Magnetic Adjustment of Receivers for the 500 Type Telephone Set

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In a telephone receiver, motion of the diaphragm results from the modulation of the field of a permanent magnet by an alternating field from voice currents in the receiver winding. For maximum receiver efficiency, the strength of the permanent magnet must be adjusted to an optimum value. By means of a new technique, the U1 receiver of the 500 type telephone set can be rapidly and precisely adjusted while an operator watches the condition of the receiver on an oscilloscope screen.

For sustained receiver efficiency in service, an adjusted magnet should retain its optimum strength under the demagnetizing effects of mechanical and electrical shock and stray magnetic fields. Permanent magnets are more stable if initially magnetized to saturation and then demagnetized to operating strength. Therefore, to obtain maximum receiver efficiency, the practice is to adjust receiver magnets by demagnetizing them to the optimum value following magnetization to saturation. This process of adjustment is usually referred to as "stabilization" because of the stable condition that results from adjusting for maximum efficiency in this manner.

Fig. 1—The initial step in stabilizing a telephone receiver is to magnetize its magnet to saturation.

When the response of a receiver to a constant applied signal is observed while the strength of the magnet is reduced from a condition of over-magnetization, the response is seen to increase to a maximum, and thereafter to decrease as the magnet is still further weakened. In the past, adjustment of the HA1 receiver for the 300-type set has been accomplished by means of a machine that automatically reduces the strength of the magnet in small steps while comparing the response at a given step with that of the preceding step. At the peak point where further demagnetization begins to reduce the response, a detecting circuit stops the machine, indicating that the receiver is adjusted.

For two reasons this method is inapplicable to the U1 receiver for the 500-type set. One reason is that the region of peak response is not defined sharply enough for dependable detection by machine methods. The other is that unlike the HA1, which effectively has only one magnet, the U1 receiver involves two magnets which are

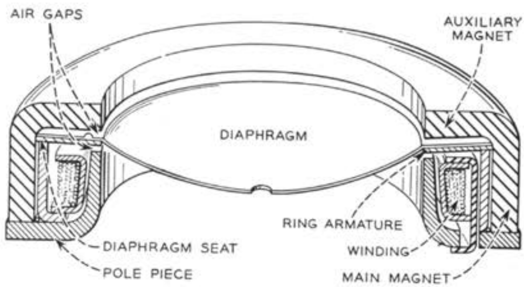

Fig. 2—Ring armature receiver.

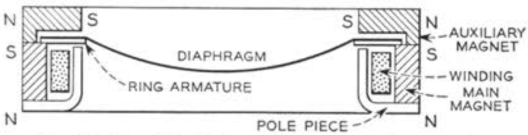

Fig. 3—Simplified view of ring armature receiver.

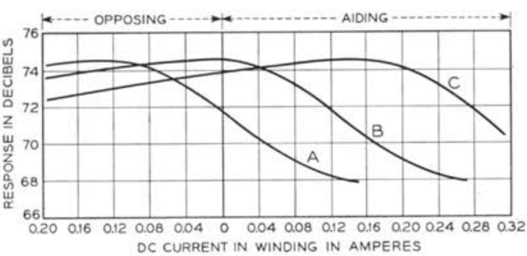

Fig. 4—U1 receiver response characteristics. A—Over-magnetized receiver. B—Correctly adjusted receiver. C—Under-magnetized receiver.

usually unequally magnetized. As shown in Figure 2, these magnets, known as the "main" and "auxiliary" magnets, are annular in shape and are mutually perpendicular. This design results in a more powerful magnetic field for voice current to modulate, and one capable of more precise adjustment. The result is a receiver which is three times as efficient. Also, since the effect of two magnets can be produced in a single piece of magnetic material by subjecting separate sections to unequal magnetizing influences, the main and auxiliary magnets can be combined into the single L-shaped section shown in Figure 2. This is done to simplify manufacture.

The dual magnetic adjustment required may be understood from a consideration of Figure 3 in which the two magnets are pictured as physically separate. The diaphragm is of plastic with a magnetic ring armature mounted at its periphery. The outer edge of this ring is seated firmly in position adjacent to the pole of the main magnet which supplies most of the controlling flux. By means of the pole-piece which is of soft magnetic material the other pole of the main magnet is brought around to operate underneath the inner edge of the armature. The armature is attracted downward toward the pole-piece and assumes an equilibrium position in which the magnetic pull is counterbalanced by the tension arising from flexure of the armature. With the main magnet overmagnetized the armature is pulled up tight against the pole-piece.

The efficiency of the receiver is controlled by the main magnet, and the first step in the adjustment is to weaken this magnet to the point of maximum receiver response. Generally, however, this initial adjustment does not insure sufficient clearance in the air-gap between the armature and the pole-piece to insure stable positioning of the diaphragm and to prevent possible interference from foreign particles. The gap is further widened by weakening the auxiliary magnet, changes in which do not significantly affect the location of the peak receiver response. The principles of the new adjusting technique may be understood by considering first how the effect of changing the magnetic field in a receiver is observed without actually altering the strength of the permanent magnet.

When direct current is made to flow in the receiver winding it will, depending on its direction, produce a magnetic field which aids or opposes that of the permanent magnet. If a signal of suitable frequency is also introduced into the receiver winding while this direct current is present, the response of the receiver to this signal for various values of the direct current may be plotted to produce curves like those in Figure 4, all of which show a point of maximum response at some value of direct current. Since the variation in response is the result of the change in magnetic field caused by the direct current, such a curve shows immediately what must be done to adjust the strength of the magnet to

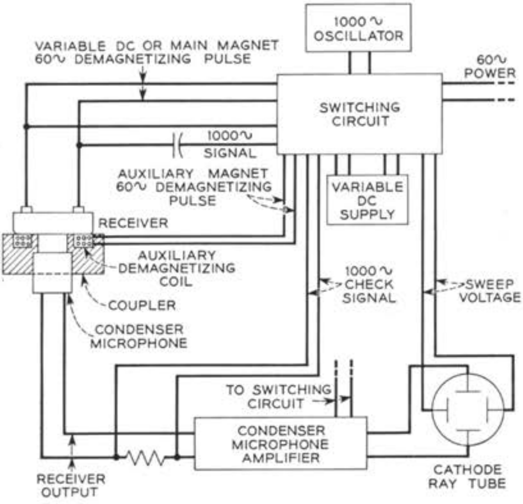

Fig. 5—Simplified diagram of receiver-stabilizer circuit. By the use of this circuit the curves shown in Figure 4 are directly portrayed on an oscilloscope screen.

Fig. 6—R. R. Kreisel watches shift in oscilloscope trace as he reduces strength of receiver magnet. Jig for coupling receiver to microphone is seen at right.

its optimum value for normal use which is with zero direct current. This is the condition represented by curve B in Figure 4. With the new technique, a block diagram for which is shown in Figure 5, these curves are directly portrayed on an oscilloscope screen.

A power source causes a voltage to vary, from a maximum positive value through zero to a maximum negative value, in about 0.65 seconds. This voltage is applied to the receiver winding to produce what is commonly called "variable dc." It is also impressed on the oscilloscope tube to produce the horizontal sweep voltage. The polarity of the horizontal sweep voltage is selected so that the oscilloscope spot is at its greatest right-hand deflection for maximum aiding current, and at its greatest left-hand deflection for maximum opposing current. By this arrangement, as the oscilloscope spot sweeps from right to left, the dc receiver current gradually falls from its maximum aiding value through zero, is reversed and then gradually rises to its maximum opposing value. Simultaneously with the dc, a constant 1000-cycle signal is applied to the receiver, and the acoustic output of the receiver resulting from this signal is impressed through a closed coupler on a condenser microphone. The condenser microphone output voltage is amplified and applied to the vertical deflection plates of the oscillograph tube to produce a vertical deflection proportional to the acoustic output of the receiver. By means of the rotating equipment which produces the horizontal deflection voltage, the vertical deflection voltage is applied at the time of maximum aiding current. It remains on until the maximum opposing current is reached.

As the oscilloscope spot shifts from right to left it oscillates vertically at the 1000-cycle signal rate and this rapid vertical motion and the use of an oscilloscope tube with a long persistence phosphor results in an illuminated area rather than a perceptible line trace. The boundaries of this area, somewhat brighter because of the slower spot travel at the end of its excursions, form an envelope trace which constitutes a plot of the receiver output versus dc and its characteristics indicate the magnetic condition of the receiver.

The demagnetizing operations required for the adjustment are automatically switched in only during the "fly back" portion of the cycle, from maximum opposing to maximum aiding current. During this time the receiver output circuit is opened, hence the receiver output is not impressed on the screen.

During the fly back period two calibrating traces are developed. Continuing to glow after the exciting voltages are removed, these marking traces persist as "bench marks" to guide the operator as he observes the receiver trace produced during right-to-left swing. One marking trace is produced by applying the receiver output for a brief interval as the dc voltage passes through zero. This marking, the O DC OUTPUT line in Figure 8, indicates the point at which the receiver output must be adjusted to peak efficiency. The other marking trace results from the application of a fixed oscillator voltage in series with the condenser microphone and equal to the voltage generated by a receiver of minimum acceptable efficiency. This marking signal being applied for a somewhat longer period than the first one produces the shaded area called the "Efficiency check band" in Figure 8. The O DC OUTPUT line and the CHECK BAND are distinguishable through varying gradations of luminescence depending on the different times during which they activate the screen. In addition to these two luminous traces, the face of the tube is marked with dc current-limit lines to provide the operator with allowable tolerance in adjusting the receiver. Maximum values of aiding and opposing dc over which the response of the receiver is examined during stabilization are preset in the machine, and determine the horizontal boundaries of the trace.

Demagnetization is accomplished by applying 60-cycle power to the receiver winding or to the auxiliary demagnetizing coil (Figure 5) depending on whether it is desired to demagnetize the main magnet or the auxiliary magnet. Figure 7 shows how the magnetizing fields for the main and auxiliary magnets operate independently. In each case the magnetic paths are restricted so that a negligible amount of interaction of the fields is experienced. In addition the coupler coil is wound with an air core and no magnetic material is used in the coupler so as to avoid magnetic shunting of the receiver magnets during adjustment.

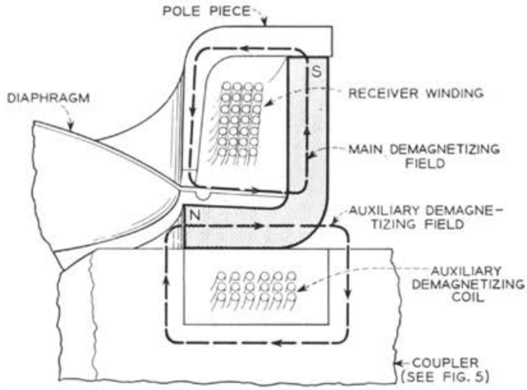

Fig. 7—Diagram illustrating independent action of demagnetizing fluxes on main and auxiliary magnets. Field from 60-cycle demagnetizing current flowing in receiver winding is concentrated in main magnet via pole-piece and diaphragm. Field from auxiliary demagnetizing coil concentrates in horizontal auxiliary magnet and does not perceptibly affect vertical section.

The first stage in the adjustment process is to demagnetize the main receiver magnet by applying 60-cycle power to the receiver winding in manually controlled increasing amounts. The principal stages of adjustment are illustrated by the oscilloscope traces in Figure 8.

With the initial state of high magnetization, the receiver is usually "frozen," that is, the diaphragm is held to the pole-piece by the flux, and the receiver has little or no output. This condition produces the trace of Figure 8a. Some reduction in the main magnet strength leads to Figure 8b in which a sharp peak registers the RELEASE POINT, or the point at which the main magnetic flux is weakened sufficiently to permit the sudden release of the armature from the pole-piece. The region of peak efficiency now appears at the far left of the trace. For current values to the right of the release point, the diaphragm continues to be held against the pole-piece. Only the portion of the characteristic to the left of the release point represents a receiver of operable condition. Further reduction of the main magnet flux moves the peak efficiency region and release point

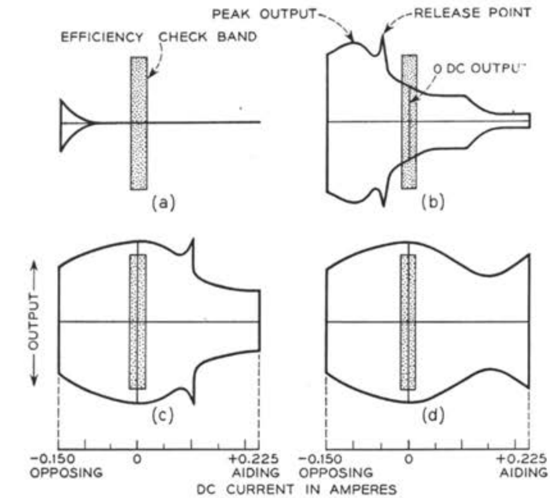

Fig. 8—Oscilloscope traces for various stages of receiver stabilization.

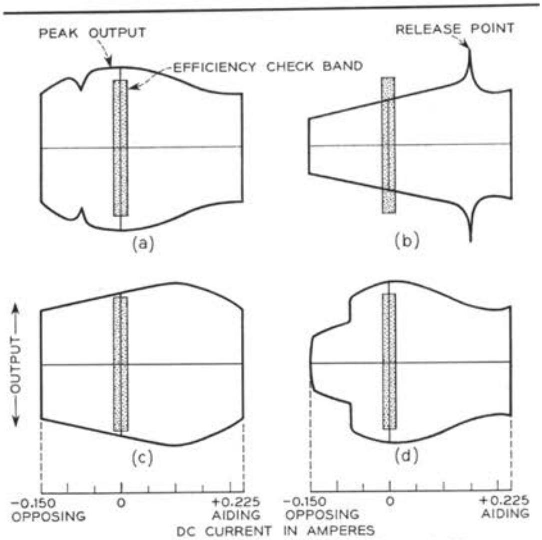

Fig. 9—Oscilloscope traces reveal mechanical flaws. A—Burrs or dirt on diaphragm seat. B—Ground separation too small. C—Weak magnet. D—Obstruction in auxiliary air-gap.

to the right as less and less opposing dc is required to produce peak efficiency. Adjustment is completed when the peak occurs at zero dc, Figure 8c.

The release point still remains as a discontinuity in the receiver output within the inspection range represented by the dc current limits of the oscilloscope trace. This condition indicates that the main air-gap remains too small and the armature might become "frozen" or blocked by any minute foreign particles which may be present. The next step, then, is to change the air-gap by demagnetizing the auxiliary magnet. This is done by applying automatically increasing steps of 60-cycle power to the auxiliary demagnetizing coil located in the receiver coupler, Figure 5. The start of the automatic stepping and the number of steps used is controlled manually and can be stopped at any step. Secondary adjustment can proceed as required from the last step used. As the auxiliary magnet is weakened, the release point is shifted toward the right

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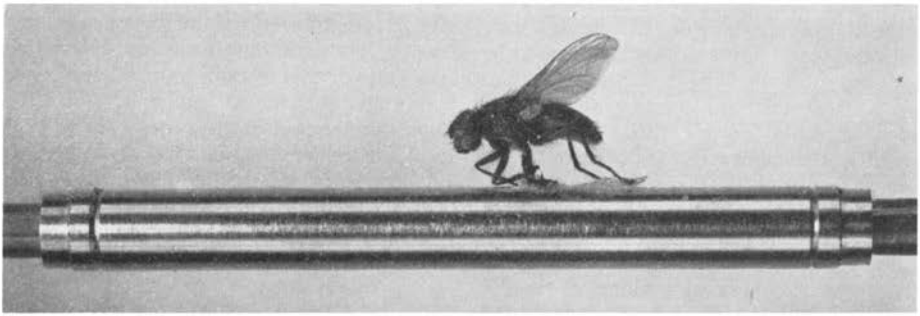
and just off the trace to produce Figure 8d which represents a completely adjusted receiver with an adequate air-gap.

Experience in the use of this machine results in ability to detect, through peculiarities of the output versus dc traces, numerous manufacturing irregularities which are not readily observed during assembly. Most important is the detection of foreign particles in the air-gap for which a separate test would otherwise have to be made. Other detectable faults are armature seat irregularities, bent armatures, burrs, low ground separation and weak magnets. Figure 9 shows some characteristic patterns which indicate the various assembly and piece-part faults as described in the caption.

A number of "stabilizers" of the type described in this article have been built by the Western Electric Company at the Shadeland plant and are in use on the assembly lines producing U1 receivers.



Comparison of the transistor repeater with an ordinary house fly — 3½ times actual size.

Tiny Transistor Repeater

Development of a new tetrode transistor for use in high-frequency equipment has resulted in the repeater seen in the illustration. Still in the experimental stage, the repeater is designed to operate as an integral part of a coaxial cable transmission system. Its diameter is only 0.15 of an inch and the length is approximately 1½ inches; comparison with the house-fly shows these dimensions much more graphically.

The small tubular case of the repeater contains fifteen components. In addition to the special tetrode transistor, a coupling capacitor, four resistors, an inductor, input and output transformers, input and output connectors, and two terminal plates, a pair of silicon diodes are used for voltage regulation. Power consumption is only about 0.1 watt, and could be reduced by half if voltage regulation were not used. Maximum undistorted power output is 10 milliwatts into a 75-ohm load, but normal output will be about 1 milliwatt. The repeater has a gain of 22 db, flat within ± 0.1 db, from 0.4 megacycles to 11 megacycles. Over this bandwidth of approximately 10 megacycles, the output noise level is about 72 db below 1 milliwatt. Although this particular model was designed to be powered by an extra wire running along with the coaxial cable, it can easily be modified to obtain power via the signal conductors of the coaxial.

As far as its transmission characteristics are concerned this repeater is capable of handling high-quality television. There are still questions concerning the best physical form for such subminiature units and how they might be employed in complete transmission systems.