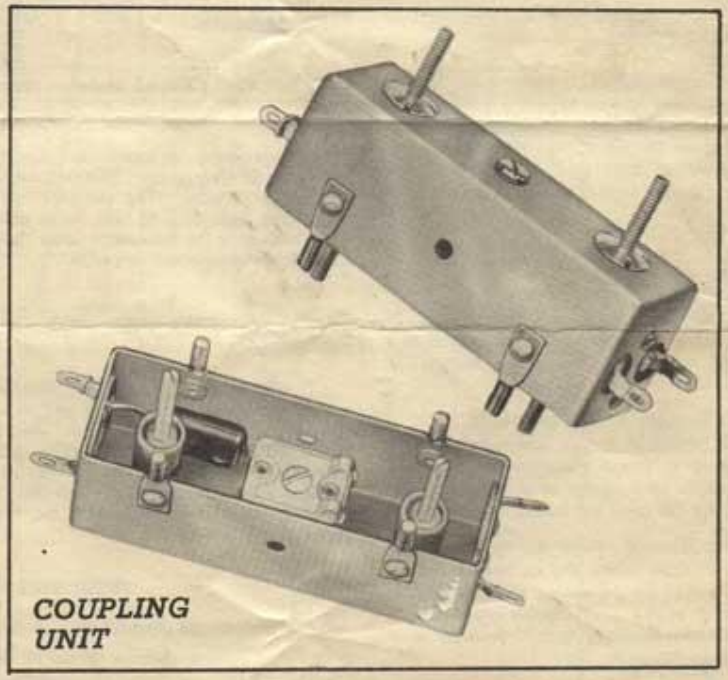
PICTURE IF AMPLIFIER CONSIDERATIONS

The bandwidth requirements of the television IF amplifier may be met in several ways. Single tuned circuits may be used, but they require excessive loading to secure a reasonably wide pass-band, resulting in low gain, and very poor selectivity outside of the pass-band. They are of importance, however, in an arrangement incorporating pairs of over-coupled tuned circuits with comparatively low values of loading. The pronounced double peaked response characteristic of such circuits necessitates a compensating action which is offered by the peaked response of the single tuned circuit.

A number of such compensated amplifiers having both over-coupled, double tuned and single tuned circuit stages were built in the F. W. Sickles Laboratory. They met band-width and gain requirements, but were not entirely satisfactory from the standpoint of the stability of the frequency response, due to the fact that slight detuning of the circuits is likely to affect the compensating action rather seriously. It was, therefore, decided to use over-coupled tuned circuits as interstage couplings throughout, loading each individual coupling unit for approximately uniform response.

Stage gain considerations require that the tuning capacity be kept at a minimum, therefore inductive tuning is preferable to capacitive tuning. In this connection it should be noted that, in addition to the more favorable response characteristic and attenuation outside the pass-band, the coupled circuits have an inherent advantage over the single tuned circuit, in that the capacitance (tube and wiring to ground) is lower in the former.



COUPLING UNIT

Various methods of coupling the two tuned circuits of each unit can be used. The coupling may be of the direct magnetic (transformer) type or it may be attained through the use of a separate coupling element common to both circuits. Direct magnetic coupling, especially when used with permeability tuned circuits is very difficult to adjust, due to the detuning effects between the closely coupled circuits. Separate coupling elements, on the other hand, facilitate alignment and permit any required degree of coupling.

The coupling element can be inductive or capacitive. It may also comprise a tuned circuit, in which case the coupling element is tuned to a point outside the pass-band; the off-resonance component acting as the coupling link. By choosing the proper resonant frequency and L/C ratio the circuit can be made to provide wave-trap action simultaneously, to further attenuate the response of the coupled circuit system outside the pass-band.

Sufficient attenuation outside the picture pass-band, is required to eliminate interference from the associated sound carrier, as well as the sound carrier and near-by picture components of an adjacent (lower) television channel. The first requirement has to be met entirely by the IF system. The latter rests on it mainly, as only partial suppression of adjacent channel transmissions can be expected from an RF selector system, if any is used at all.

Wave-traps of various designs arranged, relative to the coupled circuits, in such ways that the picture IF band is least affected, provide the necessary rejection. The above mentioned dual purpose trap constitutes only one particular form.

The problem of rejecting the associated sound carrier (or rather its corresponding frequency in the IF band) must be considered simultaneously with the function of transferring this component to the sound IF amplifier. Various methods were tried, almost all of them resulting in serious gain and band-width reductions of the picture IF channel, or in a serious loss of sound IF signal strength. After lengthy mathematical and experimental work a transformer arrangement combining series tuned and parallel tuned circuits was developed which acts efficiently as a wave-trap, coupling link and transfer agent for the sound IF frequency.

COUPLING UNITS

The F. W. Sickles Company offers the radio manufacturer, engineer, and amateur a variety of wide band television IF amplifier components. Response characteristics, circuit specifications, and suggested layout of a typical amplifier using Sickles coupling units are given on the following pages.

It is apparent that the varying requirements made upon television IF systems will not be met by one particular form of amplifier. The coupling units were, therefore, developed so that, in addition to the above mentioned amplifier, they may be used in various other amplifier combinations. Though incorporating different circuits the units are, with one exception, all the same size and are designed for sub-chassis mounting, reducing lead length to a minimum. Shield dimensions are 3¼" x 1⅝".

Generally speaking the coupling units consist of plate and grid inductors, permeability tuned; which, together with the tube capacitances, form tuned circuits. Coupling elements, either simple inductive or capacitive elements or tuned circuits offering the necessary reactive component, are fixed; except in the case of Unit No. 40. The resulting band-pass network will have a useful bandwidth of 3.65 to 4 megacycles, depending upon alignment procedure and loading. Wave filters to attenuate further the IF frequencies corresponding to the associated sound and adjacent channel sound carriers are incorporated in some of the units.

GAIN

The gain of the typical amplifier shown on page 4 is approximately 3500 for a usable bandwidth of 3.85 megacycles. The sound channel gain is approximately 4000.

A simple method of increasing the gain without adding to the number of stages is the substitution of 1852 type tubes for the 1853's used in the first two stages of the IF amplifier. Cathode resistor bias will have to be substituted for the fixed minimum bias (PAVC) assumed for the operation of the 1853's in the amplifier described. Replace R-8 and R-14 each with the R-19, R-20, C-12 network. Gains of 7000 to 8000 with a useful

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bandwidth of 3.85 megacycles and 6000 to 6500 at a bandwidth of 4 megacycles are attainable in this way.

To neutralize the effects of input capacitance and loading change caused by changing plate currents (AVC), degeneration, is applied to the converter and IF stages as may be seen in the circuit diagram. Inasmuch as substantially higher gains can be realized without this arrangement, we are experimenting with an amplifier excluding un-bypassed resistors in some of the cathode circuits, to investigate the effects of such a change on the band-pass response.

Addition of another IF stage, should it appear necessary, can be accomplished by using a wide band unit, No. 40 for example, in connection with the additional tube. If properly damped, the additional stage should alter the response of the amplifier only slightly, whereas the gain will be considerably increased. Other units, of course, can also be used, should it be necessary to change the sound carrier rejection characteristics at the same time.

WAVE FILTERS

Four wave filters are incorporated to attenuate, in the picture IF channel, the frequencies representing the sound channel and adjacent channel sound carrier. Rejection factors of 300 to 500 for the sound carrier IF and 600 to 1000 for the adjacent channel sound carrier IF (8.25 and 14.25 mc in the described amplifier) are attainable with a useful bandwidth of 3.85 megacycles.

ALIGNMENT DATA

SOUND IF CHANNEL: Alignment corresponds to standard IF alignment procedure, both adjusting screws on Units 44-R and 44-L being set for maximum response at the sound channel IF frequency.

PICTURE IF CHANNEL: Alignment of the picture IF channel should be done by means of an IF sweep generator, though point-to-point alignment using a signal generator is possible. A microammeter in the detector load circuit or a vaccuum tube voltmeter across the load may be used for tuning indication.

GENERAL ALIGNMENT PROCEDURE: Feed the generator output to the grid of the last IF tube, make the necessary adjustments, and proceed to the grid of the preceding IF tube. Alignment is simplified if the grid of the stage under alignment is disconnected from the preceding coupling unit. Provision must of course be made to maintain adequate bias.

UNIT NO. 40 2 Slotted studs — Inductor adjustments
Center screw — Coupling capacitor adjustment

Preliminary adjustment can be made by tuning both inductors to a frequency slightly higher than the high frequency peak of the desired response curve, the coupling adjustment being set several turns from its maximum capacity position. Increase the coupling slowly until the two peaks formed take the desired positions in the frequency band.

UNIT NO. 48 2 Slotted studs — Inductor adjustments
Center screw — Wave-trap setting

Set the wave-trap for maximum attenuation at the adjacent channel sound IF frequency. Re-setting may be necessary after the inductors have been set for suitable pass-band response. This unit contains a fixed coupling element, the response being controlled by the inductor adjustments only.

UNIT NO. 29 2 Slotted studs — Inductor adjustments
Center screw — Wave-trap setting

Adjustment of Unit No. 29 is similar to that of No. 48, except that its wave trap should be set for maximum attenuation at the associated sound channel IF frequency. IT IS ADVISABLE TO ADJUST UNITS NO. 48 and 29 SIMULTANEOUSLY, THE SIGNAL BEING FED INTO THE FIRST I. F. GRID.

UNIT NO. 47 2 Slotted studs — Inductor adjustments
Center screw — Wave-trap setting

Set wave-trap for maximum attenuation of the adjacent channel sound IF frequency. This unit combines with No. 45 to form a suitable network. The inductor adjustment should be made only after Unit No. 45 has been adjusted. Re-setting of the wave-trap may be necessary after the inductors have been set for suitable pass-band response.

UNIT NO. 45 2 Top trimmers–Adjustments for sound I. F. wave-trap and sound channel input circuit.

Using an associated sound channel I. F. frequency signal, set the wave-trap (side having yellow lug) for maximum attenuation in the picture IF response. Set the sound channel input circuit trimmer (side having green lug) for maximum sound IF channel output. Circuit interaction requires re-setting of both settings after alignment of Unit No. 47 is completed. When aligning the 47-45 combination the signal is fed into the converter grid.

FREQUENCIES

Sound channel IF — 8.25 megacycles
Picture channel IF — 12.75 megacycles
Adjacent channel sound IF — 14.25 megacycles

LOADING

For suitable values of loading resistors, see circuit diagram.

TELEVISION COMPONENTS

Unit No.		List Price
29		$3.50 each
47X	revised units →	3.00 each
48X		4.50 each
40		2.00 each
45		1.75 each
44L	these are now called 44XL	2.50 each
44R	44XR	2.50 each

60% discount

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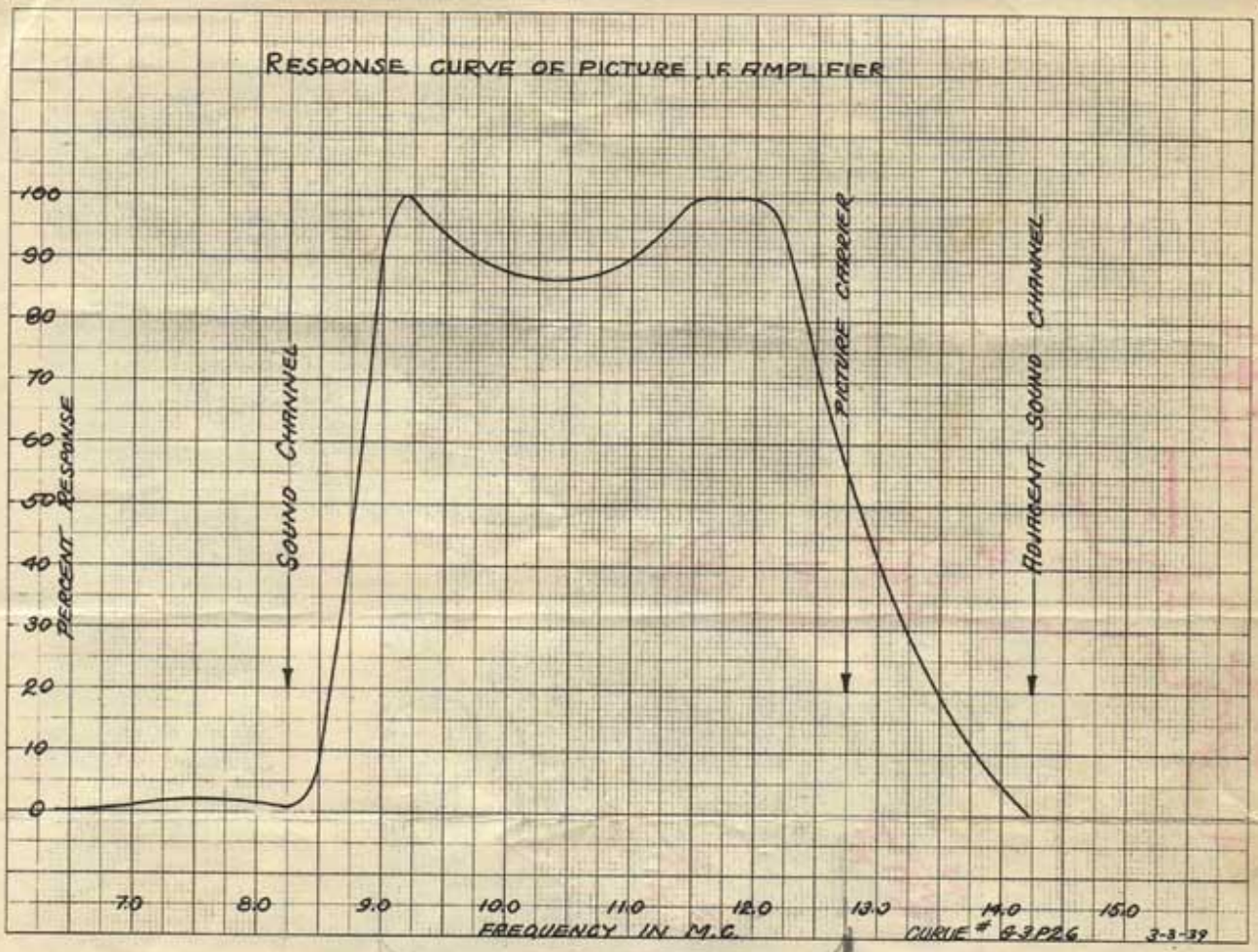

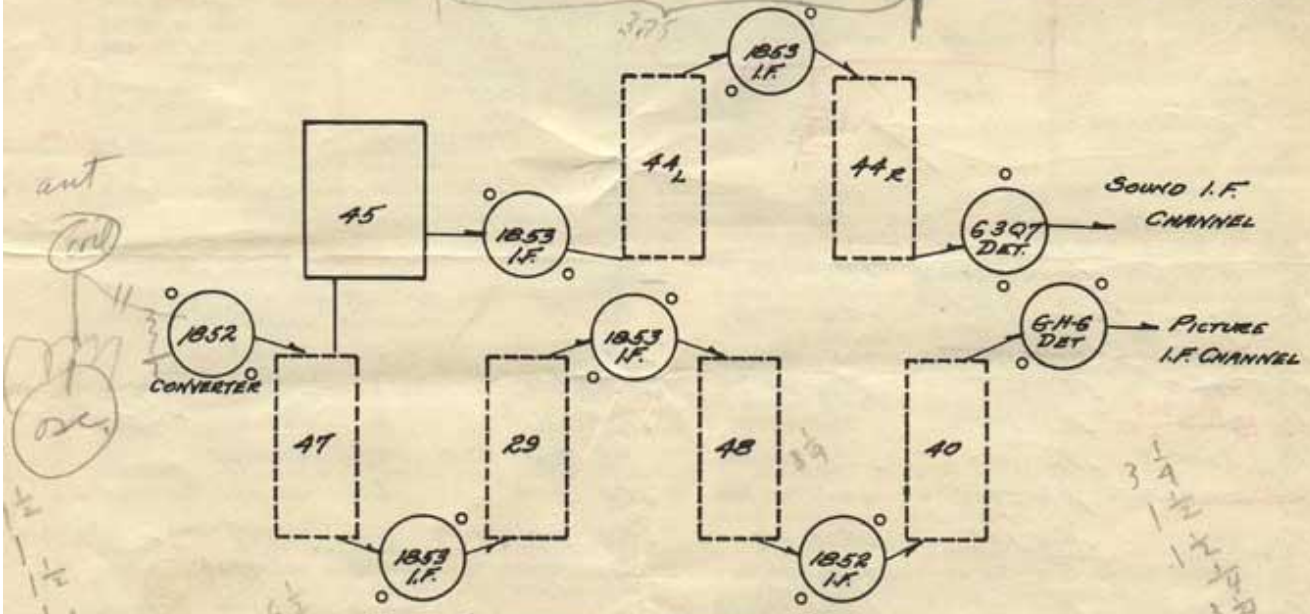

SUGGESTED CHASSIS LAYOUT
TRANSFORMERS IN DOTTED LINES
LOCATED ON UNDER SIDE

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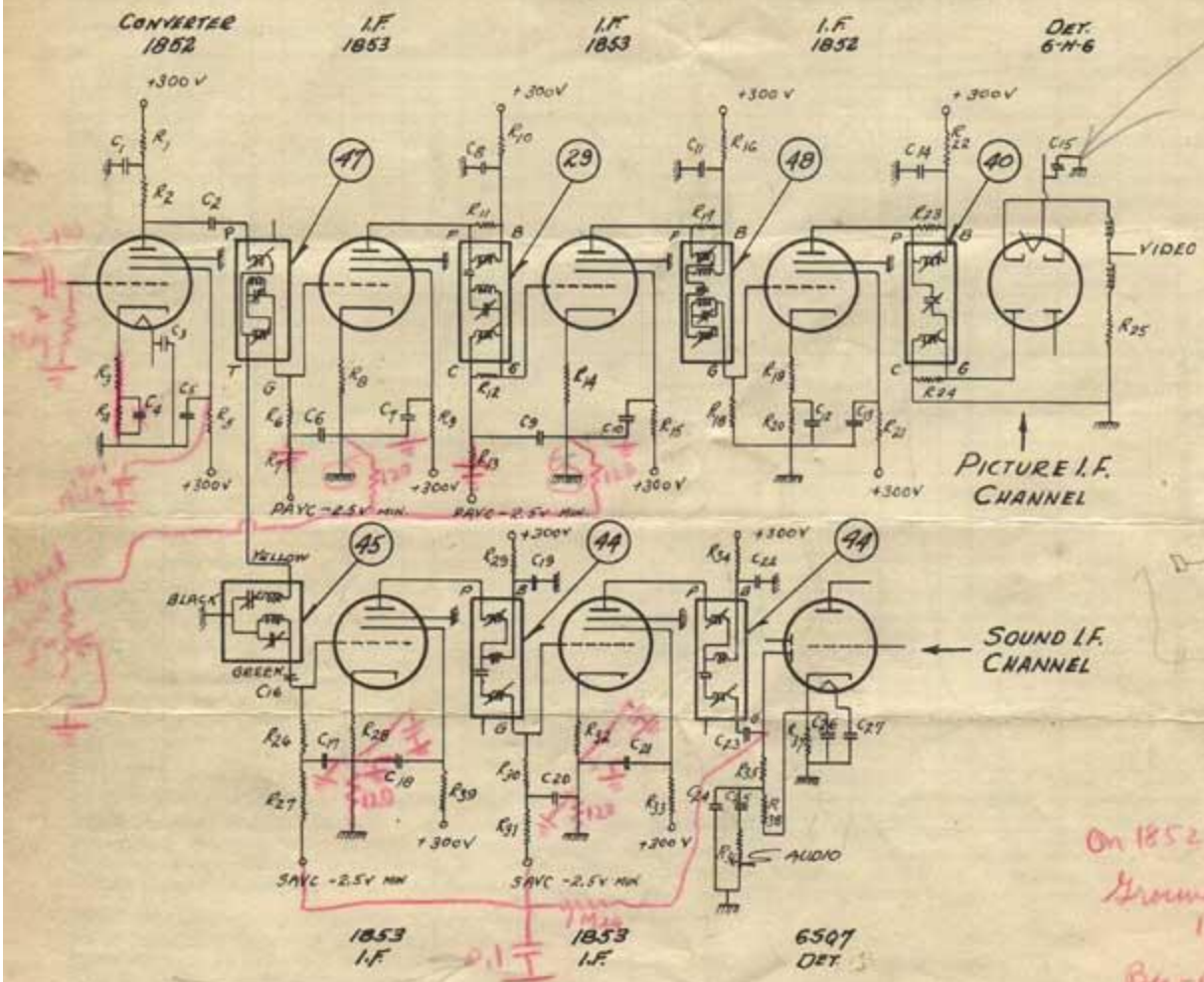

SOUND CHANNEL TRAPS ARE INCLUDED IN TRANSFORMERS 29 + 45
ADJACENT CHANNEL TRAPS ARE INCLUDED IN TRANSFORMERS 47 + 48

R_1	1000 ohms	R_{11}	7,500 ohms	R_{21}	60,000 ohms 1W.	R_{31}	100,000 ohms
R_2	3000	R_{12}	2,500	R_{22}	1,000	R_{32}	68
R_3	35	R_{13}	100,000	R_{23}	5,000	R_{33}	30,000
R_4	225	R_{14}	68	R_{24}	6,000	R_{34}	1,000
R_5	60000	R_{15}	30,000	R_{25}	4000	R_{35}	50,000
R_6	5,000	R_{16}	1,000	R_{26}	100,000	R_{36}	½ MEG VC.
R_7	100,000	R_{17}	7,500	R_{27}	100,000	R_{37}	2000
R_8	68	R_{18}	7,500	R_{28}	68	R_{38}	½ MEG 100 pot
R_9	30,000	R_{19}	35	R_{29}	1000	R_{39}	30,000
R_{10}	1,000	R_{20}	125	R_{30}	100,000		

ALL CAPACITORS ARE .01 mfd WITH THE FOLLOWING EXCEPTIONS

C_2	400 MMF
C_3	.006 MICA
C_{16}	400 MMF
C_{23}	50 MMF
C_{24}	50 MMF
C_{25}	.02 mfd
C_{26}	5.0 mfd

1 - 0.1 mfd
1 - .001 mica

On 1852's & 1853's
Ground pins
1, 7, 3
By-pass pins
2, 6

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all resistors ½ W. except those labelled otherwise

ALIGNMENT DATA FOR PICTURE & SOUND I. F. AMPLIFIER FOR DIFFERENT GAIN REQUIREMENTS:

Since the printing of the first Television Engineering bulletin a number of new problems have arisen, the most important being, Gain and Alignment. Wide Band Amplifier Alignment, difficult in itself, becomes a particular problem because of the effects of the alignment procedure on the gain of the system. Although it is possible to duplicate a certain wide band frequency response using a random alignment procedure, the gain thus obtained will vary considerably.

Various groups of amplifier arrangements were tested in order to find alignment procedures which could be followed in these various groups. Some of the results of our investigations are given herein; they are submitted with the understanding that they cannot be considered as the only solutions possible.

PICTURE I. F. CHANNEL: Alignment is generally simplified if the grid of the stage under alignment is disconnected from the preceding coupling unit. Provision must be made to maintain adequate bias. No consideration was given to the effect of Synchronizing and A.V.C. circuits on the overall performance.

COUPLING UNITS: Without altering the individual circuit of the unit, certain minor changes, (involving slight changes in the value of some of the inductors) were made in units Nos. 47, 48 and the 44's. The modified picture channel units — marked 47-X and 48-X facilitate to some extent the alignment of the channel. Use of the former units Nos. 47 and 48 will slightly modify the alignment procedure given below for the case of low and medium gain requirements; the high gain arrangement should be used with the units Nos. 47-X and 48-X.

The modified sound channel units, No. 44-X-L and No. 44-X-R (both identical electrically, but differing in the arrangement of the terminals) provide a higher selectivity in the sound channel than did the former units, thus facilitating the accurate placement of the picture carrier by means of the sound setting.

PICTURE AMPLIFIER FOR LOW GAIN REQUIREMENTS

TUBES: 1852 converter, 2-1853 first and second I.-F., 1852 third I.-F. 6H6 detector.

UNITS: 47X, 29, 48X, 40.

CIRCUIT: The original circuit, as shown on page 4 of the TELEVISION ENGINEERING DATA.

Picture-AVC (PAVC) minimum fixed bias: 2.5 volts.

ALIGNMENT: No. 40: Set both plate and grid (diode plate) system to 11.9 megacycles with the coupling condenser in the low capacity position. Tighten coupling until a low frequency peak at 9.1 megacycles and a high frequency peak at 12 megacycles are obtained.

NO. 48-X: Set trap for maximum attenuation at 14.25 megacycles. Set the inductors for an (partial) overall response showing peaks at 9.23 and 12.2 megacycles. The response should be nearly flat.

NO. 29: Set trap for maximum attenuation at 8.25 megacycles. Set the inductors for an overall response showing peaks or limits of the horizontal portion of the response characteristic at 9.15 and 11.8 megacycles. The response between these peaks should be very nearly flat.

NO. 47-X: Set trap for maximum attenuation at 14.25 megacycles. Adjust unit No. 45 as per page 2 of the Data Sheet. Returning to unit No. 47-X, set the inductors for a nearly flat response between the limits of 9.1 and 11.8 megacycles. Slight retouching of the inductor setting of No. 29 and 48-X may be required to get best results, especially the 6db. drop at 12.75 megacycles (carrier position).

GAIN: 3500 approximate.

STAGE GAINS:

Grid third I.-F. to diode plates:	13
Grid second I.-F. to grid third I.-F.:	9
Grid first I.-F. to grid second I.-F.:	3.9
Converter grid to grid first I.-F.:	7.7

FREQUENCY RESPONSE: See Characteristic on page 3 of the TELEVISION ENGINEERING DATA.

PICTURE AMPLIFIER FOR MEDIUM GAIN REQUIREMENTS

TUBES: 1852 converter, 2-1853 first and second I.-F., 1852 third I.-F., 6H6 detector.

UNITS: No. 47-X, No. 29, No. 48-X, No. 40.

CIRCUIT: The original circuit, as shown on page 4 of the TELEVISION ENGINEERING DATA, omitting R-8 and R-14 and connecting the cathodes to ground.

Picture AVC (PAVC) minimum fixed bias of minus 3 volts. The minimum fixed bias arrangement can be replaced by substituting by-passed cathode resistors of 190 ohms each for R-8 and R-14.

ALIGNMENT: The alignment procedure is the same as used for the PICTURE AMPLIFIER for LOW GAIN requirements.

GAIN: 6100 approximate.

FREQUENCY RESPONSE: See Characteristic on page 3 of the TELEVISION ENGINEERING DATA.

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PICTURE AMPLIFIER FOR HIGH GAIN REQUIREMENTS

TUBES: 4-1852 converter, first, second and third I.-F.; 6H6 detector.

UNITS: No. 47-X, No. 29, No. 48-X, No. 40.

CIRCUIT: The orginal circuit, as shown on page 4 of the TELEVISION ENGINEERING DATA, replacing R-8 and R-14 each with the R-19, R-20, C-12 network. (35 ohm unbypassed resistor in series with 125 ohms bypassed resistor). Replace the load resistors R-2, R-6, R-11, R-12, R-17, R-18, R-23, R-24 with the following load system:

LOADS: Unit No. 40: Plate: no load
Grid: 10,000 ohms.

Unit No. 48: Plate: 7,500 ohms.
Grid: 5,000 ohms.

Unit No. 29: Plate: 7,500 ohms.
Grid: 2,500 ohms.

Unit No. 47: Plate: 10,000 ohms.
Grid: 1,500 ohms.

ALIGNMENT PROCEDURE:

UNIT No. 40: Load Plate side temporarily with 5000 ohms, set coupling capacity to lowest value and peak both sides of No. 40 to 12.2 megacycles. Remove 5000 ohm plate load and tighten coupling until the response appears peaked at 12.75 and 8.75 megacycles.

UNIT No. 48: Set trap for maximum attenuation at 14.25 megacycles. Insert .01 mfd. between ground and the unmarked lug of unit No. 48. Set both plate and grid circuits for maximum response at 11.85 megacycles. Remove .01 mfd. condenser.

UNIT No. 29: Set trap for maximum attenuation at 8.25 megacycles. Set both plate and grid circuits for an overall, practically flat response with even peaks at approximately 11.85 and 9.1 megacycles. Dip should be very small. Slight correctional retouching of the plate inductor setting of unit No. 48 may be required.

UNIT No. 47: Set trap for maximum attenuation at 14.25 megacycles. Adjust unit No. 45 as per Alignment Data sheet. Returning to unit No. 47, set both plate and grid circuits for the desired overall response. Slight correctional retouching of the grid inductor setting of unit No. 29 may be required.

The following overall performance was attained:

Gain: 12,500 — 13,350: Rejection at 8.25 megacycles 110. Rejection at 14.25 megacycles 1725.

Dip: 16% maximum. Response curve same as with 1853 tubes.

TELEVISION SOUND I. F. AMPLIFIER

Five different amplifier arrangements were tested and the results listed below.

The overall gain given is the average gain, measured from the converter grid to the sound diode detector plates. It is advisable to use both diode plates in parallel; use of a single plate, as indicated in the circuit diagram of page 4 of the TELEVISION ENGINEERING DATA might cause difficulties in tuning the diode coupling unit.

UNITS: No. 45, No. 44-X-L, No. 44-X-R.

SELECTIVITY: Approximately 325 kilocycles at 2 times down in case of amplifier No. 1;

The use of an 1853 tube without degeneration as a first I. F. stage, as in amplifier No. 3, cannot be recommended: The input capacitance of the tube in this case is such that setting of the sound channel input trimmer of unit No. 45 becomes difficult.

No.	1st I. F.	2nd I. F.	Gain	Circuit Changes	Sound AVC min. fixed bias
1.	1853 degen.	1853 degen.	4060	as per pg. 4 Tel. Eng. Data unchanged.	-2.5 v.
2.	6SK7	1853	3400	* ** ***	-3.0 v.
3.	1853	6SK7	3250	* ** (*)	-3.0 v.
4.	1853 degen.	6SK7	1725	** (*)	-3.0 v.
5.	6SK7	6SK7	1450	* ** *** (*)	-3.0 v.

*Omit R-28, connecting cathode to ground.

**Omit R-32, connecting cathode to ground.

***Replace R-39 with 80,000 ohm resistor.

(*)Replace R-33 with 80,000 ohm resistor.

The fixed minimum bias arrangement can be replaced by substituting for R-28 and R-32 suitable cathode bias resistors. These resistors should be sectionally unbypassed in case of degenerative circuits, bypassed if no degeneration is intended.

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