punch" system. We can, therefore, deduce that the teleprinter equipment, isolated from the Electronic Remote Enquiry System, is responsible for introducing the additional errors.

At a later stage the electronic system will be further developed to provide our sales offices with the facility of booking seats through the interrogator key-sets to the computer, which will then store the complete seat inventory in its memory—adding and subtracting from the current seat count for each flight as applicable.

To sum up the various aspects discussed into an overall picture, it is apparent that the seat inventory system will eventually be merged with the seat availability system, with one computer processing both types of "message" formats which, at present, are handled by two different computers.

Looking to the future we are confident that with the advent of the supersonic era our organizational capacity to meet the demands of these new air transports will be geared to an even greater "Mach" on the ground.

Experience in the practical use of data transmission

By D. J. Dace

This paper is concerned with the Commercial Union Group's experience with, and the results obtained by, high speed data links between its branches and the computer centre in Exeter.

History

Before 1953 the preparation of renewal notices and accounts had been largely a manual process at the branches. During 1953 a completely integrated punched-card system was introduced to handle all our insurance work. The preparation of punched cards for an organization comprising many branch offices naturally lends itself to the establishment of centralized punching and verification of data, on economic grounds. The source documents were sent to the central units from the branches daily, and the tabulated results of the processing were returned to the branch concerned.

Our first method of data transmission was therefore by post. It was cheap and fairly reliable; the only transmission errors occurred when a branch forgot to reverse the address card in the transparent aperture of the mailing bag and promptly received their mail back again the following morning.

The punched-card system proved very efficient, but with such a system it is inevitable that there is a delay in getting source documents from the branches, punching, verifying, printing and sending the printed documents back to the branch. It was realized the immense speed of a computer would be wasted unless this time was considerably reduced. The only way in which this objective could be achieved was to decentralize data preparation, that is have the data translated at the branch into a medium which could be fed directly into the computer system, and then to ensure that this medium reached the computer in the minimum of time.

Data transmission seemed the answer to the last problem.

Telex

Early in 1959 the G.P.O. were approached on the question of data transmission. At this time telex was the only facility available and so we started thinking how we could best use this to give us practical experience in operation procedures and to discover all we could on the type of errors that this form of data transmission would produce.

The eventual result was to establish a link between our London City Office and our punched-card unit at Croydon. Tape was prepared on the teleprinter keyboard by the branch, verified by a call-over of the hard copy produced against the original source document, and then transmitted to Croydon. At the Unit the tape was fed directly into an I.C.T. 1036 tape-to-card converter, the necessary cards being thus automatically produced.

In this way we took our first step towards achieving our aim of data, decentrally prepared, being transmitted to the machine centre. Results achieved by this experimental link were very encouraging and showed that, over short distances, the use of telex was practical.

High-speed transmission

In 1960 the Company ordered an English Electric K.D.P. 10 computer. This brought to light disadvantages in the use of telex:

(*a*) The Computer was designed to work with seven-channel tape; as telex uses a five-hole code, all paper tape would need conversion, either at input or by program.

(*b*) The low speed of 50 bauds would mean a total theoretical transmission time of some 60 hours per day for our needs.

(*c*) The telex code had no parity bit or other provision for correcting or detecting errors.

By this time several manufacturers were working on high-speed transmission systems, and a survey was taken of all equipments which were available or likely to be available by the time the computer was delivered in January 1962.

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The requirements such a system would have to fulfil were:

(*a*) Be capable of transmitting at a speed greater than 350 bauds.

(*b*) Be capable of handling 1 in. wide, seven channel tape.

(*c*) Have an undetected error rate of, not higher than 1 : 10^6 characters.

Two manufacturers appeared to be capable of meeting our requirements, Automatic Telephone and Electric Co. Ltd., and Ericsson Telephones. Arrangements were subsequently made with both companies for the loan of suitable equipment for field trials in our own premises.

A.T. and E. field trials

In June 1961 we started field trials with equipment supplied by Automatic Telephone and Electric Co. between our Brighton Branch and one of our Mechanization Units at Exeter.

(*a*) *Equipment*

This was the prototype of the A.T. and E *P.T.* 750 series of equipment. Input of data to the transmitter is by means of a Ferranti T.R.5 paper-tape reader, output from the receiver being recorded by a Teletype B.R.P.E. 110 character-per-second punch. The basic transmission speed of this phase-modulated system is 750 bauds but, due to the transmission of extra parity bits for error detection and correction, the net information transfer rate is reduced to 437 bauds, or 62·5 characters (for input to the KDP 10) per second of transmission time.

(*b*) *Operators*

The equipment was operated by our own staff from the typing pool at Brighton and clerical section of the punched-card unit at Exeter. None had had any previous experience of operating paper-tape equipment.

(*c*) *Data transmitted*

The data transmitted was of two sorts:

(i) Actual data relating to new policies and cash payments.

(ii) Test data contained on loops which were used to fill in the time when no actual data was available.

(*d*) *Method of transmission*

Calls were normally established from the receiving end at Exeter using the public telephone network, but on a 'P.U.T.' basis (prolonged-uninterrupted), thus overcoming the problem of the "three-minute" pips. With the adoption of S.T.D. this problem will no longer exist.

(*e*) *Methods of checking tape*

Figures of undetected errors were arrived at by checking every character punched. No reliance was placed on counters to pick up uncorrected errors and in this way we are sure that all errors which occurred throughout the entire system, from branch preparation to computer-centre reception of the data, were discovered. Electronic counters were utilized to record errors automatically corrected by the system.

The checking of received tape took two forms:

(i) Before computer installation: The branch-prepared tape was posted to the Unit, and visually compared with the received tape. The two tapes were of different colours, one yellow and the other red, and so errors were easily detectable.

(ii) After computer installation: The two tapes were computer compared, totals of errors, when they occurred, being printed out on to the monitor printer.

Results

A summary of results is given in Table 1, but they must be qualified by the following facts.

The results shown are for the period 27 July 1961 to 9 March 1962. Some days results have been excluded:

(*a*) The period 1–7 September had some 24 undetected errors in 650,000 characters, but not one detected uncorrected error. These results were due to a transistor failure which effectively did away with the error detection facility. Even so the overall error rate was 3·7 : 10^5.

(*b*) The second period omitted was when the regular operator was sick. The replacement girl tried splicing tapes, with apparently little success, more glue depositing itself on the tape reader than the tape: 78 errors were found in some $1\frac{1}{2}$ million characters. As soon as the regular operator returned the error rate returned to its normal level.

Automatic error detection

In 11·8 million characters we have had 2,845 automatically corrected, 468 detected but uncorrected, and 41 undetected. This shows that:

85% of errors have been automatically corrected;
14% of errors have been detected but not corrected;
 1% of errors have been undetected.

Put a different way it shows that on average undetected errors have occurred every two hours, detected errors every eight minutes, and corrected errors about every minute. It must be stressed that in view of the experimental nature of the exercise many calls were made over extremely bad lines, when in normal operating circumstances the call would have been broken down and set up again. In one such call, 42 errors were detected and 174 automatically corrected, although no errors remained undetected. Error rates are expressed in characters. The corresponding bit error rate is twelve times as good.

Although the transmission error rate is shown as 3·15 : 10^6, the error rate over the whole system is far better than this. Of the 54 errors in transmission, 29 would have failed the parity check on the K.D.P. 10

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computer and would thus have been discovered. This gives an overall error rate to the system of under 1·5 in 10⁶.

Ericsson field trials

An attempt was made to hold another series of tests with Ericsson equipment between Liverpool and Croydon. These were on five hole, international telex coded tape, with equipment designed to operate at 600 bauds on a frequency-modulated system. Errors were automatically corrected, where possible, but no provision was made for the retransmission of characters when the errors were beyond the scope of the automatic-correction system. The redundancy was 58%, giving an effective transmission speed of 50 characters per second.

Many of the trunk circuits between Liverpool and London are fitted with echo suppressors. One direction of transmission is therefore blocked whilst the other direction is in use. It follows that any data-transmission system which uses both directions of transmission simultaneously cannot be used successfully on echo-suppressed circuits.

The Ericsson system is of this type and hence the trial was not successful. It is almost certain that echo-suppressed circuits will become obsolete, so that the difficulties experienced in our trial will no longer arise. It must be stressed that successful trials have been carried out with Ericsson systems by the Bank of Scotland and others, and that there is not any reason to believe that our trials with them would have been anything but successful between any other two locations.

Experiences gained during trials

Error detection and correction

Errors which occur during transmission can be divided into three divisions:

(*a*) Simple errors, usually only affecting one bit per character. These are automatically corrected by the transmission equipment, before being punched into the tape.

(*b*) More complex errors, affecting more than one bit per character, usually caused by line interference or interruption. The receiving terminal senses that the error is beyond the scope of the automatic correction system and cuts off the ARQ continuous-tone signal, which, during normal transmission, is sent back down the line from receiver to transmitter using the lower part of the frequency band. This causes the stopping of both receiver and transmitter.

The transmitter operator then retransmits the message in which the break occurred. The computer program detects the partial message, due to the absence of an end of message symbol. An example is given in Fig. 1.

(*c*) The fortunately rare errors that go undetected.

Operator intervention

Very little difficulty has been experienced with G.P.O. operators coming on to the line. As mentioned earlier calls have always been set up on a P.U.T. basis, the exchange supervisor being informed when the call has been closed. No doubt, we have been helped by the fact that all calls are set up by the receiving centre at Exeter so that by now a P.U.T. call is no novelty to that Exchange.

Paper tape

Care must be taken in the choice of paper tape, particularly when the received tape is to be read into a computer by a very high speed photo-electric reader. Most high-speed punches need an oiled tape, but these are more prone to translucency, which will affect the high-speed reader, than unoiled tapes.

Tape dispensing

It is perhaps worthy of comment that the results in Table 1 show that actual data has contained five times as many errors as test loops. This can be explained by the rather crude methods of feeding large reels of data tape into the Ferranti reader, during the early days of the trials. A.T. & E. have given much thought to this problem and the tape is now fed through a spring device which maintains a constant tension on the tape.
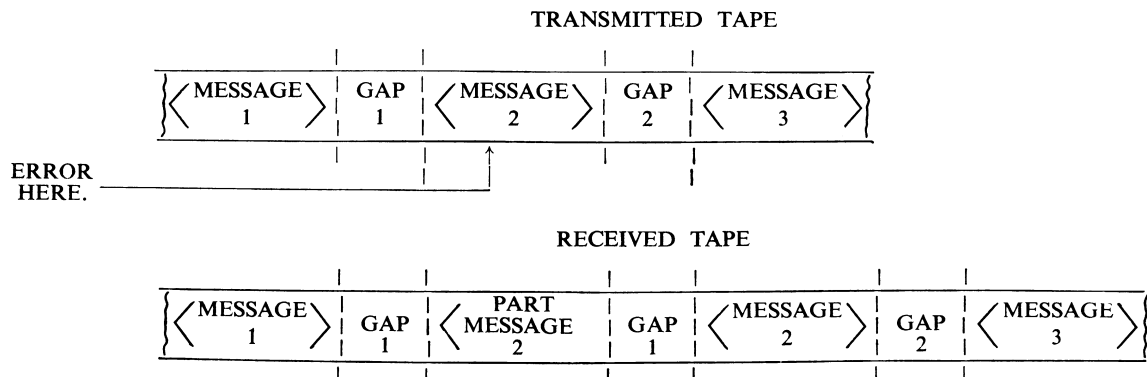

Fig. 1.—Tape sequences

Table 1

Summary of Results July 1961–March 1962

TIME OF DAY WHEN CALL SET UP	ALL DATA				TEST TAPE				CASH/NEW POLICIES			
	NO. OF CHAR-ACTERS	SELECTED/UNCOR-RECTED ERRORS	UNDE-TECTED ERRORS	UNDE-TECTED/ERROR RATIO	NO. OF CHAR ACTERS	DETECTED/UNCOR-RECTED ERRORS	UNDE-TECTED ERRORS	UNDE-TECTED ERROR RATIO	NO. OF CHAR-ACTERS	DETECTED/UNCOR-RECTED ERRORS	UNDE-TECTED ERRORS	UNDE-TECTED ERROR RATIO
9.30 a.m.	('000) 4,152	161	10	$(:10^6)$ 2·40	('000) 4,097	161	10	$(:10^6)$ 2·44	('000) 55	0	0	$(:10^6)$ 0
12.00 noon	4,436	148	9	2·03	4,184	125	2	0·47	252	23	7	27·7
2.15 p.m.	4,060	125	22	5·41	3,716	114	19	5·11	344	11	3	8·72
4.30 p.m.	4,495	107	13	2·87	3,619	93	5	1·38	876	14	8	9·03
Overall	17,143	541	54	3·15	15,616	493	36	2·30	1,527	48	18	11·8

Reliability of equipment

The equipment has proved very reliable. Perhaps the component most prone to error has been the paper-tape reader. For example included in the results is the period from 12 December 1961 to 4 January 1962 when we had twenty undetected errors in 2½ million characters. Of these twenty errors, there were six occasions when two adjacent characters were in error and one occasion when four adjacent characters were in error.

The cause of this bad patch was found to be due to an abstruse condition which may arise when the clutch/brake circuits or mechanical adjustment of the reader become faulty in such a way that the reader is slow in stepping from one character to the next. In these conditions the first character position may have been scanned before the tape actually arrives at the scanning position.

This fault has now been corrected and it is interesting to note the error rates before and after this fault developed.

To 12 Dec.
12½ million characters, 33 undetected errors; rate 2·63 : 10⁶.

12 Dec.–4 Jan.
2½ million characters, 20 undetected errors; rate 8 : 10⁶.

5 Jan.–9 Mar.
2 million characters, 1 undetected error; rate 0·5 : 10⁶.

Production equipments are now being fitted with a mechanical-sensing reader, which is proving most satisfactory.

Progress since the trials

A private line has been installed between the Computer Centre and our main London office. This is available for both data transmission and normal telephone usage

via the P.A.B.X. The switching is so arranged that the data-transmission equipment has priority on the line and the P.A.B.X. operator is unable to interrupt. The volume of transmission as yet is too low to make any direct comparison with the normal public telephone circuit, but we have been able to establish that detected errors are less than ¼ as frequent as on the switched network: i.e. 1 : 110,000 characters (every 30 minutes) against 1 : 31,250 characters (every 8 minutes).

Three branches are now equipped with transmitters. They are situated in Brighton, London and Edinburgh. The future build-up is to equip at least one branch with transmission equipment every month.

Future development of transmission equipment

The disadvantage of paper tape as on output medium of a data receiver is the relatively slow speed that it can be read into a computer. Whilst many old telephone circuits exist in this country the present transmission speed of 750 bauds, using a phase-modulated serial form of transmission, is unlikely to be exceeded. This makes transmission directly into the computer a completely uneconomic proposition, unless that machine is of such magnitude and complexity that it can be working truly in parallel on one or more additional programs.

Magnetic recording of the information at 750 bauds, and playback into the computer at a much higher speed, seems to be an answer that would make data transmission a more attractive proposition to computer users. Providing, of course, that the cost of this equipment did not exceed the cost of current equipments.

Perhaps a more imminent improvement is the automatic retransmission of all detected errors. Some transmission systems include a ferrite core store, which

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stores the block of information being transmitted and retransmits from this store in the event of an error being detected. Such systems are nearly always costly. A better method seems to be that of A.T.E. who are experimenting with the backspacing of the actual paper-tape reader and retransmission of the incorrectly received character. This system would prove an advance on the current system, in that the parity bits inserted by the transmission equipment could be made more powerful in detecting errors, as it would be unnecessary to use the excess parity bits for automatic correction of errors.

Conclusion

Our investigations and trials of high speed data transmission systems, coupled with decentralized data preparation, have convinced us of the practicability of such a system for everyday use. It is true that the normal postal service is cheap and efficient, but Commercial Union regard the cost of a high-speed line system as justified by the better service that can consequently

be offered to the assured customer and to our management: we are, after all, in a highly competitive industry.

Plans are already being formulated for the stage after all our home offices in England, Scotland, Wales and Ireland have been linked to our Computer Centre in Exeter. These plans include the provision of links with those of our overseas branches whose volume of business does not warrant the installation of separate computer systems.

One point, I trust, has emerged from this paper. To the Commercial Union Group, high-speed data transmission is now working reality.

Acknowledgement

The author is indebted to Mr. F. C. Knight of Commercial Union for permission to publish this paper and acknowledges the assistance provided by Mr. I. A. Edmonds, of the English Electric Co.'s Data Processing Division, in the early investigations of available data-transmission equipments.

Appendix

Paris—Exeter Data-transmission demonstration

The author has communicated the following record

During the period 22–26 October 1962 the Commercial Union Group demonstrated the practicability of transcontinental transmission at high speed. The demonstration was arranged in conjunction with the Comité d'Action pour la Productivité dans l'Assurance.

Delegates to the "Second International Electronics in Insurance Week" were asked to complete questionnaires relating to amortization problems. The questions were typed on an Underwood *Data-Flo* typewriter-punch and the resulting tape transmitted from Paris to Exeter at 750 bauds, $62\frac{1}{2}$ characters per second, by our standard A.T. & E. equipment.

At Exeter the problems were solved by the KDP 10 Computer and the answers output on to paper tape, and transmitted back to Paris. In Paris the paper tape was converted into a typed answer form by an Underwood Servo-Reader System equipped with a Lamson Formaliner attachment. The answers were presented in one

of eight languages, according to the nationality of the delegate asking the question.

The original intention was to set up the calls from Exeter to Paris using normal S.T.D. dialling procedures, but, unfortunately, the introduction of S.T.D. between England and France was delayed. We therefore used a normal telephone circuit which for convenience was booked for the whole period of the demonstration.

The average time for each message from transmitting the question to receiving the answer was approximately 25 seconds, made up of

1·2 seconds total transmission time both ways.
0·5 seconds computing time.
8·5 seconds to punch answer at 10 c.p.s.
15·0 seconds manual handling operations at Exeter.

During the demonstrations we are confident that there were no errors in transmission either Paris–Exeter or Exeter–Paris.

Summary of discussion at Cardiff Conference

The Chairman, Mr. L. R. Crawley (*Standard Telephones and Cables Ltd.*) We have heard a very frank discussion of the problems of data transmission in an insurance company: I am sure you are anxious to ask the speaker some questions.

Mr. M. K. Brown (*Joseph Lucas (Electrical) Ltd.*): I should like to ask Mr. Dace how much time was spent in preparation for the project and how far is it now implemented?

Mr. D. J. Dace: Early talks with the G.P.O. commenced in mid-1959 and our first telex equipment was installed later that year. As far as high-speed equipment is concerned our early approaches to manufacturers was in August 1960 and the

first trials started in May the following year. We could probably have started earlier had G.P.O. authority for line usages been given more quickly.

At the present time we have three branches transmitting data regularly and now that the system has been proved we hope to take on the remaining branches, approximately 40 in number, at the rate of one or two per month.

Mr. K. L. Smith (*IBM (U.K.) Ltd.*): Mr. Dace has made a plea for data-transmission systems providing direct input to computers from transmission circuits. It may be of interest that all IBM computers have these facilities available as standard features. These range from simple real-time channels to fully programmable transmission-control systems.

The real-time channel incorporates buffers for assembling messages from transmission circuits at line speeds and transferring these into the main store, after checking, at memory speeds. Similarly the buffers are used for despatching messages from the main store to line at the line speed. The programmable transmission-control system is a special-purpose computer associated with a standard computer for which it monitors a complete communications network. These networks can be as large as 16 telephone circuits operated in half-duplex mode, or 112 half-duplex telegraph circuits, or mixtures of the two. Facilities are included to add routing data and error-checking bits. This latter unit is used in real-time systems such as the airline seat reservation systems.

Mr. Dace also mentioned the trouble with reading oiled paper tape which he needs in his punch. May I suggest he might use Mylar tape? If he has difficulty in punching this I can recommend a machine.

Mr. Dace: As previously stated, the cost of the equipment has to be realistic and comparable with telex.

With regard to Mylar tape, apart from the expense of it, I do not know if it would be suitable for very high speed paper-tape punches where manufacturers insist on an oil content in the tape.

The Chairman: One other question I should like to ask Mr. Dace. He was using phase modulation, which I believe is not allowed on public telephones, and yet he mentioned the use of public networks. Is this correct?

Mr. D. J. Dace: The Post Office policy is that until the Post Office modulators are available they are prepared to approve complete data-transmission equipments containing their own modulators.

The A.T.E. equipment we are using has had such approval although it uses phase modulation.

The Chairman: Those of you who were at our data-transmission symposium may remember that this question of data going over telephone lines and interruption by the operator is due to the fact that an operator breaks in on a trunk call to see whether the speech is still going on. She hears just a hiss of data going over the line and assumes that there is something wrong and breaks down the line. This is being looked into by the G.P.O. One of the things, I think, which has not come out of this part of the session, is that the British Post Office are well aware of the demands for data transmission and are, I think, well ahead of demands, which are coming from industry. They are doing a tremendous amount of work. It is one of the most encouraging things I have seen in government circles that we have a nationalized body which is wide awake and is looking to you people to say what you want. It is trying to estimate what you want; I think that they will have all the things you want, when you want them, but you must let them know. They are very, very active on committees on which I am working, and on our own British Computer Society Data Transmission Committee—the G.P.O. are giving tremendous help and taking tremendous interest.

Mr. W. S. Ryan (*General Post Office*): Mr. Chairman, thank you!

Mr. B. V. Piggott (*Eastern Electricity Board*): There are two questions which I should like to ask; perhaps both speakers could give us a short answer. The first is: to what extent are they using public telephone lines, and in those cases how are they meeting and overcoming the problems of operator intervention or the pips?

Secondly: are either of them attempting any bulk trans-

missions of data, in which case are they finding that the transmission speeds available are adequate for the bulk in a given time of day?

Mr. A. F. George: In the case of S.A.S. the short answer to both of those questions is no. To start with, we are not using any telephone circuits at all for the transmission of data, only telegraph circuits because the space-availability system is actually designed to operate on a telegraph system. When we are using local circuits, where we do not have V.F. facilities, then we use a straightforward metallic circuit. The fact that this can also be used for telephone transmission is incidental and would, I think, be liable to introduce some ambiguity into the type of system we are operating; so it is better not to mention telephone circuits when describing the system.

Mr. D. J. Dace: All our transmission calls, with the exception of those to London for which we have a private wire, are made over public telephone lines. Where we are not able to call the branch on S.T.D. we set up P.U.T. (prolonged uninterrupted) calls on which the pips are absent.

Every call made is from the Computer Centre to the Branch and consequently the operators at the Exeter exchange are quite used to these calls, and in fact they stay off the line until we call them on a different number to advise them that the P.U.T. call has finished.

The volume of our transmissions will eventually be some 1½ million characters per day and we hope to receive this data over a period of about two hours, using four receivers.

Mr. J. C. Cluley (*University of Birmingham*): There are two questions I should like to ask. First of all, American experience, I believe, suggests that one can get a much lower error rate on telephone line transmission at night. Have the people who are concerned with data transmission, particularly the insurance company, tried to do any tests at night, and if so what tests have been done; is there any pronounced variation in the error rate with time of day?

The second point is that one wonders whether some kind of masking signal should be presented, along with the data, so that anyone inadvertently getting on to the circuit would have a clear indication that it was busy. If one has information sent in blocks, there may well be gaps between these in which nothing is apparently happening. If one could produce some obvious masking signal, which was not interfering with the transmission, this would indicate to anyone coming across this circuit that the circuit was busy.

Mr. D. J. Dace: We have not tried transmitting at night. This would involve keeping a staff at the branches and at the Computer Centre in order to transmit the data. The results shown in the paper, however, are split down into four different periods—during the day.

On the second point, there is in fact an ARQ tone being continuously sent from receiver to transmitter. This varies at one-second intervals from 340 c/s–410 c/s and is most certainly audible. A gap between blocks constitutes perfectly valid characters, as far as the transmission equipment is concerned, and is subject to mutilation in the same manner as are any other characters.

The Chairman: Perhaps I could be allowed to add a little in answer to this question. The *Computer Journal* has two articles, one by E. P. G. Wright* giving a description of two years of survey of all the circuits in the country and the error rates found, and one by Grimmond,† who has given a paper on simulation of errors by computer, so that extensive tests

* Vol. 4, p. 103, July 1961.
† Vol. 5, p. 94, July 1962.

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can be done without lines as well as loop lines round the country. Very, very exhaustive tests have been done both day and night, at periods during the day and periods during the night, and you can see the rate of error of detected and undetected errors.

Mr. A. F. George: Although the questioner was talking about telephone circuits, I have some interesting figures here concerning telegraph circuits and the checks we have made during the night, when we conducted our test program. I find that in three cases in particular the results agree with American experience. First, the figures show that for our Paris office during the day we made 5,000 inquiries and we had 139 detected errors; during the night we made nearly 12,000 and had only 54 detected errors. In the case of Dusseldorf during the day we made 3,800 inquiries and we received 31 detected errors; during the night we made 14,000 and received 33 detected errors.—There is a big difference there.—Finally, at Stavanger, 2,000 inquiries during the day with 127 detected errors; 9,800 at night with only 4 detected errors. So you see there is a lot to support the view that circuits do appear to be more reliable during the night than during the daytime, probably because all the mechanics are in bed, I should imagine.

Mr. K. L. Smith (*IBM* (*U.K.*) *Ltd.*): There is no mystery about the time dependence of the occurrence of errors on public telephone circuits. These errors are caused mainly by interference from the exchange switching equipment and reach a maximum rate during the busy periods for this equipment in the middle of the morning and afternoon working periods. The quietest period and lowest error rates occur between 12 noon and 2 p.m. or at night.

Private circuits do not show the same marked time dependence unless they are routed near switching equipment.

The suggestion to send idle signals between successive blocks of data is not permitted by the G.P.O. for periods exceeding one minute to avoid unreasonable overloading of multi-channel equipment. One of our customers using Data Transceivers experienced excessive errors due to suspected break-in by telephone operators. These ladies seem to become fascinated by the sound of data signals. His solution was to invite them to visit his installation, see and hear the Data Transceivers in operation and witness the effect of operator break-in on error rates.

Mr. W. S. Ryan: Regarding the last speaker, the telephone service has a lot of subscribers, both male and female, and they can be handled in different ways. When we have a particularly difficult subscriber we invite him to come round and see our telephone exchange. We then send him home quite happy.

Could I add just one point on Post Office policy here? I think one of the speakers did make the point that operators come on the line and cause interference. The last speaker has also made the point that during the busy hours there is also interference between circuits. This, of course, is quite true but the percentage of interference is small, as I think both our speakers today have made quite clear. The Post Office is very keen to keep it small and, if possible, to get it smaller. Consequently we are very chary about allowing any manufacturer's equipment to be put on any of our circuits until they have been very thoroughly tested indeed. You see, we are concerned with supplying a telephone and telegraph service for the whole of the country, in fact for the whole of the world as far as the telecommunications is concerned, while the manufacturer of data-transmission equipment is concerned with selling a very small quantity of very specialized equipment to very few customers. We have to protect the majority, at least for the time being.

Book review

The Encyclopedia of Electronics, edited by CHARLES SUSSKIND, 1962; 974 pages. (New York: *Reinhold Publishing Co.*)

This volume of almost 1,000 pages contains an alphabetically arranged collection of over 500 articles by more than 400 authors. Some of the authors are better known than others and it is noted that most are resident in the U.S.A. The articles refer to both technical and associated topics and include two dozen short biographies of outstanding contributors to the progress of electronics.

There may be a need for such a book but it is clear that all tastes will not be satisfied by the present edition. Many will enjoy browsing through the interesting, well presented and easily read contents. Others, no doubt, would have preferred a reference book with more emphasis on a restricted range of topics and with much more frequent reference to the literature.

For the purpose of this encyclopedia, electronics is interpreted to include, besides its more obvious sections, many subjects which could equally well be classified as pure or applied science or engineering. Thus mathematicians may be a little surprised that there are articles on Boolean algebra, Complex notation, Fourier analysis, integrals and transforms, Matrices, Probability, and Vectors.

It is claimed that *The Encyclopedia of Electronics* is "an immediate reference to all of electronics" and "is designed to answer questions on every aspect of the subject." Nevertheless the index has some omissions. *Punch-through* is indexed but the breakdown mechanism *avalanche* is not (although it occurs on p. 882). The only reference to *time-base* would appear to be *time-base stability, in magnetic recording*. AND, OR, NOR circuits are described under *Logical circuits* but are not indexed separately.

There is a national flavour about certain sections. Thus we are told that air-traffic control is the responsibility of the Federal Aviation Agency (p. 7). The section on Digital Computers (pp. 183–85) includes only machines of U.S.A. origin. The application of Doppler Shift to navigation is illustrated by the U.S.N. Transit Navigation System (p. 194). The Economics of the Electronics Industry (p. 200) quotes only U.S.A. statistics and it is presumed that billion is the U.S. version (i.e. 10^9) and not the British version (i.e. 10^{12}).

The articles entitled Analog computers (pp. 20–4), Computers (pp. 133–41), Digital computers and instrumentation (pp. 182–89), may interest those already, or about to be, concerned with the machines themselves. Applications are also described in the sections on Data Processing (pp. 171–73), Linear Programming (pp. 415–16), Medical Electronics (pp. 460–65), Monte Carlo Method (pp. 497–99), Operations Research (pp. 566–68), Translation by Machine (pp. 885–86).

S. KIRKBY