AUSTRALIAN BROADCASTING CONTROL BOARD
373 Elizabeth Street, Melbourne, C.1

DUP

TECHNICAL SERVICES DIVISION.

REPORT NO. 24
(Issue 2).

TITLE: A Transistorised Video Frequency Waveform Corrector.

Issued by :-

The Chairman,
Australain Broadcasting Control Board,
373 Elizabeth Street,
MELBOURNE. C.I.

TELEPHONE: 30 4321 — CODE ADDRESS: CONBOARD, MELBOURNE

TECHNICAL REPORT NO. 24.

(Issue 2).

Title: A Transistorised Video Frequency Waveform Corrector.

Prepared by: G.W. Morley. January, 1963.

(D. McDonald)
Director
Technical Services Division.
/4/1963.

Summary:

The errors in the television system response produced by the transmitter are briefly discussed. The techniques used in Australia to compensate for these errors are described together with the inherent problems associated with these methods. An alternative approach is proposed which overcomes these problems.

The principle of the proposed corrector is the addition of leading and lagging echoes to the main signal with individual and continuous adjustment of each echo. Circuit details of a corrector built to assess the potential of this method are given together with electrical and physical specifications.

The result of using the corrector for transmitter correction is included.

1. Introduction

The basic technical requirement of the television system is the faithful reproduction of brightness changes. For the purpose of this paper the requirement may be restated as the faithful reproduction of voltage changes. Thus the use of a step (square-wave) test signal will give the most direct measure of the performance of the system. For this reason the Control Board in its specification[1] places the major emphasis on the transient, rather than the steady state, performance of the system.

The errors in the various parts of the television system have been discussed elsewhere[2] and this paper will consider only the principal source of error in the transmission system, i.e., the transmitter filter-plexer combination. Because of the large rate of change of the amplitude characteristic produced by the filterplexer (at the pass-band limits) the phase characteristic varies appreciably from the ideal. In the absence of phase correctors operating at vision carrier frequencies the effect of these phase errors is minimised by the predistortion of the phase of the vision signal at the input to the transmitter.

In order to measure the performance of the transmitter-filterplexer a standard (vestigial side band) monitor[3] is used so that we may treat the combination as a two port video network. This enables the measurement of the transient or steady state performance of the combination and from a knowledge of the monitor characteristics deduce the steady-state characteristics of the transmitter-filterplexer at video frequencies. This may be done by a conventional sweep or point by point measurement of the amplitude and phase characteristics or by an analysis of the transient response[4]. Given the phase characteristic a combination of all-pass phase corrector networks can be designed[5] which will provide the degree of correction necessary.

As few television stations are equipped with group delay measuring equipment, and the calculation of the group delay characteristic from transient information is extremely tedious, another technique is now used for the precorrection of those errors. The method is to insert variable all-pass networks in the video line and empirically adjust these to optimise the transient signal obtained from the standard monitor. This method has the following disadvantages:-

(a) The output is displayed in the time domain and the effect of the variable parameters are known only in terms of the frequency domain. Thus the adjustment of the networks is more an art than a science.

(b) When variable networks are used in cascade they may introduce amplitude errors in spite of their (theoretical) all-pass nature. These errors may be reduced by replacing each of the variable networks by a fixed network constructed to have the same phase characteristic.

(c) The variable networks are variable in steps, not continuously so, and often the final settings are a compromise.

After considerable experience in this method of correction it has become apparent that a continuously variable corrector, with parameters having effects directly related to the time domain display, would offer the advantages of simpler and more precise adjustment of the transient response of the transmitter-filterplexer combination.

2. Principle of Corrector

The linear errors in the performance of a video system have been shown capable of description in terms of paired echoes[6], that is replicas of the test signal symmetrically displaced in time (leading and lagging) with respect to the main signal. A pair of echoes of like polarity correspond to an amplitude error whereas a pair having opposite polarity correspond to a phase error. Thus by the addition of suitable echo pairs to the test signal we can reproduce the response of a system to the test signal. Conversely, by the addition of echo pairs to the output of a system we can compensate for the performance deficiencies of the system.

The transversal equaliser[7] utilises this principle to provide separate correction of the amplitude and phase characteristics. In order to provide the leading echo of a pair the signal is delayed by means of a tapped delay line and a second tapped line provides the delayed (lagging) echo, the main signal being taken from the connecting point of the two lines. A single control adjusts the amplitude of each pair of echo signals, and the polarity may be made the same, for amplitude adjustment or opposite, for phase adjustment.

Because the transient test signal is most commonly used in Australia for the adjustment of the phase response of the transmitter-filterplexer, there is no advantage in using echo pairs for the separate adjustment of phase and amplitude characteristics. Rather, the individual adjustment of leading and lagging echoes will enable the correlation of the adjustment and its consequent effect on the resultant transient.

This type of corrector[8,9] has been used elsewhere but is not readily available in Australia. For this reason it was decided to construct such a device in order to assess its potential and its suitability for incorporation in the television system.

3. Description of Corrector

The block schematic of the corrector is given in figure 1. A is an isolating amplifier which drives the leading delay line B. The output from B is fed to a mixing amplifier F, and a second isolating amplifier C which drives the lagging delay line D. Tap amplifier inverters E provide leading and lagging echoes of continuously adjustable amplitude variable from positive through zero to negative polarity. The outputs of all tap amplifiers are combined in a common load and mixed with the main signal in F. The output stage G provides an output signal of one volt across an external termination of 75 ohm.

The transient response of a typical transmitter without precorrection of phase errors is shown in figure 2(a). From this it may be seen that the significant deviations from the ideal occur within ± 0.6 microsecond of the transition and these determine the range of echo delay required of the corrector. Figure 3 shows the idealised transient response of a phase corrected 5Mc/s low pass filter. The interval between the axis crossings of the pre- and post-ring is 0.1 microsecond and their positions relative to the 50% point of the transition are $\pm(0.15+0.1)$usec. In order to establish ideal pre- and post-ring by means of the corrector the tapping points have been positioned accordingly, with the addition of taps at ± 0.09usec., to give additional control of the pre- and overshoot.

The circuit diagram, figure 4, shows the detail of the units of the block schematic. To avoid repetition the tap amplifier/inverter is shown only once.

A: Input Amplifier - a simple common collector (emitter follower) stage to provide a degree of isolation between the input signal and the leading delay line. R1 terminates the incoming line; R2, R3 establish bias conditions; R5, C2 provide partial compensation for the delay line response and R4, D1 (zener diode) protect T1 against excessive dissipation.

B: Leading Delay Line - a commercial unit having 30 sections and a total delay of 0.6usec (delay per section - 0.02uSec). The nominal impedance of the line is 75 ohm, sufficiently low to permit the degree of loading imposed by the tap amplifiers. The line is terminated by the net effect of R6 and the input impedence of stages T2 and T6.

C: Isolating Amplifier - a similar unit to A which is used to isolate the leading and lagging delay lines.

D: Lagging Delay Line - as for B and terminated by R21.

E: Tap Amplifier/Inverter - each is d.c. coupled to the delay line (B or D) with a potentiometer (RV2) as collector load, and emitter resistor (R26) approximately one half the total resistance of RV2. The direct and inverted signals are added by means of R27, R26, R12. By varying the slider of RV2 from supply to collector the echo amplitude can be varied continuously from a positive value to an approximately equal negative value. The resistors R26, R27 have the same value for a given tap amplifier but the value used is such that the maximum value of the amplitude of the echo is graded as a function of its separation from the main signal, smallest amplitude being obtained from the tap amplifiers having ±0.55usec. separation.

F: Mixing Amplifier - the main signal is d.c. coupled to T2 from the leading delay line and the echoes are d.c. coupled to T3. High frequency compensation is effected by C3 and C4 and the two signals are combined in a common collector load, R9.

G: Output Amplifier - the signal from the mixing amplifier is coupled to T4 by means of the zener diode D2. This stage restores correct polarity of signal and provides gain control by means of RV1. Stage T5 is an emitter follower which will produce a 1 volt composite signal in an external load of 75 ohm. The resistor R20 provides a d.c. path in the absence of an external termination and R19, D3 protect the transistor against excessive collector dissipation.

Power Supply - a power supply capable of delivering approximately 200mA at 9 volts and of low impedance through the frequency range to 5Mc/s is used.

4. Physical Construction

The corrector has been constructed for rack mounting with a panel height of $5\frac{1}{4}$ inches and overall depth of 9 inches. The total weight of the corrector is 12 lbs.

The active units of the corrector are mounted on plug-in circuit boards and the adjustment of the tap amplifiers is by means of thumb-wheels which protrude through the front panel.

5. Specifications.

Input Impedance	...	75 ohm (nominal)
Output Impedance	...	designed for 75 ohm termination
Overall gain	...	adjustable to give Odb.
Insertion delay	...	0.6 microsecond.
Echo amplitude	...	±20% at ±0.15 microsecond, ±5% at ±0.55 microsecond.
Echo delay	...	±0.09, ±0.15, ±0.25, ±0.35, ±0.45, ±0.55 microsecond.

6. Corrector Performance

The result of the application of the corrector to a transmitter filterplexer standard monitor combination is shown in figure 2. Figure 2(a) shows the transient response of the combination before correction and 2(b) the response after correction. The time required to achieve this degree of correction is less than one minute.

7. Conclusion

The performance of the corrector as tested on television stations has proved that the degree of echo adjustment provided is adequate for transmitter correction. The direct relationship between the adjustable parameters and the output display greatly simplifies the process of correction and consequently reduces the time required. Providing the long term stability of the corrector is satisfactory there appears to be no reason why it could not be used to replace the more expensive adjustable phase correctors now in use.

References:

1. Australian Broadcasting Control Board.
"Standards for the Technical Equipment and Operation of Television Stations". February, 1958. pp 23, 26, 34.

2. Brownless, S.F.
"Delay and Transient Problems in Television Broadcasting".
Proc. I.R.E. (Aust.) V.21, April, 1960, p.253.

3. Australian Broadcasting Control Board.
"Standards for the Technical Equipment and Operation of Television Stations". February, 1958. p.8.

4. Samulon, H. A.
"Spectrum Analysis of Transient Response Curves".
Proc. I.R.E. V.30, February, 1951, p.175.

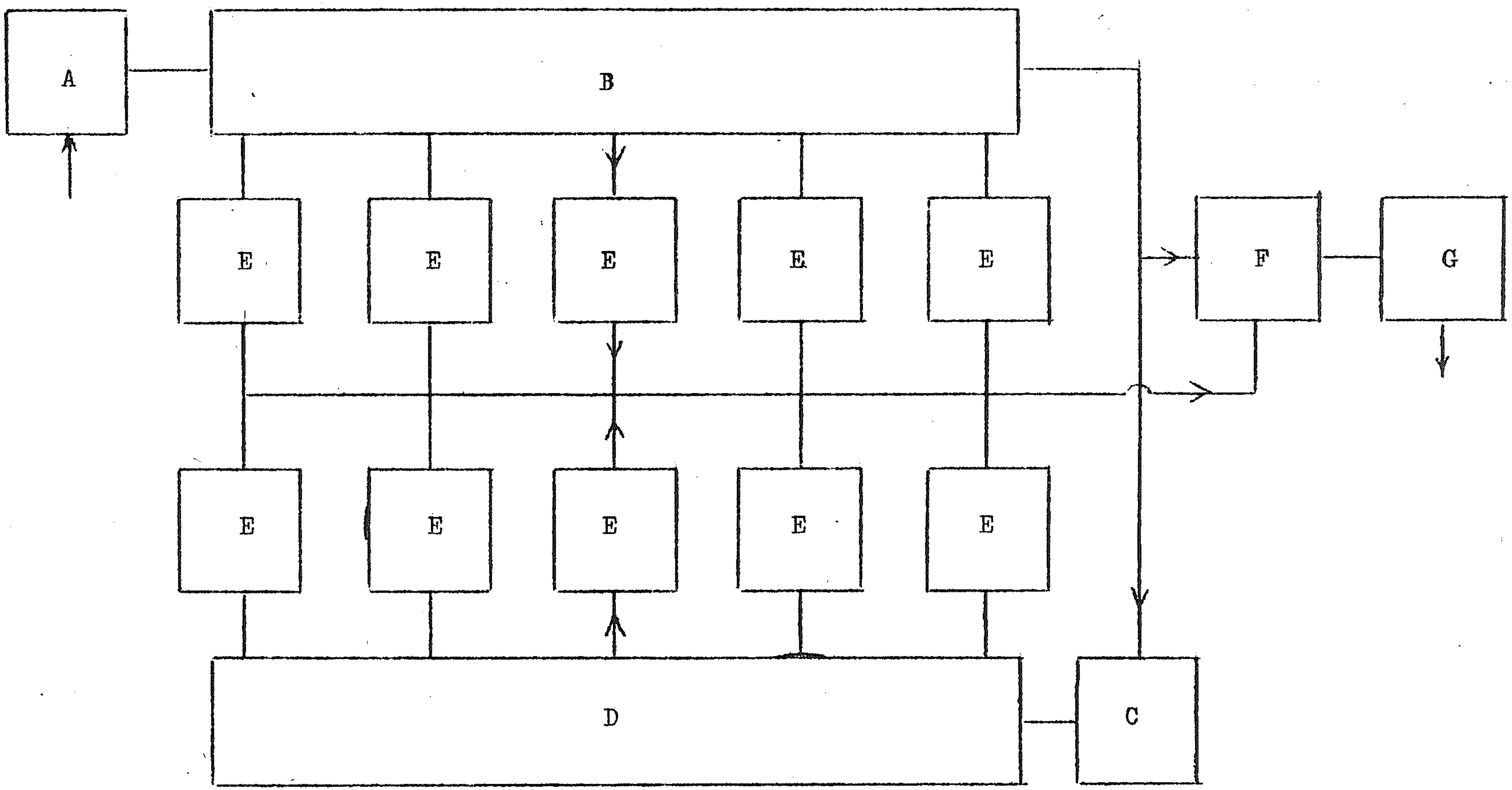
5. Davies, M. W.
"Phase Adjusting All-pass Networks".
Proc. I.R.E. (Aust.) V.23, November, 1962, p.637.

6. Wheeler, H. A.
"The Interpretation of Amplitude and Phase Distortion in Terms of Paired Echoes".
Proc. I.R.E. V.27, June, 1939, p.359.

7. Sperry, R. V. and Surenian, D.
"A Transversal Equalizer for Television Circuits".
B.S.T.J. V.39, March, 1950, p.405.

8. Seyler, A. J.
"An Experimental Time Equaliser for Television Signal Transmission". P.M.G.'s Department, C. of A.
Research Lab. Report 4763, May, 1958.

9. Osborne, B. W.
"Picture Quality Assessment and Waveform Distortion Correction on Wired Television Systems".
Journal Brit. I.R.E. V.23, May, 1962, p.399.



A – Input Amplifier
B – Leading Delay Line
C – Isolating Amplifier
D – Lagging Delay Line
E – Tap Amplifier/Inverter
F – Mixing Amplifier
G – Output Amplifier

FIGURE 1 BLOCK SCHEMATIC

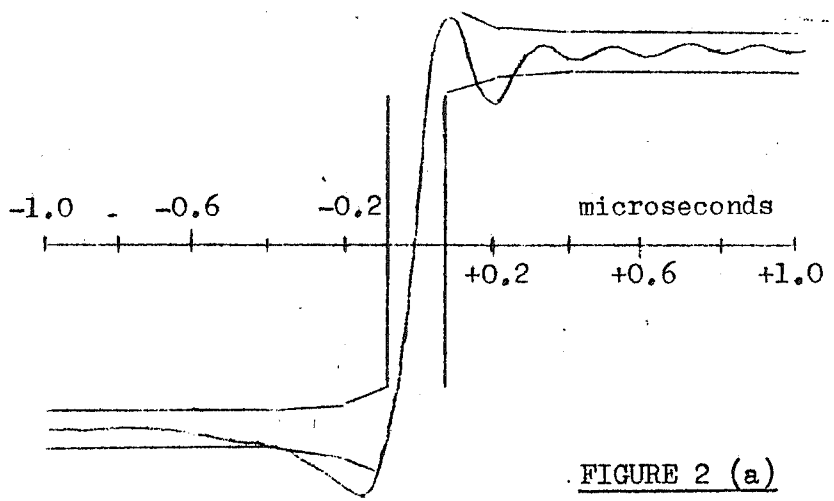


FIGURE 2 (a)

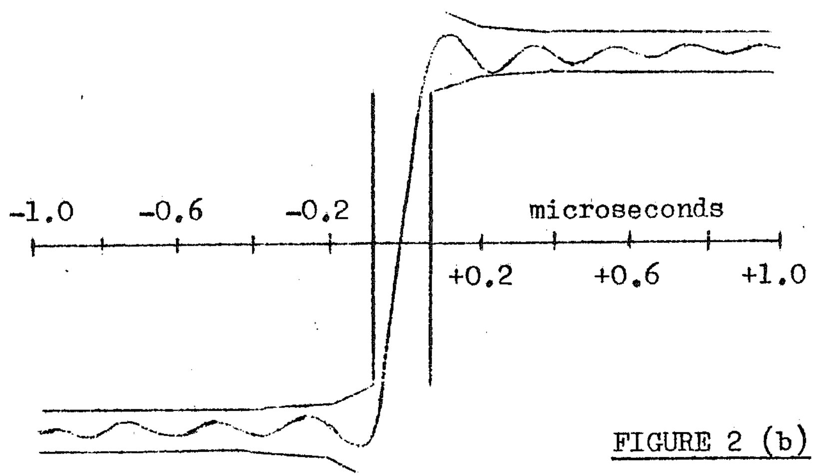


FIGURE 2 (b)

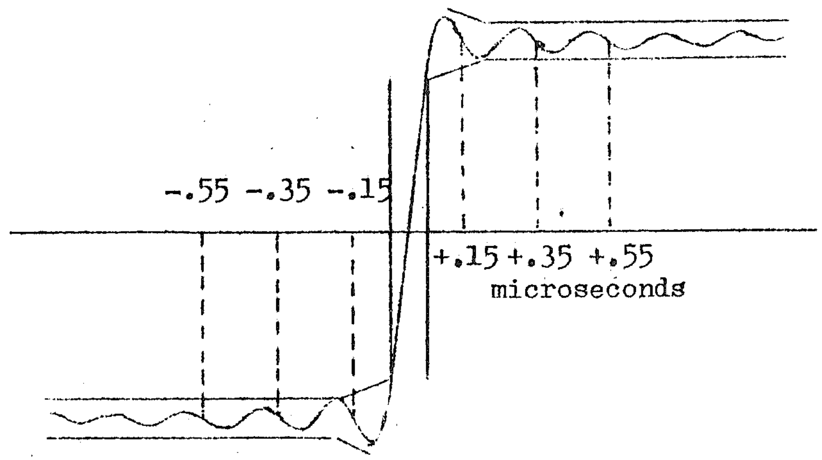


FIGURE 3

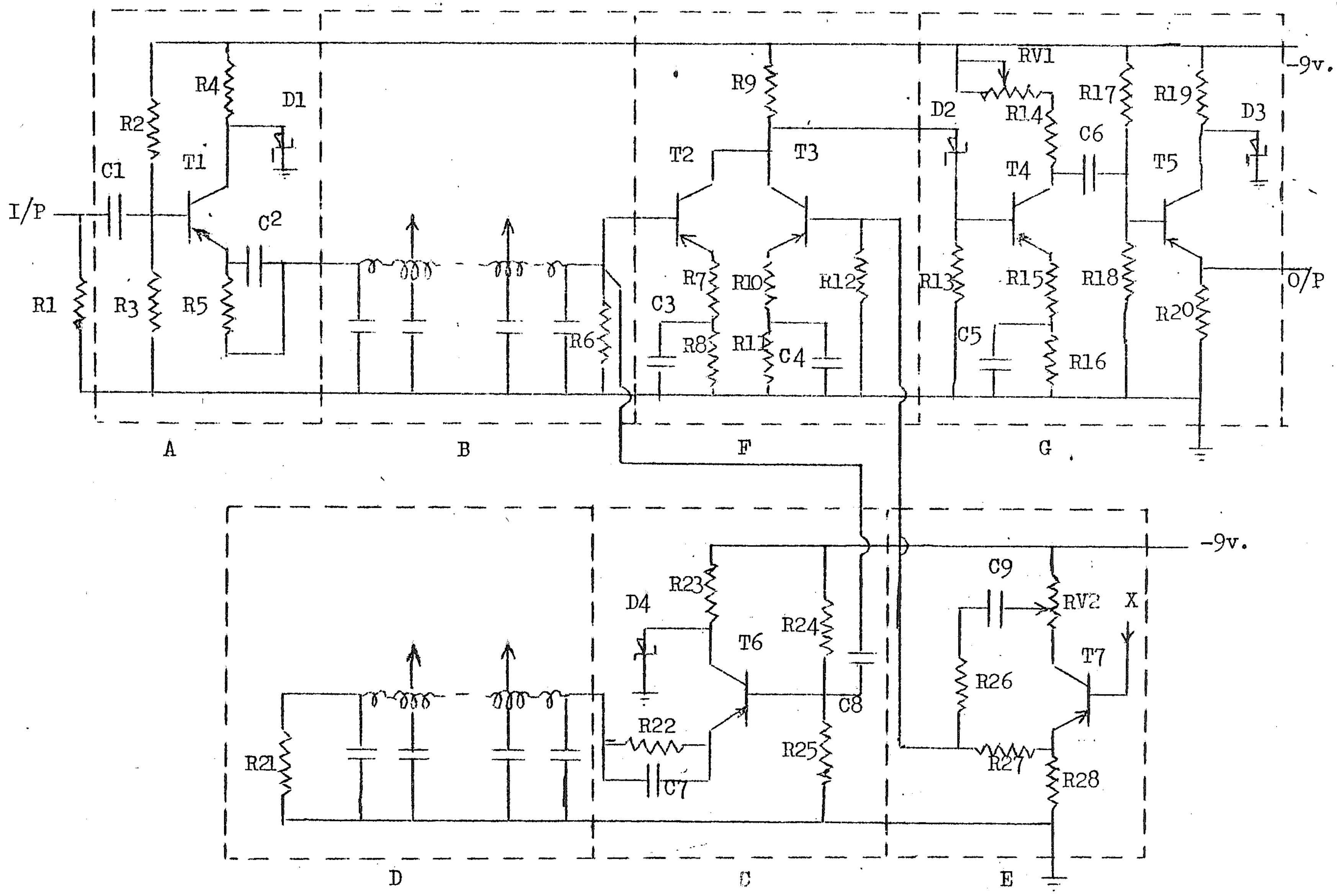


FIGURE 4 CIRCUIT DIAGRAM