An Analysis of Distortion and Fading

Clear Explanation of the Effects of the Heaviside Layer

By "M.I.R.E"

IN last week's issue possible causes of distortion and fading were dealt with, as the problem affected the transmitting station and its internal organisation. It was pointed out that although "fades" due to faulty transmissions were not impossible, the proportion of "fades" due to natural or atmospheric causes were accountable for the vast majority of troubles.

To get at the real causes of fading and distortion as well as the reason that signals on the broadcast band travel much further during the night than the day (all these points of interest having a common basis), it is necessary to consider transmission phenomenon and the existence and effect of what has become known as the "heaviside layer."

In order to understand the reasons which have led to the location of this "layer," it is necessary to make a digression and one of interest in itself.

INFLUENCE OF A VACUUM.

IF a glass vessel has installed in it a pair of metal electrodes having an air gap between them of say an inch and the terminals of an induction coil, transformer, or other source of high electrical potential are joined to the terminals, the voltage will tend to break down the air gap and force current across. Of course a high enough voltage would succeed in doing this, but for the purpose of this description a voltage insufficient is presumed. Now, if a vacuum pump is joined to the glass vessel and air gradually drawn out an interesting cycle of events follows. As the air in the glass vessel becomes reduced in pressure, current commences to pass between the electrods in the form of deep red streamers, which soon become a brighter red and fill the vessel as the air pressure reduces. The colours now change in step with their order in the spectrum of white light, and change to orange, then to a sort of yellow green, green, finally a bluey colour, after which a bright apple-green appears on the glass rather than in the interior of the vessel. Finally, with sufficient voltage, intense ultra-violet light and X-rays, result, after which the resistance between the electrodes rises to such a value with the rarifaction of the air that all current ceases.

THE initial point of interest is the particular point at which the vessel glows red all over, as it is at this stage that the resistance between the gaps is at its lowest (about 10 ohms. per centimetre for the benefit of technical readers).

THE HEAVISIDE LAYER.

NOW another digression, but also a necessary one.

The globe which we call the earth is floating in space which we say is a vacuum because of the absence of atmosphere or air such as exists on the surface of the earth. The air or gases surmounting the earth are held by gravity close to the earth, and are pressing on every square inch of earth surface at sea level with a pressure of 15lbs. In other words the weight of air pressing downward is that measure. Naturally, the pressure decreases away from the earth until at a distance probably running into hundreds of miles the air absolutely ceases and beyond is a vacuum

IT follows, therefore, that as the pressure decreases gradually from the point of sea level of 15lb per square inch to nothing there must be a certain point where the pressure corresponds to that at which the air inside the glass vessel exhibited such interesting properties of low resistance to electricity. This is found round about 50 to 60 miles above the earth's surface.

So 50 miles up, insulation ceases to exist, and the atmosphere has a resistance of about 10 ohms per centimetre compared with about 60 ohms per centimetre of earth such as would compose good farming land, and compared to infinite resistance of air at 15lb per square inch at the earth's surface

This belt of electrically conductive atmosphere is what is called the "heaviside layer."

THE FUNCTION OF SHIELDING.

IT is known, of course, that metals will reflect the waves which we call aether or wireless waves. Any substance which will conduct electricity readily will also reflect wireless waves. The metal shielding which is one of the features of modern receivers, is used to shield the tuning coils from harmful effects such as stray and interfering waves. Hence the "heaviside layer" will reflect waves too The world is, therefore, enveloped by a "ceiling" which is impervious to wireless waves and will reflect them This explains why waves travel over the curvature of the earth because they travel up and are reflected down again by the layer. Several reflections will take place when waves travel over great distances.

DURING the day the sun rains electrons, ultra-violet rays, etc. on to the surface of the layer and breaks it up, thus making it an inefficient reflector, while at night its surface is coherent and a relatively efficient reflector. In fact, all the difference between reflecting light with a bit of rusty tin as compared to using a mirror.

The layer does not present an absolutely even surface at night, although it may reflect fairly efficiently. The consequence of this is that the angular reflections of the wireless waves may be irregular and will arrive at the receiver from several different points of the compass and not at the same instant, owing to some waves having taken a less direct route than others. Directional reception proves this to be correct, as the direction the waves come in from the same transmitter will sometimes vary 40 degrees round about sunset and sunrise, when the layer is going through its transition stage.

THEORY AND PRACTICAL PROOF.

IF the electrical "phase relations" or times and direction of arrivals are such that the impulses imparted to a receiving aerial are additive, then efficient reception takes place, but if the "phases" of the currents induced by the waves are all out of step, then mushy reception as well as a loss of signal strength will result. The mushiness is easily explained by the acoustic analogy of a speaker in an empty hall being quite indistinguishable, but as soon as the hall becomes full of people and the echoes disappear the speaker's voice becomes clear and distinct. The echoes destroying clarity are waves arriving from different directions.

THIS explanation is borne out in practice by the fact that fading and distortion do not take place in daylight where the waves are dependent on atmospheric refraction to assist them a limited distance over the curvature of the earth or where one reflection at most takes place against the layer, the greater proportion of the energy travelling in a direct line from the transmitter to the receiver.

There is one outstanding practical illustration of this effect to be observed at a certain listener's place in a suburb of Wellington. 3YA, Christchurch, has consistently for months past in the afternoons filled a speaker using a 5-valve neutrodyne with the last stage of audio amplification cut out No distortion and no fading whatever Just as soon as the sun commences to dip below the horizon the signals get cranky and fade and distort in an extraordinary manner until quite dark, when the same performance continues to a lesser degree, but the full five valves have to be brought into use to get speaker volume.

ANOTHER THEORY.

CERTAIN theories have been advanced regarding the effect of earth currents from the transmitter interfering with the waves which have travelled by the aether and causing interference effects. It is not impossible that this is so under certain circumstances, but such a consideration is highly improbable for general purposes because swinging of signals at sunset can be observed by a directional receiver on an aeroplane and measurements have been made giving tolerably similar swinging observations of the same transmitter by an aeroplane with a loop on the ground and a directional receiving system definitely joined to earth, all receiving and recording their results at the same time.

Everything is apparently in favour of the "heaviside layer"

It was explained how much more efficient the layer is in its reflections night than during the day. This obviously is the reason for the longer distances covered by radio signals at night. A signal which has travelled 5000 miles may have been reflected twenty or more times, and the reflections must have been very much more efficient when it is considered that daylight ranges are approximately one-fifth of the night range of the same station on broadcast wavelengths.

THE performance of very long wave stations used for telegraphic purposes across the Atlantic, etc., follow laws which can be fitted into the idea of the "layer." Much has yet to be learned of the freak performances of the ultra-short wave stations, but the more that is learned the more the "layer" comes into prominence.

SIGNALLING TO MARS?

IN conclusion it is of interest to note that before inter-planetary signalling can be carried out, means must be found of piercing the layer It is being presumed now that wavelengths round about five metres or less are capable of doing this so that when the inhabitants of earth finally ring up Mars it may yet be on a wavelength as short as to be comparable to the wavelengths of heat or light, the shortness of whose wavelengths carry through the "layer" to bring good cheer from the sun and enable life on the earth to function on the lines peculiar to this planet

Construction Continued

pieces must be assembled nearly 1½ inches high when compressed, and so arranged that there is a gap of 1½ inches at alternate ends of each strip. This is best done in the right-angle of two flat boards nailed together, with two 3in. nails about 5 5/8in. apart. The strips are then fed into this alternately to the right and left. This pile is then gripped and pushed through the centre of the spool, and a few more strips pushed in until all is tight, but do not overdo the tightness. Sharp corners on the last few strips may cut the insulation, so snip the entering corners off and push in carefully. Now take short strips and put one in every space at each end of the core, pressing them against the ends of the spool. Now further short strips are put in the spaces between those already in at both ends. Next a set of long strips is put at one end of the side and finally the last set of long strips is dropped in one by one at the other end. A few odd ones have to be added at the outsides to level all up, and the clamps should be ready to put on at this stage.

The wooden clamps are four in number, 1in. wide, 3/8 thick and 4 5/8in. long. Holes, centres 3½ apart, are provided at each end to take the threaded brass rod, which should be cut a bare three inches in length, which will allow ample room for the nuts. The outside lamination on each side between the clamps will be loose at one end, and will vibrate, so must have some seccotine pushed under and the two be clamped down for a day until set.

The threaded brass rod used to tighten the clamps may be 3/16 diameter, one foot being sufficient when cut into four pieces. Eight nuts will be required, and 8 washers if considered necessary.

PANEL AND BASEBOARD.

The baseboard is 5½ inches wide, 6½ inches deep, 3/8in. wood, preferably battened underneath to prevent warping. Holes are drilled through which the transformer may be held in place by screws put in from under the board, into the lower edge of the clamps. The front clamp should be 1½in. from back of panel. A piece of ebonite 5½ins. by 4ins. will be ample to accommodate the output terminals, and six sockets, arranged somewhat as shown. A tin case should be arranged to cover the back and sides to keep out dust and prevent magnetic interference. If it is desired to put a tin screen behind the panel this should be ¾in. behind, then all wires from the panel and transformer can run down through holes in the baseboard and be connected by soldering underneath. Black cycle enamel makes a good finish for the tin case.

THE LAYOUT PLAN.

The plan shows the position of the various parts. At the back left-hand corner there is a small ebonite panel 1½ins. square upon which are mounted the two fuses on the alternating supply leads. These fuses, of either 40's wire or fine tinfoil strips, the latter the best, are held under washers secured by 1/8in. brass bolts and nuts through the ebonite, centres 1in. apart. An extra washer clamps the flex on each side of the a.c. input.

Behind the transformer also are the two British valve holders to accommodate the rectifier and resistance lamp. The resistance lamp does not make use of the grid connection. If desired, these two holders could be made on one slip of ebonite by inserting sockets in the correct positions, and the fuses placed across the end.

THE RECTIFYING VALVE.

The most useful rectifying valve to use is the Philips No. 328, a full-wave rectifier taking 3.5 amps at 1.75 volts on the filament, and delivering 1.3 amps at 12 to 14 volts rectified. If a battery requiring a somewhat higher voltage is connected up to charge, such voltage will be put out subject to the limitations of the transformer and the voltage drop in the rectifying valve, which latter is about 5 volts. This outfit is suitable for charging the 112-volt B battery as described in the "Radio Record," but the charging has to be done with the rows of cells connected "in parallel" as described on September 30 and October 7, 1927, a small attachment to the battery being constructed for the purpose. By this method the charging is rapid and reliable. A well-known firm of battery manufacturers in England has just put on the market an accumulator B battery embodying the elements of the above principle, which they have patented. As carried out by this firm, a number of short plates have to be unbolted and removed and two long parallel connectors bolted in their place. Speedy charging is the advantage claimed.

To work in conjunction with the rectifying valve its accompanying resistance lamp should be included in the circuit. This lamp acts as an automatic regulator. In the case of reversing a B battery to form lead plates, the battery should first be discharged, or the resistance lamp may burn out. Lamp No. 329.

The writer has been using a 328 valve for two years on very constant work, and it is still working well, which is a good testimonial to its lasting qualities.

The filament connections to the valve are the two usual ones, and the plate and grid connections represent the two-plate electrodes.

WIRING-UP.

The two ends of the primary winding of the transformer connect direct to the two fuses connected with the alternating supply of 230 volts, 50 cycles. Centre 1 and centre 2 taps connect one to each side of the resistance lamp (filament in ordinary valve) and the remaining (plate) pin is the negative output and goes to the top terminal on panel. The plates of the rectifier each connect to one of the flexes with pins on front panel, and the taps on transformer secondaries are connected to their respective sockets on panel.

Now for the filament supply. The filament is a heavy one, and although carrying 3.5 amps must only glow a dull red. Nine or ten turns should accomplish this, and these turns must be taken as equally as possible from each side of the centre tap. Try 9 turns first, increasing by one and testing until the proper output is obtained, but do not overload the filament. A voltmeter should be used and results carefully checked. Having adjusted filament voltage the rest is simple. All extra filament taps must be coiled up out of the way, care being taken that one end does not touch another and cause a "short."

Spaghetti tubing could well be used on the wiring, especially the primary leads from fuses to the transformer. Use not less than 18's d.c.c. for all connections.

The two flexibles with pins to fit sockets on panel may be ordinary lighting flex, heavy if possible. For 6-volt charging these are plugged into either respective 17 or 20-volt sockets. To charge two 6-volt batteries in series the 20-volt sockets must be plugged in. Up to 12 or 14 volts the charging current is 1.3 amps. As the required voltage increases above 14, the amperage available decreases. The resistance lamp regulates all changes, and it should be noted that this only glows a dull red in use.

The transformer keeps very cool on long runs.

Those who have not been used to connecting up accumulators for charging should note that the positive of charger connects to positive of A battery, and negative to negative. The output terminals should be clearly marked.

Should any reader have difficulty in procuring the valve and lamp, communicate with "Megohm."

MATERIALS REQUIRED

	s.	d.
Stalloy strips, 1½in. wide (108 ft, run) 3 doz. 3-ft. or 4½ doz., 2ft.	12	0
2 lbs. 18's s.w.g., d.c.c. wire	7	6
¼lb. 26's s.w.g. enamelled	2	9
6 Flush sockets, 2 pins	1	4
2 terminals		8
Philips Rectifying Valve, 328	15	0
Philips Resistance Lamp 329	5	0
2 British Valve holders	4	0
Ebonite Panel	4	0
Tin for case	1	0
Adhesive tape, empire cloth, threaded rod, nuts, etc.	5	0
	58	3