Transmission Apparatus of a Short-wave Station

A CORRESPONDENT interested in short-wave reception, Mr. A. P. Morrison, of Brooklyn, sends the following account of 3XN, the short-wave station attached to WJZ (Whippany, New Jersey):—

THE particular equipment used in the tests at Whippany is the development model of the Western Electric 7-A radio broadcasting transmitter, rated at 50 kilowatts and transmitting on 59.9 metres. It has been created to make possible the provision over areas of reasonable magnitude of broadcasting service consistent with the ever-growing requirements of its art.

The transmitter uses 25 valves, of which 14 are water cooled. The valves and their related circuits are mounted on and behind ten panels; on a floor below are installed some of the bulkier pieces of apparatus, such as transformers, generators, and filters. With the normal unmodulated output to the aerial is 50 kilowatts, the valve capacity is adequate to deliver 200 kilowatts, which are required during peaks of modulation.

Crystal Control.

WITH so many broadcasting stations on the air, it is of first importance that each one maintain its carrier frequency constant at the valve assigned by the Federal Radio Commission. To this end, the frequency of the carrier wave is controlled by the oscillation of a small quartz plate. Cut from a single crystal, with proper orientation as to the crystal-line and optical axes, the quartz plate carefully ground to a thickness determined by its desired frequency, is then associated with a master oscillating circuit. As one precaution to ensure constant frequency, the plate is mounted in a container where its temperature is held constant.

Speech currents from the control room are amplified by two stages in the set proper; the output voltage from the last of these is used for modulation. The radio frequency generated by the valve under control of the crystal is amplified in five stages. On the plate voltage of the second-stage valve is superposed the audio-frequency voltage for modulation. The audio-frequency voltage is sufficient to effect complete on 100 per cent. modulation of the carrier.

Amplification.

THE modulation stage is followed by three more stages of radio frequency amplification, each of which is a push-pull circuit. Water-cooled valves are used in the last two stages; two in one and six in the other. Tuned circuits from the enter-stage couplings and also transfer the output power to a transmission line which leads out to the antenna system. In the final tuned circuit, currents as great as one hundred amperes may flow through the heavy copper tubing of the inductance coil.

POWER for the set, amounting to about 250 kilowatts, is drawn from central station lines as 440 volt, 60 cycle, 3-phase alternating current. A major portion of this power goes to a six-phase vacuum tube rectifier, which supplies direct current at 17,000 volts to the last two stages. One motor-generator set supplies about 550 amperes direct current to the amplifier filaments; another set supplies grid-bias voltages. Outputs of both these generators pass through filters, that for the filaments using electrolytic condensers and a large choke coil.

To prevent excessive heating and consequent damage to the valves, provision must be made to remove the heat generated in operation. For many of the valves radiation into the air is sufficient, but for others water cooling is necessary.

Cooling.

THESE valves are inserted in jackets through which water flows in contact with the valve anodes. Water is led to and from its valve jackets through lengths of coiled hose. This is to provide the necessary insulation between jackets, which are connected with the anodes, and therefore at high potential, and the other parts of the cooling system which are grounded.

The water in turn is cooled by radiators, through which air is forced by large fans. About a hundred gallons of water a minute flow through the cooling system. Should the water cease to flow, or should its temperature rise beyond a safe value, power is automatically removed from the tubes.

Layout.

THE layout of the Whippany laboratory includes a control room where the speech input amplifier and related equipment are located. Adjoining it is the transmitting room itself. Along one wall of this room is an assembly fronted by seven panels, housing the auditor and radio frequency circuits.

At the end of the room is a group of three panels: one for general power control, which carries its push buttons by which the set is started and stopped; one for the 17,000-volt rectifier and one for the 1500-volt rectifier. Valves for these rectifiers are mounted behind their respective panels. The transformers and filtering equipment for the higher voltage rectifier is located directly beneath, on a lower floor. On this floor are also the motor-generator sets.

In order to keep the station and its equipment outside the more intense field of the aerial connection is made between the transmitter and antenna by a two-wire line about five hundred feet long. The voltage between wires is approximately 6000, and its line functions as any other though its power is transmitted at a very high frequency. The tuned circuits for coupling to the aerial are located in shielded compartments at the end of the transmission line directly beneath the aerial.

MUCH thought has been given to the protection of its operating staff against high voltages. Throughout the transmitters access is had to the circuits through doors and windows which must be securely locked before the circuits can be engaged; in order to open these points of access it is necessary to unlock them through a mechanism which first disconnects the power supply and grounds the high voltage parts.

All parts requiring adjustment or replacement are readily accessible. Other portions of the apparatus are arranged with a view primarily to the compactness of its equipment. This promotes economy in floor space, facilitates protection, and enables important elements to be observed by a minimum of personnel.

Radiation.

SATISFACTORY services to broadcast listeners—the sole justification of any station—requires that everything possible be done to minimise interference with other programmes. To avoid the annoying "whistle" which results from heterodyning of its carrier with that of a station occupying an adjacent frequency channel, the carrier must remain very close to its assigned value. This requirement is well met through crystal control.

Moreover, radiation of harmonic frequencies must be as little as possible, since this is in effect a transmission of the programme at a frequency which may conflict with that assigned to another station. The disturbing effect of harmonics being proportioned to their absolute value, special precautions must be taken in the construction of so powerful a transmitter.