to telephone subscribers. Possibly through experience operators would become familiar with data calls, and interruptions could then be expected to become relatively rare.

Mr. W. E. Norman (*I.B.M.*) asked whether Mr. Williams meant to imply that manufacturers' equipment would not be accepted, when he said that G.P.O. terminal equipment would be supplied.

Mr. Williams said that the present official view was that a manufacturer's design and equipment would be considered on its merits, but when Post Office equipment of comparable performance and of the same general type was available the position would be re-considered with a view to making the use of P.O. equipment mandatory. At the moment, a firm decision, one way or the other, had not been taken.

A Data Transmission Survey

By P. A. Long

This paper describes an investigation conducted by the Inland Telecommunications Department of the General Post Office during 1960. The object of the investigation was to determine the future general needs for data-transmission facilities with particular emphasis on the type of lines that will be required in the immediate future.

Introduction

As long ago as 1955, the Post Office, jointly with a punched-card machine manufacturer, was demonstrating the use of Telex for the transmission of data. Unfortunately, the idea did not catch on to any extent. However, like many other ideas, it was not abandoned but merely pigeon-holed for the time being.

At much the same time as these demonstrations, studies were being conducted in the United States into the possibilities of using telecommunication channels for data purposes (American Management Association, 1954). In due course, reports of these investigations and other American developments, inquiries from representatives of British Industry and the growing interest in computing generally led to the decision, within the Post Office, that a study should be conducted into the potential needs in this field, so that timely preparations could be made to meet any general requirements. Even at this early stage, it was recognized that the Post Office carried a heavy responsibility because of its position as the main United Kingdom provider of telecommunications channels (Long and Truslove, 1961), and because of the restriction that would be placed on national productivity if the appropriate services were not made available at the right time.

Preliminary Steps

Consideration of the steps necessary in conducting such an investigation showed that there were two main problems:

(*a*) How to obtain sound information about the probable use of facilities which were of a semi-technical nature and largely undeveloped. In this connection it was realized that the lack of general information in the computing field about line-transmission possibilities, likely facilities and techniques would, to a considerable extent, frustrate early efforts to obtain sound information about potential users' requirements.

(*b*) A market research, which normally relies on a sample of potential users, appeared to be somewhat premature, because of the difficulties of establishing the eventual market for computing machinery.

The first of these problems was tackled by a small publicity programme involving the distribution of a booklet on data transmission (G.P.O., 1958); establishing contact with computer users and manufacturers, and discussing their problems in this field; generally engendering interest in the subject through the medium of ADP journals, exhibitions, etc.

Secondly, the idea of a formal market research was abandoned and it was decided to distribute a questionnaire, on a "Survey" basis, to all known computer users and potential users in order to obtain information from a limited but informed field. For this purpose, use was made of the mailing list of applicants for the data booklet, together with such other information as had been collected during the initial contacts with users and manufacturers.

Distribution

Three hundred and thirty survey forms, together with suitable covering letters and copies of *Facilities for Data Transmission*, were issued. The addressees included banks, insurance, heavy and light engineering, chemical and electrical manufacturing, the distributive trades, oil companies, transport, computer manufacturers (in

Table 1

Classification by Industry of Survey Forms distributed

	ORDER, USING STANDARD INDUSTRIAL CLASSIFICATION	REPLY NOT RECEIVED	"ARE LINE FACILITIES REQUIRED?"				TOTAL FORMS DISTRIBUTED ($a+b+c+d+e$)	PERCENTAGE DISTRIBUTION OF COLS. $d+e$
			"NO"	"TOO EARLY TO SAY"	"YES"			
					TENTATIVE	DEFINITE		
		a	*b*	*c*	*d*	*e*		%
VI	Engineering, Shipbuilding and Electrical Goods manufacturing	11	2	9	10	9	41	17
IV	Chemicals and Allied Trades (Manufacturing and Preparation)	3	2	7	8	3	23	10
VII	Vehicle, Aircraft Manufacturers	8	2	2	9	1	22	9
XIII	Food, Drink and Tobacco Manufacture and Preparation	17	7	10	9	—	43	8
XXI	Insurance, Banking, Finance	3	8	7	5	4	27	8
XXII	Public Administration and Defence	4	9	7	6	3	29	7
XIX	Transport, Communications	12	3	1	7	1	24	7
V	Metal Manufacturers	4	2	4	6	—	16	5
XVII	Civil Engineering, Building and Contracting	1	1	3	2	3	10	4
III	Cement, Brick, Pottery and Glassware Producers	1	—	3	4	—	8	4
XVI	Miscellaneous Manufacturing Industries (Rubber, Plastic Goods, etc.)	2	—	1	3	—	6	3
XVII	Gas, Electricity and Water (Public Utilities)	6	—	7	3	—	16	3
XX	Distributive Trades (including Merchants, Brokers, Dealers)	4	3	4	2	1	14	3
X	Textile Manufacturers	—	—	1	1	1	3	2
XII	Clothing Manufacturers	—	1	1	2	—	4	2
XV	Paper Manufacturing, Printing and Publishing	2	5	—	2	—	9	2
XXIII	Professional Services	4	3	—	2	—	9	2
XXIV	Entertainment, Sports, Hotels	5	—	1	2	—	8	2
VIII	Metal Goods Manufacturers	5	2	6	1	—	14	1
IX	Precision Instruments	—	2	—	1	—	3	1
XIV	Furniture Manufacture	—	—	1	—	—	1	—
	Totals	92	52	75	85	26	330	100

their capacity as potential users), and appropriate Government Departments. These addressees and the main answers are analysed by type of interest in Table 1.

General Comments on Replies

The response to the survey (238 replies—72% of questionnaires distributed) was thought to be very good and represented a high level of interest in the subject. This interest has been emphasized by the number of inquiries concerning the use of line facilities which have been and continue to be made since the return of the survey forms. These inquiries are, in the main, of a general, unspecific character, relating to forward planning of computer installations. It seems reasonably certain, however, from their nature, that many will result in the use of lines for data transmission fairly soon.

Of the 238 replies to the survey (see Table 2), 52 (22%) gave an unqualified "No" to the question, "Will line facilities be required for data transmission?" The remainder, 186 (78%), were divided between 111 (47%) expressing the opinion that "line facilities would be required," and 75 (31%) that it was "too early to say." However, with the latter, there is a presumption that many of these will ultimately say "Yes." This 31% generally qualified their replies by stating that further

Table 2

Line Transmission Requirements

Organizations requiring line transmission	111	47%
Organizations not requiring line transmission	52	22%
"Too early to say"	75	31%
	238	100%

Note 1: Of the 111 replies stating that line facilities may be required, 26 (23%) were definite requirements; the remainder—85 (77%)—were tentative only.

Note 2: The 75 replies stating "Too early to say" also mentioned that more definite information might be available as follows:

Within 1 year	16	21%
Within 2 years	17	23%
Within 3 years	10	13%
Within 5 years	5	7%
No period given	27	36%
	75	100%

Table 3

Date Initial Requirement expected to mature

These answers relate to the 111 replies that line facilities may be required:

Required by 1961	24 (15)	21%
Required by 1962	17 (4)	15%
Required by 1963	13 (2)	12%
Required by 1964	4	4%
Required by 1965	3	3%
Required by 1966–68	3 (1)	3%
Don't know	42 (2)	38%
Existing private circuits to be used	5 (2)	4%
	111 (26)	100%

Note: The bracketed figures refer to the 26 definite projects, see Table 2, Note 1.

information would become available by a certain time. See Table 2, Note 2.

Of the 111 replies agreeing that line facilities were likely to be required, 26 (23%) stated that the requirements were definite; the remainder—85 (77%)—were tentative. An analysis of date of initial requirements is given in Table 3.

Transmission Rate

Table 4 gives details of the character transmission rates required in the 111 cases mentioned in the preceding paragraph; 125 requirements are listed, because some projects called for more than one transmission rate. It was impossible to convert the figures quoted to baud speeds, due to the lack of answers to a question concerning the code to be used, and lack of information about the error-control redundancy introduced by the

Table 4

Transmission Rate

6–7 characters per second	34 (8)	27%
10 characters per second	6 (3)	5%
20 characters per second	4 (1)	3%
25–50 characters per second	11 (2)	9%
50–100 characters per second	22 (11)	18%
200 characters per second	4	3%
300 characters per second	1	1%
400 characters per second	1 (1)	1%
500–2,500 characters per second	3 (2)	2%
Dependent on relative costs	4	3%
No speed quoted	35 (3)	28%
	125 (31)	100%

Note 1: 125 replies are quoted in respect of 111 cases, because some organizations visualize using more than one rate, e.g. in the case of a service bureau, small volumes of data might be routed over telex, and larger volumes over the public telephone network.

Note 2: The bracketed figures refer to the 26 definite projects.

Table 5

Assessment of Type of Circuit

Telex	12 (4)	9%
Public telephone network	19 (7)	15%
Private telegraph circuits (Tariff H)	18 (5)	14%
Private telephone circuits (Tariff D or E)	25 (9)	20%
Broad band circuits	3 (1)	2%
Not possible to assess	51 (5)	40%
	128 (31)	100%

Note 1: This assessment is based on traffic volume (where stated), and stated intentions supplemented by personal knowledge obtained during discussions, etc.

Note 2: 128 requirements are quoted in respect of 111 cases, because some appear to justify the use of more than one service.

Note 3: The bracketed figures refer to the service likely to be used for the 26 definite projects.

terminal transmission apparatus that will ultimately be employed in particular cases.

There are, however, two fairly clear areas of requirement, viz. for telex or private telegraph circuits, say, up to 10 (quoted) characters per second—32%—and for telephone network or private circuits, say, 20–200 (quoted) characters per second—33%. These services would apparently meet 65% of the requirements. The even division between telegraph and speech circuits is not thought to be significant, because, in discussion with interested firms, etc., there have been many marked expressions of preference for the higher speed services. Ultimately, however, much will depend on relative cost, the volumes of data, and the time available in which to

effect transmission—questions to which no satisfactory answers are yet available.

Few survey forms were completed sufficiently to enable a full and detailed pattern of users' requirements to be reconstructed. Accordingly, when compiling Table 5, showing the type of service likely to be required, viz. telegraph, speech, network or private circuit, it was necessary to take into account traffic volumes and intentions, where stated, supplemented by information obtained during discussions, etc.

Error Rates

The minimum acceptable error rates required from the transmission channel and terminal apparatus are summarized in Table 6 in respect of the 111 cases for which facilities may be required. It is noteworthy that these figures appear reasonable and probably attainable by means of suitable error-control systems.

The replies to a question about users' preferences concerning error detection or correction were not very helpful. In most cases, error detection appeared to satisfy the requirements, but the majority expressed preference for correction if the increased cost was not too great.

Duplex Transmission

From Table 7 it will be seen that 25 (23%) replies stated that simultaneous data transmission in both directions would be required. However, bearing in mind that some proposed terminal equipments utilize the return channel for supervisory purposes, this figure may have no particular significance other than as regards the need for additional channels; 78 replies (70%) stated that a duplex transmission facility was not required.

Method of Data Reception

Ninety-eight (89%) of the answers—see Table 8—envisaged that data would be received at the computing centre on to paper tape, magnetic tape, or punched cards. In only six cases (5%) was it visualized that direct connection between line and computer might be required, and in two of these cases this was only a possibility. As might be expected, two of the six replies involved computer interrogation systems for air-line seat reservation purposes.

Conclusion

The analyses in this paper have demonstrated that, on present evidence, there is a mixed demand which, in terms of transmission rate and other factors, may be satisfied by existing telegraph and speech services.

Table 6

Overall, Minimum acceptable Error Rate (excluding breakdowns)

1 character in 100,000	36 (8)	33%
1 character in 250,000	3 (2)	3%
1 character in 500,000	19 (4)	17%
1 character in 1,000,000	28 (8)	25%
1 character in 10,000,000	8 (1)	7%
No figures quoted	17 (3)	15%
	111 (26)	100%

Note: The bracketed figures refer to the 26 definite projects.

Table 7

Simultaneous Transmissions in both Directions

Facility required	25	23%
Facility not required	78	70%
Question not answered	8	7%
	111	100%

Table 8

Method of Data Reception at Centre

On paper tape, magnetic tape, or punched cards	98	89%
Direct into computer	6	5%
Question not answered	7	6%
	111	100%

Acceptable error rates appear capable of attainment by means of suitable terminal equipment, and error correction is generally preferred, if obtainable at reasonable cost. But, failing this, error detection appears to be acceptable in most cases.

These, then, are the main conclusions to be drawn from the Post Office Data Transmission Survey. It would, of course, be possible to relate the information in the accompanying Tables in a variety of ways. But most of the remaining questions of significance were either not answered, or the answers were so vague, indefinite or varied as to make analysis very difficult, and unlikely to lead to results in keeping with the effort needed to obtain them. Accordingly, there are no plans for further analyses of the Survey at present.

References

AMERICAN MANAGEMENT ASSOCIATION (1954). "A New Approach to Office Mechanization," *Integrated Data Processing through Common Language Machines.*

LONG, P. A., and TRUSLOVE, E. H. (1961). "Data Transmission—Problems and Prospects," *The Computer Journal*, Vol. 4, p. 34.

G.P.O. (1958). *Facilities for Data Transmission.*

Summary of Discussion*

Dr. Yates (*Chairman*) opened the discussion with a personal note. His establishment at Rothamsted had received a copy of the questionnaire. He could not remember the answer he had given to the question on requirements, but it was either "No" or "Too Early Yet to Say." But during the passage of a year he had revised his opinion, and it was interesting to consider why. Rothamsted dealt with agricultural research statistics, and in many cases their requirements were decidedly different from those of industry and commerce, but they had a number of agricultural research stations scattered about the country which were broadly autonomous, many of them having their own statistical departments doing statistical research. One of the things that had emerged about computers was that many of these departments felt that they would like computers, and took the view, "If Rothamsted has one, why cannot we have one?"

From what was known about large *v.* small computers, and the very great advantages of the larger ones, it was obvious that the satisfactory answer was not to say, "Yes; let every station have its own small computer." Quite apart from the efficiency or otherwise of the actual data processing the statisticians would find themselves involved in much more inefficient and difficult programming work with a series of small computers than with one large one.

Rothamsted had had a small computer since 1954, and had already had experience of the problem of making it available on a co-operative basis to other research stations. A larger computer was now on order and he believed that the main problem in data transmission would be the transmission of programs for testing, so that anybody with a special problem could do his own programming in autocode, or in terms of instructions to general programs which was possible with a large machine, and could then get it tested.

As anyone who had compiled programs knew, one of the requirements was good and speedy facilities for testing. If one had to wait a long time between each test one lost interest and went on to other work and then had to refresh one's mind before taking it up again, so that the whole process went very slowly. He hoped that they would be able to arrange matters with the more active centres having communications of this kind so that they would be able to transmit programs speedily as soon as they were ready for testing, together with the necessary tests, and get back the answers in an hour or two, so that they could proceed with their corrections and further tests.

For most agricultural research work, speed in transmission of data and results was not of paramount importance, and he thought that for most data transmission the postal services would be adequate.

There was one question he wanted to ask. When Mr. Long had referred, in connection with Table 6, to one error in 100,000, had he meant one character or one bit?

Mr. Long replied that he had meant one character.

The Chairman said that he thought that one character in 100,000 would probably be an acceptable error rate for their purposes.

Mr. N. H. Tantrum (*I.C.T.*) asked whether this country was going to break away from the present five-track international paper tape and adopt, say, eight-track tape. If so, for what period would five-track tape continue to be used?

Mr. Long, in reply, said that there had been some discussion whether Mr. Williams or he (Mr. Long) should answer that question. He could only say that the five-channel international alphabet was the internationally accepted standard for ordinary communication purposes, and he was not aware of any plans to change it. Therefore it might be assumed that the Post Office would continue to provide five-channel paper tape senders. But that was not to say that proprietary eight-channel senders could not be coupled to Post Office circuits, if they were technically, and operationally, suitable.

Dr. G. N. Lance (*United Kingdom Atomic Energy Establishment, Winfrith*) said that the two Papers had provided an excellent discussion from the Post Office point of view, but he felt he would not be out of order in talking of his Establishment's experience as users of the facilities supplied by the Post Office and by manufacturers. They used data transmitters of various sorts, ranging from the ordinary telephone to aeroplanes, but the ones he wanted to concentrate on were the card transceivers used to connect them to two other large Authority computing centres. They also used paper tape facilities. Associated with each transceiver, they had a private wire telephone circuit, which was essential if they were to communicate with their opposite number at the other end when the equipment failed—if a card jammed, or something like that.

One thing that card transceivers would not do was transmit written information. For this reason, they had supplemented the telephone and the card transceivers with a Mufax facsimile transmitter. These equipments were used primarily for sending test programs to and from the machine.

In the mornings, they tested the equipment, and the way in which it was done was quite interesting. Since they had two card transceivers, they transmitted between their own apparatus, which satisfied them that the transceivers were working properly. They then tested the G.P.O. lines by using the card transceivers on the telephone line they used to speak on. If they could speak on it, they assumed it was all right. They went through this procedure because they did not have a card-transceiver engineer on the site, and they did not want to accuse the wrong person of having a fault on his equipment. The Mufax equipment was built in such a way that it could transmit to itself. The line associated with this was a Tariff-E line, which they could test by attaching a telephone to it.

Dr. Lance went on to the question of reliability, which he said he could not overstress. It was essential for a computer user to have reliability if he wanted to send information; he must be sure that whenever he wanted to send it, the equipment was ready. The only quibble they had with the equipment was that they could send only binary-coded decimal information using the card transceivers. That was quite a restriction if they were testing programs, because they would like to send correction cards to the computers, but such cards were in pure binary form.

The equipment they contemplated would involve the transmission of magnetic tape, and this equipment would enable them to transmit either in coded decimal or in pure binary. But it would still be necessary to throw a switch, and that would involve fairly difficult practical problems. The operator at each end would have to throw a switch simultaneously. That was something manufacturers would have to think about.

Dr. Lance was speaking, he said, very much from the point of view of the off-site person using a central computer, which

* The discussion period following Mr. Long's paper also included further discussion on Mr. Williams's paper.

was a slightly different point of view from that of the person with a central computer at his own station.

Mr. W. A. Pillow (*Standard Telephones and Cables Ltd.*) said that he would like more information as to what volume of data was likely to be perfect at any given time. Table 8 gave a marking of 89% for paper tape, magnetic tape and punched cards, but that percentage ought to be broken down in order to show for what period of time the various types of initiation of transmission were used. That question was related to the real-time speed. Although there had been a volume of opinion in favour of slow-speed transmissions he could not believe that that represented the true picture, as seen by a computer user. He would have thought that in providing equipment there was an obligation to see that the information was moved between the line and the machine as quickly as possible. He thought there would later be a big claim for magnetic tape reception, so that it was more readily available to feed into the machine. Was there any prospect of the three methods of preparation—paper tape, magnetic tape, and punched cards—forming the subject of a separate survey?

Mr. Long, dealing with the question of volumes of data transmission, said that one of the unfortunate things about the survey was that although many people were able to say that they could foresee having a need to transmit data, at the moment quite a number could not say how much. There were instances where people had been able to give a guide, however, and these had been used to produce Table 5, and to break down the requirements into terms of different types of circuits. It had been assumed that if there was less than about three-quarters of an hour's traffic per day from one point to the centre—at 50 bauds per second—Telex would be the most economical service to employ. Similarly, for up to about one hour a day the public telephone network would be suitable; for longer durations, private speech or telegraph circuits were appropriate. As to details of volumes of data, Mr. Long was afraid that they had insufficient evidence to give a clear guide.

Referring to the question of a breakdown for paper tape, magnetic tape, and punched cards, Mr. Long agreed that in time magnetic tape would probably be the most popular method. Over 50% of those answering the survey were thinking in terms of paper tape, although that was probably largely due to the fact that paper tape was available today and was convenient.

Mr. I. V. Idelson (*Mullard Equipment Ltd.*) said that one of the most striking things in the rapidly changing computer picture today was the number of manufacturers offering computers which had some kind of interruption facility, or the facility of running separate programs at the same time. The realization that this was possible, and was not terribly expensive, was a fairly recent one.

Was this likely to have any effect on the picture given in Table 8? That showed a very low figure of people (6) wanting to go direct into a computer. So long as a computer could deal only with one program it was likely to be inefficient to run any kind of data link straight into it, but with the new development it might be found that there were many advantages with the direct connection. A computer might, for example, be used to do consistency checks on the incoming information.

Mr. Long said that once again he had feelings although no figures; he thought that Mr. Idelson's view was the correct one, but Mr. Williams might be able to say whether there were any technical snags in such a proposition, from the point of view of transmission lines.

Mr. Williams was unable to add much to what had been said. In his paper he had mentioned the possibilities of time-sharing. A 48 kc/s link could be matched to computers or terminal apparatus designed to cover a wide range of speeds. If a link were permanently coupled to a time-sharing computer some means would have to be found for making sure that the computer ignored false signals generated by line faults. There were many problems to be solved in that connection.

Mr. J. B. Pollard (*Atomic Power Constructions Ltd.*) said that a direct link of the kind described would be a great advantage in his case. Did Mr. Long or Mr. Williams know of any computer firms which were at present considering the technical difficulties involved in feeding transmitted data directly into the computer?

Mr. Williams said that he had discussed with an industrial user and an equipment manufacturer the use of just that 48 kc/s link, but he did not know whether it was proposed to operate on a time-sharing basis or through the use of a tape-to-tape buffer.

Mr. Long said that in the case Mr. Williams was speaking of he thought it was a magnetic tape-to-tape transaction.

Mr. W. E. Norman (*I.B.M.*) said that his firm had announced as from 23 January both a computer-to-computer link, namely the 1009 unit for use with the 1401 system, and a magnetic tape-to-tape link, for the 7070 system. The two units could also operate between each other.

Mr. L. Durand (*De La Rue-Bull/Cie des Machines Bull*), returning to Table 4, referring to transmission rates, said that the necessary rate obviously depended on the volume of data, but also on the time allowed for transmission, which was often limited. For instance, the data which was available at 5 o'clock might have to be transmitted between 5 and 6 o'clock, and that was all. A further important factor was the shape of the network. In many instances there was a centre with a large number of local transmitters which had to send information to the centre. If the number of local transmitters was small there was not a great problem, but with many transmitters not all the communications could go to the centre at the same time. There were methods of handling the problem of simultaneous transmission, but when complicated apparatus was not used, and simultaneous transmission was not possible, the volume of data was affected. Had those factors been considered in compiling Table 4?

Mr. Long said that they had not. They had decided that Table 4 would be based on a strictly factual report of the tranmission speed that different people required—the speed they stated in reply to the question asked. But they had tried to take Mr. Durand's points into consideration in assembling Table 5, which was rather more a matter of opinion than of fact.

Mr. J. L. McCarthy (*Royal Insurance Co. Ltd., Liverpool*) mentioned that one computer manufacturer had suggested a method of accumulating data at a centre when the number of peripheral branches is large. This is to install at the processing centre a small additional computer programmed to accept unmonitored transmission, over the normal telephone network, from up to six branches simultaneously, and to ensure that the information received is recognizable as valid data. It was suggested that there would be very little congestion

at the receiving end and that the cost of the computer would be more than offset by the saving on monitoring equipment and the provision of maintenance thereto.

Both Mr. Williams and Mr. Long had mentioned that many potential users seem to prefer error correction systems to those merely detecting error. It should be borne in mind that, in general, error correcting systems rely upon a specified period of clear transmission time following any period of error. If this error-free transmission time does not occur errors will be passed without correction. Would it not be wiser to have error detection with retransmission routines?

Mr. Williams thought that error detection coupled with retransmission was the most efficient method of using a telephone channel for data transmission because the amount of redundant information transmitted was small, and the proportion of undetected errors could be as low as desired. Automatic error correction was much more difficult, especially when the undetected error rate had to be very low.

Mr. Long, trying to read between the lines of the survey, said that most people were naturally attracted to the idea of error correction, because they thought it to be the answer to a maiden's prayer, but potential users, on reflection, had in many cases discovered that error correction, although something of an advantage, could be quite expensive and might offer a more inflexible system.

Mr. I. A. Edmonds (*English Electric*) said that his company's Whetstone factory, near Leicester, had ordered some high-speed transmission equipment in order to link them to the bureau at Kidsgrove. The link would be used for the transmission of programs and data to be processed on the KDF9 computer which will be installed at Kidsgrove by August/September 1961.

The equipment was a version of the A. T. & E. "SWIFT" system operating at 750 bauds on a private circuit and incorporated error-correction facilities. To each 7-bit character five further parity bits were added to provide the means of error detection and correction. The input/output medium will be punched paper tape.

A future development could be that at the computer centre a small machine, such as the KDN2, would be used as a buffer to record the received information on magnetic tape in addition to doing a certain amount of credibility-checking of the data.

His firm would very much like to use data transmission at similar speeds on the public-telephone network in the future, and perhaps Mr. Williams might give them some idea of what he considered to be the optimum speed of transmission on the public network.

Mr. Williams said that there was no simple answer to the question of the optimum speed of transmission, for several reasons, not the least of which was that the public network itself had not been designed as a whole. It had grown up over many years, and it was still growing, and yet much of the plant put in originally was still in use. The deficiency of the earlier plant, which particularly affected data transmission, was low cut-off frequency of some loaded cables. This produced delay distortion which affected the transmission of signal components above about 2,000 c/s.

Another reason was that some subscribers were unfavourably placed from the point of view of transmission; their connections would often be subject to a high loss, or to being routed on old plant with a low cut-off frequency.

Thus the choice of a transmitting speed for general use on the telephone system depends on an acceptable risk of an occasional call failure. That was why, although good results had been obtained at 1,200 bauds, he had said that he thought that too high for general application. Experience to date had shown that 600 bauds between any two subscribers was practicable with the plant existing at present, unless there was some gross fault, such as would interfere with speech in an ordinary telephone call. If two subscribers were favourably situated and they were prepared to take a chance on an occasional call being unsuitable, a higher speed could be contemplated.

Mr. Pillow wanted one point cleared up. There was nothing in the headings of the questionnaire to suggest that it had been sent only to computer users. Could they be assured on that point? It might be that we had many prospective users of data transmission who were not computer users, and their answers—if they had received the questionnaire—might have had a distorting effect on the figures.

Mr. Long was able to give an assurance that the questionnaire had been addressed to computer users and known potential users.

Mr. Taylor (*Mullard Equipment Ltd.*) thought he remembered some details of Papers given at Delft last year which suggested error bursts which were liable to occur on Post Office lines were of considerable duration—about 500 milliseconds in some cases. Would the authors of the Papers agree that with bursts of this length it would be impossible to provide any error correction system which would be worth while?

Mr. Williams agreed. The probability of a burst covering one or two bits was quite high, but the probability rapidly diminished as the number of bits in the burst became larger. The CCITT working party had suggested taking an interruption exceeding 300 milliseconds, as a fault condition, and disregarding any such periods when deriving error statistics. It was clear that there would be interruptions lasting from fractions of a millisecond to seconds, minutes, hours and even days. The probability of there being interruptions lasting a second or half-minute would be very small indeed, but it was extremely important that the users of data-transmission systems should take account of what would happen when the circuits failed.

It was important to have some organization in reserve, to take account of the fact that all rented circuits and switched telephone calls were liable to failure for quite unpredictable periods.

Mr. A. C. Croisdale (*General Post Office, London*) said that the working party to which Mr. Williams had referred had been set up largely to cover problems which had been partly discussed that morning. It had been set up by the International Telegraph and Telephone Consultative Committee (CCITT) and had held one meeting last year. A number of British manufacturers who were represented at that meeting were present today and they would appreciate the scope of the matter discussed. He mentioned that because the question of codes would be subject to international agreement.

It had been mentioned that so far the Post Office used only the international five-unit code, but they had to take a longer-term view, and they were examining, on the telegraph side, the transmission in the United Kingdom of longer codes and they had agreed that codes other than the five-unit code could be used by computer users for transmissions on the internal Telex system. The question of transmission over the international system was tied up with the equipment used

by those at the other end and may be restricted by special transmission methods used on such links.

Any future code used by computer users would preferably have to receive international recognition, but so far there was no international standard for codes. Mr. Ross had given a paper* recently in which he discussed the present state of the United Kingdom standards for six, seven and eight-unit codes. The Post Office would try to go along with any code agreed for the international transmission of data.

The attitude of the Post Office was rather different in the case of the telegraph system from what it was in relation to the telephone system. If they provided any error-control equipment for data transmission on the U.K. Telex system—as they expected to fairly shortly—it was hoped that the Post Office would be able to provide equipment for the detection of errors on the circuit, using the check system already mentioned. Developments were in hand to produce an error detection system intended to be available to telex users which could be extended later if required to provide for error correction by automatic means, i.e. by retransmission, in which case it could cope with any type of interruptions occurring on a circuit, and it was expected that it would cater for the extended codes which had been mentioned.

Mr. E. A. Griffiths (*Bristol Siddeley Engines Ltd., Coventry*) said that a little too much emphasis had been placed on the more sophisticated methods of data transmission, probably with an eye to the future. His company did not feel like being guinea pigs in an expensive experiment; they would rather leave that to Government Departments. They had operated over the last three years a perfectly satisfactory Tariff-H private-wire system between Bristol and Coventry, and they did error detection by retransmission at the other end, and then comparing what they sent with what they got back.

They now operated three computers—one at Bristol and two at Coventry—on a compatible basis, pretty well full-time, and this 50-baud system was not overloaded. The only snag was, that they were recording some data on magnetic tape at Bristol, and at $6\frac{1}{2}$ characters per second, it took a long time to transmit it on paper tape. The motor car provided the most efficient means of transferring this information at the moment, but the Company were very interested in future developments in medium-speed/medium-price equipment, suitable for transmitting over switched telephone lines. They were quite happy at the present time with the existing Tariff-H system.

Mr. Long said that Mr. Griffiths's point was supported by 27% of those in Table 5—the people who thought that the telegraph service would meet their needs for the moment. But it was surprising how many people had requirements which, for one reason or another—and it was usually not the need to move a lot of data in a short time—made the telegraph service unsuitable.

Mr. L. R. Crawley (*Standard Telephones and Cables Ltd.*) pointed out that the British Standards Institution was preparing four-, five-, six-, seven- and eight-track standards for paper tape.

Mr. A. P. Clark (*British Telecommunications Research*) referred to the point which had been made that a short burst of errors necessarily required a much longer error-free period on either side in order to achieve automatic correction of these errors, and said that that assumed one type of error-detecting and correcting code; but there were many other codes, which did not require this condition, and therefore did not suffer from this rather severe limitation.

It had been said that a rate of transmission of 600 bauds would be safe for transmission on the public network. He assumed that that applied to frequency modulation. One of the disadvantages of frequency modulation was that it required a somewhat wider frequency band than either amplitude or phase modulation for a given signalling speed.

The Chairman (*Dr. Yates*) then proposed a Vote of Thanks to the two speakers of the morning session for giving such informative and useful addresses, and this concluded the first session of the Conference.

* *See* Ross, H. McG.: "Considerations in Choosing a Character Code for Computers and Punched Tapes," *The Computer Journal*, Vol. 3, p. 202 (January 1961).

ELECTRONIC COMPUTER EXHIBITION AND THE ELECTRONIC DATA PROCESSING SYMPOSIUM

As previously reported (*The Computer Journal*, Vol. 4, p. 63), the Second Electronic Computer Exhibition will be held in the National Hall, Olympia, London, from 3–12 October 1961, under the patronage of H.R.H. The Duke of Edinburgh.

The Symposium on Electronic Data Processing will be held from 4–6 October 1961, also at Olympia.

The British Computer Society will be represented on Stand No. 50, in the gallery, and it is hoped that this will serve as a convenient meeting-point for members of the Society and subscribers to its publications. An interpreter will be in attendance and overseas visitors will be particularly welcome. New members may be introduced and orders placed for publications.