WHAT MAKES RADIO TICK?

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When radio as we know it was born after the First World War, the only previous experience upon which the engineers of that day were able to draw was that associated with telephone communication and the then recent introduction of radio telephony for wartime communication purposes. The equipment which had been satisfactory for vocal communication was pressed into service for the transmission of musical and other entertainment, even though its shortcomings for this purpose were many. For example, studio microphones were telephone handsets. However, these went largely unnoticed by the early listeners who accepted the necessity of sitting patiently round a crystal set, with headphones clamped tightly on, while the expert of the circle twiddled a dial and searched for a sensitive spot on the crystal with a 'cats whisker'. Early broadcasting stations usually consisted of two rooms; one housed the radio transmitter, and the other was the studio.

The transmitter usually consisted of a simple iron or wooden frame which supported the necessary valves, coils, and other components which were rearranged from time to time, mostly by 'cut and try' methods, in an effort to improve results. There were none of the modern instruments available and little authentic literature to enable the engineer to work with any degree of certainty or precision.
It was customary to line the studio with heavy draperies to damp the reverberant effects which gave the impression that the announcer was speaking in an enormous empty room. This was caused by the then highly omni-directional microphone patterns. The announcer usually doubled as a programme director and control operator, and sometimes even tended the radio transmitter while records were playing, since he seldom had more than one assistant, and sometimes none at all.

The transmitter aerial usually stretched above the building between two tall wooden masts, seemingly obsessed with the idea of crashing through the studio roof if given the slightest excuse. Broadcasting station owners initially operated at their own expense so they were, of necessity, also the riggers for their aerial systems. High masts were expensive to build and maintain and it became the practice to locate transmitting stations on the highest convenient hill to gain increased elevation for the aerial system at minimum expense; a practice which was later found to be quite wrong for the wavelengths used in present day broadcasting. With the passage of time and the encouragement and advertisers support that resulted from listeners appreciation of the service being rendered, facilities were gradually but continuously improved. New studios, designed specifically for the job they were required to perform, replaced the makeshift arrangements first used. Measuring apparatus was developed and new transmitters and studio equipment having known standards of performance became available and were quickly adopted by the stations. Increased revenue was put back into new plant, and engineers and technicians added to the staff. Today's modern broadcast station has a complete engineering department charged with the responsibility of providing and maintaining facilities for the most elaborate programmes.

The Broadcast Process: Before proceeding with a description of some of the engineering features of a modern station, it may be helpful to describe briefly the processes involved in transmitting sound from the studio to the listeners' home. When an artist performs before a microphone, its diaphragm is caused to vibrate by the sound waves. The vibrations are converted by the microphone into a correspondingly varying electric current in much the same way as ones' ear converts the sound waves into nervous stimulations which the brain understands as sound. The feeble electric current is amplified in the control room and mixed with the outputs of other microphones as required, and the whole is then sent to the transmitter via a pair of telephone wires. At the transmitting station the electric current is further amplified and then fed into the radio transmitter. The broadcast transmitter generates an oscillation commonly termed a 'carrier wave' which is continuously radiated by the aerial to all points of the compass. The varying current which originates in the studio microphone is used to mould. Or, to use a technical term, modulate the steady carrier wave so that it is modulated in conformity with the currents produced by the microphone.

One may well ask, why bother with the carrier wave? It is used, as the name implies, to carry the intelligence which is impressed upon it in the transmitter. If the varying current produced by the microphone was merely amplified and fed to the transmitting aerial, practically no radiation into space would occur. However, the carrier wave varies very rapidly, in the order of million times each second, and at this high frequency it is comparatively easy to arrange the aerial so that most of the energy fed into it is radiated. The use of carrier waves to convey the sound has another important advantage since many stations can operate simultaneously, each by using a carrier wave of different frequency. Thus, by tuning a radio set to the frequency of that desired, a choice of programme is made possible. The radio set converts the modulated carrier wave back into the same kind of varying current as was produced by the microphone in the studio, and the loudspeaker completes the process by changing this current back into sound waves.

The Control Room: As its name implies, the control room is the nerve centre of a broadcasting station. Various programmes which may originate in any of several nearby studios and other programmes from remote points such as concert halls and sporting fixtures all pass through the control room. Here the operator has at his disposal numerous amplifiers, volume controls, mixing circuits and elaborate switching equipment which are arranged to ensure that the desired programme is properly amplified and regulated before being sent on to the transmitter. There may be several programmes arriving at the control room from different sources, and it is most important that each is routed to its proper destination. Quite often it is necessary to 'split' certain programmes into several 'outputs', each of which is sent on by P.M.G. telephone landlines to broadcasting stations in other cities. The purpose of the 'splitting amplifier' is to prevent a fault, such as a short circuit on one landline, from disturbing the transmission in other directions. The quality of reproduction is continuously checked on a high grade loudspeaker and its volume is also kept at the proper level by means of a volume indicating meter which is much more accurate for this purpose than the ear.

Recording Equipment: Since it quite often happens that the artists or speaker cannot come to the studios at the time a broadcast is due on the air, facilities are provided for making recordings. The recording machines are installed either in the control room, or, in larger stations, in a separate room. The records most commonly used for this purpose are aluminium discs coated on both sides with a special lacquer. The disc recording machine cuts a spiral groove which is deflected from side to side by the varying current produced by the microphone and which is amplified until it is powerful enough to control the movement of the sapphire stylus which cuts the groove on the record surface. These records, known as 'transcriptions', are usually 16 inches in diameter and play for 15 minutes. They are ready for use as soon as they are removed from the recording machine. Other types of recording equipment are also used. One of the most popular being the magnetic recorder. These instruments magnetise a very fine steel wire or tape as it passes over a recording head. In this type the intensity of magnetisation is governed by the amplified current produced by the microphone. Magnetic recorders can be very compact and are easily carried to outside locations for programme material that cannot be brought to the studio, such as newsreel interviews. As much as one hour of programme material can be recorded on a single spool of wire.

Outside Broadcasts: At certain times, quite a large part of the programme comes from places that are remote from the studio. Broadcasts from theatres, meetings, and sporting fixtures must originate on the spot, so that microphones and portable amplifier equipment are sent out and set up at each place required. The prepared telephone lines which are rented for this purpose from the P.M.G.'s department. At times, the programme consists of broadcasts from one outside point after another, with the studio and control room acting as the clearing house. This usually happens on Saturdays with broadcasts coming from first one racecourse, then another, followed perhaps by commentary on a cricket match and so on. On such occasions, skilled technicians are kept busy seeing that each crossover is smoothly coordinated, but it all flows so smoothly from the radio that is sounds very simple indeed.

Studios: Whereas very little was known on the subject of acoustics when the early studios consisted of a room heavily draped with curtains, the position today is vastly different. The modern station has several studios of various sizes to suit the different types of programme broadcast. In place of draperies, the walls are scientifically treated with special sound absorbing materials. As these materials are soft and porous, they are usually concealed behind perforated sheets of fibro cement or plywood which is treated to conform to the architects' decorative scheme, and is capable of withstanding the heavy wear and tear of constant use. The sound waves pass through the perforations and the desired proportion absorbed. In the early days the object was to absorb as much of the sound as possible, but it was later realise that this took away all the brilliance from music and speech. The shapes of studios are also given much consideration, and the trend is toward using irregularly shaped rooms with the walls and ceiling broken up with heavy columns and beams. Some American studios have been built with opposite walls sloping inwards toward one another, and the ceiling set at an angle to the floor. The result looks unconventional to say the least, but it works well, which is most important.

The Auditorium: Perhaps the most popular programmes of all are the audience participation shows which come from the Auditorium. Here a stage is set for the performers and provision is made for about 300 guests who provide the applause and the laughter so necessary to artist and comedian alike if they are able to give their best performances. A separate booth is provided in part of the Auditorium from which the producer and technicians view the performance through double plate glass windows. This booth is quite soundproof and the programme is heard from a loudspeaker which enables the producer to know exactly how the programme will sound in the listeners' homes. During the rehearsal of big shows, which may take many hours to prepare for a half hour broadcast, the technicians are busy deciding the best microphone for each purpose and adjusting its position until the producer is satisfied that the balance is as perfect as can be achieved.

As many as nine or ten microphones may be set up on the stage for use at different times during the show. They are delicate precision instruments, costing from £20 to £80 each, which are ruined if dropped or knocked over, and are therefore handled with great care by the expert technicians who understand their various characteristics. To guard against accidents, two microphones are often mounted side by side at important places so that if one microphone fails, which rarely happens during a performance, another can be substituted by simply switching the connections in the control booth. This can be done so quickly that no one is likely to detect the change. The amplifier equipment in the control booth is usually duplicated too, with both equipments operating at all times so that even a major breakdown is unlikely to cause any interruption to the programme, although the effect of the nervous strain is plainly evident on the faces of the producer and technicians at such times.

Transmitting Stations: As with the control room and studios, the modern transmitting station contrasts sharply with those of the early days of radio. The site for a station is chosen so that it is as near as possible to the centre of population of the district to be served, providing that the other requirements necessary for efficient transmission can be met. Housed in a building designed for the purpose are the transmitter itself and various other items of auxiliary equipment. There are also facilities for the comfort and convenience of the technicians who are always on duty while the station is operating. The transmitter is a self-contained unit in a lacquered steel cabinet. Meters on the front of the cabinet give a continuous indication to the technician of the performance of the various circuits, and controls are provided for operational adjustments.

Personnel are protected from injury through accidental contact with high voltage circuits within the transmitter by safety doors which automatically disconnect the power if opened while the transmitter is in operation. The operator is provided with a desk on which are situated the more commonly used controls, together with a microphone and phonograph pick-up and turntable for the provision of announcements or emergency programme in the event in the event of the lines from the studio failing. The auxiliary equipment often includes a stand-by transmitter for use if the main transmitter should fail, plus a petrol or diesel driven generating set to guard against a failure of electric power supply, and sometimes a complete studio for use in emergency or on special occasions.

The Aerial System: After leaving the transmitter the signal passes along specially arranged wires known as a 'transmission line' to the aerial system which is the most conspicuous, and in some ways, the most important part of the equipment of a radio station. The function of the aerial system is to radiate the carrier wave containing the programme material in all directions, concentrating the greater part of the energy along the surface of the ground where it will be most useful in providing a strong signal at the listeners' homes. The aerial itself is usually a tall steel tower or mast which, being an electrical conductor, also serves as an aerial. This is a departure from the early practice of using two wooden masts to support the aerial which was suspended between them.

The height of the mast varies according to the wavelength used by the station and is usually either a quarter or a little more than half the wavelength; thus a station operating on 1,000 kilocycles per second, which corresponds to a wavelength of 300 meters, could use an aerial tower either 75 meters or somewhat more than 150 meters high. The higher one is slightly more efficient for certain purposes which are too involved for detailed discussion in these pages, and the cost of construction is naturally very much greater. Generally speaking, the extra cost of the very high aerial is warranted for higher power stations, especially when it is desired to minimise night-time fading and distortion which is common at a distance of from 50 to 100 miles from the transmitter.

Although the tall tower is the conspicuous part of the aerial system, it could not operate efficiently without the earth system which, though invisible, is nevertheless very important. It usually consists of 120 wires, each at least as long as the aerial is high, buried a few inches under the ground and extending in all directions from the base of the tower or mast. The work entailed inlaying such an earth system is not apparent until it is realised that there is more than 11 miles of wire to be laid out and buried to complete the installation. Fortunately, rocky mountain tops are no longer used for transmitting station sites, since it is known that low-lying marsh lands or swampy areas provide the best conditions for good radiation. Wet ground provides a good return path for the currents which are radiated by the aerial through space above the ground and which must return to the base of the tower through the earth.

As the radio programme leaves the aerial, the engineers and technicians who have guided it through the various stages, beginning in the studio, are relieved of their responsibility. It then becomes the prerogative of the listener to decide if their work has been worthwhile.