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# A NEW RANGE OF V.H.F TELEVISION TRANSMITTERS

## INTRODUCTION

For virtually the last decade there has been little real progress in the design of v.h.f television transmitters. Although detail improvements in, for example, the power supplies and colour performance, have occurred, the basic designs have remained essentially unchanged. A major reason has been the lack of new output devices available. Also, in recent years, the emphasis has tended to be with the expansion of u.h.f services. The new range of transmitting valves now available, and techniques developed during the u.h.f expansion, permit substantial advances in the design of v.h.f television transmitters. This has led to the design of a complete new range of Marconi equipments with output powers between 500W and 12kW on Band I and 500W and 15kW on Band III.

All the new transmitters are suitable for both black-and-white and colour to PAL, NTSC or SECAM standards, and will operate on CCIR

standards B, D, I, M and N, with a vision/sound power output ratio of 10/1. Modulation and side-band shaping are carried out at intermediate frequency.

With the exception of the high-power stages, and a single valve in the 1kW vision output, the new range is all solid-state, including the circuitry for control and protection. This, coupled with the use of i.f modulation at very low level, followed by several linear r.f amplifiers and with ferrite circulators for interstage couplings, provides simple, compact transmitters of extreme reliability which are easy to install and operate, being particularly suited for remote control.

Another important advantage of the solid-state design, coupled with the conservative running of the output valves, is a very rapid stabilization of output power and frequency response from a cold start. Acceptable signals can be radiated immediately the equipment is switched on and, after



Fig.1 15kW Band III Transmitter.

15 minutes, the frequency response, synchronizing and blanking levels are within specification. This is particularly advantageous where it is required to operate the transmitter in a 'stand-by' condition.

### THE NEW TRANSMITTERS

The driving transmitter, which can be operated on its own to provide an output power of 1kW or 500W, will be fully described in a subsequent article.

A general view of the 15kW Band III Transmitter, type B7205 is shown in figure 1. It will be seen that the vision and sound chains and the vision/sound combining unit form a compact, integral unit. On the extreme left is the driving transmitter. This provides modulated vision and sound drives to the final amplifiers which are mounted, with their power supplies, behind the centre doors. The vision-sound combining unit and water-cooled test load are in the right-hand section. For transport the transmitter breaks down into three units—the driving transmitter, the amplifier and the feeder equipment cabinets. As only front access is needed the whole assembly may be mounted against a wall. The overall dimensions are 4360mm long, 990mm wide and 2060mm high. The external connections required for mains supply and air can be either to the roof or through the floor. The combined r.f. output connection is from the top of the feeder equipment cabinet.

### VALVING

The driving transmitter is completely solid-state except for its vision output valve; the amplifier has one valve for the sound output and one for vision,

and these three are the only thermionic devices in the transmitter.

The valves used are:

Vision output of driving transmitter: YL1440

Sound amplifier: YL1440

Vision amplifier: YL1430

The maximum permissible anode dissipation of the YL1440 is 1.5kW and of the YL1430 12kW.

These are all high-gain, cathode-driven, coaxial tetrodes, of extremely good linearity, with ceramic insulation and air cooling, and mounted in amplifier circuit assemblies designed by the valve makers. This arrangement, ensuring a correct match between circuit and valve, extends what is already standard practice with u.h.f. high-power klystrons, and ensures that the valve is operating at its optimum. As a result excellent guarantees are given, particularly where the valve is under-run.

Different valve circuit assemblies are used for Band I and Band III; this is the chief change in the amplifier section.

For 5kW operation, the anode voltages and drive levels are reduced. This gives a worthwhile saving in the cost of the h.t. supply units, and longer valve life is reflected in the improved guaranteed life.

### BAND III VISION AMPLIFIER

A block diagram of the transmitter showing the position in the circuit of the vision and sound r.f. amplifiers is outlined in figure 2.

In Band III, the YL1430 vision amplifier valve is mounted in its circuit assembly with its anode uppermost and control grid directly earthed, simplifying construction and improving stability. The filament is biased positively with respect to earth, and the screen and anode supplies are returned to

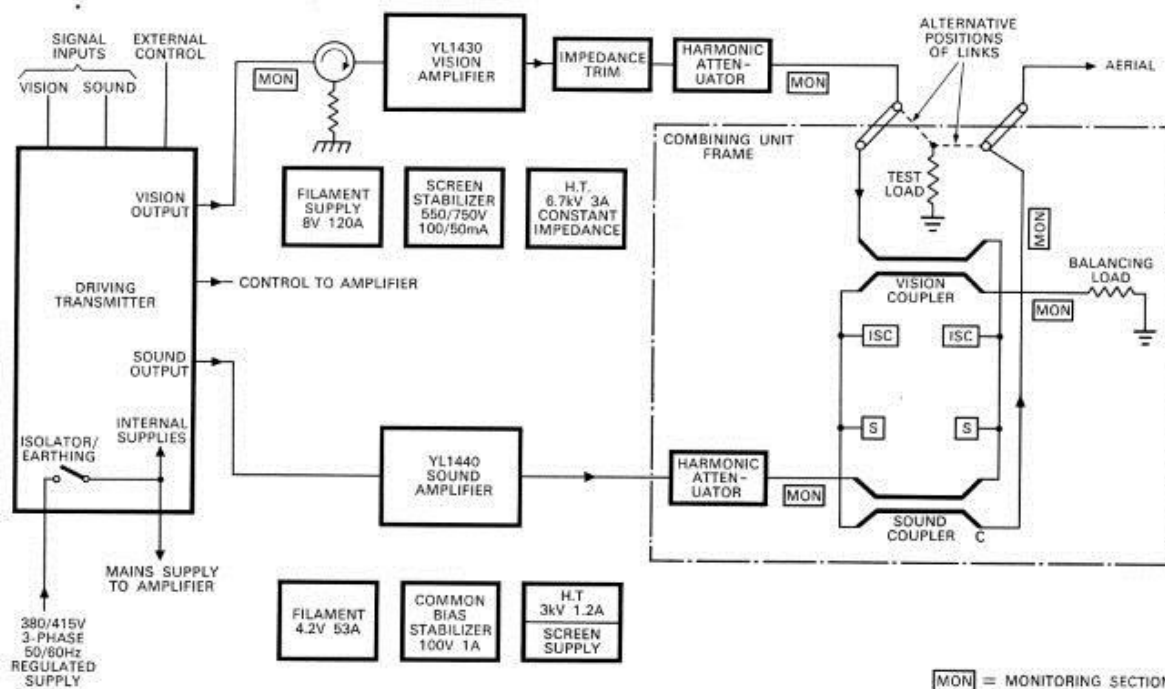


Fig.2 Block Diagram, 15kW Band III Transmitter, type B7205.

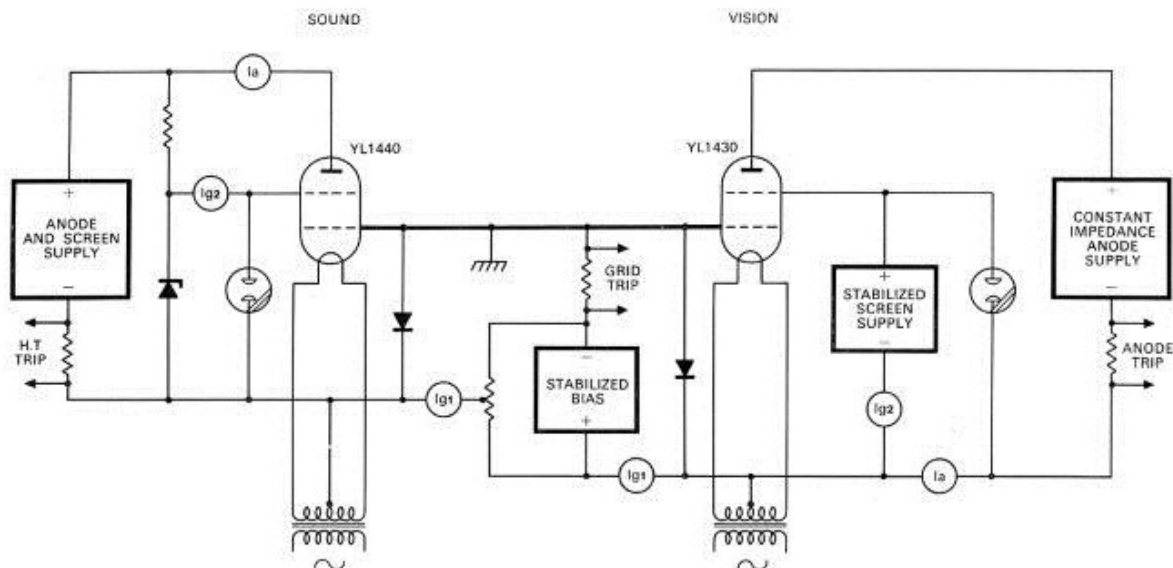


Fig.3 Arrangement of Amplifier Power Supplies, Metering and Trips.

the bias line. Figure 3 shows the supply, metering and trip arrangements. The filament is a cylindrical mesh of thoriated tungsten, thus having great strength and low heat capacity. Its heating time is in consequence one second only, permitting almost instantaneous powering of the transmitter and very rapid restoration of transmission after a mains supply failure.

The broad-band input r.f. circuit is series tuned and is coupled to a fixed tapping point on the quarter-wave coaxial filament line by a common shunt capacitor. A ferrite circulator isolates the input from the previous stage.

The screen is decoupled to the grid plane by an annular capacitor. The anode circuit is formed by the output capacitance of the YL1430 resonating with an inductive element formed by a short tube extending from the valve radiator up to the top of the anode cavity and completed by the four vertical sides of this cavity; these return the circuit to earth

and hence to the screen. This primary circuit is tuned by moving the left- and right-hand sides of the cavity, inwards to increase the resonant frequency. The valve radiator is almost a quarter wavelength from the active part of the anode and its bulk scarcely alters the effective capacitance of the anode circuit. A cylindrical blocking capacitor forms part of the tube above the radiator and isolates the direct anode potential. The heated air is led away in this tube, and when the external air trunk is disconnected, the valve can be removed and replaced. A small screw device attached to the top of the radiator facilitates this by easing the valve up a short distance and releasing it from the pressure of the contacts. The grid and screen contacts each consist of a large number of small leaf springs projecting tangentially towards the valve contact from an encircling ring, each small spring being brazed into a slot in the ring. Jig built, these contact rings are of very high precision and provide excellent electrical and thermal contact.

The necessary broad-band characteristic for vision is provided by a secondary output circuit, chiefly constructed of rigid coaxial line, and mounted below the anode cavity into which a fixed coupling loop projects. There are controls for primary-secondary coupling, secondary loading (Q) and secondary tune, all these, the anode tune, and the input circuit controls, being operated by counter-type knobs, with positive mechanical stops and locks, on the front of the assembly, which, with the YL1430 valve, is shown in figure 4.

This circuit assembly is cooled by air blown into the anode cavity. A small amount escapes to the cabinet through the space around the screen, grid and filament contacts and cools them, the bulk passing through the radiator to the exhaust duct above the valve.

### BAND III SOUND AMPLIFIER

The YL1440 valve is mounted anode up, with directly earthed grid and decoupled screen, in a

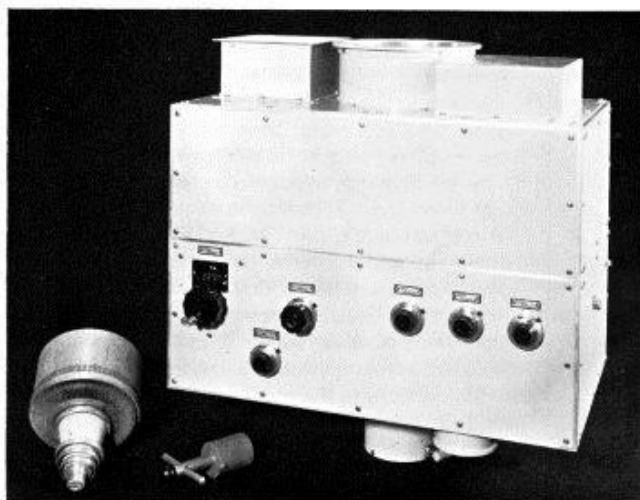


Fig.4 YL1430 valve and Band III circuit assembly.

similar way to the high-power vision amplifier. The cathode drive circuit is also similar, but on a smaller scale. The main difference is in the anode circuit, which is a vertical coaxial line, with the valve anode connected to the lower end of the tube forming the inner conductor and which is the outlet air duct. The anode circuit is tuned by a sliding short-circuit plate and the output load is coupled directly to the anode line by an adjustable disc capacitor, no secondary circuit being required for sound service. (The YL1440 vision assembly used in the driving transmitter is identical, except that it has the necessary secondary output circuit.)

The whole assembly locks forward in a tilted position for valve changing, which is performed through the central anode tube using a special tool designed for correct alignment of valve and contacts which is shown in figure 5. The air outlet is the only disconnection to be made before tilting the stage since all the r.f. and supply connections are flexible and the air inlet, via the back panel, is self sealing.

The sound deviation is  $\pm 50\text{kHz}$  or  $\pm 25\text{kHz}$  with a pre-emphasis of  $50\mu\text{s}$  or  $75\mu\text{s}$ . Frequency response and harmonic distortion over the audio bandwidth 30Hz to 15kHz are  $\pm 1\text{dB}$  and 1% maximum respectively. With 50kHz deviation the f.m. sound noise and the a.m. sound noise are  $-60\text{dB}$  and  $-40\text{dB}$  maximum respectively.

#### BAND I AMPLIFIERS

Grid and screen connections and the method of mounting the valves are as in the Band III equivalents and the input circuits are of a type suitable for the lower frequencies. On the output side there are two coupled tuned circuits for the vision amplifier

and one for the sound amplifier. The anode circuits are formed from lumped rather than distributed elements, and the vision secondary from line inductors and discrete capacitors. The anode circuit of the high-power vision stage is tuned by varying the inductive element, while the YL1440 anode is tuned by means of a series capacitor which also isolates the d.c. supply. The anode blocking capacitor of the high-power amplifier is a built-up flat-plate unit with PTFE dielectric.

The overall size of the sound amplifier is similar to the Band III equivalent, the 1kW vision amplifier accommodating its secondary output circuit within the same outline. Due to the proportions of its anode circuit the Band I high-power vision unit is taller and has a smaller plan than the Band III amplifier; it is an enlarged version of the 1kW amplifier. The cabinet is designed to accommodate all these variants, and either a Band I or a Band III assembly can be readily built up.

Because of the longer wavelength, the external radiator of the valve is much nearer the high-voltage point of the anode circuit in Band I than in Band III, thus increasing the effective circuit capacitance. This is important in vision operation, where to maintain the same circuit Q and hence bandwidth, heavier resistive loading is necessary, increasing the anode loss for a given output and requiring a reduced anode voltage and a somewhat higher current. This has little practical effect on the driving transmitter, which when operating alone has sufficient reserve valve capability for 1kW output, but the maximum output of the high-power transmitter is reduced to 10kW–12kW, according to the operating bandwidth. Operation with an output power of 5kW is unaffected.

#### VISION-SOUND COMBINING UNIT

At v.h.f., a high-power combining unit is quite sizeable and, if dismantling is ever necessary, easy access and ample room are needed. These are commonly provided by mounting the unit in an open frame with all-round access, a solution both uneconomical in space and unaesthetic. Placing the unit against a wall or suspending it from the ceiling reduces the room needed, but also cuts access.

In these new transmitters the combining unit is mounted in a castor-based frame housed beside the amplifier unit in a similar cabinet. On this movable frame are located the couplers, resonators and balancing load which form the essential parts of the combining unit, plus the sound harmonic attenuator and the water-cooled resistive test load with thermometers and flow meter. The left-hand side of this cabinet houses the vision harmonic filter and the aerial feeder. This layout combines excellent accessibility with a uniform appearance.

Connections to the frame (except for sound) are made by the rigid coaxial U-links, shown in the block diagram (Fig. 2), which allow the combined signal to be fed to either load or aerial, and the vision signal to either combining unit or load. Sound connections are by flexible cable and so can

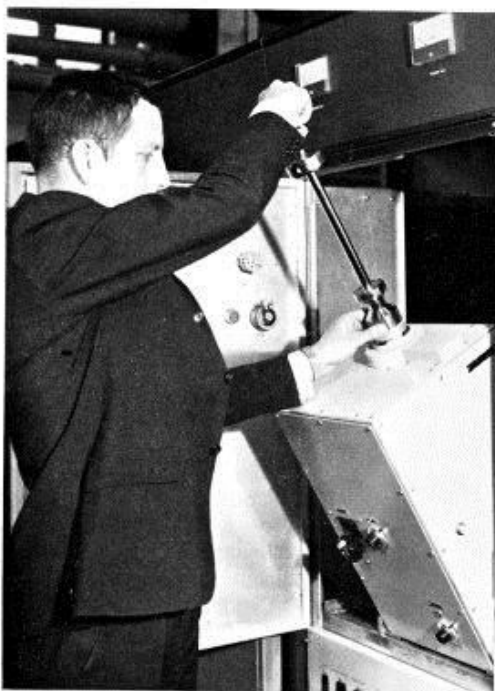


Fig. 5 Valve removal from the Sound Amplifier.

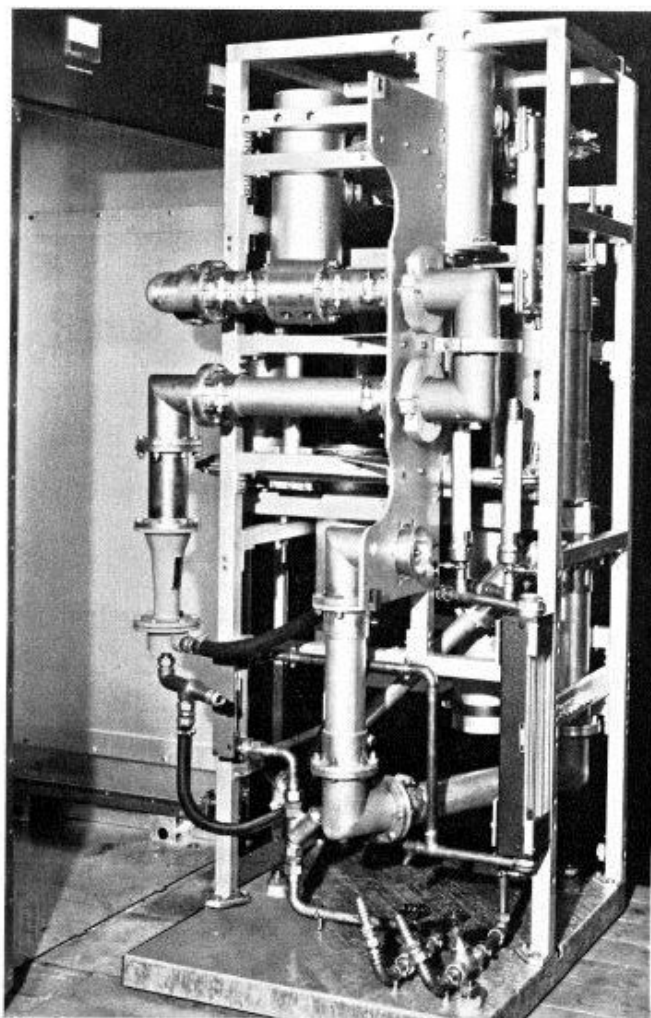


Fig.6 Combining Unit frame assembly.

easily be rearranged for any special tests. Checking the impedance of aerial, load or combining unit is extremely easy since removing the U-links gives immediate access to the feeders. The harmonic attenuators are low-pass resonant filters formed from alternate high- and low-impedance sections of transmission line inside standard feeder outer. The combining unit frame is shown withdrawn in figure 6.

The principle of the sound-vision combiner is the same in Band I and Band III and can be followed in the block diagram. Two 3dB quarterwave line couplers are linked by transmission lines of equal length shunted by two pairs of resonators. The two resonators of a pair are at exactly equal distances from the coupler ports. One pair (ISC in the diagram) are tuned to give short-circuits at image sub-carrier frequency; the other pair (S in the diagram) are tuned to sound frequency.

A signal entering the sound coupler splits into two waves in quadrature proceeding towards the vision coupler. These are reflected by the mismatches of the sound resonators and re-enter the sound coupler at such a relative phase as to add at

the combined output port C and cancel at the sound input. The small sound signals proceeding beyond the sound resonators combine in the vision coupler and are dissipated in the balancing load. A vision input signal is similarly split into two waves in quadrature travelling towards the sound coupler. Any vision side frequencies at image sub-carrier and at sound carrier are reflected to the vision coupler, combined, and absorbed in the balancing load. The wanted vision signals add at C, combining at this point with the sound signal, and cancel at the sound input port, giving the required vision-to-sound attenuation.

#### MONITORING

There are three main and two subsidiary groups of monitoring points (Fig. 2), and all are fed by directional couplers. The main groups (vision, sound and combined output) have r.f. monitor points and forward and reflected power metering. The vision power meters indicate sync level, and there are backward wave trips at the outputs of the two amplifiers.

The r.f. monitor cables terminate on a panel in the feeder equipment cabinet, from which local test gear can be fed, and they can be extended to remote test apparatus. The subsidiary probes, used in setting up the transmitter, are on the inputs of the balancing load and the vision amplifier.

Additional probes can be fitted at the amplifier outputs for phasing (used when two transmitters are paralleled) and for feeding automatic level monitors.

#### SUPPLIES AND CONTROL

The mains supply, from an external automatic voltage regulator, is distributed via an isolator in the driving transmitter. This is mechanically interlocked with a safety earthing switch which is extended into the amplifier. Not until the supplies have been isolated and points carrying dangerous voltages earthed is it possible to release keys giving access to the high-voltage areas.

The control and protection system is centred in the driving transmitter. It is a digital transistor logic system with extremely high noise immunity, proved in several designs of operational transmitters as well as in very extensive development tests, including fault-free operation in an h.f. field of 400V/metre.

The arrangement of the amplifier supplies and trips is shown in figure 3. No trips are needed in the screen supplies, both being designed not to over-dissipate their valve. The grid trip, having one terminal earthed, is a current sensing resistor working directly into the solid-state circuitry; the two h.t. trips, being off earth, operate the logic system via sealed reed relays. The gas-filled discharge gaps and the filament-earth diodes protect against short circuits.

Solid-state contactor drivers in the driving transmitter switch the amplifier power supply contactors which feed the filament transformers and the supply units via circuit breakers.

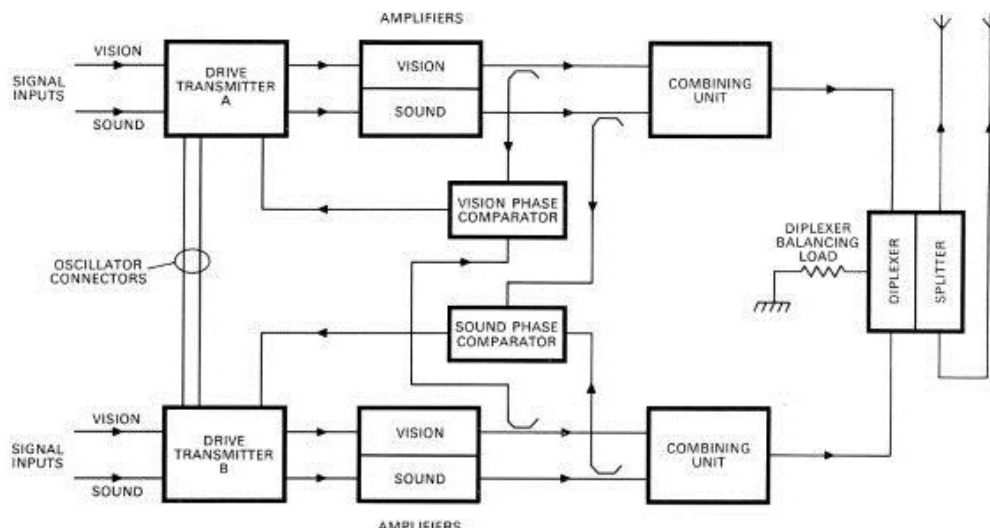


Fig.7 Block diagram, parallel operation of two transmitters.

All rectified supplies use silicon-diode rectifiers and they are protected against mains-borne surges of up to 2000V peak and against any internally generated surges. The stabilized bias is used direct for the vision amplifier and via a potentiometer for the sound. The sound anode supply, from which the zener-stabilized screen supply is derived, has a standard three-phase bridge rectifier using encapsulated silicon diodes. The vision h.t supply also has a three-phase bridge rectifier, and its smoothing is built out to a constant impedance of 300 ohms to prevent variations in blanking level which otherwise would be caused by resonances due to any sharp transitions in the picture signal. The vision screen has a solid-state shunt stabilizer and supply with adjustable voltage output.

Metering facilities are comprehensive with most of the instruments placed behind the access doors, the fascia being reserved for h.t and r.f power meters. Remote control facilities will be detailed in a later article on the driving transmitter; sensing resistors for the external telemetry gear which may then be needed are fitted in the metering circuits.

The transmitters are designed to operate from a mains supply of 380/415V three-phase, four-wire 50/60Hz. Consumption, at 15kW sync. is 30kW, and at 5kW sync. is 19kW.

#### COOLING: INSTALLATION

A single blower, with an inlet filter, cools both the driving transmitter and the amplifier. This blower is mounted externally, reducing the noise in the transmitter hall and keeping down the transmitter size. It can be positioned to suit the building requirements, giving the user flexibility in the choice of filter and recirculating system, and can be chosen to suit the altitude of the station.

If it is wished to bring the air connections overhead, they are joined to a duct system running along the length of the transmitter roof, distributing the air to the amplifier where it cools the r.f amplifiers, power supplies and feeder equipment cabinet, and

to the driving transmitter. All the heated exhaust air is collected and is available for building heating. Alternatively the air connections can be made through the floor.

The only other major connections are the 3-125 inch combined r.f output feeder and the mains supply. These, the signal leads, and if required external monitoring and control leads, can be connected either to top or bottom of the transmitter.

The transmitters will operate in ambient temperatures over the range  $-10^{\circ}\text{C}$  to  $+45^{\circ}\text{C}$  at altitudes up to 2300 metres.

#### PARALLEL OPERATION

The principle of this, by far the most reliable way of ensuring continuity of transmission, is shown in figure 7, which illustrates a system having no active elements common to the two sides.

The vision and sound outputs of a pair of transmitters are combined in a simple diplexer and then split to feed the two halves of the radiating system by separate feeders. If one transmitter fails transmission is maintained, without any break, by the output of the remaining equipment which splits equally between the aerial and the balancing load, reducing the radiated field strength by 6dB. Half of this can be recovered by bypassing the diplexer during a convenient break in the programme.

Suitable connections of the sound and vision r.f oscillators ensure that the two sides operate at identical frequencies. The correct carrier phase relationship is provided by separate vision and sound phase comparators, though this is by no means as critical as is commonly supposed, a phase difference of  $36^{\circ}$  being equivalent to a loss of only 0.5dB.

#### VISION PERFORMANCE SUMMARY

*Vision frequency response and Group Delay*

Meet all standard requirements

*Differential gain*

0.95 (min) at sub-carrier

*Differential Phase*

3° (max)

*Pulse/bar*

K 2% (max)

*50Hz square wave*

K 0.5% (max)

*Blanking level stability*

±2%

*Vision noise and hum*

Max. 55dB peak-peak below sync.

**CONCLUSION:**

In designing this range of v.h.f transmitters the requirements of reliability and easy maintenance have been emphasized by using the minimum of thermionic devices and only one electric motor. The simple but flexible cooling system permits the station layout best suited to local requirements and installation can be completed rapidly because of the small number of component units.