OPERATORS' TELEPHONE CIRCUITS

INDUCTION COILS

CONTENTS

1. GENERAL

1.01 This section presents information on induction coils used in operators' telephone circuits which are currently rated as standard for Bell System use, as well as information concerning older type induction coils.

1.02 In accordance with the present plan for standardized nomenclature, induction coils when referred to as a class of equipment (with no particular code) are now designated "transformers" whereas individually coded types are listed as "induction coils." In this practice since all induction coils referred to are coded "induction coils" and numerous references are made to them as a class of equipment as well as a particular code, the term "induction coil" will be used throughout.

1.03 An operator's telephone circuit induction coil provides efficient coupling between operators' telephone instruments and the line.

1.04 Over the years many types of operators' telephone circuit induction coils have been developed. This large number of induction coils reflects not only progress in the design art, but also the practice introduced many years ago of employing different types of induction coils for specific types of application, such as toll, intercept, PBX, etc. Most of these developments were brought about by the following factors: (1) advance from sidetone to antisidetone (all operator's induction coils developed in the last 40 years have been of the antisidetone type), (2) closed core vs open core, (3) different services such as toll, exchange, special services, etc, (4) to accommodate changes in instrument impedances.

2. SIDETONE AND ANTISIDETONE CIRCUITS

(A) Sidetone

2.01 Until about 40 years ago all operators' circuits were of the sidetone type. These sidetone circuits consisted simply of the transmitter and receiver and a 2-winding induction coil for connecting the instruments to the line.

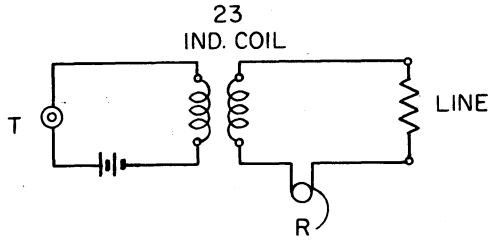


Fig. 1 - Sidetone Circuit

2.02 The No. 23 induction coil sidetone circuit shown in Fig. 1 was used for many years and a few may still be in service. Since the receiver and line are in series, it is apparent that a considerable portion of the power generated by the transmitter is dissipated in the receiver as sidetone. Noise picked up by the transmitter and heard as sidetone tends to obscure incoming speech, thereby impairing reception. Similarly the loudness of her own voice in the receiver may cause the operator to lower her speech level, thus reducing the output power from the transmitter and impairing the reception of her speech at the far end of the connection.

(B) Antisidetone

2.03 In order to mitigate these effects of noise and speech pickup, an antisidetone circuit such as shown in Fig. 2 was developed. The use of antisidetone circuits results in

increased talking level, thereby effecting an improvement in average transmission of about 4 db.

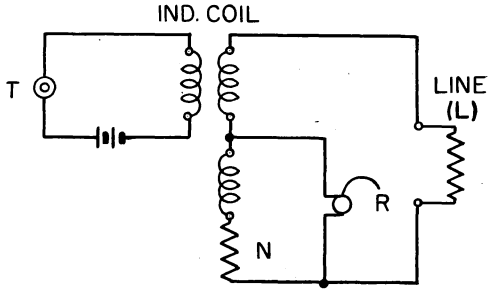


Fig. 2 - Antisidetone Circuit

2.04 An antisidetone circuit such as that shown in Fig. 2 consists of a transmitter (T), receiver (R), line (L) and balancing net (N). The latter is an auxiliary element which makes it possible to obtain the antisidetone characteristics.

2.05 The theory of an antisidetone circuit is based on two assumptions: (1) the impedances of the transmitter, receiver, line and balancing network elements are pure resistances, (2) it is further assumed that the transformer is ideal (or perfect) and that the elements and transformer windings are properly proportioned. Under such conditions an antisidetone circuit possesses the following unique properties.

(a) Each element looks into its own impedance; that is, there is perfect matching of each element with the remainder of the circuit.

(b) The power generated by the transmitter is divided between the line and network and none is delivered to the receiver (this is zero sidetone).

(c) In the receiving condition, the power delivered by the line is divided between the receiver and transmitter and none is delivered to the network.

(d) There is sufficient design flexibility to permit stressing the transmitting efficiency at the expense of the receiving efficiency or vice versa as desired.

2.06 The idealized conditions mentioned above can not be met in practice. For example, the line impedance is seldom a pure resistance, even at a single frequency; the receiver impedance is preponderantly reactive at all voice frequencies, and the ideal (or perfect) transformer is a concept rather than an actuality. However, in spite of these deviations from ideal conditions, antisidetone circuits can be designed so as to have transmitting and receiving efficiencies only slightly below the ideal values.

2.07 In a practical antisidetone circuit the average sidetone level is reduced 10 to 12 db as compared to the sidetone type circuit.

3. UNIVERSAL INDUCTION COIL

3.01 The 181B induction coil is a universal coil introduced in 1952 as standard for all types of 2-wire operators' circuits both for terminating and switched calls (including via net loss switching) and also as a maintenance replacement for any of the older types of coils. More specifically, the 181B coil will be used by local, PBX, intercept, information, toll, and special service operators.

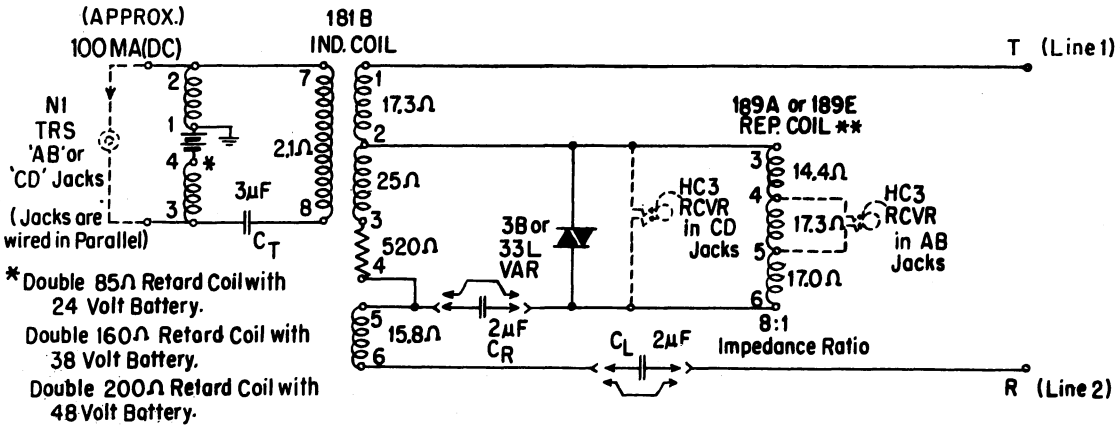
3.02 The 181B coil was designed for use with the 52- and 53-type operators' sets.

3.03 The chief advantage of the 181B induction coil is the simplification of operators' telephone circuit design and engineering procedure by having a single induction coil suitable for all types of operators' circuits.

3.04 From a design and manufacturing viewpoint, it is now feasible to neglect minor advantages (figured in terms of tenths of a db) obtained by designing special operators' induction coils for each type of operator's use. The minor transmission disadvantages of a uniform coil design are insignificant in view of the sizeable improvements which are being made in operators' transmission by the use of the 52-type set, omission of switching pads in terminating intertoll trunks, and reduction of trunk losses.

3.05 For a summary of operators' induction coils and their principal application, refer to Table II. Appearing on this table is the 181C induction coil which is merely a specially selected 181B induction coil with a close inductance tolerance deemed desirable for use in certain 4-wire hybrid type telephone circuits.

3.06 Fig. 3 illustrates the arrangement of the 181B induction coil for one method of connection into an operator's circuit using a 52-type set. The 181B induction coil is of the antisidetone type. The sidetone balancing



**Busy Test Windings of 189A or 189E Coil are not shown as they are not part of the normal Transmission Path.

The N1 Transmitter and HC3 Receiver are shown dotted as they are a part of the Operator's Telephone Set and are plugged into the Operator's Telephone Circuit at the CD or AB Jacks.

Fig. 3 - Operator's Telephone Circuit for Common Battery Type Central Offices

network is provided by the 520-ohm noninductive resistance of winding 3-4 supplemented by the 25-ohm resistance of winding 2-3. In most cases the 181B is connected on a balanced-to-ground basis as shown in Fig. 3. However, when used as a maintenance replacement for some of the older coils in circuits wired for unbalanced operation, winding 5-6 is connected in series with winding 1-2 continuing the existing unbalanced-to-ground design. This arrangement together with methods of replacing all existing induction coils with the 181B, is shown in Fig. 6.

3.07 From the standpoint of transmission efficiency, the balanced and unbalanced-to-ground types of circuits may be regarded as equivalent; however, the balanced type is preferable from a noise and crosstalk interference standpoint.

4. TRANSMISSION

4.01 In general the average grade of transmission provided by the universal induction coil (181B) and some present existing induction coils (viz. 62, 63, 65, 102A, 178A, 178D, 178E, and 178F) is approximately the same under the usual wide range of line conditions.

4.02 Operator's telephone circuits initially employing some types of induction coils (viz. 72A, 102B, 102C, 178B, and 178C) were designed prior to the availability of the 52-type set and reflect the 150-ohm resistance of the 396A transmitter unit then used. The N1 unit of the 52-type set has a resistance of 50 ohms. Changing these induction coils to a type designed for use with low impedance transmitters such as the N1 unit introduces an improvement of 1.0 to 1.5 db.

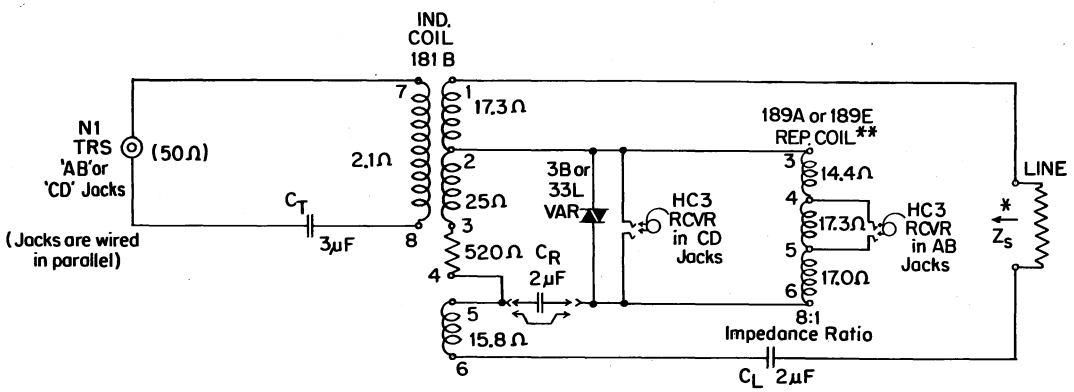
4.03 Some operators' telephone circuits using the induction coils listed in Paragraph 4.02 originally employed a 1 uf capacitor in the transmitter branch. Such a capacitor introduces a substantial loss, especially at low frequencies, when used with the 50-ohm N1 transmitter unit. Changing this capacitor from 1 to 3 uf will provide a correction for this condition and introduce a transmission improvement of about 3-4 db.

4.04 To summarize, use of 52-type operators' sets with various combinations of old type induction coils and different transmitter capacitors results in the following transmission impairments under average line conditions.

Common Battery Type Central Offices (24, 38, or 48-volt Battery Supply) Coil and Capacitor Combinations	Transmission Impairment vs 181B Coil and 3 uf Capacitor
62, 63, 65, 102A, 178A, 178D, 178E, and 178F-type induction coils (only 3 uf used)	0 db
72A, 102B, 178B, 102C, and 178C-type induction coils	
With 3 uf capacitor in transmitter circuit	1 to 1.5 db
With 1 uf capacitor in transmitter circuit	4 to 5.5 db

4.05 It is not recommended to replace existing coils with 181B or 181C coils for transmission reasons except in unusual cases. However, 1 uf transmitter capacitors should be changed to 3 uf capacitors. Of course, all maintenance replacements will require the 181B or 181C induction coils as all other induction coils (refer to Table II) are in the process of being rated "manufacture discontinued."

4.06 The impedance looking into the line terminals of an operator's telephone circuit containing a 52-type set and a 181B induction coil as shown in Fig. 4 is given in Table I.



NOTE: All Standard Battery Supply arrangements are applicable for this drawing.
* Z_s is the Impedance looking into the Line Terminals of the Operator's Telephone Circuit.
** Busy Test Windings of 189A or 189E Coil are not shown as they are not part of the normal Transmission Path.

Fig. 4 - Operator's Telephone Circuit

TABLE I

INPUT IMPEDANCE OF OPERATOR'S TELEPHONE CIRCUIT

AS SHOWN IN FIG. 4

Frequency	Z_S With 2 uf Capacitor C_R in the Receiver Circuit	Z_S Without 2 uf Capacitor C_R in the Receiver Circuit
100	625 - j553 = 834 /-41.5	144 - j442 = 465 /-72.0
200	705 - j47 = 707 /- 3.8	270 + j165 = 316 / 31.4
300	865 + j150 = 878 / 9.8	495 + j470 = 683 / 43.5
400	1015 + j178 = 1030 / 9.9	780 + j580 = 973 / 36.6
500	1090 + j133 = 1098 / 7.0	1000 + j520 = 1127 / 27.5
600	1105 + j92 = 1109 / 4.8	1115 + j405 = 1185 / 20.0
800	1080 + j45 = 1081 / 2.4	1140 + j224 = 1160 / 11.1
1000	1040 + j47 = 1041 / 2.6	1090 + j165 = 1100 / 8.6
1200	1015 + j59 = 1017 / 3.3	1050 + j147 = 1060 / 8.0
1500	960 + j83 = 964 / 4.9	1000 + j151 = 1010 / 8.6
2000	930 + j252 = 964 / 15.2	950 + j285 = 990 / 16.7
2500	1010 + j340 = 1066 / 18.6	1035 + j367 = 1100 / 19.5
3000	1050 + j386 = 1119 / 20.2	1060 + j405 = 1135 / 20.9
4000	1155 + j443 = 1237 / 21.0	1165 + j460 = 1250 / 21.5

Note: As shown in Fig. 4 the nominal values of the line and receiver capacitors are 2 uf and the nominal value of the transmitter capacitor is 3 uf. However, since the average value of these capacitors is about 10% higher than the nominal value (standardized) these data are based on the average rather than the nominal value.

4.07 Because of the closed core and shielding features, the 181B or 181C induction coils may be mounted on relay mounting plates with no restrictions from a crosstalk standpoint other than the distance between the apparatus and the operators' set jacks. With this mounting arrangement, considerable lengths of cable to the operators' positions may be involved. To meet this condition the line winding of the coil is usually divided in two equal parts (as shown in Fig. 3) so that each half may be connected to one side of the line and thus balance the wiring to the receiver. The coils may be mounted with the rest of the operators' circuit apparatus or at some distance from the location of the operators' set jacks. The maximum permissible length in a specific case depends upon the various combinations of capacitors in the line and receiver circuits.

4.08 The 181B or 181C induction coil has a silicon steel core with the return path through a silicon steel liner. Information on the 181-type induction coil is given in Fig. 5.

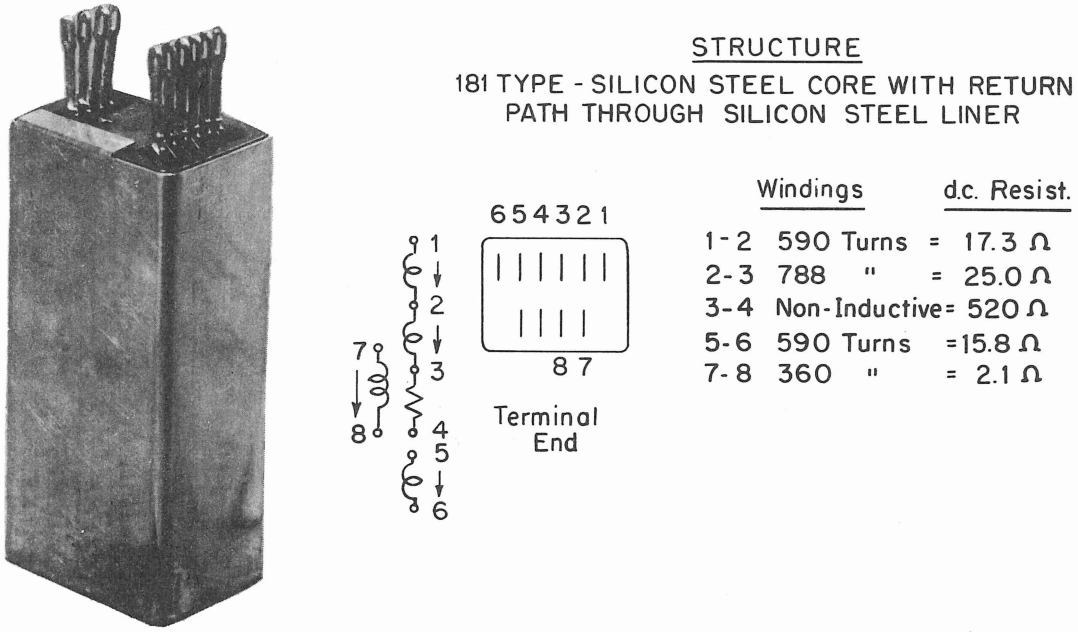
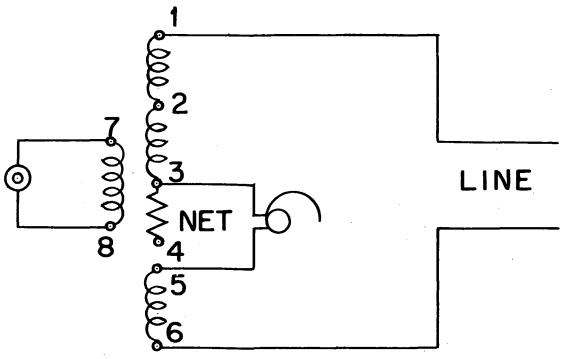
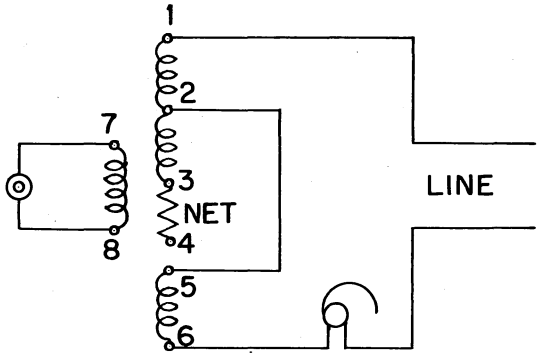


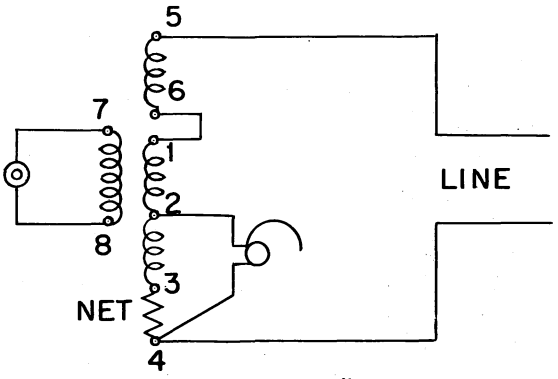
Fig. 5 - Winding and Terminal Arrangement of 181-Type Induction Coil



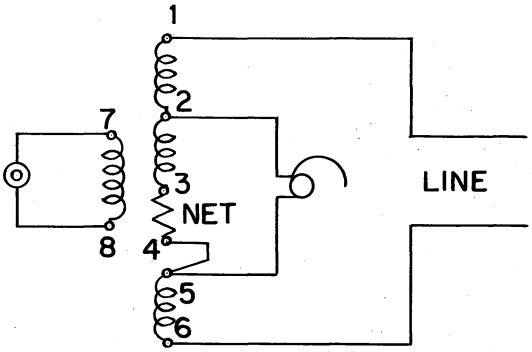
AS REPLACEMENT FOR # 10 INDUCTION COIL



AS REPLACEMENT FOR # 23 INDUCTION COIL

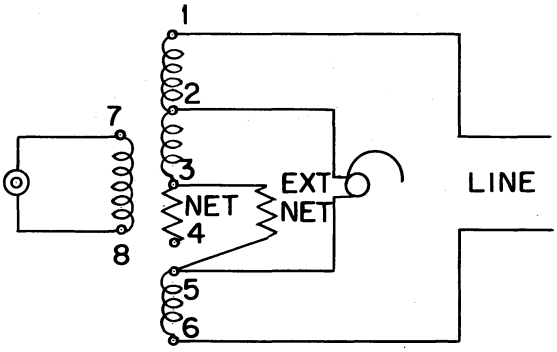


AS REPLACEMENT FOR # 24, 62, 63, 65, 72A, 102A AND 178A INDUCTION COILS



AS REPLACEMENT FOR # 102B, 102C, 178B, 178C, 178D, 178E AND 178F* INDUCTION COILS

* Using Network Provided in Coil



AS REPLACEMENT FOR 178F INDUCTION COIL WHEN EXTERNAL NETWORK IS NECESSARY

Fig. 6 - Use of 181B Induction Coil as Replacement for Existing and Old Type Coils

TABLE II - OPERATOR'S TYPE INDUCTION COILS

Induction Coil Type	Sidetone or Antisidetone	Core	Induction Coil Rating	Designed for Transmitter Impedance in Ohms	Examples of Use	Remarks
10	Sidetone	Open	MD	40-50	Magneto Switchboards	
23	"	"	"	40-50	Local	
24	Antisidetone	"	"	40-50	Toll	
62	"	"	"	40-50	"A" and "B" Operator's Circuits	
63	"	"	"	40-50	PBX	
65	"	"	"	40-50	Toll	
72A	"	"	"	150	No. 12 Switchboard	See Note 1.
102A-178A	"	Closed	"	40-50	Toll	
102B-178B	"	"	"	150	"A", "B" and Toll	Designed for circuits in which the operator either terminates or is bridged on the line. See Note 1.
102C-178C	"	"	"	150	Information, Intercept, Test Desk	Designed for terminating operators only. See Note 1.
178D	"	"	"	40-50	"A", "B", Toll, PBX	Designed for circuits in which the operator either terminates or is bridged on the line.
178E	"	"	"	40-50	Information, Intercept, Test Desk	Designed for terminating operators only.
178F	"	"	"	40-50	CAA, Special Circuits	Designed for circuits requiring a variety of sidetone balancing networks.
178G	"	"	"	40-50	4-Wire Hybrid Circuits	Same as the 178D coil except with closer inductance limits to give high trans-hybrid loss.
181B	"	"	STD	50	Universal	Replaces all types listed above except 178G.
181C	"	"	STD	50	4-Wire Hybrid Circuits	" 178G. See Note 4.

Note 1: Circuits were originally equipped with 1 uf transmitter capacitors which were satisfactory for use with the 396 transmitter. When the M1 transmitter is used, the 1 uf capacitor introduces excessive low-frequency loss. This loss can be reduced appreciably by changing the capacitor to 3 uf. In order to obtain the full benefit from the M1 transmitter, the induction coil should be changed to the 181B.

Note 2: Transmitter unit impedances: No. 234 (40 ohms); No. 396A (150 ohms); M1 (50 ohms).

Note 3: CAA - Civil Aeronautics Authority.

Note 4: The 181C is merely a specially selected 181B with a close inductance limit which is desirable for use in certain 4-wire hybrid type telephone circuits.