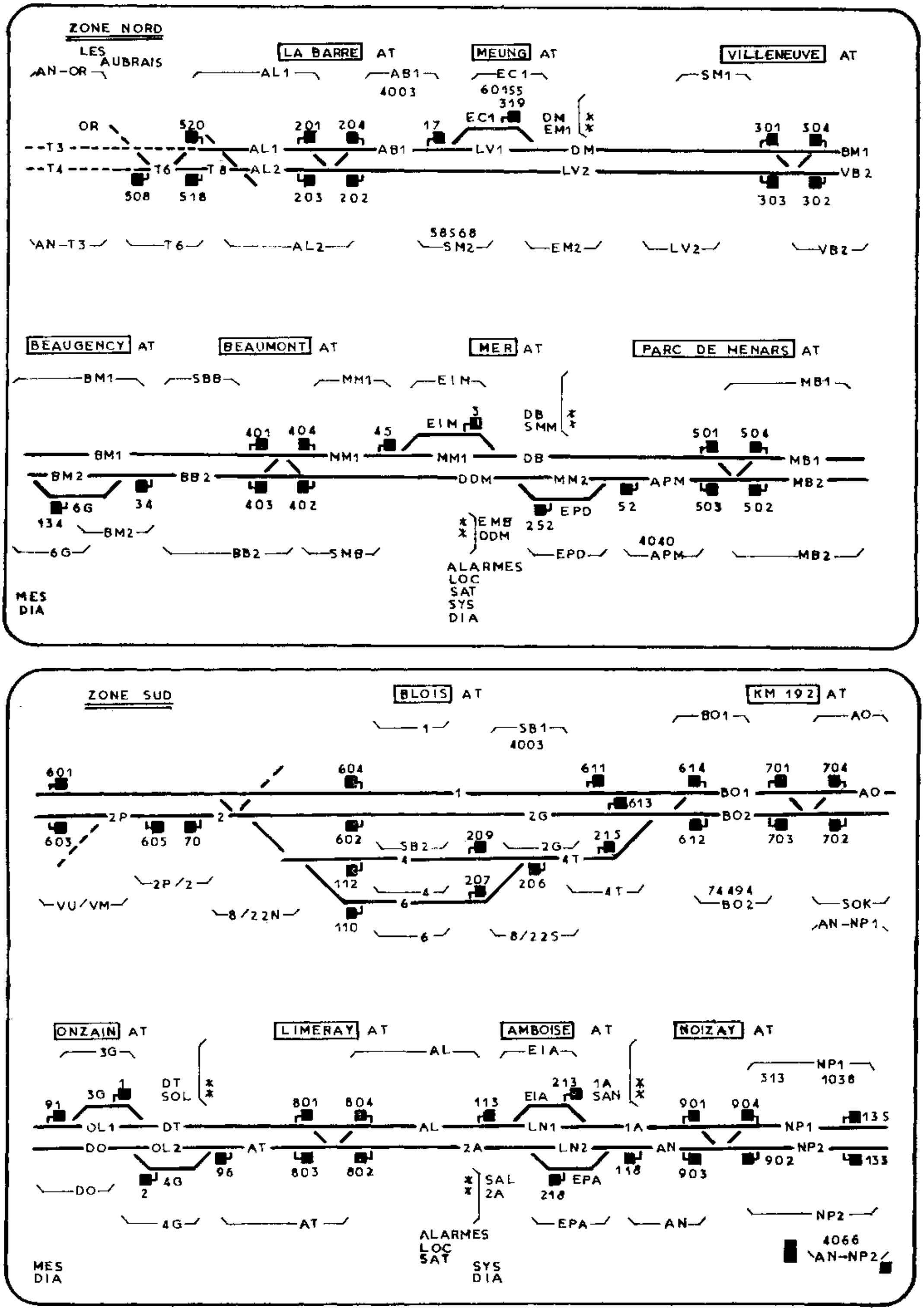


Fig. 3. Screen images.

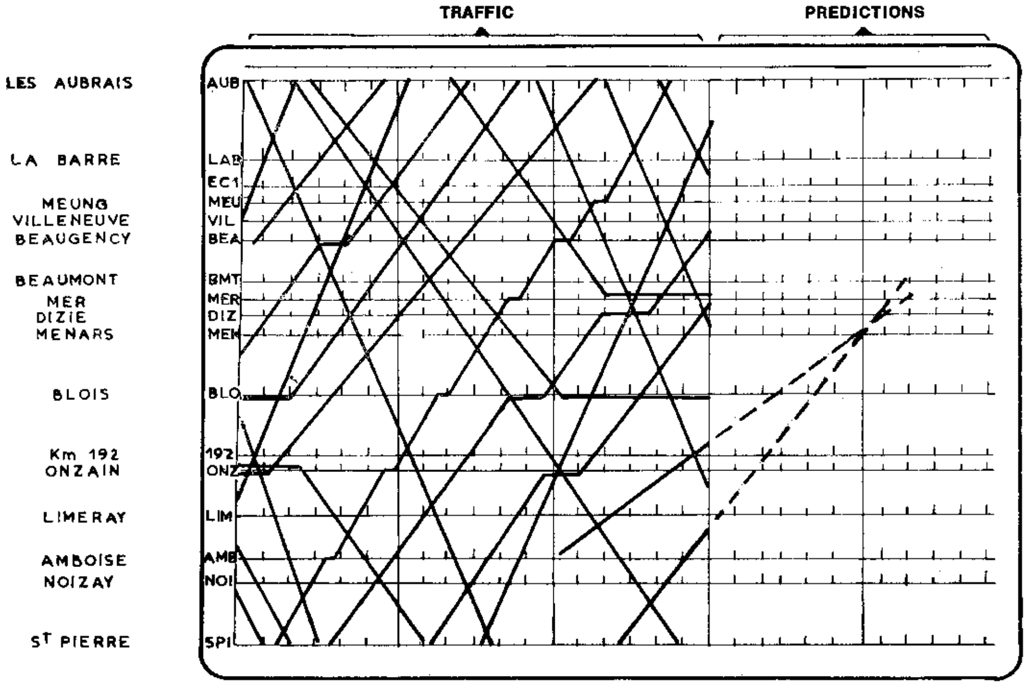


Fig. 4. Automatic graphic screen.

DETAIL OF INSTALLATIONS

The information required for making the right decision is:

- that referring to the current situation, i.e. identification and location of trains, speeds and the signalling states (routes traced or not)
- that relative to the near future, i.e. the determination of future conflict (whereby a slow train might be caught up by an express train, for instance).

The equipment used to give this information to the controller are display consoles providing three types of images:

- one traffic follow-up image (Fig. 3.) giving a simplified diagram of the geography of the entire line. It is cut into track sections, opposite which the numbers of trains using them are displayed.
  The image also displays the traced routes.
- An image of the real time-space graph of train circulation (Fig. 4.).

The slope of the line characterizing each train, gives sufficiently accurate information on the speed of the train for the controller.

At the request of the controller, the graph may be extended at a given time on the hypothesis that the train will continue to travel at the speed set by the controller, in this way displaying any possible traffic conflict.

By means of the above information, the controller can take his decisions regarding the train.

To apply these decisions, he can control the routes concerned by means of his alphanumeric keyboard.

These commands are stored in a programmer. On the approach of the trains concerned, the routes are formed as a function of the stored data.

However, note one particularity of the system: its control by exception; this means that when the situation is normal, the direct routes are traced permanently within the system (the routes are then considered as 'permanent trace' routes and the automatic feature of the centralized post does not enter into play).

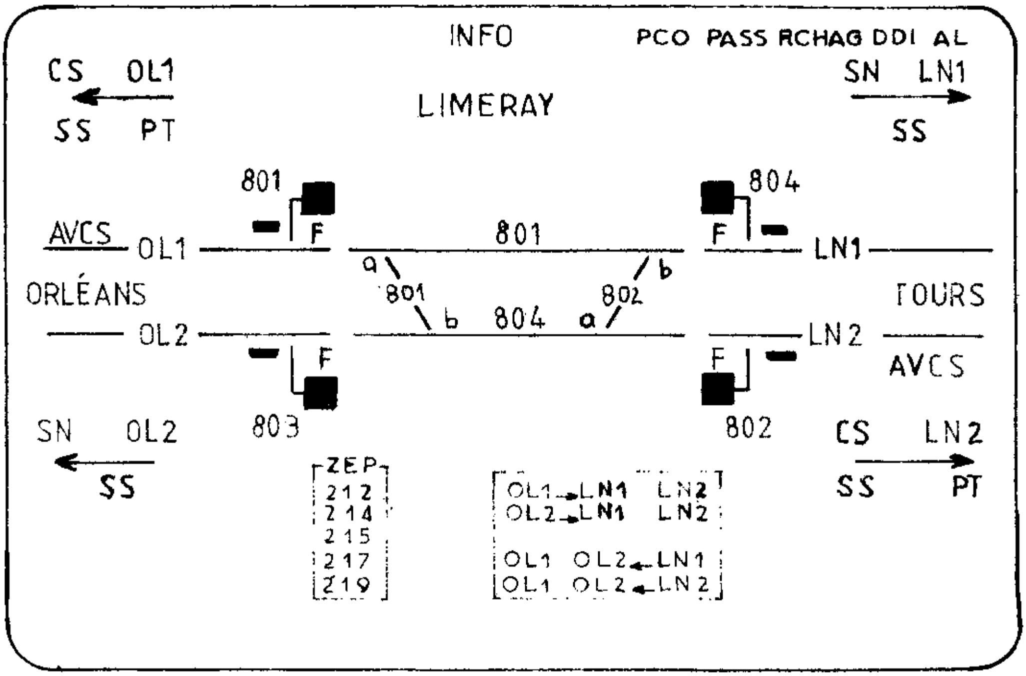


Fig. 5. Display screen (signalling type).

When a command for a non-normal situation (ordering a route to use a bypass track, or ordering a route in the opposite direction) is entered into the system, it is carried out on the approach of the train concerned, and as soon as the latter has left the switch zone, the corresponding direct track route is automatically ordered and forms immediately as part of the permanent route.

Further, in a perturbed situation, should the controller wish to obtain fine information on the signalling installations, by a keyboard entry, he can request the display on one of the screens of conventional signalling information (information comparable with that appearing on a traditional optical control panel) (Fig. 5.).

Finally, it should be pointed out that the train numbers can be entered into the system:

- currently, and normally, by the AUBRAIS and ST. PIERRE DES CORPS posts, by entry on the alphanumeric keyboard
- later, and normally, by an electric link between the follow-up systems which equip the AUBRAIS and ST. PIERRE DES CORPS zones, on the one hand, and the line follow-up system between these stations, on the other,
- exceptionally, by the controller.

Part 2: Detailed Description

by Mr. M. Poré (Jeumont Schneider)

GENERAL

The TOURS control centre (P.C.C.) installation is an illustration of the policy, for standardisation of module systems, on the SNCF as concerns data processing systems linked with railway signalling.

This module subdivision is based on the most careful possible distribution of the various functions.

The choice of a modular design, as well as structurized programming methods guarantee a quick design of each installation, a high level of reliability, safe working and a good understanding of the equipment, by the user, well adapted to his local needs. This architecture allows also an optimized availability, the interactions, in case of a software or hardware failure remaining limited.

The standard communication protocols between modules allows for the solving of any obsolesence problem. Indeed, each advance, either in technology or 'user needs' research will be well adapted. The standard procedures for transmission links being independent from the chosen technology. At this point the installation does not risk becoming rapidly obsolete and its possibilities can be adapted to the new requirements of the user.

The software of all modules is parametered. The basic program is the same for each module of the same kind, the specific features from one module to another ("description" of the module) being achieved only through parameters. The modification that may occur, thanks to a change of the surroundings (new traffic, modification of the area which is controlled by the system, new track layout), will only involve a modification of some parameters inside one (or several) module(s), or if it becomes necessary, the addition of some new modules.

The various functions carried out at TOURS include:

- traffic follow-up (train describer) function (SUIVI module)
- transport printing function (MADEX module)
- display-dialogue function (AFDIAC module)
- train list management function (FICHIER module)
- graphic traffic function (GAS module)
- mimic diagram function (TCO module)
- itinerary control function (MCI module)
- teletransmission function (SNTI).

These modules have been developed with S.N.C.F. (Division des Appareillages et Automatismes) and two suppliers: CSEE and JEUMONT SCHNEIDER.

DESCRIPTION OF MODULES: SUIVI, AFDIAC, FILE, MADEX

Train describer (SUIVI) module

The train describer module ensures the following main functions:

- localizer management
- train index management
- dialogue and received message execution
- alarm management
- filing for maintenance operators
- management of time and date.

It analyses the received messages, checks that they can be executed and, if not, supplies an alarm for the operator.

It checks the performance of the system by detecting unserviceable links, abnormalities linked with the acquisition of unit entries, etc.

All detected alarms are filed on the maintenance printer. Only those with a possible effect on transport are displayed for the operators.

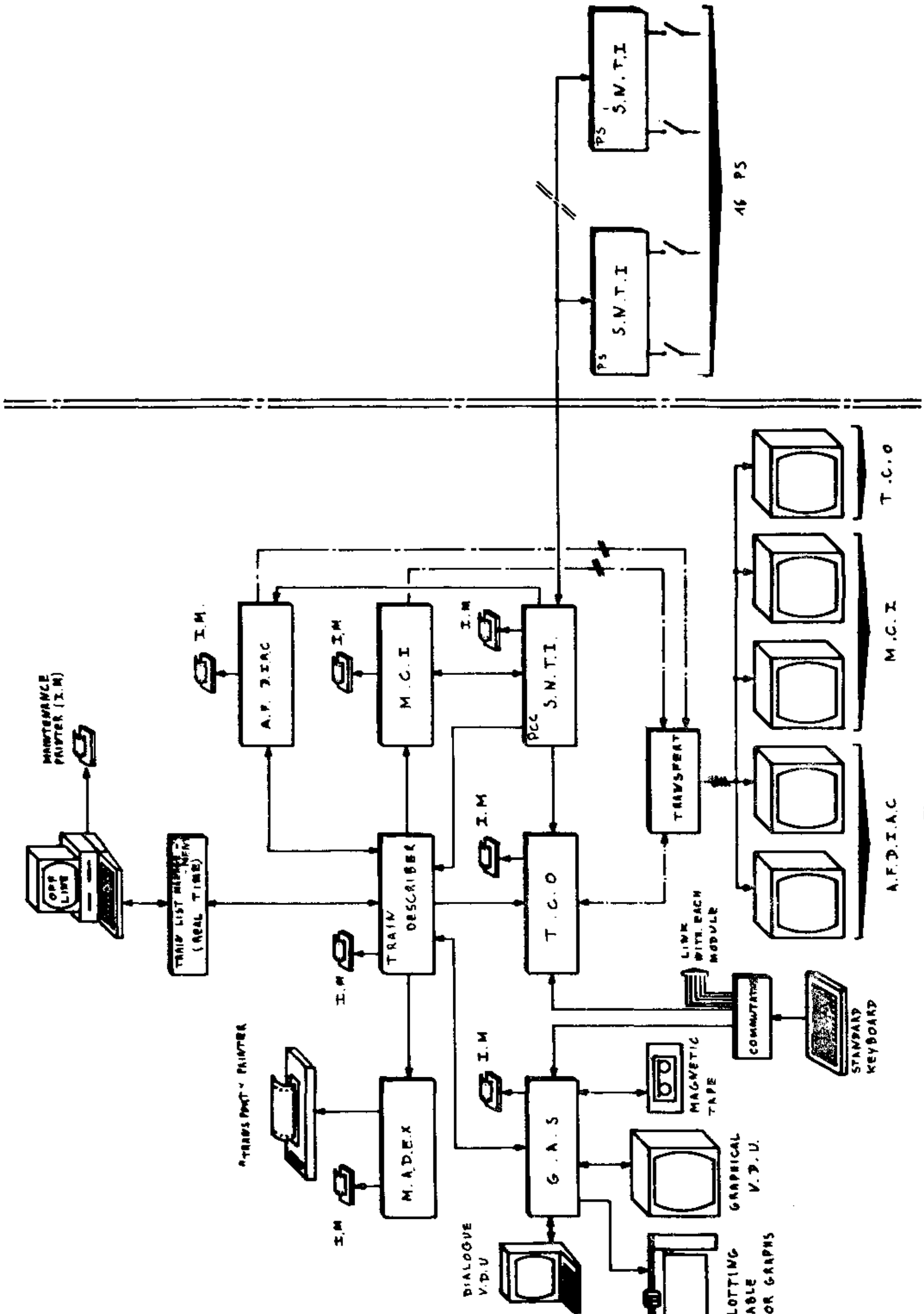


Fig. 6. General arrangement.

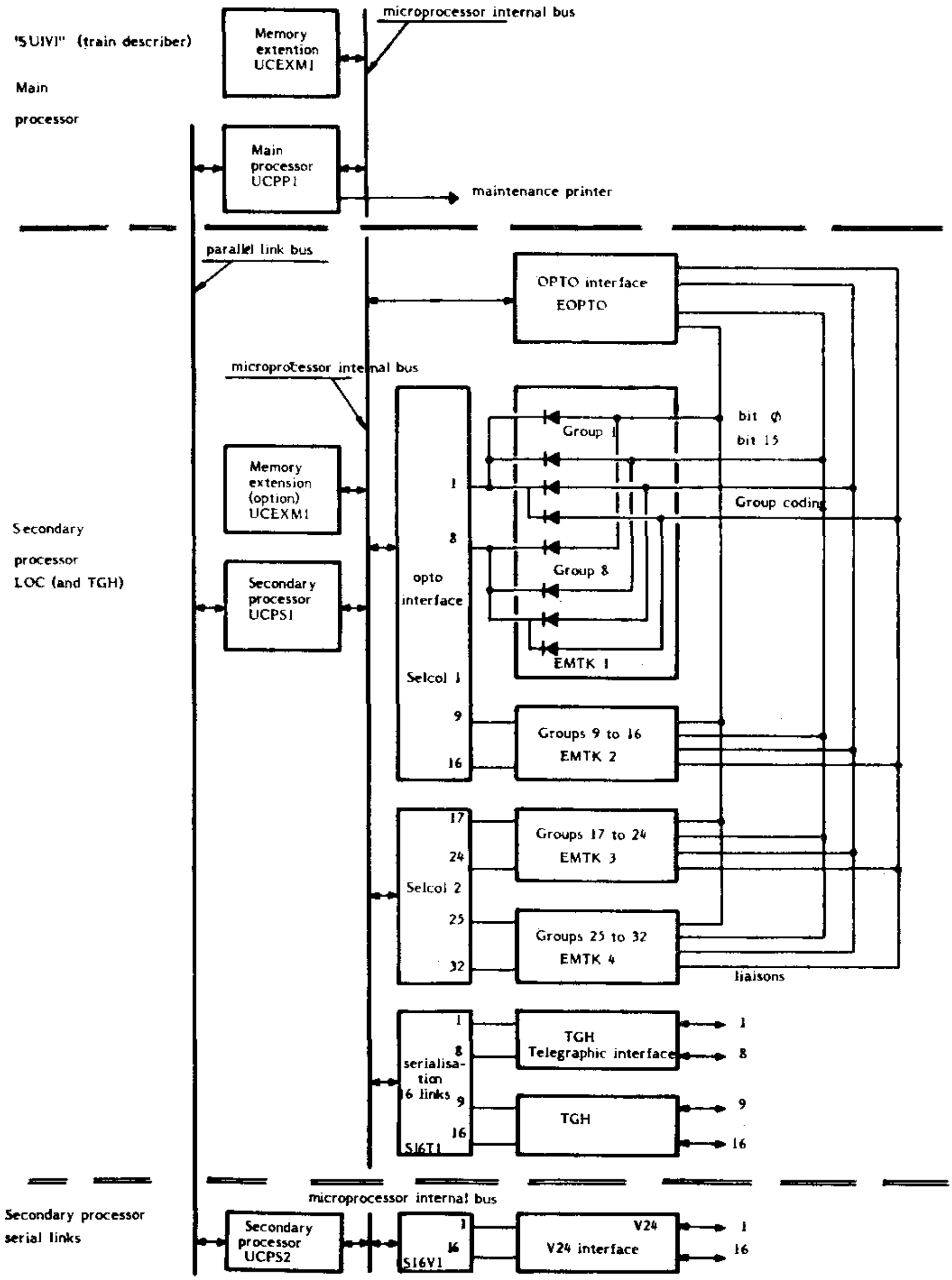


Fig. 7. SUIVI module hardware structure.

AFDIAC module hardware structure

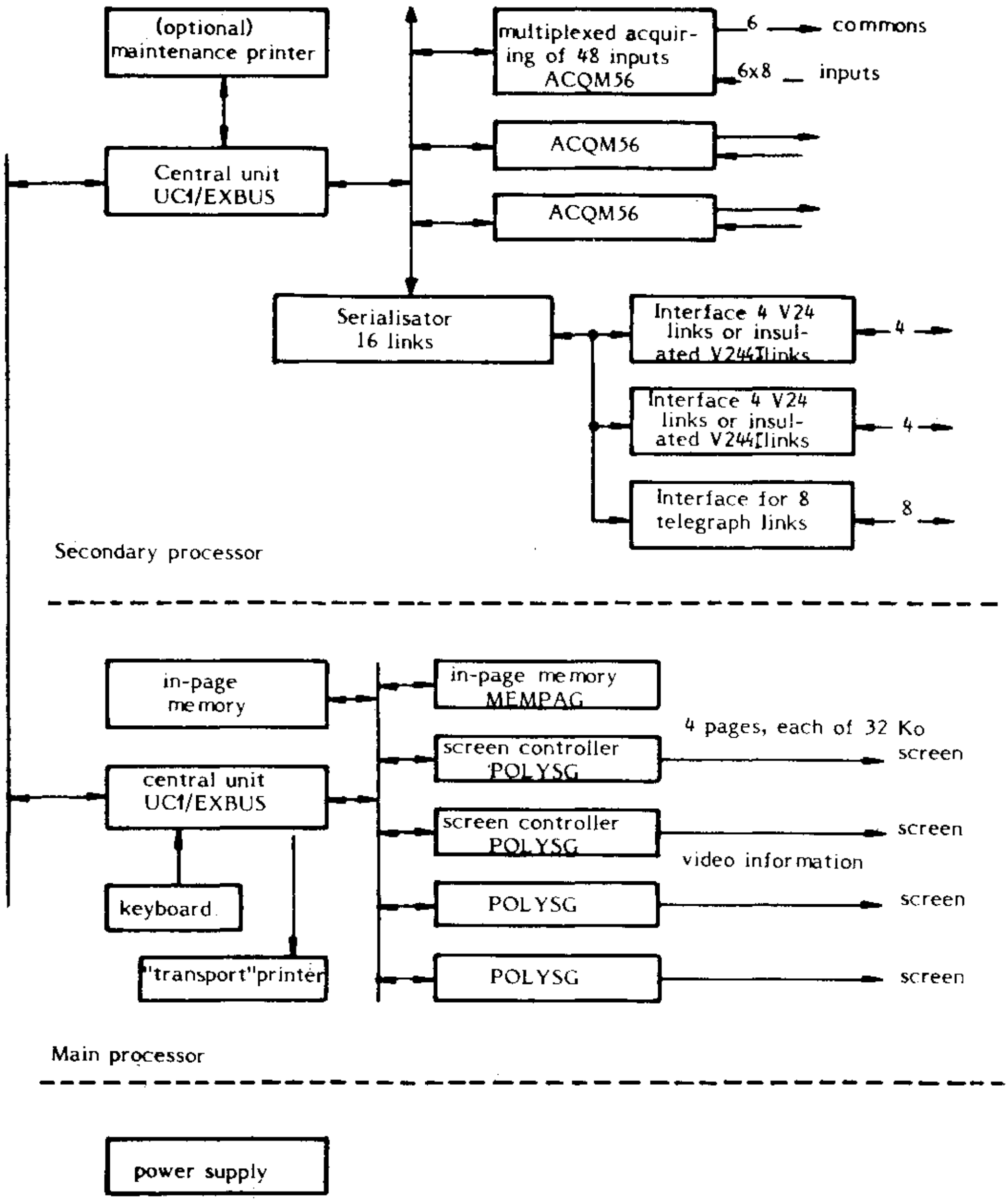


Fig. 8. AFDIAC module hardware structure.

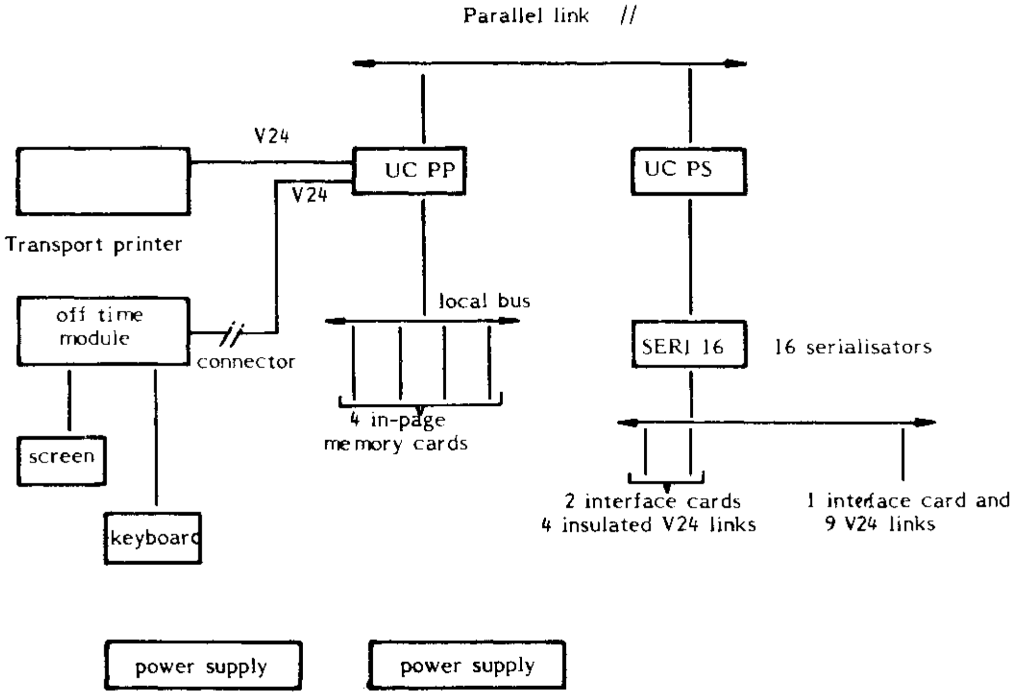


Fig. 9. FICHIER module software interface.

The train describer module sends out its information towards other user modules. It does not carry out any specific processing on this information for other users.

Display-dialogue module on several polychromatic screens (AFDIAC)

In addition to the train follower display-dialogue module functions, this module ensures the following:

- acquisition of "all or nothing" unit entries
- acquisition of remote checks from one or several standardized data processing transmission systems (SNTI)
- display of signalling checks (signals, "train approaching" zones, switch checks, ...) from data processing.

It can handle up to four semi-graphic polychromatic screens, and up to four different images which can be allocated at any time and independently of one another to each of the screens. These images consist of 48 lines of 80 columns.

Train list management system module (FICHIER)

This module consists of two different parts:

- one "real time" module
- one "off-line" module

The purpose of the "real time" module is to supply the other modules with information on circulation controlled by the same modules, e.g.: time intervals (at Tours) or routes.

This information is defined on the basis of a previously stored file. The file combines all data relative to theoretical traffic of trains during a predetermined period.

The "off-line time" module carries out three different functions:

- compilation of files independently of the real time module
- extraction of data from files (type: train succession table)
- formatting and remote loading of a file into the real time module.

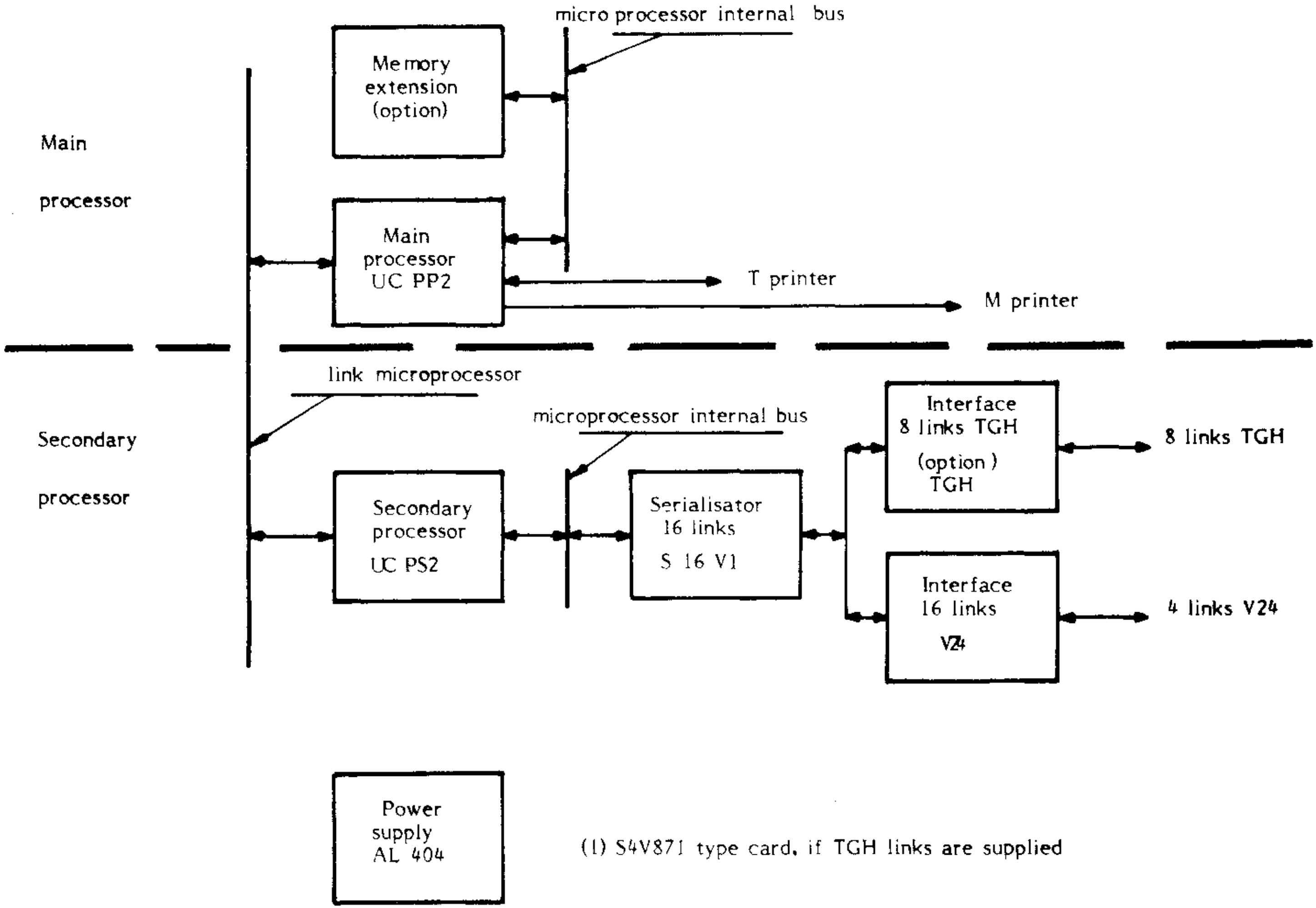


Fig. 10. MADEX hardware structure.

Transport printing module (MADEX)

The purpose of this module is to file information linked with traffic in a page layout easily used by transport operatives.

For each circulation in the train describer zone, the passage times at pre-determined points corresponding to localizing points are stored.

The printout of information relative to circulation is normally triggered by the train describer circulation output. It can assume two different aspects:

- chronological printing of pairs: passage time and designation of passage point, without any paging particularity linked with the train describer geography
- printout of passage times in geographically specialized listing zones.

MODULE HARDWARE STRUCTURE

Train describer module

This module comprises:

- the main processor dealing with processing attached to the train describer function and managing exchanges with secondary processors
- a PS V 24 secondary processor handling 16 serial links (V 24 interface)
- a PS LOC secondary processor, responsible for:

  acquiring 16 x 32 individual matrixed inputs, then ensuring the localizer function

  managing 16 low speed links (telegraph interface)

AFDIAC module

This module consists of:

- a main processor handling the display and dialogue functions

  For this purpose, it offers a memory extension card and 1 to 4 semi-graphic polychromatic screen controller cards
- a secondary processor, responsible for:

  managing serial links with the train describer module and the external modules (train describers SAAT, teletransmissions SNTI,...)

  acquiring 3 x 48 individual inputs and ensuring the localizer function

This processor can also be used on the train describer module instead of the PS V 24 secondary processor.

Capacities:

- 144 individual inputs
- 8 V 24 insulated interface serial links
- 8 telegraph interface serial links
- management of 4 screens and 4 images of 48 lines and 80 columns each
- 2 V24 maintenance printer interface serial links.

FILE module (FICHIER module)

*The real time module consists of:

- a main processor responsible for:

  exchanges with the secondary processor

  processing of consultations

  transparent storage for other modules of a file remote-loaded from the "off-line" module

  a secondary processor handling serial links and connecting it to the external modules

The use of the "off-line" module is carried out on an IBM-PC compatible micro-computer (type Personna 1600) using a hard disk, a disk drive and a printer.

Because of the processing to be carried out on the files, a base III type data management tool is used.

Transport printing module (MADEX)

This module consists of:

- a main processor used for:

  exchanges with the secondary processor

  processing intended for printing (with a high-speed printer connected to this processor)

  a secondary processor handling serial links and connecting it to external modules or to the SAAT.

AUTOMATIC STANDARD GRAPHICS MODULE (GAS)

The standard automatic graphics module (GAS) forms part of the standardized modules of the circulation control system.

The GAS module is intended to automate two of the essential traffic control functions:

- display of traffic graphs: this function is carried out in real time
- filing and restitution: the restitution func- can be carried out off-line.

One GAS module is capable of handling at the most five different graphics simultaneously. The choice of displayed graphics is by dialogue.

Microcomputer structure

The GAS module consists of two microcomputers connected together by a parallel channel.

The secondary processor handles the serial link by connecting the GAS module to the various train describer modules (SNST and/or SAAT). The secondary processor is based on a Z80 microprocessor.

The main processor produces the graphics (from the information transmitted by the secondary processor) and controls the different peripherals (keyboards, monitors, printers, etc.). The main processor is built on the 68000 microprocessor.

Functional structure of the GAS module

The GAS module microcomputers handle the following peripherals:

- a graphic colour monitor displaying train operation
- a standard keyboard for dialogue between the operator and the GAS module
- a magnetic cartridge for saving and restoring the different graphs
- a plotting table for restoring graphs on hard paper copy
- an alphanumeric console for carrying out various dialogues
- a maintenance printer.

The GAS module dialogue function

The operator dialogues with GAS module via a standard keyboard.

Two types of dialogue are apparent:

- dialogue relative to the train describer function
- dialogue specific to the traffic graphic function.

The first, is identical to those of a train describer module and include, amongst others, dialogues for identification, insertion, correction, suppression, transfer, etc., concerning traffic.

The second is used for:

- selection of displayed graphics
- changing the displayed graphics time origins
- executing train running extrapolations
- acknowledging work intervals
- saving on magnetic cartridges
- graphic restitutions on the graphic screen
- graphic restitutions on the plotting table.

The GAS module transmission function

The GAS module exchanges messages with the train describer modules.

The exchanged messages are of two types:

- messages received by the GAS in order to compile the graphics (insertions, suppressions, corrections to circulation)
- messages received and/or transmitted by the GAS within the scope of the train describer module dialogue function.

Traffic graphic display function

See Figures 12 and 1.

The graphics are displayed on a polychromatic graphic screen.

Traffic is displayed on a space-time graph, and this graph is divided into three zones allocated to:

- the past
- the real time (present)
- the future (explorations).

Another part of the graphic image is referred to as the "ancillary zone" and is reserved for dialogues, alarms and messages.

(a) Traffic graphic display

The graphic display includes:

- a fixed frame including time-space coordinates and associated reminder lines
- a representation of traffic in the forms of solid or dotted line vectors of different colours
- the index of graphic zone entry and exit traffic
- the index of traffic in the graphics zone
- the work intervals in the form of rectangles with their nature (expected or confirmed), their type (catenary, track...) and their designation
- the time intervals at certain control points
- explorations displaying the operation of traffic in a future zone.

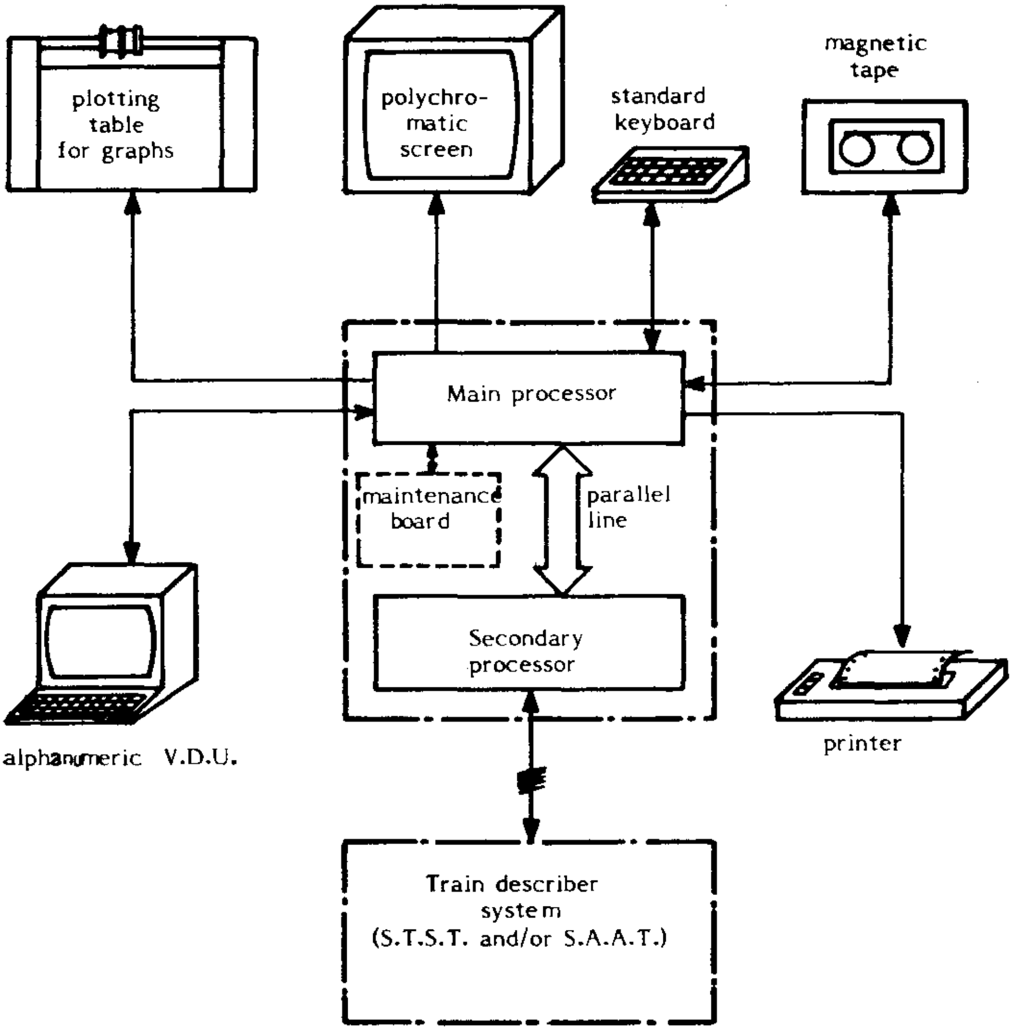


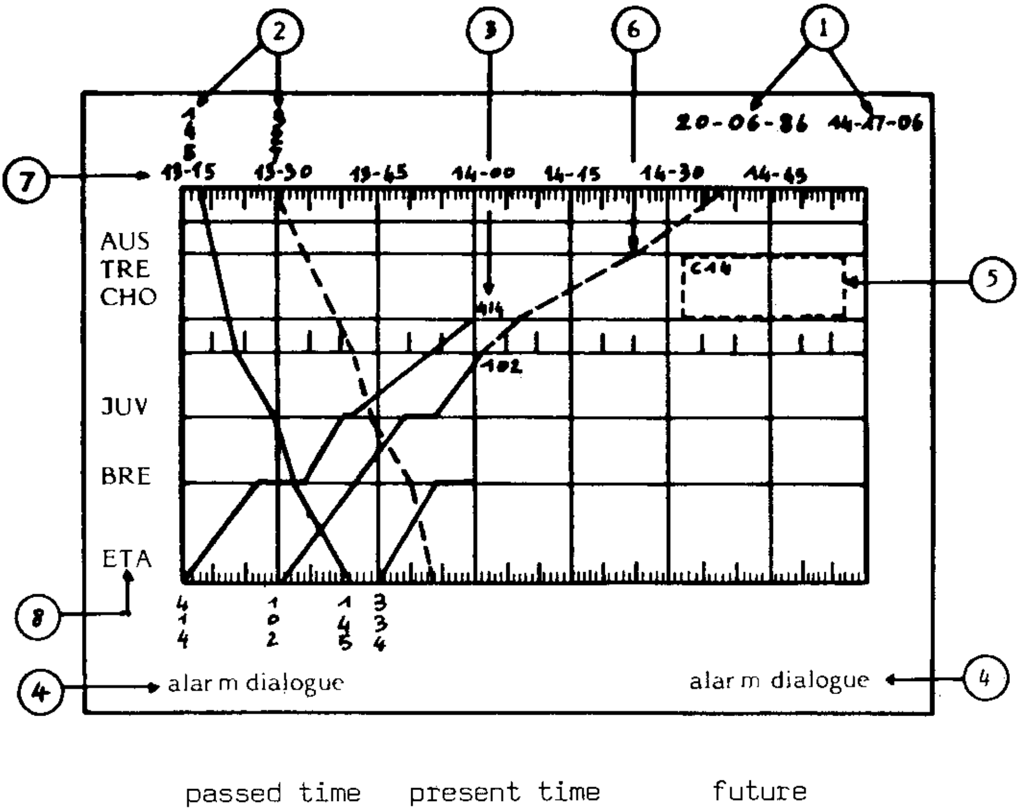
Fig. 11. G.A.S. module functions structure.

(b) Ancillary zone

Featuring:
- dialogue zone
- dialogue and system alarm zone
- message zone
- time and date zone.

(c) The graphic image is fully parametered:

- time scale
- space scale
- colour and trace type
- character size
- location of ancillary zones
- size of zones reserved for the past, the present and the future
- etc.



1 date and hour

2 index of trains within or having gone out of the controlled area

3 index of trains in the present time (eventually with a delay)

4 zone for alarms, dialogues, messages

5 working areas information

6 extrapolation of the train routes

7 hours and minutes information

8 location points with their (optional) signification

Fig. 12. Example of train graphs in the area.

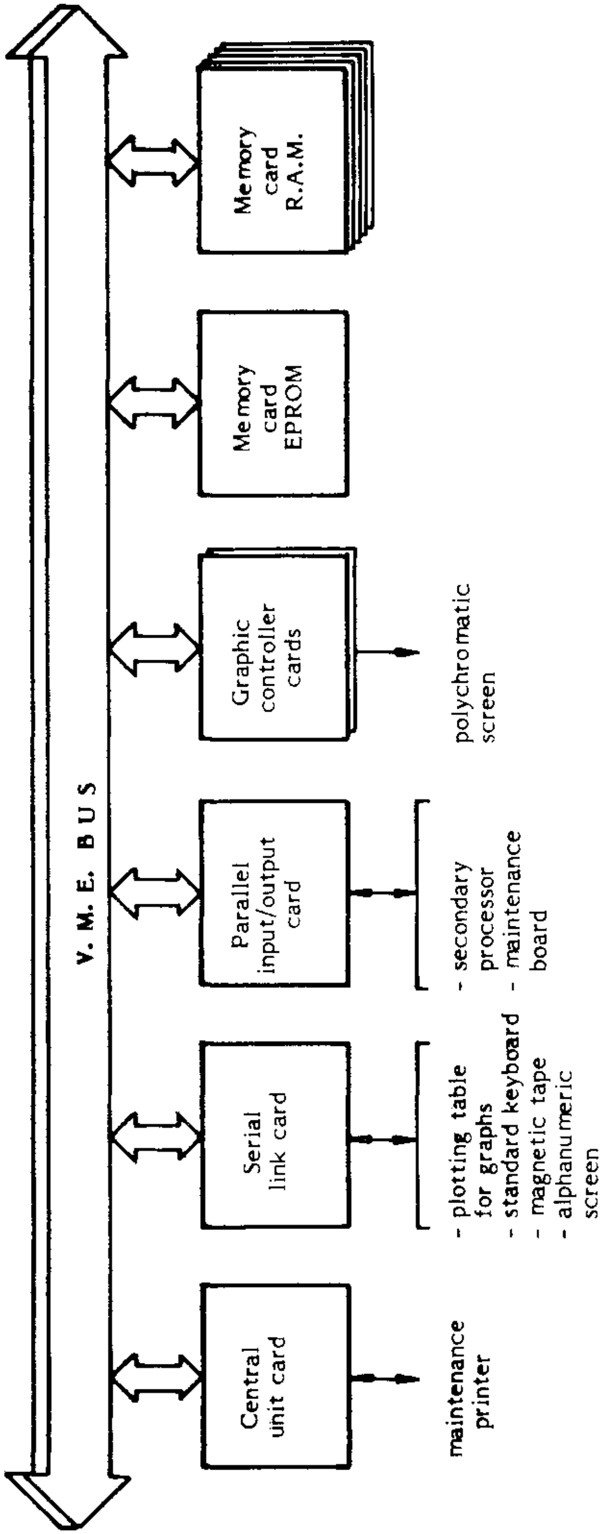


Fig. 13. Main processor G.A.S. general diagram.

The GAS module storage function

The GAS module stores information for filing and restitution of the graph.

Storage is on two media:

- a backed-up RAM for the recent past (recent past covers a period of approximately 36 hours with respect to the current time)
- magnetic medium (cartridge) for the old past.

In this case, the GAS module not only stores variable data items relative to traffic, but also fixed information items such as field parameters, vectors, etc.

The GAS module restitution function

This function uses the stored circulation graph to restitute off-line graphic display, either on the graphic screen or on the plotting table.

The restitution can be carried out:

- from information stored in the backed-up RAM for the recent past
- from information stored on a magnetic cartridge for the older past.

The GAS module alarm function

Any malfunction is:

displayed on the graphic monitor

and/or displayed on the maintenance panel indicator lamps

and/or filed on the maintenance printer.

Maintenance filing function

In addition to the alarms, the maintenance printer can print out any events occurring in the system (dialogue, transmitted and/or received messages, etc.).

The type of event is selected by a thumbwheel switch.

Hardware description of the main processor

The main processor is a multi-card microcomputer built on the basis of a VME standard bus mother board, including:

- 1 central processing unit card using a 68000 microprocessor. This card also supports the EPROM memories which contain the various parameters
- 1 serial link card to AVIS V24 standards for connection of the different peripherals
- 1 parallel input/output card for exchanges with the secondary processor and the maintenance panel
- the graphic controller cards, used for:
  - (a) a graphic central unit card
  - (b) a video memory card

Data exchanges between the main central processing unit card and the graphic central processing unit card via a VME bus, so that the shortest possible regeneration times are possible

- one EPROM memory card supporting 256 kilo bytes of "program" memories
- RAM memory cards supporting two types of memories:
  - (a) backed-up memories to store all information concerning traffic operation; this information must be safeguarded in the event of a power cut (the standard capacity of a G.A.S. module is 512 kbytes of backed-up RAM)
  - (b) non backed-up memories for temporary data storage.

Hardware description of the secondary processor

The cards used to form the secondary processor are identical to those used in the SNST modules.

A secondary processor includes:

- a central processing unit card (UC2)
- a series of adapter cards for the serial links:

  serial 16

  V24/4S and/or TGH8

The number of cards depends on the number of serial links to be handled.

CP DATA PROCESSING CONTROL MODULE - MCI

The TOURS CP data processing control system is used for:

- programming the traffic (schedulling) to ensure automatic control of routes by reference to a train describer system
- control and individual destruction by dialogue of all the line post routes
- control of all the functions required for line operation.

The current operating mode of the line is the automatic mode, and in this mode, traffic uses routes which are permanently traced throughout each station.

Where necessary, an exception can be made to the rule. In this case, the regulator establishes programming in order to:

- withdraw operation from the "permanent routing" system ("Tracé permanent"-TP)
- order routes according to the desired programming with reference to the train number
- re-establish the permanent layout network following programming

System functions

The main functions controlled by the system are as follows:

- keyboard control for dialogue
- acquisition of elementary data by means of a link with the SNTI
- programming and automatic control of the routes
- direct route control
- control of post equipment (stop indication control, transit cancellation)
- protection control
- control of serial links (SUIVI and SNTI)

Route data processing control

Routes can be controlled either after a route control dialogue (direct control) or when the conditions required for a program route control are satisfactory.

A direct control always overrides controls obtained from programming.

Programming is carried out by reference to the train number and, generally, by reference to the previous train for which a waiver to normal operation is needed.

The programmed routes are triggered by occupation of the passage request zone consisting of the approach zone.

No data processing controls can be triggered unless they are the subject of prior programming.

Working areas and catenary protection

The posts are divided into geographical "protection" areas. Each area is materialized by a relay controlled by dialogue. The protection by relay prevents the opening of signals for routes giving access to the protected area associated with it. The clearing of the protection calls for operator thinking involving the entry of two dialogues, so that the clearing of the protection is effective.

System architecture

The work station consists of two semi-graphic polychromatic screens. Each image displays:

- a field representing the track plan of part of the line
- windows in which the scheduled trains appear
- an alarm/dialogue ara.

Duplication of the system ensures availability, and changeover to a reserve unit is obtained by the operation of an INFO 1/INFO 2 switch.

Processing is by a monoprocessor Z80 based system.

Control of the serial lines:

- with SUIVI (1200 Bauds)
- with SNTI (1200 Bauds)
- with standard keyboard (1200 Bauds)
- with maintenance printer

STANDARDIZED DATA PROCESSING TELETRANSMISSION SYSTEM MODULE (SNTI)

The standardized data processing teletransmission system (SNTI) connects: the data sources (field units) and the standardized data processing equipment (MCI, TCO, SNST,...).

The system is transparent. This means that it does not ensure information combinations for user systems. Nevertheless, it can:

- sort and apportion information intended for different users,
- check the coherence of the data it receives,
- pass on data cyclically or on a change of state, depending on the systems to which it is connected.

The system operates under the control of a central post (CP) connected to one or several secondary posts (SP) which may be installed in the same geographical point to form a satellite.

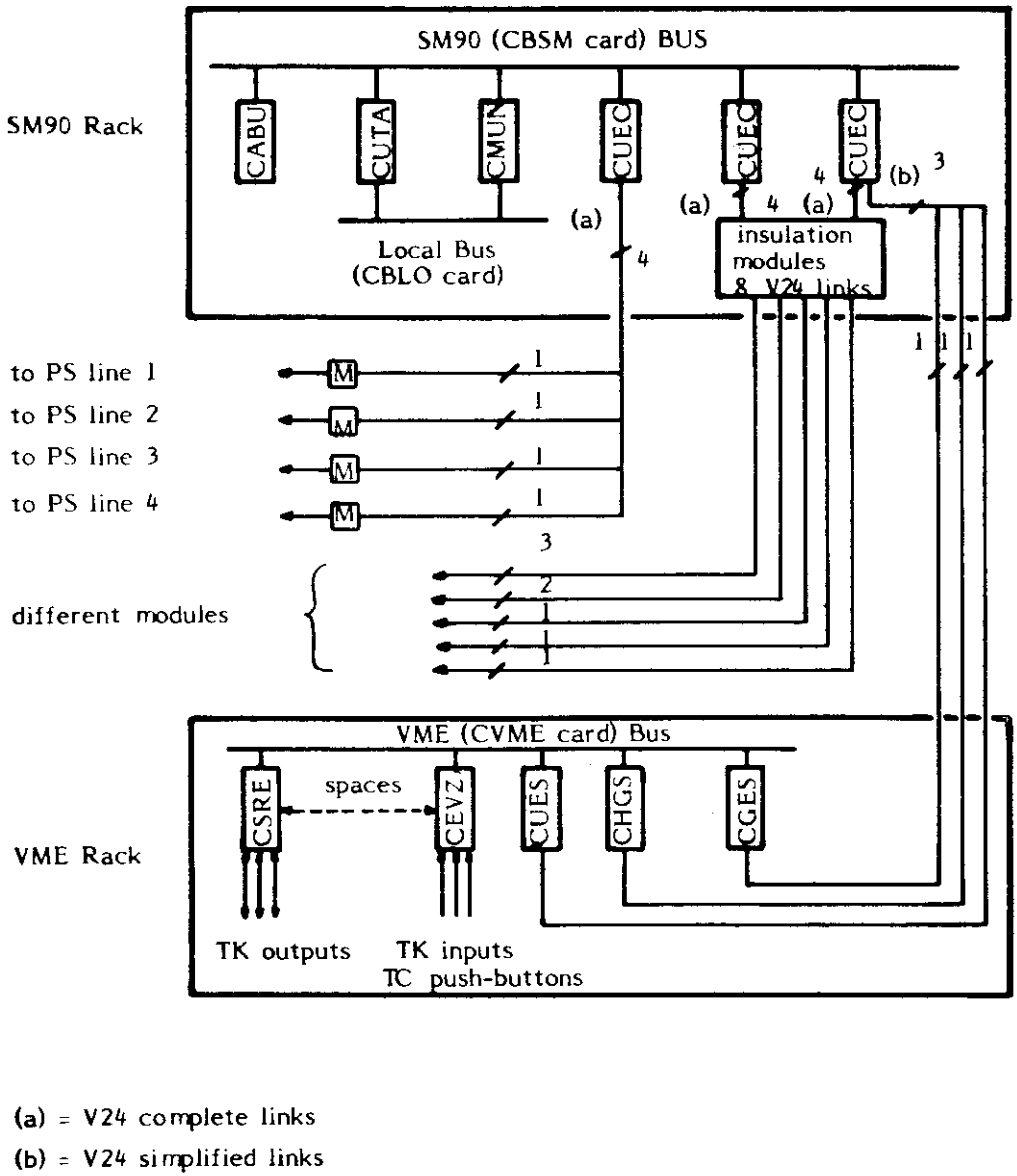


Fig. 14. SNTI PC aspects.

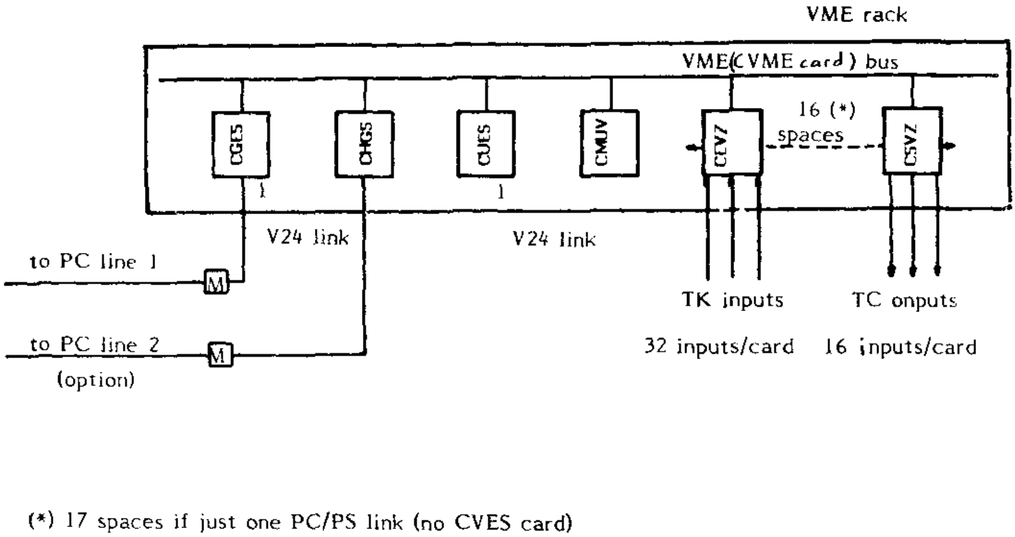


Fig. 15. SNTI PS type aspects.

System functions

The module is used for:

- data acquisition
- transmission of orders triggered in the CP to SP direction (remote control or TC)
- cyclic transmission data in the SP to CP direction (remote testing or TK)
- pass on data to user systems.

Central post

Exchanges to the SP are under the control of the CP, which interrogates each SP in succession.

The remote control orders from the data processing control module (MCI) are checked and transformed into a remote control message if the checks are positive.

Operational reliability is ensured by the duplication of the remote control orders from the MCI. The coherence of orders between one another then makes it posible to draw up a remote control message.

By parametering, the system makes a distinction between two different types of information distributions to the ooutside world:

1) to signalling users (TCO module), the check state is transmitted periodically at a constant time interval (dynamizing)
2) to the operation assistant systems (SNST) and to the MCI, the check state is supplied on each change of state.

Secondary position

Acquisition of field entries is cyclically at constant intervals.

Remote control message reception triggers (after checking) the activation of the corresponding output units.

The transmission of TK states is on interrogation by the CP.

Hardware architecture

The CP is designed on the basis of a SM90 type multiprocessor system, itself based on 68000 microprocessor.

Each SP is based on a 68000 micro connected to the various input/output cards by means of a VME bus.

Exchanges between the CP and the SP's are through serial transmission channels controlled in the multi-point mode, in accordance with CCITT recommendation V23.

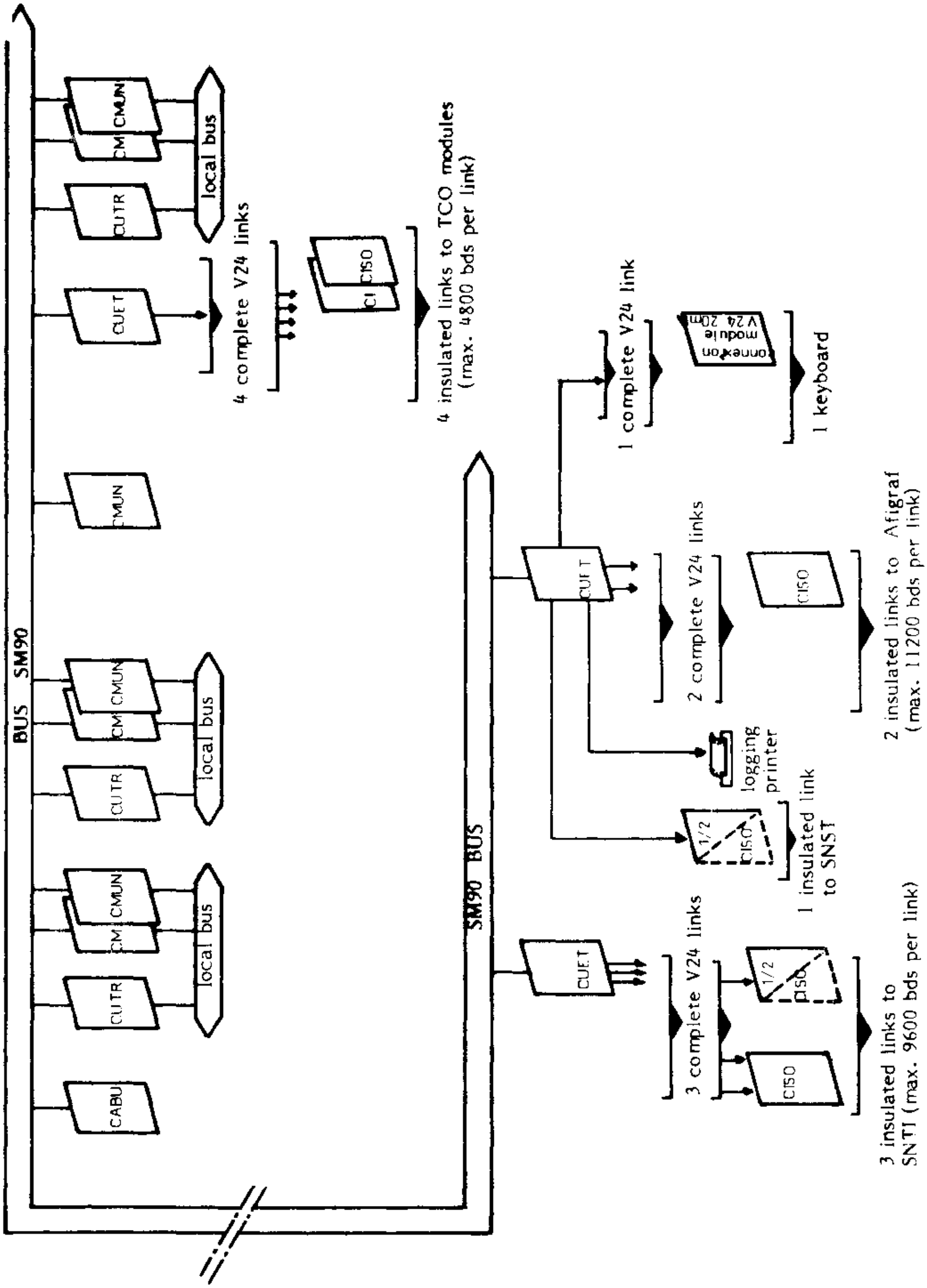


Fig. 16. Central post connections.

The TOURS application

The system includes one CP connected to 16 SP's.

The various links with the outside world are:

- 1 link to the SNST (1200 Bauds)
- 1 link to the AFDIAC (1200 Bauds)
- 1 link to the MCI (1200 Bauds)
- 3 links to the TCL (9600 Bauds).

approximately 3200 TK's
approximately 850 TC's.

MIMIC DIAGRAM MODULE (TCO)

The function of the TCO module is to generate and display, on a polychromatic screen or on a mural TCO (mimic diagram), signalling controls.

This system consists of the resolution of logic equations relating to information drawn from the posts.

Data acquisition in the posts is through a standardized data processing teletransmission system (SNTI) or within a local area by means of an acquisition system based on the SNTI.

Module functions

In addition to the signalling generation and control display functions, the TCO module ensures:

- acquisition, management and display of dialogue
- management and display of alarms
- management and display of the date and time entered by dialogue, or received from the train describer standardized system (SNST).

The TCO module can be connected to 4 screens at most and to 4 keyboards. The number of keyboards is less than or equal to the number of screens (one screen cannot be allocated to several keyboards).

Module operating principle

Two distinct processing systems ensure, independently of one another, the acquisition of an image. Two images are displayed alternately on the screen. Data acquisition and image refreshing are cyclic at constant time intervals (dynamization).

Screen display

The TCO module can handle the maximum of 20 images.

The images are selected by dialogue on the screen or screens associated with the keyboard. The same image can be displayed on several screens.

Module operating tests

Module operating tests are displayed in the image. These tests are checked prior to use of the safety information displayed in the image.

The tests involve:

- presence of fundamental colours
- three references, red green, blue, check the presence of the fundamental colours and the letters R, V, B, in light blue, confirm the right combination of the three colours
- image alternation
  The two images generated by each processing system are displayed alternately on the screen. The two images are identical except for the display indicators in light blue placed differently on each image and announcing the operation of the alternating mode by flashing.
  Through this alternation, any disagreement regarding the result of a test, performed by the two processing lines, will result in the flashing of the feature representative of the check.
- execution of processing
  One of three dark blue indicators (depending on the scale of the installation) serve to check the performance of processing (data acquisition, generation of checks, correct refreshing of images).

Warning messages, control alarms

Certain particular events (not mandatorily present on the screen at all times) will generate a warning message or a control alarm, depending on the scale of the event.

The control alarms, unlike the warning messages, require the taking of particular safety measures by the operative.

Hardware architecture

The module is designed from a SM90 multiprocessor system based on 68000 Microprocessors.

Mobile capacity

The maximum capacities of the module are:

- 16 V24 links
- 1 to 4 polychromatic semi-graphic screens (48 lines of 80 columns)
- 1 to 4 keyboards.

TOURS configuration

- 1 link (9600 Bauds) with SNTI
- 1 link (1200 Bauds) with SNST (time setting and date initialization)
- 2 screens capable of displaying 16 images
- 1 keyboard.

Technical Meeting of the Institution

held at

The Institution of Electrical Engineers

Monday, 15th December, 1986

The President (Mr. J. G. Oehler) in the Chair

The Minutes of the Technical Meeting held in London on 10th November, 1986, were taken as read and signed by the President as a correct record.

The President then introduced Mr. O. Stalder (S.B.B. Switzerland) and requested him to present his paper entitled "New Systems for Signalling and ATC in Switzerland".

New Systems for Signalling and ATC in Switzerland

*By Mr. O. Stalder**

INTRODUCTION

Since the beginning of 1986 trains have been scheduled to run at 160 km per hour for the first time in Switzerland. New signals allow this scheduled speed to be achieved between Visp and Leuk on the Simplon line. Since autumn of the same year, Zurich suburban trains between Wallisellen and Uster have been controlled by similar new signalling.

From summer 1987 onwards, trains will run in the Bern and Zurich areas to carry out practical tests of a new system of "automatic train control".

All these applications relate to the testing of new signalling and ATC systems, which are being introduced into Switzerland for the first time. The need for these systems arises from new operating requirements and experience, and they will improve operational control. They were specified by the Swiss Federal Railways and the Bern-Lötschberg-Simplon Railway and testing is also being carried out jointly. The first part of this report describes the signalling system and the second the ATC system. Details are given regarding the background, objectives, the chosen solution, operation and economics for both systems.

SIGNALLING SYSTEM

Background

The Swiss Federal Railway network com prises about 3000 route kilometres, on most of which trains can travel at 125 km per hour On 180 km of the network speeds are at 140 km per hour, and since the end of January 1986 on 17 km at 160 km per hour. As part of the new service policy in Switzerland known as RAIL 2000, stretches of line with an upper limit of 200 km per hour are planned.

For the regulation of traffic and to ensure the safety of trains, only fixed signals are used. Existing signalling has developed pragmatically from current operating requirements. Originally, the system used was based on "advance" and "main" signals, but in the course of time this developed into a speed-based system with the possibility of combined signals, i.e. those which incorporated both "distant" and "home" signal aspects. The maximum speed is indicated by a green aspect. The speeds permitted at any particular location are known by the loco driver from the working timetable. If speed has to be

* SBB Switzerland.

reduced because of the route selected (e.g. pointwork), then permission to proceed and maximum speed are shown by colour light codes. These signal aspects do not represent rigidly defined speeds, but must be interpreted by the train driver taking into account the type of train and to some extent the location.

These types of signal lights were introduced 50 years ago. The components used correspond essentially to the state of technology at that time, and since then they have only been updated in certain details. The 20 watt/40 volt lamp is supplied with DC power, and up to six lamps may be illuminated at a time on any signal post.

The RAIL 2000 concept requires the signalling to permit higher maximum speeds with additional intermediate speeds and a higher traffic frequency. To upgrade the existing system for this purpose would have meant that the current deficiencies in the system would have been magnified: e.g. more complicated illogical colour codes causing risk of unsafe confusion between aspects, and between "distant" and "home" signal aspects on a single signal post.

An internal SBB working group therefore developed a new signalling system with the objective of meeting the new requirements and overcoming the existing deficiencies. This team worked in co-operation with the Psychological Institute of the University of Bern and concentrated in particular on the question of the compatibility of the new with the existing system.

A survey of signalling systems throughout Europe gave the group a broad view of possible approaches, and they found that the N.S. system was of particular value.

The New Signalling System

The new signalling system indicates to the train driver the permitted speed; it is thus a speed-control signalling system. Each signal indicates permission to proceed at a permitted speed. All signals are "combined" signals, i.e. each is a "distant" signal for the next.

At any time these signals show only red, yellow or green colour lights representing 'stop' or 'permission to proceed'. A yellow number with a green or yellow light indicates the permitted speed and the permission to proceed. Fig. 1. shows the most important signal aspects.

The normal maximum permitted speed at a given location (depending on the braking characteristics of the train) is obtained by the driver from the working timetable. The corresponding permission to proceed is conveyed only by means of a green light ("all clear"). As at present, other local speed restrictions due to curves and work on the track are indicated by means of signs.

Speeds which are dependent on the route signalled and which are lower than the maximum in the working timetable, are displayed by illuminated figures showing one tenth of the permitted speed (e.g. 6 for 60 km per hour or 14 for 140 km per hour). These speeds apply to all trains and must not be exceeded.

The speed information thus displayed may be:

a) dependent on the route signalled, e.g. the permitted speed for a movement over points leading off the mainline. By rounding up to the nearest ten, standard speeds over points in the 'normal' position can be established at either 60 km or 90 km per hour. On the other hand, for points in the 'reverse' position, or in a curve, the permitted speeds can be graduated in 10 km per hour steps, dependent on the track geometry.

b) dependent on braking characteristics, where, because the intervals between signals are inadequate for the maximum speed, braking may be spread over several sections.

At a given signal, only one speed indication is given beside the aspect for the permission to proceed, and always the most restrictive of the possible speed indications.

Flashing lights are not used to give permission to proceed.

Fig. 2. shows three signalling examples.

Psychological Principles

This system fulfils four psychological principles.

1. Unambiguous Control Indications:
   An unambiguous indication is given to the driver as to whether he should proceed in accordance with the working timetable (so-called 'internal' control) or according to the signalled speed (so-called external' control).

CAUTION

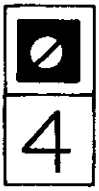
At a distance, which is at least equal to the braking distance there is a signal at danger.

STOP

ALL CLEAR: Advance at the maximum speed indicated in the working timetable.

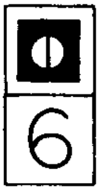
Movement permitted at the speed indicated by the figure displayed x 10.

SPEED ADVICE The speed shown applies from the following signal



SPEED LIMIT APPLICATION

The speed shown applies from the signal concerned



Signalling on "short block" sections

EARLY WARNING: The first signal shows an early warning, the next in sequence (second) gives a warning, and the third "stop".

Fig. 1. Signal aspects and their meaning.

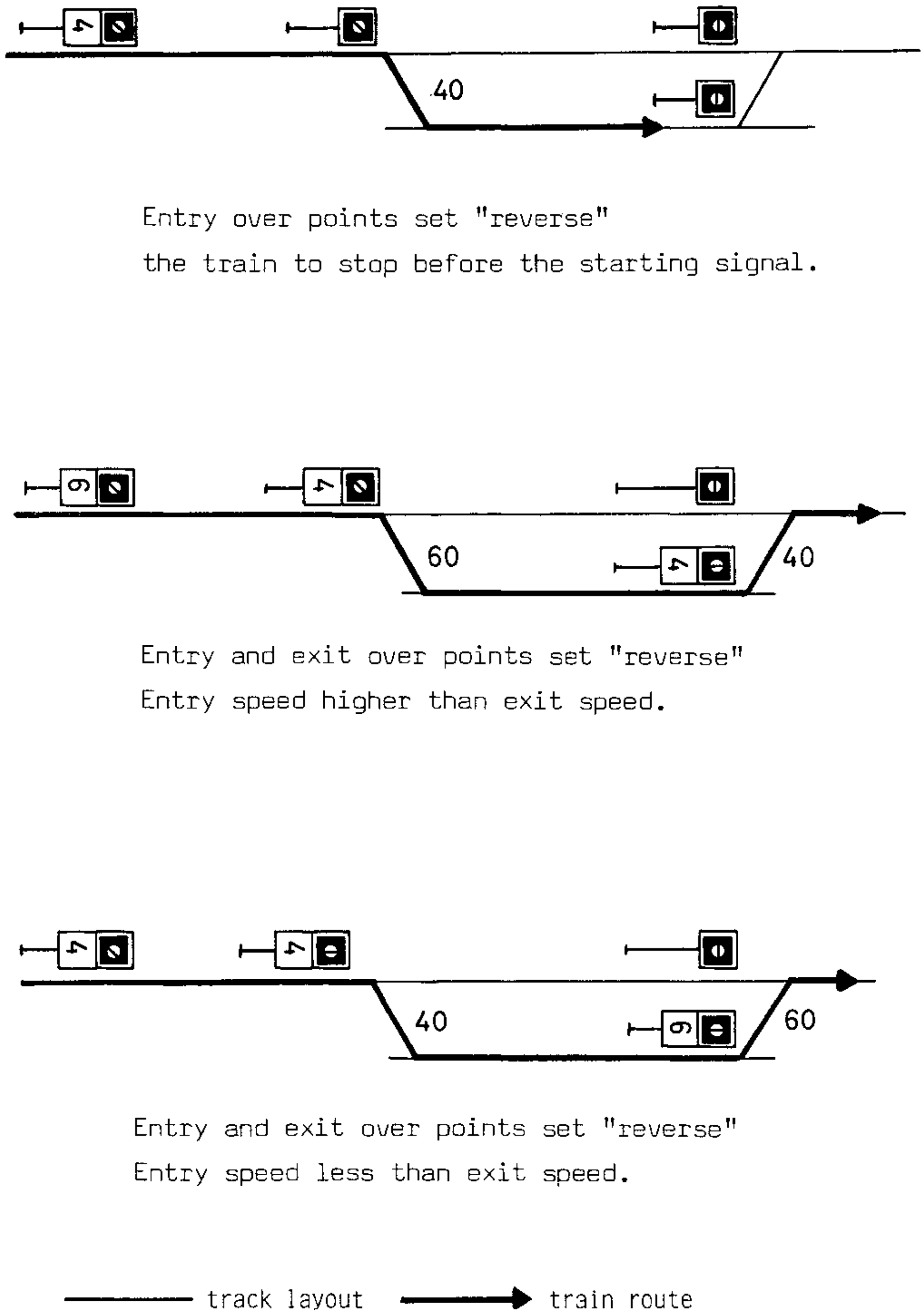


Fig. 2. Examples of signalling.

2. Emphasis on driving competence:
   The abilities of the driver are recognised, in that specific knowledge of the route and the details of the working timetable are not included in the signalling system and reliance in these areas is placed on the driver.
3. Immediacy of information requiring action:
   Those signals which require action to be taken by the train driver are displayed at the point where the action required must be implemented.
4. Succinct information:
   Only straightforward and clear information is displayed.

Movements carried out under internal control are always signalled with a green light alone. The emphasis on competance is adopted under internal control and speed limits prescribed in the working timetable are not displayed in the signalling system, because changes in these speed limits are known to the driver from the relevant regulations and his knowledge of the route.

For all other signal aspects, e.g.:-

— red light: Stop
— yellow light: Caution
— yellow light and illuminated figure: Warning of speed restriction
— green light and illuminated figure: Speed adjusted as required; the driver is travelling under 'external' control and he receives all information about permitted speed limits from the signals.

The succinctness of this information is achieved through the clear segregation of signal aspect under internal and external control. Speeds are shown directly with figures, and because two different speed indications cannot be given at a single location, the risk of confusion is eliminated.

Applications

The new system is designed with the following future applications in mind:

a) In order to achieve the required intervals between trains on the new extension of the Zurich suburban system, a particular signal aspect is used to give advance warning in the areas of stations with short block sections. This is because of the large number of block section signals which have to be observed at short time intervals. The demanding task of driving a train will be made substantially easier by the simple signal aspects of the new system.
b) Under the project RAIL 2000 the system will be used for all cases where the speed limit is 160 km per hour or will be raised to this level in future. For the speed range above 160 km per hour, cab signalling is envisaged. Using the new signalling just described, it is quite easy to convey the speed indications at trackside signals using a simple code to cab signalling equipment (see section on 'Automatic Train Control').

The objective of the new signalling system is to make the information for the driver consistently recognisable. To this end, modern technology is used, which will also help to reduce the cost of the complete system covering signalling - communication - control room.

For the permission to proceed, caution or stop aspects, only a green, yellow or red light is illuminated. The three lamps are accordingly assembled in one compact unit which can be readily adjusted. The light sources used are 20 watt/12 volt double filament lamps which are 50% more efficient in terms of illumination and reliability than those previously used. For the display of the figures giving the speed limit steps, a 50 watt /10 volt halogen lamp is used, whose light is conveyed through optical fibres, which grouped together form the required figure. Both colour lights and the figures are protected with heat resistant glass so that reliable indications can be provided under all climatic conditions.

By using AC transmission of energy, it is possible to use thinner cables (requiring less copper) and to provide control over greater distances. By using suitable relay techniques the system has been designed so that in the event of technical failures the clear or caution aspect is shown as long as possible (i.e operation can continue) and only when necessary is 'stop' displayed.

With the new signalling, the elements are so designed that components can be readily exchanged and checked at low cost in the workshop. The same signal structures are used as at present, but as the signals are smaller, loading guage problems are reduced. This allows the signals to be arranged so that they will be more visible and less often obstructed. Fig. 3. shows a signal for the new system.

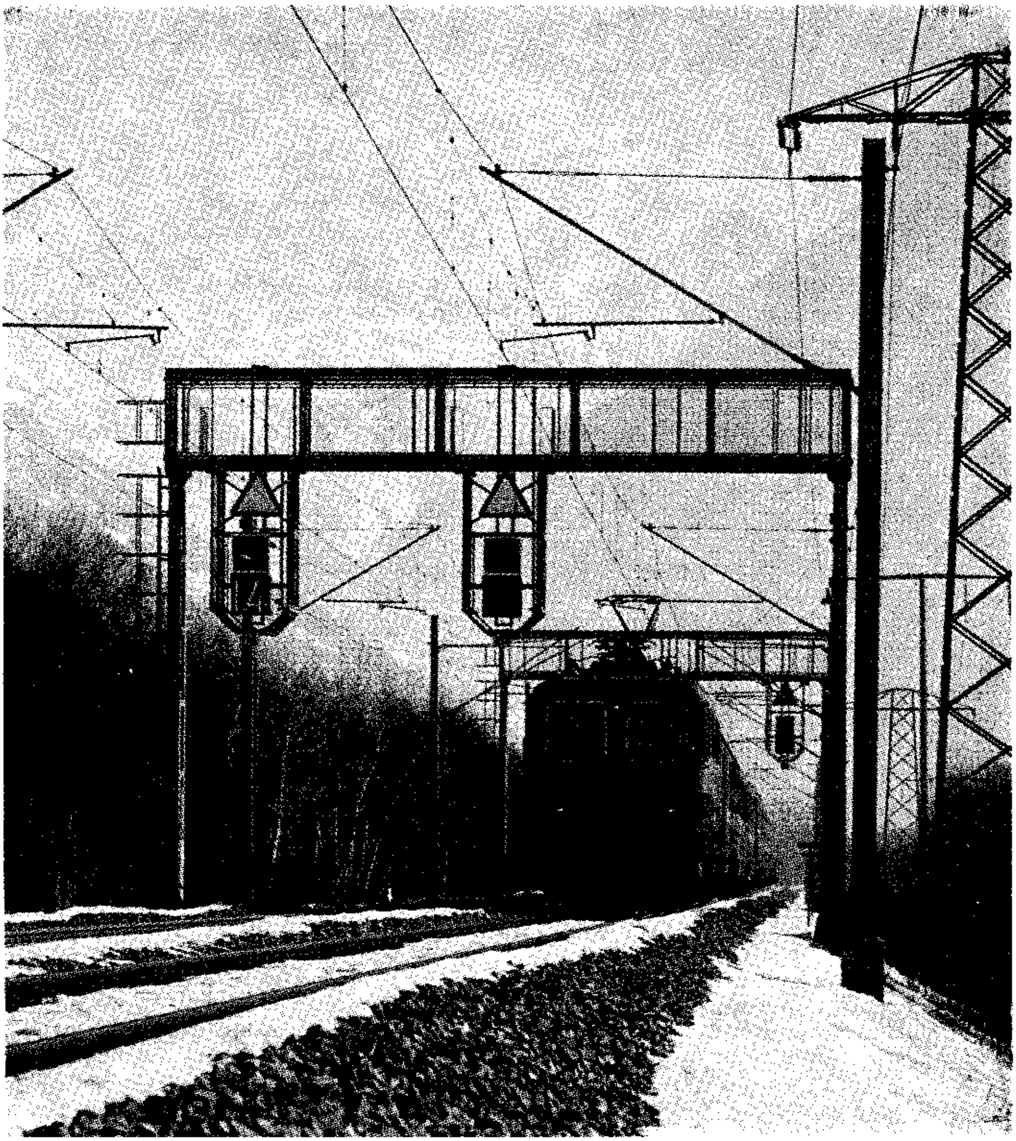


Fig. 3. A new signal.
(Photo: Integra Signum AC)

The economics of the new system have been investigated in detail. The estimated costs for the existing system were compared with the corresponding costs for the new system and a variety of alternatives evaluated. These comparisons show that savings of between 10% and 20% are achievable. The conversion to the new system appears to be economically worthwhile, because long term capital and maintenance cost will be lower.

The next steps

The new signalling system is being tested in three regions during 1986/87 on the sections from Leuk to Visp and Wallisellen to Uster as well as the Zollikofen station. In this way, practical experience will be gained for the operation and implementation of the system. A decision on its introduction will be made after the conclusion of the trials.

Forgetfulness, misinterpretation, or failure to observe a signal aspect is possible with any system. On the basis of both theoretical considerations and practical experience, one can be confident in saying that a new piece of information is most likely to be correctly interpreted if its entry into the system immediately precedes the required action. No trackside signalling system, which can only transmit information at particular points, can fully meet this requirement, because the intervals between signals must be related to the maximum permitted speed and the target distance required to bring the train to a halt, which determines the position of the caution aspect. Experience shows that this aspect can be overlooked, although in general, braking must start at that signal. The greatest safety is achieved if signalling systems using trackside signals are supplemented by speed surveillance. With such an installation it is possible to prevent irregularities which stem from failure to observe signals or incorrect interpretation of them. On this account, work is proceeding in the SBB on the new ATC system.

AUTOMATIC TRAIN CONTROL

Background

The execution of the commands conveyed by the signals is the responsibility of the driver. This railwayman, like every human being, is not completely reliable in his actions. In contrast with many mistakes which in everyday life often have no further consequences, his mistakes can have fatal results. With modern methods of operation and present enviromental influences, human reliability alone is inadequate in such cases.

A number of accidents have occurred in the last few years in Switzerland which have called attention to this fact. An internal working group was therefore set up to specify an improved ATC system.

Over the past fifty years, the SBB has been using an automatic warning system (AWS). This has been improved in a variety of ways, its application extended, and the driver is now given an optical and accoustic warning in the cab at every signalled speed restriction. Provided he acknowledges the warning, he can continue to drive unhindered. By his response, he shows that he is capable of action, but if he ignores the warning, an emergency brake application is made automatically after 100 metres, which brings the train to a halt. The same emergency brake application is initiated in any case if he passes a signal at danger. For signal aspects which do not involve any speed reduction, no information is transmitted to the train.

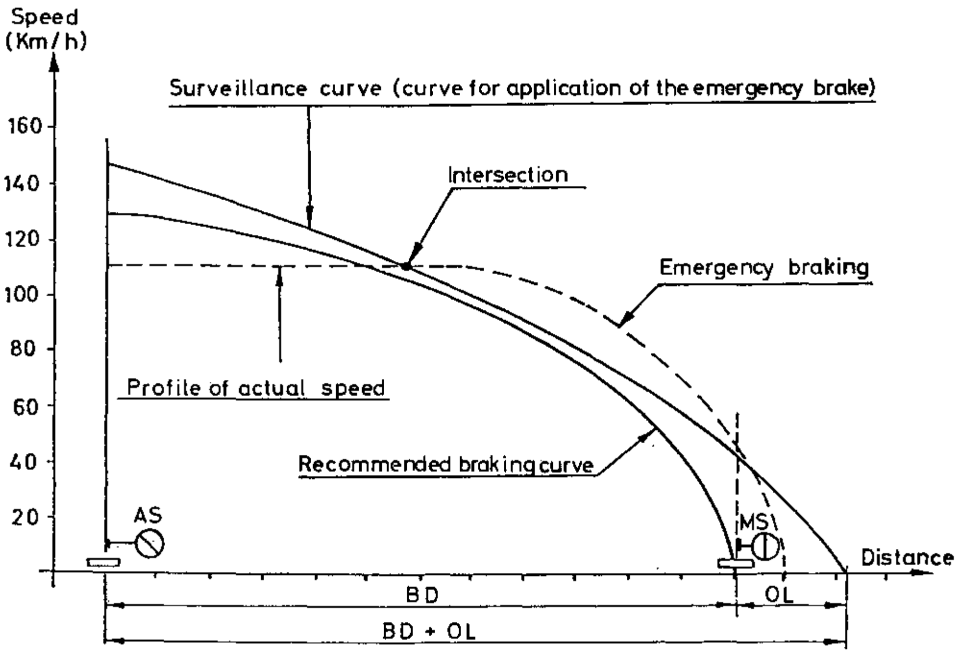
Both aspects are transmitted inductively from the track to the train. The energy required for the interrogation of the information comes from a permanent magnet mounted on the locomotive. At the trackside the field of this magnet induces an electric current in a receiving coil. This current excites a transmitting coil whose circuit is closed or open according to the aspect of the signal. On the train the signal information is decoded from the polarisation of the magnetic field of this transmitting coil. Signals which set off a warning on the locomotive are relatively frequent, and the acknowledgement of such signals tends to become an automatic habit for the driver; this has already led to serious accidents. Because a large investment has recently been made in the existing AWS, the objective given to the working group has therefore been to upgrade the existing AWS so that speed limit infractions which could lead to dangerous situations are prevented.

Meanwhile, the upgraded system must achieve a favourable cost benefit result with good operational performance and high reliability. The investigations included the results of experiments which had been undertaken during operating trials with track-to-train control in accordance with ORE A 46, RP6 (DB version). These trials were terminated in 1981.

The New ATC System

Accidents and a variety of possible solutions were analysed. The most promising solution emerged as the improvement of the existing AWS by an additional transmission channel and an electronic braking distance monitor on the train. Proposals based on systems which have been implemented were used as the starting point.

Experience shows that speed infractions which lead to dangerous operating situations arise most frequently in the braking phase, and therefore in the range of speed up to 160 km per hour only the braking phase is monitored. In this way, not only can the safety margin be improved and other investment with safety objectives in the infrastructure be diminished, but also the braking phase



ADVANCE SIGNAL WITH INFORMATION SPOT (WARNING)

AS = Advance signal with information spot
BD = Braking distance
OL = Overlap
MS = Main Signal (Stop)

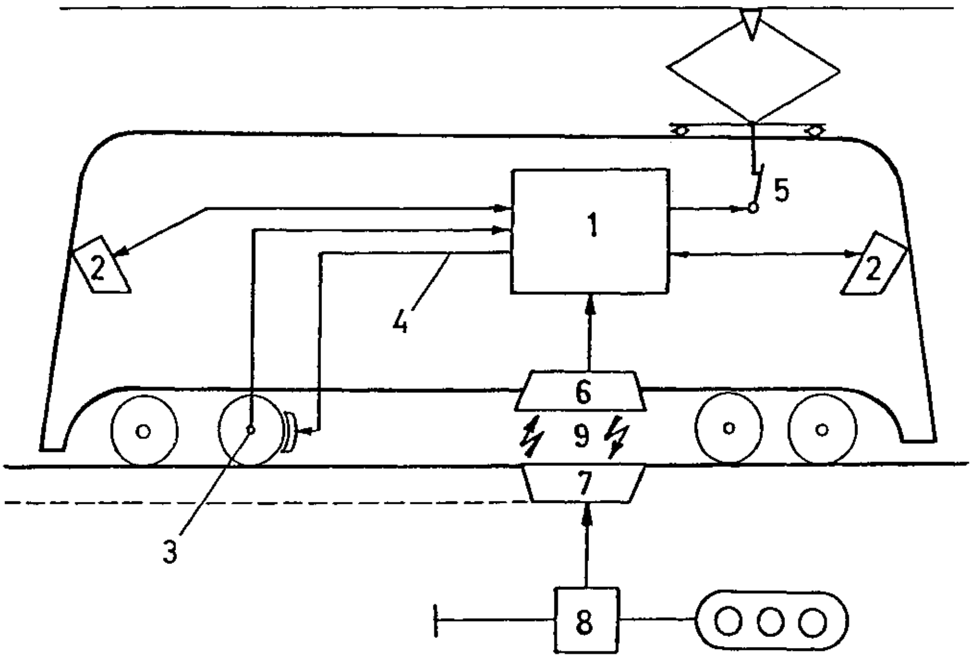
Fig. 4. Principle of surveillance for the signal sequence 'Caution' to 'Stop'.

can be extended over several signalling sections. For speeds over 160 km per hour an indicator is provided in the cab with continuous surveillance of the permitted speed.

Method of Operation

In describing the method in which the system functions the signalling situation 'caution-danger' is examined (see Fig. 4.). At a signal showing caution, a braking curve is calculated on the train. This takes account of the characteristics of the train (type of braking, braking ratio) and the characteristics of the track (gradient, target/distance and target speed). The train data is fed in by the driver at the commencement of the journey. Data relating to the track is transmitted to the locomotive at the signals.

From these two sets of data, the monitoring curve or application curve for the emergency



1. Train control equipment
2. Driver equipment and indications
3. Tachometer
4. Output for the operation of the emergency brake
5. Output for the interruption of traction current
6. Aerial for transmission and receiving
7. Information spot, can also work continuously (represented as an option by a dotted line).
8. Signal-adaptor (on an existing signal).
9. High frequency telegram transmission with safety code.

Fig. 5. Outline of the system.

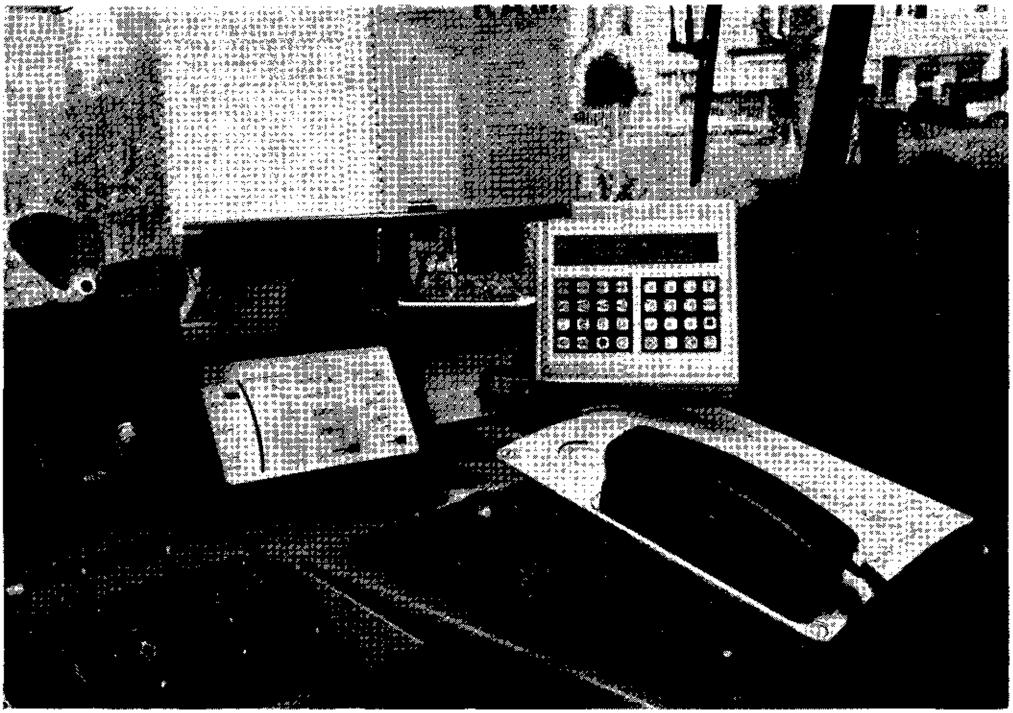


Fig. 6. Keyboard and display of the train radio equipment. (Photo: Brown Boveri)

brake is calculated. If the actual speed exceeds this curve (i.e. when the driver has not reacted correctly), the brakes are automatically applied, so that the train is brought to a halt before the danger-point (signal or set of points). The driver is in normal circumstances not hindered in his driving by this monitoring, provided he reacts and behaves correctly. He can, in certain situations, forestall this surveillance or it can be automatically released when the signalled speed reduction has been achieved. In these conditions, the driver can continue to the next information-point under his own responsibility. When the equipment initiates a braking action, this can only be terminated after the train has been brought to a halt.

Technical Design

Fig. 5. shows the main elements in the system. The trainborne equipment includes the following elements:

Train equipment, driver equipment and indications, tachometer, aerial for transmission and reception and interfaces to other equipment.

Through the driver equipment, train characteristics (type of braking and braking ratio) are input and the maximum speed shown. The characteristics are entered through the same equipment as is provided for train radio (Fig. 6.). The train aerial radiates high frequency energy to the trackside equipment and also receives 'telegrams' with track information when passing the equipment. The train control equipment processes track and train data in relation to speed (transmitted from the tachometer) and activates if necessary the emergency brake or interrupts traction current. For the speed range up to 160 km per hour, the train equipment has a single channel; the cab signalling is designed as a safety system in terms of specification and manufacture.

The track equipment consists of information-spots which radiate spot or continuous data telegrams to the train and of 'signal adaptors' added on to the existing trackside signalling system. The signalling information is obtained in an energy-saving manner from the lamp circuits, while the fixed track data is programmed into the trackside equipment.

The system is built up exclusively on the existing cable circuits, and costly additional circuits for transmission of energy and data are not required. The moving train activates the trackside equipment with its continually radiated high frequency signal, and the trackside equipment forms a telegram from the track data and transmits this in another high frequency range. The telegram is received in the train control equipment through the train aerial. The track equipment therefore functions as a transponder. The data telegram is received at least twice in its complete form at 200 km per hour and transmission is made secure against possible distortion through an error correcting code. In this way, it is sought to achieve transmission of a 'safety' quality in signal engineering terms.

Dynamic Surveillance

A procedure for surveillance of the speed is initiated by the spot transmission from the trackside equipment, and continues until the brake application is completed. Not until a new interaction starts (e.g. at the next signal) is new data transmitted and the surveillance therefore terminated or corrected. When he encounters a signal aspect indicating 'expect to be stopped' (caution) the driver can forestall the surveillance after he has reduced speed to 40 km per hour through a special procedure. The train control equipment does not react to a change in the signal aspect which starts after the train has passed and which, for example, allows a higher speed This factor is, in some circumstances, critical for operational performance, although it is without significance for most of the possible points of interaction at signals in the network. However closely the trains may follow each other, the spatial interval between them must be maintained.

Where high service densities must be accomodated, in particular around junctions and where conflicting train movements can jeopardise the stability of the timetable, the surveillance mode can, with the aid of additional technical facilities, be suspended in anticipation, or put into operation again.

This can be achieved in two ways:

a) By providing additional information points between signals (so called points of disengagement) which have the functions of repeater signals. Such points of disengagement are possible without cab signalling below 160 km per hour within the visible range of signals, and they transmit the most up-to-date information available to the train. It is also possible to provide several points of disengagement one after another.

b) With continuous transmission of signalling or 'disengagement' information before the signals concerned, it is possible to transmit a change of signal aspect to the train at any time. Because of the cost involved, this possibility is only adopted where extremely high train or signal densities are involved (e.g. the new extension of the Zurich Regional Express System, where signals frequently change aspect within the range of vision of the driver. The information is transmitted from an inductive loop between the rails (operating at the same frequency as for information points).

Equipping the Network

The system also allows permanent (as on curves) and temporary (as at working sites) speed limits to be supervised. In addition, other operating information can be transmitted to the train, e.g. channel changing for the train radio.

It is envisaged, initially, to supervise only critical braking phases between two signals (in particular home signals) on the existing network below 160 km per hour. After the system has been tested, its introduction can be achieved in stages as required, for example, by specifying the types of track and rolling stock to be equipped, so that the signalling sections thus fitted can immediately be used by the rolling stock so adapted. Signalling sections and trains which have not been equipped will, as before, be supported by the existing AWS. A range of variations in the installation will make possible a subsequent enhancement of the spot-based system in two directions:

a) The inclusion of further signalled speed reductions until AWS has been fully replaced and of surveillance of curves and site works.

b) Equipping for continuous speed surveillance over the range 160-200 km per hour, which would be restricted to the trains and sections of lines concerned.

Each of these additional stages could be provided according to need and taking account of the cost implications. The system makes it possible to add these functions without affecting the basic installation.

Economics and the next steps

As part of the economic evaluation of the new ATC system, the capital expenditure and effect on the costs of accidents were investigated. From the analysis of accident costs from 1965 to 1984 a range of expected financial liability was established for the year 1991 without and with ATC (with higher train performance). A comparison with the capital cost showed that the annual charge of the proposals lay in the same range as the reduction in accident cost. ATC will have a positive influence on the level of safety on the SBB. Market research has shown that for all market segments of passenger transport, the safety of the customer is one of the most important reasons for choosing to travel by rail. On these grounds the introduction of the system is supported.

As a result of a tendering exercise system ZUB100 produced by AG-Brunswick (Federal Republic of Germany) was chosen. The ATC system was specified in detail for the SBB and 8 locomotives and about 30 signal installations (including 4 with continuous transmission from a loop) were ordered for trial. The trials will proceed from the middle of 1987 until 1988. If they are successful, it is envisaged that the first equipment for the Zurich Regional Express system will be ordered immediately afterwards. For the production equipment, the firm Integra Signum AG, Wallisellen, as licence holder for the equipment, will be the principle contractor.

The system proposed uses the existing automatic warning system as a starting point, building up on the functions of AWS. This AWS will, where necessary, be upgraded with elements which can be added as required taking into account operational, time, or financial phasing requirements. In this way the standards aimed at on individual lines or types of train can be chosen.

All the targets set are achievable, in particular the requirements for the Zurich Regional Express system and for Rail 2000. The capital investment necessary for these two particular cases can be limited to the stretches of line and the trains concerned, without further extension of the system to the rest of the network being necessary. By setting priorities appropriately, a relationship between cost and benefits will be achieved which will ensure that the annual cost of the new system is comparable with the accident liabilities thus avoided.

The positive influence on the level of safety of the proposal is important, since market research has shown that for passenger transport the safety aspect had a high value in the choice of mode.

CONCLUSIONS

The two developments for this new signalling and new ATC have shown for the SBB, that with the aid of new technology, existing operating arrangements can be adapted to meet new requirements. In this context it is important to analyse the operational requirements to establish their real content as well as to abandon obsolete practices and to exploit the possibilities of new techniques sensibly. In order for such an approach to be successful, the signal engineer must have a fundamental understanding of operating requirements, must work in an innovative fashion (both from the operating and the management point of view) and be capable of selling new ideas and methods to the operator.

How far this has been achieved in relation to signalling and ATC in Switzerland I am confident will be shown by the results of the trials. I would like to thank all my colleagues who have contributed to this report, for their support, the management of the SBB for permission to present it and LUL for its translation into English.

DISCUSSION

Opening the discussion, Mr. E. O. Goddard asked about sighting problems with the numerical speed signs. The importance of distinguishing between the numbers 6 and 8 could be difficult, as were the signs used for temporary and permanent restrictions of speeds.

Trains intended to work at over 160 km/h were being fitted with cab signalling. There was often a need for short headway working in lower speed areas. Was it intended to equip trains in, for example, the Zurich Regional Express area with cab signalling?

Mr. Stalder replied that the numerical signs were 50 cm in height, giving a sighting distance of at least five seconds for trains below 160 km/h. Their design was based on road highway experience, to clearly differentiate between possibly ambiguous displays.

Permanent speed restrictions, such as on curves, were indicated by signs. Above 120 km/h there was a single sign. Below 120 km/h there might be two or more signs appropriate to the type of train. The driver had the responsibility of using the correct one. The system might be adjusted slightly for a new signalling system, balancing any time savings against increased cost.

Working sites had an advance warning of the restricted speed and demarcation of the beginning and end, a downwards arrow to indicate acceleration. Night indications were flashing yellow and green lights.

For working speeds of over 160 km/h the cab signalling was fail-safe, with a continuous check on speed. On lower speed lines, especially the Zurich Express Region, trains would be equipped with the new ATC, but this was regarded only as a second information channel. It was not to fail-safe standards because reliance was placed on the driver.

Mr. H. Worsley asked how the driver knew where the various speed ranges operated, both when braking and when able to accelerate.

Mr. Stalder replied that the signalling advised the driver when approaching a speed restriction so that he could brake to the intended speed at the indicated position. When the limit was raised he would continue at the reduced speed until he could see the new aspect and all of his train had passed the restriction. The maximum speed was shown in the working timetable.

Mr. M. E. Leach asked if lamp proving was provided for the illuminated figures.

Mr. Stalder replied that each speed number used one lamp, with a possibility of four lamps available, such as 4, 6, 9 and 14. On failure, the signal aspect automatically fell to yellow, which had a double filament. If the yellow failed then the aspect reverted to red. This improved availability.

Mr. R. Pope asked what checking was provided on the train characteristic information fed in by the driver, especially the braking parameters and how much continuous monitoring was installed.

What experience had there been of viewing the fibre optic signals in bright sunlight and at night. At 160 km/h, the viewing distance at five seconds was 250m which might cause problems.

In reply, Mr. Stalder stated that input of train characteristics was recognised as a critical problem. A lot of plausibility checks occurred in the input process. It could be circumvented, but was on record.

At big junctions, such as Basel and Bern and in the Zurich suburban area, continuous monitoring was provided, but not elsewhere for economic reasons. On long stretches of plain track with block sections, drivers would adjust their speed in order to proceed without hindrance.

It was not yet certain that the fibre optic signals were satisfactory under all conditions of viewing above 160 km/h. It was possible that safe ATC would be needed on locomotives working above 140 km/h, so not relying on visual signals.

Mr. G. J. W. Meecham asked if there were any safeguards for missed markers.

There appeared to be a message telegram time of about 5 milliseconds, which required a high transmission frequency. Were there any problems with interference and with interference and with propagation along the track.

Mr. Stalder replied that telegram transmission was at 50 kHz and the locomotive sending frequency was 100 kHz. Experience with other systems at 35 kHz suggested that there should be no problems with interference. The maximum propagation distance in the loop would be about 400 m, depending on the weather.

For 160 km/h working the system was continuous, each marker indicating when to expect the next, with automatic braking if a marker was missed or not working. Between markers reliance was placed on a tachometer on the train.

Mr. A. A. Cardani asked if there was a space problem in providing the separate figures in one display.

Were the two filaments of the double filament main signal lamp of the same rating, and were they connected in parallel?

It was important that the design braking characteristic was as realistic as possible, to obtain close headways without causing unnecessary interference. How was this achieved?

In reply, Mr. Stalder said that the two lamp filaments were fed separately from the interlocking, the reserve being switched on automatically when the first filament failed. They were optically in line.

Separate lamps were provided for the 4 and 14 indications, which were overlaid, together with any others required.

Testing was continuing on braking characteristics and it was thought that close tolerances could be achieved.

Mr. R. E. B. Barnard noted that, in figure 4, the surveillance curve, concerned with application of the emergency brake, did not go down to zero speed at the signal, apparently allowing a slow speed train to over-run the signal. The present AWS gave emergency braking of any train passing a red signal.

In reply, Mr. Stalder said that there had been much discussion on forcing a driver down to zero speed. It had been decided to cease the surveillance monitoring below 40 km/h. This enabled the driver to cancel any imposed restriction and to accelerate again. If the signal was over-run at red there would be an automatic emergency brake application.

Mr. K. Donnelly asked if it was thought that the system of signal aspects described could form a good European Standard.

Mr. Stalder responded that, although theoretically possible, in practice there was so much variation in approach, probably related to national psychologies, that a uniform standard was highly unlikely.

Mr. S. Hall asked if the driver was given information on recommended speed to keep within the surveillance curve, to avoid triggering the automatic brake application.

Mr. Stalder replied that experience had shown that, when recommended speed was indicated, drivers tended to keep to close to the curve and get caught out. This was undesirable. It had been decided to keep to only indicating the target speed, and possibly the target distance, relying on the judgement of the driver.

Technical Meeting of the Institution

held at

The Institution of Electrical Engineers

Tuesday, 13th January, 1987

The President (Mr. J. G. Oehler) in the Chair

The Minutes of the Technical Meeting held in London on 15th December, 1986, were taken as read and signed by the President as a correct record.

The President then introduced Messrs. R. D. Hollands and D. Barton (Westinghouse Signals Ltd.) and requested them to present their paper entitled "Continuous Automatic Train Control with Microprocessors".

Continuous Automatic Train Control with Microprocessors

By Messrs. R. D. Hollands and D. Barton**

INTRODUCTION

As the populations of cities increase, demand for better public transport grows. Transit authorities are under constant pressure to provide a more intensive service. This paper describes how the ubiquitous microprocessor is being used to help satisfy these demands. The system to be described is in parts already in passenger service in Barcelona, and as a total system package is being installed in Singapore.

AUTOMATIC TRAIN CONTROL

The overall philosophy of the Automatic Train Control system is remarkably similar to that of previous generations ot equipments. The microprocessor has however made possible a system which has many more safe speed channels, is smaller in size, and is more flexible than was previously possible. The main system features are shown in Fig. 1.

*Westinghouse Signals Limited

JOINTLESS TRACK CIRCUIT

In a modular Automatic Train Control system the foundation to which all other modules are added is the track circuit. The FS 2000 Jointless Track Circuit on which the Westinghouse train control system is based has been the subject of a previous paper to the Institution. (1)

Briefly, the track circuit operates on one of 8 carrier frequencies in the 4 to 6 Khz range, and is suitable for AC and DC electrified systems. The track circuit carrier frequency can be modulated using Frequency Shift Keyed techniques at one of 14 frequencies by the addition of Code Generators.

Modulation frequencies in the range 28 to 80 Hz (at 4 Hz intervals) are sent via the code selection circuits and are used to convey safety speed data to the train. The carrier frequency of the Jointless Track Circuit is shifted by plus or minus 40 Hz from nominal, and the rate at which the frequency shift occurs is the modulation rate.

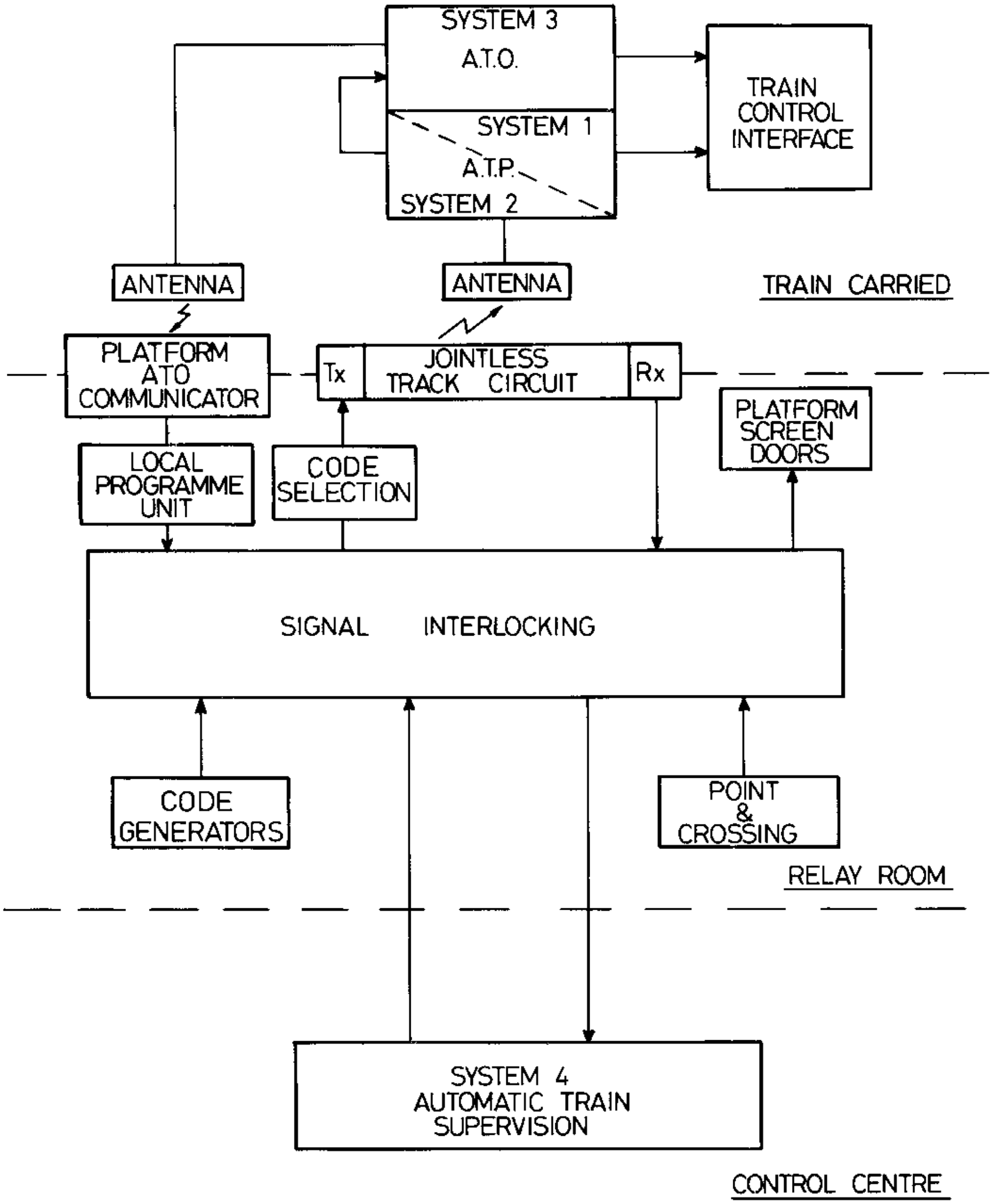


Fig. 1. Automatic Train Control simplified system diagram.

To eliminate the possibility of Automatic Train Protection (ATP) equipment responding to modulation frequencies in an adjacent track, different carrier frequencies are used for the 'UP' and 'DOWN' lines. On start-up, the ATP equipment responds only if a clear, single-carrier code is present. The carrier frequency then indicates whether the train is travelling on the 'UP' line or the 'DOWN' line.

The ATP signals are transmitted by each track circuit to the train using an alternating carrier frequency sequence, either f1/f3/f6 or f2/f5/f7. The sequence cannot be changed unless a transfer frequency (f4 or f9) is received, usually at points and crossings and transfer areas. These rigid sequence rules are used within the ATP system to detect cross talk and mixed code fault conditions.

DIGITAL SIGNAL PROCESSING

The Jointless Track Circuit receiver, Code Generator, and the train carried ATP systems utilise microprocessors to perform a full analysis of the complex Frequency Shift Keyed signal, using Digital Signal Processing techniques. It is only by using a microprocessor that such a signal can be processed, especially to make sure that the signal is Frequency Shift Keyed and not Amplitude Shift Keyed. This is a very important function because the carrier and side bands generated by both types of modulation are very similar. Electric traction systems can conceivably contain Amplitude Shift Keyed type interference, especially under fault conditions.

Digital signal processing involves the conversion of data from the time domain to the frequency domain. The method used in this equipment is known as the Fast Fourier Transform'. Many time related samples of the signal under analysis are taken and 'transformed' into a frequency spectrum.

The Digital Signal Processing technique allows many closely spaced frequencies to be accurately discriminated. Whilst it might be possible to use traditional LC filters, the physical size of the filter elements would not produce a practical design. Fig. 2. shows the comparison of a single LC filter with the required frequency discrimination and the Modulation Detection card used in the ATP system being described.

This clearly shows the practical advantage of a microprocessor system for frequency discrimination circuits. There are other advantages, in that drift with temperature no longer exists, and a bank of 14 such LC filters would cost at least five times as much as the printed circuit board.

AUTOMATIC TRAIN PROTECTION (ATP)

The prime function of the ATP train carried equipment is to constantly monitor the maximum allowable safe speed (conveyed by the Jointless Track Circuit) and train speed, to ensure that the train is never in an unsafe condition of overspeeding. A secondary function of the ATP is to provide indications, alarms and information to the train operator.

With a maximum of 14 ATP codes available it is possible to provide a flexible and easily adjustable system (Fig. 3.). The codes are organised such that between each maximum safe speed there is a target speed code, thus enabling continuous ATP protection under all speed code conditions.

The equipment consists of two sub-systems, System 1 and System 2. System 1 is designed as a safe single channel microprocessor system, System 2 is based on redundancy and cyclic checking techniques. The two systems perform the same safety functions independently of each other and in a dissimilar manner.

The nature of the design and implementation of functions between these two systems provides exceptionally effective protection against common mode failures.

The two independent systems receive ATP signals from the trackside equipment via separate ATP antennae, and train speed signals from the tachogenerators. If safe conditions are present, the ATP system holds up emergency brake relays, which, via train control circuits, hold off the emergency brakes and allow the train to proceed.

The equipment contains an extensive self-monitoring facility which, at power-on, or mode selection, carries out a sequence of checks to prove the equipment is functioning correctly. In addition, it will carry out checks of the software and hardware during the normal operating cycle, to enable faults to be detected.

Two ATP antennae are required per leading car and are mounted so that they are positioned over each running rail ahead of the leading wheels. The antennae receive the frequency shift keyed ATP signal, defining the Maximum Safe Speed and Target Speed, and pass it to the train carried ATP unit.

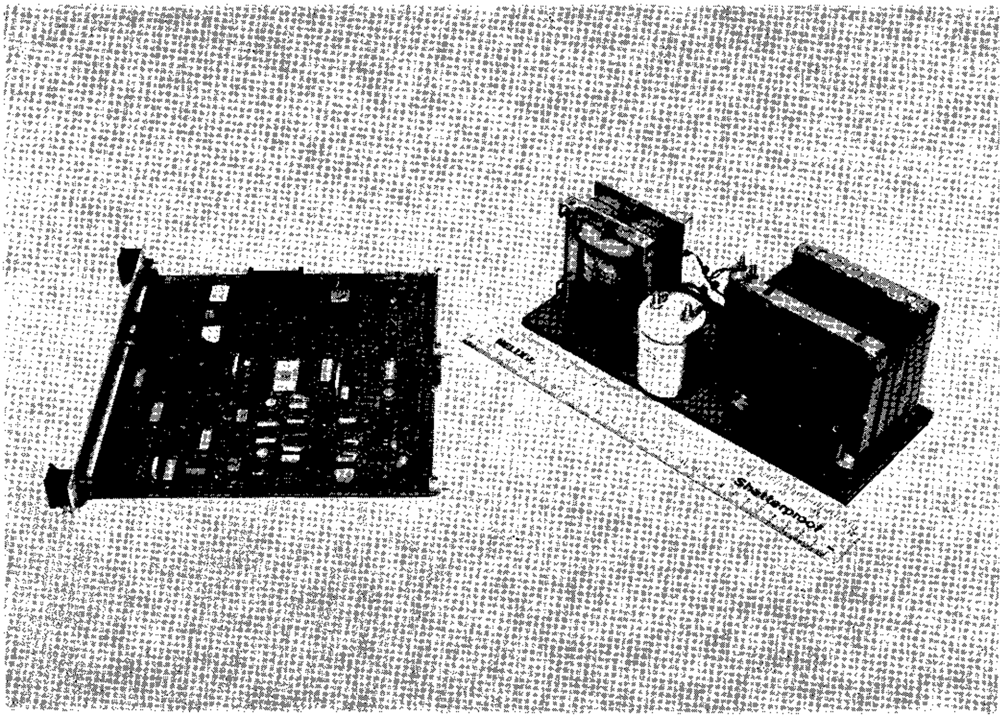


Fig. 2. Comparison between modulation card and a single L.C. filter.

The speed of the train is measured by two tachogenerators mounted on separate axles. They achieve the speed measurement by means of a transducer, which produces pulses which are frequency dependent upon the speed of the train.

The ATP unit is powered by the train battery. Within each sub-system, a power supply filters the battery voltage and converts it to several lower, stabilised voltages which are then used to power the electronics in that subsystem.

During the operation of the train, the wheels wear and reduce in diameter. This causes an alteration in the accuracy of the speedometer indications and the train speed at which the ATP overspeed emergency brake application and indications occur. To make allowances for wheel wear, Wheel Diameter Correction switches are fitted to the ATP system, and adjust the speed determining circuits so as to offset the wheel wear. This action is usually required only after the wheels have been machined to correct the profile.

SYSTEM 1

As shown in Fig. 1., System 1 forms part of the Automatic Train Protection System and is designed to fail safe principles, both in the hardware and software design. Its principle function is to prevent the train from overspeeding.

System 1 receives Automatic Train Protection (ATP) signals from the ATP antennae mounted on the front of the train, and train speed signals from tachogenerators mounted on the axles. The ATP signals carry coded information about the target speed and the Maximum Safe Speed of the train. The driver has a mode selector of No mode, Restricted Manual, Coded Manual or Automatic Train Operation. When Coded Manual or Automatic Train Operation is selected then comparison is made between the actual train speed and the maximum safe speed derived from the ATP signal. When Restricted Manual is selected, then comparison is made between the actual train speed and the maximum manual speed. Exceeding the maximum safe speed in the former case and restricted manual speed in the latter case results in the release of the Emergency Brake Relay. Selection of No Mode or a failure in the Safety System which could result in unsafe operation also results in the release of the Emergency Brake Relay.

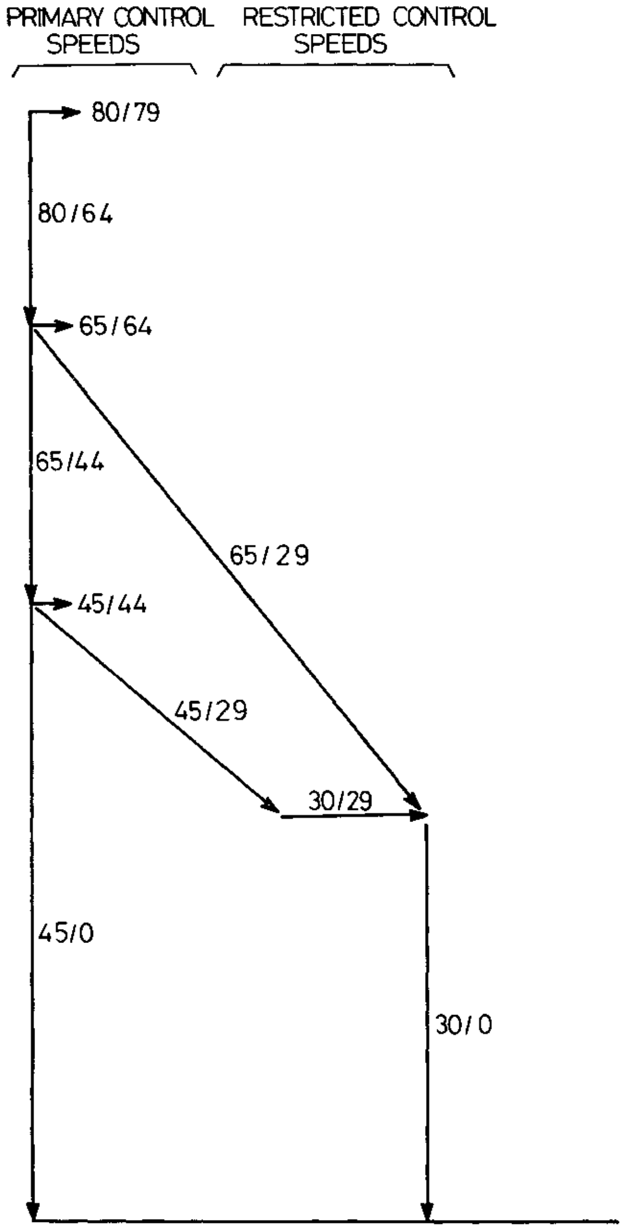


Fig. 3. Typical ATP code sequence chart.

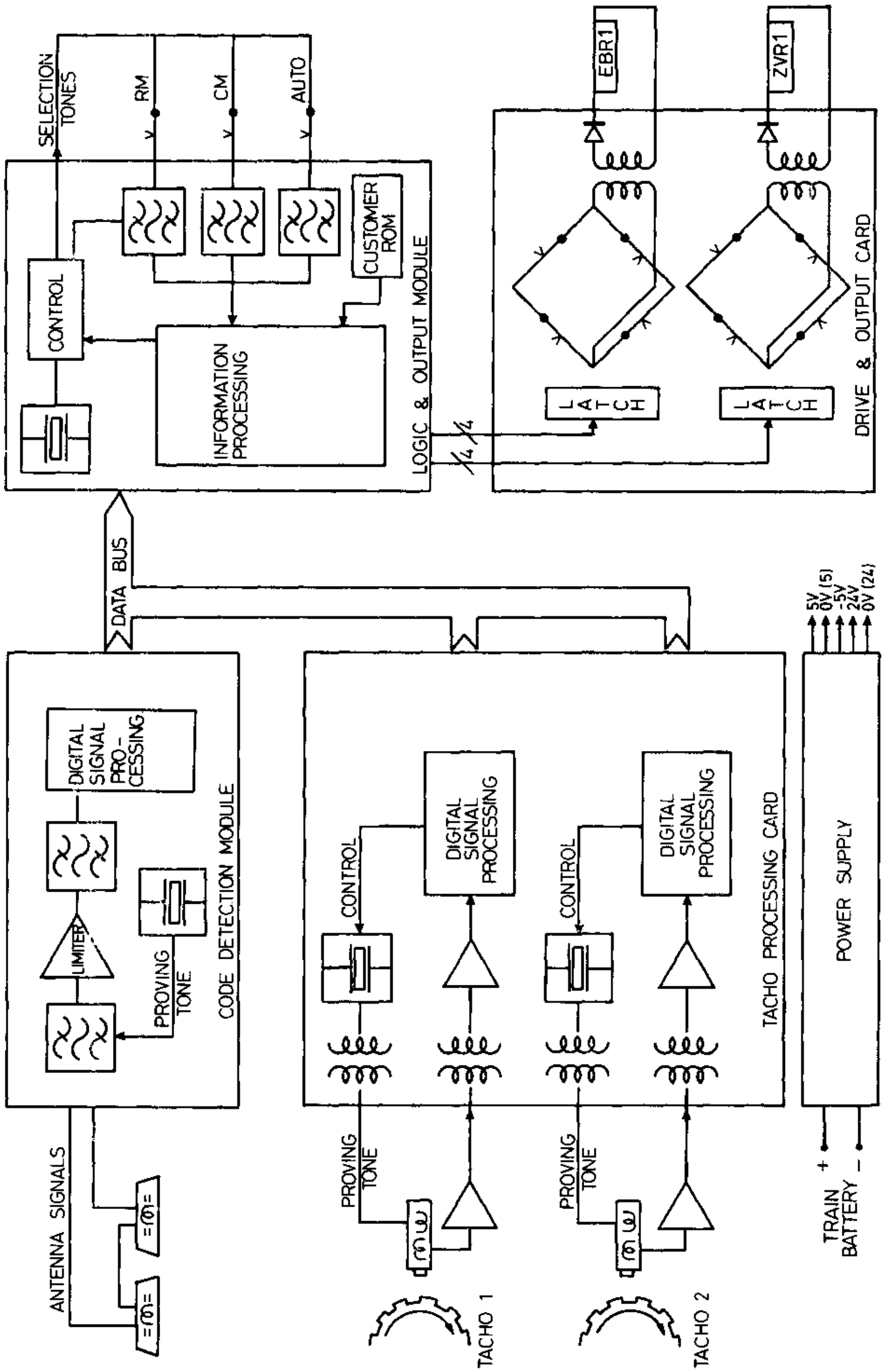


Fig. 4. System 1 schematic diagram.

The Safety System contains the following modules and printed circuit cards (see Fig.4.).

Code Detection Module

The function of the Code Detection Module is to establish whether there is a valid Frequency Shift Keyed signal present on the input from the antennae and to establish the modulation rate of that Frequency Shift Keyed signal.

The Frequency Shift Keyed signal is passed through a series of analogue filters, a limiter, and an analogue to digital converter. The signal is sampled and a Fast Fourier Transform is performed on the sampled data. The result of this Fast Fourier Transform and data on previous carriers is to establish whether:

a) an acceptable sequence of Frequency Shift Keyed carriers has been followed.
b) No Frequency Shift Keyed carrier is present.

This data is passed to the Logic and Output Module via the system data bus. The information on the bus is transmitted in a safe manner using Hamming codes to check for corruption.

Tachogenerator Processing Card

The Tachogenerator Processing Card consists of two identical, but independent channels, each performing a broad band spectrum analysis on the received signals from the tachogenerators.

The integrity of the tachogenerator is proved by sending a tone from the Tachogenerator Processing Card to the primary of the perception head. The toothed wheel turns with the train axle, and the teeth passing the perception head produce an AC waveform which mixes with the proving tone. This waveform is received back by the Tachogenerator Processing Card for processing.

The incoming signals are converted to frequency domain by a Fast Fourier Transform and the signal examined for:

a) correct frequency and amplitude of proving tone
b) correct level of tachogenerator signal and its frequency
c) any extraneous signals.

If the signals after analysis are satisfactory, the data representing the position of the tacho signal in the frequency spectrum is passed via the data bus to the Logic and Output Module.

Logic and Output Module

The two main functions of the Logic and Output Module are:-

a) determine in a safe way the state of the mode selection switches
b) using the data from the Code Detection Module and Tachogenerator Processing Card to safely determine in which state to control the Emergency Brake Relay and Zero Velocity Relay.

The mode selection is performed by sending AC signals over the mode selection contacts and examining the level and frequency of the signal received back at the safety system.

The information sent from the Code Detection Module indicates which modulation and carrier frequency is being received in the ATP signal. If it is not possible to safely decode the modulation, a message is transmitted from the Code Detection Module to the Logic and Output Module to indicate whether this is due to a failure in the hardware or due to no valid code being received from the track.

The signal from the Tachogenerator Processing Card is proportional to train speed but has to be corrected because of train wheel wear. The wheel diameter information is read from the two wheel diameter correction switches, which are set to the appropriate position when the wheel diameters are measured during the maintenance period. If the Emergency Brake Relay 1 is to be energised then a coded dynamic waveform is sent to the relay drive circuit on the Drive and Output Card. Similarly, another coded dynamic waveform is sent to the Zero Velocity Relay drive circuits on the Drive and Output Card if the Zero Velocity Relay should be energised.

Drive and Output Card

The Drive and Output Card contains the drive circuits for the outputs from the Safety System. These consist of non-vital drive circuits for system fault and code valid indications and safe relay drive circuits for the Emergency Brake Relay (Emergency Brake Relay 1) and the Zero Velocity Relay (Zero Velocity Relay 1).

The safe relays are driven by identical processor proving bridges These have three states, relay energised, relay not energised and circuit disabled. Each safe relay bridge is driven from four inputs which must apply a valid dynamic waveform. One of the dynamic waveforms causes the bridge to energise the relay, the other causes it to de-energise the relay. If either the input waveform is invalid or the waveform frequency is incorrect then the circuit is disabled, de-energising the relay.

SYSTEM 2

System 2 is designed using well proven, solid state circuits employing both digital and microprocessor techniques. As well as providing the continuous monitoring of conditions to ensure the safety of the train, it provides information to the train operator and the ATO unit and has a sophisticated built-in monitoring and data retention system for maintenance purposes. The software contains extensive self-checking of both hardware and software functions.

The basic functions of System 2 are:

a) to provide the same functions as System 1 but in a totally different manner
b) to provide indications to the train driver of operating requirements
c) to provide information to the (Automatic Train Operator) ATO controller.

The system is made up of the following module and printed circuit cards (Fig. 5.).

Train Input Data

The Train Input Data card receives a number of signals from sources external to the systems, these are filtered and processed before being passed to other cards. All inputs are electrically isolated from the train on this card.

Carrier Detection

The Carrier Detection card is one of the printed circuit cards involved with the processing of the received track signal.

The carrier card receives a band limited ATP signal from the Train Input Data card and determines which, if any, of the eight track circuit carriers is present. This function is carried out using Digital Signal Processing techniques. If the carrier is from an acceptable sequence, then the signal is hetrodyned to be evenly displaced around zero frequency and is passed to the Modulation Detection Card.

Modulation Detection

The Modulation Detection card processes the signal from the Carrier Detection to determine if a valid modulation rate is present. If a valid modulation frequency is identified successfully, a binary code corresponding to this code frequency is output to the Processor and Logic Card.

This process of detecting valid carrier and modulation is a continuous one, after each successful computation a signal is output to the Processor and Logic card which is used to control the state of the Emergency Brake Relay.

Processor and Logic

The Processor and Logic card takes the speed code signal from the Modulation Detection card and compares this with the tachogenerator signal (which it has filtered to calculate train speed). If the speed is greater than or equal to the maximum safe speed, the Emergency Brake Relay will be de-energised.

The Processor and Logic card also controls the many system checks which are carried out each time the system is energised.

Any faults detected, or demands for the Emergency Brake Relay 2 to be dropped are recorded in the non-volatile recording memory.

Train Output Data

The Train Output Data card receives a number of signals from the Processor and Logic card and passes them to external equipment.

Signals to the train interface circuits and to the ATO are isolated from the System power supplies by using voltage free contacts. An LED on the front of the card is used to indicate the state of each output.

FLEXIBILITY - SYSTEM 2

Thus far, great play has been made of the microprocessor and its use in frequency discrimination circuits. However, another key feature is flexibility.

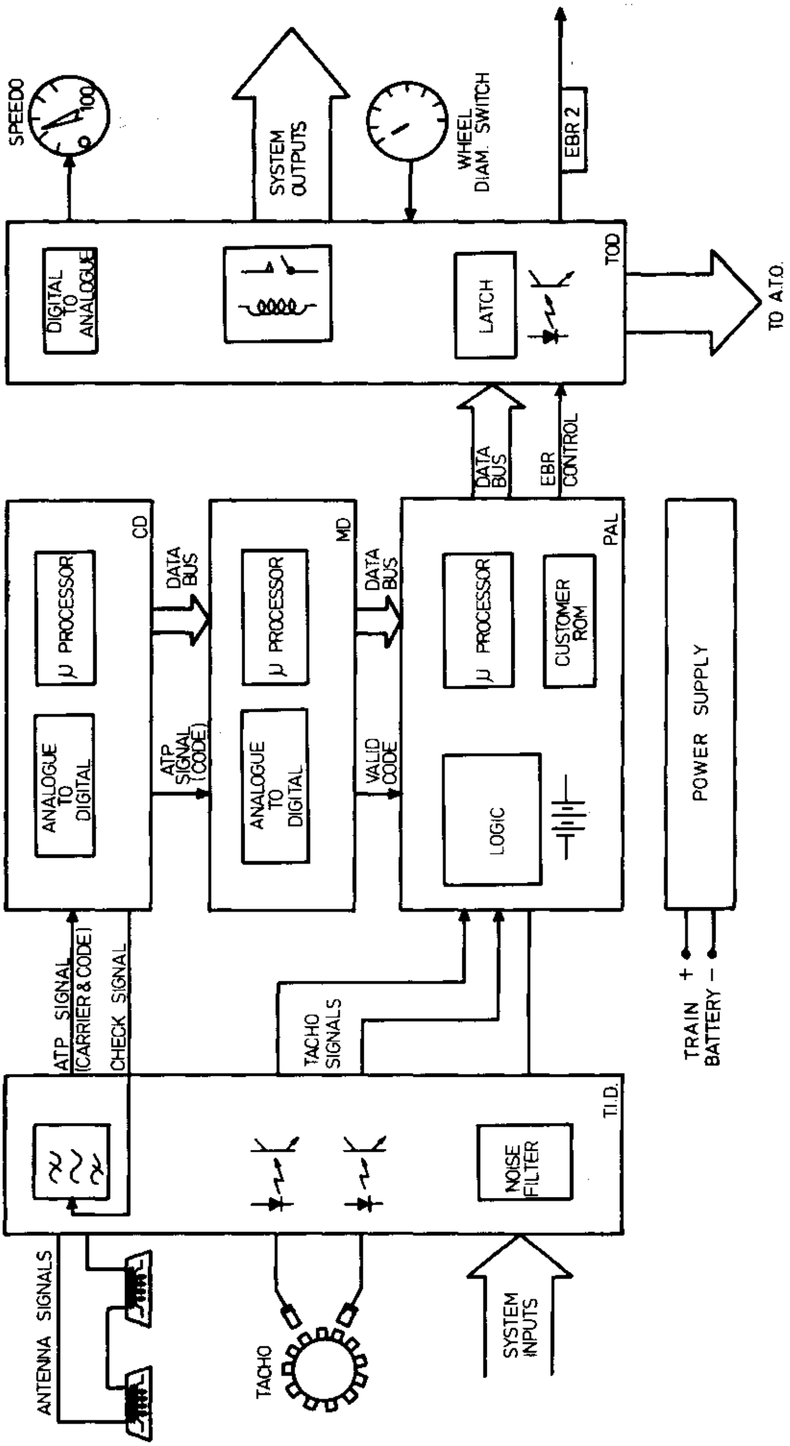


Fig. 5. System 2 schematic diagram.

Before the advent of the microprocessor and memory chips, the parameters of the system had to be fixed before the design could be started. For example, the exact speed bands would have to be fixed to enable filter design to be started, the number of teeth on the tacho would have to be fixed to enable logic circuits to be designed.

This is no longer the case. The system parameters of both ATP systems are held in memory chips, thus if for example the relationship between tacho pulses and speed bands has to change none of the hardware is affected. Apart from the ability to easily adjust mathematical relationships the different operating requirements of various transit authorities can be accomodated using a single memory chip and 'adjusting' the software.

MAINTENANCE

The arrival of the microprocessor can also bring benefit to the often neglected area of maintenance. It is certainly our experience that when the source of a fault might be train-carried or trackside, a module or unit is changed on the train and a test run booked to see if the fault has been cleared. This costly 'trial and error' approach is no longer necessary. The microprocessor has enabled a controlled approach to be applied to maintenance and enables the return of units to revenue service in the minimum possible time.

In addition to memory and timing checks which are common practice these days, tests are carried out to prove the correct functioning of:-

a) the input filter - the carrier card generates a set of tones at specified levels which are switched (under software control) to the input of the system. The signals received back by the carrier card are checked to confirm satisfactory operation of the input filter

b) A Fast Fourier Transform 'test code' is generated on the Processor and Logic card which is input to the Modulation card. Again a correct response is required back to the Processor and Logic card before the unit will be considered as functioning correctly.

These, and other static tests, are carried out each time power is applied to the unit and each time the train mode selector is moved from no mode to mode one of the driving modes.

Whilst the train is in motion, dynamic tests (of the type listed below) are carried out to ensure system integrity.

a) Once every software cycle, the Emergency Brake Relay 2 supply voltage is momentarily removed and a check to confirm this has operated correctly is performed.

b) Each time the train passes through 10 km/h the tacho signals are reversed for sufficient time for the runback logic to operate. The tacho phases are returned to their normal state before the electromechanical Emergency Brake Relay 2 can respond.

A modern train contains many electronic sub-systems and a large number of cables and interconnections. It is our view that most of the intermittent type of faults are the result of loose or poor connections. It is, however, an unfortunate fact of life that electronic equipment is a sitting target for being suspected as the source of a problem and the normal way of fault finding is to keep changing modules until it 'works'. To avoid this ritual card or module changing, the unit is equipped with a single step test feature which operates as follows:-

If, for example, the train returns from service with a complaint that the 80 km/h speed lamp does not always work, then the unit is switched to single step mode and each of the system outputs are energised in turn until the 80 km/h speed lamp is reached. This output is then left permanently set while the wiring, lamp holder and all the interconnections are checked. Once the fault is repaired, the single step switch is returned to normal and the train is ready for service.

To assist with fault diagnosis and maintenance, System 2 is fitted with a RAM and battery back up which can record system parameters and failure modes whilst the train is operational. At some convenient time in the future, a maintenance technician can plug into the Processor and Logic Card a System Test and Maintenance Printer (STAMP Box), and obtain a printout of the contents of the fault RAM.

The contents of the fault RAM will start to be printed (with the most recent event first). The printout will start by printing out equipment faults and then emergency brake applications. Normally, only a partial printout with the most recent events is required, so

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WESTINGHOUSE

SIGNALS

PROM IDS:
0) 600/000000/01
1) 600/000001/01
C) 600/000001/05

SYSTEM ID:
I.R.S.E

CAR NO:
002

DATE:

ENGINEER:

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001*EQU-019 : 00000.01HR
000/000, 000KPH : NM

001*EQU-102 : 00000.00HR
000/000, 000KPH : RM

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001*EBR-006 : 00000.00HR
000/000, 018KPH : RM+

001*EBR-007 : 00000.00HR
000/000, 020KPH : NM-

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REPORT:00003: 00000.01HR

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Fig. 6. Diagnostic system data.

facilities exist on the Processor and Logic card to terminate a printout at any particular point. A typical printout is shown in Fig. 6.

The Printout

Prior to printing out the diagnostic system data, a header is printed which gives details of the software in the memory chips and a three digit chassis serial number. This enables each ATP system to be related to a particular motive unit.

The information is presented in the form of failure codes which can, by the aid of a small 'fix it' book, be explained and the likely sources of the problem identified. The track circuit codes, train speed and operational mode are also tied to each event that is recorded.

On completion of the printout, a serial number is added, thus one would expect the entire history of each unit to be recorded in chronological order for future reference of system performance and reliability.

There will be occasions when all the foregoing maintenance aids fail to highlight the source of the problem, say for instance there is one train in the fleet that tends to underrun when performing a station stop. The problem could be in the brakes sub-system, the ATC system or perhaps traction control.

To assist in the identification of the source of such obscure problems, System 2 can be configured as a data logger. Four of the data input bits can, via voltage free contacts, be interfaced into the train control system. The logic state of these four relay contacts (open or closed) will be recorded and time tagged in the non-volatile memory. Any subsequent printout will show, in a time related manner, the logic state of the four inputs and their relationship with events occurring within System 2.

SYSTEM 3

System 3, the Automatic Train Operation System, provides automatic movement of trains over a Metro System (see Fig. 1.). To carry out these functions System 3 interfaces with System 2 to determine target train speed, and with the Automatic Train Supervising System (System 4) to determine the order in which trains move over the system. Additionally, System 3 provides a method of identifying certain train characteristics to System 4 and the signalling interlocking and a supervisory function for door control at stations.

System 3 provides the following basic functions:-

Accurate stopping at stations

Close control of trains to the Maximum Permitted Speed between stations

Signal stopping - normal running to limits set by the Safety System

Ability to enable coasting to conserve energy

Positive train identification

Self monitoring of ATO

Trackside Equipment

This comprises a Platform ATO Communicator whose main function comprises a means of generating data to be transmitted to the train and a means of receiving data from the train together with a number of trackside loops and loop feed and matching units.

All of this equipment is mounted within station areas, i.e. none is required to be tunnel mounted.

Platform ATO Communicator functions:-

a) When the train is stopped at a station to provide data which will describe in detail the next interstation stop, i.e.:

   Distance to next station stop(s)

   Position of all track circuits to next stop(s)

   Gradient information

   Coasting vectors

   Station location (surface or tunnel)

   Stopping profile (0.6 - 1.2 m/s^2)

   Time of day

   Station identification number

b) Where the train is approaching the stopping position, to transmit information to it via a recalibration loop and the main stopping loop to enable accurate stops.

c) To receive Positive Train Identification information from the train for onward transmission to the Automatic Train Supervision (ATS) System.

d) To transmit and receive information to synchronise the opening and closing of train and platform screen doors.

Train Carried Equipment

The ATO Controller is located within the same cubicle as System 1 and 2 and is mounted in the driver's cab.

The main function of the ATO Controller is to provide outputs to the train's motors and brakes to effectively control the train, based on information transmitted from the trackside via the ATO trainborne antennae and the tachos and target speeds via System 2.

The ATO Controller operates on the following inputs:-

a) Target speed from the System 2

b) Speed information from tacho's from System 2

c) Information from ATO loops

d) Wheel diameter factor

e) Driver's input

It provides the following facilities:-

a) Start up

b) Speed regulation

c) Coasting

d) Accurate station stopping

e) Signal stopping

f) Runback detection

g) Slip and slide detection

h) Fault detection

i) Alarm facilities

j) Train and platform screen door control (open/close) signals.

Flexibility - System 3

The present generation of System 3 equipment allows much greater flexibility in operational terms than previous equipments because of the microprocessor design.

One example is intelligent braking. The purpose of intelligent braking is to permit the train to continue at its present speed under speed regulation for as long as possible and then to reach the target speed between 8 and 10 metres ahead of the track circuit boundary (Fig. 7.).

The method by which it achieves this is as follows:-

a) Braking profile is generated one track circuit ahead of the next possible target speed change.

b) The System 3 has knowledge of track circuit boundaries.

c) If the target speed changes, System 3 acts on the information generated and brakes the train to the new target speed according to profile.

d) If the target speed does not change then the information generated is not used and the train continues speed regulating.

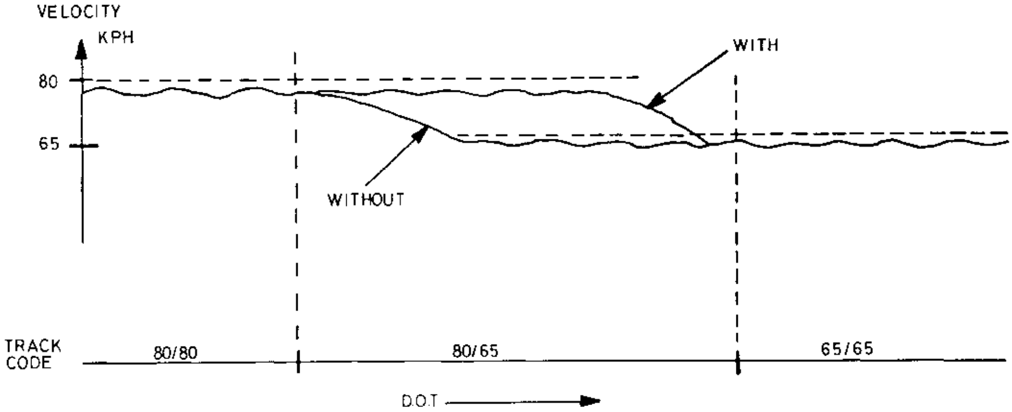

Fig. 7. Intelligent braking concept.

The advantages of intelligent braking are:-

a) That the train runs at the current safe speed for as long as it is possible.
b) At a signal stop (zero target speed) the train comes to rest 8-10 metres away from the signal (assuming the railway requires trackside signals).
c) A better train performance profile is generated, allowing clearer headways and more system throughput - an essential in today's revenue conscious operations.

MAINTENANCE

To assist maintenance the System 3 has a "health monitoring" package fitted. This records any equipment failures in a non-volatile medium as they occur and will print out the faults on a System Test and Maintenance Printer in the same manner as System 2. The maintenance technician therefore requires a single maintenance aid (STAMP box) to be able to monitor System 2, System 3 train carried and System 3 trackside.

One example of information given by the printout is:-

a) The time the fault occurred
b) The previous station name
c) Distance from previous station
d) Velocity
e) Positive Train Identification
f) Running Mode
g) Fault Mnemonic

Examples of fault mnemonics:

CF* — Card No. * faulty
MC** — Memory Chip ** faulty
COM* — Communication channel fault

PLATFORM SCREEN DOORS

On Metro schemes with station air conditioning it is an advantage to the railway to incorporate platform screen doors along the platform edge. These doors retain the air conditioning within the platform/station area and allow the tunnels to be non-air conditioned (the trains each have integral air-conditioning for the comfort of travellers).

This concept can only be entertained when the trains can be stopped accurately within the station confines to permit the train doors and platform doors to coincide.

As mentioned earlier, the Platform ATO Communicator performs an important dialogue with the train to confirm the train is stopped in the correct position before outputting a command to open the platform screen doors. The command to open the platform screen doors is output by the Platform ATO Communicator to the door control circuitry via the Signal Interlocking.

To close the doors the Local Programme Unit signals the platform ATO communicator to "initiate platform screen doors closing". The Platform ATO Communicator sends "Close Doors" to the train and the ATO drivers "Close Doors" indication is lit. When the "Close Doors" buttons are pressed the ATO sends a "Close Platform Screen Doors" signal to the Platform ATO Communicator which in turn activates the "Close" relay in the screen doors control circuit via the signal interlocking.

Both sets of doors will then close simultaneously.

SYSTEM 4

System 4, the Automatic Train Supervising sub-system is designed to monitor and supervise the operation of the Metro system (Fig. 8.).

Its objectives are as follows:-

a) Maintain service according to prescribed schedules.
b) Restore service and re-establish patterns following delays and breakdowns.
c) Raise schedules to meet passenger flow changes.
d) Provide management and passenger information in real time and in hard copy form for records.

Local Program Unit

At each interlocking within the railway network, a Local Program unit controls route setting, platform indicators and departure sequences based on timetable working for its own station area. The Local Program unit comprises two microprocessor based subsystems operating in hot standby mode (i.e. both sub-systems receive and process data but only one is permitted to drive outputs). Should a fault occur in the on-line sub-system then changeover to the other sub-system is automatic.

Some Local Programme units also control similar functions in adjacent stations that are not interlockings (termed Intermediate Stations). The equipment installed here is called a Remote Terminal unit and comprises a single microprocessor based information gather up and equipment control sub-system.

Information needed by the Local Program units in order to correctly control the interlocking and other equipment is passed to the Local Program unit by the Operations Control Centre computer. This information is the timetable for trains in the controlled area of each Local Program unit. The internal programs of the Local Program unit interpret the data to schedule trains using train code references.

The train code number is initiated when the train set first enters service for the day and is passed sequentially from interlocking Local Program unit to interlocking Local Program unit as the train progresses through the system. Most routine ATS functions will be initiated locally and monitored from the Operations Control Centre (Fig. 9.).

Operations Control Centre

The Operations Control Centre comprises manual supervisory consoles, information displays, deviation and reporting printers, track diagram panel, main and standby computers and associated equipment. The standby computer at Operations Control Centre, termed Schedule Compiler Computer, is as its name suggests, used primarily for the compilation and modification of ATS operating schedules. The Schedule Compiler CPU operates in a warm standby mode to the Main CPU. In the event of a failure ofthe Main CPU an orderly close down of any compilation activity on the Schedule Compiler CPU is instigated prior to it assuming the role of Main CPU.

The System Controller will perform monitoring functions from his console at the Operations Centre. The Train Controllers will make and implement decisions, perform tasks which are not pre-set or programmed and supervise operation of the central equipment. The ATS performs its functions automatically with selective features for manual override by the train controller. The design concepts are:-

a) Decentralisation of decision making devices which affect the routing of trains (Local Program units).
b) Synchronisation of all local program units with the central computer.
c) Requests from the central computer will modify the stored timetable data of the local program units in accordance with maintenance of schedule requirements but failure to receive requests from the central computer will result in the programmed mode of operation.
d) Fully scheduled operations modified from the Operation Control Centre and manual non-scheduled operations are provided for all equipment affecting train movement.

The Operations Control Centre computer will monitor the location of all trains on the system. The Local Programm unit controls the performance of all trains in order to minimise the effect of train delays on the operating schedule.

When the system performance varies from that scheduled, the Operations Control Centre computer determines strategies needed to maintain scheduled operation or to minimise delays and applies the required control adjustments or the Train Controller may override

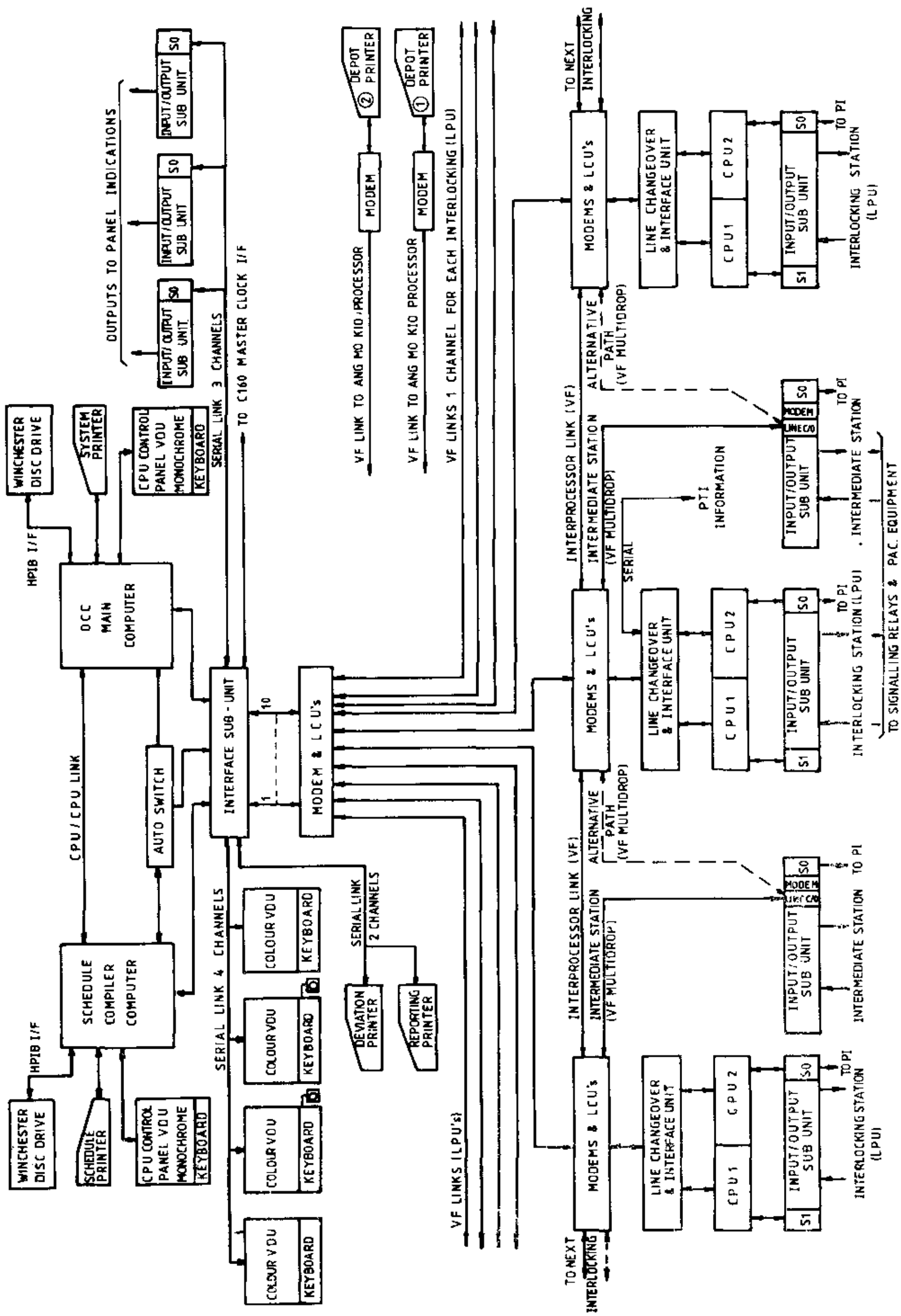

Fig. 8. Signalling computer system block schematic.

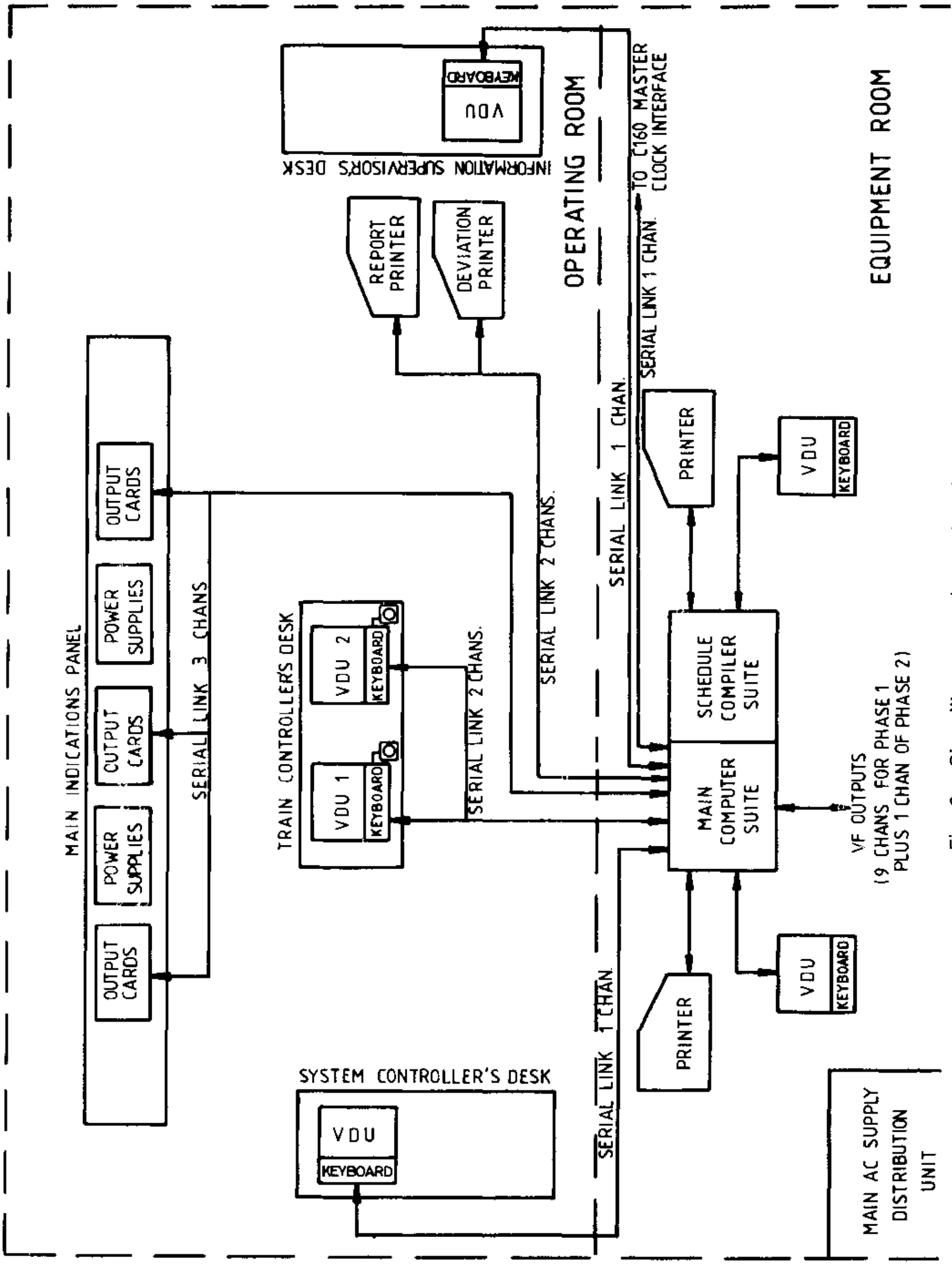

Fig. 9. Signalling computer system layout

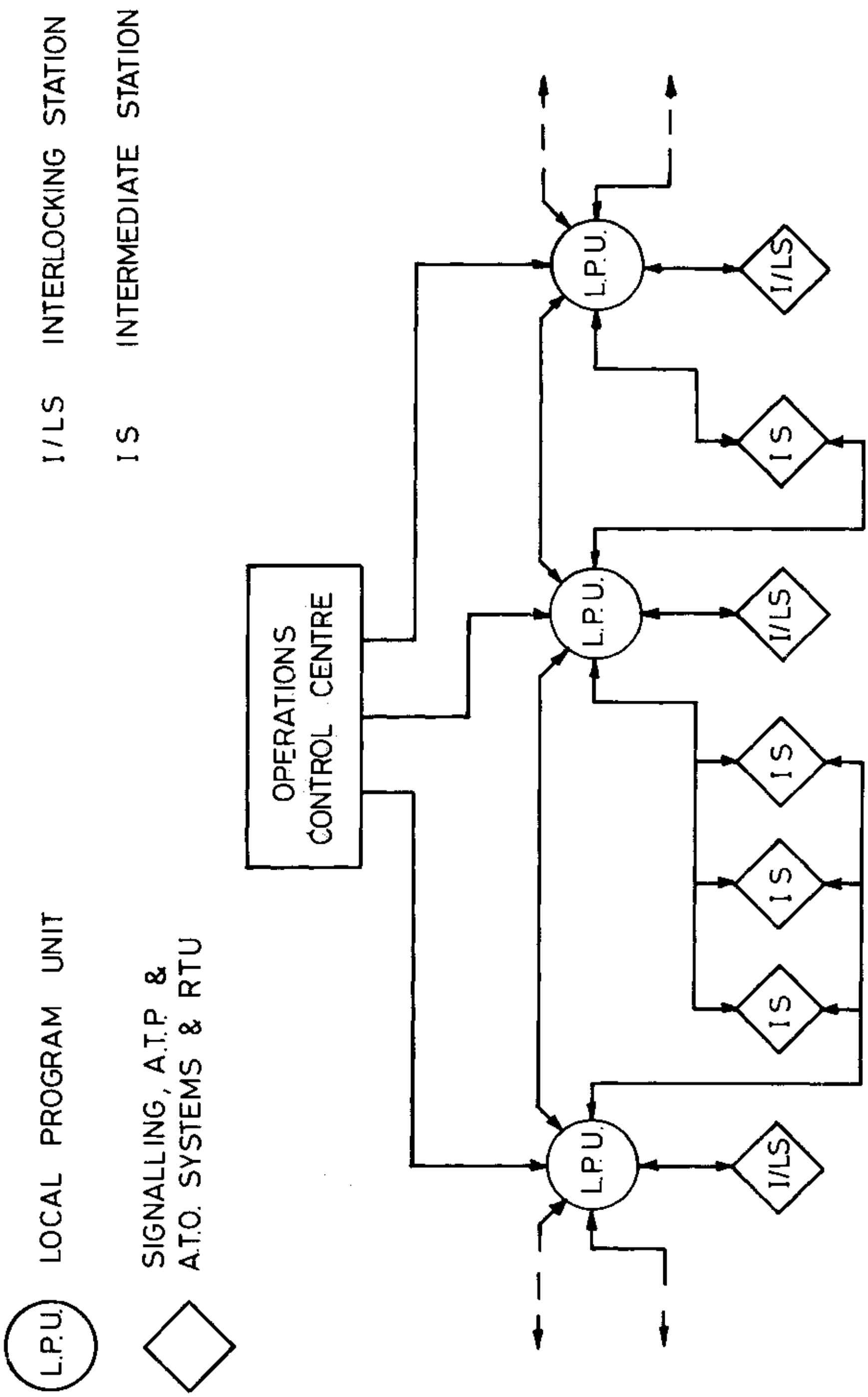

Fig. 10. Data transmission communications arrangement.

the Local Program unit strategy as he sees fit in order to maintain the current operating schedule. One or more of the following strategies may be applied:-

a) Revise the despatch schedule of a train or trains.
b) Redistribute the spacing of trains preceeding or following the delayed train.
c) Offset the entire system operating schedule.

The Operations Control Centre computer also automatically records all operating data required to evaluate operation of the system such as:-

a) Alarm conditions and the termination of these conditions.
b) Manual adjustments or control inputs originating from the control centre.
c) Changes made to the current operating schedule.
d) Logging for later recall, details of trains/functions that deviate from planned schedules by more than a predetermined time.
e) Provide running data for later retrieval from the Operations Control Centre computer i.e. car running distance.

Flexibility - System 4

An essential part of the System 4 philosophy is normal local control (from the Local Program unit) with Operational Control Centre monitoring of activity and interjection if required.

A necessary pre-requisite of such an arrangement is a secure communication path between Local Program units and Operations Control Centre. With the use of microprocessors to handle communications, a variety of optional and fallback communications paths can be used (Fig. 10.).

Typical rerouting paths are:-

a) Messages between the Operations Control Centre and a Local Program unit can be rerouted via an adjacent Local Program unit.
b) Messages from one Local Program unit to any adjacent Local Program unit can be rerouted via the Operations Control Centre.
c) Messages between a Local Program unit and an intermediate stations scanner may be routed via an adjacent Local Program unit.

When any of these fallback modes are in use due to a link failure the relevant communication area in the Local Program unit and Operations Control Centre will continuously monitor the normal link for recovery. As soon as link recovery is noted the information is relayed to Operations Control Centre. Rerouting ceases and all messages revert to the normal link.

CONCLUSIONS

In this paper, we have attempted to illustrate how microprocessor technology is being exploited to provide economic systems with greater operating flexibility, higher perform ance and additional features, whilst providing improved maintenance facilities.

ACKNOWLEDGEMENTS

Finally, we wish to thank the Management of Westinghouse Signals Limited for permission to present this paper and to thank all colleagues for their assistance.

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(1) "A Review of Jointless Track Circuits" by C. R. Brown, I.R.S.E. Proceedings, 7.2.85.

DISCUSSION

Opening the discussion, Mr. E. O. Goddard thanked the authors for an excellent paper on a very interesting subject. LUL were currently carrying out tests on some of the equipment described, particularly the block-jointless track circuits which had proved satisfactory despite the recent bad weather. It was also intended to undertake trials of ATP and ATO systems.

He asked if the system described allowed for bi-directional running and how the track circuit sequence coped. The possibility of cutting in an additional track circuit had also been mentioned, and he asked the authors to expand on how this was achieved.

He observed that, although microprocessors were very fast for each operation, their use often seemed to slow down a system. He asked what was the equipment response time of the system.

There seemed to be a number of similarities to the Victoria Line. Had that experience been of assistance in developing the system.

When using two independent systems, to avoid common mode errors, there was a danger that during development and maintenance of the software such errors creep in. What steps were being taken to ensure that common mode errors in the specification were avoided and what level of reliability was aimed for.

He asked to what extent the ATO information passed to the train was being used for on-board passenger information and in addition if it was possible for maintenance staff in the centre to determine the health of a train in service.

The authors replied that the trackside equipment at the transmit and receive ends of the track circuit were identical. For bi-directional running an additional special relay was required to prove that all opposing route contacts were in the correct position, guarding against sneak feed paths.

The optional F9 frequency was used when the normal sequence was broken by insertion of an additional track circuit late on in the design process, to avoid having to reschedule the surrounding track circuit frequencies.

EBR response time to no code was about one second, with a release time of less than two seconds. This was an inevitable consequence of the use of narrow band filters to select the required signal.

The Victoria Line started off with two completely independent safety systems. From that experience it was concluded that one safety system should be provided in future schemes, with all other equipment in a separate system. This philosophy had been used in Madrid, Hong Kong and Singapore. The safety system checked that the train speed did not exceed the allowable speed indicated by the track code.

The advantage of the microprocessor was in flexibility. All specific information, often not decided until a late stage of the design, could be placed in a PROM and plugged into a general purpose card.

Common mode errors were guarded against by making sure that the two systems were truly independent, often using different types of processors and software.

Reliability calculations were based on MIL 217D.

Passenger information was available, and could be used if the customer was willing to pay.

In future, it would be possible to down-load all the train diagnostic information at each turn round and store it on a mainframe computer, but at the time it was done by paper hard copy.

Mr. C. H. Porter asked if the duplication in System 4, particularly in the Operations Control Centre, was in micros or minis.

Was the station interlocking carried out by conventional relays or by microprocessors?

Could the track circuit frequencies be changed by software or were physical component changes needed. The former case would simplify the problem of inserting additional track circuits.

Were the cards purpose designed or were they standard Westinghouse items?

The authors replied that all local program units and all computing applications used microprocessors, apart from the OCC where minicomputers were used. The microcomputers ranged from simple functions, such as train describer displays, through intelligent applications in remote control and communications to advanced applications on trains.

Conventional relay interlockings were used at the present. There was no reason why SSI could not be used in the future.

The jointless track circuits had an inbuilt frequency, proved to be safe. It was therefore not possible to make changes.

In general, the cards were based on the S2 system but some had to be specially developed for this application.

Mr. F. M. Hewlett noted that the problem of alignment of platform and train doors was similar to that of a lift.

He noted that the diagram showed a wheel diameter input to System 3, but Systems 1 and 2 were already speed corrected to take account of wheel diameter.

He commented that analogue signal processing had been used for many years before digital methods became available. It was true that traditional LC filters were bulky and digital circuits could be neatly card mounted. In the meantime, the use of op-amps for simulating reactive components had been developed so that electronic analogue filters could also be mounted an cards.

A possible disadvantage of dealing with sampled data, as required by digital processing, was that there was no information between samples. It was interesting to note that an analogue filter was still needed to recover an analogue signal from sampled data, to fill the gaps.

He asked how safety was maintained if the processor were to stop, because the braking relay appeared to be a latch that was reset on each processor cycle.

The authors replied that the ATO took a default wheel diameter correction factor from System 2. It could measure distance very accurately because it had knowledge of where the train was from the trackside markers. It could calculate the wheel diameter correction to 16 decimal places if required. This would be checked against the default value provided by System 2.

The System 1 EBR output was dynamic rather than static. Four outputs had to be received in the right sequence, and at the right frequency, in order to energise the EBR circuit. In System 2 the feed was interrupted for a few microseconds every software cycle. Removal of voltage was proved and then the output was reinstated. Any failure would drop the EBR.

It was felt that the stability of op-amps would not be adequate for achieving the close frequency tolerances and the wide temperature range required, hence the use of digital processing.

It was agreed that anti-aliasing analogue filters were required to ensure that only the required information was processed.

Mr. T. Knowles asked if routine depot testing of the vehicles had been eliminated, reliance being placed on system tests and the maintenance printer and fault reports from drivers.

One use of the printer appeared to be to check that equipment was meeting its expected MTBF figure. Did this mean that routine maintenance was delayed until a significant failure rate was experienced.

The authors replied that every time power was applied to the equipment it went through a complex set of checks to ensure that all was well. In addition, there was a daily routine check of all the train functions before entering service.

Maintenance philosophy was the reverse of traditional. Equipment was not removed for examination, and formal failure reporting, unless system failure records showed this to be necessary. In this way, the MTBF records showed this to be necessary. In this way, the MTBF records are thought to be more realistic, and not based on statistics of equipment removed with no fault found.

Mr. D. N. Weedon asked if it would be possible to reduce the number of frequencies used for track circuit identification by taking advantage of the increased capability of transmitting digitally coded commands.

Was it intended to incorporate further commands in the ATO system?

The authors responded that the ATO track to train data transfer was made when the train was stationary.

Jointless track circuits, using the same frequency, had to be kept far enough apart to ensure that, under failure conditions, no spurious signal would be received, hence the need for the number of different frequencies used.

Mr. Weedon asked if the practical limit for frequency discrimination had been reached and suggested that different modulation frequencies might only be required to provide the 'joint' between adjacent track circuits on the same line, if the identification were provided by coding.

The authors felt that the practical limit on frequency discrimination, under working rather than laboratory conditions, had probably been reached.

Mr. C. A. Porter asked what was the least safe part of the system and, in the light of experience, what improvements could be made.

The authors replied that, to date, there had been no failures likely to lead to a wrong side failure. System 1 was a safe single channel system. System 2 had all the other functions and had an acceptable level of reliability.

Mr. C. R. White commented that, when headway was critical, it seemed wasteful to stop trains several metres in front of signals.

The response time quoted to Mr. Goddard was presumably in addition to the JTC response time.

Could the single step switch in the cab be left in the test position, thus degrading the system safety?

The authors responded that, at an ordinary signal, there was no recalibration loop so extra stopping point tolerances had to be allowed, hence the need to aim to stop several metres in front of the signal. In stations there was recalibration and greater accuracy could be achieved.

The JTC response time was just under two seconds.

When the system was switched on, one of the first things that the System 2 processor did was to check the position of the single step switch and go into the appropriate mode of operation. It would then be ignored and any change would have no effect.

Mr. J. Waller commented that the ATO communicator at each station passed on a great deal of fixed information to the train. Was there any particular advantage in this. Was it to avoid the need for extra storage of information about the whole line on the train. He pointed out that some of the information, such as distance between stations, was fixed and not likely to change. Why was information not stored in on-board PROM rather than at stations?

The authors replied that the station update provided ATO information for three stations ahead. To overcome possible marker faults, there was sufficient information already on the train from previous markers to provide a reasonable station stop. On-board PROM storage would mean storage of the entire railway and there had to be alimit on data storage.

Proposing a vote of thanks, Mr. C. H. Porter thanked the authors for a very interesting paper. The number who had turned out in the very bad weather was a tribute to them and to the interest of the paper.

Technical Meeting of the Institution

held at

The Institution of Electrical Engineers

Tuesday, 10th February, 1987

The President (Mr. J. G. Oehler) in the Chair

The Minutes of the Technical Meeting held in London on 13th January, 1987, were taken as read and signed by the President as a correct record.

The President then introduced Mr. R. E. B. Barnard (GEC-GS) and requested him to present his paper entitled "Learning to live with Microelectronic Signalling".

Learning to live with Microelectronic Signalling

*By Mr. R. E. B. Barnard**

INTRODUCTION

It is not many years since the microcomputer was a novelty, and predictions about the rapidly falling cost of micro-electronics seemed far-fetched.

In signalling, processor-based systems have been used for non-vital applications, such as remote control, train information, and centralised traffic control, for some years. Only recently has similar technology begun to be applied to safety signalling. The reasons for this are well known:

There are philosophical arguments concerning the safety of such systems which must be resolved before the design can begin, or systems can be brought into service.

The design of a new safety system has extra serial activities (e.g. in specification writing, testing, safety analysis and formal validation of software) compared with a non-vital system, and therefore tends to take longer to complete.

Most of the applications of non-vital micro-electronics in signalling have been concerned with equipment in signalling control centres or equipment rooms, where the environment is relatively controlled. Much safety equipment is, of necessity, located near to signals, points etc. or on-board trains. In all these places, the environment tends to be less controlled.

On the I.R.S.E. Convention in Sweden in September 1978, to visit the L.M. Ericsson computer interlocking at Gothenburg, and also in David Norton's paper "Safety by Redundancy?", presented in March 1979, much of the discussion centred on whether signal engineers would ever be able to accept the idea of a safety system that could fail "wrong-side", following the occurrence of a number (even an improbably large number) of practically possible simultaneous faults (Refs. 1 and 2).

*G.E.C.-G.S.

Yet today, we rely on safe computer systems in many of our new installations. Railway authorities have come to accept such design techniques much more rapidly than anyone would have predicted. The debates on safety philosophy will continue (e.g. Refs. 3 and 4), but it may now be time to consider the broader implications of the use of micro-electronics in safety signalling, and to look where the new technology is leading us, as it comes into widespread, or even universal, use.

EXPERIENCE IN THE U.K.

In his Presidential Address to this Institution in 1978 (Ref. 5), Jim Waller said:

"I shall be a sad man if in ten years time we do not have a computer-based interlocking in the U.K.".

This goal was realised in just over seven years, with the commissioning of the B.R. SSI at Leamington Spa in September 1985. Progress seems therefore to have been faster than anyone expected. The influence of British Rail, both in their Headquarters and in the Research and Development Division, has been considerable in achieving this progress in the U.K.

The actual applications of safe micro-electronics to signalling in the U.K. to the present, are as follows:

British Rail's C-APT speed display and supervision system, used on the prototype APT trains.

The B.R. Radio Token system devised for the Dingwall-Wick-Thurso line.

The G.E.C.-General Signal Ltd. speed monitor system applied to Birmingham Maglev in 1984.

The B.R. Radio Electronic Token Block (RETB) system on the Dingwall-Kyle line, in November 1984.

The British Rail Solid State Interlocking pilot scheme, commissioned at Leamington Spa in September 1985.

The B.R. RETB system on the East Suffolk and Dingwall-Wick-Thurso lines, in 1986.

The signalling contractors have been involved in much of this work, as well as in other development projects using safe computers. This Institution has already heard of the development of processor-based track circuits (Ref. 6), and the interlocking being developed for Neasden yard on the London Underground system (Ref. 7). My own company, G.E.C.-General Signal Ltd., has gained significant experience in this field, and has various safe computer projects in hand:

B.R. SSI signalling for the Docklands Light Railway, for Inverness and Yoker on B.R., as well as for use overseas.

RETB equipment for schemes on B.R.

Over 1000 single processor vital timers supplied to date, for use in relay interlockings overseas.

A General Railway Signal Co. (G.R.S.) Vital Processor Interlocking, using a single channel technique, for London Underground Ltd. at Northolt.

Train control for the Docklands Light Railway, including dual-processor vital speed monitor, and vital inductive data link systems.

In-house development of other safe computer products and systems.

From this experience, it is now starting to become clear just how the broader implications of using processor technology in a safety industry will have to be met. In the process, some established attitudes will have to change.

THE DESIGN PROCESS

Most engineering designs start with a problem; a requirement for the provision of equipment to carry out a particular function. The design engineer makes the maximum possible use of existing techniques, materials and equipment, injects some ideas of his own, and produces a conceptual design for a solution to the original problem. The implementation phase of the work then converts this concept into a detailed design, and manufactures, tests, instals, commissions and brings it into service. Novelty can enter this process in two ways; the equipment itself may be of novel design, or the system may be configured from standard building blocks in a novel way.

Fig. 1a and Fig. 1b contrast the design processes for conventional and processor-based safety equipment. With conventional safety equipment, the activities are carried out largely sequentially,and the dependency of the start of manufacture on the completion

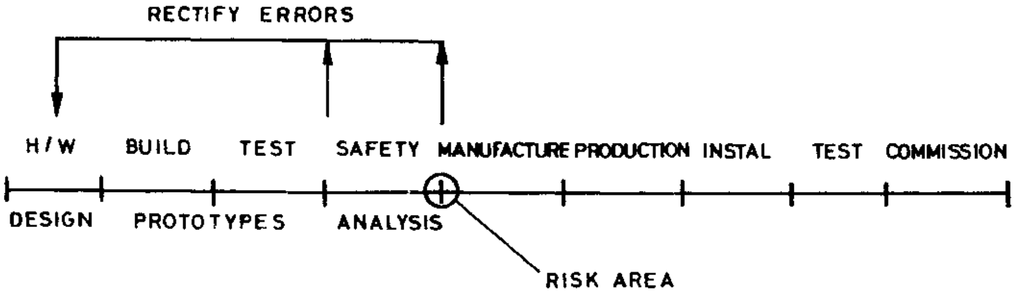

Fig. 1a. Design of safe hardware system.

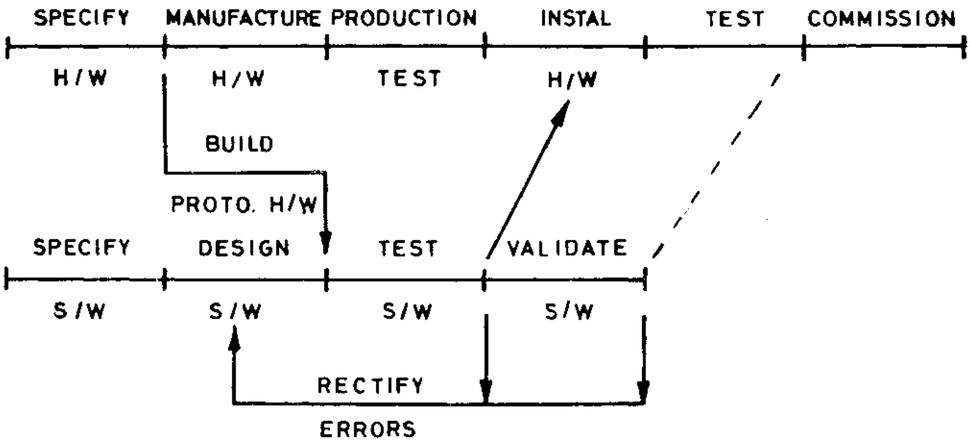

Fig. 1b. Design of safe computer system.

of safety analysis is a major risk point. To maintain delivery dates, it is frequently necessary to commit sizeable sums of money by starting manufacture before all the safety analysis is complete. This can sometimes make replacement of some equipment necessary, on jobs with a high development content and a tight timescale.

With processor-based systems, provided that the software can later be made to run and test the hardware correctly, the standard items of hardware can be manufactured, tested, and even installed on site and used to test the outside equipment, whilst the software is still being designed, tested on prototype hardware, and validated.

Because the "manufacture" of software does not have a long lead time, or a high cost (consisting of the programming, checking and insertion of EPROM's), the formal software validation only has to be finished in time for the final testing and commissioning on site. However, it is obviously costly, and disruptive to other commissioning work to return modules to the workshop, update their software and retest them, once they have been installed along a railway line!

Micro-electronics can enter safety signalling in various ways, as outlined below:

Safe computers as products

In signalling, safe computers can be used to make better products, which are then used in the existing relay-based systems, without any other change in philosophy. An example of this approach is in the area of vital timers for approach control, route locking release etc.

For many years, G.E.C.-General Signal Ltd. used synchronous motor pulse generators in relay rooms, and fitted ratchet timers in interlocking circuits to provide non-decreasing timing functions. However, the ratchet timer device (which had been a standard part of telephone exchange equipment when it was first used in signalling) was becoming expensive and troublesome to obtain. Many attempts have been made over the years to devise a satisfactory electronic equivalent, but it was not until the General Railway Signal Co. in the U.S.A. developed their Safety Assurance Logic technique (using a single micro-computer in a way which tests its own operation thoroughly), that G.E.C.-G.S. found a solution. We adapted the G.R.S. "Microchron" timer design, to suit an input from a 50 Volt D.C. relay room power supply, and to drive a BR930 output relay. The resulting ZT7000 series timers (Fig. 2.) may be used in interlocking circuits, where fixed times are needed (e.g. 90 sec., 2 min., 4 min., etc.), or as free-standing timers in trackside apparatus cases. The latter can be set by wired links on the plugboard to give a precisely defined delay of up to 20 minutes, in 1 second steps.

Other examples of micro-electronic equipment used in this way include track circuits which employ processors to generate and to decode the signal, electronic block control systems to connect a series of interlockings at passing loops on a single line, etc.

Safe computers as systems

Ultimately, a more effective use of a new technology may be to rethink the entire system design, and devise a totally new way of achieving the required function, making the best use of the new techniques.

An example of this approach is the vital speed monitor, originally developed by G.E.C-G.S. for Birmingham Maglev, and now being used on the Docklands Light Railway (DLR).

The DLR is built to follow various existing track alignments with the minimum of civil engineering work. As a result, it has sharp curves and steep gradients. However, being designed originally as an intermediate capacity system, it has short trains, and does not have to operate below 3 1/2 minute headway.

The traditional method of monitoring the speed of trains on urban railways is to transmit one of a number of coded signals to a train in a particular track section, via the track circuits. Each code represents a value of a maximum speed permissible for the train, and is selected according to civil speed limit, or distance clear ahead of the section. On board the trains, the signals are picked up and decoded. They select a speed threshold value, which is compared with the actual speed of the train, measured by means of pulse tachometers, and will cause a brake application if the train travels too fast. The precision of control on such a system is defined by the number of speed codes available.

To minimise journey times on a system such as DLR, a large number of coded track circuits, each with a large number of speed codes would have been needed, together with relatively complex on-board equipment.

Fig. 2. G.E.C.-G.S. ZT 7000 Series vital timer.

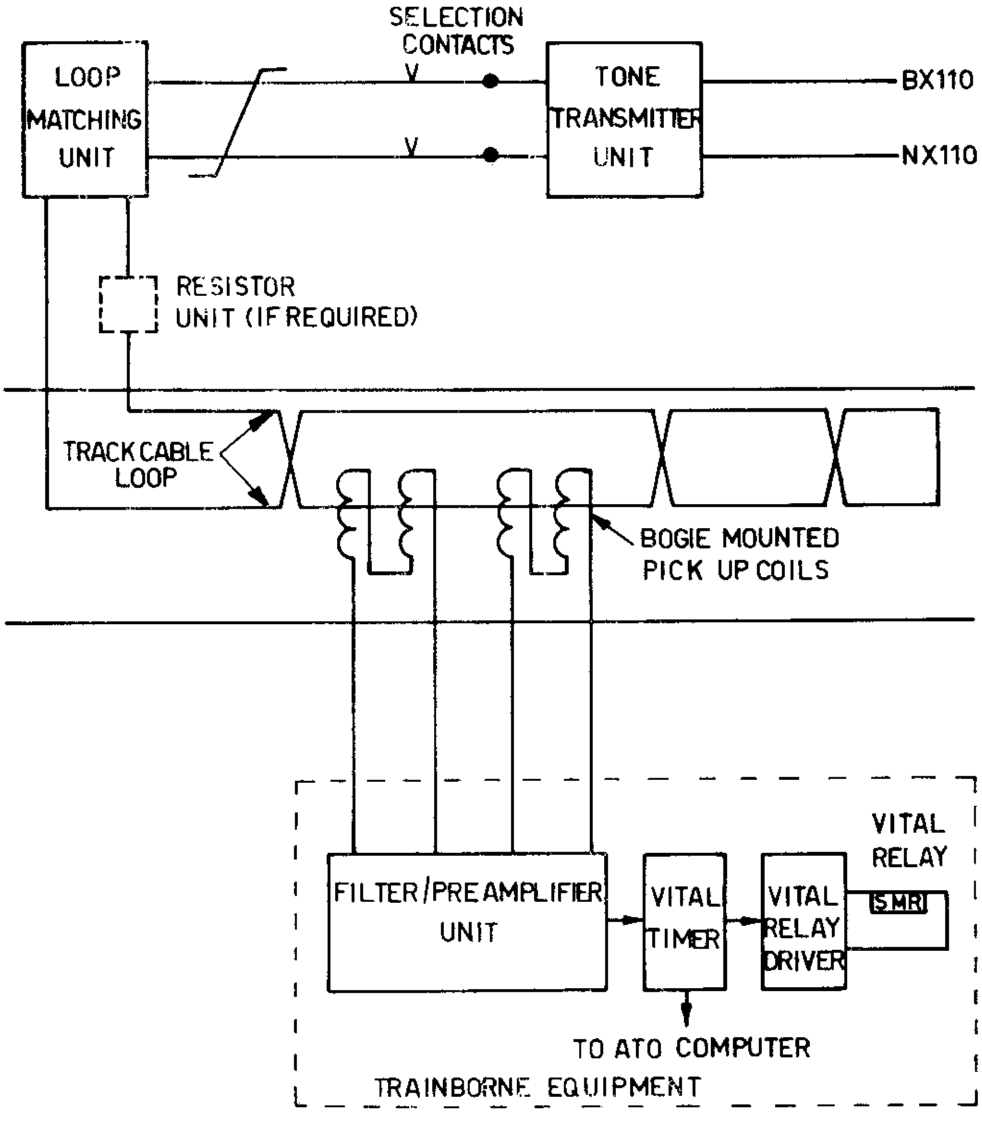

Fig. 3a. Docklands speed monitor system concept.

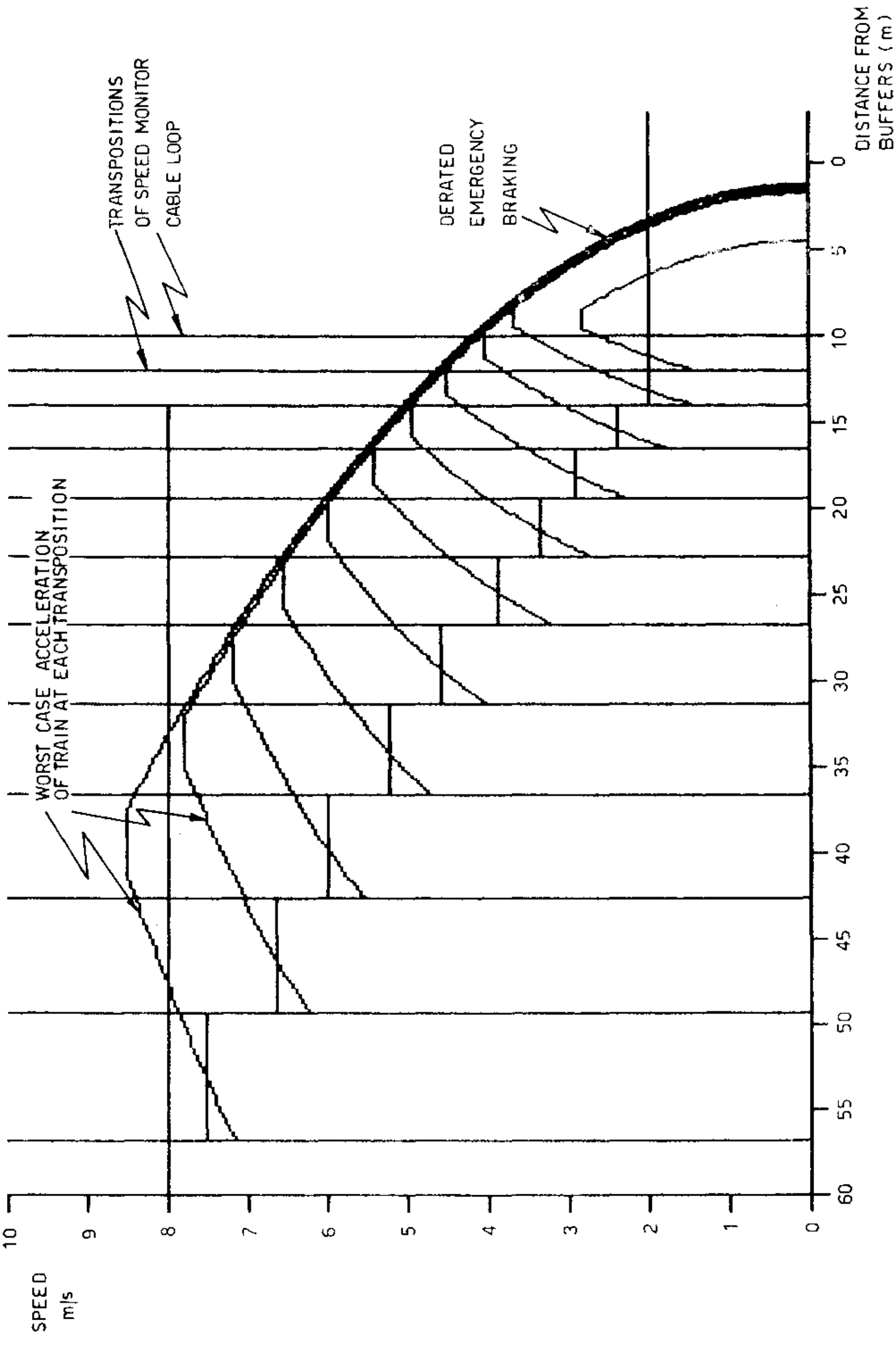

Fig. 3b. Typical speed monitor computer simulation.

The solution adopted by G.E.C.-G.S. was to make use of computer techniques to give a much more cost-effective system of speed monitoring (see Fig. 3a).

Cable loops are laid on the track throughout the railway, and fed with an audio frequency current. The cables forming these loops are transposed at intervals calculated by a computer programme, so as to allow a train travelling at the maximum safe speed to pass over one transposition per second. Pick-up coils on the trains detect the field pattern at each transposition and provide inputs to a dual-processor vital timer, which maintains an output to a vital relay when the train takes one second or more to pass between successive transpositions. By varying the spacing of transpositions, any civil speed limit can be monitored, and the correct deceleration of trains approaching lower speed sections of track can be proved safely.

The equipment is very simple, consisting at the trackside of tone generators feeding up to 1200m of track loop, however many changes of speed limit occur within that distance. The on-board equipment consists of pick-up coils and their interface, a vital one-second timer, a signalling relay and its driver circuit.

This solution is possible for two reasons:

Because of the use of two computer programmes; one to generate the required transposition locations and the other to check these locations by a simulation of worst-case train performance (see Fig. 3b).

Because safe computer techniques make the design of an accurate vital timer a practical proposition.

More radical examples of rethinking the signalling function, using the features that computers perform best, such as data communication and processing of data in a repetitive manner, include the various radio-based signalling systems coming into use around the world, as well as moving-block systems for transit applications, using safe central and trainborne computers, communicating with one another by means of an inductive data link along the track.

Such signalling systems as these replace almost all trackside apparatus, track circuits, signals etc. As signal engineers, we might argue at length about the particular strengths and weaknesses of any such system, but one thing is certain; having accepted safe computers as a part of railway signalling, we are very soon going to have to question our established ideas about train detection, block section working, and many other fundamentals of our profession, which have been built up over the years.

Level of modularity

In relay-based signalling installations, the level of modularity is low. The building blocks of these installations; relays, transformers, reed FDM, track circuit equipment etc. each carry out one simply-defined function. They are each required in relatively large numbers, to the same design, with the aim of obtaining economy of scale in manufacture, spares holding etc. The penalties paid for this low-level modularity are in the cost of housing each unit, and the cost of interconnecting the units.

When micro-electronics are used, particularly in more severe environments, there is a benefit to be gained from having a higher level of modularity. The common circuit areas such as processor, EPROM, RAM, power supplies, interface circuitry etc. can service a complex function almost as easily as a simple function, so that the additional cost of carrying out more tasks in the same unit is often quite low.

Thus, with micro-electronics, it may be beneficial to use a wider range of different, large modules, as long as the differences can be confined to software, or to very limited areas of hardware.

The B.R. SSI Multiprocessor Module is an example of relatively high-level modularity since three form a complete interlocking. The G.E.C.-G.S. version of this unit is already used in at least eight ways, covering SSI interlocking, diagnostic and simulator processors with different data link message formats, and RETB interlockings with and without interfaces to SSI modules. More variants are certain to follow in the future.

None of these modules, as they are held as spares, is directly interchangeable with any other, but they have identical hardware, and only the programmes, i.e. the EPROM contents, are different.

Users have already realised that modules need to be held without location-specific data, to reduce the spares holding, but perhaps in the future, spares will also have to be held without programme installed, or even with several different programmes installed.

The cost of fitting more than one programme in a micro-electronic unit is small, and it may, in many cases, be possible to design modules that can function in a number of quite different ways, according to what they are told by the system in which they are installed. Some systems, in fact, restrict all the location-dependent data to one unit, and load the appropriate data into other units in the system during system initialisation, or as new units are plugged in (Ref. 3).

Another very simple example of this is the 'system address' in B.R. SSI data messages. This address is learnt by trackside functional modules when they are first powered up in the system and is stored in non-volatile (NV) memory. Subsequently the modules will only respond to messages containing the system address, until such time as special measures are taken to clear the NV memory. This eliminates the risk from crosstalk between cables due to damage, without increasing the required spares holding of modules by making them system-specific.

MODELLING, SIMULATION AND TESTING

In the past, the only way of proving a new design was to build a series of prototypes as the design evolved, and subject each to extensive practical tests. Practical tests are always necessary, but it is very costly to do more than checking the final design, before starting quantity manufacture.

Modern computer techniques give the possibility of proving much of a new design in theory, without building any hardware at all. On some military projects, all the software is written twice; once for a full system simulation to prove the control algorithms, and then in final form to suit the actual hardware. This appears inefficient, but may actually give the shortest project timescale. In addition, the safety of a computer system relies to some extent on the correctness of written specifications, and the better these are tested, by modelling and simulation, the greater the assurance that the final product is safe.

Small-scale simulation and mathematical modelling programmes can be written specifically for particular projects, and most of today's engineers can write these as a matter of course.

At the opposite extreme of the range of simulation activities are the 'Masterdriver' train simulators provided by Marconi Instruments Ltd. for the Seoul Subway and Singapore Mass Transit Railway (Fig. 4). Such simulators are sophisticated pieces of equipment, including interactive video displays which allow the choice of different routes at junctions, and a cab that is essentially the same as that of a real train. The provision of such a system is appropriate as part of a complete railway or metro project.

Simulation facilities, which can be built sooner than the actual railway, enable staff training, in normal and fault situations, to be undertaken earlier, cheaper and faster than normal. This can be a major justification for providing the equipment.

However, there are some secondary benefits to the designer. The control algorithms to be adopted in the various parts of the train equipment (traction control, brakes, ATC etc.) can be tested with one another at a relatively early stage, and problems can be identified and corrected before the running of the first train. This applies not only to the normal running of trains, but also to the fault location and recovery strategies and procedures, which are difficult to get right. When such a simulator is provided, it may indicate the need to incorporate extra fault indications, and fallback operating methods, which will make the difference between a railway that runs effectively as soon as it enters service, and one that does not.

TEST BEDS AND TEST TRACKS

Practical testing is an essential part of the design of any new system. Track circuits and track-to-train communication systems are some of the more difficult parts of a safety signalling system to test, since they can only be tested fully in a reasonably typical situation.

Railway authorities are often very helpful to signalling contractors in providing facilities to test track circuits. Full train control, however, is much more difficult to test, requiring the equipping and running of trains, as well as access to the lineside. The Tyne and Wear Metro test track (with its later use for testing

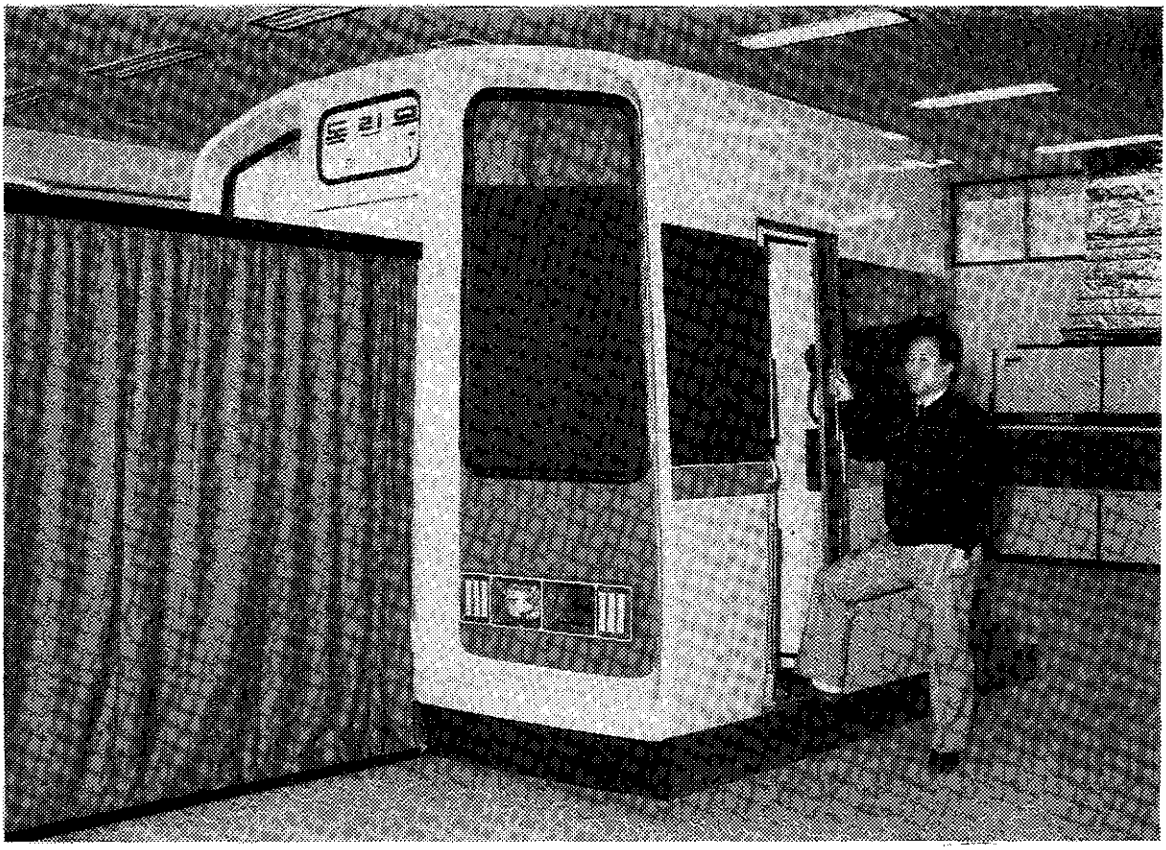

Fig. 4. Marconi Instruments LTD master driver simulator.

equipment for the Hong Kong Mass Transit Railway), and the UTDC test track in Kingston Ontario, are rare examples of integrated test facilities.

G.E.C. has made use of a number of test sites in recent years, including sites on B.R. lines for proving track circuits and trackside ATC, an old power station for testing novel propulsion and train control, as well as factory sidings in Trafford Park for testing new ATC equipment. For DLR, all the vehicle systems (traction and brake control, a traction motor, ATP, ATO and emergency driving positions) were assembled on a computer-controlled dynamometer test bed at the Preston works of G.E.C. Traction Ltd., to enable interfaces to be tested, including closed-loop speed control. The aim of this was to reduce the commissioning time of vehicles on site, within a very tight project timescale.

SAFETY ANALYSIS AND SOFTWARE VALIDATION

The tasks of checking the safety of hardware, the correctness of software, and of documenting these analyses, are essential ones for safety signalling engineers.

These tasks should be carried out by people independent of the original designers, and this may lead to a problem; the people doing only this analysis on a project may see it as a boring and non-creative exercise. They are often reluctant, therefore, to do much of this work. A solution may be to try to automate the repetitive aspects of it, leaving skilled engineers primarily to make judgements on the small percentage of the results from the automated analysis which are not self-evidently safe. The opinion of a skilled independent analyst is a crucial element of all safety proving, and should never be replaced by a computer programme.

A worry with this approach is how to ensure that the original designer and the analysis programme do not make any identical wrong assumptions, thereby missing some hazard.

One practical way in which this might be overcome is by various industries pooling their resources to develop, and then adopt, standard design techniques. We may be seeing the start of this with technology designed specifically for safety applications. Examples of this are; The Royal Signals and Radar Establishment's Reduced Instruction Set Computer called VIPER, with its programming language NEWSPEAK (so called because it is impossible to express unsound ideas in it!), and static code analysis tools (such as MALPAS and SPADE). These techniques are still in their infancy, are largely intended for military applications, and have only very belatedly started to emerge into the commercial arena (Refs. 8 and 9).

It would be a difficult decision for signal engineers to throw in their lot with another industry, with different aims, and constraints. Will we, in 10 years time, be producing interlockings indistinguishable in appearance from avionics or missile systems, with software written in NEWSPEAK or ADA, and the safety assured by the use of a suite of military verification programmes? Unlikely though it seems, it is one of the options we have to consider in the quest for cost-effective designs, since the money to develop such tools may only be available in the defence industries.

MANUFACTURE

There can be no doubt that manufacturing safe computer hardware is a less specialised activity than making BR930 relays, or Reed FDM equipment. However, it has its own problems.

One of the perennial problems in the electronics industry is the early obsolescence of components, and "almost-but-not-quite-compatible" replacements. Some problems (not safety-related) have been experienced with SSI, where the second source components do not behave identically to the first source ones. A worry with some safe computers is that a batch defect on an LSI chip could cause a common-mode failure. The chance of this is reduced by the special measures taken in the design to carry out extensive self-testing of all critical circuit and software elements, but it is this sort of worry which has led to developments like VIPER.

Another problem is that of testing production equipment. The move towards "standard" electronic hardware is seen as an opportunity to reduce the requirements for skilled factory labour, and Automatic Test Equipment (ATE) is installed as part of this process. ATE needs careful application to achieve its aims, and on a new design the combination of minor drawing errors, minor carelessness in assembly and minor weaknesses in the ATE programmes, can effectively prevent any equipment being produced, unless skilled engineering staff are available to break the deadlock. It is not possible to "test" quality into the manufacturing process, and there is no substitute for people who understand what they are doing.

A new set of controls is needed, to ensure that production equipment leaves the factory with the correct software installed, with EPROM's blown to the approved methods, and checked by a responsible person. The contents of an EPROM are sufficiently mysterious that many production people do not understand the significance of the testing they are carrying out.

DATA-DRIVEN SYSTEMS

In a relay interlocking, the location-specific information is contained in the wiring between the relays. This set of "data" is prepared by signal engineers, who convert track plans into control tables, control tables into relay circuit diagrams, and then by wiremen who convert the circuit diagrams into actual wiring.

For a system, such as a computer-based interlocking which has to be capable of being applied to many different sections of railway, there is an obvious benefit in using a general purpose programme and location-dependent data. An interlocking programme rather like a specialised high-level language interpreter is needed, to enable the signal engineer to input the requirements of the control tables in a form familiar to him, and have these requirements executed by the safe computer system.

Data preparation

With B.R. SSI for example, the signal engineer still converts track plans into control tables of "source data", which are a shorthand form for expressing familiar signalling concepts. The source data tables act as input to a set of data compiler programmes, which check the data format, and produce tables of data memory contents. These have a very close relationship to the source data. They can be checked, by means of either an automated decompilation, or manual checking process, and are then blown in EPROM's for installation in the interlocking hardware.

Perhaps the most difficult feature of data preparation for signal engineers to come to terms with is the unfamiliar syntax of the data. There are two approaches to helping the user overcome these sorts of problems:

Produce documentation to a much higher standard. Programmers are none too keen on writing user manuals anyway, and very often the results are intelligible only to another programmer. Putting this into perspective, the documentation available to a new designer of relay interlockings is also generally very poor, but in this case there may be more practical experience available in the design office.

Provide automated syntax checking programmes. This is the approach being adopted by B.R., for SSI, when the Design Office Workstation is used. The question is posed, however, of whether such a system is a substitute for the applications engineer understanding thoroughly what he is doing.

Data testing

An obvious advantage of a computer-based interlocking system, like SSI, is that data for a new application can be tested on any set of hardware, even before the production equipment has been built. To do this however, a simulator system is needed, capable of being updated quickly, applied to any layout, with any set of signalling principles.

Experience shows that the commercial computers used up to now for these simulators have tended to be unreliable (both in their hardware and in their purchased software) compared with the interlocking itself, and that a series of trivial problems can easily extend the time taken to test data against control tables.

It is to be hoped that the B.R. Design Office Workstation, which provides simulation and data testing facilities, can overcome many of these difficulties.

There is a need to train signalling application engineers to be sufficiently familiar with the quirks of computer systems, so that they can assemble and test micro-electronic signalling systems with confidence.

IN-SERVICE DIAGNOSTIC AIDS

To the signal maintainer, even the sound of a relay interlocking conveys diagnostic information, and he can usually localise a fault, either by this means or by observing the state of relays, without disturbing the circuits at all.

With micro-electronic systems, there are no such aids to fault finding provided by chance Computers carrying out activities serially, and communicating via serial data links, are difficult to monitor, and the provision of parallel outputs to banks of LED's on equipment racks-an expensive and power consuming solution for a large system. However, it is relatively easy to provide an additional output port, to give regularly updated values of the major system variables. A diagnostic unit can then be provided to display a selection of these variables. Such a unit may be built-in, or may be a separate portable item.

The Automatic Train Operation (ATO) system on Birmingham Maglev has such diagnostic equipment. The ATO is processor-based. and carries out a variety of tasks, including speed control, sequencing, position determination, fault processing etc. On each Maglev vehicle, there is a built-in diagnostic board, giving a display of a selected byte in memory, and variables such as actual speed, ATO target speed, speed error, position, vehicle status etc. can be selected. This is adequate for most fault-finding in service. During commissioning however, a greater level of visibility of processor operation is needed, and so a VDU terminal can be connected to the diagnostic port, to display the current state of a large number of system variables simultaneously. This enables testing and de-bugging to be carried out effectively. There is also provision for connection to a data logger, or to give analogue outputs to operate a tape-recorder or chart-recorder. These can give results for later analysis off-site.

An alternative approach to the provision of diagnostic data is the use of non-volatile (NV) memory to record the state of critical variables on the occurrence of certain trigger events, such as faults, loss of power etc. This approach is used on B.R. SSI, as well as on the Maglev system. On SSI, it is used in conjunction with an NV RAM Reader unit by the technician at the repair workshop, to tell him why the processors thought that the module failed. On Maglev, the sequence of events leading up to any fault is stored, in case the power is subsequently lost. The first-line technician can interrogate this non-volatile memory to lead him towards the original source of the fault.

The ATC equipments supplied by G.E.C.-G.S. for the Recife Metropolitan Railway in Brazil, and for the Docklands Light Railway, are different in design. They are both provided with Depot Test facilities, to simplify fault-finding and regular maintenance on trains.

In Recife, the continuous cab signalling and speed supervision systems are subjected to a thorough diagnostic test at intervals of 2-3 weeks. This test checks virtually all aspects of the equipment, and also allows the maintenance staff to detect any equipment which is starting to degrade (e.g. power supply voltages falling, due to component drift) before the train fails in service. The depot test equipment (Fig. 5a) contains a 68000 based VME computer system, programmed in 'C'. This generates simulated cab signal currents in a cable loop laid on the track in the depot, and controls a generator of simulated 3-phase signals representing the output of the axle-end speed detector on the train. The equipment is plugged in to a test socket on the outside of the train, to control and monitor the on-board electronics and relay equipment. In operation, the test technician can carry out a full 'Go/No Go' test on the train, which results in a "Pass" or "Change... equipment" message on a VDU. Alternatively, the technician may select an individual test, and obtain results on the VDU in terms of measured voltage levels, timings, etc.

The depot test facility on DLR (see Fig.5b) is rather different. Since there is already a powerful processor (the on-board ATO computer, with the diagnostic facilities already mentioned) monitoring the trainborne equipment, there is no trackside depot test computer. Test signals fed into cable loops on the depot track are generated by a processor-based portable test box carried on to the train for the tests. This box enables the sensitivity level of the various ATP receivers on the train to be checked, and it also generates simulations of the field pattern experienced by trains passing at high and low speeds over transpositions in the speed monitor cable loops.

Such specialised test equipment is a very small part of the cost of the whole signalling system, but there is always a danger that a very highly competitive situation at the tendering stage of a project may lead to such items being omitted, and may then leave the customer without the benefit of proper diagnostic aids, when he has to operate and maintain the railway. Perhaps customers should be particularly careful to specify their maintenance philosophy at the tender stage, and ensure that this problem does not arise.

RELIABILITY, AVAILABILITY ETC.

A relay-based signalling scheme has quite a large amount of diversity built in to it, by virtue of the physically separate circuits used for each function, or route. Certain elements, usually not concerned directly with safety, are common to the whole scheme (e.g. power supplies and cable routes, operators' control facilities etc.) and on the largest schemes, these are often duplicated, to provide an improvement in availability.

Safe computer systems are highly centralised, in that the processor carries out different functions in sequence. Instinctively, the designer might aim to include more fault tolerance as the results of losing the system become more severe, or as the accessibility of the equipment is reduced (e.g. at the trackside, or on-board trains). The designer has to make the difficult decision as to whether to pay the (significant) extra cost to obtain a fault-tolerant system, or whether he can meet the MTBF requirement purely by careful design.

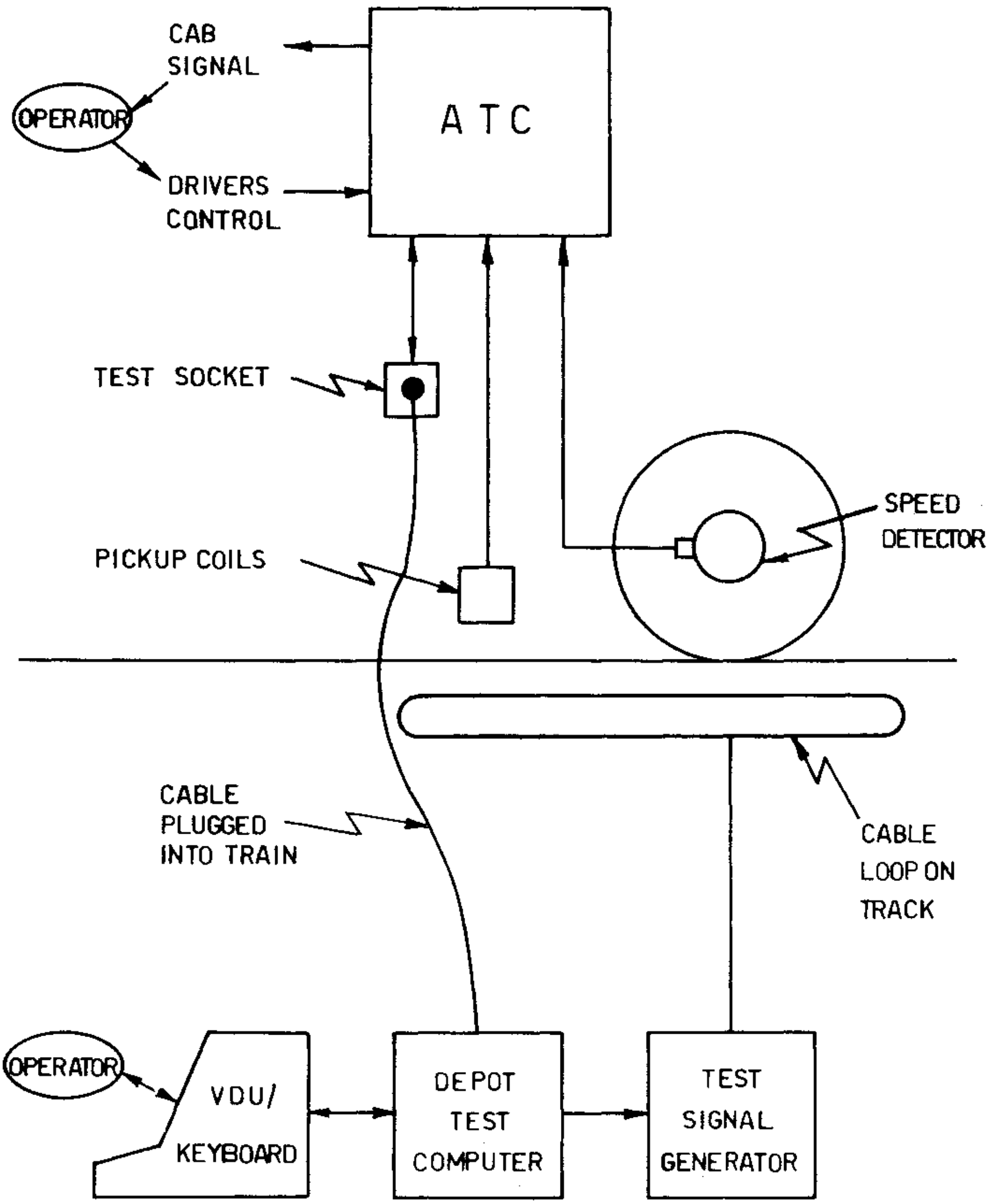

Fig. 5a. Depot tester concept - Recife Metro.

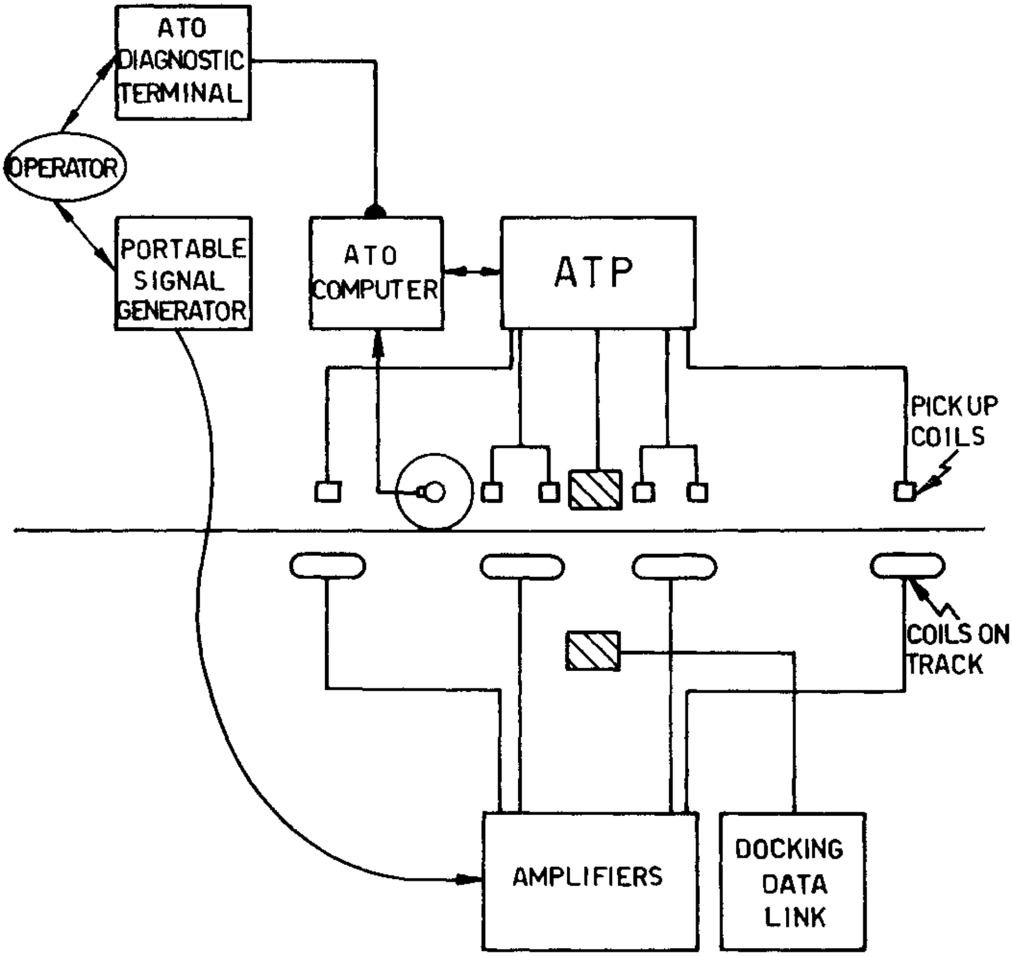

Fig. 5b. Depot tester concept - Docklands Light Railway.

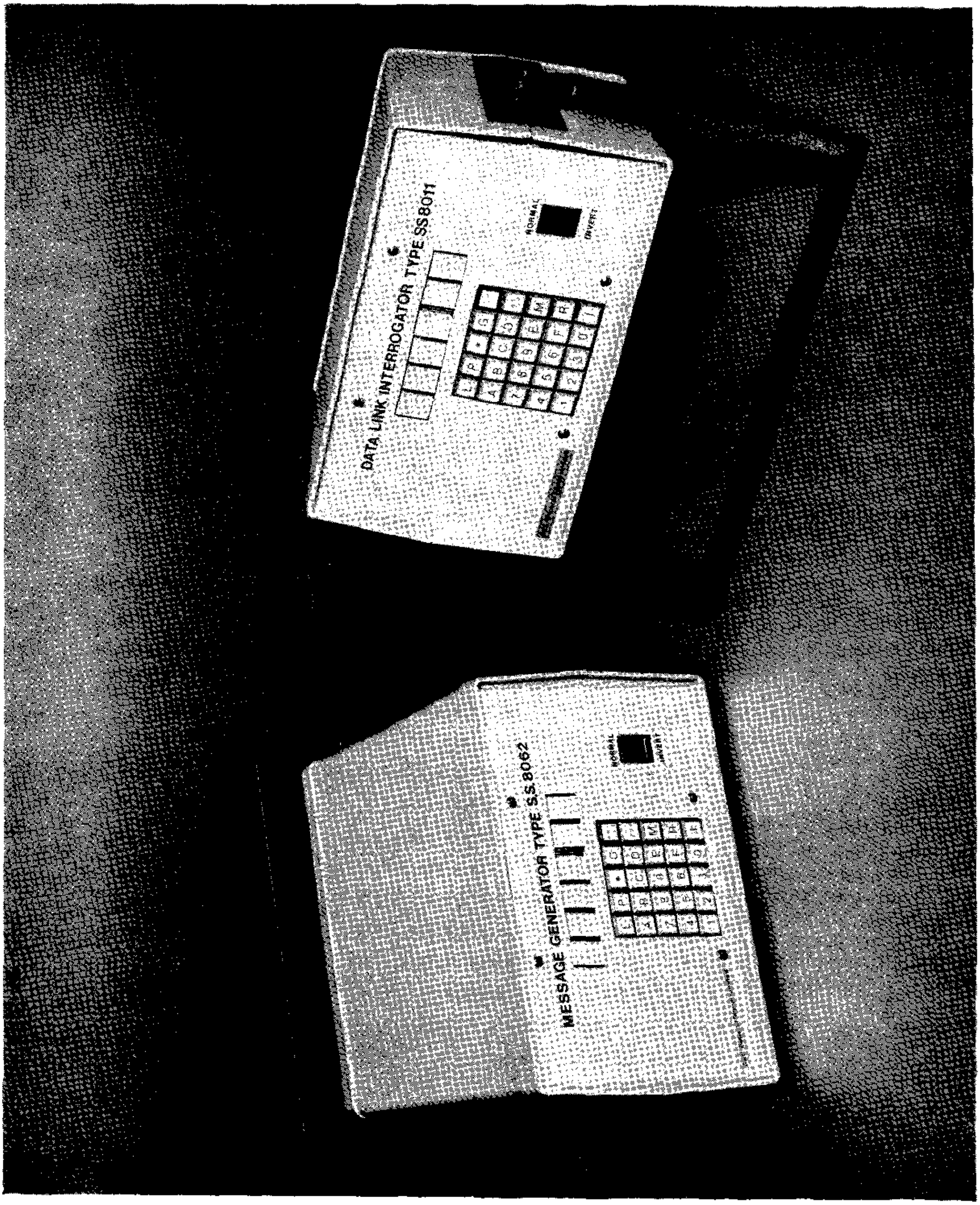

Fig. 6. Examples of B.R. SSI in service test equipment.

The writers of performance specifications must avoid over-specification as much as under-specification of requirements. It is very easy to add an extra zero to the required MTBF, when writing the specification. The manufacturer has to minimise the financial risk of failing to meet the performance requirement, and may have to over-complicate the design by providing unnecessary fault tolerance. This may leave the customer with a much more difficult task throughout the life of the equipment.

Predictions of MTBF for computer systems, based largely on military data bases, often seem to be very pessimistic. The experience so far gained with systems in harsh environments is about as reliable as had been predicted, even when (as with SSI trackside modules at Leamington Spa) it is subjected to gruelling pre-commissioning tests. The expense, and complexity, of adopting a triplicated processor configuration in such cases would probably not be justified.

CONCLUSIONS

Signalling in the future is, I believe, going to be very different from the past. There will always be a place for the "traditional" signal engineer, with his experience of railway operations and his knowledge of signalling principles, but at almost every stage in the implementation and maintenance of signalling schemes, new skills are evolving (and will have to be taught).

The new technology can be used, with care, to provide more cost-effective signalling, and to provide quite different signalling functions.

Standard micro-electronic safety products and systems developed in advance are already being used on new schemes, but I believe that as confidence grows, and the correct tools are devised to make the tasks more controllable, safe software can be written or adapted, and validated, for each new project.

ACKNOWLEDGEMENTS

I should like to thank the directors of G.E.C.-General Signal Ltd. for permission to present this paper, and numerous colleagues for their assistance, and for their advice, much of which has, I hope, been incorporated.

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DISCUSSION

Opening the discussion, Lt. Col. A. G. Townsend-Rose thanked the author for a thought provoking paper.

He stressed the need for indicating to the technician what was going on inside the microprocessor. Leamington Spa seemed to do this well.

He questioned the view that software was relatively cheap to produce and enquired whether the mean time between failures should be achieved by careful design or by the use of fault tolerant software. Also at what stage did semi-conductors cease to function properly.

Lt. Col. Townsend-Rose continued stating that he had noted that SSI did not behave exactly like a relay interlocking, as seen by the signalman. The railways needed to ensure that signalmen were aware of the implications of new technology. The new skills required of technicians was well covered by the paper.

He asked if two-out-three would be the method of the future or would a single high confidence computer be acceptable.

Finally Lt. Col. Townsend-Rose commented on the Maglev braking characteristics shown in figure 3b. There was a critical point outside the station from which the worst situation would occur. This was not apparent in the graph.

The theory of the Docklands signalling appeared to be right, but there was still a need for it to work in practice.

In response, Mr. Barnard said that it was recognised that there was a need for training for all people working with the system. The design workstation would enable the signalman to be trained on the new system before it was installed.

He thought that the arguments about two-out-of-two, two-out-of-three or a single processor would continue for some time. What mattered was learning to live with it and to be able to repair it quickly in service.

Figure 3b was derived from an early version of the Docklands data. One advance made between Maglev and Docklands had been the development of better applications programs, to enable more precise positioning of the markers. In Docklands there were any number of critical points from which proper stops were just achievable. The speed monitor system had one advantage, in that the timer period could be adjusted to slow down all vehicles on the system. This was useful during commissioning, when there was some uncertainty about vehicle performance.

On Docklands, most of the route setting would b done automatically. Experience with the Maglev system, where there was no staff on the vehicle to deal with emergency situations, had shown the need to make faults clearly known to the operator so that he knew what to do about them. The Control Centre operator was normally just monitoring the system, not intervening, and this was likely to spread to new BR schemes. There was a difficulty in making sure that such people understood what was going on and were able to spot peculiar events as soon as they happened. There might be a need for regular deliberate tests of the signalman's ability to cope with emergencies.

Mr. R. C. Short commented that experience had shown that it was essential not to load up the computer with additional tasks, just because it was there. In practice, software was not as flexible as might be thought and "a non-volatile" memory was essential for failure diagnosis.

The idea of a speed control system based on counting the track cable transitions had been suggested over 20 years before, with the BR "wiggly wire". Advances in micro-electronic technology had made it practicable.

There was a requirement for more efficient methods for checking and validating safety software. BR were very active in this field. The SSI workstation had many in-built facilities to automate the checking of vital system data but there was scope for further development.

A common data language for all vital sys tems would be of great benefit. Common software and hardware tools could then be used for data preparation and checking.

A comprehensive data preparation manual had been provided for the SSI design workstation, supplemented by the in-built syntax checking.

Looking to the future, there was a need to learn more about how micro-electronic equipment could fail. Existing design and self-checking facilities were aimed at conjectured possible failure modes. There had been little experience, so far, of actual failures.

Designing equipment for reliable operation under high electromagnetic interference was also more an art than a science and, again, needed further experience.

In response, Mr. Barnard said that, given the correct tools, changing software could become a more manageable and quicker process, with greater confidence in the product.

Any common language for data preparation and testing should be at a level for understanding by signalling engineers. Syntax checking should deal with coding problems.

A significant population of SSI equipment was now in existence. No pattern of failures had emerged so far, apart from certain batches of components. It was too early to say if some of the failures which were envisaged at the design stage, and for which complex hardware and software checking had been provided, would actually occur. It would be very useful to keep a database of the ways in which systems did fail in practice.

Mr. C. A. Porter commented that one problem with living with anything was component obsolescence. In other industries it was accepted that electronic systems were replaced every five to ten years. Railway authorities expected systems to work for 20 years and would prefer 40. The signalling industry had to use components that were freely available on the general market and create economic systems from them. It was no longer able to produce its own components. Currently used components had such long lives that, when they did fail, replacements were no longer available. Specification of a spares policy was becoming increasingly difficult. Some systems might have to be replaced because the equipment designer had not allowed for replacement of component parts.

In response, Mr. Barnard said that, in the past, part of the cost of relay interlocking had been the provision of workshop facilities, by the contractor or the customer, for maintenance and repair. There was no modern equivalent for electronic equipment.

Mr. B. Hillier asked if the Docklands Line inductive loops had suffered from the attentions of permanent way people or from theft.

Mr. Barnard replied that the speed monitor system required markers at regular intervals along the track and that the cable loops were the only way to provide them. The system was new and there had been little maintenance to date.

Mr. C. A. Porter intervened to say that very little cable had disappeared from the site. There had been problems with damage to the cable retaining clips, due to installation staff "legging" trollies along the track. Once staff had been suitably advised there were no further problems. Similarly, permanent way staff might not realise the significance of the cables unless this was pointed out to them.

Mr. K. E. Hodgson commented that major signalling schemes, such as Yoker, had a projected life of 25 to 30 years. It was expected that sub-systems would need to be replaced several times in that period. There was a need for such replacement to be taken into account at the design stage.

The paper suggested that the railway signalling profession needed to ally itself to some other industry. Movement into the electronic world had meant that signal engineers, who understood the problems, were still needed, although they might not have the commanding role that they had in the past.

It was probably too early to start talking about failure statistics to measure the success of the new systems with any confidence. There was still a need to study failure modes.

Mr. Barnard replied, that like-for-like replacement of current electronics should be possible, but may be costly.

There was a great deal of commonality in the sort of control hardware that was being used in various industries. The signalling industry was increasingly becoming a user of telecoms services in all varieties. Many industries were concerned with information processing and display and many people working in this area. It was not possible to predict how the railway signalling industry would develop. It was likely that the application of signalling principles would remain, although the skills offered by the people concerned may change.

Mr. B. H. Grose asked if the transposed loop system checked the phase reversals at each transposition, as had the original BR "wiggly wire", or did it only look at the effective amplitude modulation.

Mr. Barnard replied that the transpositions of the "wiggly wire" were detected using phase detection technology that was not available at the time of the BR experiments.

Mr. B. D. Heard commented that it was worth remarking that the computer was only a small part of the cost of the whole scheme.

The trackside equipment, signals, point machines, track circuits and cables formed the major part and were still expected to last for 25 to 40 years. What would be required of the suppliers was equipment that could be easily replaced and updated without impairing the inherent level of safety.

He asked if the ATO compared the "wiggly wire" transitions with an on-board tachometer and how was this done on Maglev?

Mr. Barnard responded that the immense development costs of systems like SSI required that there was timely exchange of information from the contactors on component supply difficulties and from the users on when equipment was starting to wear out and reach the end of its useful repairable life. There needed to be ample time in which to justify the cost of a redevelopment exercise to design replacements. It was virtually certain that, in ten years time, the SSI modules being installed would not be directly interchangeable with the current ones.

On the Docklands railway there was a hierarchy of ways of measuring distance. The station to station distance was defined by the inductive data links. The number of transitions between strategic points was stored on the train. The tachometer indicated wheel revolutions, which were affected by wheel wear and wheel slide in braking. Each method was used to recalibrate the finer resolution method. While running between stations, the number of transpositions passed was more informative than wheel revolutions but station stopping position was most important.

On Maglev, Doppler radar was used to measure speed. This could be integrated to determine short distances but it was not adequate for long distances, due to inherent errors in the process.

In proposing a vote of thanks to the author for an interesting and stimulating paper, Mr. F. M. Hewlett commented on the suggestion that software costs were relatively low, contrary to commercial computer experience. In the railway environment the hardware needed to be far more rugged and reliable, and hence more expensive. He also emphasised the benefit, brought out in the paper and the discussion, of close co-operation between supplier and user.

Technical Meeting of the Institution

held at

The Institution of Electrical Engineers

Monday, 9th March, 1987

The President (Mr. J. G. Oehler) in the Chair

The Minutes of the Technical Meeting held in London on 10th February, 1987 were taken as read and signed by the President as a correct record.

The President then introduced Mr. Dickens who was kindly standing in for Mr. R. C. Nelson (BR-ScR) and requested him to present Mr. Nelson's paper entitled "Yoker Integrated Electronic Control Centre".

Yoker Integrated Electronic Control Centre

*By Mr. R. C. Nelson**

INTRODUCTION

Railway Signal and Communications Engineering has been in a state of evolution from the earliest days when an enterprising railway employee decided to control the points for which he was responsible from levers grouped together instead of walking from one set of points to another for every train movement. Inspiration for the mechanical signal probably came from naval practice and a small hut with chair and stove completed the specification for a comfortable and none too arduous existence. Many of mankind's best inventions have their origins with someone seeking to ease the burden life has placed upon them rather than from reasons of philanthropy or the pursuit of wealth. This tale may well be apocryphal but that is of no great consequence. The important fact is that once railways grew beyond the stage of merely being a link between colliery and town, there was a need to find a method of controlling train movements in a manner that combined safety and efficiency. For 150 years this policy has not changed.

Undoubtedly, the first attempts were makeshift and not always successful but professionalism in Railway Engineering was not long in becoming established, since when, the Railway Signal and Communications Engineer has led the world in the creation of control systems. For the first 75 years these advances were not well documented, but over the 75 years that have elapsed since the formation of the I.R.S.E. every advance has been the subject of a paper and discussion at the meetings of the Institution.

This paper is intended to follow this policy and give a description of how microprocessor Engineering is being applied to signalling systems on British Railways in the form of the Integrated Electronic Control Centre. It is a cumbersome name and may yet be displaced by a more euphonious title. However, the present day fashion for acronyms is useful and already the initials IECC are in regular use.

*B.R.- Sc.R.

Distributed computer systems

Computer control in the manufacturing and processing industries has been a well established feature for many years. Machine tools are controlled in this manner and computers are relied upon for supervisory and operational purposes in the petro chemical, nuclear, steel and electrical generation industries. In recent years the move has been to link computers rather than have each computer system operating in isolation.

In a distributed computer system the computers, which control the various stages in a complex flow process communicate with each other, thereby obtaining information that will influence the manner in which each computer controls its own particular function. Developments in communication links for computers and advances in microprocessor technology have allowed this change in control engineering.

Few staff are required to be on duty, it being sufficient to have one supervisory point with perhaps only one or two people keeping watch on a process that has a high volume output, little or no rejection arising from poor quality and stringent safety standards. The computers have sufficient self diagnostic capacity to give warning of failure or problems and to substitute alternative methods of operation more rapidly than can be achieved by humans.

Railway signalling systems are integrated control systems and have been from the days of the mechanical interlocking frame, through the era of relay interlocking and into the solid state interlocking.

The IECC is yet another step in this process, albeit a significant one.

Design objectives of the IECC

The primary objective of an IECC is to exploit the opportunities presented by the recent and rapid advances in microcomputer technology for the purpose of signalling trains and to provide comprehensive real time information systems for passengers and staff by making maximum use of proprietary hardware.

The design of the IECC also has to meet the following objectives:-

(a) To use network techniques for linking the microprocessors that are required in signalling and information systems.

(b) To have a unified language for communication around the network and within each system connected to the network.

(c) To have a tranparent communications link to allow future changes without the need to change systems connected to the network.

(d) Upward compatibility from the selected family of microprocessors.

Origins of the IECC

There could be a temptation to regard the IECC as an entirely new approach to the design of railway signalling systems and one which has little to acknowledge from current practice. Superficially, thoughts of this nature are understandable, as we are talking about a signalling system that is entirely automatic, has no hard wired panel and uses nothing but electronic components. However, closer examination of each of the sub-systems that comprise an IECC readily reveals a railway parentage of excellent pedigree.

Electronic Engineering is not new to railway signalling. For quarter of a century there has been a steady growth in the application of electronic devices, initially in non safety applications and increasingly, as electronic components have become more reliable, smaller and cheaper, directly into safety circuits. Perhaps the most dramatic change has been with interlockings where, until recently, electro-magnetic relays dominated, yet already the microprocessor based solid state interlocking has become the standard for new signalling schemes on many administrations. A two wire data link suffices for the connection between the SSI and data link modules that serve the trackside equipment. Control panels continue to be of the hard wired push button style as there has not been complete acceptance of the television monitor as the sole means of display but the few applications that exist have demonstrated the feasibility of this method.

Automatic Route Setting is by no means a recent innovation on railways but generally was applied on the basis of "first come, first served" at junctions or to a pre-programmed pattern which could take no account of late running. In 1983 the Southern Region of British Railways introduced a microprocessor based system on the Three Bridges Scheme. It applies to the Haywards Heath area on the Brighton line. The software is written in a manner that allows the pattern of route setting to be changed in accordance with predetermined strategies for trains that are running out of course.

Passenger Information Systems have also become computer-based and can provide information on a real time basis by means of information obtained from the train describer.

Train describers, of course, were one of the first applications of computers for railway signalling purposes and many of the earliest computers are still in service having outlived their counterparts in non-railway applications by many years. Clearly the sub-systems that form the modern signalling system were all capable of being computer-based and already, as can be seen in Fig. 1., the interdependence of the sub-systems had reached an advanced state. The next stage was to establish the possibility of linking the sub-systems in the manner of a local area network and also, if not entirely, eliminate the human link, give consideration to having a signalling and information system that could operate automatically for a high proportion of the working day. Fig. 2. demonstrates how the standard NX panel, relay interlocking, train describer and information systems can be represented in computer style configuration.

THE COMMUNICATION NETWORK

An IECC is a distributed system and the vital part of distributed systems is the communication link.

The communication link has to provide data to each sub-system at speeds appropriate to the nature of work performed by the sub-systems and with a reliability that is related to the function of the the system under consideration. Clearly, a railway signalling system requires rapid flows of data to the interlockings in order to ensure that routes are set as soon as they are required and, in return, the signalman must have up to date information on the control panel of the state of the main components of that system, e.g. track occupancy, position of points and description of trains. Total failure of this process is not acceptable.

There are several methods of providing a communications network. The one selected for the IECC is based on a proprietary local area network (LAN) product as it comes nearest to meeting the requirements of the IECC in terms of minimising development costs, satisfying speed of transmission, providing a high degree of reliability and in ensuring that the system does not become life-expired prematurely due to lack of spares or inability to adapt it to changed circumstances.

Signalling and information networks

The configuration adopted for the IECC is shown on Fig. 3. The IECC consists of a number of discrete sub-systems, each of which is responsible for a particular function. It is not necessary for every sub-system to be present on every IECC and consequently information is not distributed around the network in a general manner but, instead, each sub-system in need of data goes directly to the source of the data. In order to reduce the load on the network, it has been constructed in two parts, the signalling network and the information network with a device known as a gateway providing the intelligent interface.

The sub-systems that form an IECC are:-

Signalling Network:

(a) Signalman's Display System (SDS)
(b) Automatic Route Setting (ARS)
(c) IECC System Monitor (ISM)
(d) Interlockings (SSI or RRI)

Gateway:

Information Network:

(a) Passenger Information System (PIS)
(b) Management Information System (MIS)
(c) Staff Information System (SIS)
(d) Track to Train Radio (TTR)
(e) Adjacent Signalbox Link (ASL)

Reliability of operation is achieved by duplication of the networks and duplication of each sub-system linked to the network.

Network definitions

In order to appreciate the operation of a communications network, the following terms require to be understood:-

(a) SYSTEM - A processor that performs a set of tasks.
(b) MASTER - A system that initiates communications.
(c) SLAVE - A system that does not initiate communications.
(d) NETWORK - A common communication link shared by a group of systems.
(e) SENDER - The initiating and controlling system for a particular communication sequence.
(f) RECEIVER - The responding system for a particular communication sequence.
(g) CHANNEL - A two-way communication path between a pair of systems.
(h) CONNECTION - Activation of a channel which is to be dedicated for a particular communication.
(i) LINK - A number of channels between a pair of systems.

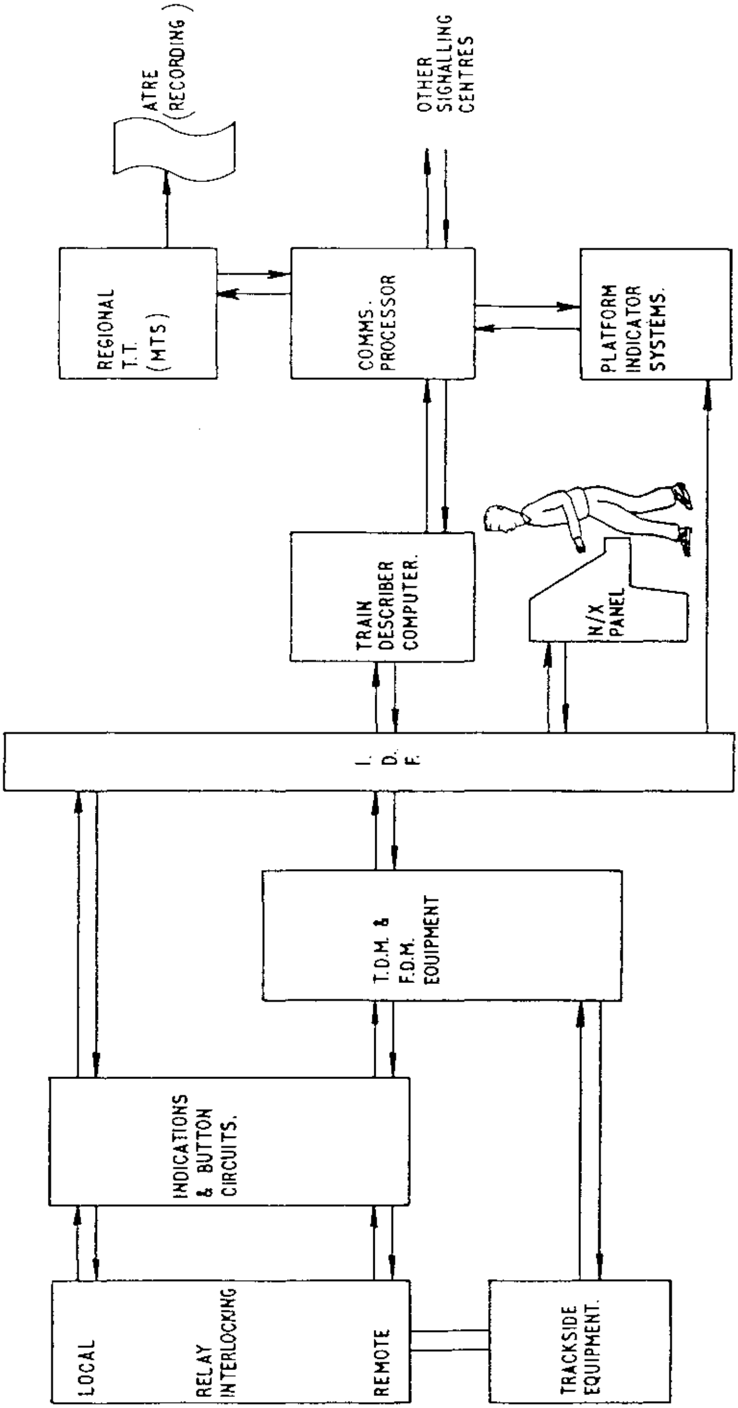

Fig. 1. Typical modern signalling system.

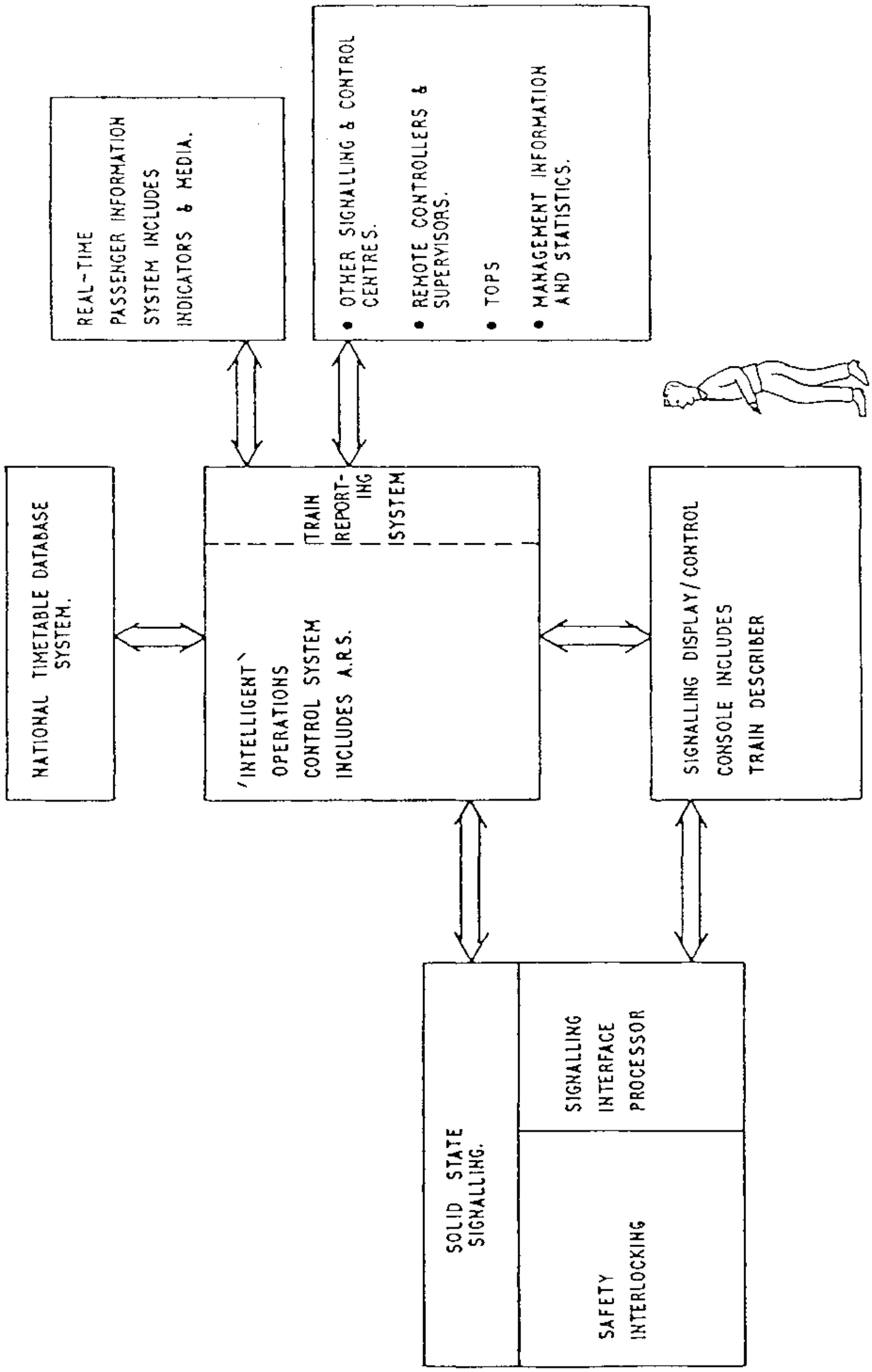

Fig. 2. Computer based signalling and control centre of future.

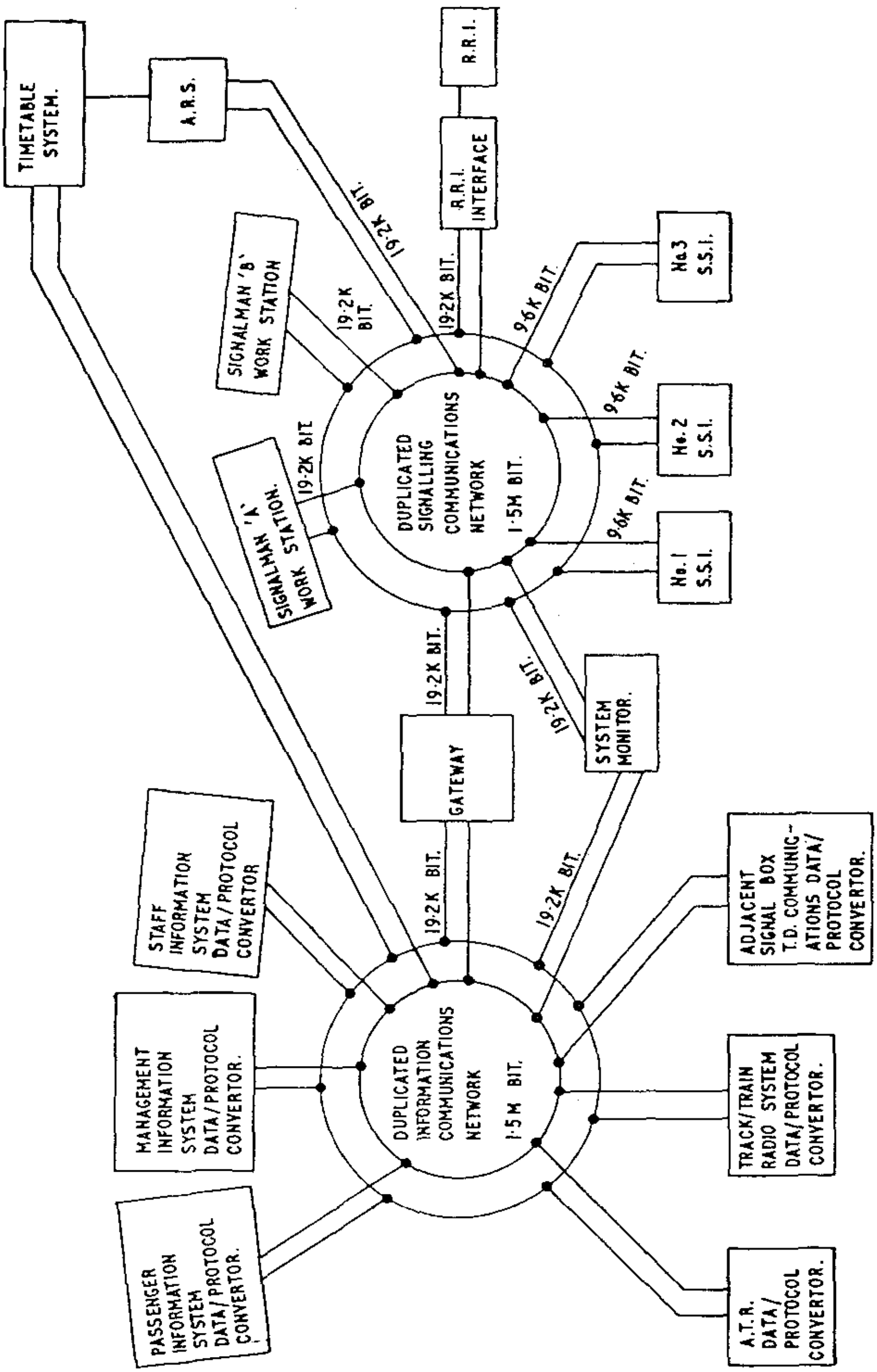

Fig. 3. IECC network configuration.

Network architechture

There are several options available for the architecture of a LAN, the most widely known being:-

(a) Register Insertion Ring

(b) Token Passing Ring

(c) Baseband bus

The chosen method had to meet the very exacting requirements of an IECC in terms of connection times, throughput, flexibility, transparency, reliability and cost. Connection times place a particularly onerous burden on the protocol as a master system requiring to establish communication with another sub-system has to select the channel and make the connection within 10 milli-seconds. Data transfer time must not exceed 250 mS, following which the master breaks the connection. In order to ensure the sub-system processors deal only with current data, each master attempts to make a connection with each of the relevant sub-systems in cyclic fashion on a priority basis. Under normal conditions a communication requirement should be satisfied within 250 milli-seconds.

The register insertion ring was selected as the most appropriate method for the requirements of an IECC and 1.5 megabits per second operating speed ensures the specified connection times. The greatest delay in network propagation occurs at the nodes as there is a small but finite delay to the 80 character message at each active node.

This method also permits virtual circuits to be established, thus providing a private communications path between two sub-systems for the exchange of messages.

Messages are transmitted in ASCII format containing the identity of the sender and the identity of the receiver. Each node has four identities allocated to it, thus allowing systems to communicate without the need to establish which leg of the duplicated network or which of the duplicated sub-systems is in use.

System duplication

A hot standby duplicated system is an essential feature of an IECC. There is duplication of the network and duplication of the sub-system, with each partner of a sub-system being linked directly to the network. One leg of the network, along with the associated nodes and sub systems linked to these nodes, is designated "Main" whilst the other one is designated "Standby". The multiple identities allowed by the use of virtual circuits means that main and standby sub-systems are continually updated and are also able to communicate with each other by means of the network thus eliminating the need for an extra communications port.

The computer designated as standby will run its application software and monitor its partner which will be running as the main computer. It will change to main status if it detects a failure in its partner or if instructed manually to changeover.

HARDWARE

Hardware that will become outdated in a short time or be unable to be adapted to accomodate enhancements or change is not acceptable for an IECC. Common hardware from one well established manufacturer, concentration on a family of boards, along with a standard bus and backplane will minimise spares holdings and test equipment, allow change of boards between sub-systems and reduce repair times.

These features give the high availability demanded of an IECC.

The selected bus architecture is the MOTOROLA VME bus. It will support a large variety of proprietary and third party products. Only four boards are required to meet the requirements of all sub-systems of an IECC, these being:-

(a) MVME 101 monoboard microcomputer. It has an MC68000 16 bit m.p.u. with 256k of memory and RS232 ports for connection to the network. It runs the network and duplication services software.

(b) MVME 123 Microprocessor Module. It has an MC68010 cpu with 512k byte RAM. It runs the main application software.

(c) MVME 211 RAM/ROM/EPROM It has 512k byte storage for the software.

(d) MVME 215-2 RAM It has 512k for extra RAM and provides battery back up for power failure.

Fig. 4. shows the layout of the bus for the signalling display system computer unit.

The cards fit into standard racks in 19 inch Euro Rack cabinets which measure 1800mm x 600mm giving 38U of racking space.

SIGNALMAN'S DISPLAY SYSTEM (SDS)

The SDS is the controlling point of the IECC taking the place of the NX panel. It comprises one or more work stations each consisting of up to five high resolution (768 x 364 pixels) monitors with 20" screens. One monitor is required for information called up by the workstations keyboard or for the display of the track layout either for the entire area that is controlled from that workstation or for close up views of specific sections of the line. Fig. 5. shows the block diagram of the SDS hardware.

A video switch using co-axial relays allows switching of the RGB video signals from either of the computer units to the selected monitor. This facility combined with the duplication of the computers and the network ensures the high reliability which is particularly essential for the SDS to avoid the possibility of no picture being available to the signalman.

Whilst route setting on an IECC is intended to be automatic by means of ARS, a manual route setting facility is necessary. A solid state QWERTY keyboard with capacitive coupled keys can be utilised to call up the signal numbers of each route and the appropriate function key is then operated. In order to speed up manual route setting, the tracker ball method is also incorporated. The tracker ball has the appearance of a yellow snooker ball partially recessed in the workstation table. By spinning the ball, a cursor can be aligned over the appropriate function on the monitor and operation of the associated push button in the tracker ball unit corresponds to the pushes on an NX panel. The keyboard is used also to enhance display detail on the monitors such as track circuit and point numbers or to interrogate other sub-systems, the information then appearing on the general purpose monitor.

The VDU's have a permanent display of the track layout supplemented as appropriate with route set indications, track circuit occupation, signal aspects, point positions, train descriptions, possessions and isolations, in accordance with size, colour, presentation, as defined in the B.R. specification for VDU's used for signalling operation.

AUTOMATIC ROUTE SETTING (ARS)

ARS eases the burden of simple repetitive tasks imposed on the signalman and is the key to reducing staff levels, thus forming one of the principal reasons for investment in this form of signalling control.

Fig. 6. shows the functions to be carried out by the ARS. It keeps an updated model of the state of the area with information obtained from the interlockings and the SDS. This information is related to the timetable plan which is obtained from the timetable processor. Predetermined regulation strategies are applied in order to establish the priorities for route setting at junctions and at termini. The ARS has the ability to test the freedom of routes by means of its model state of area and send commands to the SSI to set routes in the order determined by these regulation strategies.

It has the ability to set up to 20 routes per minute and calculate the route setting of up to 50 trains in real time on an area that could have up to 800 available routes.

The SDS supplies train description information to the ARS and the ARS supplies the SDS with alarms for route setting faults, track circuits occupied or cleared out of sequence and non time tabled train movements. These alarms appear on the general purpose monitor.

IECC SYSTEM MONITOR (ISM)

Central monitoring, testing and configuration control is essential to the management of an IECC. The ISM provides:-

(a) Overall network management and maintenance.

(b) Management of alarms.

(c) Logging of errors.

(d) System and network configuration management.

(e) Generation of messages to sub-systems.

(f) Interception of messages passing between sub-systems.

(g) Emulation of sub-systems.

(h) System interrogation.

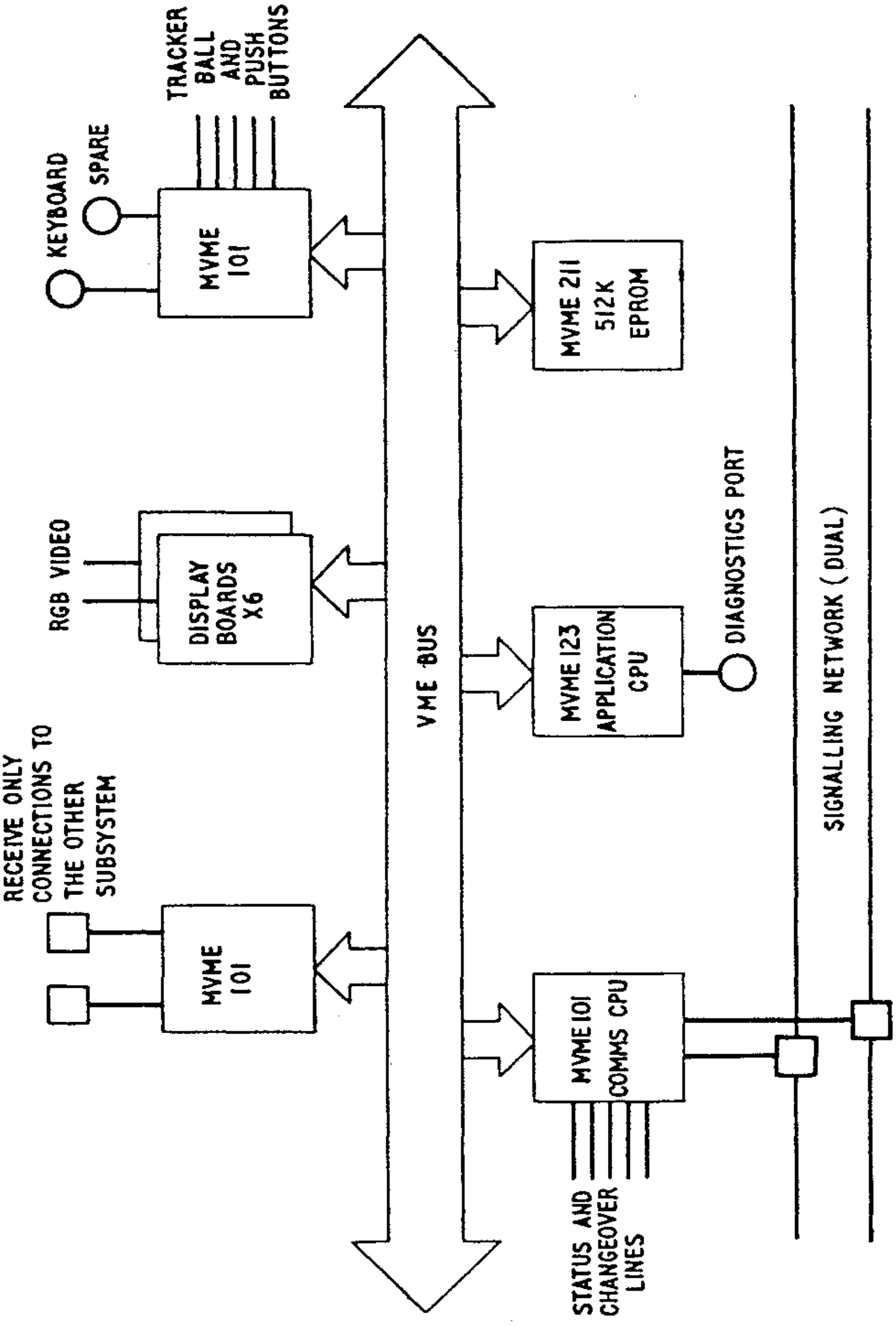

Fig. 4. SDS computer unit.

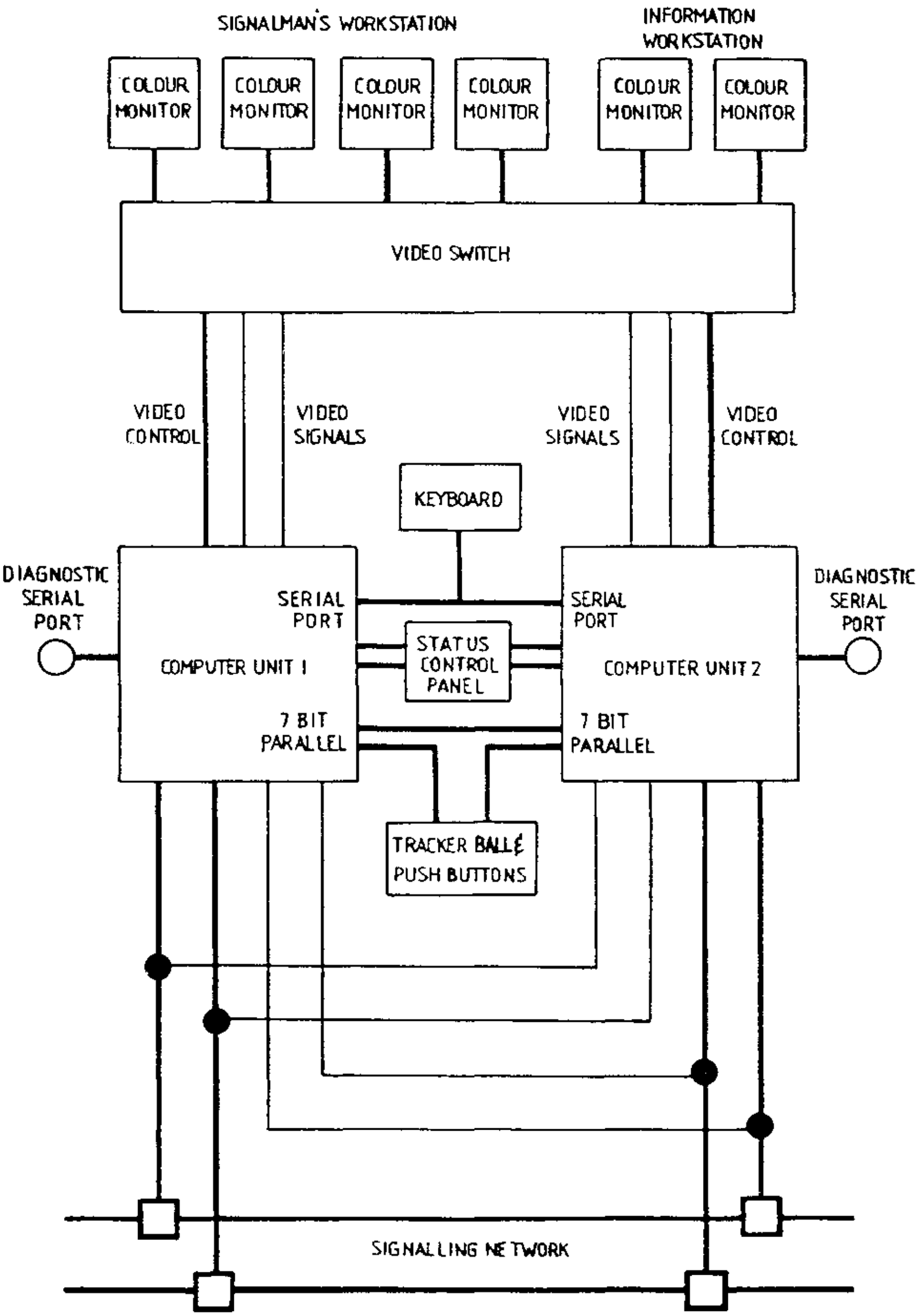

Fig. 5. SDS block diagram.

The ARS generates large volumes of logging information but this information will be held within the ARS. Other sub-systems will use the ISM logging facility which is provided on high capacity tapes in ASCII format.

Alarms and errors reported via the network to the ISM can be categorised into class 1 and 2 levels and an appropriate form of display applied to the technician's monitor and to the signalman's general purpose monitor.

The ISM can be interposed between any two sub-systems thus allowing analysis of the data being passed between them. It is linked directly into both legs of the information network and both legs of the signalling network thus giving direct access to all nodes and both computer units of the sub-systems.

Interrogation and reprogramming of nodes and sub-systems will be achieved by means of the ISM and it provides also manual switching facilities to change the status functions (main/standby/available/disconnected).

THE GATEWAY

The Gateway is an event driven sub-system which sends and receives messages from both networks. The information network requires data on track circuit occupancy, train descriptions, routes set, signal aspects and identity of contingency plans though each sub-system on the information network has its own specific permutation of this data.

Change of state is transmitted from the sub-system (ARS, SSI) to the gateway and held there. The gateway has to have capacity for an area that can contain up to 200 signalled routes, 200 signals, 200 berths, 200 track circuits and 100 trains.

Conversly there is a data flow from the information network to the signalling network. Adjancent signal boxes communicate in this manner, providing train description data for the SDS and the ARS.

Each sub-system on either network will interrogate the gateway for the data that it requires from the relevant sub-system on the other network.

IECC CAPACITY

The size of an IECC, in data terms, can be gained from the following statistics:-

An SDS has 1M byte capacity
A gateway has 350k byte capacity
An ARS has 150k byte capacity
An SSI has 40k byte capacity

INTERLOCKINGS

The British Railways standard SSI is an inherent part of the IECC though provision can be made for relay interlockings to be controlled from the signalling network. The interlocking is a slave which means it acts only on instructions from other sub-systems. Instructions to set routes will come in hexadecimal code from the ARS or the SDS. The gateway, ISM, ARS, SDS will each request regular updates of information. This information is held on the communications processor associated with each interlocking and there is a file for each of these master sub-systems to allow them to be served simultaneously. The signalman's VDU should, at worst, never be more than 1250ms out of step with information held on the communications processor.

The sub-systems on the information network are coupled to the network by data protocol convertors. The convertors change the protocol required for the network into the protocol required for the devices that are to be connected to the network, e.g. train radio, passenger information system or adjacent signal box link. A protocol convertor consists of the VME bus and the MVME boards, thus providing standardisation with the equipment used on the sub-systems of the signalling network.

THE YOKER IECC PROJECT

The North Clyde Suburban Railway

Yoker is one of several towns on the banks of the River Clyde between the upper limits of navigation in the centre of Glasgow and the start of the Firth of Clyde at Gourock. These towns grew and prospered on shipbuilding and although little shipbuilding remains, there is still sufficient passenger traffic to sustain the long established North Clyde Suburban Railway. The suburban railway network around Glasgow is extensive and there are two low level routes through the City of Glasgow to give through running from Helensburgh and Balloch in the West to Airdrie in the East via Queen St. Low Level and to Motherwell and Lanark in the South East via Central Low Level. The Airdrie to Helensburgh line, and branches, was British Railways pioneer venture into 25kV traction in 1960, along with the Manchester to Crewe scheme.

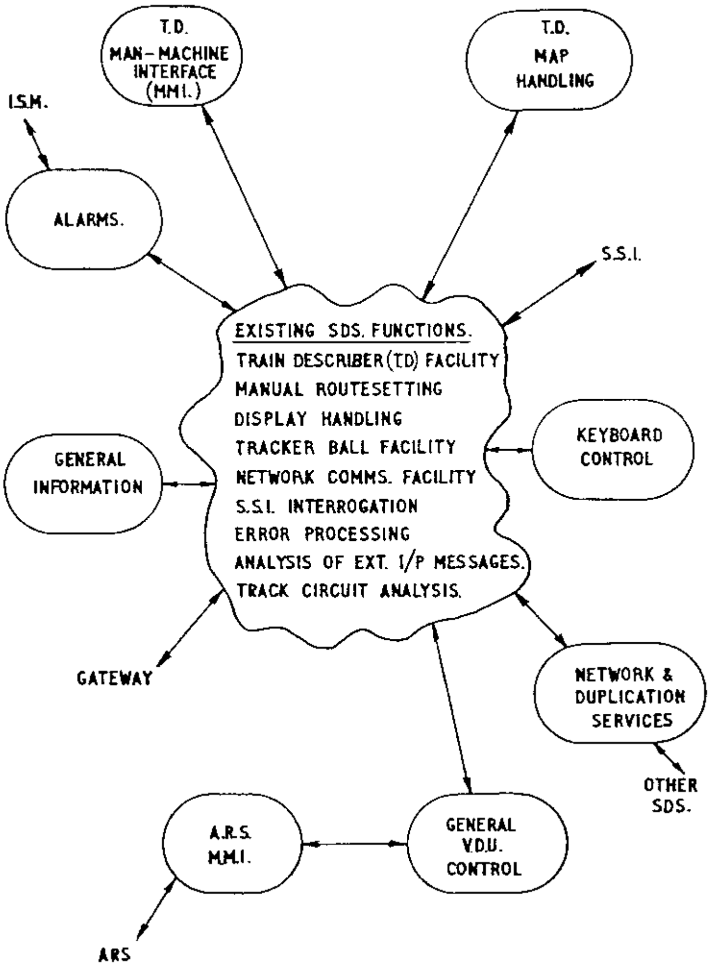

Fig. 6. ARS functions.

Existing signalling system

The introduction of 25kV traction in 1960 required a major resignalling scheme but the scheme came too early to allow the application of remotely controlled relay rooms. Power boxes with NX panels and route relay interlockings were provided at Hyndland and Dumbarton to control the lines within a 2 mile radius of these localities but elsewhere the existing mechanical signalboxes were retained. Lever frames control points and shunt signals and the multi-aspect main line signals are controlled from switch panels mounted on the block bench. Absolute block working applied to the mechanical signalboxes and train describers were provided at Hyndland and Dumbarton power boxes. Since 1960 the freight traffic has declined but headway requirements necessitate the retention of the mechanical signalboxes even though sidings and loops have been removed.

Strathclyde rail review

Whilst the Glasgow suburban services are well patronised, receipts do not cover expenditure. Strathclyde PTE makes good the deficiency, currently running at £26m p.a., as part of their policy of having an integrated public transport service in the Strathclyde Region. A joint review of these services has been carried out by Strathclyde and ScotRail to identify ways of reducing costs whilst improving the service to the customer. To meet these objectives on the North Clyde services, the following action was agreed:-

1. To have one depot for train servicing and stabling of stock. At present the 51 class 303 units required to operate the North Clyde service are cleaned at Bridgeton but inadequate capacity in the yard means that only a few units can be based there, the rest being held at Airdrie, Helensburgh, Balloch, Milngavie and Springburn.
2. To have one train crew depot instead of the present seven crew depots.
3. To replace the present 17 signalboxes with one signalling centre.
4. To combine servicing depot, train crew depot and signalling centre with a common administration service under the control of an Area Management team responsible for the North Clyde Service.
5. To have driver only operation on the electric units.
6. To have a real time passenger information system at each of the 47 stations.

The requirements for a combined train servicing train crew depot were met by locating the new depot on the site of the former freight yard between Yoker and Garscadden stations. This site has the advantages of having sufficient space and being midway between Airdrie and Helensburgh. The administration building for the depot will incorporate the control room for the IECC.

Glasgow North suburban train services

The daily train movements on the lines that are to be controlled from Yoker are shown on Fig. 7. Traffic regulation on these lines is a skilled task due to multiplicity of signalboxes and the fact that there are 11 "flat" junctions. Only Finnieston Jcn. possesses a flyover facility and it is unlikely that the other junctions will be reconstructed in this manner. Between Hyndland East Jcn. and Finnieston Jcn., the timetable headway is 5 minutes off peak and is 2 minutes at peak times. The alternating pattern of the train service requires both these junctions to be operated for every train movement. Between Westerton Jcn. and Craigendoran Jcn., paths have to be found for the passenger and freight trains for the West Highland Line. The Springburn line is a branch line in passenger terms but it is a through line for freight trains. These trains run also on the Airdrie line between Bellgrove Jcn. and High St. Jcn. At Sunnyside Jcn. freight trains cross the Airdrie line to gain access to Gunnie Yard.

Despite these difficulties, the Glasgow North "electrics" have a good reputation for timekeeping, frequently attaining 95% right time on a daily basis. Nevertheless, once the service pattern goes awry for any reason, the lack of centralised control impairs the task of restoring normal services. Keeping the customer and, indeed, the staff informed under these circumstances is a near impossibility and does little to enhance the railway's image.

Centralised control, automatic route setting, a real time information system, and train radio, are features that are essential for a suburban train service of this nature.

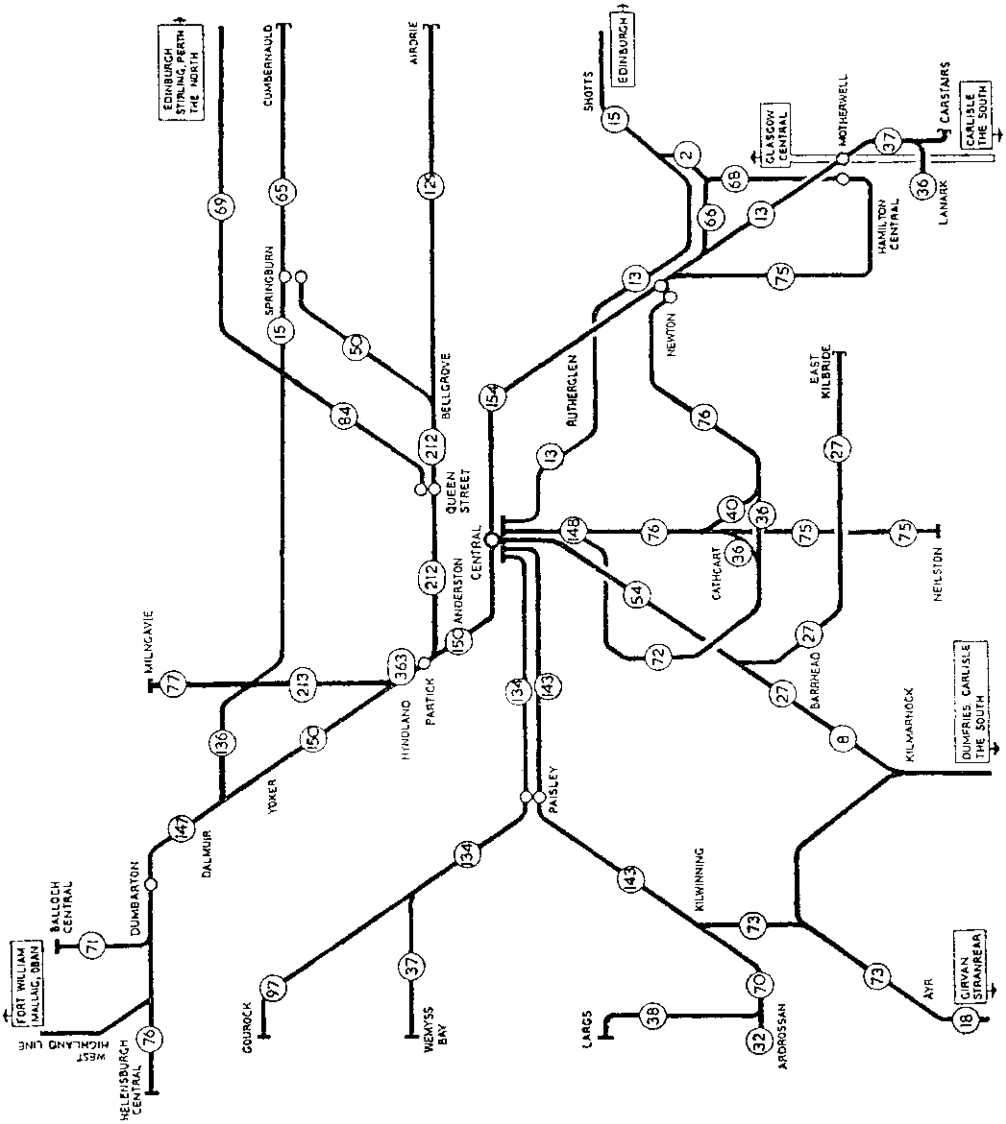

Fig. 7. Multiple unit passenger train movements (24 hr. period - ECS not included)

The Yoker resignalling scheme

The principal statistics for the Yoker Scheme are:-

Route Miles	64.6
Single Track Miles	110.9
Point Ends	116
Running Signals	212
Shunt Signals	42
Signalled Routes	334
Track Circuits	428
Solid State Interlockings	5
Relay Interlockings	1
Work Stations	2

The SSI's will be housed in the equipment room adjacent to the control room at Yoker. Each SSI controls a defined area as shown in Fig. 8. The relay interlocking is located at Craigendoran.

This interlocking was commissioned in 1984 and economically it made sense to provide an interface between the IECC signalling network and Craigendoran rather than replace the relay interlocking with an SSI.

Work stations

Two controllers, each with their own work station, are required for the supervision of train movements. The boundary between their areas of responsibility is shown on Fig. 8. Work station design is in progress with the assistance of ergonomics experts from Loughborough University. First thoughts on how the control room will appear are shown on Fig. 9.

A third position, for supervisory purposes only, will be provided but it is not intended to be staffed continuously.

Diverse routing

Concentration of the SSI's at Yoker obviously increases the possibility of catastrophic failure should the data link cables suffer damage. To mitigate the effects of such damage, diverse routing techniques have been applied. Advantage has been taken of the existence of the two routes between Dalmuir and Hyndland to give duplicated and separate cable links for the lineside equipment associated with the Yoker Hyndland and Finnieston interlockings. The lineside equipment served by the Sunnyside interlocking will be fed by two separate p.c.m. links over telecomms. trunk cables. Dumbarton will be served by duplicate p.c.m. links but the lack of an alternative route limits the effectiveness of this method.

Fig. 10 shows the proposals for diverse routing.

Communication with trains

The electrical multiple units will be fitted with a secure UHF radio system thus allowing driver only operation. Fixed stations linked by landline to Yoker ensure complete radio cover over the entire system and hence the drivers of these trains will have no need of signal post telephones.

The West Highland trains are hauled by locomotives from a captive fleet specially fitted with a VHF band III radio system for operation on the RETB system on this line. These trains will use this radio for communication with Yoker when running between Craigendoran and Westerton. Signal post telephones will be required between Springburn and High Street and at Sunnyside Jcn. as there can be no guarantee of radio fitted locomotives on the freight trains.

Information systems

At the time of writing this paper, a decision on the nature of the information systems to be provided had not been taken. It seems certain, however, that there will be public address facilities at every station with synthesised voice announcements actuated by the train at specified localities. The information network will provide relevant information for the announcement.

At present, Partickhill, Charing Cross, Queen St. L.L., Central L.L., Argyle Street, Anderston, Exhibition Centre and Hyndland Stations have split flap indicators controlled from Hyndland signalbox. These indicators could be driven from the Yoker information network and, of course, there would be no need for the dedicated operator that the present arrangement requires.

Fringe signalbox links

The data links to Motherwell, Glasgow Central, Cowlairs and Slighthill are coupled to the information network at Yoker through data protocol convertors. T.D. information on any berth in these four signalboxes/centres can be displayed on the Yoker operator's general purpose display monitor.

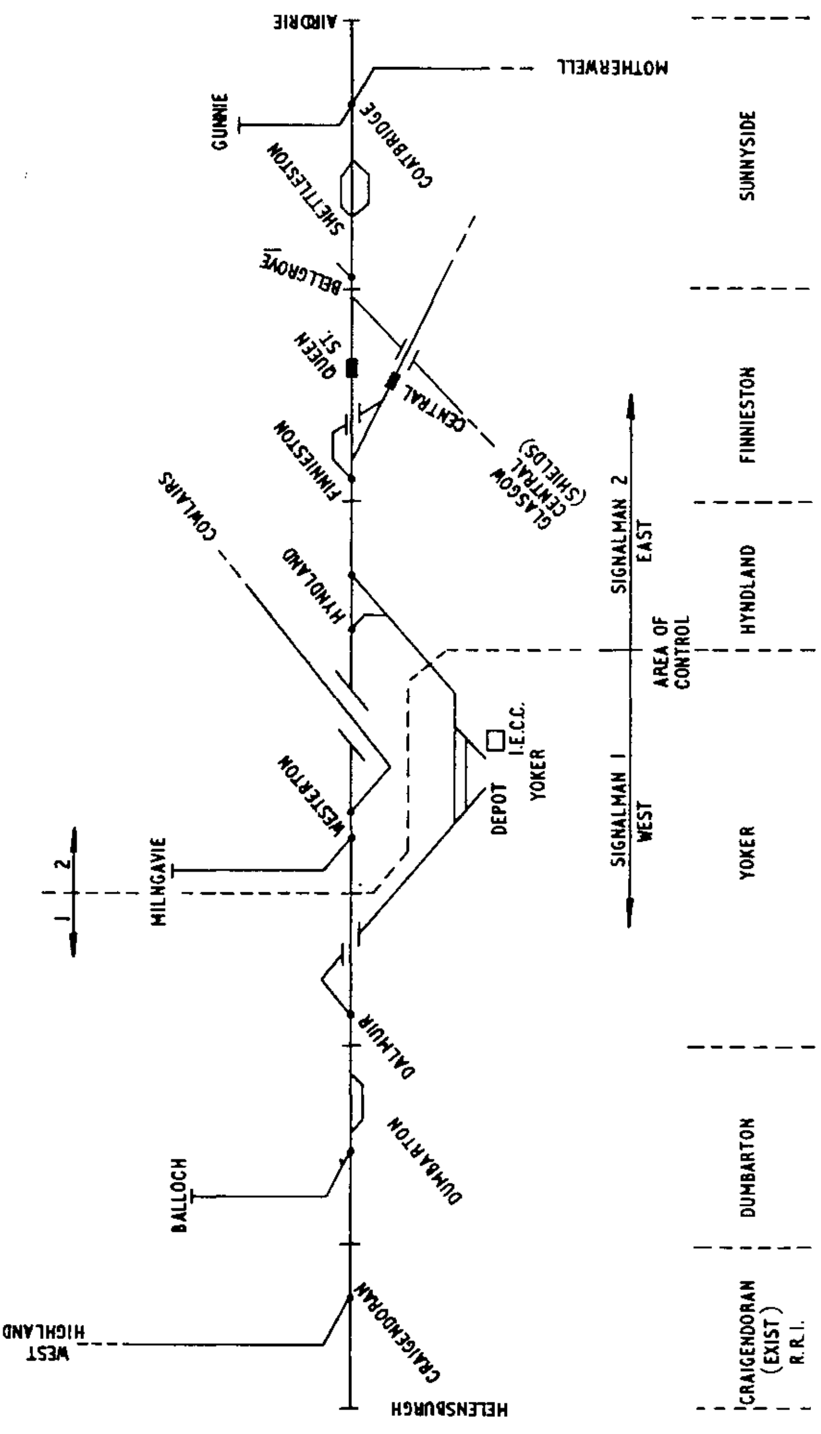

Fig. 8. Yoker resignalling interlocking areas (SSI)

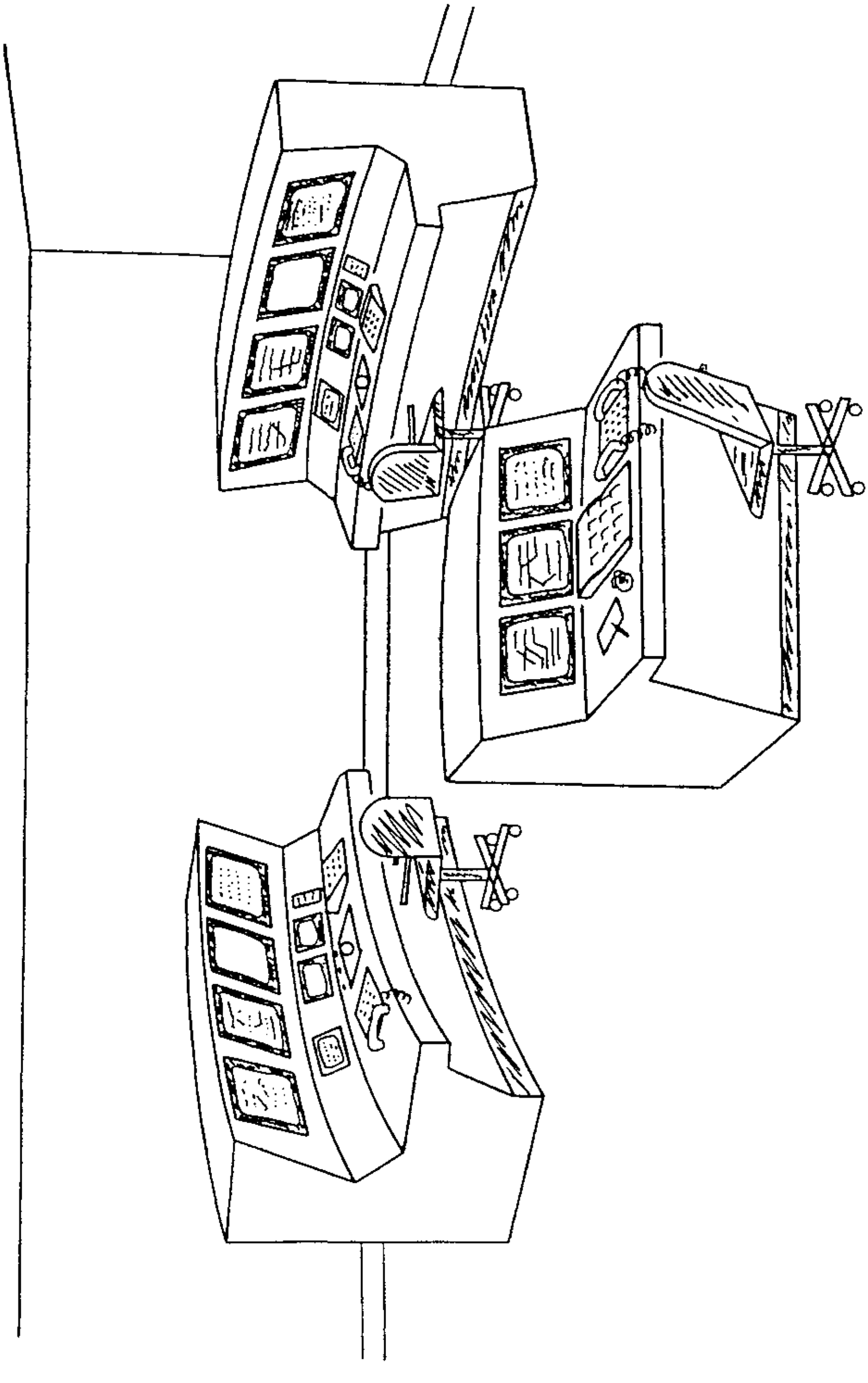

Fig. 9. Integrated electronic control centre - operating room concept.

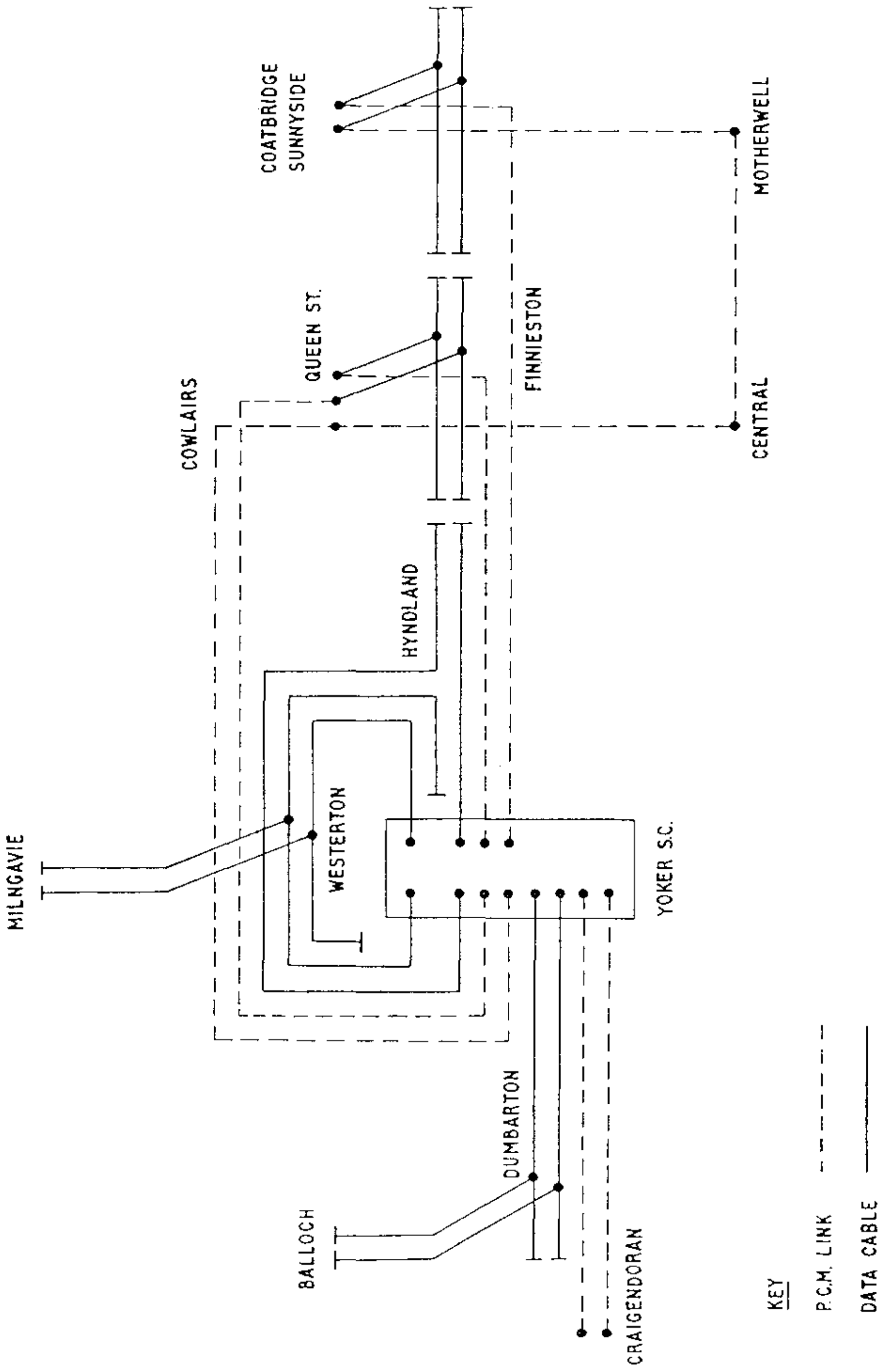

Fig. 10. Yoker data transmission network.

CONCLUSION

The introduction of the IECC concept to British Railways represents a fundamental change to the signalling of trains and the provision of real time information to passengers and staff. It is not an exaggeration to say that the IECC can be compared with the major advances of previous decades such as mechanical interlocking, colour light signals, relay interlockings, remotely controlled relay rooms and SSI. This paper can serve only as an introduction to the subject as each system on the IECC is worthy of technical paper of its own.

ACKNOWLEDGEMENTS

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DISCUSSION

Opening the discussion, Mr. D. Lamb thanked Mr. Dickens for presenting the paper on behalf of Mr. Nelson and asked him to convey the best wishes of the meeting to Mr. Nelson for a speedy recovery.

There have been arguments on the merits of panels and VDU's, whereby signal engineers have tried to copy a panel and present it on a VDU. At the same time the signalman may not need to have an overview of the network when he has little control over much of it.

Were there difficulties of acceptance by the user of the automatic route setting system?

How much training was required by the first-line technician. If his job was reduced to that of a board changer, how was his interest to be maintained?

How did the complex network recover from a power failure. What happened to data in the memories. How was it ensured that the resulting picture was correct.

Was the system flexible enough to be used for much larger and, perhaps more important, much smaller schemes with only one rack of solid state interlocking?

In reply, Mr. Dickens said that the overview provided was more basic than the NX panel, which was all that was required. The close-up view had all the information expected on an NX panel, as was required by the operators.

It was his impression that signalmen were happy with the automatic route setting, although he understood that, at Three Bridges, they would sometimes switch it off in order to keep their hand in.

At the present time everything was new and everybody, including the technicians, were enthusiastic. The problem of retaining that interest was very difficult, but had to be faced.

As with a conventional system, this system would recover from power failure in a safe manner. In any sub-system, the microprocessors would decide to enter a stand-by and master state after a delay of one minute.

The question of flexibility had not yet arisen. Perhaps Southern Region colleagues could comment.

Mr. C. Hale intervened to say that, at Three Bridges, the signalmen were initially doubtful of the automatic route setting but a recent check had shown that it was being used as the normal course. They agreed that it got traffic back to normal running in a quick and effective way. The signalmen occasionally went into manual to remind themselves how to operate it.

Mr. P. Cuffe commented that the Dublin DART had some simplified elements of the Yoker scheme, but without any solid state interlocking. They were using commercial DEC computers in a main and hot stand-by configuration. The DEC regular maintenance man attended in normal commercial working hours, thereby reducing the system to one machine at a heavy traffic time.

Some common mode failures had been experienced, in the changeover switch itself.

Mr. Cuffe asked if consideration had been given to using tied British Telecom data lines as an alternative to the railway route for the over-ride facility.

The operators appreciated the overview facility, especially in difficult circumstances, to get a picture of the whole system. However, it was a surprise to find that two permanent screens were adequate for the Yoker scheme. Dublin used 12 screens for a smaller system.

He also enquired if the traction supply control was in the same room as the signalling.

In Dublin there were two men on duty, one was the overall signalman and the other acted as relief. CCTV crossing supervision was on a separate desk. The men rotated every two hours.

For Dublin, there were two categories of audible alarm, critical and informational. The number of alarms generated needed to be restricted, otherwise they became trivialised.

When selecting what data should be logged, it was necessary to have flexibility and room for afterthought.

Time stamping of reports could present problems, either between separate systems with clocks not in synchronism or under failure conditions when record serial numbering became reset.

He noted that the Electricity Supply Board had found it useful to provide a duplicate system display for the information of management. DART had found that there was no difficulty in retraining signalmen and technicians in the new system, but no thought had been given to the needs of management.

Mr. Cuffe noted that there was mention in the paper of the use of Band 3 VHF radio in lieu of signal post telephones. This could cause problems of integrity of identification.

It appeared that the intention was to commission the whole scheme in one go. Ten local panels had been commissioned in phases on DART, before the auto-routing was tested. A full rush hour service was run in the early hours of a Sunday morning and revealed a number of problems that had not been shown up by computer simulation. Also there had been queing problems on inter-computer data exchanges.

In conclusion, Mr. Cuffe stated that the system generally worked well, and was appreciated by operators and public alike. He had merely outlined a number of difficulties that had to be overcome.

In response, Mr. Dickens acknowledged the problem of the main to standby change-over.

The SSI system did not have local interlockings, therefore the question of over-ride did not arise. Long line data links used the BR PCM systems to avoid cabling costs.

It had been possible to get the whole of Yoker, with one small exception, onto on 20 inch screen, which was quite readable.

The SSI printout gave an indication when something was wrong. It was for the technician to deal with this. There would be tapes recording what happened, to enable the sequence of events to be determined.

It was accepted that there might be problems with the Band 3 radios and that tight discipline between the drivers and signalmen would be required.

He agreed that commissioning would be difficult. It was intended to proceed in seven stages, using the simulators to check the interlockings as they were put in. That left the problem of the train describer radio system.

Mr. H. Ryland commented that there had been much discussion on what should appear on a VDU. Suggestions ranged from a super-view of the whole of the West Coast main-line to very detailed pictures of a small local area. It had been agreed that what was needed was an overview, with sufficient detail to show a train description in each section and the relevant signals. Most of the main route setting could be operated at this level. Each of the two signalmen were provided with two permanent screens of overview showing their area of control and a further screen for selection of a close up of any area.

It was noted that SSI used a data driven system and that the software had to be constructed only once. Configuration for any application was by data prepared by the signal engineer.

The display system was applicable to any size of scheme, up to something larger than Yoker, which did not completely fill the two over-view screens. The automatic route setting system was also largely data driven, although it was possible to insert small amounts of software to meet special operating requirements.

The alarms at Yoker were in four categories, system alarms, signalling alarms, train describer alarms and automatic route setting alarms. They appeared on different parts of the screens, to avoid confusion.

A centralised clock was provided on the system and the time distributed over the network to ensure consistency.

All SSI logging was on tape, to avoid drop-out problems which could make a disk system difficult.

SSI used uninterruptable power supplies to try to avoid power failure problems. The displays would not restore until the necessary information was obtained from the SSI's. Missing information would show up as red, as would occur on TDM link failure. The flashing colon in the time display was driven by the software, giving assurance that the computer was actually working.

Mr. P. W. Stanley commented on the content of VDU displays. One problem was to provide an acceptable alternative to the systems that everyone had become accustomed. Simpler displays were probably quite adequate, and cheaper to produce.

There was a need for proper training of maintenance staff to ensure that they could correctly identify failures, particularly intermittent failures, so that unnecessary changing of boards did not occur. The connectors were a weak link in the system.

The Achilles heel of any system was the cable bringing information into the signalbox from outside. This became most important when a centralised interlocking was installed, without local interlockings.

Mr. Dickens agreed with Mr. Stanley on the question of complexity of VDU displays.

The technicians terminal was intended to inform him which board, or complete module, required changing.

Alternative routing of cables was supposed to be provided for SSI, but there were questions of cost. Beween Dalmuir and Hyndland, the data links went around both sides of the loop. The PCM links were also duplicated.

THE INSTITUTION OF RAILWAY SIGNAL ENGINEERS
(Incorporated 1912)

SEVENTY-FOURTH ANNUAL REPORT

January 1st to December 31st, 1986

MEMBERSHIP

The following table gives details of the membership changes during the year and the numbers in each class at the close of the year.

	Elections, Re-admissions Transfers		Deaths		Resignations		Lapses		Transfer to higher class		Registered Membership December 31st, 1986		
	Home	O'seas	(h)	(o)	(h)	(o)	(h)	(o)	(h)	(o)	(h)	(o)	Total
Corporate Members													
Honorary Fellows	-	1	-	-	-	-	-	-	-	-	12	6	18
Fellows	10	13	5	1	-	6	-	2	-	1	135	218	353
Members	4	23	2	1	3	2	-	-	3	6	277	167	444
Non-Corporate Members													
Honorary Fellows	-	-	-	-	-	-	-	-	-	-	1	-	1
Technician Engineers	4	6	3	-	5	4	-	-	-	1	141	46	187
Associates	14	36	1	-	11	2	1	-	2	5	172	189	361
Graduates	4	3	-	-	-	-	-	1	4	2	79	18	97
Students	12	6	-	-	7	4	2	2	9	10	272	45	317
Technicians	5	8	-	1	8	4	-	-	3	1	239	71	310
	63	96	11	3	34	22	3	5	21	26	1328	760	2088

There has been a small overall increase of thirty-one members during the year made up as follows:-

Corporate Members

Honorary Fellows	+ 1	
Fellow	+ 9	+30
Members	+20	

Non-Corporate Members

Associates	+27	
Students	−20	+ 1
Technicians	− 6	

Recruitment during the year was slightly higher than in 1985 but there was a marked increase in recruitment overseas which overall was 50% higher than in U.K. The largest part of the overseas increase was in the corporate membership grades of which the non-U.K. element is now 60% of the total compared with 46% at the end of 1985. This is indicative of the increasingly international nature of the Institution's activities and the support and interest which exists overseas.

The Council is grateful to the Recruitment Committee and those concerned in Australia, South Africa, Zimbabwe and elsewhere for the work they do in making people in or connected with the profession aware of the Institution and the benefits of membership.

OBITUARY

The decease of the following members during the year was noted with deep regret: Mr. T. J. Aldridge, Mr. R. G. Bates, Mr. A. Brown, Mr. J. H. Currey, Mr. D. M. Hall and Mr. L. W. H. Lowther (Fellows); Mr. F. B. Anstey and Mr. S. D. David (Members); Mr. A. P. H. Crepin and Mr. J. Stratton (Technician Engineers); Mr. W. J. A. Sykes (Associate); Mr. B. A. Thomas and Mr. E. R. Welch (Technicians).

AWARDS

The Council noted with great pleasure the award in the 1987 New Years Honours List of the O.B.E. to Mr. W. H. Whitehouse, Past

President and Director of Signal and Telecommunications Engineering, British Railways Board.

FINANCE

Mr. A. Etchells relinquished his position as Treasurer after the A.G.M. in April 1986, and his position has been taken by Mr. C. H. Porter.

On the income side, there was a net surplus of £2660 arising from a small surplus from the Convention of £1201, which represents just over 1% of the turnover for the Convention, together with an increase in investment income to £8685. Subscription income increased by £3715 as a result of the increase in subscription rates in January 1986, and there was a small increase to £576 in the profit on sales of text books and Technical booklets.

On the expenditure side, accommodation costs both for technical and committee meetings have increased sharply to a total of £1925, due in the main to the IEE increase in charges. The increase in Treasurer's fees is due to having an overlap of four months at the beginning of 1986 between the two Treasurers. Although two newsletters were published in 1986, the cost in the Expenditure statement reflects the cost of one issue only. This is because provision had been made in the 1985 Accounts for three issues to be published in 1985, whereas in the end, only two were printed. The provision for this third issue in 1985 has been used to offset the cost of the two issues published in 1986, resulting in a charge of £688 to this year's accounts.

The single largest increase has been an increase of £3838 in the cost of printing the Proceedings and Technical Papers. Of this, £1319 was the difference between the actual costs of printing/distribution of the 1982/83 issue of the Proceedings, and the amount provided for them in the 1983 accounts. In addition, one extra technical paper was published. There is now a separate fund shown in the Balance Sheet to pay for the backlog of Proceedings. In looking at ways of reducing printing costs, Council has agreed to a reduction in thickness of paper for the Technical Papers, and is assessing the effect on costs of reducing the thickness of paper used in the Proceedings.

To improve income, joining fees which have remained static for many years, were increased with effect from January 1987, and subscription rates will be reviewed during 1987 to see if any increase is required in 1988.

The I.R.S.E. Scholarship Fund, set up in 1984, continues to increase, with a total income of £918, which, because no award was made in 1986, was added to the capital value of the fund. The Council's aim is to keep the value of the fund, and any award, in line with inflation to ensure that a meaningful amount is available as an incentive and reward for members taking the examination.

PROVINCIAL AND OVERSEAS SECTIONS

The overseas Sections in Australia, South Africa and Zimbabwe and the Midland & North Western, Plymouth, Scottish, Western and York Sections in the United Kingdom continue to thrive and each arranged its own programme of events during the year.

The Council is most grateful to the Officers of all Sections both at home and overseas for the work which they undertake on behalf of the Institution in organising meetings and other events.

The Officers of the Sections were:-

Australian Section: Chairman, Mr. J. Rees; Vice-Chairman, Mr. I. F. Ritchie; Hon. Secretary/Treasurer, Mr. A. R. McKenna.

South African Section: Chairman, Mr. R. B. Woodhead; Vice-Chairman and Secretary, Mr. H. Z. Ostrofsky; Treasurer, Mr. J. C. Van de Pol.

Zimbabwe Section: Chairman, Mr. A. R. Brown; Vice-Chairman, Mr. A. J. C. Thompson; Hon. Secretary/Treasurer, Mr. J. H. Oliver.

Midland & North Western Section: Chairman, Mr. P. H. Trickett; Vice-Chairman, Mr. B. Ashmore; Hon. Secretary, Mr. I. R. Bridges; Hon. Treasurer, Mr. B. J. Arthurs.

Plymouth Section: Chairman, Mr. A. M. Peters; Vice-Chairman, Mr. C. R. O'Connor-Boyd; Hon. Secretary/Treasurer, Mr. J. Stiles.

Scottish Section: Chairman, Mr. J. H. Clayton; Vice-Chairman and Hon. Secretary, Mr. S. J. Hailes; Hon. Treasurer, Mr. W. R. Graham.

York Section: Chairman, Mr. S. R. Batty; Vice-Chairman, Mr. E. M. H. Galloway; Hon. Secretary/Treasurer, Mr. D. T. Plummer.

Western Section: Chairman, Mr. G. J. W. Meecham; Vice-Chairman, Mr. S. J. Tomlinson; Hon. Secretary/Treasurer, Mr. D. M. Sausins.

AFFILIATED S & T TECHNICAL SOCIETIES

The following S & T Technical Societies remained affiliated to the Institution and the Council wishes them success: Birmingham, Carlisle, Leicester, London (Southern Region), London Transport, Manchester and Western Region.

EXAMINATIONS

The Institution's Signalling Examination was held in October at a number of centres both in the United Kingdom and overseas. Of a total of 22 candidates, the following eleven were successful:-

Section A—Parts 1 & 2—Railway Signalling: M. L. Bridle, A. L. Coombes, C. S. Dennien, P. M. J. Ellingworth, R. G. Halse, N. S. Harrowby, J. W. Hoadley, B. C. Smith, C. F. Smith, M. J. Spencer, P. J. McQueen.

There were no candidates for the Telecommunications Examination.

The Council is grateful to the Examination Committee for setting and marking the papers, to the Invigilators and to the Officers of the administrations at the examination centres for facilities so kindly provided.

THORROWGOOD SCHOLARSHIP

None of the candidates who sat for the Institution's 1985 Examination achieved the required standard (a Pass with Credit) to justify consideration for the award of the Thorrowgood Scholarship and no award for 1986 was therefore made.

COUNCIL MEETINGS

The Council met on nine occasions during the year.

TECHNICAL MEETINGS

Six technical meetings were held at the Institution of Electrical Engineers in London during the year and full programmes of meetings were also arranged by the Provincial and Overseas Sections.

The average attendance at the London meetings during the Presidential year 1985/86 was 87 compared with 91 in the year 1984/85 and the decline in attendances, albeit small, which has been evident over the last ten years therefore continues. This is disappointing having regard to the fact that papers generally have been of a high standard covering a variety of subjects and giving a wide range of interest. This decline in attendances, if continued, must sooner or later raise a question mark over the pattern and venue of London meetings bearing in mind that costs at the Institution of Electrical Engineers are high and continuing to rise.

Attendances at meetings arranged by the Provincial and Overseas Sections were by and large encouraging and it is hoped that support in this important area of Institution activity will continue.

TECHNICAL VISITS

The President was supported by 101 members from nine countries when a technical meeting and visit was held in the Netherlands on 21st and 22nd February. On Friday, 21st February, in Utrecht, Mr. De Jong, Technical Director of Netherlands Railways, welcomed the members to Holland and a technical paper entitled "Microcomputer Based Interlocking at Hilversum" was presented by Mr. P. Middelraad (NS) and Mr. A. Zillmer (Siemens). On Saturday, 22nd February, members visited the installations described at Hilversum and other projects in the Amsterdam and Zaandam areas. The Institution is grateful to Netherlands Railways and to Siemens for the facilities and generous hospitality provided.

On Friday, 21st November, a party of seventy-four members representing eight countries met in Paris where a technical paper entitled "The New SNCF Electronic Interlocking at Tours" was presented by Messrs. R. Retiveau (SNCF) and J. Pore (Jeumont Schneider). The following day the members visited Tours to inspect the installations described in the paper. The visit concluded with lunch and the Council is most grateful to SNCF, Jeumont Schneider, Alsthom, CSEE and Silec for facilities and hospitality so kindly provided.

ANNUAL GENERAL MEETING

The seventy-third Annual General Meeting was held in London on 21st April and this was followed by the inauguration of the new President and Presidential Address, a transcript of which was subsequently circulated to all members.

The composition of the Council for 1986/87 was announced as follows:

President: Mr. J. G. Oehler

Vice-Presidents: Mr. C. Hale and Mr. T. S. Howard.

Members of Council from Class of Fellow: Messrs. W. G. Boddy, J. Catrain, E. O. Goddard, B. D. Heard, M. W. Heaton, F. Kerr, R. C. Nelson, C. A. Porter, F. G. Rayers, J. Waller.

Members of Council from Class of Member: Messrs. R. V. Atkin, R. E. B. Barnard, D. A. Edney, A. P. Harvey, R. L. Wilkinson, D. J. Wittamore.

TECHNICAL BRIEFS

The preparation of further Technical Briefs following the publication of that covering Route Control Systems (L.T. practice) has

THE INSTITUTION OF RAILWAY SIGNAL ENGINEERS
BALANCE SHEET AT 31st DECEMBER, 1986

	31st Dec. 1986 £	31st Dec. 1986 £	31st Dec. 1985 £	31st Dec. 1985 £
Accumulated Fund				
As at 1st January, 1986	65279		49141	
Plus excess of income over Expenditure	2660		1856	
Transferred from International Conference Fund	-	67939	14282	65279
Current Liabilities & Provisions:-				
Subscriptions Received In Advance	594		1256	
Sundry Creditors and Accrued charges	1350	1944	3399	4655
International Conference Fund				
Balance at 1/1/86	10000		25670	
Additions during the year			3612	
	10000		29282	
Less Transferred to				
Scholarship Fund	-		5000	
Accumulated Fund	-	10000	14282	10000
Proceedings Fund (See Note 1.)				
Balance at 1st January, 1986	20000		13500	
Less Provision for 82/3 Issue	6000		-	
	14000		13500	
Provision for 1985/6 Proceedings	7500	21500	6500	20000
		101383		99934

Notes: 1. Provision for cost of Proceedings for 1983/4, 1984/5 & 1985/6

		31st Dec. 1986 £	31st Dec. 1986 £	31st Dec. 1985 £	31st Dec. 1985 £
Fixed Assets					
Office Requisites at net amount standing on the Institution's books at 31st December, 1947 (separate figures of cost and depreciation not being readily available) and additions at cost to date		307		307	
Deduction Depreciation		307	-	297	10
Computers		7623		7116	
Less Depreciation		3722	3901	1781	5335
Investments in Government Securities at cost			19804		19804
Note - Mid-Market Value 1986 £20,272 1985 £20,477					
Current Assets					
Sundry Stocks at Cost:-					
Technical Booklets	4140				
Less write-off provision	4140	-		-	
Textbooks		880		1680	
IRSE Ties		348		323	
Past Presidents' Badges		394		460	
Presentation Plaques		295		15	
Thorrowgood Scholarship Medals		624	2541	624	3102
Sundry Debtors & Payments In advance			2793		3229
Cash at bank:-					
Current Account		(160)		2292	
Deposit Account		4000		2000	
National Giro Account		80		397	
National Savings Investment Account		64790		58009	
Cash in Hand		2273		1921	
Convention Accounts		1361	72344	3835	68454
			101383		99934

INSTITUTION OF RAILWAY SIGNAL ENGINEERS THORROWGOOD SCHOLARSHIP BEQUEST FUND BALANCE SHEET AS AT 31st DECEMBER, 1986

THORROWGOOD SCHOLARSHIP BEQUEST FUND CAPITAL FUND	31st Dec. 1986 £	31st Dec. 1985 £	THORROWGOOD SCHOLARSHIP BEQUEST FUND	31st Dec. 1986 £	31st Dec. 1985 £
As at 1st January, 1986	1861	1771	Quoted Investments at Cost	1563	1563
			Note - Mid-Market Value 1986 £1440 1985 £1381		
Add surplus for year to 31st December, 1986	92	90	Current A/C IRSE	70	-
			Cash at Bank Deposit A/C	320	298
	1953	1861		1953	1861

THE INSTITUTION OF RAILWAY SIGNAL ENGINEERS SCHOLARSHIP FUND BALANCE SHEET AS AT 31st DECEMBER 1986

CAPITAL FUND	31st Dec. 1986 £	31st Dec. 1985 £		31st Dec. 1986 £	31st Dec. 1985 £
Balance as at 1st January 1986	6569	200	National Savings Investment Account	7487	6419
Donations during year	184	961	Sundry Debtors	-	150
Amounts transferred from Institution	-	5000			
Investment interest	734	408			
	7487	6569		7487	6569

President: J.G. OEHLER
Vice-President: C. HALE — Members of Council
Treasurer: C.H. PORTER

REPORT OF THE AUDITOR TO THE MEMBERS OF THE INSTITUTION OF RAILWAY SIGNAL ENGINEERS

I have examined the attached Balance Sheet and annexed Income and Expenditure Accounts for the Institution, the Thorrowgood Scholarship Bequest Fund and the Institution of Railway Signal Engineers Scholarship Fund, which have been prepared on a historic cost basis. Subject to the remark that subscriptions from Members have been included only to the extent of the amounts received, in my opinion, the Balance Sheets and Accounts give a true and fair view of the state of the Institution's affairs at 31st December 1986 and of the Excess of Income over Expenditure for the year ended on that date, and comply with the Companies Act, 1948 and 1981.

29 Muncastergate
York.
3rd March 1987

W.V. Townsend
Chartered Accountant

THE INSTITUTION OF RAILWAY SIGNAL ENGINEERS
INCOME AND EXPENDITURE ACCOUNTS for the year ended 31st December, 1986

	31st Dec. 1986 £	31st Dec. 1986 £	31st Dec. 1985 £	31st Dec. 1985 £
Proceedings & Technical Papers				
Proceedings				
Provision for 85/6 issue	7500		6500	
Extra cost of 1982/3 issue	1319		-	
Printing Papers & Blocks	7090		5571	
Editing	140		114	
Prizes	96	16145	83	12268
Booklets & Textbooks				
Stock 31st December, 1985	5734		4196	
Printing & Distribution	293		2095	
	6027		6291	
Less Stock 31st December, 1986	5020	1007	5734	557
Provision for loss on Booklet Stocks		86		(142)
I.R.S.E. Ties				
Stock 31st December, 1985	323		283	
Purchases	367		429	
	690		712	
Less Stock 31st December, 1986	348	342	323	389
Expenses of Meetings				
Accommodation	1167		926	
Refreshments less recoveries	136	1303	225	1151
Office Expenses				
Secretarial & Committee	3785		4015	
Treasurer's Fees	1750		1275	
Postage & Miscellaneous Expenses	4644		3860	
Committee Meeting Accommodation	622	10801	451	9601

	31st Dec. 1986 £	31st Dec. 1986 £	31st Dec. 1985 £	31st Dec. 1985 £
Subcriptions Received:				
Arrears in respect of earlier years	2256		2364	
For the Current Year	25397	27653	21574	23938
Donations		74		150
Entrance Fees		88		59
Engineering Council Registration Fees		892		471
Income From Proceedings				
Sales - including papers	165		78	
Advance Copy Registration fees	2238	2403	2155	2233
Sundry Sales				
Booklets & Text Books	1583		788	
IRSE Ties	331	1914	485	1273
Interest on Investments - Gross		8685		7810
Examination fees		67		76
Functions				
Surplus on 1986 Annual Convention	1201		1699	
Surplus on Dinner & Dinner Dance	(14)		27	
Surplus on Technical Visits	81	1268	(24)	1702

Printing & Stationery	4849	4695			
Past President's Badge	66	131			
Auditor's Remuneration	260	200			
Examination Costs	89	86			
Engineers Registration Board Fees	893	401			
Grant to Zimbabwe Section	-	250			
Newsletter	688	1877			
Computer Depreciation	1950	1781			
Computer Maintenance Contracts	649	649			
Secretarial Expenses - Australia	671	386			
Loss on foreign exchange	309	790			
Institution Entertaining	276	786			
Balance being excess of Income over Expenditure	2660	1856			
	43044	37712		43044	37712

THE INSTITUTION OF RAILWAY SIGNAL ENGINEERS THORROWGOOD SCHOLARSHIP BEQUEST FUND
INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st DECEMBER, 1986

	31st Dec. 1986 £	31st Dec. 1985 £		31st Dec. 1986 £	31st Dec. 1985 £
Scholarship Prizes - Current Year	-	-	Interest on Investment	92	90
Surplus Transferred to Capital Fund	92	90			
	92	90		92	90

THE INSTITUTION OF RAILWAY SIGNAL ENGINEERS SCHOLARSHIP FUND
INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st DECEMBER 1986

Scholarship Prizes - Current Year	-	-	Interest on Investment	734	408
Surplus Transferred to Capital Fund	918	408	Donations	184	-
	918	408		918	408

progressed but slowly due to the difficulty in finding suitable authors prepared to undertake the work. The Papers Committee is currently considering how the production of further Technical Briefs might be accelerated.

TEXT BOOK

Copies of the text book "Railway Signalling" continue to be available for sale to members of the Institution at £12.00 per copy. Applications for copies should be addressed to the Hon. General Secretary.

PROCEEDINGS

The 1982/83 edition of the Proceedings was published during the year. The expectation that the 1983/84 edition would also be published before the end of the year was unfortunately not fulfilled but it is expected to be ready early in 1987. The delay in publication of the Proceedings is a matter of concern to the Council and a determined attempt is being made to produce the 1984/85 and 1985/86 editions during 1987 in order to reduce the backlog.

NEWSLETTER

Two editions of the Institution's Newsletter were published during the year and the Council is grateful to Mr. M. W. Hewitt for the editorial work he undertakes in connection with the production of this publication.

RAILWAY ENGINEERS FORUM

The Institution continued its association with the Railway Engineers Forum, of which the Institutions of Civil, Electrical and Mechanical Engineers are also members, and two successful and well supported meetings were arranged during the year.

Mr. T. S. Howard is now Chairman of the Forum Committee and Messrs. R. V. Atkin and J. Waller also represent the Institution. The Council is grateful to them for their assistance.

COMMITTEES

The following were elected to serve on the Standing Committees shown and the Council is grateful to them for the work they undertake on behalf of the Institution.

General Purposes Committee: Messrs. J. G. Deane, P. H. Dibden, M. H. Govas, C. Hale, T. S. Howard, P. N. Lane, G. B. Nelson, P. Robins, K. Smith, W. A. Warner, C. White and H. Worsley.

Management Committee: Messrs. J. Catrain, E. O. Goddard, C. Hale, T. S. Howard, F. Kerr, C. A. Porter, F. G. Rayers, P. F. Wing and D. J. Wittamore (Hon. Secretary).

Examination Committee: Messrs. J. D. Corrie, C. J. Edwards, D. A. Hotchkiss, C. Law, D. Poole, Q. J. A. MacDonald, J. Martin, R. W. Penny (Hon. Secretary), R. Pope, M. Scott, P. W. Stanley and C. White.

Papers Committee: Messrs. A. D. Fleet, C. Hale, T. S. Howard, F. M. Hewlitt, M. E. Leach (Hon. Secretary) and L. G. Mackean.

Finance Committee: Messrs. C. Hale, T. S. Howard, N. S. Hurford, C. A. Porter, C. H. Porter (Hon. Secretary) and F. G. Rayers.

Recruitment Representatives' Committee: Messrs. C. Hale, R. L. Wilkinson Council representatives), J. C. Adair, B. Ashmore, M. I. Carson, C. Cheek, A. J. Davies, P. H. Dibden, K. Donnelly, D. A. Edney, A. J. Fisher, M. W. Hewitt, R. McCulloch, D. Miles, D. Straton, E. S. Thomson and M. W. Thwaite.

Student & Graduate Section Committee: Messrs. R. V. Atkin, D. A. Edney, C. Hale (Council representatives), G. K. Brown, J. Cope, J. P. Carter, S. J. Hailes, S. E. Murton, (Hon. Secretary), P. Robertshaw and G. F. Wire.

The President was, ex officio, a member of all Committees and attended their meetings as occasion required.

SUMMER CONVENTION

The Summer Convention was held in Austria, based on Vienna from 20th to 23rd May inclusive and was made possible with the generous assistance and support of ITT Austria Gesellschaft mbH and Siemens Atkiengesellschaft Oesterreich. The generous support of Integra (Zurich) Ltd., Clough Smith Ltd., G.E.C.-General Signal Ltd., M.L. Engineering (Plymouth) Ltd. and Westinghouse Signals Ltd. is also acknowledged.

131 members, 57 of whom were from overseas, and 86 ladies representing 13 nations participated in the Convention. A full and interesting technical programme, including visits to U-Bahn and S-Bahn installations, together with trips to a marshalling yard and research laboratories, were supplemented by a number of enjoyable social events, the highlight of which was a visit by members and ladies to Mariazell.

The Institution is indebted to the Austrian State Railways and the Vienna Arsenal for allowing their operations to be viewed.

MEMBERS DINNER

The Annual Members' Dinner was held in the Refectory at the Institution of Electrical Engineers, London, after the Annual General Meeting on 21st April. The principal guest was Mr. Hans Eisenring, General Manager, SBB Technical Department and other guests included Sir Robert Reid, C.B.E., Chairman British Railways Board; Mr. G. H. Hafter, O.B.E., Chairman, Railway Division, Institution of Mechanical Engineers; Mr. E. J. Harris, Managing Director, Westinghouse Signals Ltd.; Mr. M. L. Boden, Managing Director, G.E.C.-General Signal Ltd.; Mr. F. G. Rayers, Director, M. L. Engineering (Plymouth) Ltd. and Mr. W. H. Whitehouse, Director of S & T Engineering, British Railways Board.

DINNER & DANCE

One hundred and twenty-nine members and guests attended the Annual Dinner and Dance which was held on 24th October at the Metropole Hotel, London. The principal guest was Mr. F. C. Pictet, Swiss Ambassador to the United Kingdom, who was accompanied by Mrs. Pictet, and a successful evening was enjoyed by those present.

CONCLUSIONS

During my year of office I was pleased to have the opportunity to visit all the Provincial Sections in the United Kingdom and was impressed with both the level of attendances at the meetings and the lively discussions which followed the reading of the technical papers. It was a matter of considerable regret to me that I was unable to visit the Sections overseas, but it is increasingly apparent that the commitment and interest of members in these areas continues to strengthen, and the involvement of so many members both at home and overseas can only enhance the status of the Institution and the signalling and telecommunications profession.

Despite the encouraging attendances elsewhere, it is disappointing that the numbers at technical meetings in London continue to decline, and this may be due to the move of regional offices and the domicile of individual members to areas further away from the City. However, it is important that papers of a high standard, covering areas of new technology, continue to be presented at all our meetings and the animated and sometimes controversial discussions which take place will, I am sure, continue to attract worthwhile attendances.

The significance of the Institution on the International scene is growing, as will be seen from the increase in membership overseas. The Council is well aware of the expectations which members overseas have of the Institution and will continue to strive to meet them. Consideration is currently being given to holding a second International Conference in London in the year 1990 following the enormously successful Conference in 1984.

The Institution could not exist without the commitment of the many members who serve on Council and the various Committees both at home and overseas. All of this work is undertaken on a voluntary basis by members who, in many cases, have demanding jobs in the profession and their involvement is therefore limited by the time available to them. In the United Kingdom, the decentralisation of some British Rail offices has certainly not helped in this respect. I would, however, like to acknowledge the strong and valuable support which the Institution receives from British Rail employees. If the high standards to which the members have become accustomed are to be maintained, still further efforts will be required, and it may be necessary to give further consideration to the way in which the Institution's increasing administrative workload is undertaken.

Whilst the Institution can be considered very successful in its activities today, we must, like any other undertaking, recognise that conditions around us and technology are changing rapidly, and awareness and flexibility are essential if we want to ensure success tomorrow.

Finally, I must record how much I have enjoyed my year of office and I would like to express my thanks to the Officers, Members of Council and the members of all the various Committees for their help and support. My experience during the year leaves me in no doubt that the Institution will continue to fulfil the expectations of its members in the future. For me it was a great and memorable year, and so, to all of you, my sincerest thanks.

J. G. OEHLER (President)

21 Avalon Road,
Earley, Reading,
Berks RG6 2NS.

January 1987

Seventy-Fourth Annual General Meeting

Minutes of Seventy-Fourth Annual General Meeting held at The Institution of Electrical Engineers, London on Wednesday, 15th April, 1987

The President (Mr. J. G. Oehler) in the Chair

At the request of the President, the Hon. General Secretary read the notice convening the meeting. It was then proposed by Mr. R. Pope, seconded by Mr. D. C. Webb and carried that the Minutes of the Seventy Third Annual General Meeting held on 21st April, 1986 be taken as read and they were signed by the President as a correct record. The Hon. General Secretary then read the Auditor's Report.

The President commented upon the main features of the Annual Report for the year 1986 and, at the request of the President, Mr. C. H. Porter, the Treasurer, reviewed the Balance Sheet and Statement of Accounts. The President then asked whether anyone wished to discuss any point arising from the Annual Report and Accounts. There being no response it was proposed by the President, seconded by Mr. F. P. Wiltshire and carried that the Annual Report and Statement of Accounts for 1986 be adopted.

The President announced that no nominations additional to the Council's recommended list were received from the members and no ballot was, therefore, necessary. The Council for 1987-88 would be:-

President: Mr. C. Hale

Vice-Presidents: Mr. T. S. Howard
Mr. F. G. Rayers

Members of Council from Class of Fellow:
W. G. Boddy, J. Catrain, E. O. Goddard, B. D. Heard, M. W. Heaton, A. C. Howker, F. Kerr, R. C. Nelson, C. A. Porter, J. Waller.

Members of Council from Class of Member:
R. V. Atkin, R. E. B. Barnard, D. A. Edney, A. P. Harvey, R. L. Wilkinson, D. J. Wittamore.

The President announced that the Institution's present Auditor was Mr. W. V. Townsend, ACA, of 29 Muncaster Gate, York, and that Mr. Townsend had indicated his willingness to continue in this capacity for a further year. It was proposed by Mr. P. Barker, seconded by Mr. W. S. Morton and carried that Mr. W. V. Townsend, ACA, be appointed Auditor to the Institution for the year 1987.

The President announced that the winner of the Institution's Thorrowgood Scholarship for 1987 was Mr. M. J. Spencer of BR Western Region and he invited Mr. Spencer to come forward to receive his scholarship medallion, which he did amidst applause.

The President then asked whether anyone present wished to discuss any other business. There was no response.

The retiring President then invited the new President, Mr. C. Hale, to take the chair, which he did amidst applause, and Mr. Oehler invested him with the Chain of Office.

The President invested Mr. Oehler with his Past President's medallion and called upon Mr. F. G. Rayers to move a vote of thanks to Mr. Oehler for the very able way he had conducted the Intitution's business during the year. Mr. Rayers' proposal was carried with applause.

The President then delivered his Inaugural Address. Mr. M. E. Leach proposed a vote of thanks to the President for his address and this was carried with applause.

The President announced that the next Technical Meeting in London would be held on Friday, 9th October and that full details would be announced in due course.

The meeting then terminated.

Australian Section

The officers for the 1986 session were:-

Chairman: Mr. J. Rees (New South Wales)

Vice-Chairman: Mr. I. F. Ritchie (Victoria)

Members of the Committee were: Messrs. N. F. Reed, F. J. Londregan, B. A. Morris, R. J. Logan (New South Wales); F. C. Baker, C. J. McNamara, R. H. Detering, R. L. Legg, R. G. Cumming, R. W. Greene (Victoria); W. B. Johnston (South Australia); A. L. Neal, D. E. McCauley (Western Australia); B. P. Tumalty, W. H. Johnson, L. F. Brearley, F. J. Darch (Queensland).

Sec./Treasurer: Mr. A. R. McKenna (Victoria)

Hon. Auditor: Mr. N. C. Cousins (Victoria)

Messrs. B. A. Morris, R. J. Logan, R. G. Cumming, R. L. Legg, R. W. Greene, L. F. Brearley & D. E. McCauley will remain in Office for 1987.

During the year three meetings of the Australian Section were held as follows:-

March 21/23, 1986 — Annual General Meeting, Wollongong, New South Wales.

Members and visitors numbering 133, met at Sydney Station on Friday, 21st March, for morning tea courtesy of SRA NSW, then proceeded by double deck interurban Electric Train to Thirroul (courtesy of SRA) for inspection of the new signalling and Communications works, including the first SRA Fibre Optic Link.

The Ladies proceeded directly to Wollongong.

On completion of the inspections, Members were conveyed by road coach to the North Beach International Hotel, Wollongong, where they were joined by the Ladies for lunch.

The Annual Meeting and Dinner was held in the North Beach International Hotel, afternoon of Friday 21st and morning of 22nd March.

Messrs. J. Rees and I. F. Ritchie were re-elected as Chairman and Vice-Chairman respectively, along with the new committee.

Technical Papers were presented by:-

Mr. F. J. Londregan, Project Engineer, SRA NSW. "The Electrification of the Illawarra Railway", with video film showing relaying of Trackwork, Overhead Construction and Coal Cliff Yard redevelopment.

Mr. R. G. Myers, MIRSE, Communications Engineer SRA NSW. "Communications in the Illawarra Electrified Areas".

Mr. A. J. Brock, GEC NSW. "Illawarra resignalling for Electrification Construction".

Mr. M. Wheals, GEC Digital. "Illawarra Train Describer and Telemetry System"

On Saturday 22nd, members made an inspection of the new Wollongong Control Centre, while the Ladies had a scenic tour of the area.

Saturday evening, all attended the Macarthur Estate Winerey for Dinner and Bush Dance.

A tour of Wollongong and Port Kembla was made by bus before departure for Sydney Robertson and Moss Vale (buses by courtesy of GEC).

August 1/2, 1986 — Technical Meeting, Brisbane, Queensland.

Members and visitors met at Roma Street Station on arrival of the Brisbane Limited from Sydney, when following morning tea provided by the Q.R. the Dual Guage facilities at Roma Street were inspected.

The Technical Meeting was held during the afternoon of Friday 1st and the morning of Saturday 2nd in the Railway Centre, Edward Street, Brisbane when Technical Papers were presented on developments in Intermittent Automatic Train Control as follows:-

Mr. A. C. Howker, FIRSE, WB&S. "Trivial pursuit and Brief History of ATC".

Mr. B. A. Nobbs, Plessey. "Intermittent ATC and Associated Identification Systems".

Mr. H. B. Luber, MIRSE, Siemens Industries Limited. "ZUB 100 ATC System".

Mr. T. Perry, WB&S. "WABCO ATC Systems.

Mr. R. T. Black, Ericsson Signal Systems. "The ERICAB 700 ATC System".

The papers were well received and were followed by a lively discussion period.

A Dinner was held on Friday 1st at the Capital Hotel.

November 21/22, 1986 — Technical Meeting, Melbourne, Victoria.

Members and visitors met at Spencer Street Station on Friday 21st then proceeded by Metrail services to Museum Station for an inspection of the Station facilities.

Lunch for Interstate members was provided at Spencer Street, courtesy of M.T.A.

The Technical Meeting was held in Metrail offices, 50 Market Street, Melbourne, on Friday afternoon and was opened by an Address by Mr. K. Shea, Managing Director, Metropolitan Transit Authority.

Technical Papers were presented by:-

Mr. A. A. Carey, FIRSE, MTA. "Melbourne Metropolitan Signal Systems review".

Mr. P. Cartner, MIRSE, MTA. "Melbourne Metropolitan Train Control Centre (Stage 1 completed)".

Mr. P. de Visser, MTA. "Metrail Integrated Services Digital Network (ISDN).

Following the Technical Meeting, Members travelled by bus to Dorset gardens Motel, Croydon for a Dinner and overnight accomodation.

On Sturday 22nd the party went by bus to Belgrave for inspection of Narrow Gauge (Puffing Billy) Mechanical Signalling facilities, then onward to Menzies Creek aboard Puffing Billy for an inspection of the Narrow Gauge Museum.

An inspection was then made of the Flashing Light level crossing protection at Main Road, Clematis, using Harmon PMD2 Motion Detection system, which was hosted by Mr. M. D. Thomson, FIRSE and Mr. C. Rutledge, Signal Supervisor, Emerald Tourist Railway Board.

Papers detailing the Motion Detection System were presented, following lunch at Yarra glen.

The Committee extended their thanks to the authors and presenters of the various Technical Papers read throughout the year.

Membership

Proposers and seconders should ensure that the candidates meet the criteria set out for the class of membership sought, the form is correctly set out and copies of supporting documents are included where necessary.

This practice will avoid delays in the processing of applications.

Membership of the Australian Section at 31st December, 1986 was 280.

Honorary Fellow Australian Section

The Committee elected Mr. F. Stewart (F), Victoria, an Honourary Fellow of the Australian Section and also in appreciation of his services to the Section. That is in assisting to inaugurate the Section, then supporting it for what will be 40 years, on 14th November, 1987.

Finance

The Audited Balance Sheet for the year ended 31st December, 1986, showed that the financial position of the Section had been satisfactorily maintained.

South African Section

At the end of the 1987 Session the membership of the local section stood at 103. This was made up as follows:-

Fellows	20
Members	25
Associates	19
Technician Engineers	8
Technicians	28
Students	3
Total	**103**

This number is down on our peak of 125 due to a number of members leaving the industry due to the downturn in railway expenditure.

The officers for the section were:

Chairman: H. Z. Ostrofsky

Vice-Chairman: S. A. P. Folgoza

Hon. Secretary: B. J. van der Merwe

Treasurer: J. C. van de Pol

Members of General Committee: G. le Grange, R. B. Woodhead, H. van der Venter, K. S. Connolly.

Four Technical Meetings were held during the 1987 Session together with the Annual Dinner and the Annual Technical Visit.

The session opened in March with a discussion paper on ATCS. The initial presentation and the subsequent discussions were conducted by Das Coetzer and Peter Gibbons. The suitability of the philosophy and concepts of ATCS were discussed at length and various opinions given as to its applicability to the South African scene.

Our second Technical Meeting, held in May addressed the subject of WAN's, MAN's and LAN's, being an overview of the various types available and the various uses to which area networks may be put. The paper was presented by Peter Davies of Bankorp whose delivery was lively and interesting. The speaker certainly knew his subject.

The Annual Dinner took place on Friday, 26th June, 1987 and again it was held at Sturrock park, the venue for our previous dinners. The guest speaker was Mr. Claude Slogrove, former Assistant Chief Signal Engineer of South African Railways, who has been in retirement for some years.

The third Technical Meeting held in August introduced us to Management Information Systems as required by the railways to monitor the running of suburban traffic. Mark Doornekamp of Siemens presented the paper and showed us the functions and operation of the system recently installed at the New Durban Control Centre.

The Annual Technical Visit took place on Saturday, 5th September, 1987. The tour took us firstly to the recently commissioned SSI installations at Midway and Lenz, where we were able to witness the adaptation of the British Railways concept to South African signalling principles. The next stage of the tour was to the Control Centre at Randfontein Estates Gold Mine where the benefits of CTC on a private railway were amply demonstrated. The visit culminated with a visit to the Millsite Locomotive Depot where some of the remaining steam locomotives were on show. One loco was in steam and took participants on short trips on the footplate.

The fourth Technical Meeting was held in October and was combined with the Annual General Meeting. The technical contact consisted of a presentation by Mannie Bernard of Grinel Electronics on the monitoring of brake pipe pressure at the rear of the train. The design and development traumas that he went through to end up with a successful product were vividly portrayed in his excellent delivery.

Zimbabwe Section

The membership of the Zimbabwe Section has remained static in the year under review but it is pleasing to note a tendency to obtain a higher grade of membership. In this connection congratulations are extended to Mr. L. Magombo who passed the 1987 Signalling Examination.

At the A.G.M. held on 19th March at the Lions Den, Grey Street, Bulawayo, a presentation was made to Mr. A. R. Brown of a miniature wooden staff produced by the Signal Workshops.

Meetings:

19th March
28th Annual General Meeting
(Attendance - 12 members, 9 visitors)

30th April
"The Watt Watchers" paper presented by A. J. C. Thompson
(Attendance - 11 members, 7 visitors)

28th May
"German High Speed Line Hanover-Wurzburg", presented by guest speaker H. Huesmann
(Attendance - 11 members, 5 visitors)

30th July
"Computers and Railway Signalling" presented by guest speaker P. Whitehead
(Attendance - 8 members, 1 visitor)

5th September
"Financing of Projects in Zimbabwe" presented by guest speaker G. Bethke

26th November
"Load Control at Dabuka" paper presented by S. Silcox
(Attendance - 14 members, 7 visitors)

All the meetings were held at the Lions Den, Grey Street. The committee extended a vote of thanks to Lions for the use of their premises.

On 3rd December a cocktail party was held at the BAC bowling club for members and wives together with guests from S.O.R.E.

The committee extended their thanks to those who presented papers, it was much appreciated.

Midland and North Western Section

Following a major reorganisation of the London Midland Region, the 1985/86 Committee of the North West Section found it necessary to alter its Constitution.

The Section will now be known as the Midland and North Western Section.

The geographical area covered by the section is now extended to take in Nottingham, in addition to Birmingham, Crewe, Manchester, Preston and Carlisle.

Lectures for this session will continue to be held at Birmingham, Crewe, Preston, Manchester and Carlisle, and the committee hope that the enlarged Section will better serve the needs of the membership.

The Committee for the 1986/87 session consisted of the following members:-

Chairman: Mr. P. Trickett

Vice-Chairman: Mr. R. Ashmore

Secretary: Mr. I. R. Bridges

Treasurer: Mr. B. J. Arthurs

Visits Secretary: Mr. J. Stowell

Others: Messrs. D. Bickell, R. Buckley, P. Dibden, E. C. Hawes, D. Parkman and G. Walden.

The 1986/87 Session was the first year since the implementation of the revised constitution. The Section now encompasses many more large centres of population. This hopefully now represents an improvement in the lecture locations for the membership.

Despite these efforts, however, attendance at meetings has not been as high as in previous years, with an average attendance of 20. The Section now consists of around 294 members.

The Committee has been busy during the past 12 months updating membership lists and entering details onto a newly created computer data base. This will hopefully enable contacting members to become much more efficient in the future.

The Section Bulletin was revived during the past year with the issuing of an Autumn '86 Bulletin and a Spring '87 Bulletin. A Summer '87 Bulletin will be produced shortly.

During the past Session a very interesting visit was made by members, families and guests to the Festiniog Railway, who very kindly provided a special train for our use. The train ran from Blaneau Ffestiniog to Boston Lodge and back, stopping at various points of interest en route. These included Dduallt signal box, Tan-y-Bwlch automatic route setting interlocking and Boston Lodge works.

Another visit later in the year took a party to view the Post Office Railway, deep under London's streets. This was an excellent visit with a chance to see some interesting signalling ideas.

Scottish Section

The Scottish Section's programme for the 1986/87 session covered six meetings and the AGM. On the whole, they were well attended, with an average of 31 people at the meetings.

Unfortunately the session got off to a bad start when an Inter-Area competition failed to produce the promised teams. Even on the day of the event the Committee expected six teams to turn up; however, only one full team actually appeared at the venue, much to the disappointment of the Committee. Another disappointment was the cancellation of our meeting on "Policing the Modern Railway", with its associated visit to the new British Transport Police HQ in Glasgow; this was caused by one of the heaviest snow-falls for some time, which led to the early closure of our offices.

There was good attendance at the Sections two telecoms orientated lectures, on 'Modernising British Telecom' and 'Telecommunications on an Electrified Railway'; it is good to be able to report interest from both Telecoms and Signalling Departments at these lectures.

The most interesting lectures, however, were those on "RETB Inverness - One Year On", in which Ian Buchanan, the Signal Engineer (General) in ScotRail, looked at the problems and experiences associated with the extension of the Dingwall - Kyle RETB pilot scheme to cover the line from Dingwall to Wick; and Peter Rayner's paper on "Get it Right and Keep it Running", first given to the IRSE's International Conference in 1984, but still relevant and very thought provoking, particularly as he was able to update the paper with new thoughts on recent problems.

Several members of the Section were involved in preparations for the Institution's 1987 Convention in Scotland. A sub-committee was formed to help with the local arrangements, and others were called in to help with displays, guiding, etc.

At the AGM, a presentation was made to the Section's out-going Chairman, John Clayton, who had served on the Committee for all of its life as a Section of the IRSE, and previous to that as Secretary of the S & T Technical Society for "longer than anyone cares to remember".

Western Section

The first event of the session followed the close of the AGM at Bristol, with a post meeting visit to the Wessex Water Authority Regional Operators Centre in Bristol. Members who attended were able to inspect the control panel and have an explanation of how the Remote Control/Telemetry system controlled the water supplies in the region.

In September a Section party of 20 enjoyed a visit to the Big Pit Mining Museum in Blaenafon, South Wales. Here they were able to descend 300 ft. underground and inspect Underground Railways of a different kind as well as seeing how coal was extracted from the pit.

The 1986/87 session of Technical Meetings began in October in Bristol with a talk by Mr. L. Crosier of British Rail (WR) entitled "Signalling Operations of Yesteryear". Mr. Crosier gave a very interesting talk, well illustrated with slides and reminiscences of his days as a signalman. (Meeting attendance 23).

The second Technical Meeting was held in November in Chippenham. Mr. B. Hesketh of British Rail (LMR) presented his paper "All change at Crewe". Mr. Hesketh's presentation started with a brief history of Crewe prior to the re-signalling. He then went on to describe how Crewe Station was shut to traffic for seven weeks whilst the resignalling was carried out, explaining the logistic problems and the equipment used. He then showed slides of Crewe during and after the re-signalling, explaining the complexity of some of the routes signalled. He summed up his talk by complimenting the staff and contractors who had achieved such a large task within the time schedules. (Meeting attendance 37).

The final Technical Meeting of 1986 was held in Bristol on 14th December. Mr. M. Hanscomb of British Rail (WR) presented a Film Evening on Railway Signalling History. Mr. Hanscomb showed a program of films which included many interesting historical items including one on how the modern freight network evolved from the earliest slate/quarry railways. He also included some light hearted railway footage from popular comedy films. (Meeting attendance 37).

The first Technical Meeting of 1987 was in January at Bristol and was the Presidential Visit to the section by Mr. J. Oehler. The subject of this talk was "SSI: Scheme Design and Site Testing" by Mr. R. Fenton (BR HQ) and Mr. C. Latarche (BR HQ). Unfortunately this meeting coincided with the worst weather of the winter and Mr. Latarche was unable to attend because of heavy snow. Mr. R. Fenton, at short notice gave the talk solo and began by giving a description of how the data was structured and prepared. He gave details of how the work stations are configured and how they can be used for data preparation and testing that data thoroughly. (Meeting attendance 71).

The next Technical Meeting was in February in Chippenham with the IEE Bath and Chippenham Area. Mr. C. White of London Underground Ltd. and Mr. J. D. Corrie of Westinghouse Signals Ltd. presented a talk based on their paper "Neasden Depot An Application of Computers to Interlocking". Mr. White began the talk with an introduction to interlocking and how they worked. He then applied this philosophy to the interlockings used on LUL. He then explained the specification requirements for the Neasden Interlocking (CBI) illustrating the layout at Neasden Depot with colour slides.

Mr. Corrie then continued to talk explaining how the contractor had approached the task of producing a Computer Based Interlocking to the high standards required for a safety system. He explained some of the hardware and software techniques adopted and showed how strong management of the project was required to ensure these standards were met.

Following these meetings a tour of the Neasden Interlocking, undergoing system test in the WSL test area was conducted. There was also an opportunity to view the "Model Railway" training facility, which included control desks, interlockings and automatic train operation, that WSL had produced for Singapore MTRC. (Meeting attendance 54).

At the end of February a Section party of 22 attended a Technical visit to the Post Office Railway in London. Following a briefing on the history of the Railway a most interesting tour of the railway, including the depot, maintenance facilities, signal cabins and interlocking, was conducted.

The final Technical Meeting of the session was held in March in Newport, Gwent, with the PWI South Wales Section. The subject of this meeting was "The Severn Tunnel and Sudbrook Pumping Station" and was presented by Mr. B. Pearce of British Rail (WR). Mr. Pearce gave a very interesting account of the Severn tunnel which was 100 years old last year and the Sudbrook Pumping Station. (Meeting attendance 41).

The committee wishes to thank British Rail (WR) for the use of their premises for the Bristol meetings and Westinghouse Signals Limited for the many facilities provided in the support of the section.

The Committee for the 1986/87 session comprised the following:-

Chairman: Mr. G. J. W. Meecham

Vice-Chairman: Mr. S. J. Tomlinson

Hon. Sec./Treasurer: Mr. D. M. Sausins

Others: Messrs. A. P. Harvey, B. C. R. Brinkler, M. F. Wilkins and P. A. Wride.

York Section

The following statement shows the membership position at the end of the year with the comparable figures for the previous year:-

	1986	1987
Corporate Honorary Fellows	1	1
Fellows	12	12
Members	45	48
Non-corporate Graduates	16	14
Technician Engineers	26	26
Associates	14	14
Technicians	57	52
Students	39	36
Total	210	203

The composition of the Committee for the 1986/87 session was as follows:-

Chairman: S. R. Batty (Technician)

Vice-Chairman: E. M. H. Galloway (Fellow)

Committee Members: W. G. Boddy, R. Pope (Fellows); D. Dyson (Member); S. D. Muirhead, B. W. Mulvana (Graduates); A. K. Kelly (Technician).

The 33rd Annual General Meeting took place on 8th April, 1986 (Attendance 14) and six technical meetings were held during the year, as follows:

October 2nd, 1986 — "Signalling Practices and Costs Appropriate to the Railway Business", by K. E. Hodgson (Attendance 45).

November 11th, 1986 — "Application of Radio Electronic Token Block to the East Suffolk Line", by J. K. Tomlinson and R. Wade (Attendance 61).

December 11th, 1986 — "M & E E Fixed Equipment for the ECML Electrification", by M. Stuart (Attendance 38).

January 14th, 1987 — Meeting cancelled due to bad weather.

February 11th, 1987 — "Data Systems" by R. Jones (Attendance 34).

March 3rd, 1987 — "Recent S & T Development on the Southern Region", by C. Hale (Attendance 38).

April 8th, 1987 — "Yoker Integrated Electronic Control Centre", by R. C. Nelson presented by D. Dickens (Attendance 43).

Mr. Hale's paper was originally planned to be given on the 14th January and then to avoid its presentation in the authors IRSE Presidential Year (1987/88) was given on 3rd March instead of the planned one on "Electrification Interference Testing" by Messrs. E. S. Thomson and N. Davis. We look forward to the latter paper in our 1987/88 programme.

The York Section were pleased to welcome the President of the Institution, Mr. J. G. Oehler, who came over from Switzerland to attend our November meeting.

Once again, in October, arrangements were made for candidates to sit the Institution Examination in York. Congratulations to Messrs. A. L. Coombes and P. M. J. Ellingworth on their success in the signalling paper.

The visits programme for 1986 got underway with a visit to GEC-General Signal at Trafford Park. In addition to the signalling activities a brief look at the generator manufacturing facility on the same site was included. A buffet lunch was provided and this was much appreciated.

Visits to Glasgow Underground and Tyne and Wear Metro took place in June. In both cases we were given a comprehensive tour of the Control Centres and Train Depots.

A visit to H.M.S. York in Rosyth Dockyard gave members a chance to see one of the Royal Navy's most recent warships. A most enjoyable day out for all concerned.

The final visit of the season was to the new Baker Street Control Centre on the London Underground. The visit also included a look at some older traditional signalling equipment at King's Cross on the Victoria Line.

The Annual Dinner and Dance was once again held in the Henley Suite at the Viking Hotel. Guests of honour were Mr. C. Hale and his wife. This was Mr. Hale's first official function following his recent election as IRSE President for the year 1987/88.

Whilst a reduced number of 62 guests attended, those present seemed to enjoy the opportunity of meeting old friends and taking part in the dancing.

CHAIRMAN'S CONCLUSIONS

It has been a privilege to be your Chairman once again and to be able to report another successful year with good attendances at our technical meetings. Being Chairman of a provincial section means that you are invited to attend meetings of the Council, held in London, and to take an active part in the discussions of the Council, an experience I have enjoyed.

On behalf of the Committee I want to thank Messrs. Thomson and Davis for agreeing to postpone their paper to another occasion to enable Mr. Hale to visit us in March. One disappointment was that Robin Nelson, due to illness, was unable to present his paper to us, but Dennis Dickens (who started his railway career with the S & T Department in York) ably presented the paper for him.

We are indebted to Stephen Muirhead for his work in organising visits for us, his task is not easy these days due to continuing job losses and closure of works and he is always open for any suggestions members may have of places we could visit.

Members of the York Section acted as demonstrators and party guides when the Institution visited East Suffolk to see the Radio Electronic Block System.

Finally my thanks to all the Committee for their support during the year, especially to Derek Plummer our Hon. Secretary/Treasurer for his hard work in running the Section. I hope that my successor, Eddy Galloway, enjoys his first term as Chairman and that you will give him the support that past Chairmen of the Section have received.

S. R. BATTY
Chairman April 1987

1986 Examination

Application Paper Question 7 — Typical Answer

The answer below was offered by a candidate in the 1986 Examination. This answer was awarded good marks, although it fell short of full marks in several respects.

Question

State the principal function of a train describer and list some other uses which are now made of the information it contains. State three methods by which a train's description may be entered into a train describer system and explain the operation and data transmission sequence used between a fringe box and a train describer to ensure that descriptions are properly registered in the memory of the train describer storage medium.

Answer

The principal function of a train describer is to give the signalman the positive identity of every train under his control. This means that, at large power boxes, he does not become confused as to which is which and make mistakes routing trains.

In addition, the train describer "databank" may also be used for:

i) Working platform indicators/tape recorded public address announcements automatically.

ii) Reporting the passing times of all trains at various key locations to regional control offices. Some systems can identify late running trains by comparison with a master timetable system, and report trains "by exception" - i.e. only those which are late!

iii) Automatic route setting equipment also makes use of the train describer, to identify which train requires which route.

iv) Special alarms - such as the class 9 alarm for unfitted freights ascending a 1 in 100 gradient.

Descriptions may be entered into the train describer in several ways:

1. Between panel boxes, a train will cause its own description to arrive with it, by means of a transmission system between the two boxes that takes as its inputs various indications received back at the panel as the train progresses. As it reaches some predetermined point, its description is automatically transmitted to the adjacent box, where it is displayed in a "train approaching" berth on the panel until the train actually arrives.

For a train that originates within the signalman's boundary, he must put the description into the relevant train describer berth himself. He is able to do this by means of a "set-up" keyboard and interpose buttons adjacent to all berths. For a train which arrives not from another panelbox, but from an adjacent mechanical signalbox, the signalman at the mechanical box will set up the train description in a special "fringe box unit" at the mechanical box, and will transmit the description forward when the train leaves.

The fringe box unit must therefore contain a keyboard on which the signalman sets up the description. As the description is entered, it is displayed in a "set-up" berth. If a mistake is made, a cancel button clears the set-up berth. When the signalman is content that he has entered the correct description, he can select a transmit button. Once pressed, this button causes the description to be sent to the panel where it is displayed in the "train approaching" berth. It is also displayed in a "last sent" berth on the fringe unit, as a reminder to the signalman at the mechanical box. The signalman at the panel must acknowledge the arrival of this description.

Coming from the panel, the fringe box unit displays 1st train approaching, 2nd train approaching, and train at signal. These are also acknowledged as they arrive in the train approaching berth. Facilities are provided to cancel descriptions that have been sent in error these cancellations must also be acknowledged in similar "handshaking" procedures to "train approach" procedures already described.

Commentary

Paragraph 1 "Databank" use ii)

Reports to other places than only the regional control offices, particularly to adjacent panel boxes as the candidate mentions later with respect to description entry.

Paragraph 2

When a question asks for three methods, marks are awarded for each so it is worthwhile structuring the answer so that it is obvious where marks can be awarded. In this case the candidate has given three clear paragraphs. The answer to the next part of the question on transmission sequence, follows on without reference to the structure. In this case this is a good answer and the responses to each part of the question are discernable. Many candidates who fail do so because their answers do not cover the whole question. Structuring the answer to the question therefore helps the candidate to avoid ignoring part of a question as well as assisting the examiners not to overlook marks.

Penultimate Paragraph

Although the signalman at the fringe box enters a description by pressing keys and checking a display on the fringe box equipment, what happens to achieve this is that the code for each key pressed is sent to the panel box train describer which sends back the display to the panel box train describer which sends back the display to the fringe box "set-up" display. In this way the signalman is, in practice, checking the description as already registered in the train describer storage medium unless this has been corrupted in transmission from the main box. The chances of identical corruption to key codes sent to the fringe box is very low, so, when a signalman then presses the "transmit" key to show that he is satisfied with the description in his "set-up" display, he is, by implication, accepting the description registered in the train describer. Use of the fringe box "transmit" button does not cause transmission of the description but instead causes a code to be sent to the main box which permits the train describer to use the description which has just been entered. Therefore, it is the signalman's acceptance of the description as sent to him from the train describer which ensures that the description is properly registered in the memory of the train describer storage medium.

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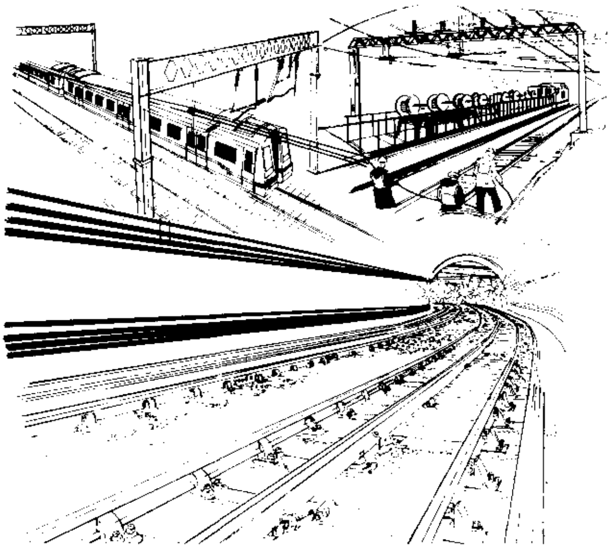

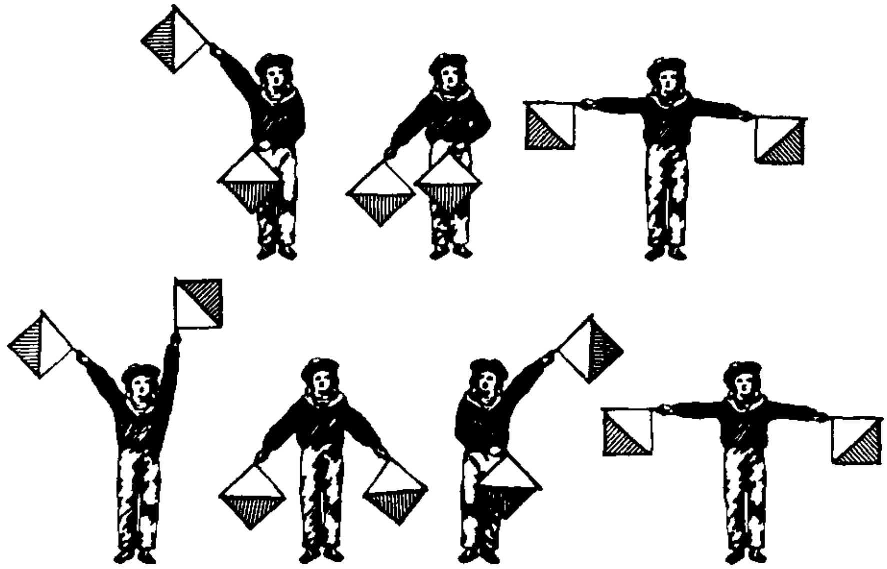

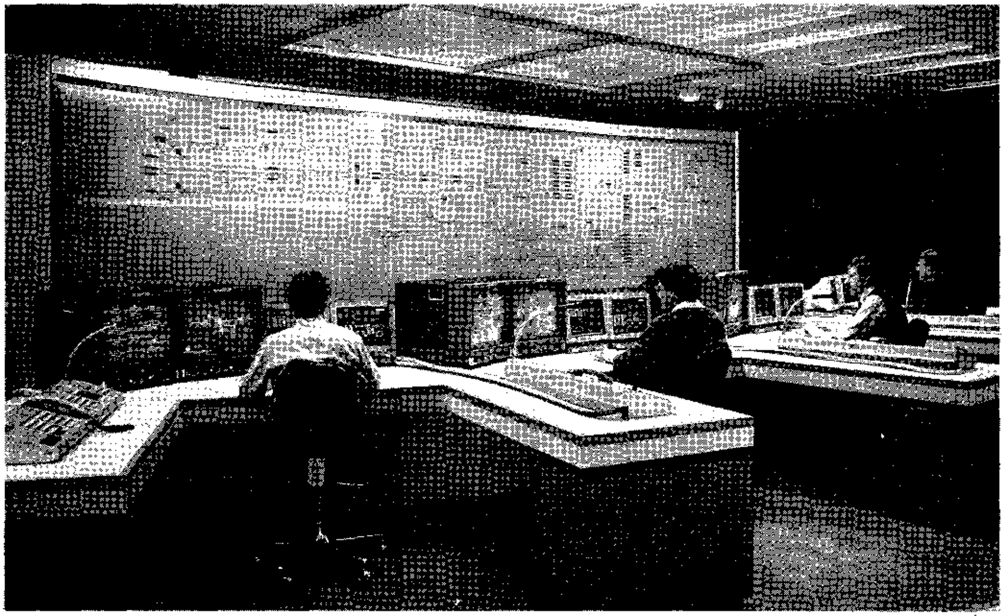

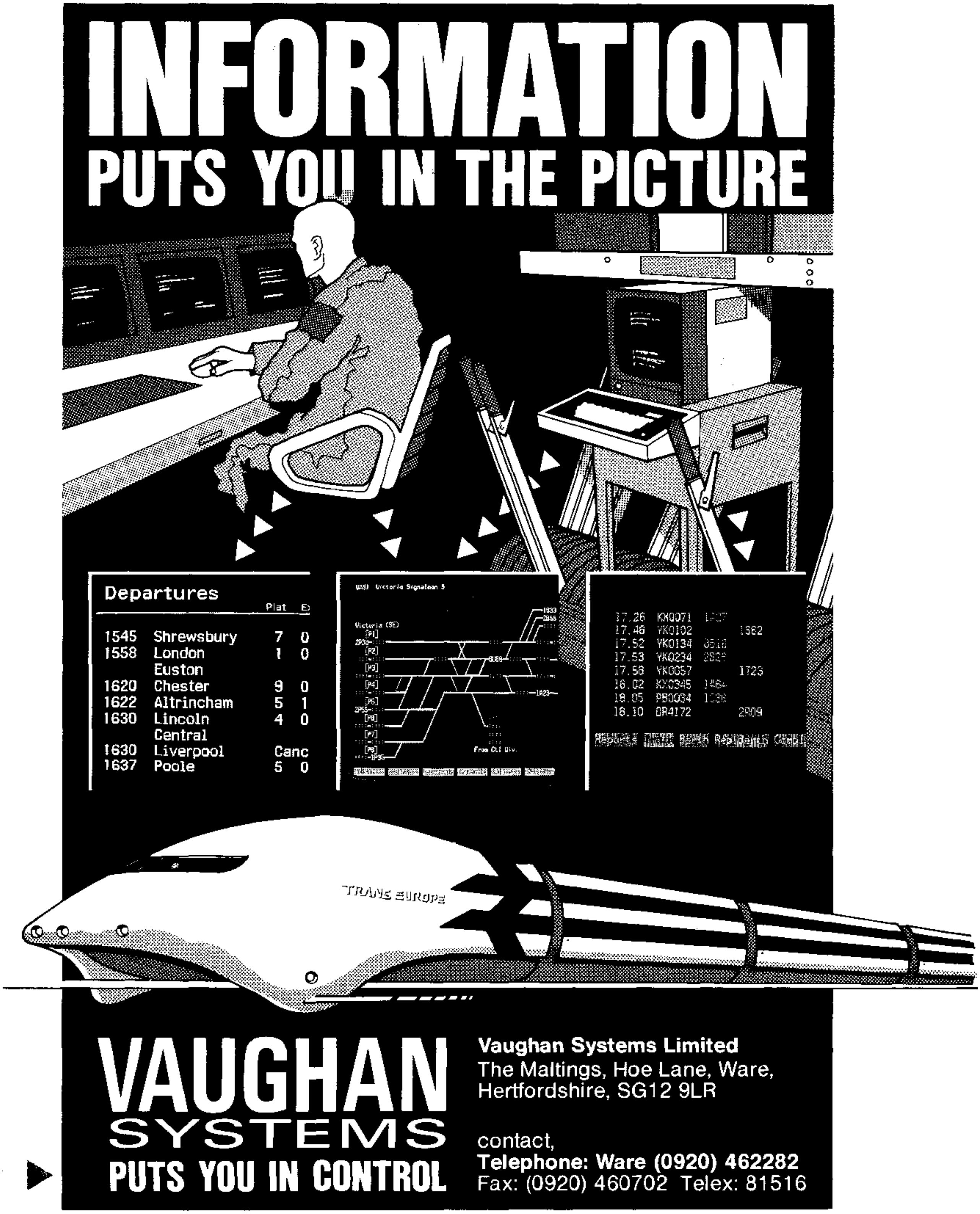
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1620 Chester 9 0
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