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The Mode of Connection of Additional Bells to Automatic Telephones

(Issued by Installation Standards Subsection, Telephone Equipment section, Headquarters)

1. Introduction

1.1 The introduction by the A.P.O. of a new standard automatic (801) telephone provided a convenient opportunity to examine the mode of connection of additional bells and other auxiliary alarms. This paper discusses the main factors which were considered in the development of the practices currently employed and which are detailed in the "Substation Installation Diagrams" Handbook.

1.2 Recommended Distribution. These notes should he distributed to all Country Divisional Engineers, Internal Plant Installation Engineers and Maintenance Engineers.

2. History

2.1 Single telephone services

The need for an additional bell remote from the integral bell of the telephone has always been recognised in this .country, and the earliest telephone circuits show the telephone bell extended to terminals from which a parallel connection to another bell could be made.

However, nearly 50 years ago telephone circuits introducing a series strap between two terminals in the bell circuit were adopted. Older types of telephones were converted to this arrangement so that by removing the strap an extension bell could be connected in series with the bell in the telephone. On automatic telephone services the connection of additional bells in series has been retained to this date with the exception of three particular types of service. These are the parallel telephones, the portable telephone, the extension switch or intermediate telephone facilities.

2.2 Parallel telephone services

(i) The first parallel telephone arrangements permitted only two telephones in the one room. These were connected by a 2-wire cable, and the bell in the second telephone was disconnected.

An extension bell, if required, was connected in series with that in the first telephone.

(ii) Three wire circuits to prevent dial impulse distortion when dialling from the second telephone were introduced about 25 years ago. The principle of this circuit was to use only one 2 m.f. capacitor to perform the condenser functions in the bell circuit, spark quench and the transmission circuit for both telephones. This same 3 wire circuit also provided a path for the parallel connection of the bells of both telephones. The equal division of the current through the electrically identical bells was sufficient, even when connected to the then limit length line of 650 ohms, to satisfactorily operate the bells.

(iii) More recently, the number of parallel telephones permitted (with parallel bells) was increased to three, and the single room limitation was removed for handset type instruments.

2.3 <u>Portable telephone services</u>

(i) The first automatic portable services employed pedestal telephones. Thus the induction coil, condenser and bell were included in a fixed bellset and a three wire connection was required to each socket outlet to associate these with the switch-hook, transmitter, receiver and dial in the portable instrument. A 2-pair lead-covered cable was used to provide the 3 wire circuit. There was no portable bell, and any extension bell was connected in series with the bell in the telephone bell set.

(ii) With the introduction and use of the 162 A.T. and 232 A.T. telephones for portables, a similar arrangement followed still using a 3 wire circuit.

(iii) The 300 type telephone, with an integral bell, was at first arranged for portable working as before, with the telephone bell disconnected. In 1941, it was decided that, at the subscribers request, the telephone bell should be allowed to remain in circuit and also that a second instrument should be permitted on portable services. The circuit was similar to that for parallel telephones with the telephone bells and the bell in the fixed bellset operating in parallel, but if any other alarm equipment was required it was connected in series with the fixed bell in the bellset.

(iv) With the introduction of P.V.C. cable to replace L.C., a 3 wire cable was developed for parallel and portable services. This was used exclusively for about 10 years.

(v) Very recently, at the conclusion of an extensive field trial, it was decided to dispense with the bellset unless the subscriber requested a fixed bell or alarm permanently connected to the line. (E.I. Tel. Substation I 0006 refers). Thus if only one instrument is required, without a fixed bell, a two wire circuit will suffice, but if the subscriber requires a bell permanently connected to the line, a 3 wire circuit with a bellset or other alarm equipment will still be required.

2.4 C.B. Extension Switch and Intermediate Telephone services

The C.B. extension switch and the intermediate telephones used for auto. services permit a bell and capacitor to be across the exchange line at both the main and extension when the switch is in the "exchange to extension" position. A contact of a slugged series relay removes the main telephone bell circuit from the line whilst the extension telephone is in use. Any additional extension bells or other alarm devices are connected in series with the bell in either the main or extension telephone, or in the interswitch or bellset associated with the intermediate telephone. (Two extension bells or one extension bell and one extension buzzer are required to ensure that all calls received at the main station are indicated at the extended alarm location, irrespective of the circuit conditions set up by the main station switch or keys).

2.5 Number of Bells

In all cases the accepted limit to the number of bells or their equivalent that may be connected to any automatic exchange line at any time has been three.

3. Performance Considerations

3.1 Reliable operation of the bell may be expected with a 17 c.p.s. current of 8 mA for 59 type bells (300 and 400 series telephones and 2½″ extension bell) and of 5 mA for the 801 telephone bells.

3.2 The capacitive reactance of the telephone condenser is high at 17 c.p.s., the most commonly used ringing current frequency. Because of this and the series resistance of the line, the greater inductance of series-connected bells permits more current to flow through each bell than if they were connected in parallel. This effect is accentuated by the reduction of the telephone capacitor value from 2 m.f. to 1.8 m.f. and to 1.5 m.f. for other design reasons and the increase of the line resistance limit, for signalling purposes, from 650 ohms to 1000 ohms.

3.3 Experience has indicated that where similar bells have been connected in parallel there have been no undue difficulties and tests of combinations of 59 type bells with 801 telephone bells have been satisfactory. However, troubles would occur if parallel combinations of dissimilar bells or their equivalent, such as the 6" weatherproof bell or the alarm relay circuit with the shunting rectifier, were generally permitted.

3.4 The configuration of a 300 or 400 A.T. bell circuit is such that it shunts the transmission path during conversation. Because of the high impedance of the bell coil to speech frequencies there is very little increase in attenuation. However the parallel connection of additional bells increases this attenuation, and the parallel connection of an alarm relay with a shunting rectifier, which is low impedance to speech frequencies, cannot be tolerated.

3.5 The effect of the bells on a service failing to operate is serious, and is one of the least likely of the commoner faults to be detected and reported promptly. Comparing series and parallel connection of bells as a contributory factor to such failures, it is considered that the possibility of an open circuit fault is higher than that of a short circuit. However, the remote testing for an open circuit fault would be more reliable than for a short circuit bell fault.

3.6 (i) For "free plug" or portable services the connection of the telephone bells in series necessitates a normally made contact in the outlet sockets to complete the bell circuit when one telephone is unplugged. This contact was not provided on the old pattern 4 pin sockets but it is a feature of the new 6-pin 610 socket.

(ii) The reliability of the bell circuit is reduced to some extent by the introduction of-series contacts, but the 610 socket is of good design with adequate contact pressure and follow. Therefore the risk of failure should be slight. The wetting effect of the high A.C. ring supply voltage should remove any possibility of coherer troubles.

4. Installation Factors

4.1 Installation standards for wiring should conform to a basic pattern of connection which provides for easy conversion from one type of standard facility to another and will be easily assimilated by the installers.

4.2 Alarm equipment, including additional bells, is an optional feature of most of the Standard Telephone Facilities. Provision for their connection at the initial installation, thereby reducing subsequent difficult and costly rearrangements to a minimum is preferred, and generally is not uneconomic.

4.3 The preferred~ standard for interconnecting two or more internal telephones or telephone outlets on a service is a 4 wire cable. This will accommodate meet of the Standard Telephone Facilities, including additional alarms.

4.4 Where two or three telephones are connected to a service on a "free-plug" basis (plugs readily removable from the socket), the internal connections within each telephone must be similar as they may be interchanged by the subscriber. For these services a series bell connection requires separate "in" and "out" conductors in the telephone line cord for the bell. An additional conductor in this cord is also required to complete the bell circuit to the telephone capacitor unless a separate capacitor is mounted externally and connected in the cable wiring.

4.5 Socket 610 and Plug 603 provide terminations for six conductors in a telephone line cord. The following table indicates the standard allocation:

Plug 603 Terminal No.	Line Cord Conductor Colour	Normal Function when Required
1	Green	Earth for push buttons
2	White	"A" leg of line
3	Red	Bell circuit "In"
4	Orange	Bell circuit "Out"
5	Black	Capacitor connection
6	Blue	"A" leg of line

Table 1 - Line Cord Conductor Allocation

4.6 To reduce the ingress of dust and other foreign matter which may adversely affect the operation of the contacts 610 sockets for portable services should be mounted in a horizontal position only.

5. Summary of Bases for Current Practices

5.1 The series connection of additional bells and alarm equipment to telephone services is preferred.

5.2 Telephone 801 are normally provided with a three conductor cord and when used as single telephone installation a series bell connection is easily obtained by removing a strap on socket 610.

5.3 Parallel telephone installations with the bells connected in parallel are satisfactory provided that

(i) a single capacitor is used

(ii) the telephone in which it is contained has its plug made captive (The disconnection of this telephone would seriously impair the performance of the others on the service and produce dangerously high induced voltages during dialling)

(iii) the bells are of the ~9 or 800 type.

(iv) the line loop resistance does not exceed 1000 ohms.

Provided that the above conditions are met, the standard 3 conductor line cord can be retained for both 801 and earlier type telephones.

5.4 The three conductor cords of 801 telephones should be replaced with six conductor cords when installing a "multiple telephone" portable service where a fixed telephone, or extension bell with which a capacitor could be associated, is not to be installed. If the three conductor cords were retained a separately mounted capacitor would be required. The arrangement of the bells in series is practicable if four wire cable is installed and increases the safe operating margin.

5.5 Telephones fitted with four pin plugs and sockets for portable installations will continue to use parallel bell connections.

5.6 The limit of 3 bells or their electrical equivalent per automatic service has proved adequate in practice and general relaxation of this limit is not proposed. However, if more than three are sought the practicability of each case should be considered on its merits.