WESTINGHOUSE RADIO STATION AT SAXONBURG, PA.

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WESTINGHOUSE RADIO STATION AT SAXONBURG, PA.*

By

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Summary—*Westinghouse Radio Station KDKA, at Saxonburg, Pa., was built to provide up-to-date equipment for regular broadcasting and for high power experimental work on either long or short waves.*

Power equipment consists of a 12-phase, 900-kw, 30-kv rectifier using three anode mercury pool type tubes, a 6-phase, 450-kw, 22-kv rectifier, four 10-kw, 3-kv motor generator sets for bias and intermediate amplifier plate supply, six 40-kw, 40-volt motor generator sets for filament power; a 400-volt storage battery for small tube plate voltage and for substation control; and two 12-volt, 1600-ampere hour storage batteries for small tube filament supply.

Present transmitter apparatus includes a 300-kw output stage using six Westinghouse type AW-220 tubes; a 5-kw intermediate power amplifier; a modulator for the 5-kw stage, a crystal control and intermediate amplifier unit; a high level modulator with provision for six AW-220 tubes for experiment or modulating the output stage operated class C; and a 50-kw power amplifier for regular broadcasting using six water-cooled tubes plate modulated by a transformer coupled class B push-pull modulator.

The four audio circuits to the studio in Pittsburgh go underground for several thousand feet to prevent r-f pick-up.

The cooling water system employs heat interchanges.

The Westinghouse Radio Station at Saxonburg was built to provide up-to-date equipment for the regular broadcast activities and to provide facilities for high power experimental work on either long or short waves.

The station is located on a 120-acre site approximately twenty miles north of Pittsburgh. The building is a brick structure 32 feet by 82 feet with a front wing 24 feet by 32 feet. It houses all of the equipment except the rectifier transformers and filter chokes which are arranged on a platform at the rear of the building. Fig. 1 is a front view of the building.

Power is brought into the building at 2300 volts through under ground cables from the substation on the north side of the property. One panel of the main switchboard in the station contains the operating controls, relays, meters, etc. for the two sources of 25-kv, 3-phase power at the substation.

* Decimal Classification:———. Original manuscript received by the Institute, March 4, 1932.

All of the power equipment is located in the basement of the building, leaving the main floor free for the radio-frequency and control apparatus. Fig. 2 shows the layout of the apparatus. The equipment is divided into two general groups—broadcast and short-wave or experimental. As far as possible the regular broadcast equipment is installed at the north end of the building. The main switchboard is at the center of the apparatus room and all essential controls are brought to this point.

Fig. 1—Front view of Westinghouse radio station at Saxonburg, Pa.

In the belief that the broadcasting activities in this country will follow the European trend toward higher power, it was decided that a carrier of approximately 300 kw completely modulated was about the limit of possibilities with tubes of the present design. One rectifier capable of delivering 900 kw at 30 kv was therefore included in the equipment. A second rectifier of 450 kw at 22 kv was also included. All necessary auxiliary equ'pment was provided to facilitate development of methods of modulation and operation of tubes at high power.

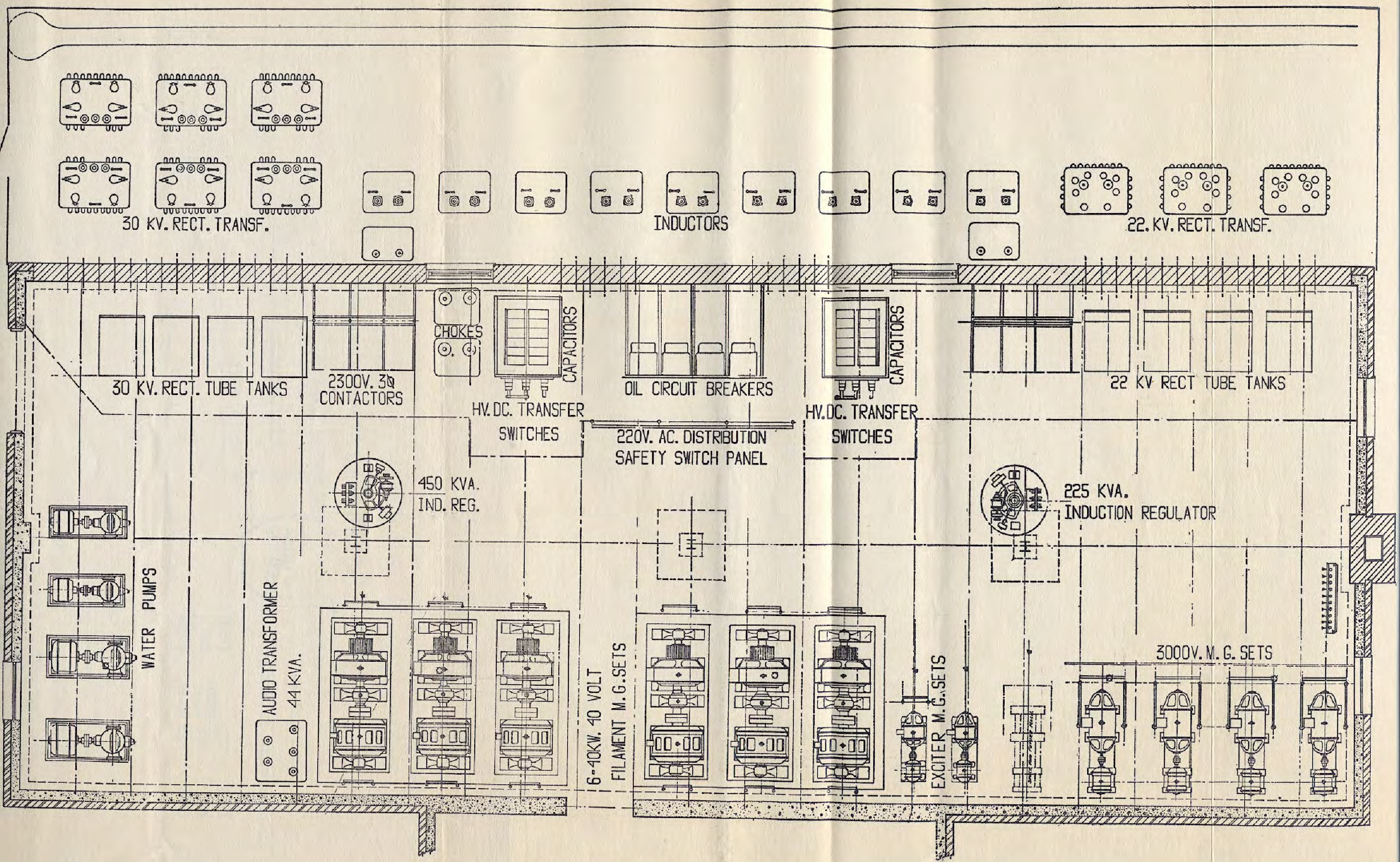

Fig. 2a—Layout of apparatus in basement.

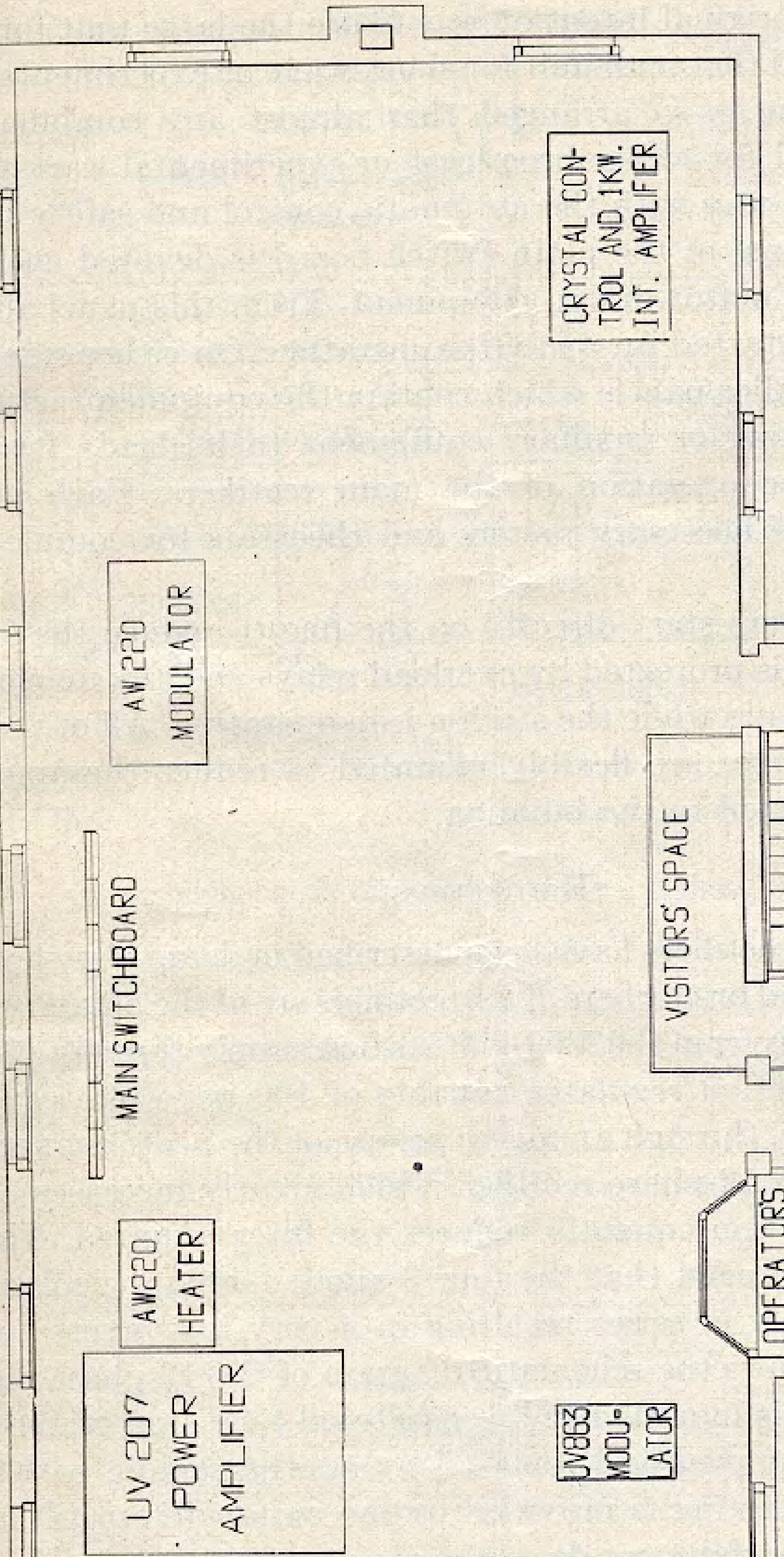

Fig. 2b—Layout of apparatus on main floor.

Although the original intention was to use the large unit for broadcast operation and the small unit for short-wave or experimental work, the control system is so arranged that almost any combination of units can be used for either broadcast or experimental work without interfering in any way with the automatic control and safety features provided. One panel of the main switch board is devoted entirely to the control of the motor-driven equipment. From this panel all of the machines can be started up ready for operation. On either side of this panel are two smaller panels which contain the equipment actually to connect the rotating or auxiliary equipment to its load. Two other panels control the operation of the main rectifiers. Each panel is equipped with the necessary meters and rheostats for complete control.

All of the motors start directly on the line to reduce the starting time. Each motor is protected by overload relays and any machine can be isolated for repairs while the station is in operation. All of the heavier rotating machines are flexibly mounted to reduce the amount of vibration transmitted to the building.

Rectifiers

The two main rectifiers have been described in detail elsewhere[1] and will only be outlined briefly here. Both rectifiers are of the polyphase type and operate directly from the 2300-volt station supply through a 3-phase water-cooled induction regulator capable of 100 per cent regulation. The 30-kv rectifier, through an ingenious use of the Scott connection is the equivalent of a 12-phase rectifier, which greatly increases the ripple frequency and consequently reduces the filter required. The connections are so arranged that the four 3-anode mercury pool cathode tubes are effectively in series resulting in a very low inverse voltage per tube. Fig. 3 shows the schematic diagram of the 12-phase rectifier. Each of the tubes is mounted in a separate oil tank in a cradle which may be readily removed and replaced by another cradle with a new tube. Automatic starting is provided by the motor-driven tilt mechanism operated by push button from the main control panel. The 22-kv rectifier is similar except that an ordinary 6-phase transformer connection is used with four tubes respectively in series. The schematic diagram of this rectifier is shown in Fig. 4. Midtaps are provided on each of the rectifiers to supply plate voltage for intermediate stages. To facilitate the use of the rectifier for experimental use provision has been made to make various combinations of rectifiers, filters, and mod-

[1] R. L. Davis, "Power equipment at new KDKA station," presented at A.I.E.E. Meeting, March, 1931, Pittsburgh, Pa.

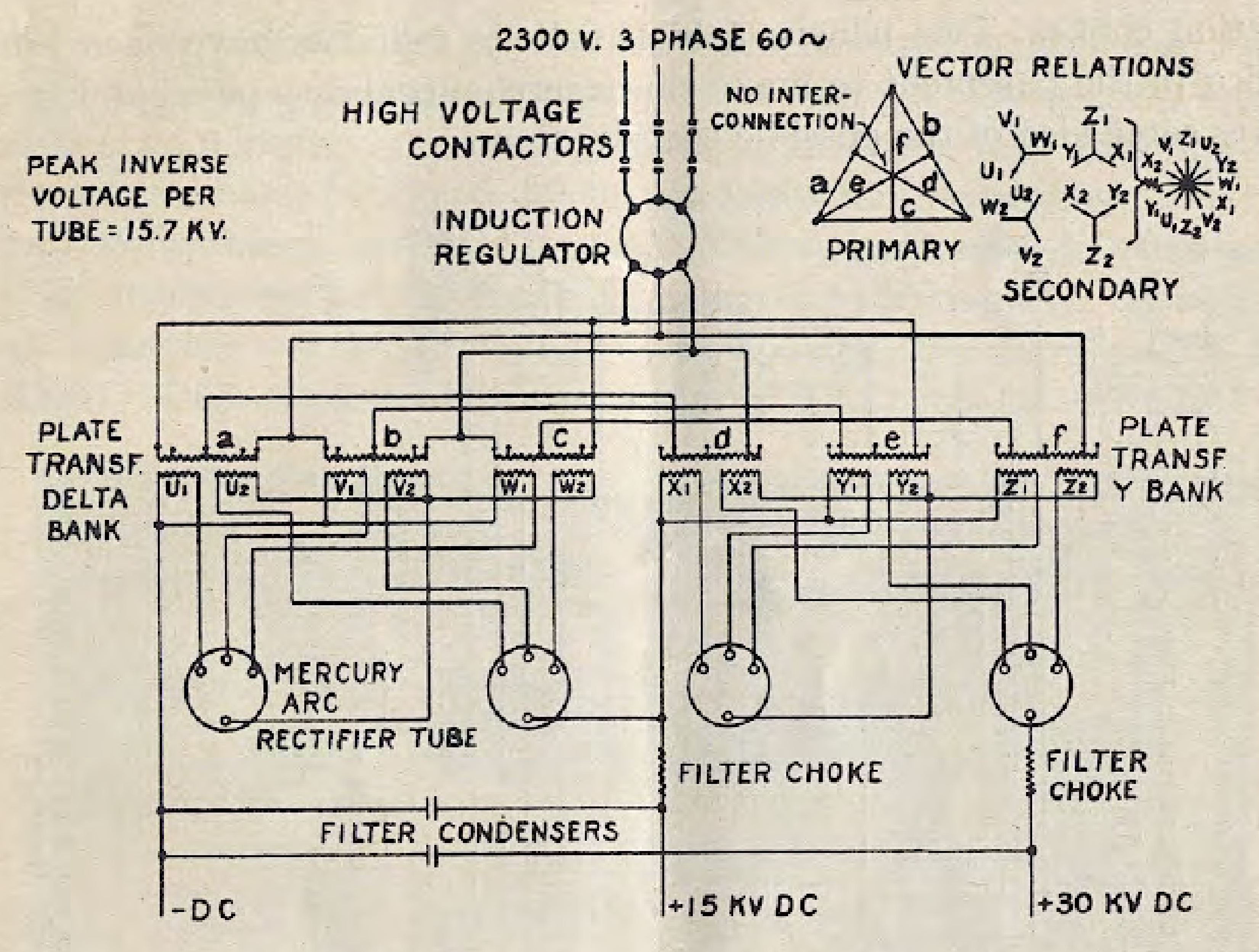

Fig. 3—Schematic diagram of 30-kv 12-phase rectifier.

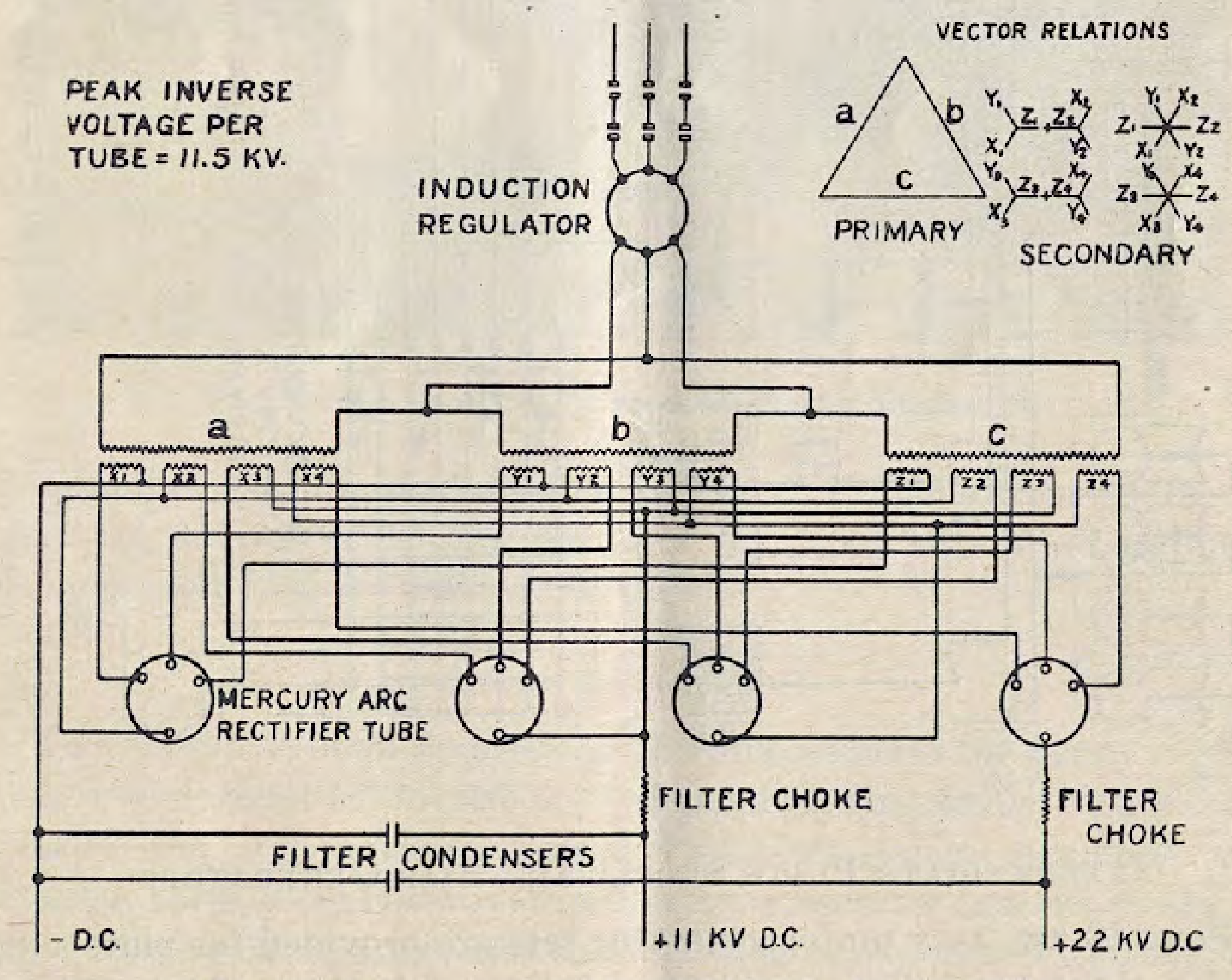

Fig. 4—Schematic diagram of 22-kv 6-phase rectifier.

ulation chokes. Two panels of high voltage switches have been provided in the basement to make this interchangeability possible. Fig. 5 gives some idea of the possible combination.

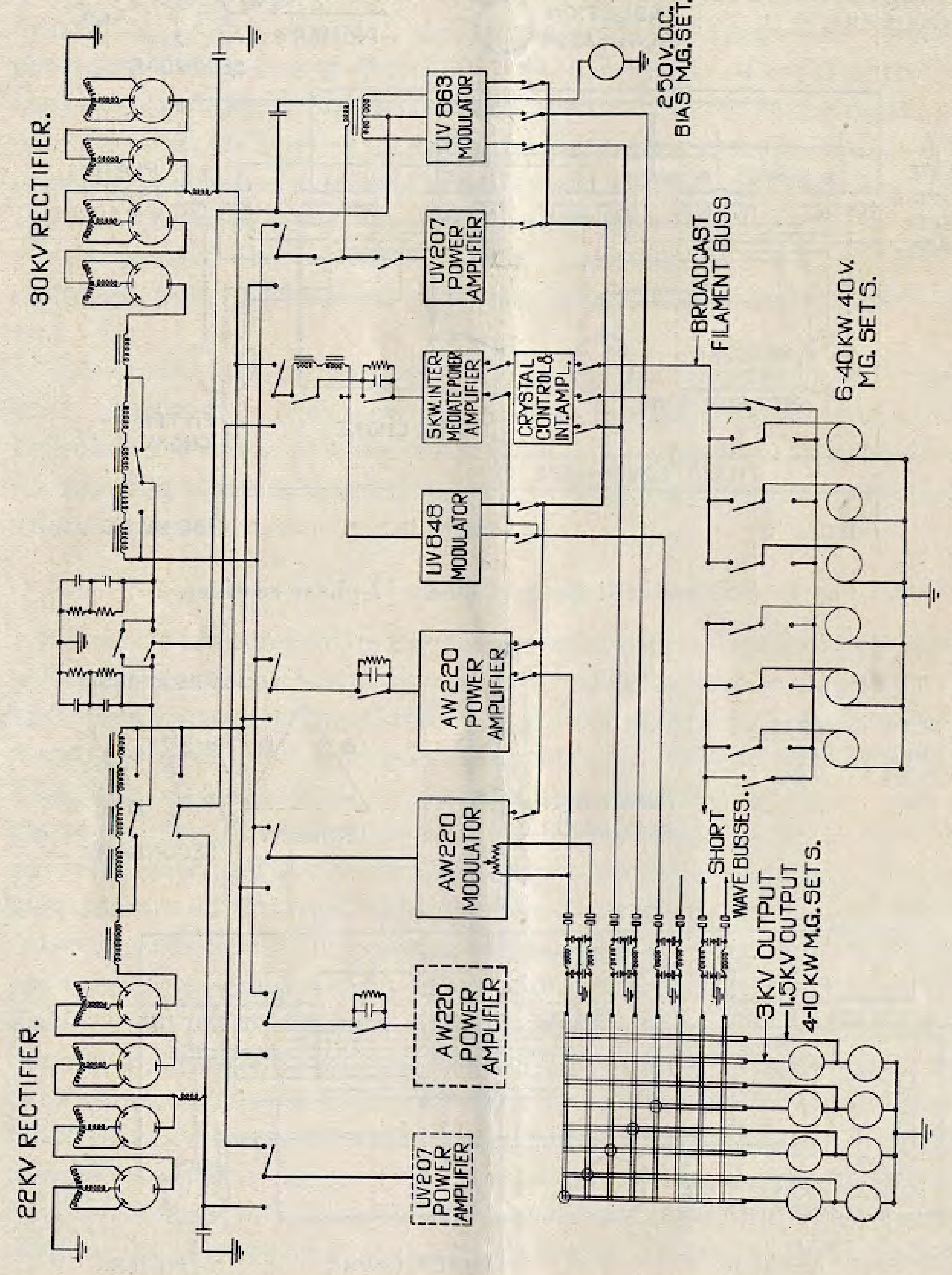

Fig. 5—Schematic circuit diagram.

Intermediate Plate Supply and Bias Generators

Four 10-kw, 3-kv motor generator sets are provided for plate supply for the intermediate amplifier stages and for bias. Two of these were intended for use with the broadcast equipment, one with the short-wave equipment and one for spare or experimental use. Each machine is equipped with a suitable filter and may be used for either plate or bias supply on any apparatus by means of the "cross-hatch" plugboard shown in Fig. 6. 3000-volt contactors, controlled from the main switchboard, are used to connect these generators to their load. These contactors have two breaks in series with magnetic blow-outs, rapid moving contact arms, and wide opening, to insure utmost reliability. One of them on test interrupted 5 amperes at 3000 volts on

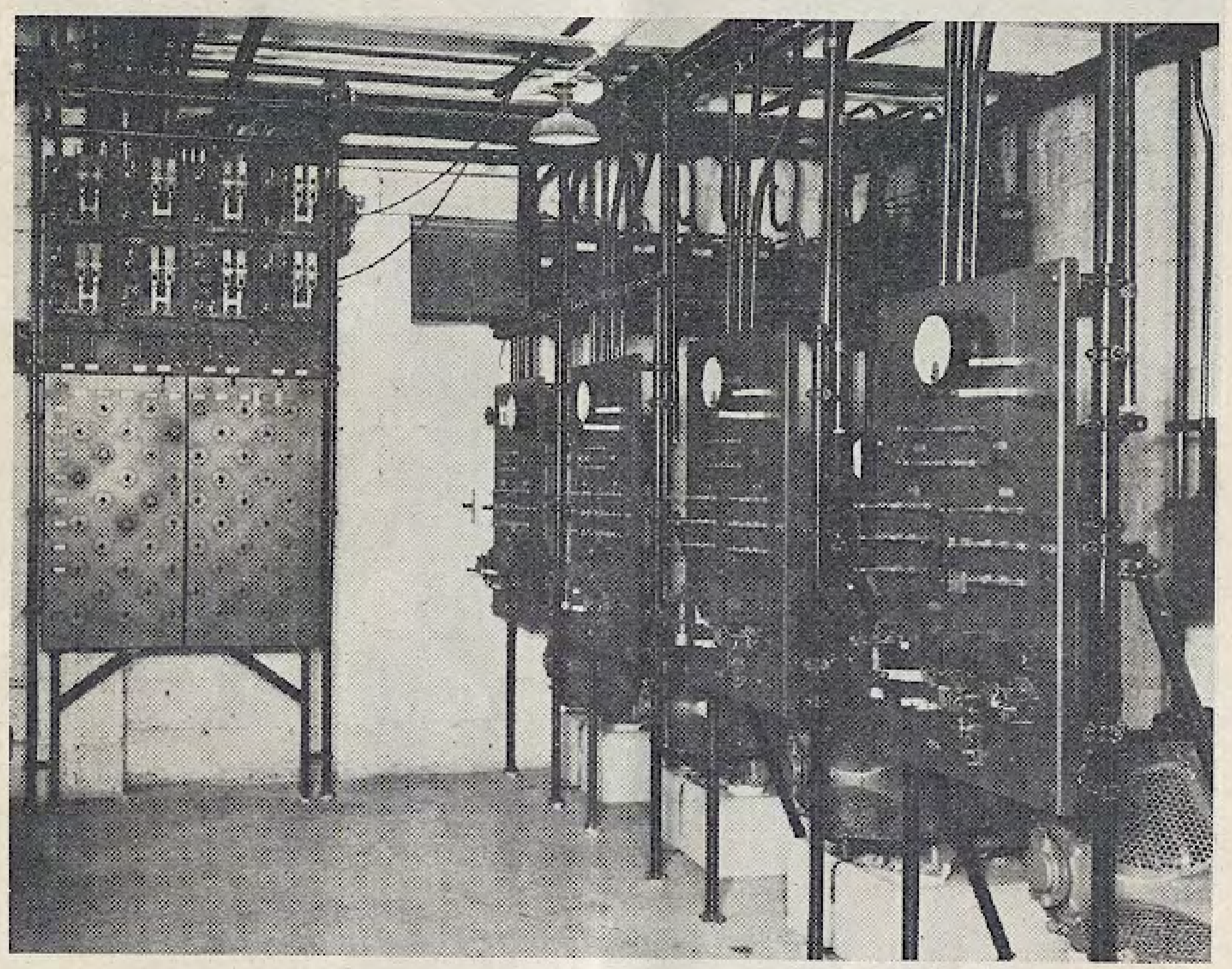

Fig. 6—3000-volt motor generators and plugboard.

an inductive load many thousands of times. The generators were designed for radio applications and have very good regulation and output voltages which are easily filtered.

Filament Supply

To supply the 6000 amperes at 40 volts required for filament supply it was decided to operate several machines in parallel rather than to install one large machine. A total of six 1000-ampere machines were installed, three of which would normally be used for broadcast equipment, two for short-wave, and one for spare or experimental use. The control is so arranged that any number of these machines may be set up to supply the load as one machine. A single push button starts them and a single rheostat on the main switchboard controls the voltage of all of them. Individual rheostats are used to adjust the machines for an equal division of load. The machines were especially designed for radio applications having large air gaps, skewed slots, and a large number of commutator bars and a symmetrical arrangement of armature coils to reduce the ripple voltage. Fig. 7 shows the installation of these machines.

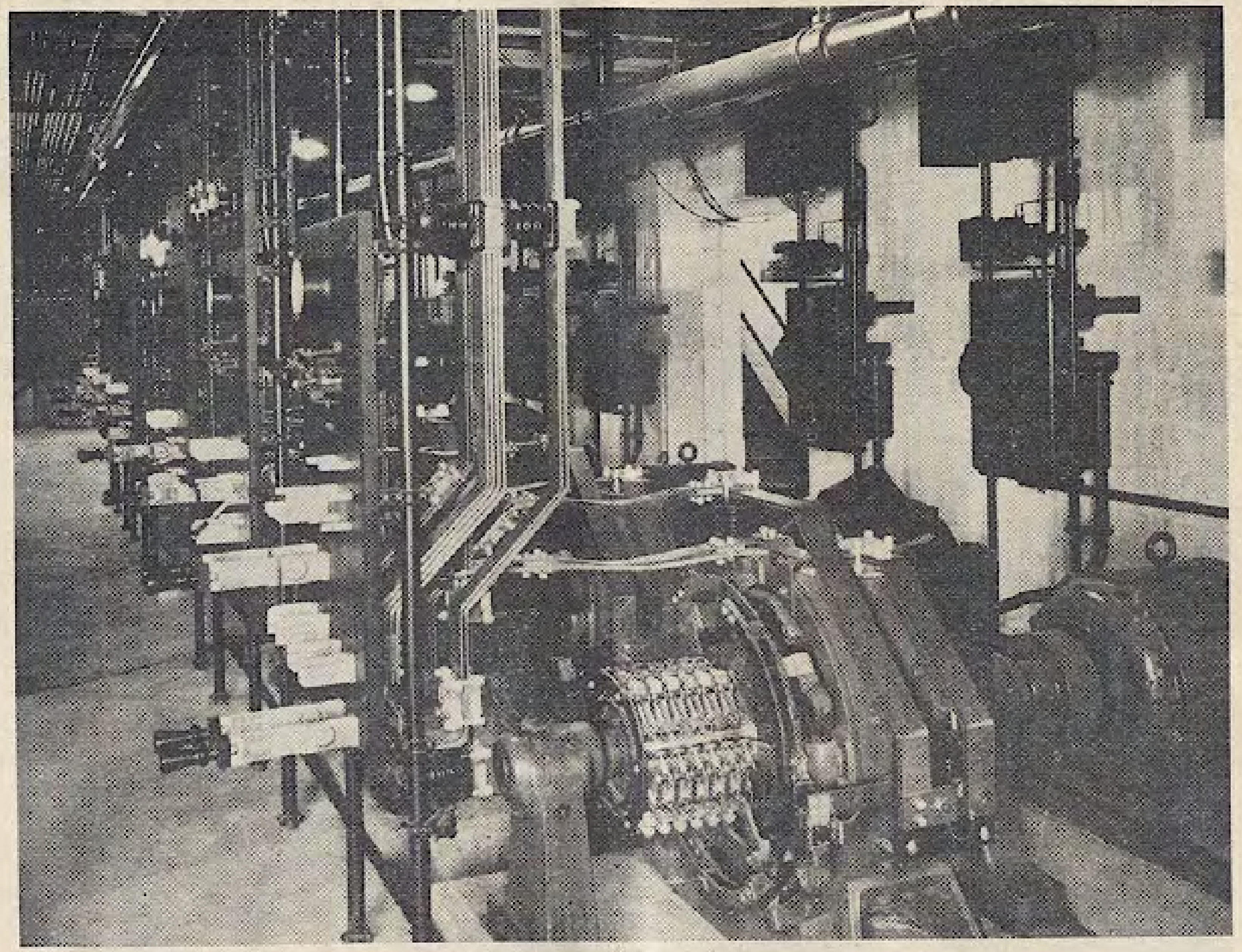

Fig. 7—40-volt, 1000-ampere filament motor generators.

Storage Batteries

A large 400-volt and two 12-volt storage batteries are provided to supply the smaller radio-frequency amplifier tubes and all of the speech input equipment. Motor generators equipped with filters charge these batteries continuously at a low rate.

The 400-volt battery is also used to operate the 25-kv circuit breakers in the substation.

Radio Frequency Equipment

The original intention was to use this station for higher power than 50 kw. An output stage, shown in Fig. 8, was therefore installed which was capable of supplying a carrier of approximately 300 kw using six of the AW-220 tubes designed by the Westinghouse Research Department and described by I. E. Mouromtseff.

The crystal control and intermediate amplifier are similar to the corresponding units in the 50-B broadcast transmitter described by Kaar and Burnside in a previous issue of the I.R.E.[2] Two crystal oscillators with individual heat boxes and buffer amplifiers are included which are operated entirely from storage batteries to reduce voltage variations which would influence the frequency of the crystal. These

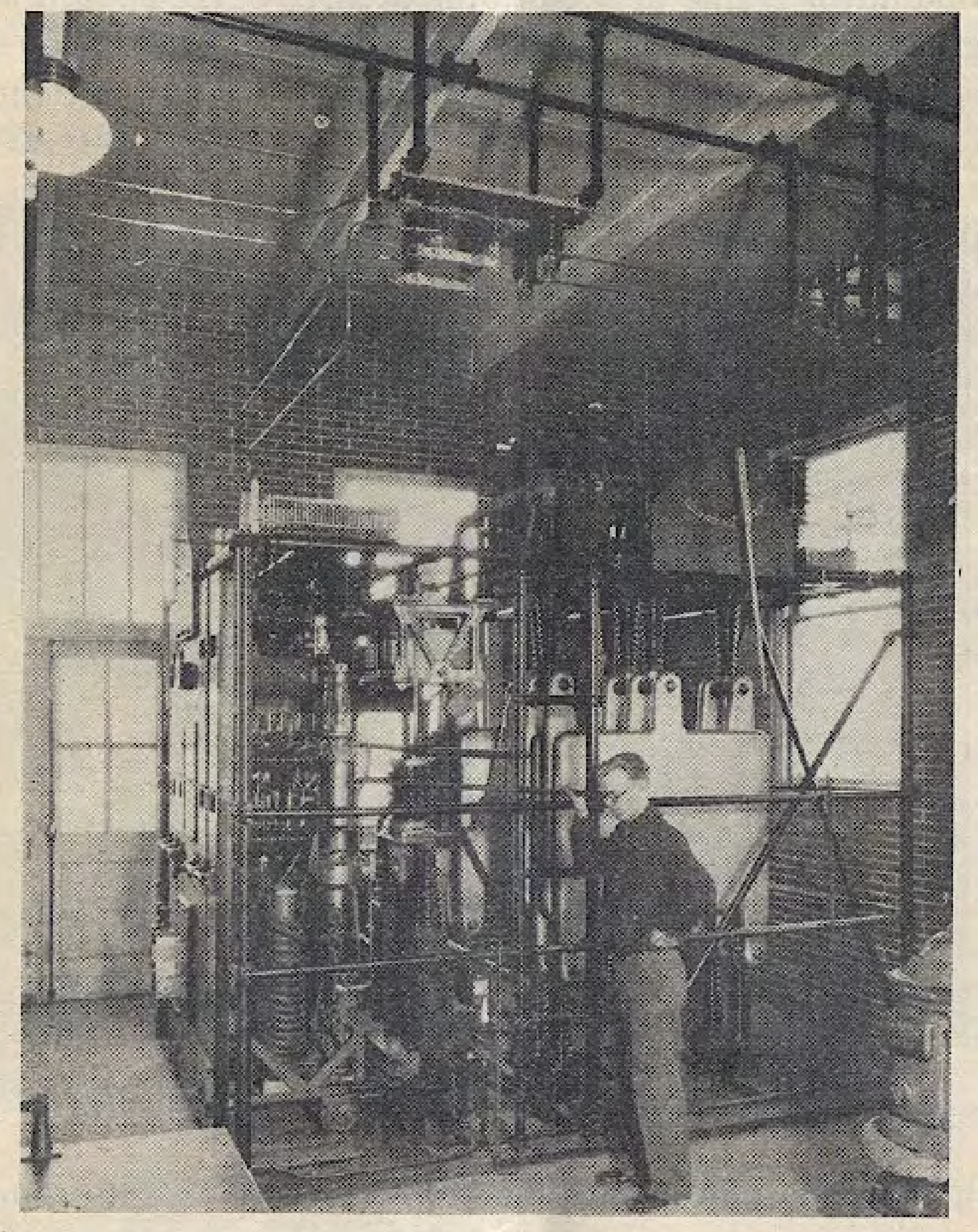

Fig. 8—AW-220 radio-frequency output stage.

precautions make it possible to maintain the transmitter well within the limits specified by the Federal Radio Commission.

The output of the buffer amplifier is amplified by one UX-860 tube and by two UV-849's in parallel before it is impressed on the grids of two water-cooled tubes operating push-pull. The tuned grid circuit on the AW-220 output stage is inductively coupled to the plate circuit of the water-cooled tubes.

[2] I. J. Kaar and C. J. Burnside, "Some developments in broadcast transmitters," Proc. I.R.E., 18, 1623; October, 1930.

A modulator with position for four UV-848 tubes, but normally using only two, is used to plate modulate the water-cooled stage through a voltage dropping resistor by-passed by a capacitor, to obtain about 90 per cent modulation. The modulator and oscillator obtain their plate supply from the midtap of the rectifier through suitable filters and modulation chokes.

The modulator frame also contains a three-stage speech amplifier consisting of two 50-watt stages and one stage of two UV-849's in parallel impedance coupled to the modulator tubes, The frequency characteristic of this equipment is flat within 2 db from 30 to 10,000 cycles.

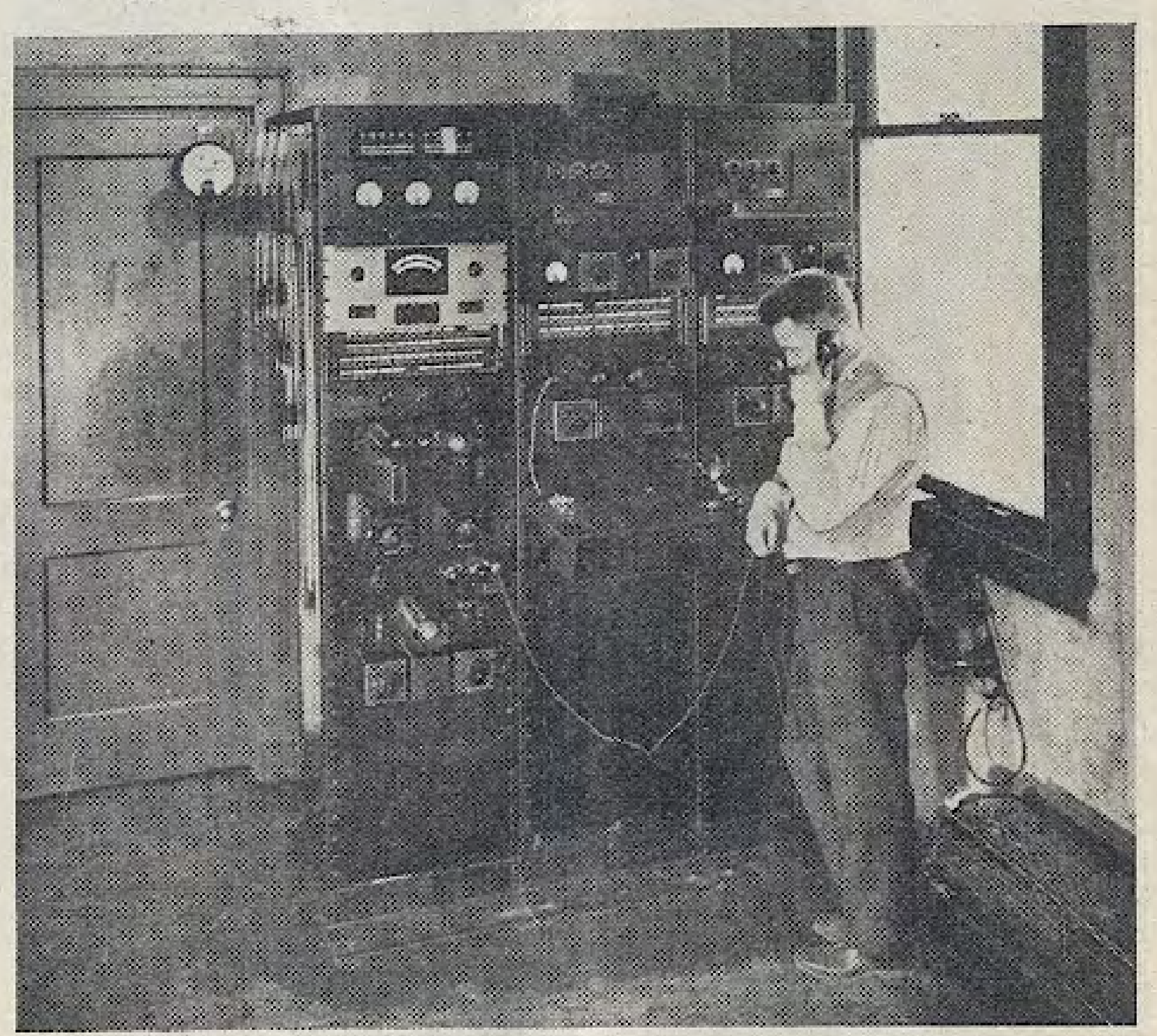

Fig. 9—Line amplifiers and associated equipment.

A high level modulator with positions for six AW-220 tubes is provided for experimental use or to modulate the output stage when class C operation is used.

A tube heater rack was also installed as it was believed that it would be advantageous to keep the filament hot on two spare tubes as there is quite a mass of metal to be heated up. In practice it was found to be an unnecessary precaution so the frame is not now used.

All of the equipment just described was intended for experimental work and operation at high power. For operation at 50 kw, which is the maximum allowed by the Federal Radio Commission for regular operation, we are installing a power amplifier using six water-cooled tubes which will supply a carrier of 50 kw. This stage will be plate

modulated by a transformer coupled class B modulator. The smaller rectifier has been temporarily modified to use six UV-857 tubes in a 6-phase, single-Y circuit for use with the new output stage. This limits the voltage to 19 kv and the current to 20 amperes, which is ample for a 50-kw carrier.

Audio Equipment

Four audio circuits to the KDKA Studios in Pittsburgh are provided. These come in to the station underground for a distance of several thousand feet to prevent radio-frequency pick-up. Fig. 9 shows the audio equipment in the control room. Relays are provided so that

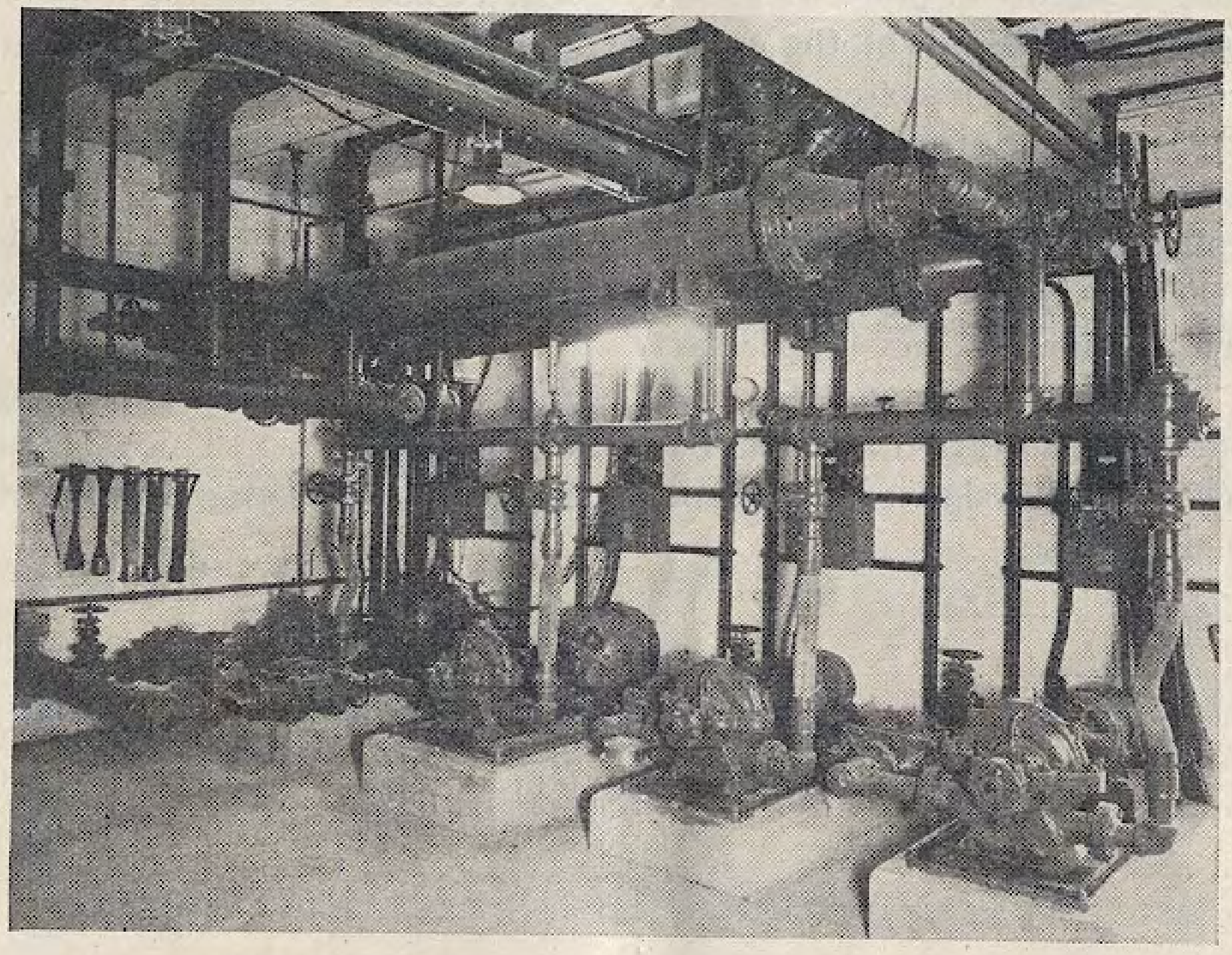

Fig. 10—Water pumps and heat interchangers.

lines may be changed from the pulpit. In case of an emergency announcement, it is only necessary to operate one switch, which automatically disconnects all loud speakers and the studio line and puts the microphone amplifier into operation.

Cooling Water System

The tube water-cooling system is unique in that heat interchangers are used. The water circulated through the tubes should be soft, but the well water, the only supply avialable at the station is extremely hard. It was decided to use rain water to cool the tubes. Fig. 10 shows the arrangment of the pumps and heat interchangers.

Pumps, provided in duplicate, circulate the water from the small sump through the tubes and the heat interchangers, and back to the sump. Arrangements are made to collect the roof rain water in this sump. A natural pond on the property was enlarged to provide sufficient water to keep the tube water at a safe temperature. Several filters are provided to prevent foreign matter clogging the water system. Flow meters and thermometers are generously used throughout the equipment.

The heat interchangers are of standard design and will cool 300 gallons per minute from 140 degrees to 132 degrees F using 270 gallons per minute of pond water at 110 degrees and discharging it at 119 degrees F. With all of the equipment in operation with present efficiencies the water system must dissipate approximately 1000 kw.

Every precaution has been taken to prevent interruption of service both by the conservative design of apparatus and by provision of duplicate equipment which may readily be switched into operation. All of the equipment is protected by overload relays, and interlocks have been provided wherever necessary.

This paper is intended only as a brief description of the Westinghouse Radio Station at Saxonburg. Some of the more technical phases such as the design of the rectifiers and tubes are being covered by other papers.