Expert Describes the Plant

Intense interest is being evinced on every hand in the opening of 2YA, the Dominion's new high-powered broadcasting station, and it is certain that a wave of development will start from this point which will carry broadcasting forward to an era of expansion and service which will have a far-reaching effect on the country. In the following article Mr. Keith H. Thow, the expert appointed in connection with the installation by the Standard Telephones and Cables, Ltd. (formerly Western Electric Co., Ltd.), gives an interesting and full explanation of the plant and its capacity.

The Plant.

The microphones, speech input equipment, and the radio transmitter used at 2YA, the new Wellington station, were all designed and built by Messrs. Standard Telephones and Cables, Ltd. (formerly Western Electric Company, Ltd.).

The manufacture and testing were carried out at the company's works at Hendon (London, N.W.). During his stay in England for the Dominion Premiers' Conference, the Right Hon. Mr. J. G. Coates visited the company's works to inspect the equipment, and expressed his appreciation of the high quality of the transmission.

With the exception of the meters and a few of the valves the whole of the equipment is British made, and is a fine example of the very latest radio-engineering practice combined with the highest quality of workmanship, finish, and materials.

The whole equipment from the microphone to the aerial is designed to give the greatest possible faithfulness of transmission of speech and music frequencies, extreme stability of wavelength, and high efficiency. That it attains these ambitions is indicated by the following:—

(1) Curves taken in the laboratory show that absolutely faithful reproduction is obtained up to at least 80 per cent. modulation, using audio frequency inputs varying from 35 to 9000 cycles. Above 80 per cent. and up to 100 per cent. modulation the distortion is so very slight as to be quite unnoticeable on a receiving set.

(2) A three hours' carrier stability test on 351 metres (i.e., 854 kilocycles), with readings taken every 15 minutes, showed a maximum variation of only 50 cycles—which is less than .006 of 1 per cent.

(3) When delivering 5 K.W. of unmodulated carrier to the aerial the equipment requires from the supply mains approximately 32 K.W. at a power factor of 80 per cent.

The Microphones.

Two types of microphone are used—the "double-button carbon" type and the "condenser" type. In each of these the duralumin diaphragm, only one-thousandth of an inch thick, is stretched radially to such a degree that its natural or resonant frequency is higher than 7000 cycles per second, i.e., almost at the upper limit of music frequencies. This tension on the diaphragm reduces the efficiency somewhat, but this defect is amply compensated by the extra faithfulness obtained and the high "gain" of the speech amplifier enables the feeble output of the microphone to be amplified to a level suitable for operating the radio transmitter. The condenser microphone is even less efficient than the carbon one, so much so that its output requires an extra stage of voltage amplification before being fed into the ordinary speech amplifier.

This apparently serious drawback is, however, completely nullified by the fact that this microphone gives perfectly faithful reproduction without any of the hiss due to carbon microphones.

The speech amplifier forms parts of the speech input equipment (located at the studios), the various components of which, in the form of panel units, are mounted on a three-bay vertical iron rack. All panels are of steel and metal dust covers, which serve also as screens, and protect the apparatus mounted on the panels.

The Panels.

The various panels, with brief descriptions of their functions, are as follow:—

(1) Volume Indicator Panel.—This consists of a valve detector which rectifies a small but definite portion of the output of the speech input amplifier. The rectified current is measured by a direct current galvanometer mounted upon the gain control panel. The input (from speech input amplifier) is controlled by means of switches, which enable a standard deflection of the galvanometer to be obtained in any part of the volume range.

The volume indicator is used in conjunction with the gain control for maintaining the output of the speech input amplifier at the correct level.

(2) The Signal and Control Panel is provided to enable any one of a number of different relay lines to be selected, and to carry the apparatus necessary for communicating with the studio.

(3) The Speech Input Amplifier consists of three stages, the first being voltage amplification, and the second and third power amplification. Normally the plate voltages are 130 volts for the first two stages and 350 volts for the last stage, but provision is made for running all three stages on 130 volts, if desired. Grid bias for the first stage is obtained by using the potential drop across a small resistance in the filament circuit, but batteries supply grid bias to the second and third stages. The panel is equipped with meter jacks, enabling currents in the plate and filament circuits, and also in the microphone buttons to be checked.

(4) The Gain Control Panel carries two 24 step potentiometers and the galvanometer associated with the volume indicator panel. The two potentiometers are connected in a special manner, in the grid circuit of the second valve of the speech input amplifier and by means of them the output can be varied in steps of two over a range of 96 transmission units. The two potentiometers are operated jointly to obtain the coarse adjustment and either one of them independently to obtain the fine adjustment.

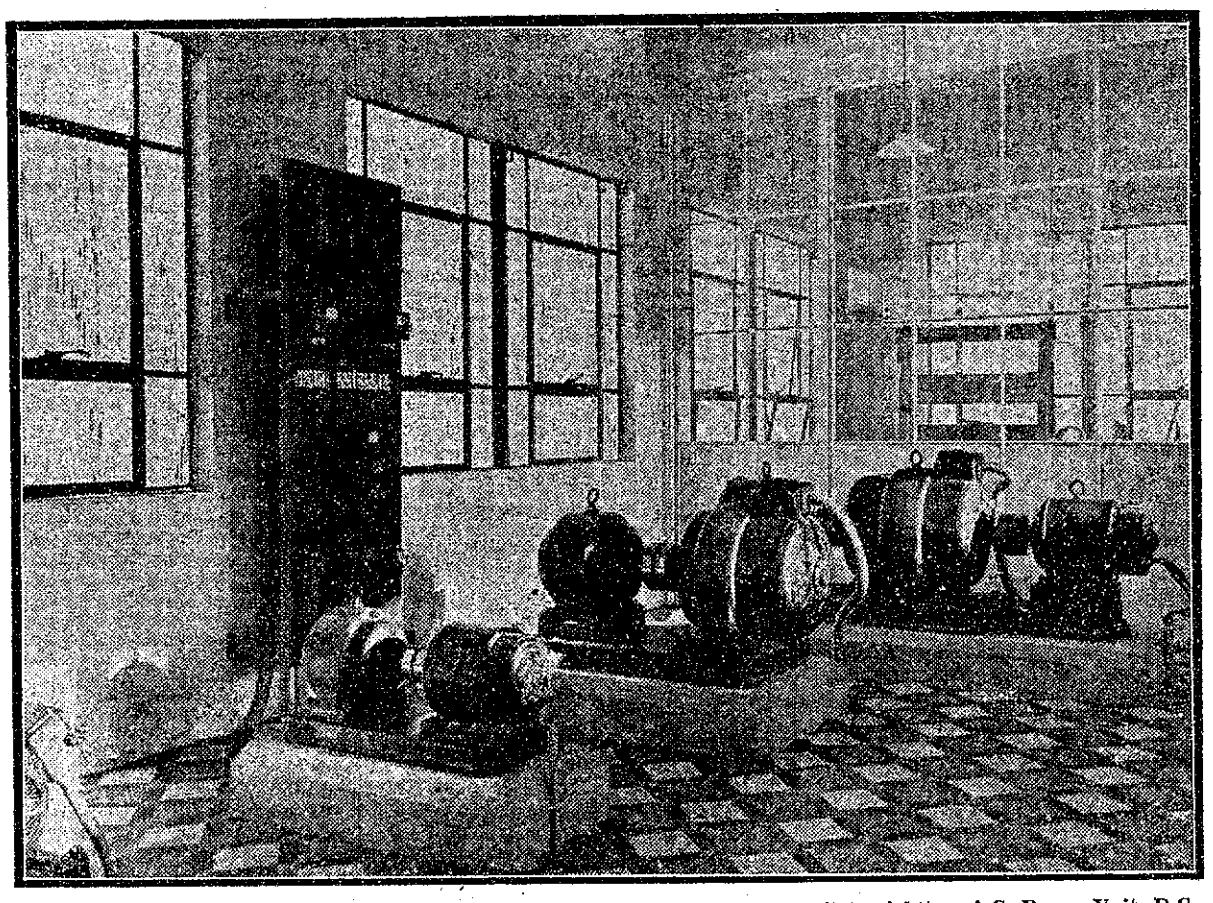
(5) Meter Panel.—The meter panel carries the following instruments:—

Ammeter, reading 0-4, for measuring filament currents.

Milliameter, reading 0-100, for measuring plate and microphone currents.

Milliameter, reading 0-5, for measuring plate currents

Two plug-ended cords are provided, one associated with the ammeter and one with the milliameters for plugging into the appropriate jacks on the various panels. To eliminate the possibility of injuring the milliameters the plugs are of different sizes, so that only the proper instrument can be brought into circuit. A key is provided for reading the current on the low scale milliameter, the high scale instruments being normally in circuit as soon as the plugs are inserted in the jacks.



Front view of the transmitting plant, showing the six units as follow (from left to right):—A.C. Power Unit, D.C. Power Unit, Oscillator-Modulator Unit, Rectifier Unit, Power Amplifier Unit, and Tuning Unit.

(6) Radio Receiving Panel.—The radio receiving panel, together with the associated aerial, enables a number of loud-speaking receivers in various parts of the premises to be operated and enables the programme to be monitored "on the air." The circuits comprise a detector and two stages of audio-frequency amplification. Resistance capacity coupling is used between the detector and the first amplifier and transformer coupling between the amplifier valves. The last stage is choke-capacity coupled to the ouput.

Rheostats for adjusting the filament currents and jacks for measuring the plate and filament circuits are provided. A coil holder for accommodating plug-in coils and a variable condenser for tuning are also provided. The volume level of the output is controlled by means of a potentiometer connected in the grid circuit of the second valve.

(7) Monitoring Amplifier Panel.—This panel enables the output to be monitored either by means of the radio receiver or at the output terminals of the speech input amplifier, the desired point being selected by the operation of a key.

Filament rheostats and jacks for controlling and measuring plate and filament currents and a potentiometer for regulating the output are also provided on this panel.

The Amplifier.

The output from the speech input amplifier is fed to the land line connecting the studio and radio transmitter at a fairly high volume level. This is done to reduce the proportion of line noise to signals. On arrival at the transmitter the volume level is reduced to a suitable value by means of a non-inductive resistance shunted across the line. It is then passed into a 50 watt speech amplifier valve which further amplifies it before it is fed to the modulator valve.

The Carrier Wave.

A special feature of this equipment is the generation and modulation of the carrier wave at low-power. This low power modulated wave is subsequently amplified by means of two stages of power amplication, the second stage feeding the aerial with 5 k.w. of unmodulated carrier. It is important to note that with 100 per cent. modulation the peak output may rise to nearly 20 k.w.

The carrier is generated by means of a 50 watt valve using a specially stable form of Colpitts oscillator circuit, further stability of wave length being ensured by the use of a "master separator" valve interposed between the master oscillator and the first modulated high frequency amplifier.

In the output circuit of this master separator valve is included a non-inductive potentiometer which regulates the feed to the modulated high frequency amplifier. This high frequency amplifier is choked-coupled to the modulator valve so that modulation is accomplished by means of the Heising or constant current method. The output from this modulated high frequency amplifier is transferred by means of a special interstage circuit to the grids of four 250 watt air cooled valves in parallel which constitute the first stage of power amplification. The output from this stage feeds the final stage comprising two 10 k.w. water cooled valves operating in parallel. The inter-stage circuits used throughout are specially designed for maximum efficiency and capacity coupling is used to eliminate harmonics. In each case the coupling capacity is shunted by a non-inductive resistance which forms a stabilising load on the preceding valves and also assists in matching the impedances of the plate circuit of one stage with the grid circuit of the next stage.

Source of Power.

The filament supply for the water-cooled power amplifier valves and both plate and filament supplies for all air-cooled valves are provided by motor generators. A 250 volt generator supplies grid bias to all valves, the different voltages being obtained by means of fixed potentiometers. Grid bias to the modulator valve is however supplied by a continuously variable po-

The 10,000 volts plate supply for the tentiometer.

final stages is obtained from a 3-phase single wave rectifier operating in conjunction with a high voltage step-up transformer, a smoothing choke and a bank of smoothing condensers. These condensers are connected in series parallel to give a total capacity of 3.2-3 microfarads. The connections between each condenser in a series bank are made by means of 5 ampere fuse wire, which blows in the event of a breakdown in any one condenser, thereby protecting the remaining two in the bank.

High resistances are shunted across the condenser bus-bars to equalise the load and also to discharge the condensers when the plant is shut down.

As the filaments of the rectifier valves are at the full high-tension voltage above earth potential they are lighted from the mains by means of step-down transformers. The windings of these transformers are insulated for 30,000 volts R.M.S. The plates of the water-cooled valves are practically at earth potential, so that no special precautions have to be taken to insulate them The plates of the amplifiers are, however, at 10,000 volts above earth potential. The cooling water from the circulating pump is fed directly into the anode jackets of the rectifier valves, which are connected in series and thence through rubber hose coils to the anode jackets of the amplifier valves (also in series). The outlet water from the latter being carried through another hose coil to the cooling radiators are thence back to the circulating pump. The length of the water column in these hose coils is sufficient to provide an insulation resistance to earth of approximately one megohm.

As will be seen from the accompanying photograph, the radio equipment is arranged in the form of six panel units with a frontage of 18ft. 6in. An expanded metal cage or enclosure 10ft. 6in deep and the same height, namely, 6ft. 6in., as the panel units, encloses all the high voltage apparatus. The motor generators and circulating pump are located in a separate room.

Protective Devices.

Protective devices and alarms are provided for automatically shutting down the station in the event of a fault developing and for indicating the location of such a fault, as follows:—

(a) Fuses and all circuits.

(b) A gate switch which automatically cuts off the 800, 1600, and 10,000 volts supplies when the gate is open.

(c) Water pressure and water temperature indicators to remove all voltages from the water cooled valves in the case of failure of the water supply.

(d) Isolating switches to break the primary circuit of the high tension transformer and the field circuit of the 1600 volt generator so as to protect the operators while adjustments are being made.

(e) Overload relays in two phases of the primary circuit of the high tension transformer in order to remove the voltages in the case of an overload.

(f) A time delay relay to give a delay of 15 seconds in order to allow the filaments of the power amplifier valves to warm up before the high voltage is applied.

(g) A 250-volt relay to ensure that the necessary grid bias potential is applied to the power amplifier valves before the high voltage is applied.

(h) An overload relay in the earth side of the 10,000-volt supply in order to remove the high voltage from the anodes of the valves of the power amplifier in the event of an overload.

(i) Spark gaps across each of the three phases and the neutral point of the secondary of the high voltage transformer to protect the insulation in the event of high voltage surges. Current limiting resistances are provided in series with the spark gaps.

(j) A time delay relay to give a delay of 20 seconds in order to allow the filaments of the valves in the oscillator-modulator unit to warm up before the high voltage is applied.

(k) An overload relay in the earth side of the 1600 volt supply to remove the high voltage from the anodes of the valves in the oscillator-modulator unit in the event of an over-load.

(l) Fuse wires connecting to the busbars the individual condensers that make up the 10,000 volt smoothing condenser, to isolate any condenser in the event of it breaking down.

The safety of the personnel is adequately ensured by the above safety devices and by the fact that the front panel is absolutely "dead."

The Panel Units.

From left to right the panel units are as follow:—

(1) The Alternating Current Power Unit.—This carries all the relays, contactors, fuses, etc., associated with the motors and rectifier and also an oil switch for connection to the incoming power mains. The overload relays and their associated current transformers which are included in the leads to the primary circuit of the high voltage transformer are also included in this unit. A voltmeter is provided, which in conjunction with a six position switch enables the voltage of each phase of the incoming mains to be measured and also the voltage across the primary of each of the three rectifier filament lighting transformers. The latter voltages can be regulated between limits by means of rheostats connected in series with the supply. Two push button switches on the front panel serve to operate the contactors which start the motors and switch power on to the rectifier unit.

(2) The Direct Current Power Unit.—Contains the voltmeters field rheostats, time delay and overload relays required by the four D.C. generators. A push button switch in conjunction with time delay relays completes the field circuit of the 1600 volt generator.

(3) The Oscillator Modulator Unit.—Contained in this unit are the Master Oscillator, Master Separator, Speech Amplifier, Modulator and modulated high frequency amplifier valves and also the first stage of power amplification. The interstage circuits comprising inductances, tuning and coupling condensers and load resistances, are also included in this unit. The top front panel carries nine meters which indicate the currents at every important point in the circuits.

(4) Rectifier Unit.—This contains the water-cooled rectifier valves and their filament lighting transformers. The front panels carry the R.H.T. voltmeter and also three rectifier plate current meters.

(5) Power Amplifier Unit.—The two 10 K.W. valves with their associated hose-coils, radio frequency chokes, stopping condensers, anti-singing coils, neutrodyne condenser etc., are contained in this unit.

(6) Tuning Unit.—This contains the closed circuit and aerial tuning inductances together with the necessary tuning and coupling condensers and the aerial series condensers. The latter are shunted by a non-inductive high resistance to provide the leakage path to earth for any static charge collected by the aerial. A small monitoring rectifier valve is also included in this unit.

The circuits used in this equipment are the very latest radio engineering practice and are probably quite new in Australia and New Zealand. The special features are efficiency, stability of wave length, faithfulness of transmission and freedom from harmonics.

An artificial aerial comprising variable inductance capacity and resistance is mounted on the smoothing condenser rack, to enable tests and adjustments to be made without radiation, and consequent interference, from the outside aerial.

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