RADIO TRANSMITTER FACILITIES

EDITED

by NIPPON HOSO KYOKAI (NHK)

PRINTED

by JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

* * * * * * * * *

NHK CENTRAL TRAINING INSTITUTE

1-10-11, Kinuta, Setagaya-ku,

TOKYO 157, JAPAN

Radio Transmitter Facilities

1.1 Constitution of radio transmitter stations

The constitution of a radio transmitter station varies greatly, according to the scale of output-power, the number of transmitters to operate and whether the station will be operated attended or unattended. In addition to these, the type of cooling system and redundant system to adopt have great influence to the constitution of the station. A sample is shown in Fig. 1.1.1. Besides the main broadcasting transmitter, there are such equipment as follows.

(1) Relay equipment.

STL receiver, program line, radio relay receiver, limiter amplifier, input-switching board, etc.

(2) Redundant facility.

Ancillary equipment, standby equipment and switch-board.

(3) Short-wave and other associated radio equipment.

(4) Remote control equipment and communication equipment.

(5) Antenna system.

Feeder, tuning house, grounding facilities, antenna, supporting steel tower, aircraft objection light.

(6) Communication telephone equipment.

(7) Studio equipment.

Studio, microphone, head-amplifier, record-player, tape-recorder, etc.

(8) Measuring instrument.

Precise meter, character measuring instrument, carrier frequency measuring instrument, vacuum tube tester, etc.

(9) Ancillary facilities for cooling-system.

Electric dust-collector, well, water-pool, etc.

(10) Ancillary facilities for power-source system.

Remote supervision control-board, battery, insulation oil-filter, etc.

(11) Ancillary facilities for emergency power generator.

Automatic engine starter board, fuel-tank, fuel suction pump, cooling water pump, cooling water-tank, starter compressor or starter battery, silencer, dummy resistor water pool, warehouse for oily materials, etc.

(12) Unloading facilities.

Crane, rail, trolley, etc.

(13) Cable channel, conduit, pit, duct, etc.

(14) Ancillary materials and warehouse.

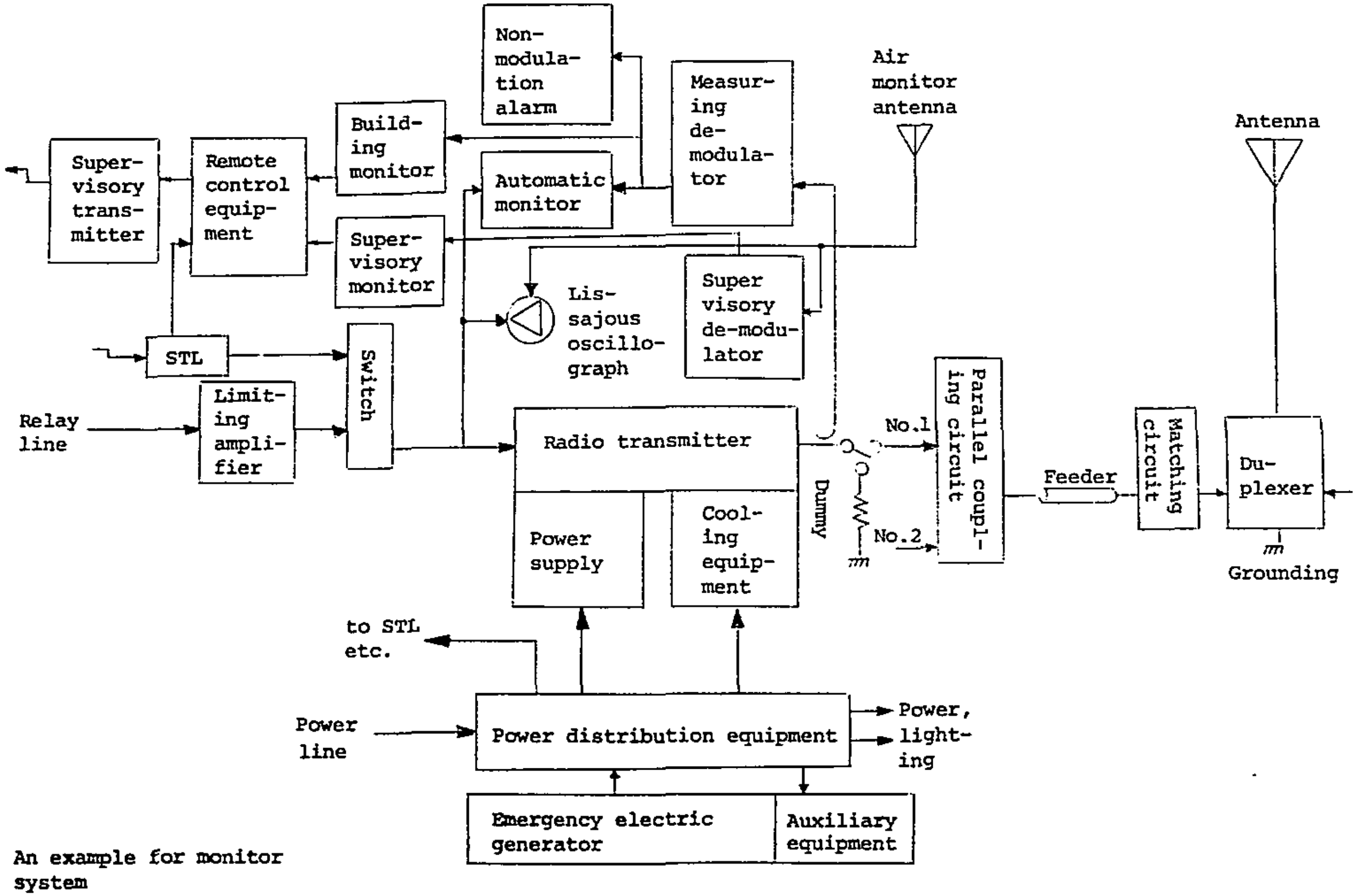

Fig. 1.1.1 Constitution of radio transmitter station

(15) Workshop.

Tools, machine tools, material warehouse, etc.

(16) Station facilities.

Indoor illumination, outdoor illumination, emergency lighting equipment, fire-alarm, fire extinguisher, air-control and ventilation equipment, city telephone, entertainment room, water supply facilities, lavatory, sewage disposal tank, etc.

1.2 Control circuit

The functions required for a control circuit of transmitter facilities are; ① simple operation, ② sufficient protection of equipment, ③ ensure of continuous broadcasting. Further, the reliability of control circuit itself is required to be better than that of the main equipment.

(1) Functions of control circuit.

(i) Start, stop

(a) To enable start-stop (44) or switching (83) by simple manual operation at hand, remote control operation or predetermined time-clock-signal operations.

(b) After confirming that the equipment is in safe and normal working condition, in accordance with the start and stop schedule (63, 69, 80, 84), it will automatically proceed to the next step and normal operation will be ensured. The progress of each step will be indicated by lamps.

(c) The interlocking circuit will protect the vacuum tubes and parts (02, 62, 73), and ensure the security of human (92, emergency shut-down). It will also avoid faulty operation (86).

(d) Manual operation is also possible (43).

(ii) Operation

The operation condition of the equipment will be checked whether the equipment is operating within its specified range and, if it is beyond the range, necessary adjustments will be taken (23, 55, 90). The abnormality of equipment is also supervised and indicated (30, 48).

(iii) Trouble

The occurence of emergency will be detected (12, 26, 33, 47, 51, 60, 76, 87), and the relative operation of equipment will be turned down to protect the transmitter (05, 52, 72), and indicate the abnormal position (30). An alarm will notify the operators (28), and activate the remote control system (85) and if necessary, activate the fire fighting equipment (29).

(iv) Continuation of operation.

As troubles are apt to be caused by temporary over-load and sparks, etc., restart of equipment should be automatically tried (79) to continue operation. After the specified number of restarts, further restart is to be avoided for protection of equipment (66). If a redundant system is available, this is to be started in accordance with the predetermined priority order (44), and switchover is to be made to re-enter operation. With regard to an extremely short period of electric power interruption, the warming-up time-relay circuit is to be shorted to decrease the period of failure (62).

1.3 Ancillary circuit and facilities.

(1) Parallel coupling circuit

In case of parallel operation of two transmitters, it is normal to adopt a bridged T-type parallel coupling circuit to compose the high-frequency output power, without interaction between transmitters.

This is because ① the construction of the circuit is simple than other ones and is symmetrical in form. ② The balance adjustment is easy, and ③ coupling-loss is small. ④ As the input/output impedance is identical, the switchover operation can be provided smoothly. ⑤ It has good filtering effect against harmonics, etc. Fig. 1.3.1 indicates the circuit.

Since the unbalance component of both inputs only flow through the balance arm, the amplitude and phase of inputs should be adjusted so that this current will be minimized.

In case of one of the transmitters happen to stop, the out-put power will become 1/4.

The procedures of adjustment are as follows.

(i) Match the resistance value of R_A and R_B sufficiently.

(ii) Adjust the values of C_A and C_B, in conformity with the calculated values.

(iii) Adjust L_1 and L_2, so that there will be no variation in the input impedance, while short-circuiting and open-circuiting the oposing terminals. The values of L_1 and L_2 should be completely identical.

(iv) Apply the high-frequency power and adjust L and C carefully so that the leakage between both terminals will be minimized.

(2) Dummy resistor.

For dummy loads, mat resistors, enamel resistors and water cooled resistors are used. In the near future, there is a trend of using water-cooled oxide film resistors and evaporation-cooled ceramic resistors. If pure water is not used for water-cooled resistros, chloride treatment or sunbeam shielding is to be applied to prevent growth of waters weeds.

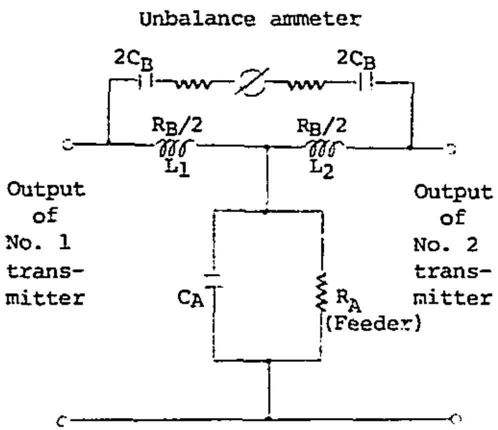

Fig. 1.3.1 Bridged T type parallel coupling circuit

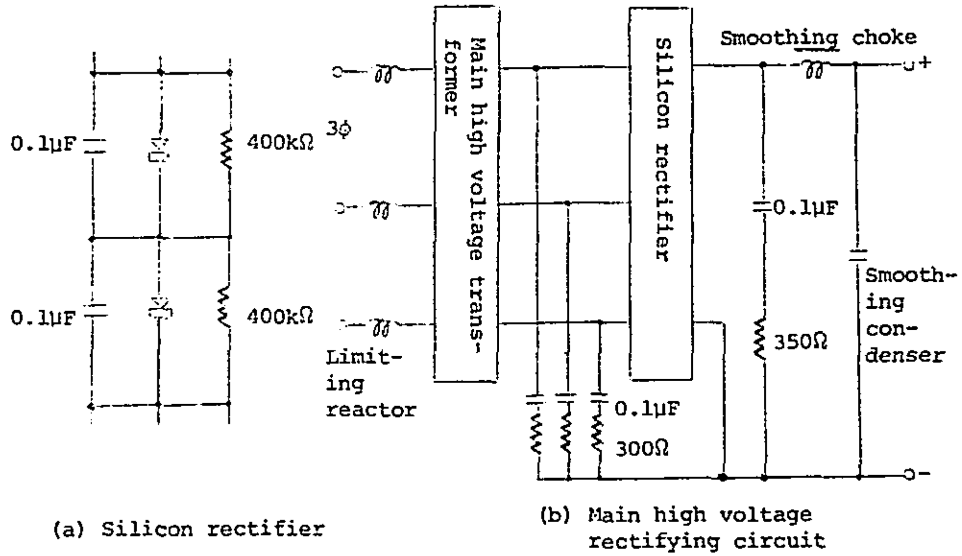

Fig. 1.3.2 Silicon rectifying circuit

(3) Power supply circuit.

(i) Power supply for filaments.

(a) In case of indirectly-heated tubes, the tube life will be extended if a voltage slightly lower than the rating is applied. Care should be taken so that the voltage difference between the heater and the cathode will be small.

(b) In case of thoriated tungsten filaments, the filament voltage is slightly decreased to reduce noise and extend the tube life. However, if the filament voltage is decreased excessively, dynatron oscillation may occur. In NHK's standard, a rating between 0 ~ -5% is specified.

(c) In case of tungsten filaments, the condition is almost similar with the case of thoriated tungsten. The heating power is determined by the necessary quantity of radiation current. For prevention of rush current, a leakage transformer is to be adopted.

(ii) Bias power source.

In general, a simple one could be used. However, in case of class B_2 amplification, which the regulation must be good, it will be necessary to decrease the DC resistance of the circuit.

(iii) Plate power source.

Silicon rectifiers are convenient and are mostly used. The following items indicate the precausions for application. (refer to Fig. 1.3.2).

(a) C and R are connected in parallel with the rectifier element to equalize inverse voltage distribution, suppress abnormal voltage due to carrier accumulation and, bypass high-frequency current, etc.

(b) In order to absorb the surges, C and R connected in series are respectively inserted in the secondary circuit of the main high-voltage transformer and, in the input of the smoothing filter.

(c) In case a main-high-voltage transformer of low impedance is used, a current limiting reactor is inserted in the primary side, to limit the short-circuit current.

(4) Cooling equipment.

(i) Forced air cooling.

Matters of importance are to reduce the ventilation resistance of the air-duct, and prevent the generation of noise, and remove the dust accumulated in the duct.

In order to reduce generation of noise, the air-velocity (standard value is about 6 m/s) is not to be increased unnecessarily, and the cross-section of the air-duct should not be increased suddenly. Other precausions to take are to wrap the duct with sound absorbtion materials and to connect the blower to the duct with canvas, so that the vibration will not be transfered.

Precausion should be taken with regard to generation of noise, when the station is going to be located in residential areas.

Furthermore, in cold districts, precausion should be taken to prevent inhale of fine-snow. The air-intake should be located in a position, so that it will not be closed up by drifted snow. The electric dust collector should be used under the specified air-velocity, otherwise the efficiency of collecting dust will be drastically decreased.

Large pieces of dust can be removed by using air-filters. However, the high-voltage section and congested part should be carefully cleaned. As an electric dust collector generates ozone, which will deteriorate natural rubber products, synthetic rubber products should be used.

The necessary air-flow $Q(m^3/min.)$ is given by;

$$Q = 50\ P/\Delta T$$

where P is the total loss (kW) of vacuum tube and ΔT is the rise in temperature (°C).

(ii) Water cooling

Precaution of leakage, prevention of pipe clogging and control of water quality are matters of importance. As water leakage often causes serious trouble, care must be taken in the construction and tightening of pipe connection. It is also important to avoid inclusion of foreign substances or precipitates in the cooling water, which may clog the water pipe.

In order to decrease the electrolytic corrosion of the water jackets, it is effective to use water of good quality to increase the specific resistance, and to elongate the current passage by employing coils. The leakage current is to be suppressed to 15 mA or less. It is also effective to apply cathodic electrodes to concentrate the electrolytic corrosion at the electrodes, for the prevention of the electrolytic corrosion. Degradation of specific resistivity of water can be regenerated by means of ion exchange resin.

In case the temperature of the cooling water is excessively low, the piping should be wrapped with insulation materials, to prevent occurance of dew-drops on surface of piping, which may cause trouble.

The necessary flow-rate Q (liter/min.) for cooling water is given by;

$Q = 14.3\ P/\Delta T$, where P(kW) is the total power loss in the tube and ΔT is the difference of temperature of outlet and inlet water, which should be maintained within the rage of 5 ~ 12°C.

(iii) Evaporative cooling.

Since the water consumption is low, quality control of water is easy and as the water presure is low and the risk of water leakage will be negligible. As the large latent heat of water is utilized, the amount of circulating water will be less and evenif forced air cooling is to be employed in the condenser, the necessary electric power will be extremely low. The important point of designing and maintenance is the control of water level, heat resistivity of piping, maintenance of water quality.

(iv) Natural air coolcing.

To utilize the chimney effect for cooling indoor and inside of equipment. Objects generating heat should be placed in a vertical position, so it will not disturb the natural cooling airflow. Devices which are not to be warmed up should be placed at a low position, and precaution should be taken to prevent adherence of dust to equipment.

In case of using ventilation fans or exhaust blowers, be careful that air will not be circulating, in a limited space. Therefore, precaution should be taken with regard to locate the position of the through-holes of the cabinet, etc., according to the ventilation theory.

(5) Protective equipment.

(i) Protection of passive circuit.

Protection can be ensured by use of discharge-gaps, arresters, fuses, no-fuse breakers, etc.

Be careful that if the surface of a sphere-gap gets stained or roughened, the voltage of discharging will drastically decrease.

(ii) Protection attributable to the function of control circuit.
(protection of active circuit)

In case of occurance of any abnormal condition, which may cause damage to equipment, immediate detection is necessary to stop the operation of equipment. It consisists of detector of abnormal portion, and logic circuit breakeer.

(iii) Surge protector.

When a spark happens to occur in an antenna system of a high-power transmitting station, the arc will be sustained by the transmission power and damage the feeder matching element of tuning circuit, and furthermore, generate high voltage which might damage the main transmitter equipment. Therefore, a device to detect the high-frequency power abnormality of the load side quickly and cut-off the high-frequency power is needed. This device is called surge protector.

The detector portion consists of a directional coupler located at the output side of the final stage tank-circuit, and detects the reflection of waves from the feeder. With regard to the positive peak of modulation, the operation point should be set in consideration of the enduarable voltage of the feeder and, variation of the load impedance due to snowdrifts. An exessive fixed bias can be impressed to the buffer amplifier stage to stop the excitation.

(iv) Others.

When the main high-voltage of class B modulators are cut off, the audio input signal will become excessive and may dismantle the cathode coating of the sub-modulator tube, because there will be no negative feedback.

In order to prevent this, the audio input signal must be first shortcircuited, and open circuited after the main high-voltage is provided.

(6) Safeguard facilities

Besides the devices related to the controling circuit, such as door-switches, there are devices such as grounding rods. discharge resistros for condensers, guard fences. A DC path is provided between the antenna element and grounding, to prevent lightening and surges damages, due to atmospheric electricity.

(7) Metering circuits

The following considerations are to be taken for using meters in transmitters.

(i) Shielded wiring should be used under strong high-frequency electric field, and the terminals must be short-circuited with mica-condensers.

(ii) The multipliers for meters.
The earth terminal of multipliers must be fastened completely to the grounding.

(iii) Do not put meters in portions of high-voltage. If necessary, use an insulator to insulate it from grounding and cover the meter face so that nobody will touch it.

(iv) With regard to heavy weight vacuum tubes, external metering terminals are often provided in the cathode circuit, to measure the cut-off bias voltage of the tube without unloading the tube.

(v) Thermometers, manometers, etc., provided with external relay terminals are often used to activate safe-guard and alarm circuits.

(8) Alarm circuit

Alarm circuits are usually used for the following items.

(i) Items included in the alarm circuit are such as; carrier interruption, decrease of output-power, operation of over-load relay, operation of surge protector, operation of no-fuse-breaker, abnormality of receiving/generation voltage, abnormality of battery, abnormality of power receiving/distributing system, abnormality of cooling water, operation of STL squelch, etc.

(ii) Operational failures, such as non-modulation.

(iii) Abnormalities which may lead to serious damage, which should be treated immediately, such as degradation of auxiliary air-blower, decrease of feeder-gas preasure.

(iv) Operation of backup facilities, whether the backup transmitter is in complete condition ready for backup, whether there is trouble in the emergency power-generator for backup operation.

(v) Mal-operation of accompanying facilities, trouble in building facilities, etc.

(vi) In case remote control system is adopted. Operation condition of automatic monitor, abnormality of power-supply, abnormality of power generator, occurance of fire, fire extinguisher, opening of station entrance door, etc.

It should be mentioned that the alarm circuit relay will be remaining in the holding position, even after the cause of trouble is recovered. It is to be reset after confirmation of the trouble. In case the function of the alarm buzzer is killed, a lamp will notify that it is not in operation.

(9) Trouble-shooting facilities

In order to make it easy to check the place of trouble, some switches are provided in the circuit to cut apart the circuit which are not directly concerned with the operation of the equipment.

(10) Supervisory and control equipment.

The following equipment are usually included.

(i) Starting control equipment of transmitter, emergency shut-off of transmitter, switchover to ancillary transmitter, operation condition of transmitter, indication of trouble of transmitter.

(ii) Modulation degree meter, lissajous oscilloscope, carrier output-power meter, linear detector for measurement.

(iii) Air-monitor antenna, supervisory de-modulator, audio sound- monitor, monitor selection switch, building monitor.

(iv) Non-modulation alarm device, automatic-monitor receiver.

(v) Control relay-clock

(vi) Transmitter input selector switch.

(11) Insect proof facilities

Spark may occur if insects acces the tank circuit area. It is quite difficult to set the over-load relay in a condition, so that it will activate against spark but not at peak of modulation. In order to prevent insects from coming inside the transmitter, the transmitter housing should be completely closed, and screens should be mounted on ventilation windows. It is also effective to put light-traps for insects outside of the station building.

As the inside of tuning house is somewhat warm because of the heat generated from the components inside, rats and snakes will enter. To prevent these animals from entering, metallic screens and filters should be mounted onto the duct mouth and ventilation windows.

(12) Prevention of high-frequency leakage.

The methods normally adopted are such as;

(i) The use of shielded boxes and shielded wires.

(ii) To use large-size grounding wires.
To insulate the high-frequency grounding wires from the container case, and connect the wire-lead to the grounding at an appropriate one point. Use a separate return wire for the antenna connection and do not ground it in common with the equipment grounding.

(iii) Basically, it is desirable to install the transmitter on the ground floor, to shorten the grounding wire length for the purpose of reducting induction to other equipment.

(iv) In case induction to equipment is to be strictly avoided, it is effective to insert blocking filters in the audio circuit and power-supply wirings, and insert $\lambda/4$ stubs in the feeder of the VHF receivers, in accordance with the frequency in use.

1.4 Maintenance

An equipment designed by an experienced engineer and manufactured carefully will have almost no trouble, but it will still be necessary to provide sufficient maintenance during intervals of operation, to extend its life.

The basic concept of maintenance is to realize the principle of operation completely and have affection to the equipment. This is identical to the case of breeding animals. It is also important to pay sufficient attention to carry out the work safely.

Basic precautions in respect to the maintenance of equipment is to refer to instruction manuals. The basical items are given as follows.

(1) Items of inspection during operation

Reading of meters, setting of adjusters, oil-level of transformers and chokes, gas-pressure of feeders, colour of moisture absorbent material, amount of water in water-tank, discoloration of heat-sensitive papers, indication of OLR operation, odor, abnormal noise, oil leakage, water-leakage, generation of sparks, dismantle of ventilation rubber tube, motor temperature, specific gravity of electrolyte in battery, appearance of antenna, etc.

(2) Items of inspection during halt operation.

(i) Transmitter.

Temperature of each portion should be checked immediately after the transmitter is turned off. Particular care should be taken in respect to conductors carrying large current. Care should be taken to see that the equipment power source is completely disconnected and that no resuidual charge is remaining in condensers.

To check trace of discharge, contamination of insulators, any discoloration of parts, clogging of air cooling fins, oil leakage, loosening of bolts and screws, appearance of rust, dismantle and discoloration of heat sensitive papers, scattering of screws and metal dust, etc.

Finaly, an overall test should be carried out.

(ii) Testing of pilot-lamps and trouble indicator-lamps.

(iii) Calibration of meters.

(iv) Measurement of operation current and operation-time of relays.

(v) Silicon rectifiers

Check of capacity of the parallel connected condensers and terminal connections, and reverse current.

(vi) Magnet switches.

Check of contact surface and cleaning.

(vii) Cooling water system

Check of tightening fittings, relacement of cathodic protection bars, cleaning of water fur.

(viii) Water cooled dummy.

Cleaning of water fur, replacement of packings, measurement of DC resistance.

(ix) Rotary machines

Supply of lubrication oil, grease. Check of oil contamination. Tension of V belt and, if necessary, replace it. Check of loosening of grounding terminals.

(x) Pump

Tightening of gland packing, and if necessary replace it. Measurement of motor insulation.

(xi) Air blower.

Clening of filter. Check of canvas breakage.

Measurement of air-flow.

(xii) Feeder, tuning house.

Cleaning and checking of terminal clips, switching-blade and cable-head.

Polishing of trace of ball and adjustment of ball-gap space.

Care should be taken to ground antenna to prevent damage from atmospheric electricity.

Extermination of animals in trough. Check of gas-pressure of feeder.

(xiii) Antenna.

Check of crack in insulator of base portion.

Measurement of antenna impedance. Check of air-craft objection light, flasher switch, and Austin-transformer.

(xiv) Power reception facilities.

Cleaning of insulators. Disassemble OCB for maintenance.

Measurement of endurable voltage, degree of oil-oxidation and volumetric resistivity.

If necessary, filtration or change of insulation oil. measurement of insulation resistance of cable.

(3) Maintenance of backup facilities.

(i) Batteries.

Cleaning. Measurement of specific gravity. Supply of electrolyte and charging.

(ii) Ancillary materials.

Check of quantity, custody and condition of maintenance.

(iii) Ancillary vacuum tubes.

Avoid to store in a condition so that it may not fall and be damaged by earthquakes.

(iv) Ancillary transmitter, redundant equipment.

Checking and operation tests.

(v) Measuring instruments

Check of operation, including calibration.

(vi) Fire alarm.

Operation test.

(vii) Fire extinguisher.

Checking of effective period, recharge.

(viii) Safeguard facilities.

Checking and operation test.

(4) Maintenance plan.

(i) Maintenance manuals.

(a) The standard maintenance intervals.

(b) Maintenance instructions.

(c) Reference values for maintenance.

(d) Indication of relevant check sheet numbers.

(ii) Maintenance schedule

Allocate each item of maintenance in the annual schedule, in accordance with the standard maintenance intervals. Schedule for operation tests and usage of stand-by equipment should also be included.

(5) Precausion against disasters and items of test to be carried out thereafter.

(i) Earthquakes.

Collapse and damage of equipment. Disconnection and short-circuit of wires. Disconnection of clips, etc.

Leakage of water, oil or gas. Abnormality of steel tower, insulators, guy wires. Abnormality of well-pump, water reservoir. Damage of buildings.

(ii) Storm.

Leakage of rain, entery of rain and wind. Damage of antenna system. Collapse of safety-fence.

(iii) Thunder bolt

Burning of spark-gap and grounding chokes. Burning of insulator.

(iv) Fire (indoor) (For outdoor, see page 21)

Initial fire fighting will be most important by using appropriate fire extingushers.

(6) General precausion for maintenance.

(i) Realization of way of operation of system and present status of equipment.

(a) Filing of drawing diagrams.

General schematic diagrams, detailed diagrams and terminal-wiring diagrams should be orderly filed, to cope against abrupt necessity.

(b) In addition to the transmitter diagrams, diagrams of electric power reception-board, program lines and water cooling system should be prepared.

(c) To prepare a diagram showing the sequence of operation of relays. To make an indication on the relays showing which one should be magnetized during regular operation state, so that it will be easy to find out the abnormal portion.

(d) Indicate the route of piping by colours, according to their purpose.

Mark an arrow on the piping to show the direction of flow.

(e) Frequent checking will be necessary for portions usually out of sight.

(f) Indicate the route of buried constructions and objects.

(g) Remove all unnecessary wirings.

(h) Put suitable names on each equipment to prevent confusion and misunderstanding.

(ii) Education of handling instruction.

(a) Thorough study of instruction manuals.

(b) With regard to portions where operation is complicated, use graphic displays or block diagrams for instruction.

Example: Handling of valve system, kind of lubrication oil to use.

(iii) Preparation of maintenance.

Preparation of heat sensitive papers and check sheets. Put refrencial mark on meter face.

(iv) Revision of maintenance manual.

To arrange the contents to meet the present state of equipment.

(7) Measures against trouble.

The following are considered to be effective. However, the contents should be applicable to meet the equipment.

(i) Guidance table for searching the cause of trouble.

(ii) Add some switches in order to divide the circuit to make it easy to find out the cause of trouble.

(iii) Preparation of machinery tools.

Normal tools, special tools, temporary connection cords, wedges for forcibly closing magnet switches, etc.

(iv) Indication of emergency treatments.

Indicate the places to be connected temporarily for recovery of operation.

Indicate the portion which can be removed.

(v) Consolidation of redundant equipment, auxiliary parts.

(vi) Addition of protection devices.

(vii) Re-check of items to be provided with alarm.

(viii) Consolidation of telephone and emergency communication equipment.

(ix) Training of recovery of presumed troubles.

(8) Post-trouble care.

Care should be taken to the following items.

(i) Reflection of trouble treatment.

(ii) Investigation of primary cause.

(iii) Records on trouble should be made in detail.

(iv) Special supervision should be taken with regard to occurance of sucsessive troubles.

(v) Investigation of possibility of occurence of similar trouble.

(vi) Re-check of operation conditicn and setting of reference values.

(vii) Supplement of auxiliary equipment and materials.

(viii) Re-check of maintenance intervals.

(ix) Feedback of information to maintenance plan.

(9) Measures against earthquakes.

In case of earthquakes, equipment may happen to fall or glide, and the wiring will be cut. The following items are important for preventing damage of earthquakes.

(i) The center of gravity is to be set as low as possible, to ensure stability of standing.

(ii) Joint equipment together to enlarge the bottom surface for prevention of upsetting.

(iii) Install equipment firmly to floor with anchor bots.

(iv) Tall cabinets, equipment set on floor should be also fixed to the wall, if available.

(v) Install rubber mats under equipment on floor to increase the friction coefficient. Rubber mats will also absorb vibration energy.

(vi) Long pipings for fuel and water are apt to accept un-expected force at certain places. Therefore it is preferable to apply flexible piping at these places.

1.5 Troubles of high power transmitters and its measures for prevention.

(1) Abnormal voltage

(i) Generation of abnormal voltage caused by parasitic oscillation.
In case of high-power transmitters drawing large current, severe parasitic oscillation often occurs, due to the high transconductance of vacuum tube. Sufficient measures should be provided to stabilize the transmitter.

(ii) Generation of abnormal voltage caused by resonance.

(a) Resonance of modulation choke.
The modulation choke may resonate because of its distribution capacity and stray capacity.

(b) High frequency rejector
In case a high frequency rejector is inserted in a circuit, parallel resonance will occur near the series resonance frequency with the condenser of the circuit, when it becomes inductive. Therefore, if the rejector is not adjusted completely, there is possibilities of generation

of abnormal voltage. The rejector should be inserted in a place where the fundamental carrier voltage is low.

(iii) When the excitation of transmitter becomes off by the actuation of surge protector, the operation of modulated tube will be cut-off and the electromagnetic energy in the modulator choke will charge the neighbouring capacities, and become the cause of generation of high voltage. In order to prevent this, speak-gaps are to be inserted in terminals of the modulator choke. As it is dangerous when the load impedance of the modulator becomes abruptly opened, audio input terminals are short-circuited simultaneously with the operation of the surge protector (refer to Fig. 1.5.1).

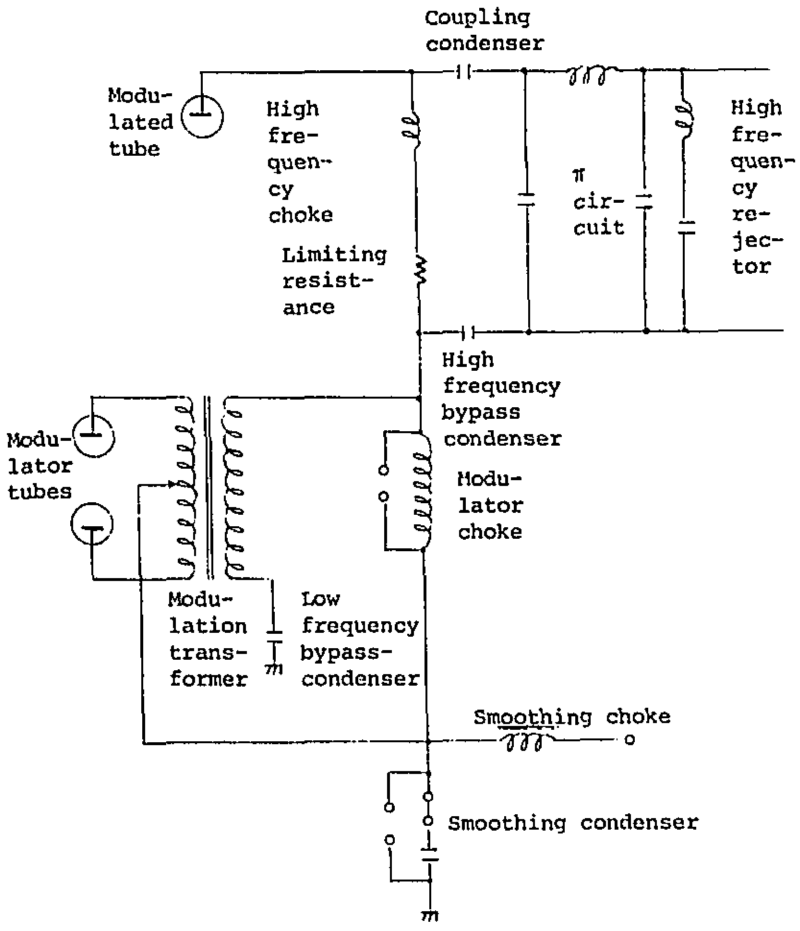

Fig. 1.5.1 Class B plate modulation circuit

Contrary to the above, when the load side of the modulator choke is short-circuited, the choke current begins to increase and, after the energy is accumulated sufficiently, the OLR will operate to cut off the power source. As majority of this energy charges the smoothing condenser in a reverse direction, abnormal voltage oscillation occurs.

This can also be suppressed by installing spark-gaps at both ends of the modulator choke.

(iv) Clipper.

In case a large click is involved in the audio input, it can not be removed by the limiting amplifier, and it causes to rise abnormal voltage at the modulator output, which results as a spark at the modulated stage. It can be prevented by using a clipper in the audio amplification stage, to clip the peak by approx. 120 %.

(v) Measures against flash of grid circuit.

Flashing of a vacuum tube is extremely dangerous because high voltage will be directly applied to the grid circuit. Measures are to use needle-gaps in the grid circuit to suppress this voltage.

(2) Abnormal current

(i) Current limiting reactor.

In case a short-circuit happens in the load-side of the main high-voltage transformer, a large rush current will flow, and if the impedance of the transformer is low, it will damage the rectifier, etc. Therefore, a current-limiting reactor is inserted in the primary side of transformer.

(ii) Measures against flashing of modulated tube.

In order to limit the short-circuit current caused by flashing of the modulated stage vacuum tube, a limiting resistor is sometimes inserted in the plate circuit, between the high-frequency choke and power source.

(3) Corana spark.

(i) Gap of variable condenser.

It is preferable to provide the tuning of high-power stages by using flappers instead of variable condensers. A gap spacing of 1 mm is considered to be suitable for a peak voltage of 1 kV. However, the enduable voltage will be reduced greatly, by the presence of dust or roughened surface resulted from sparks.

(ii) Dust and other objects.

Dust and small insects should be avoided completely. In particular, cleaning of DC high voltage portions should be carried out frequently, where dust is apt to stick. In general, spark gaps should not be installed outdoor, because they are apt to discharge, due to deep smog or beginning of rainfall, and become the cause of instability.

(iii) Protection against corona.

As the electric field concentrates to sharp edges of metallic objects provided with high voltage, the edge become the cause of corona and flash-over. To prevent this phenomenon, the edge should be rounded off. The radius of curvature should be kept large, even if the amount of current is small. The diameter of copper tube should be 6-8 mm for a peak value of 20kV. For voltage exceeding 20 kV, a corona ring should be applied.

If a free potential circuit is left alone, corona will be generating therefrom. Therefore, this kind of circuit should be connected to the high-voltage circuit or the ground circuit.

(iv) Stress cone.

In high voltage shielded cables, the electric firld concentrates to the edge portion of the shielding, and often breaks the isolation. To relieve this damage, a stress cone construction, similar to the method of termination of extra-high voltage power cables are to be provided.

(4) Heat generation.

(i) As high power transmitters deal with large current, the size of conductors should be large. The capacity of high-frequency current should be determined by the peripheral length (mm) of the cross-section, instead of the area of the cross-section because of skin-effect. In case of a coil, a periphereral length (mm) identical to the value of current can be adopted. For a wire conductor, current 30 % larger than this rating is permitted. However, the range of frequency should be within the medium frequency range and the current is to be the effective peak value of modulation. No temperature rise should be percepted, even by applying this current for 30 min. Attention must be paid to the current capacity of the condenser and contact of blade-type switches. The clips of the coil should be mechanically strong and, particularly stable in contact-pressure.

Also, in copper tube wiring, the size of conductor to use should be slightly larger than those mentioned in the above case, in consideration of mechanical strength. Both ends of the tube should be smashed and fastened by pins.

In case the copper tube connection is soldered, connection by bolt should be also applied. No braided wire should be used for short-circuiting the coil.

(ii) Dielectric loss.

The parts set in high electric field of high-frequency generates heat because of the dielectric loss. If a surplus length of coil is left to the end of the coil, excessive high voltage will be induced. Therefore, it is important to decrease the unused portion of coils and keep it at a low potential. It is also important not to use materials of large dielectric loss, e.g. bakelite, acryl, etc. These may become the cause of fire.

(iii) Eddy current loss.

High frequency magnetic flux will concentrate to the iron portion of chassis, screws, metal fittings of stand insulators, and heat will be generated by the eddy current loss.

Chassis should be applied with metallikon, and screws and fittings should be made of non-ferrous metal and, magnetic shield should be provided to the installation part of wall-bushings.

(5) High frequency induction interference.

(i) Induction to audio input and meters.

If the modulated high-frequency is induced to the audio input, a feedback circuit will be formed and reduce the SN ratio. Therefore, shielding is necessary. If high frequency is induced to measuring instruments, the measurement of characteristics will become difficult.

Precautions are necessary to be considered at high-power transmitter stations.

(ii) Induction from other stations.

It is a common situation that two or more high power transmitter stations are located close together. In this case, cross-modulation will be induced to each other station, and there is a possibility of skin burning during maintenance work. Therefore, a trap or a rejector is to be provided to prevent this phenomenon.

(6) Prevention of induction.

(i) The high-frequency will be induced to the telephone line and become the cause of cross-talk. Measures to prevent this is to insert suitable bypass-condensers and ground the high-frequency component or employ the lowpass filter. It is also important to decrease the grounding resistance.

(ii) Incomplete metallic contacts may become the cause of harmonics and cross-modulation. The contact should be made complete or otherwise separated.

(iii) Long metal structures, e.g. fences, etc. may become scorching and be dangerous to touch. Measures to prevent this is to ground the long structure, at many points.

(7) *Others*

As large sized parts are incorporated in a high-power transmitter station, transportaion of parts will not be easy at time of failure. In case of emergency, extension-wire could be temporarily used to connect necessary equipment or parts into the main circuit. In addition, as such special wires can not be easily procured, it is necessary to stock these materials in advance.

Fire (outdoor)

Fire fighting should be carried out so that heat will not influence guy-wires, and especially alloy sockets. Fire fighting of the neighboring feeders, guy wires, etc. are also important.