Colour Conversion or National Television Transmitting Stations

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Telecom Australia is responsible for the installation and operation of the television transmitting stations providing the National Television Service. This paper describes the approach adopted by the then Post Office in converting these stations for colour, including the performance investigations undertaken and the equipment modifications required to allow the introduction of a colour television service on 1st March, 1975. The paper also describes the configuration of facilities adopted at the converted stations and concludes with a discussion of the problems of converting the Hobart station while maintaining service.

Editorial Note: This article was presented at the Annual Engineering Conference of the Institute of Engineers, Australia held in Hobart in February 1975, and published by the Institute in the Annual Engineering Conference Papers. Their approval to republish it is gratefully acknowledged.

INTRODUCTION

Monochrome television broadcasting began in the National Television Service in 1956 with the establishment of stations to serve Melbourne and Sydney. Over the period 1959-1967 a further 37 high power transmitters were established by the then Post Office which extended the National Service to the remaining capital city stations and to all except the more remote regional areas. Further extension and improvement in the coverage of the National Service has since been achieved by the installation of low power transmitting and translator stations; at 30th June, 1975, there were 99 such station with a further 26 in the process of construction. This development is shown in Fig. 1. All Australian television services are transmitted in the VHF band.

Telecom Australia is also responsible for the provision and operation of the programme relay facilities which interconnect the transmitting stations with the studios of the Australian Broadcasting Commission where the programmes are produced. With the exception of direct studio-transmitter links established for several capital city stations, the programme relay facilities are provided on the National Broadband Bearer Network. The colour conversion of this network is not discussed in this paper, nor are the colour conversion works required at the studios of the ABC.

In 1969 the recommendation of the Australian Broadcasting Control Board that Australia should adopt the PAL system of colour transmission was accepted by the Government of the day. The previous years of monochrome television had resulted in the development in the industry of considerable expertise and to draw upon this, Industry Working Parties were established involving representatives from television companies, equipment manufacturers and both commercial and national broadcasting organisations. These working parties developed basic system standards for Australia and these were duly embodied in the ABCB publication (Ref. 1) and APO specification (Ref. 2).

COLOUR TELEVISION SIGNALS

Colour television signals have waveform and spectral characteristics which differ from those of monochrome television signals. These differences are such that colour signals impose additional demands upon equipment designed originally for monochrome services. Some of these demands are fundamental to colour signals and must be met before colour services can take place while other demands affect the faithfulness with which the picture is transmitted.

The waveform characteristics of Australian colour and monochrome television signals are shown in Fig. 2, and it can be seen that the proportion of the signal which can be occupied by visible picture information has increased from 100 units to approximately 170 units. As a result, the colour

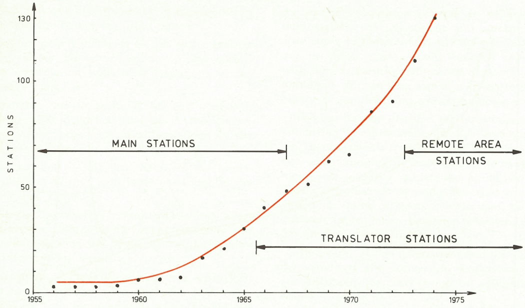

Fig. 1 — National Television Development.

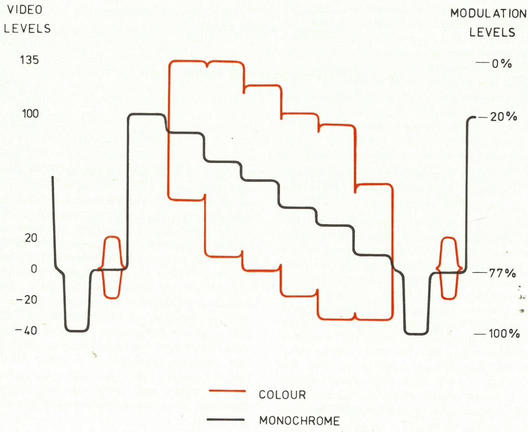

Fig. 2 — Television Line Waveforms.

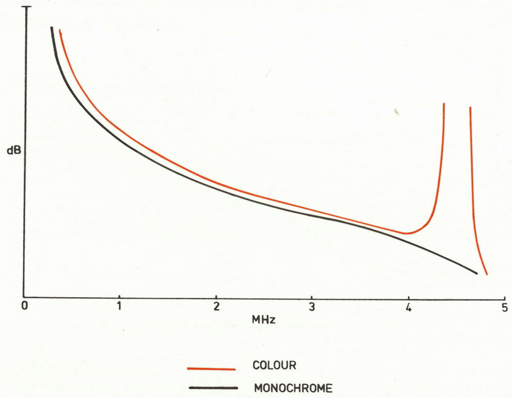

Fig. 3 — Frequency Spectra of Typical Signals.

signal has increased susceptibility to level dependent or non-linear distortions, which affect the accuracy of the picture reproduction.

The excursion of picture information into the portion of the signal occupied only by synchronising information in a monochrome signal affects synchronising signal processing circuits normally used in monochrome equipment. It should be noted that the modulation levels apply to an ideal double sideband signal. In practice this is modified to a vestigial sideband signal in the transmitter prior to transmission, with the result that the amplitude of the high frequency colour or chrominance information is reduced to one half. In addition the synchronising portion of the colour signal includes the "colour burst" which is essential for decoding the colour information in the transmitted signal.

The distribution of spectral energy in colour and monochrome signals is represented in Fig. 3.

The increased level of high frequency energy is due to the inclusion of the colour information, in the form of a colour sub-carrier of approximately 4.43 Mhz on to which the hue or colour itself is phase modulated and the saturation or strength of the colour is amplitude modulated. As a result the colour signal makes increased demands upon the frequency dependent performance characteristics of the transmitting equipment and also increases the frequency range over which level dependent distortions are significant. Deficiencies in these performance characteristics affect the accuracy of picture reproduction. In particular, the different time delays of the frequencies associated with colour information and the picture or luminance information affect the "registration" of the colour with the the picture. The addition of the colour sub-carrier to the vision and sound carriers increases the likelihood of intermodulation and spurious radiation problems.

With the recognition of these characteristic differences between monochrome and colour television signals, the more important basic tests appropriate to explore and quantify the colour performance of monochrome equipment are listed below:

- Differential gain and phase — this test measures the non-linear distortion arising in the chrominance information with level variations in the luminance signal.
- Chrominance non-linearity — This test measures the non-linear distortion arising in the chrominance information with level variations in the chrominance signal.
- Luminance Shift — this test measures the luminance changes arising with level variations in the chrominance signal.
- Luminance-chrominance inequality — this test measures the difference between the gains and the time delays of the luminance and chrominance information, respectively.

A description of these and other tests which can be used to explore the adequacy of monochrome equipment for colour operation is given by Bartlett (Ref. 3). These tests were used in an initial assessment of monochrome equipment in the National Service undertaken in the development of the conversion programme as described in the next Section.

DEVELOPMENT OF CONVERSION PROGRAMME

The basic equipment at National Television transmitting stations falls within five groups:

- Transmitters
- Translators
- Antenna systems
- Studio-transmitter direct links
- Ancilliary Equipment comprising
  Programme Input Equipment
  Local/emergency programme source
  Test and monitoring facilities.

In each of these categories the equipment has been supplied by a wide range of overseas and local manufacturers during the period extending from 1956, when television commenced in Australia, to the present time. The equipment shows the changes in design practice with solid state component availability over the years and different installation reflect developments of station equipment configuration philosophies.

Following the announcement that colour television would be introduced, an assessment was made of the colour transmission performance of this wide range of monochrome transmitting equipment. The assessment was based upon previous experience and knowledge of the equipment and included performance measurements, using the previously discussed tests, on selected representative items. The assessment also included consideration of operating and maintenance aspects of the existing equipment, such as reliability, long term stability of adjustment and current maintenance costs, to determine if any deficiencies develop-ing in these areas would become unacceptable with the increased performance demands of colour operation. Recognition was also given to the desirability of standardising station equipment.

This assessment enabled the development of two interacting programmes; firstly an engineering works programme covering the ordering, installation and funding of replacement items of equipment and secondly, a detailed equipment investigation programme covering the colour evaluation of specific items of existing equipment to enable a decision to be taken between retention, re-design or complete replacement.

The results of this assessment and the subsequent investigations and conversion works that followed are discussed for each group of equipment listed above.

TRANSMITTERS

Table 1 shows the range of high power vision transmitters employed at main 100 kW ERP National Stations and summarises the basic conversion work required. The majority of these transmitters including that at Canberra has been supplied by one Australian manufacturer. This manufacturer was the only supplier able to provide a colour conversion modification kit for their transmitters. Accordingly, the transmitter at Canberra was converted to colour operation by this manufacturer as a model exercise, to enable a full assessment to be made of the colour conversion equipment and the conversion procedures adopted in relation to the cost and final performance achieved. From this work, guidelines were developed for the evaluation and conversion of other transmitters, particularly those provided by this manufacturer.

The transmitters at Melbourne, Sydney and Hobart were supplied by overseas manufacturers who were not in a position to assist with conversion components. These stations were among the first National Stations to commence operation and the transmitters were not capable of conversion to colour operation without extensive and un-economic modifications. They were therefore replaced. Details of the colour evaluation tests conducted on the original Hobart transmitter are discussed later. The other high power transmitters of overseas origin are of more recent design and were assessed as being capable of successful conversion to colour operation, although, in the case of the transmitters at Brisbane, Adelaide and Perth it was necessary to replace major components associated with the band shaping and combining of the vision and sound transmitter outputs.

TABLE 1 — CONVERSION OF HIGH POWER VISION TRANSMITTERS

Group	Country of Manufacture	Station Configuration, Frequencies and Location	Opening Date	Conversion Work
1A	Australia	Parallel 10 kW Ch 3—Canberra	1962	Manufacturer to convert as model exercise
1B	Australia	Parallel 10 kW Ch 2, 3, 4, 16 locations	1963-1967	APO to convert based on: (a) Experience from Canberra (b) Investigation of detailed requirements (c) Modification kit from manufacturer
1C	Australia	Parallel 10 kW Ch 5. 2 locations	1965	APO to convert as for Group 1B pending change of Channel allocation requiring new transmitters
1D	Australia	Parallel 5 kW Ch 6-9. 4 locations	1965-1966	APO to convert as for Group 1B
2A	U.K.	Main 18 kW-4kW standby Ch 2 Melbourne and Sydney	1956	Complete replacement
2B	U.K.	Parallel 10 kW Ch 2 Brisbane Adelaide and Perth	1959-1960	APO to convert based on: (a) Investigation of detailed requirements (b) Replacement of major components (c) Redesign of major circuitry
2C	U.K.	Parallel 10 kW Ch 0, 1 5 locations	1963-1965	APO to convert based on: (a) Investigation of detailed requirements (b) Redesign of major circuitry
2D	U.K.	Parallel 5 kW Ch 6 1 location	1964	APO to convert as for group 2B
3A	Japan	Parallel 10 kW Ch 4, 5 2 locations	1963	APO to convert based on: (a) Investigation of detailed requirements (b) Redesign of major circuitry
3B	Japan	Parallel 6 kW Ch 5A 1 location	1963	APO to convert as for group 3A
4	Holland	Main 22 kW -5 kW standby Ch 2 Hobart	1960	Complete replacement
5	Australia	Parallel 10 kW Ch 7 1 location	1966	APO to convert based on: (a) Investigation of detailed requirements (b) Redesign of major circuitry

The high power sound transmitters were not influential in determining the conversion work required but where the vision transmitters were to be replaced then the associated sound transmitters were also replaced as the two are closely integrated in modern equipment.

The transmitters at low and medium power stations have been installed during the last three years, with few exceptions. The equipment is consequently modern in design and was provided with an awareness that the introduction of colour services was imminent. An assessment of the colour performance of these transmitters showed that satisfactory colour operation could be achieved with minor equipment additions and modifications. These low power stations are not normally staffed and the long term stability of adjustment and performance of the equipment is an important maintenance consideration. In some cases a lack of stability has proved to be a limitation in monochrome operation and with the additional performance demands imposed by colour operation equipment replacement is necessary.

Replacement Transmitters

The replacement transmitters employ low level intermediate frequency modulation techniques in

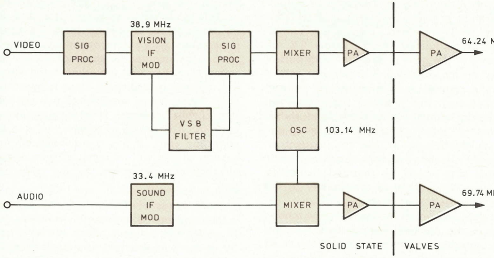

Fig. 4 — Block Diagram of Intermediate Frequency Modulated Transmitter.

accordance with the latest transmitter design philosophy. The principal advantage of IF modulation is that signal processing can be done at low level both before and after modulation. This enables increased use to be made of physically small and highly reliable components and solid state devices, with the result that complex circuitry of improved performance and stability can be designed without sacrificing overall transmitter reliability. A typical modern IF modulated vision transmitter with associated sound transmitter, such as shown in block diagram form in Fig. 4, employs only three electron tubes. Detail of such transmitters is described by Bartlett (Ref. 4) and by Ohshima, Sakai and Higashi (Ref. 5).

The new transmitters are arranged in parallel pairs of both vision and sound transmitters, with all units in operation simultaneously. This configuration avoids interruption to the service in the event of failure of one transmitter and is now standard at all high power National transmitting stations.

Converted Transmitters

From Table 1 it can be seen that the majority of high power transmitters in the National Service were capable of conversion to colour operation, but considerable detailed investigation and redesign of circuitry would be necessary. Although the monochrome transmitters to be converted have been supplied by various manufacturers, it is found that there are common limitations and problems experienced in converting these to colour operation. The components of transmitters in which problems occur and the solutions adopted are as follows:

Modulator

The monochrome modulators used in the medium and high level modulated transmitters in the National Service were unable to satisfactorily handle colour signals without considerable modification. The deficiencies were inter-related and were evident to differing degrees depending upon the transmitter design. They occur in four main areas.

Firstly, the modulators were unable to produce a sufficient output voltage to modulate the transmitter to the lower carrier levels required in colour operation.

Secondly, the requirement in colour operation for modulation by high amplitude high frequency chrominance signals causes modulator output stages and their power supplies to suffer overloading and excessive heat dissipation in their attempts to produce sufficient reactive current to drive the capacitive load presented by the modulated amplifier stage. The modulator in the transmitters supplied by the main Australian manufacturer was a well integrated design for monochrome signals and all the above problems were evident on colour signals. The modification proposals prepared by the manufacturer overcame these by increasing the supply voltage to the final modulator stages and replacing the output stage valves with types of increased dissipation rating, supported by power supplies of higher capacity. The overseas transmitters were found to have a greater margin in their design with the result that a small increase in the gain of an early amplifier stage overcame the modulation depth limitation and only in the case of the Japanese transmitter was it necessary to overcome an output stage overheating problem by means of a replacement valve with increased dissipation rating. Achievement of modulation depths below 5% of the carrier level at the peak of synchronising pulses is dependent on the condition of modulator valves and on careful setting up to prevent grid current caused by any excessive amplifier input voltages from introducing counter-acting black level shifts. The performance defects arising from being unable to modulate below 5% are not frequent or serious enough to justify the more extensive modulator changes that would be required to ensure this could always be achieved, particularly in the case of the overseas transmitters.

The third deficiency in all the monochrome modulators used in the National Service was that the back porch clamping circuits caused interference to the colour synchronising burst which is located on the back porch of the colour signal. The most common method of avoiding this interference, and the method adopted by the main Australian supplier in their modulator modification, is the insertion of a rejection filter at colour sub-carrier frequency to isolate the effects of the clamp circuits at colour frequencies. This method does not entirely eliminate disturbance to the burst information and two alternative methods are bing tested for use on other modulators. The first alternative method is the insertion of a resistor rather than a tuned filter in the clamp line. This removal of reactive elements minimises disturbance to the burst information by only at the expense of clamp efficiency. The second alternative method is the timing of the clamp pulse on the small portion of the back porch not occupied by the burst. In concept this is the superior method as complete independence is obtained between clamp operation and the burst, but complex circuitry is required to ensure that the clamp pulse is correctly positioned, particularly during the field blanking interval, and to ensure continued correct operation of blanking level feedback systems.

The fourth deficiency requiring alteration in monochrome modulators was in the operation of signal processing circuits designed to compensate for non-linearity of the modulation characteristic and limiting circuits designed to prevent excessive signal amplitudes. Synchronising pulse stretching circuits operating on a "stretch and clip" basis interfere with chrominance information extending beyond the black level and they were modified so as to operate only at luminance frequencies. Peak white clipping circuits were similarly modified to avoid interference with chrominance information extending beyond white level. Other linearity correction circuits found in monochrome modulators do not provide adequate correction at chrominance frequencies over the increased range of picture information found in a colour signal, and they make no provision for differential phase correction which is necessary with colour operation. Therefore they were supplemented at the modulator input by a colour correction unit providing a full range of signal processing facilities. There is evidence that in some monochrome modulators the existing correction circuits introduce differential phase errors or are difficult to set up in conjunction with the colour correction unit. If this is confirmed all signal processing circuits will be removed from operation and all correction performed by the colour correction unit.

This process of off-setting errors in one part of the equipment by introducing compensatory errors in another part directly affects the long term stability of the overall equipment performance and has implications for the operation and maintenance of the station. This aspect will be carefully watched as experience is gained with converted stations.

Filterplexer and Other Coaxial Components

All medium and high level modulated monochrome transmitters are equipped with filterplexers to provide vestigal sideband shaping and to combine the output of the vision transmitter with the associated sound transmitter. The outputs of each of the vision/sound transmitters are further combined and connected to the aerial system by various coaxial components such as diplexers and switching frames. The filterplexers supplied with the monochrome transmitters do not offer the same level and stability of performance of parameters such as in-band insertion loss and return loss as do more recently available filterplexers. In addition the design does not reflect such colour requirements as the suppression of the colour sub-carrier image frequency to avoid spurious out-of-band radiation, and adequate cross-insertion loss between the sound and vision input ports which guards against the production of a visible 1.07 Mhz component in the transmitted signal from inter-modulation between the sound and colour sub-carrier. An evaluation program involving measurement of individual filterplexer characteristics was commenced which included measurements on the transmitter-filterplexer combination in those cases where the filterplexer characteristics varied from those obtainable from a replacement unit. The aim was to determine those transmitters where the filterplexer represented the limiting factor in achieving satisfactory stable colour performance. These measurements showed that the in-band insertion loss of the monochrome filterplexers does not vary outside 0.5 dB across the band and does not jeopardise the power-bandwidth performance of the transmitter-filterplexer combination. The out-of-band insertion loss was generally satisfactory but in some cases an additional coaxial notch filter is required to suppress the colour sub-carrier image frequency to better than 60 dB below peak carrier. The filterplexer cross insertion loss was found to be of the order of 30 dB and measurements with both vision and sound transmitters in operation showed that the 1.07 Mhz product is over 60 dB below peak vision power which is satisfactory. The return loss of the existing filterplexers was found to be worse in some part of the band than the 40 dB to be expected in filterplexers of the new design, with deteriorations in some cases of down to 25 dB at the high end of the band. In this situation the overall transmitter-filterplexer frequency response was examined to assess the presence and position of variations caused by changes in the filterplexer input impedance. In some cases these variations improve the overall response by providing a lift at the high end of the band which can compensate for the minor insertion loss deficiencies in the filterplexer. In other cases the variations act the opposite way and degrade the response at the high end of the band or introduce mid-band disturbances. These variations are usually rapid in terms of frequency and cannot be off-set by normal transmitter tuning adjustment without seriously affecting the power-bandwidth performance. When this occurs the only scope for improvement lies in the addition of matching elements between the filterplexer and the transmitter.

If the overall frequency response of the transmitter filterplexer combination could be made satisfactory, notwithstanding the filterplexer return loss, then the existing filterplexer was not replaced, as the influence of the return loss upon other parameters is marginal as argued by Blair (Ref. 6).

It was found that fewer than 10% of the filterplexers in the National Service monochrome transmitters needed to be replaced as an essential part of the colour conversion work. Where this was done the associated coaxial components were also replaced.

TRANSLATORS

The key factor in the performance of translators with colour signals is the linearity of the common amplifiers which handle vision signals including colour sub-carrier and sound signals. The most critical measure of this linearity is the level of the 1.07 MHz intermodulation product for which a level of 50 dB below peak vision carrier level is required.

An evaluation programme was commenced to assess the level of this intermodulation product for each type of translator used in the National Service. Most translators proved satisfactory for colour operations although in some cases it was necessary to improve the performance by a minor adjustment of the amplifier operating conditions.

ANTENNA SYSTEMS

The antenna systems installed in the National Service seek to achieve a reflection coefficient of the antenna input of 1.5% at vision carrier tapering to approximately 3.0% and 5.0% at the lower and upper band limits respectively. This requirement was developed from original work by the BBC and includes a consideration of colour signals. Installed antenna systems meet this requirement with only a few marginal exceptions and it is not expected to replace any antenna systems solely for colour performance reasons. An investigation programme was undertaken to ensure that the antenna systems had not deteriorated in performance since installation.

STUDIO-TRANSMITTER DIRECT LINK

Direct studio-transmitter links using microwave radio systems are installed at the capital city stations in Melbourne, Brisbane, Adelaide, Perth and Hobart. These systems were installed in the period 1956-1960 and the equipment is obsolete in design with unsatisfactory colour performance and presents an excessive maintenance requirement. All links were therefore replaced with modern equipment.

ANCILLIARY EQUIPMENT

The majority of the ancilliary vision equipment at the main National Stations was replaced with modern solid state units designed for colour operation. Equipment replaced includes video distribution and clamping amplifiers, stabilising amplifiers, video switches, waveform and picture monitors, monitoring receivers, synchronising pulse generators and test signal generators. Specialised colour television equipment being supplied includes a test pattern generator and encoder.

COSTS

The costs associated with the colour conversion of the National Television Service transmitter stations are summarised in Table 2.

TABLE 2 — ESTIMATED TRANSMITTING STATION CONVERSION COSTS

Conversion Work	Estimated Final Cost $M
Complete replacement of transmitters and translators	1.2
Modification and partial replacement of transmitters and translators	1.7
Replacement of aerial systems	—
Replacement of studio transmitter direct links	0.3
Replacement of ancilliary equipment	2.5
Total	5.7

STATION EQUIPMENT CONFIGURATION

The increased availability of solid state equipment of high reliability has enabled the configuration of station facilities, particularly in the programme input equipment area, to be progressively simplified over a period of time from that adopted when the major stations were established. A simplified block diagram of the configuration now adopted at a typical converted station is shown in Fig. 5.

PROGRESS AT 1 MARCH, 1975

By 7 October, 1974, progress with conversion work had reached the stage where colour test transmissions were introduced from capital city stations. These test transmissions were subsequently extended to all National television stations and associated translators. These test transmissions which involved test patterns and programme material, proved most effective in enabling available resources to be directed towards the conversion of those aspects of each item of equipment causing the most visible performance deficiencies. By this means it was possible for all National stations to commence regular colour services at a subjectively acceptable level on the official 'C-Day' of 1 March, 1975.

Following this date, the conversion work as planned continued at the majority of regional stations. Completion of this work ensures that the

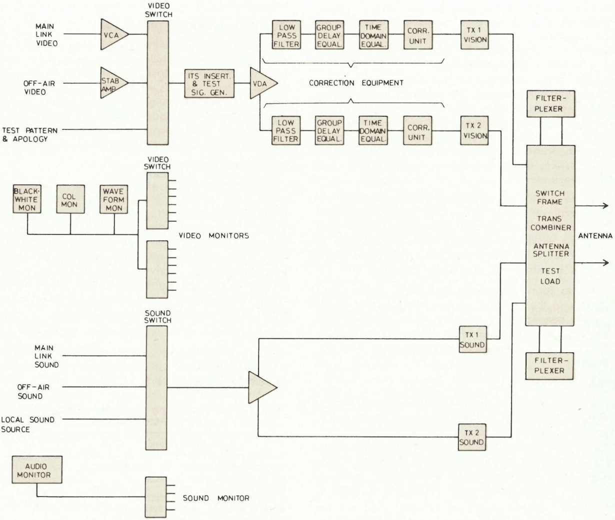

Fig. 5 — Simplified Diagram of Facilities at Typical Converted Station.

stations fully comply with transmission standards and are adequately equipped with the operating testing and monitoring facilities for reliable long term colour operation. Over 75% of stations were fully converted by the end of 1975.

EVALUATION TESTS ON ORIGINAL HOBART TRANSMITTER

The original transmitter at ABT2 Hobart comprised a 5 kW modulated amplifier stage driving a 22 kW linear amplifier stage. In the event of the failure of the 22 kW final stage, the output of the 5 kW modulated stage could be connected to the antenna system directly. This allowed programme to be maintained on low power.

The effect of this arrangement on evaluation work was that testing had to be carried out after close down each night and yet the transmitter had to be ready for operation by the following morning. Also, any work involving existing circuitry was lengthened because any unsuccessful modifications had to be removed before the morning. Overall tests were carried out from the input of the transmitter through all the stages in their normal configuration through the filterplexer into a precision dummy load. It was found that high amplitude high frequency signals suffered serious crushing to less than one half correct amplitude. Work was then undertaken to determine which particular sections of the transmitter were causing the distortion and to see if the performance could be improved. This was done by examining the performance at the output of the 5 kW modulated stage with the stage terminated in a precision load. It was found that serious signal degradations occurred, with the response to high amplitude, high frequency signals being 4 dB down to 5 MHz above vision carrier. This could not be improved by transmitter retuning.

The performance at the output of that stage is shown in Table 3.

TABLE 3 — COLOUR PERFORMANCE OF ORIGINAL HOBART TRANSMITTER

Test	5kW Mod. Stage	22kW Lin. Stage	Overall	Spec.
Chrominance/ Luminance Inequalities				
Gain	—5dB	—4dB	—8dB	—0.8dB
Phase	—100nS	—70nS	—	—30nS
Differential Gain	28%	35%	—	5%
Differential Phase	4°	4°	—	5°
Chrominance Non-Linearity	42%	60%	—	7%

With the 5 kW modulated stage driving the 22 kW linear stage terminated in a precision load, it was found that the high frequency performance of the 5kW modulated stage was further degraded. This was due to the loading from the 22 kW stage input and arose from poor matching of impedances between the output of the first stage and input of the next. No tuning adjustments were provided for interstage matching. The only way to set-up the two stages was to tune them as a pair. This was done and a further set of measurements were made and the results are also shown in Table 3. The performance although improved slightly at the high frequency end of the band was still not satisfactory. The differential gain had further deteriorated. With the output of the linear stage connected through the filterplexer the response was further degraded at high frequencies as shown in Table 3.

The inadequate power capability at high frequency is a basic characteristic of the original transmitter and could not be overcome without extensive modification.

INSTALLATION WORK AT HOBART

The paramount problem at all stages of the installation work was the essential requirement to keep the existing equipment operational so as to maintain service. This problem effected both the decision as to where to locate the new transmitter equipment and the sequence in which the new equipment installation was to take place.

Location

The transmitter hall at Hobart has a floor area of 300 square metres. However, location of the new equipment was restricted to a relatively small portion of the floor area for the following reasons:

- It was preferable to maintan a similar equipment/ building configuration to that existing.
- The switching frame of the new transmitter had to be near to the existing antenna feeder entry point.
- The new equipment could not be located so close to the existing transmitter as to prevent maintenance access.
- It was necessary to have suitable accommodation directly under the transmitter for forced air cooling equipment.
- Any holes that were required in the floor had to avoid the lattice of floor supporting beams.
- Any new rigid coaxial feeders, air ducting or cables had to avoid existing feeders, ducting or cables.

Fig. 6 shows the arrangement adopted. The new transmitter suite is located parallel to and behind the original transmitter. They were spaced apart

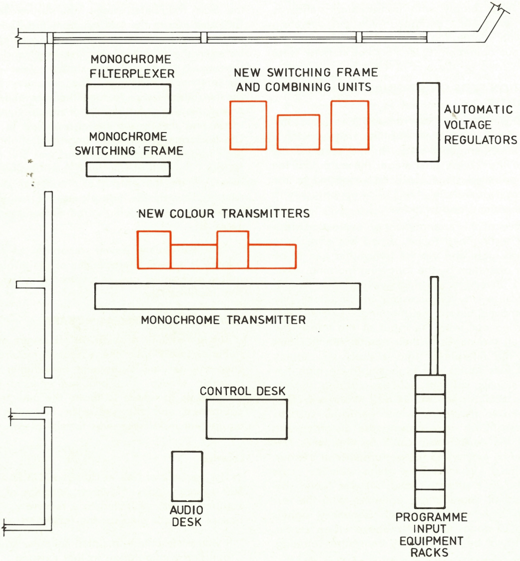

Fig. 6 — Layout of ABT-2 Hobart.

in such a way that the rear doors on the original transmitter could be opened for maintenance access and the front doors and panels on the new transmitter could be opened or removed for installation access. Fig. 6 also gives an appreciation of the reduction in size of the new transmitter units in comparision with the original 15 year old transmitter.

Fig. 7 shows the arrangement at the rear of the original transmitters. The temporary repositioning of the transformers seen to the right of Fig. 7 provided space at the rear of the new transmitters for the new combining units and switching frame. This satisfied the requirement of having the new switching frame close to the area of the old one in order to gain access to the main antenna feeders.

The basment area under the new transmitter was clear of any other air ducting or equipment and no problems were met in locating air blowers directly under the power amplifier cabinets. Fortunately the new positioning allowed for holes to be cut for air ducting and cables without fouling the floor beams. The only spatial problem to arise was that an original set of rigid coaxial feeders passed over the new transmitters and would foul the air cooling ducts above one unit. The location of the feed-

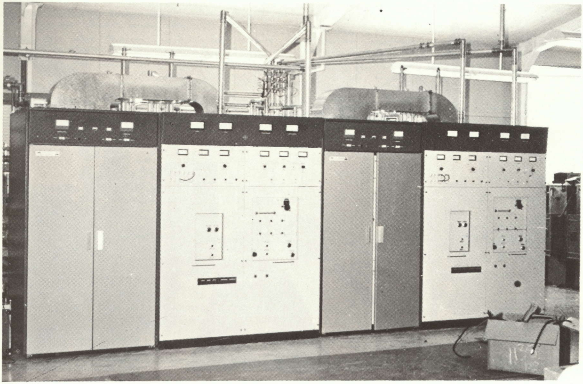

Fig. 7 — Arrangement of Rear of Original Transmitter.

ers can be seen in Figure 7. On closer inspection, it was found that only the bottom pair of feeders would foul the air duct. The bottom two feeders are only used for testing either the sound or vision transmitters into dummy load, without the filterplexer. Consequently removal of the bottom pair, during the final stages of installation, would only reduce the test facilities of the original transmitter for a short period.

Sequence

It was first necessary to clear the area that the new transmitters and associated equipment would finally occupy. A large portion was already clear as can be seen from Figure 7. However it was necessary to relocate the original power supply components away from the area to be occupied by new frames. It was fortunate that most of the original power supply leads were too long and had been folded back in the cable trunking under the floor. This allowed transformers and chokes to be moved without extensive recabling. The rearrangement was carried out after programme hours and the power requirements were checked and tested before programme the following morning.

Holes were cut in the floor prior to the delivery of the transmitter equipment. The floor thickness is 152 mm (6 inches) and diamond drills were employed. The inevitable hidden conduit was hit by the drilling, successfully extinguishing the whole of the basement lighting system.

It was decided that the new transmitter furthest from the original feeders would be installed first. The second one would then be put in position and when the time was reached for air to be supplied to the second unit the two lower feeders would be removed. This sequence provided a margin of safety in that if a failure in the original monochrome transmitter required it to be tested into dummy load, there would be one of the new transmitters that could be put to air with programme while the two test feeders were being replaced.

Transmission

At the correct stage in the installation, it was necessary to connect the new transmitters to the antenna system. The final arrangement was to connect the main external antenna feeders via suitable reducers to the $2\frac{1}{8}$ in. rigid coaxial feeder used from the new switching frame. The mono-

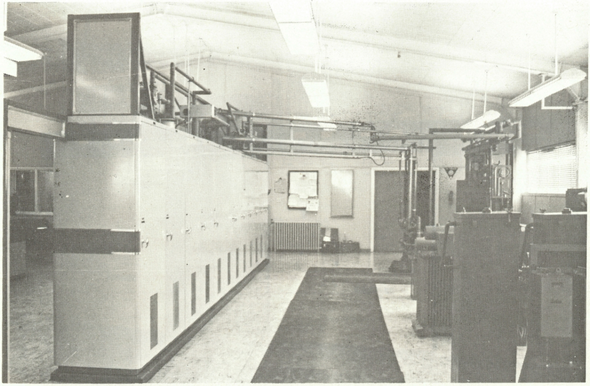

Fig. 8 — New Colour Transmitter at Hobart.

chrome transmitter was connected by $3\frac{1}{8}$ in. rigid feeder to the main external feeder via a switching frame, which contained several electrically operated coaxial switches. This arrangement enabled the output from the monochrome filterplexer to be connected to:

- Dummy Load
- Both halves of the antenna via a power divider.
- Upper antenna only
- Lower antenna only

The new switching frame provides the same facilities but was not brought into full use until the two transmitters had been completely tested and the main antenna feeders connected to the $2\frac{1}{8}$ in. feeder. It was however, advantageous to retain the antenna splitting facilities, in case of a fault. An electrically driven coaxial switch was located in series with the feed from the monochrome filterplexer, for use as a 'change over' switch between the monochrome and colour installations, whilst maintaining full antenna switching flexibility. The main purpose of the changeover facility was to enable the new colour installation, 10kW at first, to be put to air for trade test transmissions of colour test pattern. Normal monochrome programmes were then broadcast using the monochrome transmitter whilst work continued on the new colour transmitters. Finally when the colour installation was complete and the permanent connections made to the antenna feeders, the monochrome installation was removed completely, leaving the final arrangement as shown in Fig. 8.

CONCLUSIONS

The National Television Transmitting Stations have been converted to colour operation by the modification of those items of equipment unable to handle the increased transmission demands of colour signals. If the necessary modifications were expensive or the item was becoming a maintenance liability then the item was replaced. This engineering approach was aimed at providing a colour service in compliance with Australian Standards, at minimum cost. Experience with colour operations is expected to show the areas in which there is an opportunity to improve further the standard of the service in both quality and reliability and to reduce the maintenance costs.

REFERENCES

1. Australian Broadcasting Control Board: 'Technical Standards for the Australian Television Service'; April 1970.
2. Australian Post Office: 'Television Transmitter and Translator Equipment'; Specification 871, Issue 5, January 1972.
3. Bartlett, H. F.: 'The Preparation of Television Transmitting Stations for Colour'; Proc. I.R.E.E. Aust., Vol. 31, No. 9, September 1970.
4. Bartlett, H. F.: 'Design Trends in Television Transmitters'; Proc. I.R.E.E. Aust., Vol. 34, No. 9, October 1973.
5. Ohshima, T., Sakai, T. and Higashi, S.: 'New Series VHF Television Broadcasting Transmitter'; NEC Research and Development No. 20, January 1971.
6. Blair, R. H.: 'Colour Conversion of National Television Plan'; Symposium 'Broadcasting — The New Era', University of Adelaide, August 1974.

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