THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL

Vol. 50 JANUARY 1958 Part 4

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Price 2/6 net

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Flameproof Telephones and the Development of a Table Model

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U.D.C. 621.395.721.1:614.83

This article outlines the methods of ensuring that telephones used in situations where dangerous gases and vapours are present do not cause explosions, and refers to the arrangements for certification of the degree of safety provided by specific items of telephone apparatus. The article then refers briefly to existing Post Office flameproof telephones and continues with descriptions of two versions of a newly developed table model flameproof telephone.

Introduction

ALTHOUGH the telephone works at such low power that its safety in everyday use is never in question, there are circumstances in which great care must be taken to ensure that a spark at a contact or at an accidental disconnexion cannot cause an explosion if dangerous gases or vapours should be present.

Oil refineries and chemical plants are perhaps the two main places which spring to mind when considering where explosive gases might occur, and with the increasing consumption of both oil products and synthetic materials, and the consequent increase in the number and size of the industrial plants concerned, the safety of life and plant from the dangers of explosion is worthy of all the care and attention that is given to the design and manufacture, and the installation and maintenance of special equipment.

Telephone apparatus for use in mines, which is not fitted by the Post Office, is outside the scope of this article. The design, installation and maintenance of all telephone and signalling apparatus for use in mines is governed by the Mines and Quarries Act 1954, and the specific requirements are given in Statutory Rules and Orders No. 797 and No. 1407: 1938.

Methods of Providing Safety

Although alternative methods are occasionally used in heavier forms of electrical engineering, in telephone engineering the two principal methods of providing safety utilize either a circuit that is safe because it cannot cause a dangerous spark (intrinsic safety), or a mechanical construction that will withstand an internal explosion and will not transmit flame outwards to an external explosive atmosphere (flameproof construction).

These two methods, which are described in more detail in the following sections, are the subject of practical tests which are imposed on actual items of equipment by the Safety in Mines Research Establishment at Sheffield and Buxton. On the results of these tests, a Flameproof Certificate is issued by the Ministry of Power, or a Certificate of Intrinsic Safety is issued by H.M. Chief Inspector of Factories, Ministry of Labour and National Service, or the Ministry of Power, depending on whether the equipment is for use in industry or coal mines. The equipment is type tested, i.e. the item that is tested is regarded as fully representative of the manufacturer's normal production and the certificate covers this normal production. Any subsequent change to the drawing mentioned on the certificate requires further certification.

There are cases, however, where it is not practical to use either of these two methods, and in such cases safety can be ensured as far as possible by the method and standard of construction. The Factory Inspectorate of the Ministry of Labour and National Service again issue a certificate after consultation with the Safety in Mines Research Establishment. An example of this type of certification is described later when dealing with the development of the flameproof table telephone (1,000-ohm version).

It has not yet been practicable to make a telephone handset and cord flameproof according to the requirements of B.S.229 "Flameproof Enclosure of Electrical Apparatus," and hence, although telephones are commonly described as flameproof, usually only certain parts have been certified as such. Consequently it should be realized that in these instances the term "flameproof" is not strictly correct as a description of the complete telephone, but it is used as a convenient indication of the type of installation for which the telephone is intended.

Intrinsic Safety

Protection by the method of intrinsic safety is achieved by using a safe source of supply, either primary cells whose open circuit voltage does not exceed 24V, or a special transformer of 15V r.m.s., or in the case of a magneto telephone, by using an approved generator. All these sources of supply have limited short-circuit currents, the limitation usually being obtained by using series resistors or in the case of the generator by the inherently high impedance of the windings in conjunction with a non-inductive shunt resistor. Furthermore, the supply must not be earthed. Together with the limiting of the source of supply, it is usual to fit protective devices in the form of non-inductive resistors or metal rectifiers across the inductive components of the circuit to by-pass the inductive energy that would normally appear as a spark at switching points during the operation of the circuit. By these means any sparks, which might appear at switching points or at any point of fault, are of such low intensity that they are incapable of igniting the gas or vapour which might be present. Intrinsic safety is the statutory method used for signalling and for telephones in coal mines (Mines and Quarries Act 1954). The main reason for this is the need for the telephone system to keep pace with the moving coal face without undue attention to the standard of cabling.

Flameproof Apparatus

With protection in the form of flameproof apparatus no steps are taken to prevent the sparking that would normally occur during operation of the circuit or which might occur under fault conditions. The protection is obtained by enclosing the components in a robust metal enclosure, defined in B.S.229 : 1957 as:—

"A flameproof enclosure for electrical apparatus is one that will withstand, without injury, any explosion of the prescribed flammable* gas that may occur within it under practical conditions of operation within the rating of the apparatus (and recognized overloads, if any, associated therewith), and will prevent the transmission of flame such as will ignite the prescribed flammable gas which may be present in the surrounding atmosphere."

The design of such an enclosure is based on the following data. All joints in a flameproof enclosure must be either flanged joints, spigoted joints or screwed joints without the

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* The term "flammable," now used by the British Standards Institution, is synonymous with the more common term "inflammable."

intervention of any loose or perishable packing. The width of these joints and the maximum permissible gap are related to the groups of gases and vapours listed in B.S.229. The flange width in general should be at least 1 in. with a maximum permissible gap of 0·016 in., although where the gap can be more accurately controlled, widths of ½ in. are now acceptable. The maximum gap related to the ½-in. flange is 0·006 in. for the gases encountered in the petroleum and chemical industries.

The tests to ensure that the maximum permissible gap is not exceeded are made by checking that each part of the mating surfaces of the flanges does not vary from a true plane by more than half the stated figure, i.e. for telephone equipment covered by this article, the maximum variation is not greater than 0·003 in.

Where an operating rod or spindle passes through the wall of a flameproof enclosure, it must be of metal and the hole through which it passes must be such that the effective length of the flame-path is not less than 1 in., fitting as closely as operating conditions permit. In no case must the diametral clearances of the flame-path exceed 0·016 in. and 0·008 in. for gases in Groups II and III respectively.

For the purposes of flameproof certification, gases are divided into four groups as follows.

Group I covers requirements for coal mines.

Group II covers, in general, the petroleum, chemical and paint industries. Prior to 1957, this group was divided into five sub-groups *a*, *b*, *c*, *d* and *e* according to the types of gases met in particular classes of industry.

Group III, divided into two sub-groups, covers (*a*) the more sensitive vapours of the petroleum industry and (*b*) coal gas and coke oven gas.

Group IV. The gases (including hydrogen and acetylene) in this group demand a maximum permissible gap which is too small to be practicable to justify certification on the basis of type tests. It is possible to produce apparatus which will withstand a hydrogen test but it is doubtful whether the same standards of construction could reasonably be expected in commercial production. Approval for individual apparatus for use with gases in this group is usually given in the form of a Test Report issued by the Ministry of Power.

When apparatus is certified, the certificate quotes the groups of gases for which the apparatus is considered suitable. The apparatus should not be used in gases of other groups even though the test conditions appear to be the same. If the apparatus were suitable for use in other gases, quite naturally the manufacturer would ensure adequate certification to increase his sales.

The onus for prescribing the groups of gases which might be encountered in any telephone installation rests with the subscriber. Care should then be taken that any apparatus which is used is certified for those groups.

Existing Flameproof Apparatus

Because of the rigid mechanical requirements, flameproof apparatus has always tended to be strictly functional, and in general the lack of aesthetic appearance has not been questioned.

Fig. **1** shows the Post Office Telephone No. 149, which has been available for use on automatic and C.B. systems for many years. A similar instrument, the Telephone No. 153, has also been available for magneto working. These telephones will continue to be available for installations where the newly developed table telephone cannot be used. They are wall-mounted instruments and are weatherproof.

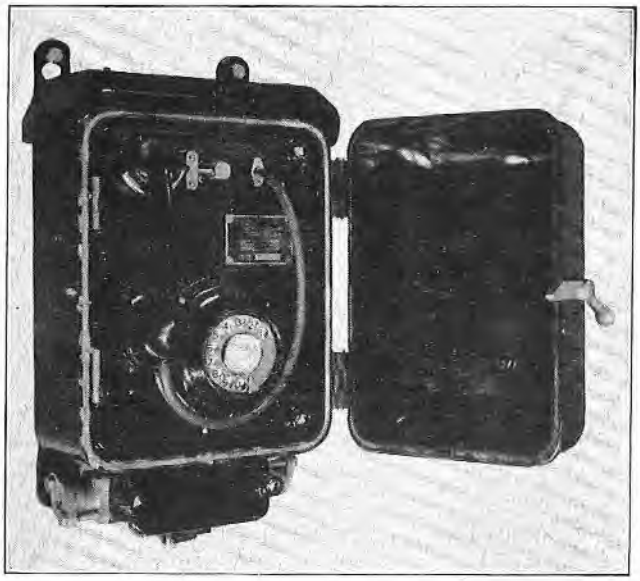

Fig. 1.—Telephone No. 149.

Certificates of flameproof construction which they carry (Groups II and III for the Telephone No. 149 and Groups I and II for the Telephone No. 153) relate only to the enclosure of the more dangerous elements of the circuit such as the dial and the switch-hook contacts.

Development of a Flameproof Table Telephone (600-ohm Version)

The remarkable developments by the oil industry in the production, refining and distribution techniques of petroleum products have created an increased demand for telephone equipment. It is now commonplace to have remote control rooms in which are housed metering and recording equipment together with the control desks. Telephones are essential features in these control rooms and, apart from their flameproof properties, it was considered desirable that they should be similar to the conventional table telephones if the appearance and function of the control rooms were to be maintained. Consequently the development of a table model was put in hand, and it was soon apparent that the design would have to be based on the following lines:—

(*a*) The bell should be housed in a separate enclosure due to the difficulty of finding a suitable arrangement for the bell gongs. The gongs could not be mounted on the outside of the telephone case if appearance were to be preserved, and they could not be mounted inside, for there they would not be heard.

(*b*) The line connexion to the instrument should be via a flexible cable to permit the telephone to be moved to suit the convenience of the user.

These two considerations led to the design of a unit in which is housed the bell and also the terminal block for the connexion of the rigid permanent line.

The bell coils are mounted inside the case and their cores are carried through the case to actuate the bell-hammers. The bell and terminal unit, which is shown in Fig. **2**, can be fitted in a convenient place near the telephone, and connected to it by a tough rubber-sheathed cable, which is a permitted cable in areas when only an occasional hazard may exist. Being a separate unit, the bell and terminal unit can also be mounted as an extension bell if desired.

A range of glands has been developed to enable conduit or any of the accepted forms of permanent cabling for hazardous areas to be connected easily and safely to the bell and terminal unit.

The case of the telephone instrument, shown in Fig. **2** and **3**, is constructed throughout in aluminium alloy LM6,

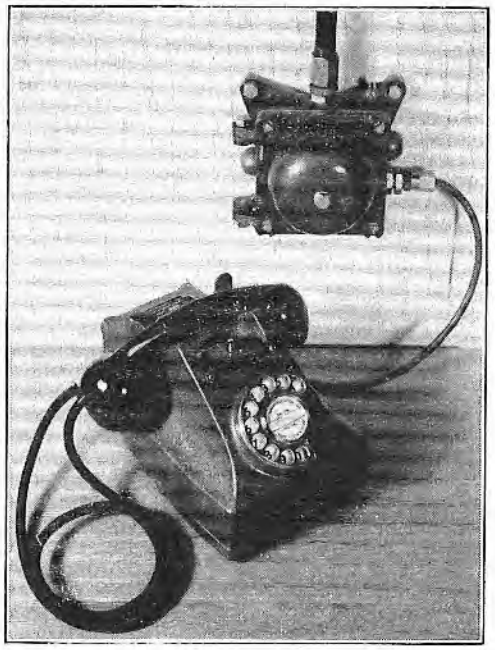

FIG. 2.—FLAMEPROOF TABLE TELEPHONE AND BELL.

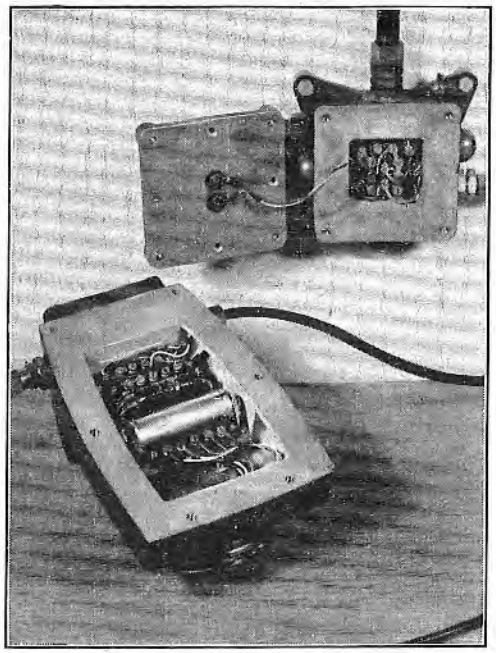

FIG. 3.—FLAMEPROOF TABLE TELEPHONE AND BELL WITH COVERS REMOVED.

the use of which not only permits a great saving in weight, but, more important, because of its low magnesium content, precludes the possibility of frictional sparking which might occur with other materials if the instrument were accidentally dropped.

The case consists of two compartments: (*a*) the main enclosure in which are housed the circuit components and (*b*) the terminal chamber. This segregation is normal practice with all flameproof electrical apparatus to ensure that the main enclosure is not disturbed when connexion or disconnexion of the line wires is required.

The cover of the main compartment serves as the base of the instrument and is fitted with four rubber feet. It is secured to the body by six triangular-headed screws, which are recessed to discourage unauthorized access. A warning notice is embossed on both covers to the effect that the circuit must be isolated elsewhere before either cover is removed.

The dial is of the latest "trigger" type, and the mechanism can be detached from the instrument case by removing three screws located round the rim of the dial case. Owing to the extra friction due to the flame-path along the operating spindle, it is necessary to return the finger plate back to normal independently of the dial mechanism, so enabling the dial mechanism to operate unhindered. In this method of operation the finger plate flies back under the action of its own spring and is locked in the rest position until the dial mechanism has returned to rest. Otherwise the dial would be very prone to mis-operation. Provision is also incorporated in the dial to lock the mechanism for C.B. working.

The remaining elements of the circuit within the case are mounted on a chassis that can easily be removed for attention.

It was evident during the development of the table instrument that it would be difficult and impractical to make the handset and cord of flameproof construction. Hence it was decided to try to make the transmission circuit intrinsically safe by limiting the maximum short-circuit current at the microphone to be less than the minimum igniting current as ascertained from test conditions. Tests using pentane as the representative vapour were conducted by the testing staff of the Safety in Mines Research Establishment and were made with the standard 600-ohm circuit telephone connected to standard Strowger circuits. It was found that under loop conditions ignition could be obtained with zero line and with both a.c. ringing current and d.c. transmitter feed current causing a spark in the microphone circuit with the microphone short circuited. Such a condition could arise with a sticking F relay in the final selector at the exchange and, simultaneously, an instrument fault. The chances of such a condition are extremely remote, but when safety is concerned such are the conditions of test. It was found possible to reduce the intensity of the spark to a safe level under these conditions by inserting a 160-ohm resistor in the circuit as shown in Fig. **4**. Although this resistor reduced transmission by about 2 db in each direction and reduced the line signalling limits by 160 ohms, the losses were regarded as unavoidable in the interests of safety.

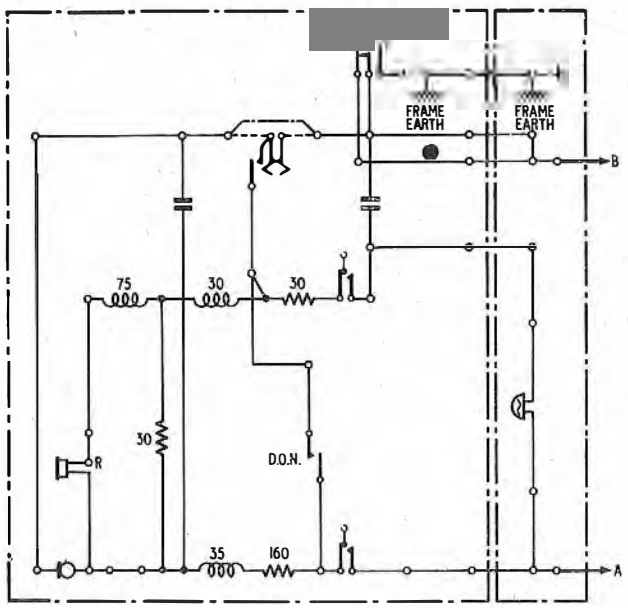

FIG. 4.—CIRCUIT OF THE 600-OHM FLAMEPROOF TABLE TELEPHONE.

Development of the Flameproof Table Telephone (1,000-ohm Version)

With the advent of the 1,000-ohm loop telephone circuit it was decided that any new flameproof telephone should take advantage of this latest development if it were to have a useful life without modification.

Further, while the tests on the 600-ohm version had proved the handset circuit to be safe under the conditions of test, no proof was available that the circuit would still be intrinsically safe if the instrument were to be connected to any of the many earlier and different systems used by the Post Office. A very involved testing program would have been necessary to check the safety of the circuit in practical tests in conjunction with all these circuits and circuit elements and, moreover, possible earth fault conditions were an additional point of doubt. The new table telephone (600-ohm version) was, however, an improvement on the existing instruments.

Because of all these points it was decided to utilize the 1,000-ohm loop circuit (Fig. 5), and in consultation with the Safety in Mines Research Establishment a different approach was made to the problem of the safety of the handset and cord.

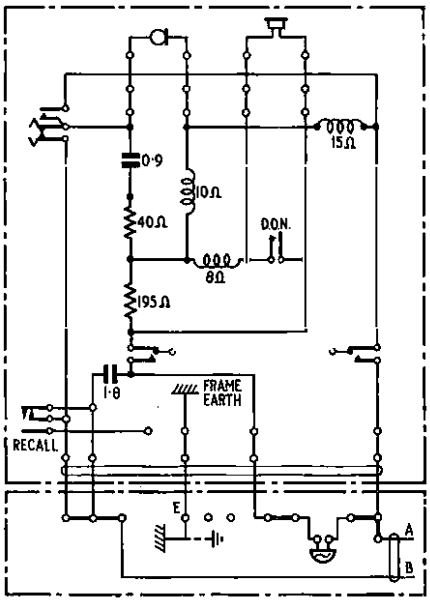

Fig. 5.—Circuit of the 1,000-ohm Flameproof Table Telephone.

As mentioned earlier, an accepted method of providing an adequate degree of safety under practical working conditions is by ensuring a suitable design and standard of construction.

The scheme adopted in this instance was:—

(*a*) To fill the free space where pockets of gas or vapour could possibly collect in the Handset No. 1,[1] which is used in conjunction with the 1,000-ohm circuit. This was done by fitting a moulded rubber insert at the back of the transmitter, and fitting rubber plugs into the ends of the hollow handle to seal the space around the wires. No filling was required for the receiver end of the handset because the presence of the lead weight was considered sufficient.

(*b*) To secure the receiver and mouthpiece caps to prevent unauthorized entry. The caps on the Handset No. 1 are both of the screw-on type and it was decided that the use of Allen screws to secure the cups would give adequate safeguard against indiscriminate removal.

(*c*) To provide some form of metallic braid to a robust tough-rubber sheathed flexible handset cord which should be firmly secured at each end. The type of cord which met the approval of the testing authority is "Stranded 55/·004 in., 4-core, V.I.R. 0·02-in. radial, neoprene sheathed 0·04 in. nominal, braided with 0·006-in. tinned copper wire and covered overall with nylon cordonet."

This telephone with the 1,000-ohm circuit has now received its certificates as follows, the bell and terminal unit and telephone case remaining as for the 600-ohm version.

Complete Telephone ..	Factory Inspectorate Certificate No. 202
Telephone Case	Flameproof Certificate No. F.L.P. 3651
Bell and Terminal Unit..	Flameproof Certificate No. F.L.P. 3652

These certificates were based on B.S. 229 : 1946 and cover groups II(*a*) and II(*b*).

Installation and Maintenance

With all the care and attention taken in the design and certification of these special telephones, it is obvious that they should be installed carefully and maintained in good condition. The precaution of disconnecting a circuit at a point outside the area of risk or at a certified switching point should always be taken before opening flameproof apparatus in an area of risk. When covers are replaced, the flanges should always be wiped clean to ensure that the joint gap is not widened by any trapped dirt or foreign objects. Any repairs or replacements must be in conformity with the drawings specified on the safety certificates, and, because of this, only minor replacements are permitted in the field. The ultimate success of the standard of safety provided by the apparatus depends on the standards of installation and maintenance.

Conclusion

The foregoing is but an outline of the certification of telephones for use in locations where there might be an occasional danger from explosive gases or vapours. Present-day knowledge of the behaviour of explosive mixtures is the result of years of research and the statistical evaluation of very many practical tests, and its application to telephones is only part of the work of the Safety in Mines Research Establishment, where all types of industrial equipment are dealt with.

In addition to gases and vapours, there are many dusts which ignite easily and explode with considerable force. These dusts, many of which are of such common materials as cocoa, flour and sawdust, demand precautions which are, if anything, more exacting than the flameproof construction that has been described. In addition to the flameproof construction, it is necessary to make the equipment completely dustproof. The use of flameproof equipment for protection in dusty atmospheres is not therefore justified and the publication of a British Standard on this subject is awaited with interest.

Acknowledgments

The authors wish to express their appreciation of the co-operation that they received in the testing and certifying of the new telephones from the Safety in Mines Research Establishment and the Inspectorate of Factories. They also wish to record that the request for a flameproof table telephone came from the Oil Companies Materials Committee.

[1] Spencer, H. J. C., and Wilson, F. A. The New, 700-Type Telephone. *P.O.E.E.J.*, Vol. 49, p. 69, July 1956.