

# Telephone Receiver Operation PART 1

**T**he speech signals that arrive at a telephone receiver are extremely small (*usually less than 0.1uW*). Therefore a telephone receiver must be very efficient in design to convert this signal into acoustical energy.

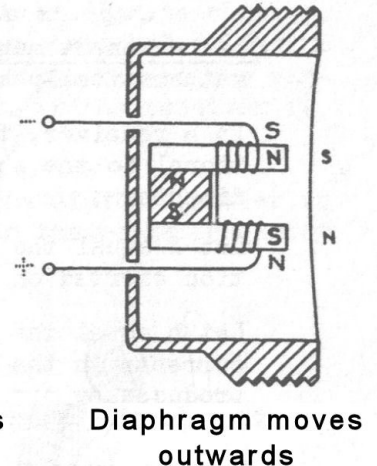
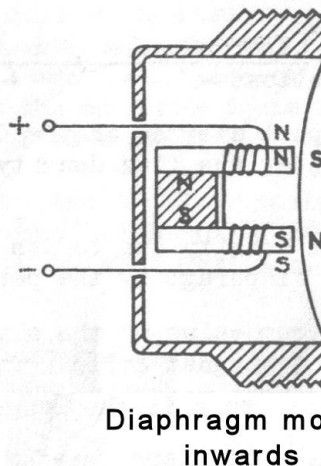
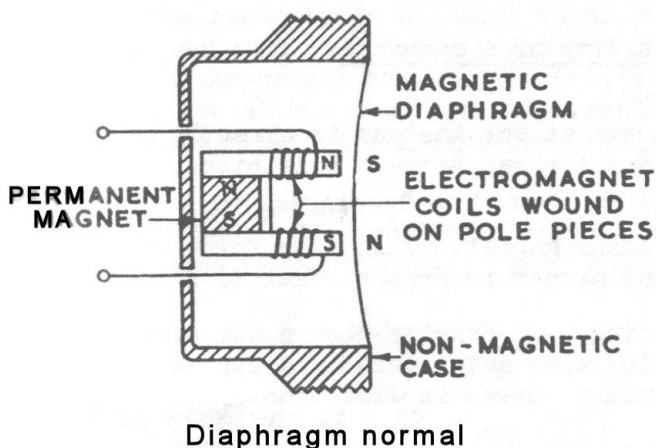
Speech signals consist of a wide range of frequencies which must be faithfully reproduced by the receiver so that the speech output will not be distorted. The telephone receiver must be designed for maximum sensitivity (*or volume efficiency*) as well as for good quality reception.

Two different types of receivers were in common use in the telephones we collect:

- (1) Receivers with a diaphragm of a magnetic material such as those used in bell receivers and in the 200 and 300 series telephones.
- (2) Receivers with a non-magnetic diaphragm such as those used in the 400 and 800 series telephones.

attraction is increased and decreased depending on the polarity of the signal. Thus the magnetic diaphragm moves closer and further away from the pole pieces. This produces the sounds heard in the receiver.

It is important to maintain the air gap between the pole pieces and the diaphragm to a minimum to just prevent the diaphragm touching the pole pieces during normal operation. The tips of the pole pieces are usually lacquered to maintain a small air gap in the magnetic circuit and to prevent the diaphragm sticking should it contact the pole pieces during operation. occasionally it is necessary to fit a thin paper ring between the diaphragm and the



## (1) Principle of Operation - Magnetic Diaphragm.

Electromagnet coils are wound on the pole pieces of a permanent magnet (*either horseshoe - in the case of the 200 or 300 series telephone - or bar or "L" shaped magnet in the case of the older bell receiver*). The end polarity of the pole pieces is the same as the magnet poles to which they are attached. the flexible magnetic diaphragm is attracted to these pole pieces by the magnetism of the permanent magnet. As the alternating current of the speech signal passes through the coils, the magnetic

receiver case to maintain the necessary gap between diaphragm and pole pieces.

It should be noted that, in a receiver without a permanent magnet, the diaphragm is attracted to the pole pieces irrespective of the polarity of the speech current in the coils. The diaphragm is attracted twice for each cycle of current. This results in a sound with a frequency twice that of the original sound and results in the production of harmonic frequencies which were not present in the original sound. It can also be proved mathematically that the inclusion of a permanent magnet increases the sensitivity of a receiver.

## Diaphragms

Early receivers used a soft iron diaphragm. As soft iron is a good magnetic conductor, eddy currents are induced and circulate in the diaphragm resulting in a considerable reduction in the efficiency of the receiver.

Later receivers use a thin diaphragm (*about 10 mils for greater flexibility*) of a magnetic alloy which has good magnetic properties and also with a higher resistance to reduce these eddy current losses. The two typical materials are...

**Stalloy** (*diaphragm No. 18*) An alloy of iron, silicon and aluminium. Used in receiver types 1A (*Bell receiver*) and the inset receiver type 1L (*used in earlier 200 and 300 series handsets*).

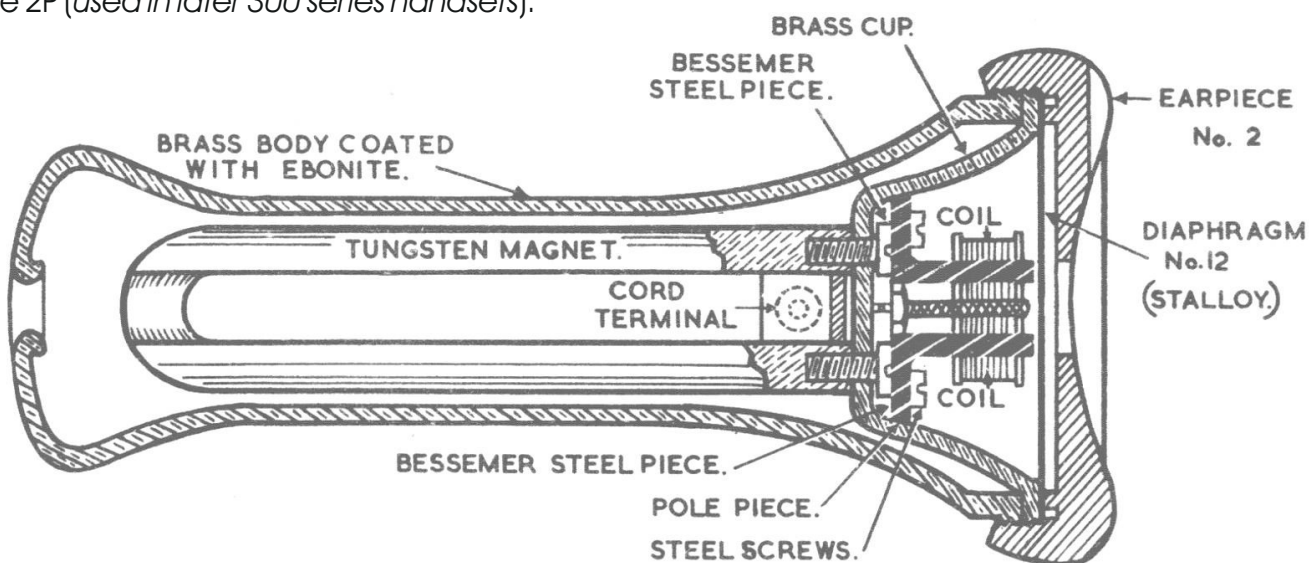
**Permendur** (*diaphragm No. 25*) An alloy of iron, cobalt and vanadium. Used in the inset receiver type 2P (*used in later 300 series handsets*).

## Receiver Type 1A (Bell Receiver)

The 2 L-shaped soft-iron pole pieces carry the electromagnetic coils and are screwed to Bessemer steel pieces clamped to the inside of a brass cup by steel screws. These screws also hold the tungsten-steel permanent magnet which may be either two bar magnets yoked together at the far end or a single horse-shoe magnet (*as shown in diagram*).

The **stalloy** diaphragm is seated on the edge of the brass cup with a clearance to the pole pieces of 13.5 mils with a 1 mil tolerance.

The resistance of each of the two coils is 30 ohms (total 60 ohms). The impedance varies from about 115 to 450 ohms over the voice frequency range of 200 to 3000 cps and it is about 250 ohms at 1000 cps.



**Cross section of later type Bell receiver**

The diaphragm is usually varnished on both sides to prevent corrosion. When only one side is varnished, this side must be placed towards the ear.

Diaphragms must be removed or replaced by gently sliding sideways over the pole pieces. This prevents any sudden attraction to the pole pieces which may permanently distort the flat surface of the thin diaphragm and affect its operation.

In the type 1A bell receiver, the assembly is enclosed in a brass case insulated with an ebonite coating. An ebonite earpiece (No 2) is screwed into position on the outer brass case to hold the diaphragm and assembly in position. A shallow recess in the outer rim of the earpiece allows the "howler" signal from the exchange to be heard if the receiver is left off hook with the earpiece downwards on a flat surface.

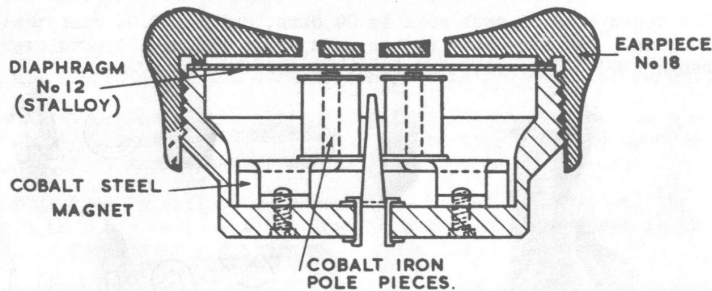
*Future articles look at the 1L, 2P and Rocking Armature receivers and the 164 & 184 handsets.*

# Telephone Receiver Operation PART 2

In a previous article we looked at the operation of the magnetic diaphragm receiver in general and in particular, the 1A bell receiver. Here we look at the two types of receivers used in the 200 and 300 series telephones.

## Inset Receiver Type 1L.

This receiver uses short cobalt-steel permanent magnet which provides higher flux density than the tungsten-steel magnet used in the Bell receiver. The case is either aluminium or moulded bakelite which is threaded so that a bakelite earpiece (No 18) can be screwed to hold the diaphragm in place.

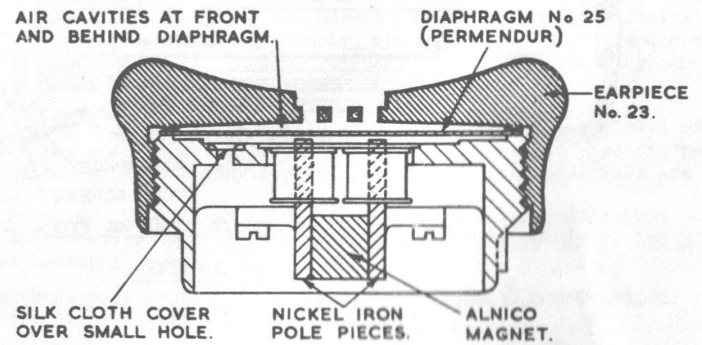


Type 1L Receiver

The resistance of each coil is 40 ohms (total 80 ohms). the impedance varies from about 110 to 710 ohms over the voice frequency range and is about 350 ohms at 1000 cps.

## Inset Receiver Type 2P.

This receiver uses a short Alnico permanent magnet composed of aluminium, nickel, iron and cobalt. the coils are fitted on nickel-iron pole pieces.

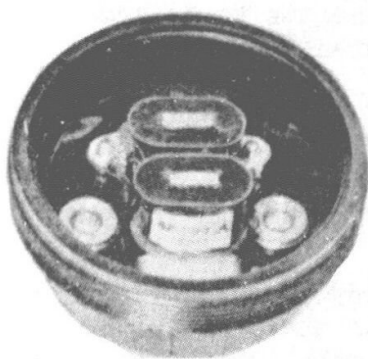


Type 2P Receiver

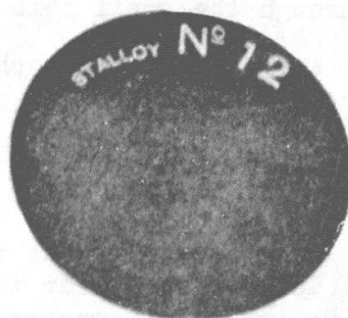
The magnet and pole piece assembly are mounted on either a die-cast aluminium case or a case of moulded phenolic material which is threaded so that the bakelite earpiece (No 23) can be screwed to hold the diaphragm in position.

The DC resistance is about 55 ohms. The impedance varies from about 100 to 640 ohms over the voice frequency range and is about 290 ohms at 1000 cps. The type 1L and 2P receivers do not have Bessemer steel pieces as in the Bell receiver (1A). However, the wide pole pieces provide an alternative air path of large cross-section at the base of the coils which shunts the high reluctance of the permanent magnet for the changes of flux in the magnetic circuit.

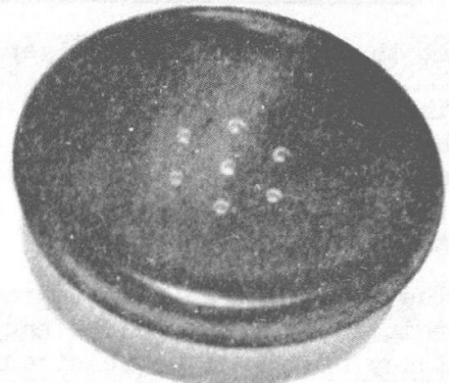
The 1L receiver is fitted with a **stalloy** diaphragm No 12 and an earpiece No 18 which has seven holes drilled at its centre (see diagram below for details).



1L Receiver



Diaphragm No 12

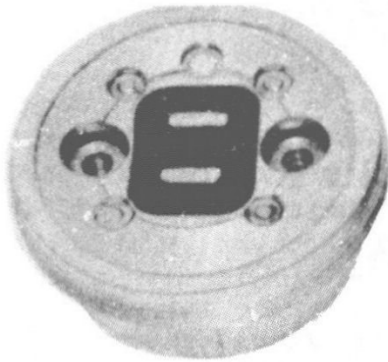


Earpiece No 18



The **2P** receiver is fitted with a **permendur** diaphragm No 25 and an earpiece No 23 which has four small holes drilled in a recessed cavity at its centre.

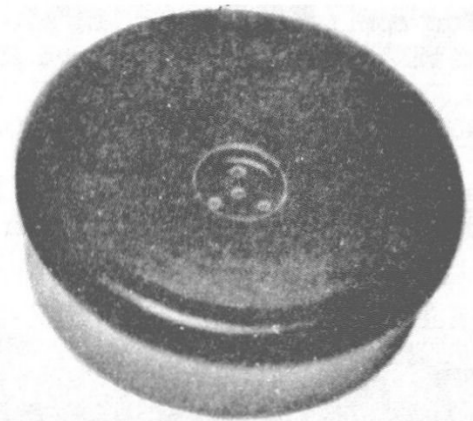
*Future article will look at the Rocking Armature receiver and the 400 handset.*



**2P Receiver**



**Diaphragm No 25**



**Earpiece No 23**

When the wrong combination is used the volume efficiency of the receiver is reduced and the quality of the reproduced speech is impaired.

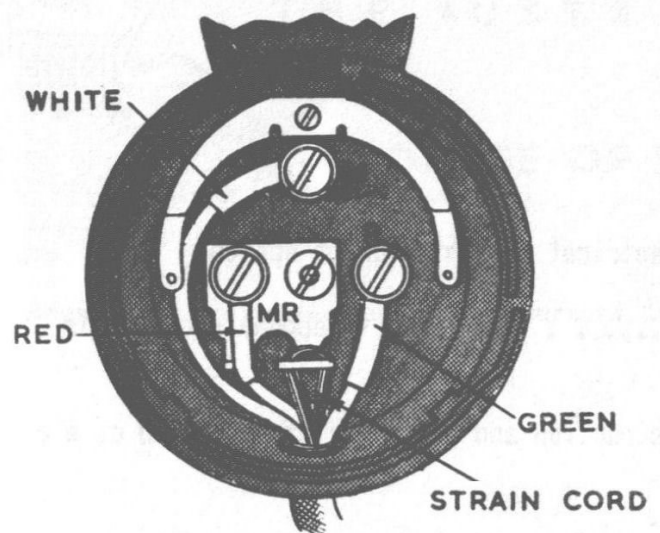
#### **Handsets No 164 and No 184.**

The handsets No 164 and No 184 are found on 200 and 300 series telephones. They both use transmitter inset No 13 and receiver type 1L or 2P. Either handset can be fitted with either receiver type depending on the telephone model and manufacturer.

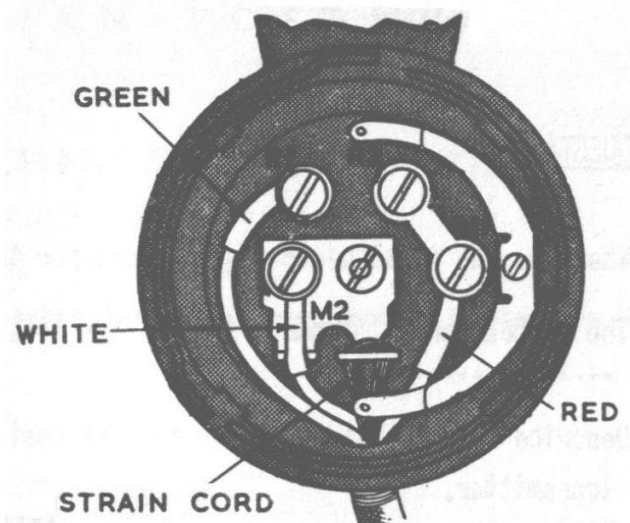
The 1L receiver is secured to the handset by two 3BA x 9/16 inch fixing screws. The 2P receiver uses two 3BA x 1-1/16 inch screws. These screws also make the electrical connections between the ends of the coils and the wires moulded into the handset.

Handset No 164 uses a cord 3306 (3 conductor, 3 feet, 6 inches long). White = M (transmitter), Green = R (receiver), Red = MR (transmitter/receiver common).

Handset no 184 has four terminals to facilitate a four conductor cord (4306 or similar). When a three conductor cord (3306) is used a strap needs to be fitted as shown in the diagram between the M1 terminal (transmitter) and R2 terminal (receiver).



**Handset No 164**



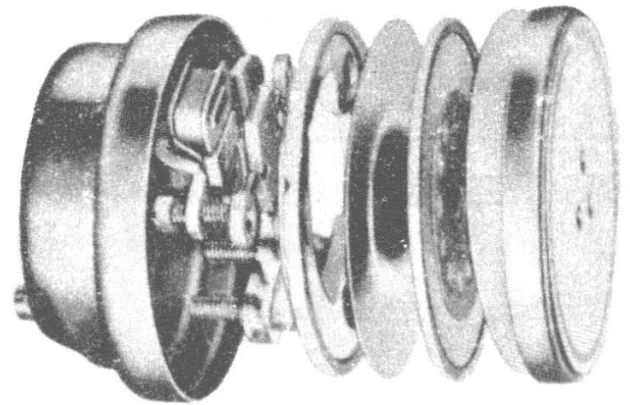
**Handset No 184**

# Telephone Receiver Operation PART 3

In previous articles we have looked at the receivers used in the 200 and 300 series telephones. here we look at the rocking armature receiver used in the 400 series handset.

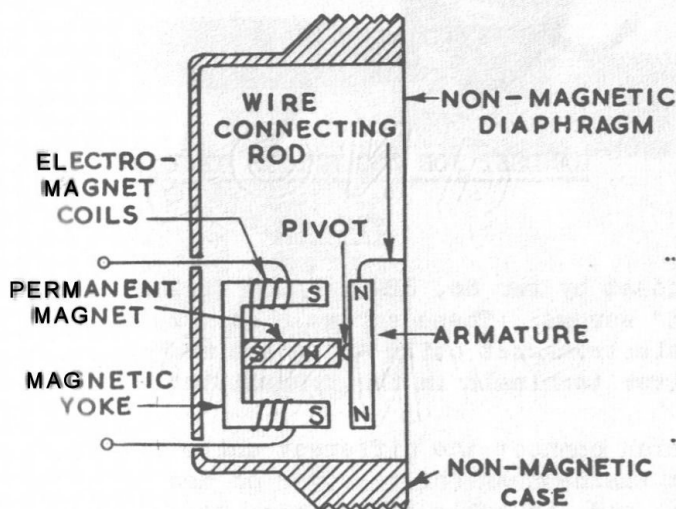
In the 1L and 2P receivers the magnetic diaphragm has to perform a dual function in which both its magnetic and acoustical properties are used. These two requirements conflict reducing the performance of the unit. A compromise has now been made.

In the rocking armature receiver (*at right*) used in both the 400 and 800 series telephones, these two functions are separate. The magnetic function is confined to the rocking armature and the acoustical function is handled by a light non-magnetic diaphragm, each designed for individual best performance.

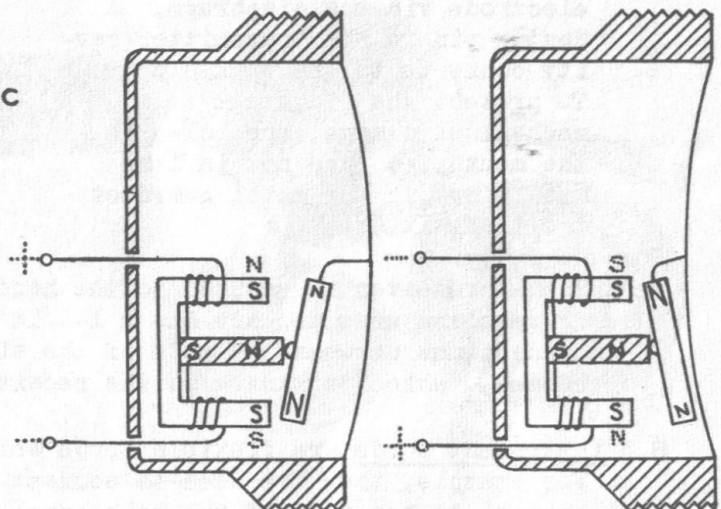


**Exploded view of rocking armature receiver**

The DC resistance of the receiver is 20 ohms. The impedance varies from about 50 to 200 ohms over voice frequency range and is about 150 ohms at 1000 cps.



**Diaphragm normal**



**Diaphragm moves outwards**

**Diaphragm moves inwards**

The permanent magnet is a small alcomax bar magnet (*an alloy of aluminium, nickel, cobalt, copper and iron*), mounted between two arms of a U shaped yoke of permalloy (nickel-iron alloy) which forms the two pole pieces. The armature rocks or pivots on the magnet and is mechanically connected by a wire rod to a light flared non-magnetic alloy diaphragm.

In the normal condition with no current in the coils, the two ends of the armature are equal distances from the pole pieces. When current flows in the coils, the electromagnetism strengthens one south pole of the magnetic yoke and weakens the other and the armature is attracted to the stronger pole. Thus, when alternating speech currents flow the armature is



alternatively attracted to either pole of the magnetic yoke and this movement is transmitted to the diaphragm via the wire connecting rod.

Shown at right is a typical response table for the main 3 types of receivers. Note the response of the rocking armature is nearly a flat

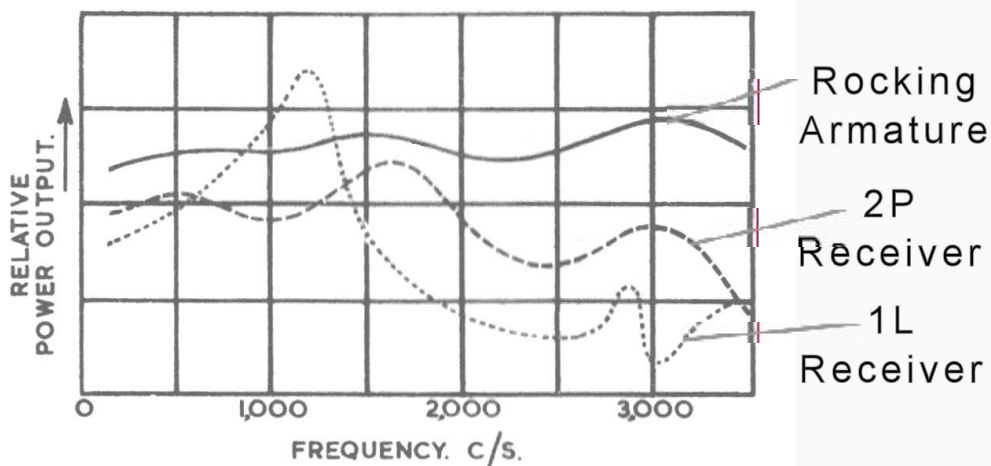
line whilst the response of the 1L and 2P receivers varies greatly as the frequency increases.

### The 400 Series Handset.

This handset uses Inset Transmitter No 13 (same as the 164 and 184) along with a rocking armature receiver. It is fitted with either a 3306A or 4306 cord. It is assumed that the 3306A cord would be required where the 400 handset was used to replace a 164 handset such as on a 300 wall set as used in public telephones. It may also apply where a 400 handset is used on a 2+4 or 3+9 switchboard.

A rubber sleeve is fastened to the cord to reduce wear where it passes through the rectangular entry hole in the handset. This sleeve also performs the function of a strain cord in preventing the cord accidentally being pulled out thus prevent damage to the wires in the cord.

The 3306A and 4406 cords are unique in that they are especially designed for use in the 400

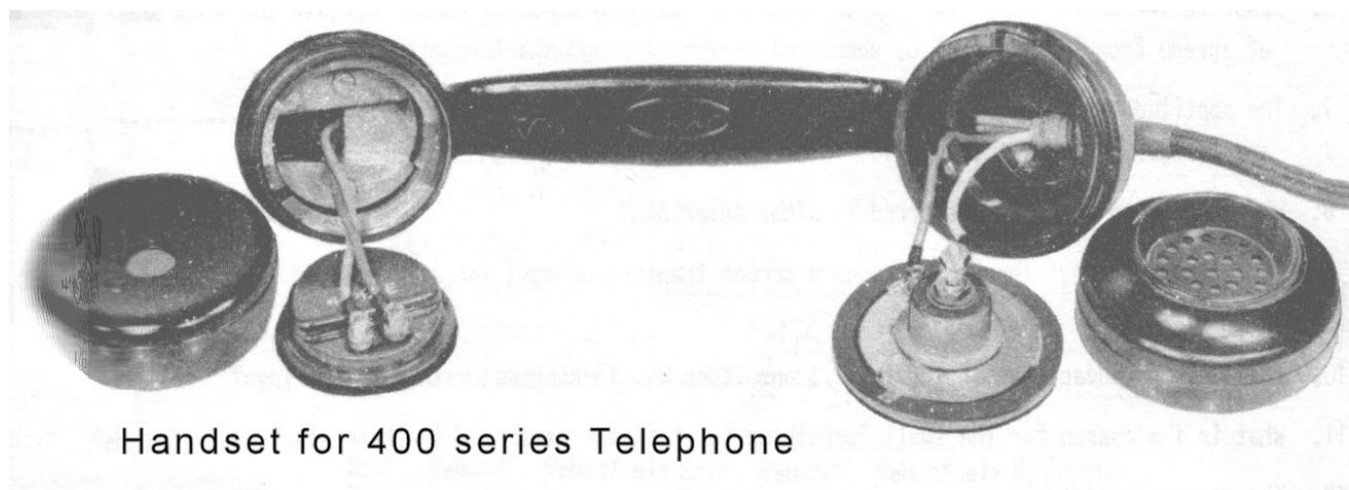


Response Curves of the 3 Telephone receivers

type handset. The two receiver wires (*red and green*) are made longer to feed up the hollow centre of the handset to terminate on the rocking armature receiver. One transmitter wire (*white*) is fitted with a terminal post which fits into the hollow rear electrode of the transmitter. The other transmitter wire (*blue*) has a terminal which fits under the screw on the flat side of the transmitter. Both earpiece and mouthpiece screw on and the receiver and transmitter are both locked so as to not turn when the cap is fitted thus preventing damage to the wires.

The 800 handset uses the same rocking armature receiver as the 400 type. The transmitter required is also a No 13 **BUT** it must be the later type which is fitted with the two terminal studs to allow connection of the transmitter wires in the coloured 800 series handset cords.

Reference for this series of three articles was "Telephony 1" produced by the Australian Post Office.



Handset for 400 series Telephone