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Subscribers' Private Meter Equipment

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Detailed telephone accounts will be replaced by bulk-billing when subscriber trunk dialling is introduced, and to give subscribers the equivalent of the Advise Duration and Charge (A.D.C.) facility, private meters may be provided at their premises on a rental basis. These meters will register the total chargeable units and also the units chargeable for the last call, or series of calls, made. This article describes the method of signalling meter information from the main exchange to the subscribers' premises and also the development of the types of meter to be used on individual exchange lines and at private branch exchanges.

INTRODUCTION

ON the introduction of subscriber trunk dialling (S.T.D.), private meters will be available, at appropriate rentals, for association with the telephones of direct exchange lines and for association with the switchboards of private branch exchanges (P.B.X.s). Meters for individual lines will register total chargeable units, and also indicate the units chargeable to the last call, or series of calls, made. Meters associated with P.B.X. installations with more than three exchange lines have to meet other requirements. The method of signalling meter information to subscribers' premises from the main exchange is the same for all the types of meters described in this article.

EXCHANGE EQUIPMENT AND METHOD OF SIGNALLING

Development of the Metering System

The periodic-metering system[1] which is being introduced with S.T.D. involves the operation of the subscriber's exchange meter while conversation is taking place. It is possible to arrange for the subscriber's private meter to operate at the same time as the exchange meter or for the information to be stored at the exchange and repeated over the line on completion of the call. The former arrangement is considered preferable as it avoids the cost of storage equipment. It is necessary, however, to ensure that signals sent from the exchange to operate the private meter are inaudible. Any system using d.c. signals is likely to cause interruption to speech, so it was decided to use a.c. signals.

The use of a super-audio frequency to obtain the desired inaudibility would involve special frequency-generation equipment, special distribution arrangements and, probably, in view of the high attenuation of underground cable pairs, a transistor amplifier at the subscriber's premises. On the other hand, a system transmitting longitudinal 50 c/s current pulses over the earth phantom of the subscriber's line could be comparatively cheap and would, theoretically, be noiseless provided lines and apparatus were accurately balanced with respect to earth. However, little information was available about the values of longitudinal 50 c/s voltage of short duration that could be transmitted with the nominally balanced transmission bridges and lines existing in the field, without noise becoming audible during speech. (The C.C.I.T.T. recommended limits, for psophometric e.m.f.s., of 5 mV for open-wire circuits and 2 mV for cable circuits apply to continuous noise). It was known that serious noise interference had been experienced on certain shared-service lines that were subject to interference from the 50 c/s national grid system, and that this had been due to the generation of harmonics in the bridge rectifier and relay connected between each line and earth[2]. It appeared, therefore, that the subscriber's private meter would have to be of a design considerably different from that of any Post Office standard meter, and many tests were made to prove the feasibility of the scheme and to determine the required characteristics of the private meter.

As a result of these tests transverse psophometric voltages of 1 mV were found to be tolerable, and 2 mV disturbing, and it was decided, from a design point of view, that if possible psophometric transverse voltages during metering should not exceed 0·2 mV. (It is of interest to note that when an a.c.-operated private meter, in common use on the Continent, was tested using a signal voltage of 80 volts, 50 c/s to give the meter its minimum operate current of 35 mA, noise levels of the order of 5 mV were measured). The tests showed that if a meter could be designed to operate at a current of about 1–2 mA with an applied voltage of the order of 30–40 volts, the system would be satisfactory from a noise-level point of view. To avoid the provision of extra spring-sets in the telephone circuit to isolate the meter during dialling or ringing operations, the meter would be required (*a*) to have negligible shunt capacitance to minimize dial-pulse distortion, and (*b*) to be sharply tuned to 50 c/s to prevent false operation to ringing current at 17 c/s or 25 c/s. As described later, meters have been designed which can be operated with an acceptable margin of safety over subscribers' lines of 1000 ohms resistance. Using imperfectly balanced transmission bridges, transverse noise voltages of the order of only 0·03 mV were measured on good lines and 0·3 mV on lines with leakance unbalance.

Circuit Operation

Fig. 1 shows the simplified circuit arrangement for operation of the private meter on a direct exchange line. Transformer T1 is of a type specially checked during manufacture to ensure good balance of the secondary windings. Relay M is operated on outgoing calls in parallel with the subscriber's ordinary meter, the meter pulses being of 200–250 ms duration, repeated at intervals determined by the charging rate. The operation of relay M results in a longitudinal voltage of 45 volts, 50 c/s being applied to the phantom of the calling subscriber's line from earth at the transmission bridge to earth via the private meter at the subscriber's premises. The figure of 45 volts ensures satisfactory operation of the meter without it being high enough to cause saturation of the injection transformer or to cause noise. Capacitor C1 and the primary of the injection transformer form a

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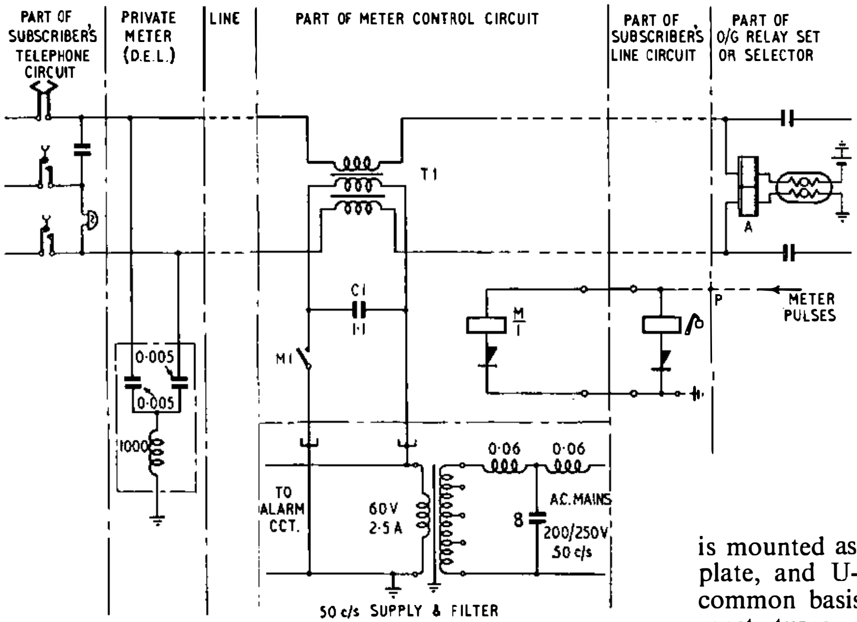
[1]WALKER, N., Periodic Metering. (In this issue of the *P.O.E.E.J.*)

[2]COBBE, D. W. R. Noise Interference from External Sources *P.O.E.E.J.*, Vol. 48, p. 41, Apr. 1955.



The 1,000-henry inductor in the private-meter circuit is the operating coil of the meter

FIG. 1—SUBSCRIBER'S PRIVATE-METER CONTROL CIRCUIT

parallel-tuned circuit such that minimum current is drawn from the supply. Provision is made for the inclusion of a filter in the mains supply if measurements on installation indicate that the harmonic content of the 200–250 volts mains supply exceeds 0·2 volts r.m.s. for any odd harmonics from the fifth upwards. The cost of the filter and the additional current consumed render its universal adoption undesirable.

On a call within an exchange, two subscribers, each equipped with private meters, may be connected together via the transmission bridge of a final selector. Since the transmission-bridge relays are inductive to transverse currents only, the bridge offers a low-impedance path to earth to the longitudinal metering currents and the called subscriber's meter is therefore effectively shunted. The voltage developed across this meter is of the order of 5 mV and there is therefore no chance of it operating.

Depending on the number of subscribers equipped with private meters, the control equipment can be placed between the subscriber's line and the associated L and K relays, i.e. be provided on the basis of separate equipment for each line, or can be placed between uniselector outlets and first selectors, i.e. provided on a common basis. Provision on a common basis would mean that 50 c/s meter-pulses would be transmitted to some subscribers' lines which were not equipped with private meters, including shared-service lines. Since shared-service subscribers' lines are connected to earth via the bell circuit, metering current would flow, dependent on the type of telephone used. While the thermistors in the bell circuits of certain telephones (e.g. Telephones No. 312) would not become sufficiently low resistance during the 250 ms meter-pulse, even at maximum pulse-repetition rate, for any effects such as bell tinkling or noise to develop, the rectifier and relay circuits used with other types of telephones (e.g. Telephones No. 310) would respond to the meter pulses, thereby causing noise and bell tinkling. Furthermore, the occurrence of the earth-calling condition on one of a sharing pair of circuits would produce noise if it coincided with a.c. meter pulses being transmitted on the other circuit of the pair. Provision of the metering equipment on a common basis would only be made, therefore, if trunking arrangements permitted segregation of shared-service subscribers. Future developments in the provision of shared service might remove this limitation.

When a separate metering control circuit is provided for each line fitted with a private meter the circuit is arranged to permit routine testing of the subscriber's exchange meter without transmitting a.c. meter pulses to the private meter. This requirement does not arise, of course, when the metering equipment is provided on a common basis.

The line a.c. injection equipment is mounted as a relay-set, two circuits on one mounting plate, and U-point strapping caters for connexion on a common basis or connexion on a "per line" basis to most types of subscribers' linefinder or uniselector circuits.

THE SUBSCRIBERS' PRIVATE METER

When the decision was taken to provide for a meter at the subscriber's premises, to be operated over the phantom circuit to earth, it soon became apparent that an entirely new and sensitive metering device would have to be developed. Existing Post Office apparatus had been designed to take far more power than could be allowed for the projected meter. A 100-type meter, for instance, needs about 40 mA for operation.

A review was made of the various meters that were available both in this country and abroad, but none appeared to meet the requirements, and the development of a suitable instrument was therefore put in hand. The two versions of the meter which were evolved are shown in Fig. 2 and 3. That shown in Fig. 2 has been coded Meter No. 19/FRA, while the version shown in Fig. 3 has been coded Meter No. 19/SSS.

Appearance

Because the meters will be used in subscribers' premises, appearance is of prime importance, and considerable effort has been expended in producing the final designs, both of which have been approved by the Council of Industrial Design.

A clock-face presentation was adopted because it was considered that at a normal operating voltage of 30 volts (minimum 20 volts), which was then under consideration, the wheel type of meter would need too much current, particularly as the meter was to give two readings, i.e. the total chargeable units and the units charged to the last call or series of calls. The latter reading is analogous to the "trip" reading on a car speedometer and will be referred to as the "trip" reading in this article.

It will be seen that both versions of the meters have three hands. The units hand and the resettable trip hand move one division of the scale for each operating pulse while the hundreds hand moves progressively over its scale, each division of which represents a complete revolution of the units hand. The trip hand is returned to zero by depressing the arm on one meter or by pressing the button on the other meter. Although the two designs are

FIG. 2—METER NO. 19 FRA

quite different in construction and appearance, every effort has been made to ensure that the scales are similar.

Electrical Characteristics

One of the difficulties encountered during testing was to obtain sufficient rejection of the ringing voltage while retaining the necessary sensitivity to the operating voltage. For the ringing voltage a test figure of 120 volts, 25 c/s was adopted to cover adequately the highest voltage likely to be encountered under light ringing-load conditions. The normal operating voltage originally selected was 30 volts, but this was later increased to 45 volts to assist in making the meter insensitive to ringing voltages. Many circuits were considered in attempts to solve the ringing-rejection problem but as it was desirable to reject the ringing voltage even with the A wire disconnected, as might arise under fault conditions, a straightforward series-tuned circuit appeared to be the best practical approach.

The approximate values of the components finally chosen are indicated in Fig. 1. One meter has an impedance of approximately 75,000 ohms at 50 c/s in the operated position and takes a total current of approximately 0·6 mA, i.e. 0·3 mA per line wire. The circuit is sharply tuned, so that a variation in frequency of only $1\frac{1}{2}$ c/s reduces the operating current by 20 per cent. The other meter takes approximately 0·3 mA total current. Although the normal operating voltage is 45 volts, it was decided that the meters should operate satisfactorily at 32 volts, 50 c/s to allow for possible variations in: (*a*) the voltage and frequency of the mains supply and the standby generators, (*b*) the tolerances on the mains transformer and the injection transformer, and (*c*) the possible increase in friction in the mechanism over a period of use.

The meters take so little current that any out-of-balance voltages and consequent noise are negligible. Similarly the transmission loss due to the meter is negligible, the loss of 0·8 db in the metering circuit being due to the presence of the injection transformer.

The value of the capacitors is so small that the presence of the meter on a subscriber's line will not be detected by normal test-desk procedure—neither will normal line-testing affect the meter.

FIG. 3—METER NO. 19/SSS

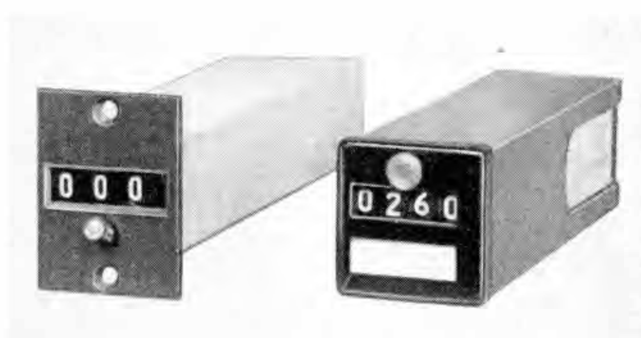
Use

The subscribers' private meter will be available for use with exclusive direct exchange lines, including those with extensions, small cordless switchboards, P.B.X. extensions and house exchange systems. It will be supplied complete with a 54 in. grebe-grey cord which normally will be connected into the instrument terminal block. A cover in the base of the meter gives access to the cord connexion screws, but the meter is sealed to prevent further access.

METERING AT PRIVATE BRANCH EXCHANGES

For economic reasons the subscribers' private meter is used for metering at cordless private manual branch exchanges with not more than three exchange lines. It is too bulky, however, for use on larger switchboards and for these the number-wheel type of meter has been adopted. Of the meters that were available, the exchange type (Fig. 4(*b*)) was chosen for total metering, but none met the requirements of trip metering and for this purpose a suitable meter (Fig. 4(*a*)) had to be developed. To meet the wide range of P.B.X. voltages, two versions of this meter have been produced: Meter No. 20A for 20–30 volt working and Meter No. 20B for 40–55 volt working.

These meters require too much power to be driven direct from the metering signal. This poses no problem



(*a*) (*b*)

FIG. 4.—(*a*) RESETTABLE COUNTER (METER NO. 20A) USED FOR TRIP METERING
(*b*) EXCHANGE-TYPE METER USED FOR TOTAL METERING

since power is available from the P.B.X. battery. It does however entail the provision of a metering unit (Fig. 5) to convert the incoming signal into a suitable pulse for operating the total and trip meters.

Facilities

The facilities available with number-wheel counters are total metering only, trip only and both total and trip.

Total metering is required by a subscriber wishing to keep a running total of his call charges. It is provided on a line-by-line basis and, clearly, in order to provide an overall total charge, all lines must be metered. Each line requires a metering unit, which can be used for trip-metering where this facility is also required.

Trip metering enables the operator to determine the costs of individual calls when required to do so by the subscriber. Thus under S.T.D. it replaces the Advise Duration and Charge service hitherto available to the operator. It is available as "straightforward" and "switched" metering, to meet the respective needs of the heavy and light user. With straightforward metering, switchboard meters are permanently associated with exchange lines, whereas with switched metering the meters, normally limited to two per switchboard position, are permanently associated with rotary switches, each of which gives access to up to 10 lines. Straightforward metering is not, however, appropriate for multiple-type installations where the larger number of exchange lines to be served and the appearance of the same lines on several positions would require the provision and accommodation of a large number of meters, and the duplication of the displays might create operating difficulties. Instead, the limit on the number of meter/switch combinations is raised to three. With switched trip-metering a measure of straightforward working can of course be achieved by the operator leaving idle meters switched to late-choice lines.

Although the facility itself is not affected, switched trip metering can be provided either by switching meters to metering units, already provided where total metering is practised, or by switching to line a combination of a metering unit permanently connected to a meter. The latter method, using fewer units, is normally adopted for economy where total metering is not required.

At cordless manual switchboards the use of the subscribers' private meter restricts the facilities to (*a*) combined total and trip, and (*b*) switched trip-metering. The latter is provided by a single meter connected to a 2-position or 3-position lever key for line selection. In this application the "totals" reading is of little significance.

The Metering Unit

The metering unit, Unit, Metering, No. 1A (Fig. 5), provides an output pulse of 100 ms minimum duration, after a delay of not less than 70 ms, from line signals in the range 37–45 volts, 48–51 c/s, 180–320 ms duration. This minimum output pulse ensures satisfactory meter stepping at the lower limits of the operating voltage ranges, e.g. 20 volts for Meter No. 20A, 40 volts for No. 20B; the delay of the device, together with the operating lags of the meters, guards against false operation by line-to-earth surge currents, as occur for instance when the line is under test from the exchange test-desk. The line current at 45 volts, 50 c/s is 1·2–1·5 mA, which is higher than that for the subscribers' private meter but necessarily so to allow for subsequent possible changes in the characteristics of the relay. The unit gives good rejection of incoming exchange ringing current especially where, under fault conditions, the ringing return circuit is completed via the metering unit and earth. Samples of the unit have been immune under such conditions to 25 c/s ringing at voltages exceeding 120 volts.

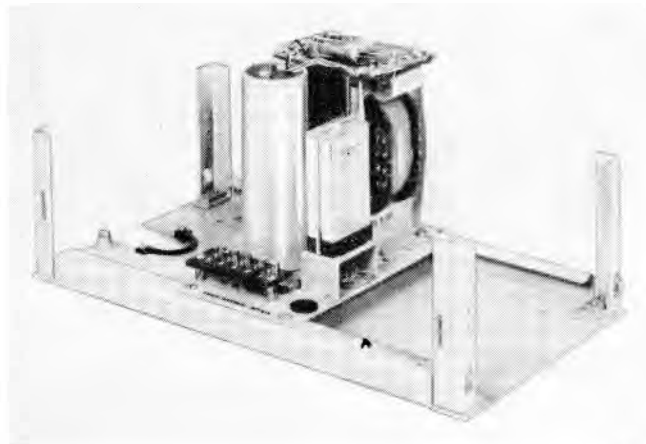


FIG. 5—METERING UNIT (UNIT, METERING, NO. 1A) MOUNTED ON A THREE-WAY PLATE

The relay, a miniature plug-in type of proprietary design, is polarized and has a one-side-stable characteristic. Thus the low-power-consumption feature of the polarized relay has been utilized, whilst avoiding the complication (that would arise with existing both-side-stable types) of providing stabilized power supplies at P.B.X.s for biasing purposes. In the circuit (Fig. 6) the function and value of capacitor C3 call for special comment. This capacitor smooths the rectified signal but, more important, provides, together with the effective resistance of the acceptor circuit (C1, C2, L1), a means of preventing transient operations of the relay. This integrating circuit also delays the metering signal but undue pulse shortening is avoided by the action of C3, which retards the release of the relay, and by the ringing of the tuned circuit on cessation of the signal.

Too high a value of C3 would introduce a delay which is too great for satisfactory operation of the relay to metering pulses, whereas with C3 too low in value short transient pulses would set up circulating currents in the relay-capacitor circuit sufficiently large to operate the relay and thus to nullify the effect of the time-delay feature. The value chosen (10μF) is therefore a com-

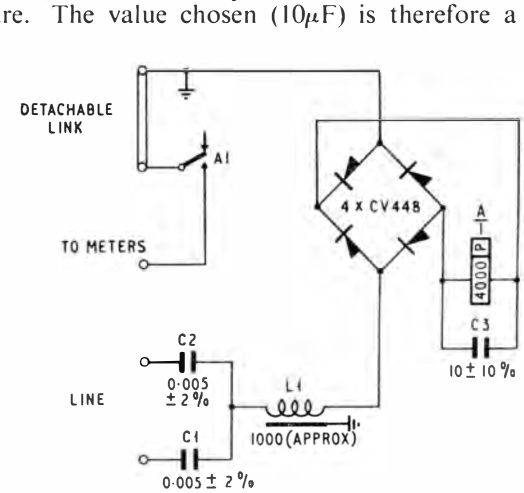


FIG. 6—SCHEMATIC DIAGRAM OF METERING UNIT

promise, and to achieve a close tolerance a metallized-paper-dielectric capacitor is used.

Mounting of Equipment

In choosing mounting arrangements for the equipment, the needs of the operator have naturally come first. The trip meters must be mounted on the switchboard and the readings clearly visible. In main exchanges timing meters are fitted to the key-shelf but there are practical objections to using this method for existing types of P.B.X. Instead, at P.B.X.s, the meters are mounted at eye level. Totals meters, being of less concern to the operator, are mounted away from the switchboard. Metering units are also mounted away from the switchboard in a suitable location such as the apparatus room, where one is available.

At single-position cord-type switchboards, trip meters and rotary switches are housed in a case fixed to the side of the switchboard. Two meters and two switches can be accommodated in one case. For multiple installations the meters, etc., are mounted on a plate and fitted in the face panel. Totals meters are fitted in groups of five in wooden cases, mounted in a convenient position away from the switchboard.

At P.A.B.X. No. 1 switchboards, the trip meters, rotary switches and sundry supervisory equipment (described later) are mounted in a box fixed to the top of the switchboard. Totals meters are mounted as previously described.

Cordless manual switchboards have the subscribers' private meters fitted to a plinth on top of the switchboard, with the lever key fixed above the second exchange-line indicator and positioned for horizontal throw.

For wall mounting of metering units, mounting plates with 6 in. deep dust covers are provided having capacities for 1, 3 and 5 units. The 5-way plate is suitable also for mounting on apparatus racks having 19 in. mounting plates.

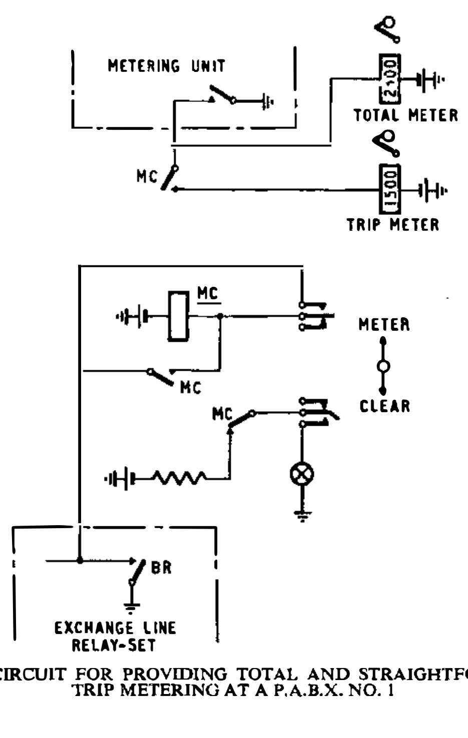


FIG. 7—CIRCUIT FOR PROVIDING TOTAL AND STRAIGHTFORWARD TRIP METERING AT A P.A.B.X. NO. 1

Supervising Facility for P.A.B.X. No. 1 Switchboards

In order to effect trip metering at P.A.B.X. No. 1 installations a supervisory circuit is necessary both to advise the operator of clears and also to prevent the trip total being added to by a directly dialled follow-on call.

A suitable circuit for straightforward trip metering is shown in Fig. 7. To start trip metering, the key is moved to the non-locking "meter" position, and then to the locking "clear" position. The first movement operates relay MC, which connects the meter to the metering unit, and the second movement prepares the circuit for the supervisory lamp. At the conclusion of the call, relay MC in releasing disconnects the meter and lights the lamp. This is extinguished on the restoration of the key to normal

With switched trip metering, the "clear" function of the key is dispensed with, the lamp circuit being completed via contacts of the rotary switch, which, when rotated to "off," or to an unused position, extinguishes the lamp.

Difficulties Encountered at Private Branch Exchanges

The maintenance of accuracy in the meter readings and the prevention of noise in the telephone loop are complicated at P.B.X.s by the fact that in certain circumstances the P.B.X. circuit may offer to the metering signal a path to earth of much lower impedance (zero in the worst case) than that of the metering unit. When this occurs the meters fail to register and a loud noise is heard on the line.

In most cases, difficulty can be avoided by appropriate operating procedures, and strict discipline in this respect is required. This will not, however, always overcome the difficulty and the intruding earth has to be masked from the metering unit. This is done by fitting a double-wound choke in the exchange line (one winding to each leg) connected so as to be inductive to longitudinal signals but non-inductive to transverse currents.

CONCLUSION

The metering arrangements that have been described will meet the known requirements of direct-exchange-line and P.B.X. subscribers. The P.B.X. arrangements are flexible in that they are readily adaptable to meet special requirements, e.g. totalling of switched trip readings. They also allow the facilities to be added to existing installations with a minimum of constructional change to the switchboard, and enable the work to be carried out with small disturbance to the operation of a working switchboard.

ACKNOWLEDGEMENTS

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