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TELEPHONE TRAFFIC FLOW

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Page

1. INTRODUCTION.

1.1 "Telephone traffic" refers to the volume of calls passing through an exchange or part of an exchange. Just as a technician uses an ammeter to measure current through a circuit, so the traffic section technician uses similar equipment to measure telephone traffic flow. It is possible to take the reading indicating the number of calls at a particular instant, at regular intervals over a period of number of periods, or it is possible to take a continuous recording of the variations in traffic flow during a period.

1.2 With automatic telephony, a large proportion of the cost of providing a telephone service is that needed to provide the common switching equipment in the exchange. The quantity of common switching equipment necessary is dependent upon both the number of calls and the average duration of the calls. Telephone traffic flow records are used as a basis for determining the quantities of automatic switching equipment which provide the best compromise between traffic carrying capacity and economical considerations.

1.3 Telephone Traffic Engineering concerns itself with the collection and usage of telephone traffic data for predicting the quantity of common plant used in a network. Traffic Engineering can be divided into two main categories:-

(a) Traffic Design.

(b) Traffic Supervision.

Traffic Design is the task of collecting traffic data and using it in specific projects at particular points in time. This is the task of the Traffic Engineering Sub-section located in the Planning Branch.

Traffic Supervision is the task of ensuring that the average grade of service provided by a network is satisfactory at all points in time. Traffic Supervision is more the concern of the Engineers and Technicians associated with the Equipment Service Sections.

1.4 It can be seen that a knowledge of Telephone Traffic Flow is essential for both future planning and for maintaining the existing service at a required standard. This note describes the nature of telephone traffic and introduces the principles of traffic flow measurement.

2. GENERAL CONCEPT OF TRAFFIC.

2.1 "Traffic" is a term of common usage. We think in terms of car traffic, pedestrian traffic, plane and telephone traffic.

In each of these traffic forms there is a source or originator demanding service, a system or method of selecting or guiding the service, and the means whereby the service is provided.

For example, in car traffic there is the person wishing to use the car, the steering mechanism together with the signposts etc., indicating the direction to the desired destination, and the lanes on the highway which provide the means whereby the car can travel to its destination.

In telephone traffic, this can be related to the person wishing to make a call, the dial acting as a selecting device and the selecting switches, trunks and junctions providing the means whereby the call can proceed to its destination.

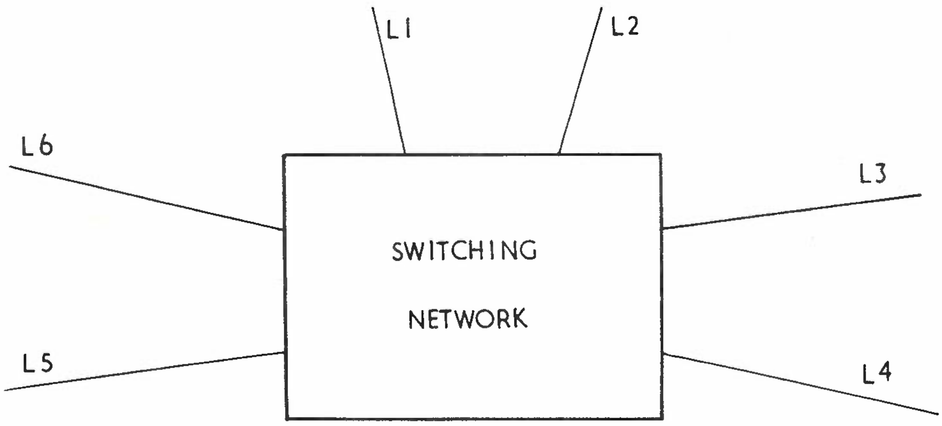

FIG. 1. SIMPLE NETWORK.

Each telephone line in Fig. 1 can "demand" a connection to any other line within the network. Such a demand is termed a call.

A call is the basic item of telephone traffic. The average number of calls over some specified period is called the average offered telephone traffic.

2.2 In practice, a telephone call through the network will pass via a number of switching points or switching stages. At each stage there are a number of incoming source circuits (inlets) which can be switched to a number of outlets (Fig. 2). The basic traffic problem is to provide sufficient circuits so that a certain specified proportion of call demands can be satisfied within prescribed cost limits.

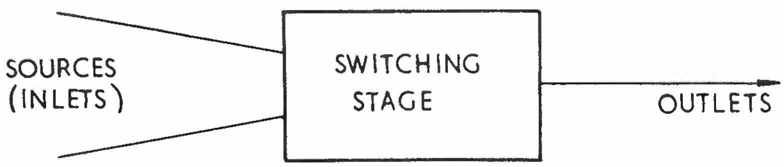

FIG. 2. A BASIC SWITCHING STAGE.

2.3 Additional complications occur in practice due to a variety of circumstances. This is shown in block diagram form in Fig. 3. When the "A" subscriber originates a call, the automatic switching equipment searches for a free connecting path to the "B" subscriber. Assuming that a free route is available, there are still three possibilities; the B subscriber may answer, the B subscriber may not answer, or the B subscriber may be engaged on another call. In the case of the last two possibilities the caller is now confronted with the need for a decision; to give up or to try again. If the decision is to try again, a further decision must be made as to whether the new call is made immediately, after a short wait, or some time much later.

If all connecting paths on any attempted call are all busy, a state of congestion occurs and that call cannot proceed. The caller is once again faced with the decision of abandoning the call or making a fresh attempt.

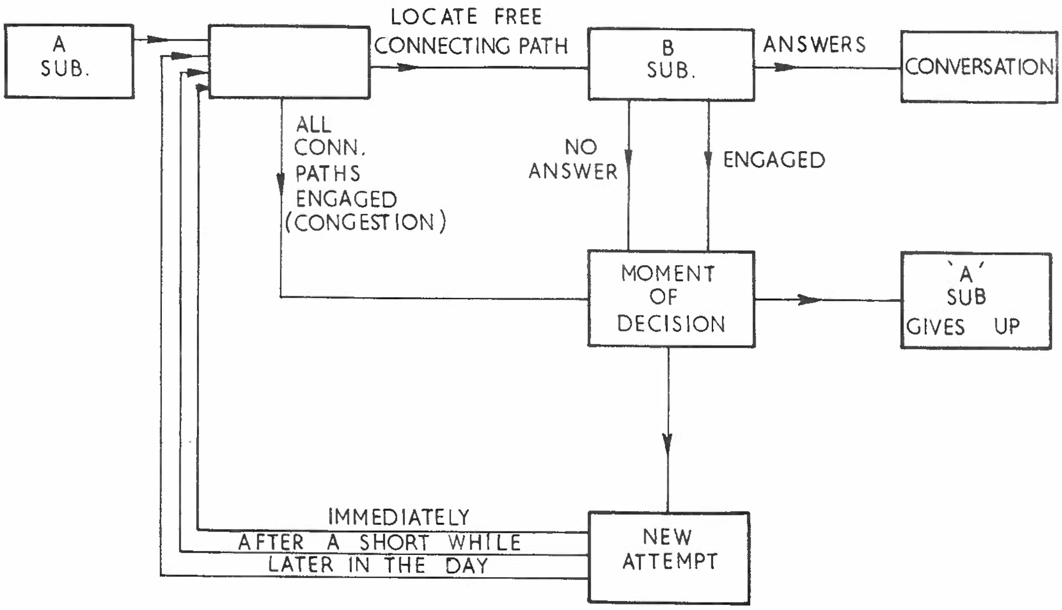

FIG. 3. POSSIBLE OUTCOME OF A CALL.

3. NATURE OF TELEPHONE TRAFFIC.

3.1 SHORT TERM FLUCTUATIONS. The number of calls coming into an exchange is a quantity which varies as a result of a wide variety of circumstances. Any particular subscriber may originate a call as the result of some circumstance such as opening the morning mail, confirmation of social plans, the need to order household requirements etc..

Although these individual calls are random, many of the factors causing them are of a regular nature. As a result of these fairly regular contributing factors, the telephone traffic in any one particular exchange will exhibit certain characteristics in its regular variation. Fig. 4 shows a typical continuous pen recording of the traffic flow over a group of circuits during one hour.

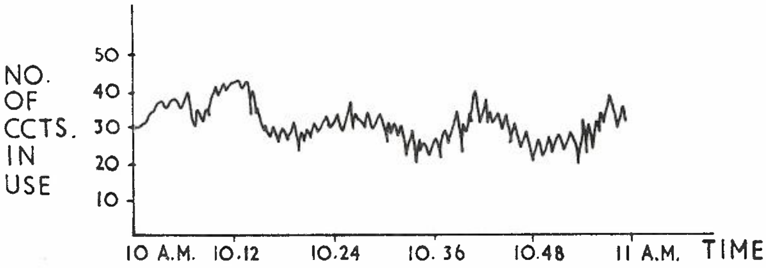

FIG. 4. TRAFFIC FLOW DURING ONE HOUR.

If the exchange in question is in a business area where most of the offices commence at the same hour, it has been observed that a number of the factors contributing to the initiation of a telephone call will occur in many offices at somewhere near the same time. Most exchanges serving a business area exhibit a marked morning peak and afternoon peak as shown in Fig. 5.

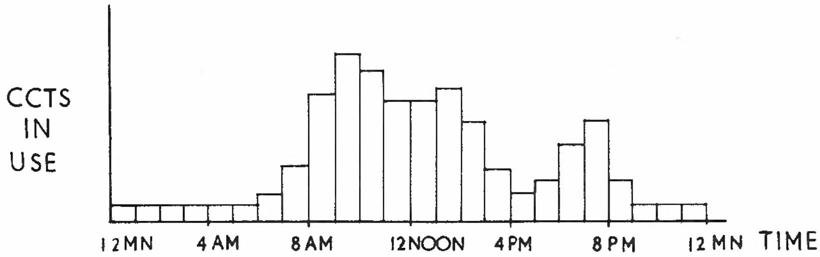

FIG. 5. TRAFFIC FLOW DURING 24 HOURS.

The graph in Fig. 5 represents the average of each hour of traffic during a 24 hour period. In an exchange serving a residential area there is often a heavy peak in the evening due to social calls as well as the normal morning and afternoon peaks.

3.2 LONG TERM FLUCTUATIONS. The traffic flow in an exchange also varies from day to day and from season to season. Fig. 6 shows typical seasonal variations in telephone traffic, based on an average taken over a five day working week.

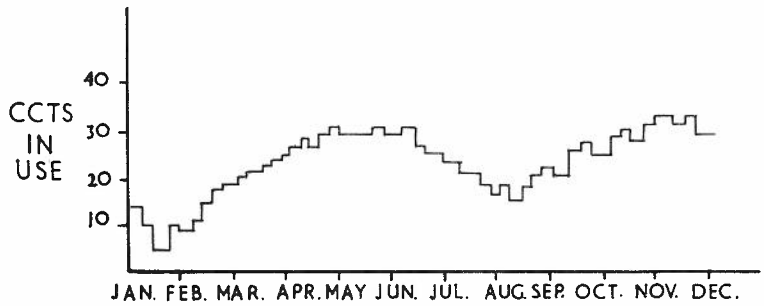

FIG. 6. SEASONAL TRAFFIC VARIATIONS.

If equipment quantities were calculated from the low January reading, the equipment provided would not be sufficient to carry the traffic during the busy November - December period. "Busy season" variations are met by providing sufficient equipment to carry the traffic during the busiest consecutive four weeks of the year. One method of determining this period is by examination of the exchange battery discharge readings. This method shows the period in which the exchange as a whole is at its busiest, but does not show that some particular routes may be busier at other times of the year.

As the traffic flow in most exchanges varies from day to day, traffic measurements are made over a period (often one or two weeks) so that a representative estimate of the average traffic is obtained.

3.3 VARIATIONS IN CHARACTER. In addition to the daily, weekly or seasonal variations, traffic may also be classified according to the degree of random traffic fluctuations from one instant to another about the line of average traffic flow. The three main classifications are:-

- Pure Chance Traffic.
- Traffic Smoother than Pure Chance.
- Traffic Rougher than Pure Chance.

Fig. 7 shows the three types of telephone traffic.

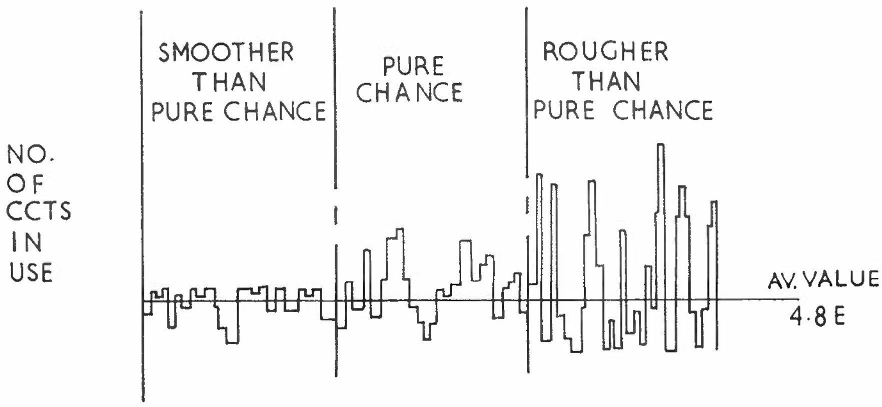

FIG. 7. THREE TYPES OF TELEPHONE TRAFFIC.

In each type of traffic shown in Fig. 7, the average value of traffic over a period is the same (4.8 Erlang). However, when determining amounts of equipment, it is necessary to consider the average traffic and also the type of traffic, as the "rougher" the type of traffic the more switches are necessary to carry the amount of traffic.

As an example, consider a group of ten circuits. If we take the extreme case of ten people all speaking for one hour, then ten circuits would carry an average of ten Erlang. If the same ten circuits at a later stage were in use and idle for equal periods, the average traffic over the observed period would only be five Erlang, even though there were many periods when all ten circuits were in use. (The traffic measuring unit "Erlang" is defined later in para. 4.2).

- PURE CHANCE. Traffic which is assumed to be pure chance is generated by a large number of individual subscribers who make their calls independently of the calls of the other subscribers.

In practice, groups of subscribers larger than 200 tend to generate this type of traffic. In Fig. 8, the average number of simultaneous calls during the period 'T' is represented by the value 'A'. The amount that the traffic varies from this "mean" is shown as V.

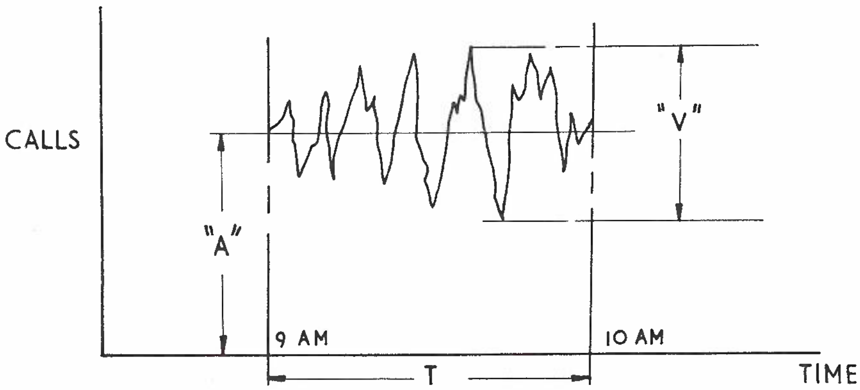

FIG. 8. VARIATION AND AVERAGE.

- SMOOTHER THAN PURE CHANGE. Traffic of this type is characterised by fluctuations about the average which are smaller in general than those of Pure Chance Traffic.

Smooth traffic may be observed on direct or first choice routes where alternate routing is used, and also on the early choice circuits of a step-by-step grading; the smoothing effect is due to the limited number of circuits available to handle the offered traffic, so that peak fluctuations overflow to an alternate route or to the late choice circuits in the grading (Fig. 9).

- ROUGHER THAN PURE CHANCE. This traffic is characterised by fluctuations about the average which are greater than those of Pure Chance Traffic. This type of traffic occurs in the late choice outlets of a grading or on the traffic overflowing from the direct routes to an alternate route (Fig. 11). As the later choices are only taken into use when the earlier choices are busy, the traffic on such choices shows a number of large sudden peaks, interspersed with periods of low volume traffic. This type of traffic flows on D.S.R. overflow routes (Fig. 10).

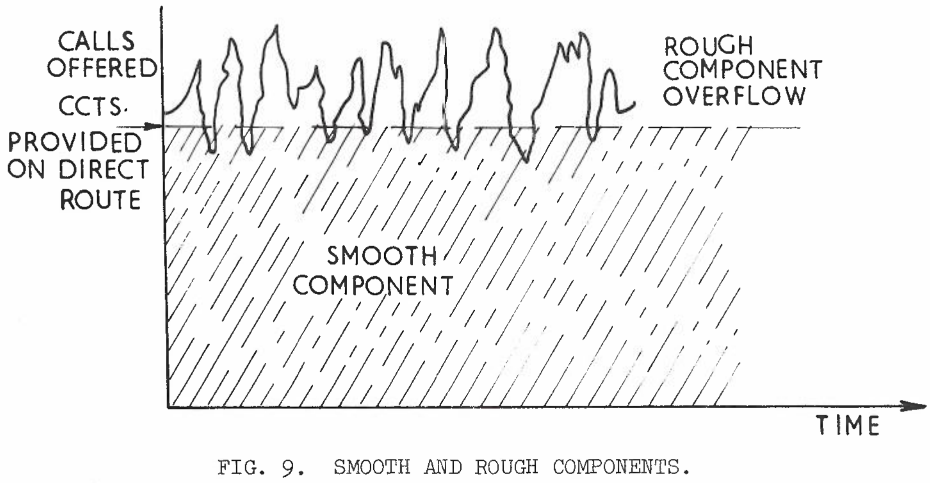

FIG. 9. SMOOTH AND ROUGH COMPONENTS.

3.4 In both Figs. 10 and 11, where a direct route is provided, the traffic is first offered to that route. If the traffic offered is greater than can be carried by the available direct routes, then the overflow traffic is offered to the alternate route. This overflow traffic is rougher than pure chance, while the traffic carried by the direct routes is smoother than pure chance.

Where a direct route is not provided, the traffic is first offered to the alternative route. This means that the traffic offered to the alternative route is a combination of first offered "pure chance" traffic and overflow "rougher than pure chance" traffic.

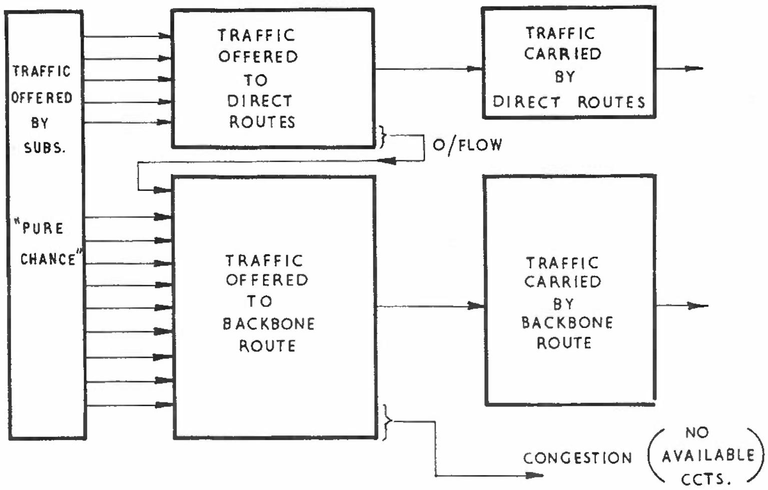

FIG. 10. TYPICAL D.S.R. TRAFFIC PATTERN WITH ALTERNATIVE ROUTING.

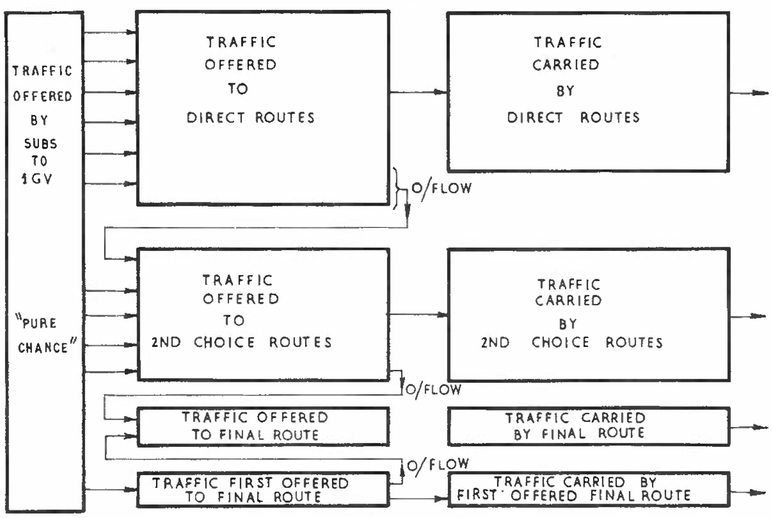

FIG. 11. TRAFFIC PATTERN - ARF 1GV ALTERNATIVE ROUTING.

4. TELEPHONE TRAFFIC TERMS.

4.1 BUSY HOUR. The quantity of switching plant at an exchange must be sufficien to switch through the number of calls at any one time. As it is uneconomical to provide for short peaks of extremely heavy traffic, it is necessary to adopt so arbitrary measure as a balance between the economical considerations and the high traffic handling capacity. The amount of equipment provided is that required to switch the "busy hour" traffic at a "standard grade of service". This means that not more than a certain proportion of calls will be permitted to fail because of a lack of switching equipment.

One method used to determine the busy hour of the traffic carried by a group of circuits on a number of measuring days is as follows:-

- Determine from the traffic readings the average traffic for each half hour during the measuring period of each day.
- The average traffic for each half hour is averaged over all of the measuring days. For example, the traffic from 9 a.m. to 9.30 a.m. is averaged for all of the days, and each other half hour is treated in a simila manner.
- The busy hour is selected by choosing the two consecutive half hours havi the largest average.

This method produces a busy hour known as the Time Consistent Busy Hour (T.C.B.H.) and is the standard method used within the A.P.O.

4.2 UNIT OF TRAFFIC FLOW. Traffic may be measured at an instant or averaged ov a period of time. The internationally accepted unit of telephone traffic is t Erlang (E or Erl).

The telephone traffic (in Erlangs) being carried by a group of circuits at a given instant is the number of simultaneous conversations in progress at that instant. For engineering purposes, it is frequently convenient to average the traffic carrie by a group of circuits over a period of time. If "A" is the average number of simultaneous connections during an observation period, then an average traffic of "A" Erlang is said to be flowing during this period.

4.3 HOLDING TIME. The two factors determing the amount of traffic are the number of calls made during a period and the holding time of each call. To simplify considerations, it may be easier to consider the average holding time for all calls If the holding times for all calls are totalled and the divided by the number of calls (n), the result is the average holding time (h).

$$h = \frac{t1 + t2 + t3 \text{ etc.}}{n}$$

It may be an advantage to express the holding time as a fraction of the total observation period.

$$H = \frac{t1 + t2 + t3 \text{ etc.}}{nT.}$$

The holding times of the individual calls must be measured in the same units as the total Time. Where the time T is one hour (as in the busy hour), H becomes a fraction of one hour and n is the number of calls during that hour.

H and n are known, the average traffic A can be calculated from A = nH where the total number of calls and H is the average holding time of a call. This ession may also be given as A = CT where C is the total calls and T is the age holding time.

PLE. At a certain telephone exchange, a total of 5000 calls are originated ng the busy hour. If the average holding time of each call is 2½ minutes, ulate the traffic flow in Erlangs during this period.

$$\begin{aligned} \text{Traffic Flow } (A) &= nH \\ &= 5000 \times \frac{2.5}{60} \\ &= 5000 \times 0.0416 \\ &= 208.3 \text{ Erlang} \end{aligned}$$

ne call lasted for one hour, one circuit would be occupied for all of that od and there would be an average traffic A = 1 Erlang on that circuit. If each lasted only 3 minutes, 20 calls could be accomodated on the same circuit in one . The average traffic flow A = nH would still be 1.

MEASUREMENT OF TELEPHONE TRAFFIC.

TYPES OF TRAFFIC MEASUREMENT. The three main types of traffic measurement are:-

- Occupancy Measurements. These are measurements of circuit occupancy on existing equipment. These may be divided into two types:
  - (a) Circuit Occupancy - Measurements concerning the occupancy of individual items of equipment.
  - (b) Route Occupancy - Measurements concerning the number of simultaneously occupied devices on a route or within a group of devices.
- Dispersion Measurements. Measurements which record the destination of each call.
- Holding Time.

ıpancy measurements determine the adequacy of trunking on established networks, eas dispersion measurements provide information which is independent of existing ıking and is used when planning re-grouping or re-routing of telephone traffic.

METHODS OF OCCUPANCY MEASUREMENT. The normal method of telephone traffic occupancy measurement is to observe the number of occupied circuits at ılar intervals during the period of measurements. Some methods of observing ffic are:-

- Visual Count.
- Pen Recorder.
- Erlang (hour) Meter.
- Traffic Recorders (Mechanical).
- Resistor Type Traffic Recorders.

5.3 Visual observation of switch groups is tedious and slow, although it may sti be used in some R.A.X. or P.A.B.X. situations. Generally, observations are made electrically, determining the free or busy condition by testing a wire exten from each switch.

Pen Recorder. A portable chart recorder is used by some Traffic Engineering Divisions where measurement of only one or two groups is required. Measuring lea from a number of circuits are arranged together in a group, which is either sampl at two minute intervals or read continuously and the volume of traffic is recorde by the pen recorder on a moving paper chart.

ERLANG HOUR METER. This meter works on a similar principle to the ampere-hour meters used to record A.C. power consumption. The rotational speed of the shaft driving a 6-digit counter is proportional to the traffic flow of the group being read. From the total reading at the end of a period, the average traffic can be ascertained. This meter can only measure one group of circuits.

MECHANICAL. In this type of recorder, the traffic leads are connected in turn by uniselector switching mechanism to a subscribers type recording meter. The number of switches in use is obtained by subtracting the reading on the meter before the recorder is set in motion from the reading at the end of the cycle whe all leads in a group have been measured. One example of this type of recorder is the B.P.O. Traffic Recorder, the principle of which is shown in Fig. 12.

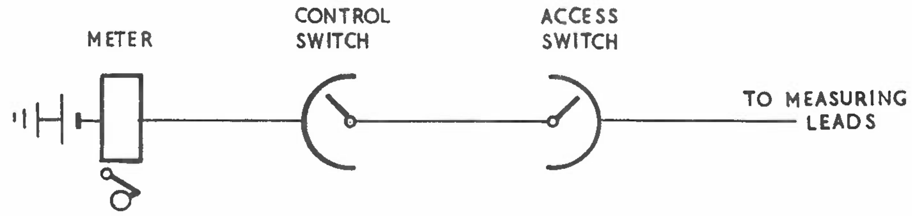

FIG. 12. B.P.O. TRAFFIC RECORDER.

RESISTOR TYPE TRAFFIC RECORDER. One example of this type of recorder is the A.P.(Traffic Recorder, Resistor Type, described in E.I. TELEPHONE, Exchanges Q 0010 (t(drawing CE 11168). With this type of recorder, on each circuit to be measured, a reading point is selected which is at earth potential when the circuit is busy. A high value resistor (usually 100 000 ohms) is connected to this reading point and from the other side of the resistor special wiring is provided to the recording equipment. In step-by-step equipment a typical connecting point is the incoming private connection on a group selector. In later crossbar circuits, the resistor often incorporated in the relay set circuit, and the traffic recording lead is referred to as the TKT lead.

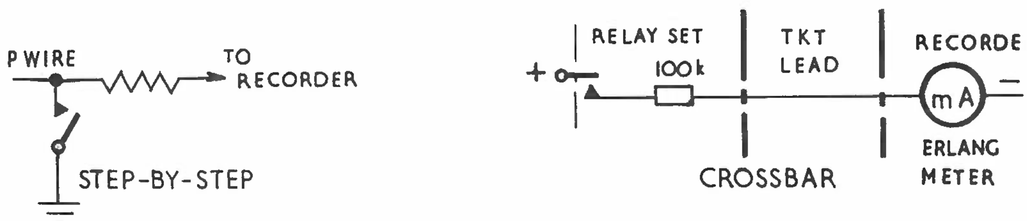

FIG. 13. BASIC PRINCIPLE OF RESISTOR RECORDER.

he basic circuit shown in Fig. 13, when the switch or relay set is in use, ent flows through the resistor and meter. The meter is calibrated in Erlangs registers one Erlang when one circuit is in use. In practice, circuits are not ected individually to the meter, but are commoned together in groups, with a from each group to the meter. As the meter is able to read 200 Erlang, traffic s from up to 200 circuits may be connected in one group. Fig. 14 shows how a er of such groups may be connected via an access switch (in this case a motor elector) and how facilities are also provided which enable connection to an matic tape recorder which records on a magnetic tape or punch paper tape.

may be used to position the switch on the group required or alternatively the ss switch can be stepped automatically, with sufficient time provided for the rding of each group reading before stepping to the next position. A lamp field sually provided to indicate which group is being tested.

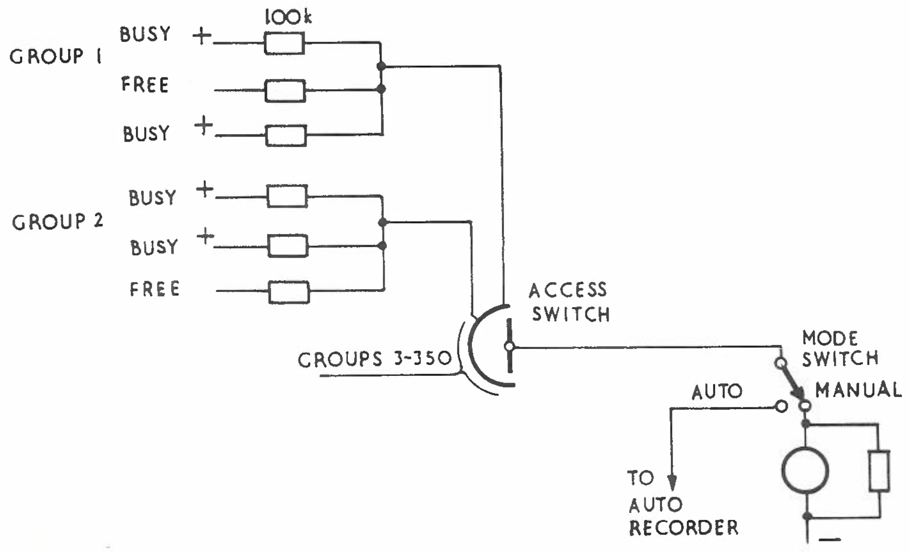

FIG. 14. RESISTOR TYPE TRAFFIC RECORDER.

ı the resistor type recorder, each circuit is used within the one group provides additional parallel path, and the total current flow through the meter is portional to the number of circuit simultaneously engaged within the group under t.

s method is sometimes referred to as the "Analogue Method" because it is a resentation of one physical system in terms of another (i.e., telephone traffic terms of resistance).

A.P.O. has developed a "Mark III" Traffic Data Equipment, which also uses the istor principle for its occupancy measurements. It consists of a crossbar BDH k with relay sets, a traffic I.D.F., and a meter and manual control panel. It is igned to collect three types of data:-

- Route Occupancy.
- Circuit Occupancy.
- Dispersion.

escription of this equipment and its operation when performing occupancy surements is given in the paper "Introduction to Automatic Traffic Data Equipment".

6. ADDITIONAL REFERENCES.

6.1 There are some items of equipment mentioned in this paper which, quite deliberately, have not been described in full detail. For those who wish to study the subject in greater depth, the following references are recommended:-

- A.P.O. Traffic Recorder, Resistor Type — E.I. TELEPHONE Traffic Q 0010
- Siemens Erlang Meter — PLANNING Traffic D 1330
- Basic Telephone Traffic Theory — PLANNING Traffic B 1100

7. TEST QUESTIONS.

1. *Define the term "average offered telephone traffic".*

2. *What is meant by the term "congestion" in relation to telephone traffic?*

3. *Explain the effect of repeated attempted calls to a busy number on the overall traffic situation.*

4. *Show how you would expect the telephone traffic to vary seasonally in*

   (i) a popular seaside resort

   (ii) a ski resort

   (iii) a capital city shopping centre.

5. *In what way does the character of telephone traffic affect the amount of switching equipment required?*

6. *Define the term "Erlang".*

7. *What is meant by the term "Standard Grade of Service"?*

8. *List and briefly describe each of the three main types of traffic measurement.*

9. *Describe the basic principle of a resistor type traffic recorder.*

END OF PAPER