AUSTRALIAN BROADCASTING CONTROL BOARD

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ENGINEERING SERVICES DIVISION

REPORT No. 37

TITLE: TELEVISION LOCAL OSCILLATOR INTERFERENCE IN THE CHANNEL 1/ CHANNEL 4 SPENCER GULF AREA.

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CONTENTS:

Summary

In areas where television channels 1 and 4 have been jointly allocated, local oscillator radiation from receivers on channel 1 may interfere with receivers tuned to channel 4.

To investigate this problem, a tour of the Spencer Gulf region was made between 26 and 30 May 1975.

Viewer complaints are more numerous in this area than in other 1/4 areas; vertical polarisation, which is suspected as an aggravating factor, is used.

The investigation was directed at gaining data on the mechanism of interference, and an impression of the extent to which it occurs. Receiver installations were examined to see whether improvements could be effected.

A particular goal of the investigation was to determine the extent that local oscillator interference was effectively radiated by the antenna system rather than directly from the receiver chassis, and to evaluate the effectiveness of a solid-state wideband antenna isolating amplifier in reducing interference.

For such an experiment, a simple situation is required where one receiver is the predominant interference source for one other receiver. A number of suitable cases were supplied by the Whyalla District Radio Inspector.

Six cases were fully investigated in Whyalla, two in Port Augusta, and one partly investigated in Port Pirie.

Field intensities, and signal voltages, were measured using a Rohde and Schwarz HFV VHF portable Field intensity meter, and a 300 ohm/50 ohm balun where necessary. All signal voltages quoted in this report have been corrected to a 300 ohm measurement point.

In some cases where the interfering local oscillator signal could not be resolved on the field intensity meter, interference levels were judged subjectively.

CONCLUSION

Interference to reception of channel 4 caused by local oscillator radiation from some receivers tuned to channel 1 is a widespread and disturbing problem in the Spencer Gulf area.

Of eight interference cases fully investigated, six proved to be caused predominantly by radiation from the antenna system of the offending receiver. In these six cases, installation of an antenna isolating amplifier reduced the interference effect to a negligable level. Where the radiating receiver was fed with a sufficiently strong signal voltage, such that a transmission line filter tuned to supress signals around 94 MHz would not noticably degrade reception of channel 4, effective interference reduction could be achieved with this simple device.

Many interference situations are aggravated by poor or unsuitable antenna systems.

Surveying the results of this investigation, it is noticable that Kriesler valve receivers of vintage approximately 5 to 12 years, comprise the majority of offending receivers in the cases seen.

The only fully effective and permanent solution to the 1/4 interference problem is a transmitter channel change. In the Spencer Gulf region, channel 4 could be altered to 3 or 5A; alternatively, channel 1 could be moved to channel 0. Retaining 4, or using 3, would have to be carefull evaluated in the light of FM planning for the region.

On a piecemeal basis, a significant improvement in the interference situation could be accomplished by a campaign of investigation and modification of antenna systems and radiating receivers. By concentrating on the worst cases, initial results should be rapid; further work would follow a law of diminishing return, and the problem is unlikely to ever be entirely eliminated by this approach.

METHOD

After introductions, and admission to each house, an observer is stationed at each receiver; contact is maintained using low power 27 MHz transceivers.

Interference effects are subjectively judged as the radiating set is taken through its fine tuning range. With a fine tuning position giving maximum interference, the antenna is disconnected from the radiating set. If the interference effect disappears (background interference of different frequencies may be present from other local oscillator sources), it is deduced that antenna radiation predominates. Two devices, an isolating amplifier, and a stub filter, are separately connected between the radiating set and antenna and the subjective reduction in interference noted. At the receiver suffering interference, the antenna is disconnected, and the incoming Ch. 4 vision carrier signal voltage is measured. All voltages are corrected to 300 ohm measurement point impedance. If the interfering local oscillator signal can be resolved on the F.I. set it is measured with the radiating set antenna on, and off, and with the isolating amplifier and stub filter in turn connected into the antenna system.

A visual inspection of the antenna systems is made, their position is noted, and the position of receivers within the house is noted. In some cases a field intensity measurement is made in the street outside, 2 metres above ground.

ADDRESS		Offending Set type	Comments on Spacing	Comments on Antenna System	Field Intensity in Street dBu (1uV/m)		Radiation from Antenna ?	Effect of Installing		General Comments
Offender	Complainant				Ch. 1	Ch. 4		Isolating Amplifier	Filter Stub	
WHYALLA										
34 Campbell St.	38 Campbell St.	Kriesler E177 Fineline Deluxe	Antennas 20 m. apart		57	63	YES	-26dB	-17dB	Serious, picture unwatchable. Only very faint interference wit[h] either amplifier or stub.
15 Shulz St.	13 Shulz St.	AWA K9Z Deep Image	attached houses, sets 4m. apart	faulty antenna system at No. 13 giving very low signal	-	59	Chassis -16dB with shield	-	-	severe interference. Reduced to low level when valve shield replaced on tuner osc. tube.
15 Smoker St.	17 and 3 Smoker St.	Kriesler 25T	9m. spacing between antennas at 15, 17	at No. 3, long vertical feeder unbalanced by connection to gutter whip	-	-	YES	No. 17, -17 dB No. 3, -18 dB	-25dB -17dB	cure effected by eithe[r] isolating amplifier or stub.
37 Charles Av.	41 Charles Ave.	Kriesler (11 yrs. old)		interference had been cured by better antenna at No. 37 (yagi)	-	62	YES			
14 Billing St.	12 Billing St.	Kriesler 25	detached houses	No. 12 has new antenna, yagi with coax feeder	-	-	YES	either isolating amp or stub removes interference		interference produced for tests by detuning No. 14.
4 Sly St.	2 Sly St.	Kriesler 25	8 metres between sets	8 metres between ¼ wave gutter whips	66	60	mainly chassis	-	-	can fine tune No. 4 to minimise interference, but residual annoying level remains

ADDRESS: Offender	ADDRESS: Complainant	Offending Set type	Comments on Spacing	Comments on Antenna system	Field Intensity in Street dBu (1uV/m): Ch. 1	Field Intensity in Street dBu (1uV/m): Ch. 4	Radiation from Antenna ?	Effect of Installing: Isolating Amplifier	Effect of Installing: Filter Stub	General Comments
PORT AUGUSTA										
90 Pybus St.	84 Pybus St.	Kriesler 25	Spacing between antennas 90 m.		56	53	YES	removes interference	Removes interference but reduces sig. Ch 4 too much	Severe interference
1 Thelma Cr.	3 Thelma Cr.	Philips early model	detached houses 17 m. between antennas		-	-	YES	no tests done, but removing antenna stops interference, so isolating amp also would		Very severe interference (worst example seen)
PORT PIRIE										
17 Barry St.	14 Barry St.	a new colour set?		both houses using horiz. polarized Adelaide broadside arrays only	77	73				No. 17 not home, so unable to investigate PMG may follow this up.

SOLUTIONS TO THE PROBLEM

Partial or complete solutions to the 1/4 interference problem fall into two broad categories; a solution applied at the receiver end, or a solution at the transmitter end.

1. RECEIVER SOLUTION

With the present policy followed by PMG Interference Inspectors, often little can be done with 1/4 interference complaints. The most common remedy seems to be fine tuning of the radiating set to minimise interference to one particular neighbour. Where neighbours coexist on a friendly basis, they can cooperate and repeat this procedure from time to time as drift occurs. Better antenna systems can be recommended, and if a set fault or maladjustment is suspected, a service overhaul can be reccommended. As these measures cost the viewer money, they are often not followed up.

In practical interference cases investigated, antenna radiation was the predominant interference source (true in 6 of the 8 cases fully investigated). Many of these problems could be alleviated by well designed antenna systems. A typical poor installation consists of a long vertical run of open ribbon to an Adelaide broadside array mounted on a high tower, with the feeder unbalanced by connection to a quarter wave gutter mounted whip on the way. In other cases omnidirectional gutter whips are mounted on neighbouring houses in close proximity. With intelligently located yagi arrays, and coaxial feeder, many of the problems could be minimised. Remaining severe interference cases could often be cleared by use of an isolating antenna amplifier, or in cases where the radiating receiver is obtaining a stronger than adequate channel 4 signal, by a simple fixed tuned antenna filter. Such devices should be permanently installed within the set, rather than hung on the back where they can easily be tampered with.

Of the remaining interference cases, the radiating set would have to be serviced, possibly modified to reduce chassis radiation (see Appendix 3), or in extreme cases, completely replaced.

This approach would require teams of at least two officers with fairly wide policy and financial powers. New antenna systems, isolating amplifiers or filters, set modifications, and subsidies to replace badly offending receivers, would have to be financed from government funds.

The extent of the interference problem is far greater than indicated by the number and distribution of complaints. Many people tolerate interference, particularly of an intermittant nature, without complaint either because of their temperament or through ignorance of the avenues of complaint available. When the District Radio Inspector took up office in Whyalla, and his presence became known, the number of complaints from this town grew.

Even after these measures had been carried out (and to do a thorough job each town in the region would have to be canvassed virtually on a door to door basis), a low level background interference is likely to persist.

From our investigations, we formed the impression that the majority of sets in use are old enough to use valve tuners. With the long term replacement of this generation of receivers with more modern designs using solid state tuners (assuming these follow the pattern revealed in laboratory tests of having significantly lower local oscillator radiation than earlier valve sets) it would be expected that 1/4 interference problems may largely disappear. Several mitigating factors should be kept in mind; replacement of valve receivers will take many years to complete, the likely intrusion of european sets with 38.9 MHz IF may negate the lower levels of radiation, and with colour sets the possibility of minimising interference by fine tuning adjustment will be lost.

The receiver solution does have an advantage over all other approaches. Although it is unlikely to ever completely eliminate the problem, it is a measure which can be implemented progressively, on a scale dependant on the funding commitment. Undoubtedly, even limited work to locate and treat the most severe cases would produce considerable interference relief, while further work would follow some law of diminishing return.

2. TRANSMITTER SOLUTIONS

2.1 FREQUENCY OFFSET

Either Ch 1. or Ch 4 could be altered in frequency by a large offset of 0.5 to 1 MHz. Supposing Ch 1. was lowered in frequency by this order. Based on CCIR protection ratio curves, sets with IF's of 36.5 to 36.875 MHz are on a steep section of the curve, which has a slope of about 50dB/MHz. Thus lowering the frequency of Ch 1. by 0.5 MHz might be expected to reduce the interference by about 25dB.* This change would require retuning of the transmitter antenna, and retuning or replacement of the filterplexer.

In practice such an offset would possibly offer only a partial solution. No improvement at all occurs where sets having 38.9 MHz IF are involved. And with old sets the IF may have drifted considerably, or the sets may be used with the fine tuning away from the nominally correct setting (many fine tuning controls cover several MHz). In most of the worst interference cases we investigated, the local oscillator frequency of the offending set was very close to the Ch. 4 vision carrier.

A frequency offset would certainly improve the situation, but it is doubtful if the improvement would justify the cost. And as a matter of policy, such a large offset may be undesirable.

* Experimental work carried out by Dixon and Pierson indicates that with typical Australian receivers the slope of the protection ratio curve is not so favourable, suggesting a reduction of interference of only 4 to 7dB for a 0.5 MHz offset.

2.2 TRANSLATORS

Introduction of translators in the major Spencer Gulf towns would virtually eliminate the 1/4 interference problem. Pockets may remain outside the areas they serve where interference problems could exist. A translator at Cowall, installed because of the low field intensity in this town, changes channel 1 to 6, and 4 to 8. Consequently no 1/4 problem exists.

However, field intensitites in Whyalla, and probably in most parts of Port Augusta, and certainly in Port Pirie, are adequate, so translators would be difficult to justify on a lack of signal strength basis; elimination of 1/4 interference would have to be the basis for translator establishment.

Creation of a network of translators around Spencer Gulf may be wasteful of channels and difficult without interfering with direct reception of Adelaide channels, so prized by many country people, and would leave little remaining area to be served by the primary station.

A 1/4 problem exists even in Port Pirie, in spite of high signal strengths, because unsuitable antenna systems are in widespread use.

2.3 TRANSMITTER - CHANNEL CHANGE

Allocation of channels 1 and 4 in the same area has proved to be a bad choice. The most permanent and satisfactory way to eliminate the interference problems this has resulted in, in fact the only practical way to completely eliminate these problems, is to change one channel. As channel 4 lies within the FM band, it is preferable to move 4 rather than 1.

A new transmitting antenna would be required, and there may be problems wit the cross section of the tower being too large, although this does not imply that the whole tower need be replaced.

The channel change would have to be heavily subsidised, if not entirely financed, from government funds. If a channel change occured, the opportunity could be taken to double the effective radiated power of GTS, to bring it into line with the national station. GTS presently requires a new filterplexer, so this is one portion of the cost which could be met by the station. Other more minor expenses would also arise, such as changes to the translator at Cowell, advertising the change, and possibly compensation to GTS for loss of revenue if they were off the air during a changeover period.

If channel reallocation occured, either because a high power station change channel or because translators are introduced, new receiving antennas would be required for optimum reception, involving viewer expense.. Simple compromise antennas such as the gutter whip, which comprise one half to two thirds of all systems in Whyalla, would work on other channels. Many people with yagis may find reception adequate without a change; however some viewers would face the cost of a new antenna.

If channel 5A is chosen, further costs for modification of sets not tuning this channel will occur.

CHANNEL AVAILABILITY

Please see Appendix 4.

Channels available to relocate GTS-4 are limited, largely by the restriction that channels adjacent to those used in Adelaide are unavailable. Spencer Gulf viewers have a large investment in elaborate antenna systems directed at Adelaide.

Any removal of the option of occasionally, under favourable conditions, being able to watch Adelaide channels would precipitate a public outcry.

This restricts the choice to channels 3, 5*or 5A. A move to 3 or 5 would not require any alteration to receiving antenna systems or receivers, whereas if 5A was used, some viewers would incur expense for antenna/receiver modifications.

Use of channels 3 or 5 would have to be coordinated carefully with planning of the FM service. Use of these channels cancels the advantage of moving GTS-4 from the FM band: consequently consideration could be given to moving ABNS-1, which could probably be shifted to Channel 0. This has the added advantage of keeping the change in a government operated area.

COST OF SOLUTIONS:

No cost estimates of the various solutions proposed can be made without considerable additional research, outside the scope of this report.

Channel reallocation of one of the high power stations, advocated as the most effective and complete, and probably the quickest solutuion, is believed to be also the most expensive.

Establishment of several translators is likely to be of the same order of cost as the receiver solution; both these apprcaches have disadvantages already discussed.

* Interference to channel 5 by local cscillator radiation of receivers tuned to channel 2 could make 5 an unwise choice.

Acknowledgements:

Mr. G.P. Whitfield, A.B.C.B. State Engineer in Adelaide, organised preliminary arrangements for the trip, and liason with the PMG Department Radio Section. The Adelaide office provided a vehicle and the helpful assistance of Mr. M. Mazzie, Engineer Class 2. Mr. A. Jordan, Technical officer Grade 2, Regulatory and Licensing Subsection, Radio Section PMG Department, Adelaide, travelled to the area in a separate vehicle and provided cheerful help in the investigations. At Whyalla, Mr. J. Parry, the District Radio Inspector, provided suitable cases for investigation over the whole Spencer Gulf region, and was generally most cooperative and helpful.

Mr. E. Downing, Manager GTS4, took an interest in our work, and is to be thanked for running the GTS-4 transmitter with test pattern and music during the day for the duration of our experiments.

APPENDIX I

26 May WHYALLA

8.25 pm FORESHORE MOTEL

Measured incoming signal on 300 ohm ribbon:

95.25 MHz Channel 4 Vision Carrier 69.2 dBu (2.9mV)

Local Oscillator Interference 93.8 MHz 64.7 dBu (1.7mV)

94.3 MHz 34.7 dBu (54uv)

Another strong local oscillator signal was observed on the F.I. set, but disappeared before a quantitative measurement could be taken.

Picture impairment: noticable and annoying. Unwatchable on some fine tune settings.

27 May WHYALLA WEST. Campbell Street

Field Intensity in the street, 2 metre above ground

Ch 4 Vision 63.5 dBu (rel 1uV/m) 1.5mV/m

Ch 1 Vision 56.6 dBu 680uV/m

Complainant:

No. 38 Antenna: quarter wave whip on gutter

TV Set : Thorn 7209 (valve tuner)

Also complaints from several neighbouring houses

Offender:

No. 34 Antenna: Yagi, about 20 metre distant from No. 38's antenna

TV Set : Kriesler "Fineline Deluxe" E177 approx. 5 years old.

The interference was serious at No. 38, picture unwatchable behind high contrast interference pattern, when No. 34 tuned for best picture on Ch. 1.

At No. 34, voltages on 300 ohm ribbon:

Ch 4 vision 60.7 dBu (1.1mV)

93.8 MHz Local oscillator Signal 52.7 dBu (430uV)

Note that the fine tuning at No. 34 had to be altered somewhat to move the local oscillator signal sufficiently away from the vision carrier to make it resolvable on the FI set (120 kHz bandwidth). The general technique involved in most cases investigated was to move the local oscillator signal sufficiently away from the vision carrier to be resolvable (if it wasn't already, with the radiating set tuned to the best picture on Ch. 1) and leave it at this setting to measure quantitative effects of experiments at the radiating set. Then the experiments would be repeated, adjusting the fine tuning of the radiating set over its full range each time and observing the subjective effect on the Ch 4 picture at the complainant's house.

With the isolating amplifier connected at No. 34

Local osc. signal 26.7 dBu (22uV). Only very faint interference visible.

With 10dB paid connected at No. 34,

Local osc. signal 46.2 dBu (210uV). Picture considerably improved, now watchable but with some interference still visible.

Comments: the "10dB" pad has made a reduction of 6.5dB: This relatively small reduction caused a disproportionate improvement in picture watchability.

With approximately a quarter wave open circuited 300 ohm ribbon stub (26½" long) connected across antenna terminals at No. 34,

Local osc. signal 35.7 dBu (61 uV) picture quality quite good, only faintly noticable interference with No. 34 tuned for best picture on Ch. 1.

Measuring the incoming voltage at No. 34 antenna lead-in,

Ch. 4 vision 74.7 dBu (5.2mV)

With the stub attached, although it is a slightly altered physical situation from when the stub was on the TV set, we get:

Ch 4. vision (with stub) 59.7 dBu (970 uV)

this is a reduction in signal strength of 15dB. However because of the high signal strength initially, the stub causes no noticable picture deterioration on Ch. 4 at No. 34.

SUMMARY

		Difference from 52.7 dBu	
Incoming sign. at No. 34	60.7 dBu		
Local osc. interference	52.7 dBu		Bad Interference,
Local osc. - isolating map	26.7 dBu	26 dB	Good picture - faint interference.
- 10dB pad	46.2 dBu	6.5 dB	Watchable - some interference.
Quarter wave Stub	35.7 dBu	17 dB	Good picture, faint interference.

CONCLUSION

In this situation, where the offending set had a good antenna installation giving a strong incoming signal, a stub filter provided sufficient attenuation of local oscillator interference to virtually cure the problem, without noticably degrading the reception of Ch 4 at the offending set.

The isolating amplifier also provided a solution. The stub filter was left in place at No. 34.

27 May. WHYALLA (North West) Shulz Street

Field Intensity in Street, 2m above ground:

Ch 4 Vision 58.5 dBu (840 uV/m)

Ch 1 Vision - not measured.

Complainant:

No. 13 Antenna - Yagi, long lead in (see further comments later)

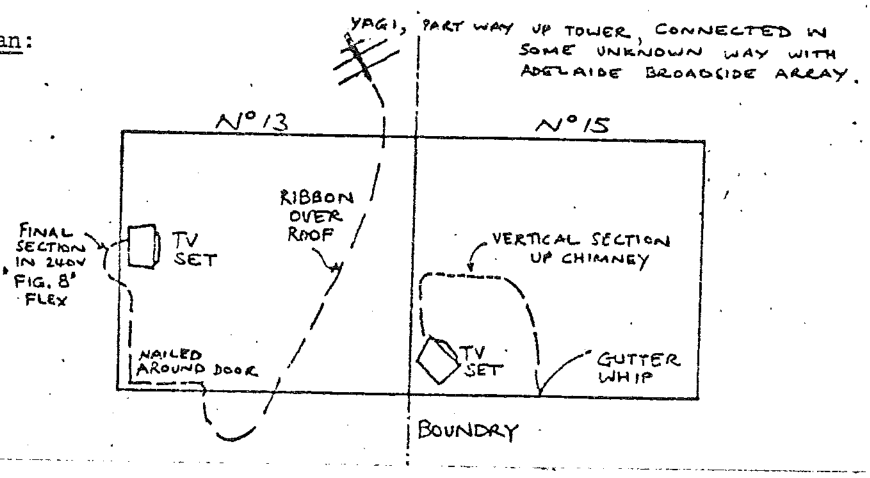
TV Set - AWA Radiola Deep Image Model P2Z

Offender:

No. 15 Antenna - quarter wave whip on gutter

TV Set - AWA Deep Image K9Z. Valve tuner, no shields on tuner tubes.

Sketch Plan:



Antenna Installation No. 13

The antenna installation is worthy of some comment, as it considerably added to or perhaps completely caused much of the complainants trouble.

Outside the rear door, a 50 ft. tower supporting a broadside array pointing at Adelaide (these systems are common in the Spencer Gulf area), also served to support the local channel yagi, mounted part way up the tower. Ribbons from the array and the yagi were inteconnected in some unknown way, giving a single ribbon lead in to the house. This passed over the whole roof and entered in around the top of the front door. The ribbon was nailed down the length of the architrave, and ran along the floor to the TV set, the final 2 metres being in "figure-8" mains flex.

The incoming signal level measured at the TV set was very low, indicating a fault in the antenna system. The incoming ribbon measured open-circuit, although the yagi included a folded dipole. Finally, it should be noted that the very long incoming ribbon (which was probably open circuited somewhere) almost formed a large loop around the adjacent radiating st.

Nos. 13 and 15 Shulz Street comprise a "duplex" Housing Trust house. The plan on each side of the party wall is a mirror image, so neighbouring TV sets are in effect in adjacent rooms; in some cases back to back separated by only a brick wass.

Severe interference was noted at No. 13. This did not reduce noticably with the antenna at No. 15 disconnected - a case of direct chassis radiation.

Incoming signal voltage at No. 13

Ch. 4 vision 44.7 dBu (173 uV)

- this low signal because of an antenna/feeder fault.

Local osc. interference at No. 13:

93.8 MHZ { antenna on at No. 15; 38.7 dBu (86 uV)
antenna disconnected No. 15; 32.7 dBu (43 uV)

It was possible to adjust the fine tuning at No. 15 to give an acceptable picture there on Ch. 1, whilst minimising the interference at No. 13 to a tolerable level.

With a PMG owned AWA P6 portable TV set operating on its own whip antenna, placed next to the existing TV set in No. 15, no interference was evident with the AWA P6 correctly tuned to Ch 1. However, with the P6 grossly mistuned such that it was unwatchable on Ch. 1, it was possible to produce some interference bars at No. 13.

28th May.

The follow up to this case is interesting. Although it is not normal PMG policy to take the back off TV sets, we returned to Shulz Street with an assortment of valve shields. On this second visit, measuring the local oscillator interference at the icoming antenna lead of No. 13 gave:

94.3 MHz. Local osc. interference 41.7 dBu(122u Volt)

With the owner's permission, valve shields were fitted to the tuner tubes at No. 15.

This reduced the local oscillator interference to 25.7 dBu (19.2 uV), a reduction of 16dB.

Although faint interference was visible at No. 13, fitting valve shields at No. 15 had reduced the problem to the level where a quite tolerable picture was obtained at No. 13, irrespective of the fine tuning setting at No. 15. However, we adjusted the fine tuning at No. 15 to minimise the remaining slight interference. As the adjustment was at the rear of the set, and the owner was an elderly man, it seems probable that the fine setting will stay unaltered.

No. 13 still suffered a noisy picture because of the faulty antenna installation, and we tried to explain this to the occupant.

This case was interesting, as it existed because of two abnormal conditions -

(i) faulty antenna installation at No. 13 giving a very low incoming signal voltage and having a very long (and possibly open circuit and hence unbalanced) feeder ribbon forming a physical loop around the vicinity of the radiating set.

(ii) lack of valve shields on the tuner tubes in the offending set. It is very important that the oscillator tube be well shielded in valve tuners.

Correcting either one of these conditions would have produced a cure. We corrected (ii), and advised the occupant at No. 13 to improve (i).

27th May <u>WHYALLA</u> Smoker Street

No. 15, 17 and No. 3

No. 15 was causing interference to the other half of the duplex property, No. 17. There was also a complaint from No. 3, more than a block away down the street. Presumably the intervening neighbours were also experiencing some degree of interference from No. 15, but had not lodged complaints.

Field Strength is Street - not measured.

Complainants:

No. 17 Antenna: Yagi mounted part way up Adelaide mast

TV Set : Healing 24 "Colorado" - valve tuner

No. 3 Antenna: Quarter wave gutter whip, connected in parallel with Adelaide mast. Long unbalanced ribbon to Adelaide mast.

TV Set : not noted. However there was a valve console, and a more modern 12" portable in use.

Offender:

No. 15 Antenna: Yagi mounted on roof. About 9 metres from antenna at No. 17.

TV Set : Kriesler 25T valve tuner (shields intact) about 10" ribbon in back of set.

Measuring incoming signal voltages on the antenna lead in at No. 17 gave:

Ch. 4 vision carrier 64 dBu (1.6 mV)

Local osc. signal 93.9 MHz 48 to 53 dBu (250 to 420 uV) flucuating somewhat.

Removing antenna lead at No. 15

Local osc. signal 23 dBu (14 uV)

Putting the isolating amp in circuit at No. 15, with about 14" of connecting ribbon to set,

Local osc. signal: 33dBu (27 uV)

With a 26½" open circuit stub at No. 15

Local osc. signal: 25dBu (18uV)

In this case either the isolating amplifier or the stub produced sufficient reduction in interference to constitute a cure.

Measuring the incoming signal voltages on the antenna lead in at No. 3:

Ch. 4 Vision carrier 58 dBu (800 uV)

Local osc. signal 94.2 MHz 45 to 46 dBu (180 uV)

With antenna disconnected at No. 15

Local osc. signal 24dBu (16 uV)

With set at No. 15 on another channel

Local osc. signal 24 dBu (thus this is the noise level)

With isolating amp at No. 15,

Local osc. signal 24dBu (16 uV)

With stub at No. 15,

Local osc. signal 29 dBu (28 uV)

It will be noticed that the stub appears more effective than the isolating amplifier as far as No. 17 is concerned, whereas the reverse is indicated at the more distant house No. 3. However, either measure is quite effective, and reduces the interference to a minor level, comparable with the general background of interference from other sets.

As the stub caused no noticable degradation to the Ch 4 picture at No. 15, it was left permanently in place.

No. 15 TV set was fine tuned on Ch. 1 with the stub in place to minimise the small amount of interference still observable at No. 17.

28 May WHYALLA Charles Avenue (approximately midway between Davies and Opie Streets)

This location is on the NW extremity of the town, and is hidden from Spencer Gulf by the water supply reserve hill. It was selected because we expected it to be one of the poorer reception areas in the town. However, a field intensity measurement in the street showed that the signal strength in this area was comparable with values measured in the other parts of Whyalla we had visited.

Field Intensity in street, 2m. above ground:

Ch. 4 vision: 61.5 dBu (1.2 mV/m)

Past History

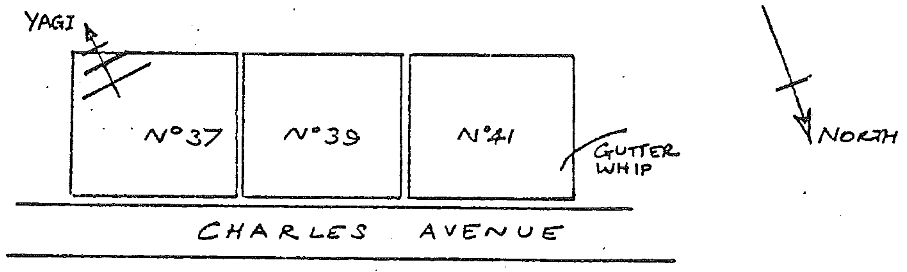
No. 37 had been causing interference to No. 41 and several other neighbours This problem was cured when No. 37 had the TV set serviced and a Yagi antenna installed, pointing away from No. 41 who is using a quarter wave whip.

No. 37: Antenna: Yagi at rear of house

TV Set : Kriesler (approx.) 1964 valve model

No. 41 Antenna: quarter wave gutter mounted whip

TV Set : AWA valve model



At No. 41 the incoming signal voltage on the antenna ribbon is:

Ch. 4 vision 54dBu (450 uV)

A weak local oscillator signal originating at No. 36 could be detected at No. 41. but the level was too low to cause any appreciable inteference, and too low to experiment with.

Other interference complaints in Charles Avenue which we attempted to investigate were:

No. 21, interfering with No. 23 No. 21 not at home.

No. 119, intefering with No. 117, No. 117 not home.

28th May Other unsuccessful visits we made on this day were;

No. 6 Pattinson Close, interfering with No. 8

No. 6 would not allow us to enter the premises

No. 23 Burns Street, interfering with No. 27,

No. 23 not at home.

On the afternoon of 28th May, we travelled to Cowell, 67 miles south of Whyalla. This is a low signal strength area for channels 1 and 4, and is now served by a local translator, translating Ch 1 to 6 and 4 to 8. Consequently the 1/4 interference problem does not now exist in Cowell.

Our visit was at Mr. G. Whitfield's instigation. At the local telephone exchange a number of TV sets were available for experiment, ranging from modern solid state colour sets to old valve receivers with high local oscillator radiation.

A National CP2000 colour set was set up running from an outside antenna via coaxial cable, and tuned to Channel 4.

Incoming signal voltage (in 300 ohm) was:
Ch 4 vision 50dBu (320 uV)

With a Philips valve receiver (23CT 7/213) spaced 2½ metres away, tuned to Ch 1 and with no antenna connected, considerable interference was produced on the National Set. Touching the diecast knob on the Philips tuner considerably increased this interference level, indicating that the Philips tuner chassis was "hot".

Using a table about 4 metres away from the TV sets, the F.I. meter was set up to measure local oscillator radiation from the Philips set.

At 95.2 MHz, values measured were:

38dBu,

61dBu, with a 2 metre wire clipped to the tuner knob, and trailed along the floor.

Removing the Philips tuner, RF filters were installed on all supply leads and the AGC lead. These filters consist of 2 or 3 ferrite beads (2 to 3 uH) slipped over the lead, and a ceramic or mylar bypass (.0047uf) to chassis on the side of the inductance away from the tuner. As no earth strap was evident between the tuner chassis and the main chassis, a piece of hookup wine about 25 cm long was added to interconnect the metalwork.

With these modifications the tuner was refitted to the cabinet and local oscillator radiation remeasured, giving:

47 dBu,

61 dBu with 2 metre clip lead.

Surprisingly, the local oscillator radiation has increased. Cutting the earth lead between tuner and main chassis leaves the value measured with the 2 metre clip lead connected unaltered, but reduced the figure with no clip lead to:

earth strap cut, no clip lead: 29dBu.

At this point it was noticed that the above figure was varying by about 10dB depending on the location of personnel working in the exchange.

In this case, RF bypassing seems ineffective, probably because local oscillator radiation is dominated by the tuner chassis being at an RF potential. Leaving the whole experiment at this rather inconclusive stage, we had to return to Whyalla (to fit valve shields at No. 15 Shulz Street - described earlier).

28 May (Evening) WHYALLA Billing Street,
- central suburban part of Whyalla

No. 12 receiving interference from No. 14. These are detached houses, separated by a driveway. Originally No. 12 had an antenna on the chimmney closest to No. 14.

Now No. 12 has a new Rank Arena 22 Colour Set, and a new antenna installation, with a Yagi mounted on the rear corner of the roof (the furthest corner from No. 14) and a coaxial lead in. This antenna installation has virtually solved the problem, and it is only by detuning the set at No. 14 to the extent that Ch. 1 is unacceptable that interference becomes evident at No. 12. No 14 also has a yagi antenna, with ribbon feeder.

The spacing between the yagis is about 13 metres.

The interference producing set at No. 14 was a Kriesler 25 valve set, 4 to 5 years old.

At No. 12, the incoming signal voltage on the antenna lead was:

Ch. 4 vision (in 300 ohm) 61dBu (1.1mV)

Setting the fine tuning at No. 14 to produce interference at No. 12, we were unable to locate the local oscillator signal on the F.I. set, so had to limit the experiment to subjective evaluation.

Disconnecting the antenna from the set at No. 14 removes almost all the interference. At some fine tune positions very faint interference bars are still visible.

A quarter wave open circuit ribbon stub produces about the same subjective effect as the isolating amplifier; that is, almost all the interference is removed except for faint traces at some fine tuning settings. However, in this case, the stub noticably degreades the Ch. 4 picture at No. 14.

Before we left No. 14, fine tuning on Ch. 1 was adjusted to produce no perceptible interference at No. 12.

SLY STREET

No. 2 and 4. Called at these houses. One occupant in bed, so we arranged to call the following day.

29 May WHYALLA Sly Street,
Central suburban area.

No. 2 and No. 4

These houses are two halves of a Housing Trust duplex house.

Complainant:

No. 2 Antenna: quarter wave gutter mounted whip
TV Set : Thorn valve set.

Offender:

No. 4 Antenna: quarter wave gutter mounted whip

TV Set : Kriesler 25 valve set.

Both antennas were mounted on the gutter above the living rooms windows in the front of the house, with about 8 metres spacing between them. The TV sets were located in the front living rooms, but not back to back. Separation between sets was approx. 8 metres also.

Signal Intensity in Sly Street, 2 metres above ground:

Ch 4 vision: 60dBu (1mV/metre)

Ch 1 vision: 66dBu (2mV/metre)

Incoming signal voltage on the antenna lead at No. 2 was:

Ch. 4 vision 65dBu (1.8mV)

Whereas at No. 4 (the offender), where the antenna installation is apparently very similar to No. 2, the incoming signal voltage on Ch. 4 was:

Ch. 4 vision 44dBu (160 uV)

Obviously the antenna installation is faulty, and the Ch. 4 picture was poor; noisy and of low contrast.

Disconnecting the antenna at No. 4 causes the bad interference at No. 2 to reduce somewhat, but it is still unacceptable, suggesting that chassis radiation is significant in this case. Consequently with either the isolating amplifier or a stub filter moderate interference still exists.

Fine tuning the set at No. 4 to minimise interference at No. 2 helps, but the residual interference is still evident; we had to leave this unsatisfactory situation in existence.

In the above case the local oscillator radiation could not be resolved on the F.I. Set, so we were limited to a subjective evaluation.

WHYALLA Thorn Model 9064 Colour TV Set

The radio inspector at Whyalla has investigated a case where a new colour set (Thorn 26" model 9064) installed at No. 20 Panter Street is causing local oscillator interference to a neighbouring set at No. 18. These two houses are attached, and evidently the sets are positioned in close proximity, on opposite sides of a brick wall. He suspects that interference is also being caused to No. 22. The investigation has been hampered by the uncooperative attitude of the owner of the colour set; she has threatened the radio inspector with legal action.

Consequently we did not attempt to investigate this case. Subsequent enquiries to AWA/Thorn reveal that this model is locally manufactured and has the standard 36.875 MHz IF. It uses a Matsushita transistor turret tuner (model ENT6752 EB or possibly ENT6751EB).

We have previously made measurements on a ENT6751EB tuner at head office, and it appeared not conspicuously worse than other solid state turret tuners.

29 May WHYALLA MT. LAURA Altitude 579 feet.

Mt. Laura is a prominant high point north west of Whyalla, about 7km direct line distance from the central parts of Whyalla. There is a road to the top (blocked for the last section by a locked gate), and a building and radio masts on the summit.

Should a TV translator ever be planned for Whyalla, Mt. Laura is the obvious location.

I walked to the top of Mt. Laura, with the F.I. set. Measuring field intensity about 2m. above the ground level, but at the edge of the escarpment overlooking Whyalla, gave:

Ch. 1	vision	86 to 88 dBu	(20 to 25 mV/m)
Ch. 4	vision	76 to 78 dBu	(2 to 2.5 mV/m)

The levels appear adequately high for good quality off-air reception.

29 May PORT AUGUSTA

We arrived at Port Augusta in mid-afternoon.

Very few interference complaints are received from Port Augusts. Contributing reasons are (i) lack of a resident radio interference inspector, and (ii) house styles most houses are detached, and the incidence of the duplex house design is lower than in Whyalla. Otherwise, from our brief experience there, the interference problem seems to be potentially quite bad. Both cases wer looked at involved whole sections of streets receiving interference, and in one case the interference was the most severe case we observed on the whole tour.

PYBUS STREET

Complainant:

No. 84 Antenna: roof mounted yagi, ribbon feeder connecting two outlets parallel wired.

TV Set : Healing "Las Vagas" 25 valve receiver

Offender:

No. 90 Antenna: Quarter wave gutter mounted whip

TV Set ; Kriesler 25 (approx. 9 years old) valve receiver

The spacing between antennas at No. 90 and No. 84 is about 90 metres.

Other houses in the vicinity also suffer interference.

Signal strengths in street:

(outside No. 90)

Ch. 4 vision: 53 dBu (440 uV/metre)

Ch. 1 vision: 55 to 57 dBu (560 to 700 uV/metre)

With the F.I. set connected directly to the antenna terminals of the Kriesler at No. 90, the local oscillator voltage (in 300 ohm) was approximately 78 dBu (8mV) over the fine tuning range, 92 to 96 MHz.

However, at No. 84, it was difficult to resolve the local oscillator signal from No. 90. Several other weak local oscillator signals were found, but the visible interference was originating at No. 90, confirmed by switching channels there.

Removing the antenna from the set at No. 90, or fitting a stub filter, or installing an isolating amplifier, all removed any visible interference at No. 84, leaving only a faint background of interference bars originating from other unknown sources. At this time of the afternoon Ch. 1 was showing "Sesame Street", whereas Ch. 4 was transmitting a test pattern (at our request) so it would be expected that a large number of sets would be in use on Ch. 1.

Later, with the antenna back on the set at No. 90, interference at No. 84 was less objectionable than initially. We formed the impression that the high level of local oscillator radiation from the set at No. 90 was an intermittant condition.

29 May. In the evening we returned to Pybus Street. Now there was no evidence of local oscillator interference to TV pictures, although several strong local oscillator signals were measured in the street.

Wandering up and down the street with the F.I. set, we localised a signal from a house approximately opposite No. 92, on 94.3 MHz and of about the same strength as the Ch. 4 Vision carrier, measured in the middle of the street. We verified that this house was using a TV set on Ch 1 (an HMV 25 valve set) and that this was the source of the

94.3 MHz signal.

Another house, several houses along from No. 84 (probably No. 75 or 78) was also radiating a strong signal at approx. 94 MHz but we did not verify this.

However, as no subjective interference was visible in spite of the presence of these strong local oscillator signals, there was nothing further that we could do.

Other complaints had been reported from Nos. 11, 12 Collings Street, which runs into Pybus Street about a block from No. 90. Possibly these houses can be included with the Pybus Street problems, although we did not have time to investigate Collings Street.

Thelma Cresent No. 1 and No. 3

29 May.

This was a new complaint, previously uninvestigated.

Using the narrowband (30kHz) VHF receiver mounted in the PMG vehicle, and slowly driving along the street, the radiating receiver was located. The local oscillator frequency was close to the vision carrier and could not be resolved on the F.I. set.

Complainant:

No. 3 Antenna: quarter wave gutter whip

TV Set : not noted

Offender:

No. 1 Antenna: quarter wave gutter whip

TV Set : Old model Philips valve set.

The houses are both detached brick structures on typical suburban size blocks. Spacing between antennas is about 17 metres.

No. 3 was experiencing very severe interference, the worst example we observed on the whole tour. The picture was completely obliterated by solid high contrast bars. Altering the fine tuning setting at No. 1 reduced the interference at some points, although at all settings the picture at No. 3 was unwatchable.

Removing the antenna from No. 1 removed virtually all the interference. As the occupant at No. 1 was about to retire for the night we could not pursue the experiment further. In this situation an isolating amplifier would be expected to perform well.

Although we would have liked to return the following morning, the occupant at

No. 1 was going out, and no mutually suitable time could be arranged before we were due to return to Adelaide.

Because of the severity of the interference in this case, it seems likely that other sets in the vicinity would also be affected.

30 May PORT PIRIE Barry Street, midway between Lydeanorf and Hutchinson Streets, (South-western portion of town)

Signal strengths in street (2 metres above ground)

Ch 4 vision	73 dBu	(4.5 mV/metre)
Ch 1 vision	77 dBu	(7mV/metre)

Complainant:

No. 14 Barry Street:

Antenna: Adelaide broadside array, 4 dual elements, mounted 10 feet above roof apex. Also an indoor horizontal spiral had been tried.

Offender: (alleged)

No. 17 Barry Street:

Antenna: very similar to No. 14, Adelaide broadside array about 10' above roof.

TV Set : a new colour set, according to No. 14.

The occupant at No. 17 was not a home when we called, so we were unable to determine the make or the model of colour set, or even to verify that this was causing interference to No. 14.

Local 1/4 antenna systems seem to be almost nonexistent in Port Pirie.

However the high towers supporting Adelaide broadside arrays (horizontally polarised) which are a feature of the skyline of Spencer Gulf towns, are most prominent in Port Pirie; a forrest of untidy steel. Some of these antenna systems are obviously of recent installation; they are by no means all a relic of the days when Adelaide offered the only signals.

PORT PIRIE:

While in Port Pirie we visited GTS-4 and met with the manager, Mr. Ewan Downing. He explained another aspect of the 1/4 interference problem. Evidently GTS-4 receive many complaints from viewers mistaking local oscillator interference for faulty transmission on Channel 4. These people are often sceptical of explanations by GTS-4 management that the problem lies elsewhere. In many cases poor antenna installations aggravate the problem. So he has an interest in educating viewers, both to explain the nature of 1/4 interference, and to explain the advantages of an effective antenna installation. However he feels that any advertising material for this purpose would have far more impact if authorised by the Australian Broadcasting Control Board, rather than GTS-4, even if it was televised by Channel 4.

Channel 4 labours under a considerable handicap because of this interference problem; in severe cases programs are unwatchable, in many less severe cases there is an annoying background interference effect of variable intensity.

Eventually the ABCB will have to acknowledge that an unwise choice of channels has been made; authorising some explanatory and educational meterial for use by GTS-4 would seem to represent a reasonable initial step.

APPENDIX II

TV ANTENNA ISOLATING AMPLIFIERS

USING HYBRID MICROCIRCUIT OM321

INTRODUCTION

Four amplifiers have been constructed in diecast metal boxes (120 x 60 x 43 mm external) with self contained power supplied. These amplifiers use the Philips type OM321 hybrid, and incorporate baluns to provide balanced 300 ohm input and output.

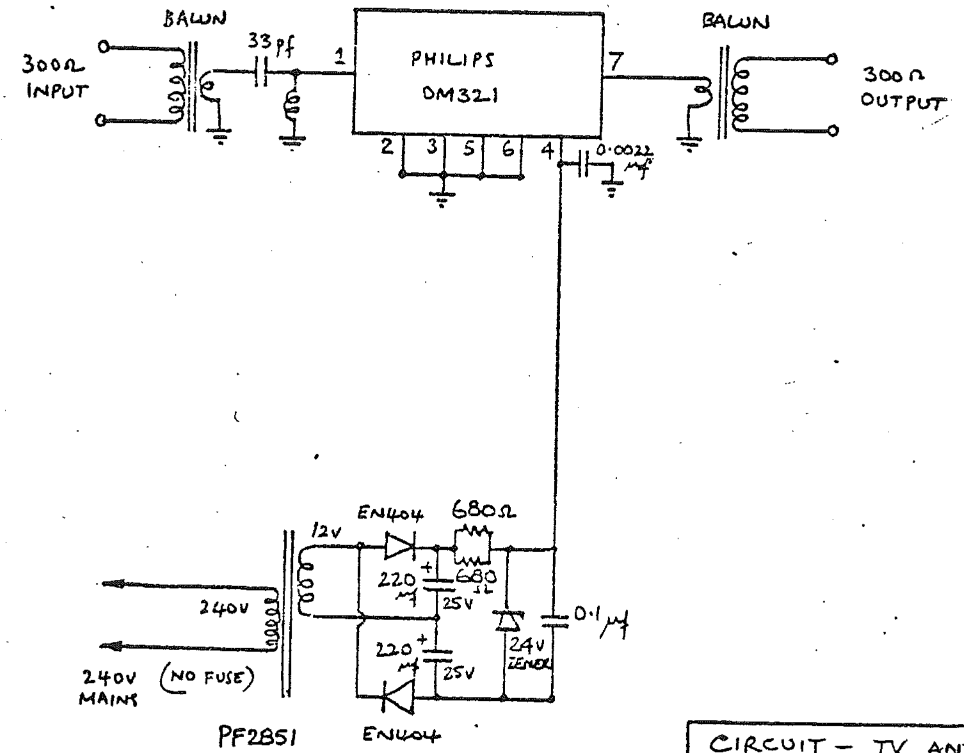
A simple high pass filter is included at the input to roll off the response below the TV band.

The amplifiers may be identified (nos. 1 to 4) by centrepunch marks on the case and lid.

PERFORMANCE

This was measured using, and including two Hatfield 50 ohm/300 ohm baluns.

Amplifier No.	Reverse Gain (dB)		Forward Gain (dB)	
1	100 MHz	-32.2	50 MHz	12.2
			100 MHz	13.3
			200 MHz	13.1
2	50 MHz	-35	50 MHz	13.3
	100 MHz	-32.5	100 MHz	13.5
			200 MHz	13.8
3	100 MHz	-33	50 MHz	12.8
			100 MHz	13.5
			200 MHz	13.1
4	100 MHz	-32	50 MHz	-
			100 MHz	14.5



CIRCUIT – TV ANTENNA ISOLATING AMPLIFIER

APPENDIX 3

REDUCTION OF LOCAL OSCILLATOR RADIATION BY EXPERIMENTAL MODIFICATION OF TV SET TYPE ASTOR "FRINGEMASTER 23" (VALVE)

Introduction

Older model TV receivers employing valve tuners generally produce high levels of local oscillator radiation, with chassis radiation predominating over antenna radiation.

One such receiver was investigated to explore the mechanism of this radiation, and methods by which it may be reduced. All tests were done with the tuner switched to channel 1 only.

Approach and Results:

The Astor "Fringemaster 23", with the hardboard backpanel removed, was mounted on a trolley in the centre of the laboratory floor, and about 3 metres distant from a Singer NM 37/57 EMI/FI set and dipole. The F.I. set was used purely to measure relative radiation valves so the effects of modifications could be gauged.

A dipole antenna connected to the ASTOR produced no detectable increase in local oscillator radiation, so subsequently no antenna was used with the TV set.

Measured local oscillator radiation (L.O.R.) was initially 44dB.

The tuner panel (also containing the loudspeaker, and volume, contrast and brightness controls) was demounted from the cabinet, and swung out to the rear to an accessible position. All leads were long enough to allow this, except for the earth strap which was extended with a clip lead.

With the tuner in this position, L.O.R. increased to 47dB (+3dB).

The valve shield was removed from the oscillator/mixer tube. This caused the L.O.R. to increase by 13dB to 60dB.

Removing the shield from the R.F. tube appeared to have no effect.

A tinplate box with soldered seams was constructed to cover the top of the tuner, i.e. the portion from which the tubes protrude. This box was a push fit over the tuner chassis, and was soldered to the chassis on the three accessible sides for a total of about 30% of the box perimeter.

This had very little effect, reducing L.O.R. by perhaps 1dB, to approximately 46dB.

The next step was to solder small pieces of tinplate over most of the holes and punchouts in the tuner chassis. In addition, the clip-on shield covering the bottom of the tuner chassis was soldered to the chassis along one long edge and in several other spots. This also had very little effect, causing another 1dB reduction to bring the L.O.R. to 45dB.

The tuner in the ASTOR set does not have preset fine tuning, but uses a variable cam shaped dielectric vane which passes between a metal button mounted on the rear of the tuner chassis (and forming part of the oscillator tuned circuit) and an earthed metal bracket.

A tinplate shield, in the form of a shallow box, was constructed to cover the fine tuning capacitor, and was soldered in place. This produced no change in the L.O.R.

It can thus be seen that fairly extensive additional shielding produced no worthwhile improvement for this tuner.

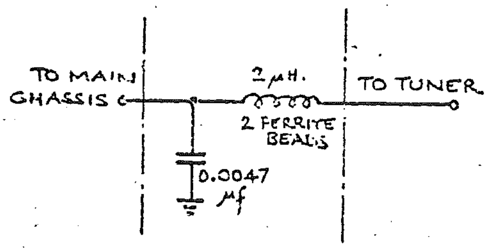
The next move was to look more closely at the connecting leads between the tuner chassis and the main chassis.

The tuner I.F. output is connected to the main chassis by a shielded lead and a coaxial plug. Disconnecting this plug from the main chassis produced no change in L.O.R., showing that no radiation from this source was originating from the main chassis.

The only other connections to the tuner are three flying leads loomed together, carrying high tension (200V), heater voltage (6.3v), and AGC voltage. These are unshielded and connected to the tuner on a small unshielded insulated panel.

Simple RF filters were installed on these three leads, as close as possible to the tuner chassis.

The filters consisted of a 2μH inductance, formed by two ferrite beads, and a 0.0047μf. bypass to the tuner chassis. A mylar capacitor was used for the H.T. bypass; 50v. ceramics were used for the other bypasses.



Filtering the leads in this way produced a marked reduction in L.O.R., by about 15dB.

With a tinplate shield fitted over the filters and the general area where the leads enter the tuner chassis, an additional improvement of about 4dB was obtained.

Installing the tuner chassis back into the cabinet in its proper position produced a further reduction in L.O.R., giving a final figure of: 19 to 22 dB.

When this is compared with the initial L.O.R. value of 44dB, it is seen that the modifications have produced a 22 to 25dB improvement.

Note that in this sort of work, a repeatability of at best ± several dB is all that can be realistically expected. Slight changes in the test environment, e.g. movement of people in the laboratory, limit the resolution available.

As no antenna was connected to the TV set, the question arises as to whether the reduction in chassis radiation would be swamped by radiation from an antenna? On connecting a dipole antenna to the modified set, the radiation decreased by 2 to 11dB depending upon the dipole location in front of or behind the set, and the position of people in the laboratory.

This is interpreted as indicating that radiation from the antenna is less than or comparable in magnitude to that from the modified set chassis.

CONCLUSIONS

By simple modifications to a valve tuner, the local oscillator radiation on channel 1 has been reduced by 20 to 25 dB.

The most significant gain comes from simple (and inexpensive) RF filtering of supply and AGC leads to the tuner, and shielding of their entry point to the tuner.

Additional shielding over the remainder of the tuner provides no worthwhile improvement. However it is important that the shield over the oscillator/mixer tube is properly installed and effective.

Obviously this tuner has not been designed with minimum local oscillator radiation as an objective. At the design stage, several simple and cheap alterations could have been chosen to achieve the 20 to 25 dB lower levels of local oscillator radiation obtained in this investigation.

The precautions necessary are:

1. R.F. bypassing of supply leads and separate shielding of the R.F. filters used. It would probably be wise to run supply leads in shielded cable also, although the effect of this has not been investigated.
2. Somewhat better shielding.

APPENDIX 4

AVAILABILITY OF CHANNELS - Spencer Gulf Area.

Channels already in use for high power transmissions are:

Adelaide: 2, 7, 9, 10

Bluff: 1, 4

Mt. Gamber: 8

And for low power translators:

Cowell: 1 → 6

4 → 8

Port Lincoln: 6 → 3

8 → 5

Channel Spacing (MHz between vision carriers)

	Channel	Spacing to next channel
$ #	0	11
	1	7
Adelaide	2	22
¢	3	9
	4	7
* ¢	5	36
	5A	37
* ¢ #	6	7
Adelaide	7	7
¢ #	8	7
Adelaide	9	13
Adelaide	10	7
#	11	

local osc. (Adelaide 2 → 5)

local osc. (6 → Adelaide 10)

RESTRICTIONS:

\# adjacent channel

$ possible sporadic E

¢ in use for low power translators

* local oscillator radiation

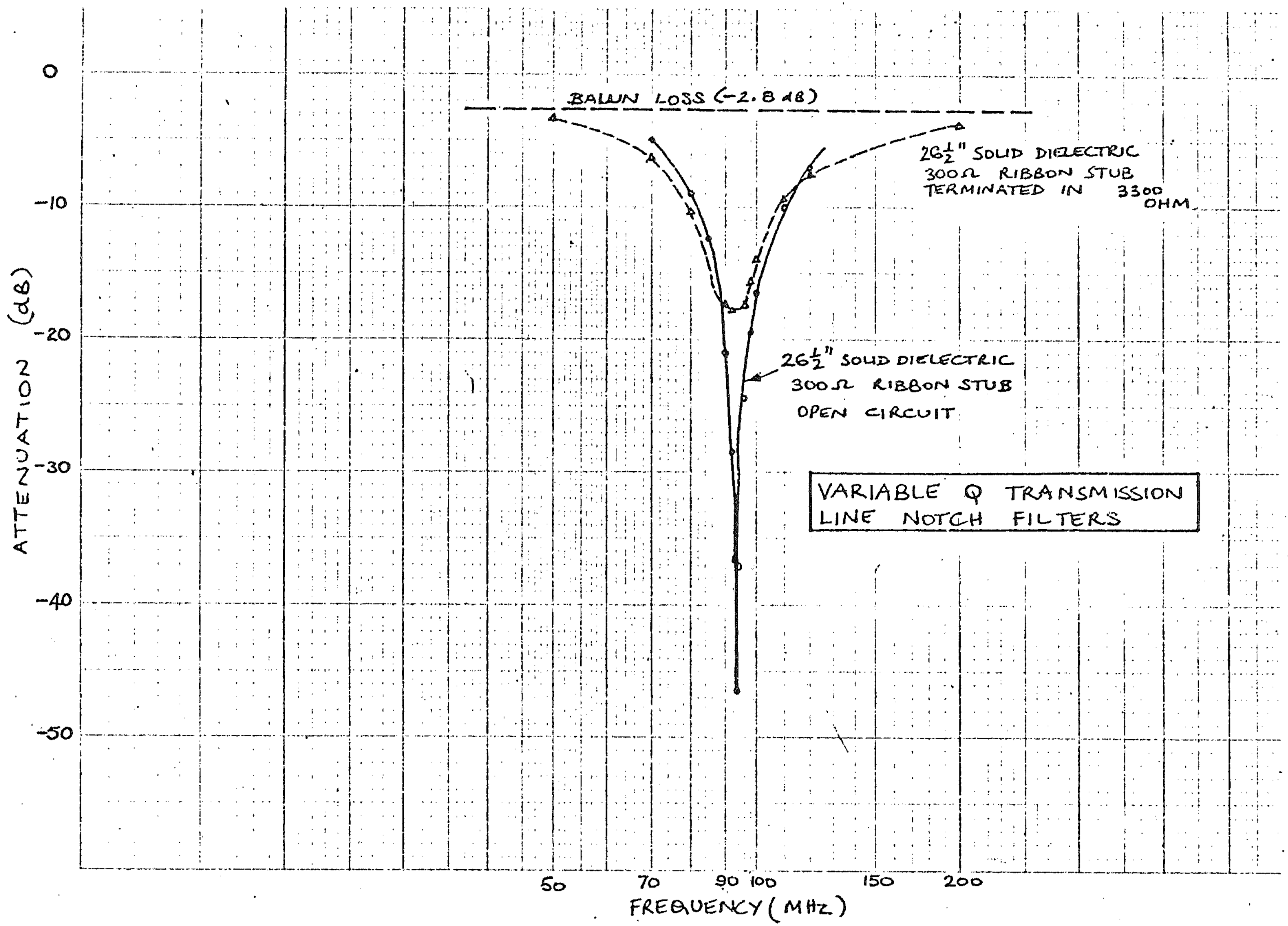
APPENDIX 5

VARIABLE Q TRANSMISSION LINE NOTCH FILTERS:

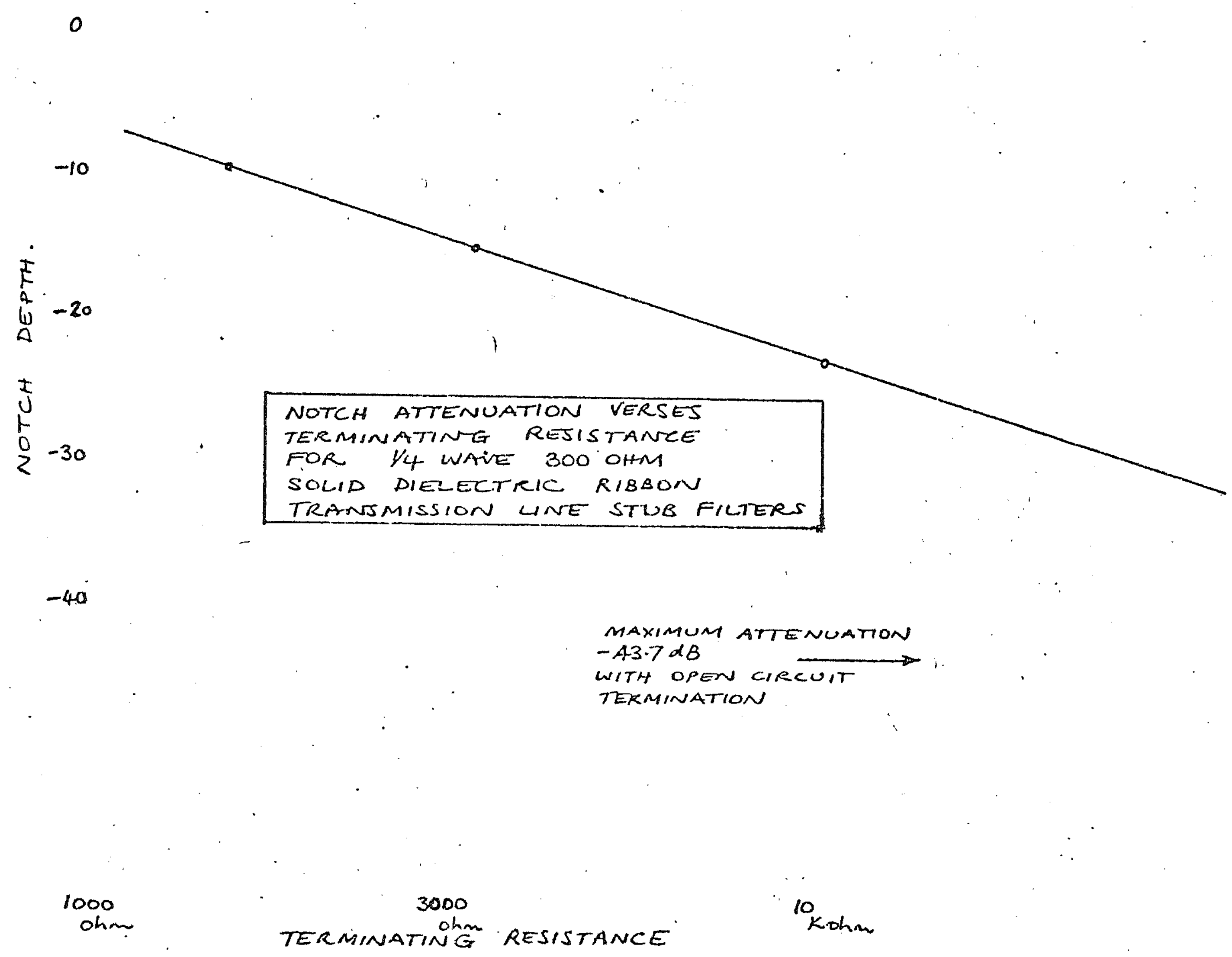
In some interference cases, reduction of local oscillator antenna radiation by as little as 10dB is sufficient to improve an interference situation from objectionable to acceptable. Quarter wave ribbon notch filters have been useful in some cases where the permanent fitting of such a filter does not degrade reception of channel 4 noticably.

However such a filter introduces a deep (over 40dB) narrow notch, difficult to position accurately in frequency.

By terminating the transmission line filter with a defined resistance rather than an open circuit, the depth of the notch can be controlled as the Q of the filter is lowered. Graphs attached shows measured responses for a quarter wave filter (i) open circuited and (ii) terminated in 3300 ohm, and also the relationship between terminating resistance and notch depth. These curves give a guide to the design of narrow band attenuators of very simple form.



BALUN LOSS (-2.8 dB)
26½" SOLID DIELECTRIC
300Ω RIBBON STUB
TERMINATED IN 3300 OHM
26½" SOLID DIELECTRIC
300Ω RIBBON STUB
OPEN CIRCUIT
VARIABLE Q TRANSMISSION
LINE NOTCH FILTERS
0
-10
-20
-30
-40
-50
ATTENUATION (dB)
50
70
90
100
150
200
FREQUENCY (MHz)



NOTCH ATTENUATION VERSES
TERMINATING RESISTANCE
FOR 1/4 WAVE 300 OHM
SOLID DIELECTRIC RIBBON
TRANSMISSION LINE STUB FILTERS
NOTCH DEPTH.
0
-10
-20
-30
-40
MAXIMUM ATTENUATION
-43.7 dB
WITH OPEN CIRCUIT
TERMINATION
1000 ohm
3000 ohm
10 Kohm
TERMINATING RESISTANCE