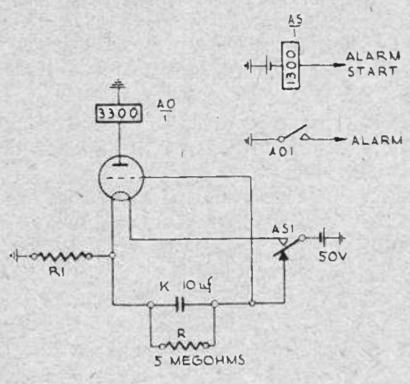
circuit. On the release of the alarm relay, the condenser will be re-charged practically instantaneously and the circuit will be ready for re-operation and will again provide the normal delay period. For a delay period of 30 seconds or longer a 10 mf condenser and a 5 megohm resistor would be the approximate values required.



Q. 4, Fig. 1.

(b) The factors which limit the delay period are:—

(i) The capacity of the condenser.

(ii) The value of the resistance.

(iii) The type of valve used.

By suitably choosing different capacity values of the condenser and making a corresponding selection of the discharge resistor, a wide range of discharge times is available, allowing that the delay period will also depend on the type of valve used.

(c) The type of valve used should be suitable for operating on the exchange voltage (50 volts). A power amplifier valve having a directly heated filament would be suitable. These valves are designed to function with anode voltages up to 150 volts, but, when used in the delayed action circuit, the anode voltage may be 50 or less.

EXAMINATION No. 2586.—SENIOR TECHNICIAN—TELEPHONE—(C) TELEPHONY II.

A. W. McPherson

SECTION I.

Q. 1.—(a) What do you understand by the following terms:—

Space charge,
Amplification factor,
Mutual conductance,
Negative feedback?

(b) What are the advantages of negative feedback as applied to an amplifier?

A.—(a) Space Charge.—The number of electrons emitted from the cathode in a vacuum tube is dependent upon the temperature of the cathode, and in the case of a diode the rate at which these electrons are attracted to the plate is determined by the positive potential applied to the plate. Assuming a fixed-plate voltage, the space current will rise as the temperature of the cathode is increased until a point is reached when an increase in cathode temperature will have no effect on the space current. This occurs when the cathode is emitting more electrons than are being attracted by the plate and consequently free electrons surrounding the cathode being themselves negatively charged tend to repel the similarly charged electrons leaving the cathode and so counteract further emission. This is called the space charge effect. If a third element called the control grid is inserted between the cathode and plate, the space charge effect can be controlled by the voltage on this grid.

Amplification Factor.—The amplification factor (μ) is the measure of the amplification of which a tube is capable and is numerically equal to the ratio of the change in plate voltage (dEp) required to effect a given change in plate current, to the small change in grid voltage (dEg) necessary to produce the same change in plate current; all other electrode values being maintained constant.

That is, $\mu = dEp/dEg$.

Thus if a 10-volt change in plate voltage is necessary to produce the same change in plate current as a 0.1-volt change in grid voltage, then

$$\mu = 10/0.1 = 100.$$

Mutual Conductance.—The mutual conductance (gm) or grid-plate transconductance of a tube is the rate of change of plate current (dIp) with respect to a small change in grid voltage (dEg), all other electrode values being maintained constant.

That is, $gm = dIp/dEg$.

The mutual conductance is expressed in micromhos (microamperes per volt) and is also equal to μ/RP where RP is the plate resistance of the tube. It provides an indication of the design merits of the tube and actually represents the slope of the plate current-grid voltage characteristic curve.

Negative Feedback.—When some of the amplified energy in the output of a circuit employing electron tubes is coupled back to the input circuit to be re-amplified this process is called "feedback." If the impulses fed back are in phase with the input signal, the feedback is said to be positive. If the energy fed back is in phase opposition to the input signal the feedback is said to be negative, and since the resultant grid voltage is lower in the case of negative feedback the amplification is decreased. Negative or inverse feedback can be applied to one stage of amplification or a number of stages as a whole.

(b) By constructing an amplifier with a higher gain than is required for the particular application, and then using negative feedback to offset this high gain a greatly improved amplifier is obtained. The advantages of negative feedback are:—

(i) Change of tubes in the amplifier circuit will not materially affect the gain.

(ii) Gain of amplifier is unaffected by slight changes in filament and plate supply voltages.

(iii) The gain frequency characteristic can be made "flat" over a very wide range of frequencies. Alternatively, the feedback circuit can be employed for equalisation purposes if required.

(iv) The harmonics produced by the amplifier are considerably reduced.

(v) The maximum power output for a certain percentage harmonic distortion is increased and the gain load curve considerably improved.

(vi) The noise level is reduced.

(vii) Output and input impedances can be controlled and these impedances are substantially independent of tube changes and supply voltage variations.

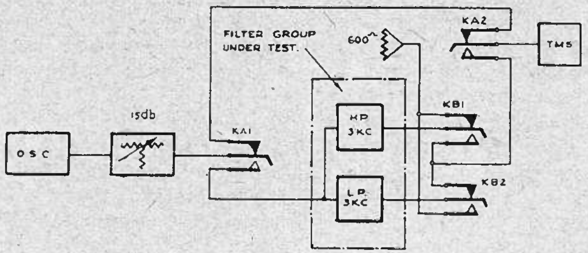
Q. 2.—You are required to measure the frequency-loss characteristics of a 3 kC high and low pass filter group. Describe the testing equipment you would require and give a diagram illustrating the test circuit

you would employ. Describe the procedure of the tests and state what precautions would be necessary to ensure correct results.

A.—The items of testing equipment required to perform the tests are:—

- (a) Variable frequency oscillator to cover a frequency range of 100 C/s to 50 kC/s with an output impedance of 600 ohms. The output should be free from harmonics.
- (b) Transmission Measuring Set suitable for operation over above frequency range.
- (c) Variable attenuator—600 ohms.
- (d) 600 ohm termination.
- (e) Switching keys.

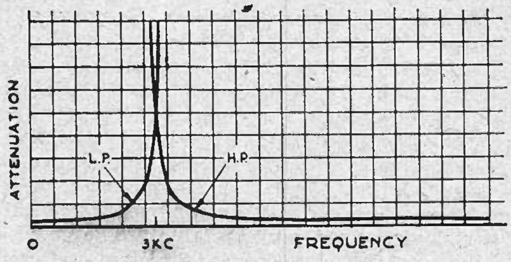
Fig. 1 shows in block schematic form the arrangement of the equipment.



Q. 2, Fig. 1.

Testing Procedure: With the keys in the position shown in Fig. 1 the oscillator frequency is set at 100 C/s and the attenuator adjusted until a suitable output is indicated on the transmission measuring set. A convenient figure in this case would be 1 mW. KA is then operated and in this position the signal is measured through the L.P. filter. The difference between the two readings on the T.M.S. represents the loss through the L.P. filter, and this figure should be very low at 100 C/s. The operation of KB inserts the H.P. filter in the testing circuit and again the T.M.S. reading is noted. The loss through the H.P. filter should be high at this frequency.

The above procedure is repeated at intervals of 200 C/s up to 2500 C/s, after which measurements should be made at 100 C/s intervals up to 3.5 kC/s so that the slope of the cut off of each filter may be determined. Subsequent measurements are made at 0.5 kC/s intervals up to 50 kC/s. A gradual increase in attenuation of the L.P. filter will be noted as the nominal cut-off frequency of 3 kC/s is approached, and between this frequency and 3.5 kC/s approximately a progressive decrease in attenuation of the H.P. filter will be observed. The attenuation frequency characteristics exhibited by the filter group under test should approximate the shape of the curves shown in Fig. 2.



Q. 2, Fig. 2.

Precautions:

(a) The tests should be conducted with the filters connected as a group as shown in Fig. 1.

(b) When the L.P. filter is being tested the H.P. filter should be terminated in 600 ohms and vice versa.

(c) The output of the oscillator should be checked on the T.M.S. at each testing frequency.

(d) If the oscillator output contains harmonics, false readings may be obtained through the H.P. filter at frequencies within the pass range of the L.P. filter, especially between 1500 C/s and 3 kC/s. These effects can be minimised by the insertion of a 3 kC/s L.P. filter between the oscillator and the variable attenuator at the frequencies concerned.

(e) If the impedance characteristics of the filter group vary with frequency, reading errors in the pass range of each filter due to this cause may be minimised by ensuring that the loss in the attenuator is at least 15 db. and also by inserting an additional variable attenuator set at 15 db. between the filters and the measuring equipment. This provides masking impedances sufficient to enable reasonably accurate results to be obtained.

Q. 3.—(a) Define the terms "decibel," and "the transmission equivalent of a circuit." Why is it that loss measurements referred to a level of 6 milliwatts are approximately 8 db. less than when referred to a level of 1 milliwatt?

(b) The input of an amplifier having 600 ohm input and output impedances is connected to a sine wave generator of equal impedance, and the output of the amplifier is terminated in a 600 ohm load impedance. The generator output is 30 db. below 1 milliwatt and the gain of the amplifier is adjusted until the amplifier is dissipating 1 watt into the load. Determine the gain of the amplifier.

A.—(a) **Decibel.**—The decibel notation is used to express the relative magnitude of two amounts of electrical power. When the common logarithm of the ratio of any two quantities of electrical power is unity the difference in level between them is defined as 1 bel. The bel is too large for practical purposes and consequently the decibel, which is 1/10th of a bel, is employed. For two electrical powers P1 and P2 the difference in level between them expressed in the decibel notation is given by:

$$\text{decibel (db)} = 10 \log_{10} (P_1/P_2).$$

If the impedance at both power levels is the same, then the difference in level may be calculated thus:

$$\text{db} = 20 \log_{10} (E_1/E_2) \text{ or } 20 \log_{10} (I_1/I_2)$$

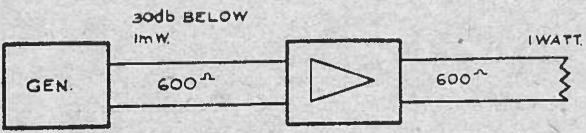
where E and I are voltage and current respectively.

Transmission Equivalent.—In general, the power transmitted along a telephone circuit is subjected to both losses and gains, the former due to lines, exchange and other apparatus, the latter due to amplifying equipment. The resulting net efficiency of transmission is known as the overall "Transmission Equivalent" of the circuit and is computed by prefixing the appropriate signs to the various losses and gains and determining their algebraic sum. If the resulting quantity is positive there is an overall gain, and if negative there is an overall loss.

Levels of 6 mW and 1 mW respectively represent a fixed ratio of 6 : 1 and, therefore, any measurement referred to either one of these reference levels may be expressed in terms of the other by the use of the following conversion figure:

$$\begin{aligned}\text{db.} &= 10 \log_{10} (6/1) \\ &= 10 \times 0.7782 = 7.782 \text{ db.} \\ &= 8 \text{ db. approx.}\end{aligned}$$

Thus, a measurement of —10 db. with respect to 1 mW is —18 db. with respect to 6 mW, and similarly a measurement of $+10$ db. with respect to 1 mW is $+2$ db. with respect to 6 mW.



Q. 3, Fig. 1.

(b) The conditions of the problem are shown in Fig. 1.

The output power referred to 1 mW is:

$$\text{db.} = 10 \log_{10} (P_1/P_2) \text{ where } P1 = 1 \text{ watt and } P2 = 1 \text{ mW.}$$

$$\therefore \text{db.} = 10 \log_{10} (1/0.001) = 10 \log_{10} 1000 = 30 \text{ db.}$$

Therefore, the power measured at the output of the amplifier is $+ 30$ db. with respect to 1 mW. The gain of the amplifier is $+ 30 - (-30) = 60$ db.

SECTION II.

Q. 1.—One channel of a three-channel carrier telephone system equipped with normal 1,000 c.p.s. ringers is reported faulty due to intermittent bursts of 17 c.p.s. current during conversations. Discuss the possible causes of the trouble and describe the steps you would take to rectify the fault.

A.—The 1000 C/s ringer is normally in circuit across the line during conversations and consequently it is necessary to include a guard feature in the design of the ringer to ensure that only pure 1000 C/s or 1000/17 C/s applied to the channel will cause the ringer to transmit 17 C/s to the switchboard. Intermittent bursts of 17 C/s during conversations indicates that the guard feature is not functioning correctly, thus allowing the ringer to operate on speech currents.

It is assumed that the ringer under consideration is of the type which includes two tuned circuits in the output of the ringing receiver. The first is sharply tuned to 1000 C/s and will respond only to a pure tone of this frequency or 1000/17 C/s. The output of this tuned circuit is applied to a rectifier bridge to operate a relay which sets up the condition to transmit 17 C/s to the switchboard. The other tuned circuit is anti-resonant at 1000 C/s and the output of this circuit is applied to another rectifier bridge containing a guard relay. When frequencies other than 1000 C/s, such as those which occur during a conversation, are applied to the channel at a level sufficient to be capable of energising the ringer, they are accepted by the anti-resonant circuit and the guard relay operates to prevent 17 C/s from being transmitted to the switchboard.

In order to prevent false operation of the ringer upon receipt of short bursts of 1000 C/s which may occur during speech, a delay is introduced in the relay train which applies 17 C/s to the switchboard.

The faulty condition reported in this case could be caused by a failure of the guard circuit or the relay delay circuit. Alternatively, an excessively high level on the channel concerned, excessive channel noise, or channel interference may render the guard circuit ineffective.

In order to isolate the trouble it would be advisable to first check the line-up and noise level of the channel and make adjustments as necessary. Assuming, however, that the fault is in the ringer, the correct procedure is to patch the ringer out of service and insert a spare ringer in its place. This will provide service on the channel while the fault is being located.

The delay and guard circuits would then be tested with the aid of the facilities provided on the ringer test panel.

Delay Circuit: The time response of the ringer is tested by the application of a test tone of 1000 C/s to the line side of the ringer for periods of 0.4 sec. and 0.7 sec. through the agency of a telephone dial associated with the ringer test panel. In this test condition the full operation of the ringer for the application of 17 C/s to the switchboard is indicated by the lighting of a lamp on the ringer test panel. The lamp should not light when the tone is applied for 0.4 sec., but should light momentarily when the tone is applied for 0.7 sec. If these conditions are not obtained it will be necessary to check the relays concerned for faulty operation and make adjustments as required.

Guard Circuit: This may be tested by using a convenient telephone circuit in the carrier station as a medium for the application of speech to the line side of the ringer at a level approximating that of the channel. If the ringer operates fully to apply 17 C/s to the switchboard during this test it will be necessary to check the operation of the guard relay and associated equipment in the guard circuit until the source of the trouble is located.

An alternative method of checking the guard circuit would be to use a variable frequency oscillator as a source of energy for the observation of the response of the ringer to frequencies in the V.F. range.

Q. 2.—Describe the functions of the following equipment when used in conjunction with a three-channel carrier telephone system:—

- **(a) Equalisers between the receive directional filter and the receiving line amplifier.**
- **(b) Volume limiters.**
- **(c) Balance networks.**

A.—(a) One of the factors which tends to decrease the intelligibility of telephone speech is unequal attenuation of different frequencies as they are transmitted over various circuits. For example, the attenuation of a non-loaded open wire circuit is greater for the higher frequencies than for the lower frequencies and this difference in attenuation is directly proportional to the length of the line. Therefore, on long circuits it is frequently necessary to employ attenuation equalisers to correct the unequal attenuation of the line. An equaliser consists of a network of inductances and capacitances so arranged that the attenuation v. frequency response of the network is the inverse of that encountered on the normal aerial or cable circuits concerned.

In a three-channel telephone system the equalisers between the receive directional filters (RDF) and the receiving line amplifier are employed for the purpose of correcting the unequal attenuation of the line (and certain equipment) so as to maintain the level on all channels substantially equal at the input to the receiving amplifier. These equalisers are separated into two main parts, viz., fixed and variable. The fixed equaliser is designed to compensate for any distortion introduced by the attenuation v. frequency characteristics of the R.D.F. preceding the equaliser, and the transmitting directional filter (T.D.F.) at the distant terminal or repeater, and also to compensate for the frequency v. attenuation characteristics of a fixed length of open wire line over the band of frequencies being received. The variable equaliser is for the purpose of making adjustments upon installation, and subsequently as necessary, to suit the length and characteristics of the actual line section preceding the particular terminal or repeater.

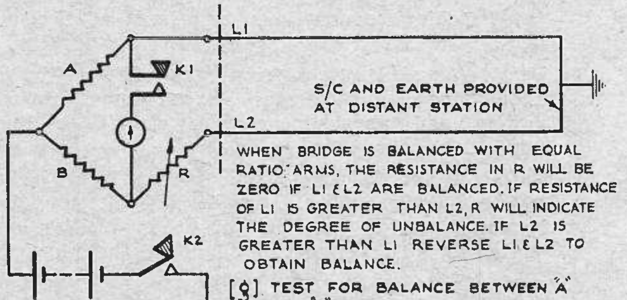
(b) The characteristics of metal rectifiers used as modulators require that the voice input voltage shall be low in comparison with the applied carrier voltage. Fixed pads are employed in some systems between the hybrid coil and the modulator on each channel to reduce the level of the V.F. to a suitable value, but it is usual to precede modulators of this type with a volume limiter whose function is to keep the V.F. input voltage to the modulator from exceeding a predetermined value regardless of the level delivered by the subscriber. Volume limiters usually take the form of neon tubes or metal rectifier elements. At signal amplitudes below those at which limiting takes place the volume limiter produces negligible loss in the speech circuit.

In cases where one channel of a three-channel system is used for V.F. telegraph transmission, pads are preferred to the volume limiter on this channel, as the latter may cause mutilation of the telegraph signals, but it is important that the other two channels be fitted with volume limiters to prevent peaks of V.F. from the speech circuits from interfering with the telegraph signal frequencies.

(c) In order to couple together the V.F. transmitting and receiving sides of each carrier channel for connection to the two-wire line to the switchboard, it is necessary to employ a 2 wire-4 wire terminating network or hybrid coil. The efficiency of the hybrid coil depends upon the amount of loss which can be introduced between the receiving side and the transmitting side of the 4-wire circuit. This loss would be infinite under the conditions that the impedance of the 2-wire V.F. line is accurately matched by an artificial network connected to the hybrid coil. This network is known as a balance network and in a carrier system, where the equivalent of 4-wire working is obtained from terminal to terminal by the grouping of the send and receive carrier frequencies, a simple series network consisting of 600 ohms and $2\mu F$ is a reasonable simulation of the 2-wire V.F. circuit.

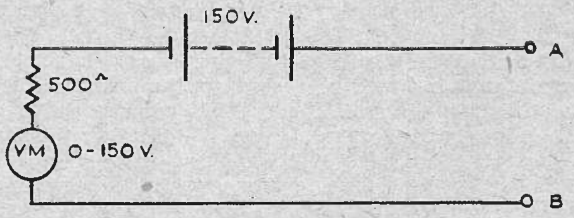
Q. 3.—(a) A physical open wire trunk circuit terminating on a combined bridge and voltmeter trunk test board is reported out of order. Describe the tests you would carry out to ascertain the nature of the fault.

(b) Assuming that one side of the circuit is earthed, describe the test employed to locate the position of the fault. Give a diagram of the bridge circuit and derive the formula applicable.

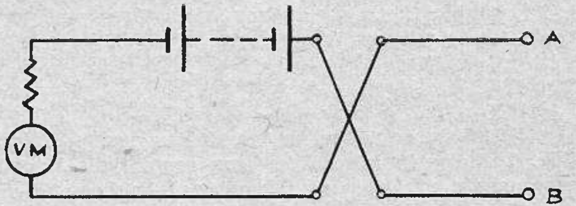


WHEN BRIDGE IS BALANCED WITH EQUAL RATIO ARMS, THE RESISTANCE IN R WILL BE ZERO IF L1 & L2 ARE BALANCED. IF RESISTANCE OF L1 IS GREATER THAN L2, R WILL INDICATE THE DEGREE OF UNBALANCE. IF L2 IS GREATER THAN L1 REVERSE L1 & L2 TO OBTAIN BALANCE.

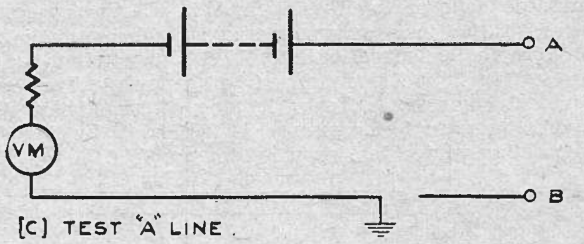
[g] TEST FOR BALANCE BETWEEN "A" AND "B" WIRES.



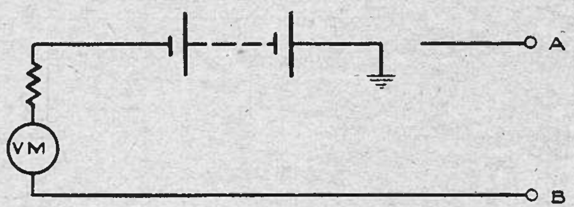
[a] TEST PAIR.



[b] TEST PAIR - LINE REVERSED.

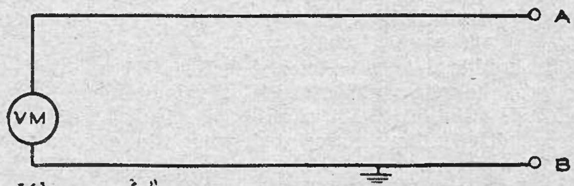


[c] TEST "A" LINE.



[d] TEST "B" LINE.

[e] TEST PAIR—FOREIGN BATTERY.



[f] TEST "A" LINE—FOREIGN BATTERY.

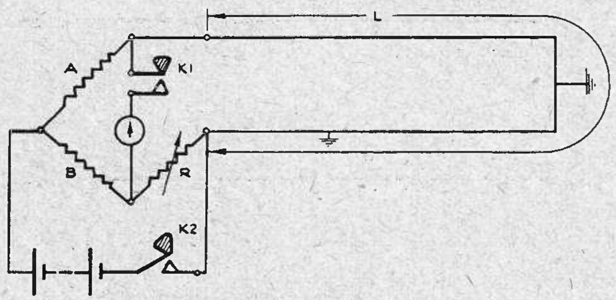
Q. 3, Fig. 1.

A.—(a) When a trunk line is reported out of order a fault docket is received by the engineering staff, and in a large centre the trunk-line master card is attached to the fault docket and passed to the testing officer, who first makes a preliminary test to ascertain if the fault is in the line or equipment. Assuming the fault to be in the line, the testing officer proceeds to test the line after first making any patching arrangements as necessary. Line tests are made from the LINE jacks of the trunk test board (T.T.B.), using the voltmeter test set and bridge to determine if the fault is any of the following:—

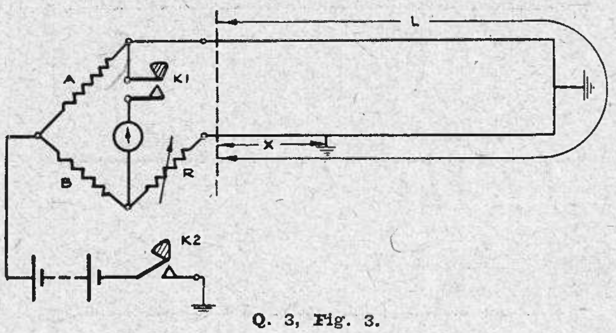
(i) Short circuit or loop between A and B wires.
(ii) Contact between one or both wires and earth.
(iii) Cross with another pair.
(iv) Open circuit.
(v) L.I.R.
(vi) Foreign Battery.
(vii) Unbalance between A and B wires.

Fig. 1 shows in schematic form some typical testing arrangements available at a combined bridge and voltmeter T.T.B.

(b) The position of an earth fault may be located by using the Varley Loop Test which, by the operation of the appropriate keys on the T.T.B., sets up the conditions shown in Figs. 2 and 3. Before proceeding with the tests arrangements should be made for the line to be looped on the T.T.B. or patch panel at the station immediately beyond the fault. The location test could be made by looping at the distant terminal, but greater accuracy is obtained by keeping the section under test as short as possible.



Q. 3, Fig. 2.



Q. 3, Fig. 3.

After having checked to ascertain that no stray currents exist on the loop, the first test to be made is the loop measurement, the conditions for which are shown in Fig. 2. In this case the bridge is balanced when $AR = LB \therefore L = AR/B$, and if the ratio arms A and B are equal, then $L = R$.

K2 should always be closed before K1 so that the line will be charged before the galvanometer circuit is closed. Similarly, K1 should be released before K2. The sensitivity keys associated with the galvanometer should be operated progressively as the balance condition is approached.

When the loop reading is determined the appropriate keys on the T.T.B. are operated to obtain the conditions shown in Fig. 3. A balance is obtained when

$$B\,(L - X) = A\,(R + X)$$
$$\therefore BL - BX = AR + AX$$
$$\text{and } AX + BX = BL - AR$$
$$\therefore X = (BL - AR)/(A + B).$$

When the ratio arms A and B are equal

$$X = \tfrac{1}{2}\,(L - R).$$

The resistance of the fault forms part of the battery circuit and, therefore, does not affect the location test, provided that the resistance is low compared with the normal I.R. of the line. When the balance condition is reached the reading is checked by reversing the polarity of the testing battery, and having obtained a resistance value of X, which is the resistance of the faulty wire from the testing office to the fault, the distance to the fault can then be computed from the line data recorded on the trunk-line master card.

The formula $X = \frac{1}{2}(L - R)$ is the fundamental Varley loop formula for equal ratio arms and can be applied to a circuit even though the two wires of a pair are of unequal resistance.

Where it can be safely assumed that the two wires of a pair are of equal resistance a simplification is possible and the formula reduces to $X = L - R$. In order to obtain the distance to the fault in this case, it is necessary to divide the loop resistance to the fault by the loop resistance per mile of the wire gauge concerned.

In the former case, where $X = \frac{1}{2}(L - R)$ it is necessary to divide the single wire resistance to the fault by the single wire resistance per mile of the wire gauge concerned.

Q. 4.—(a) Fig. 1 attached represents in single wire form the Nelson office circuits of lines 1040/1, 95/6, 277/8, and 10/11. Line 1040/1 is proved open circuit and it is necessary to preserve service on the following circuits:—

(a) Telephone traffic circuits—
Nelson-Waterloo Nos. 1 and 2;
Nelson-Wellington Nos. 1, 2 and 3;
Waterloo-Wellington No. 1.
(b) The physical program circuit.
(c) Cailho Morse No. 2.

List the patching connections you would carry out in the Nelson office assuming that line 95/6 is available as a spare high pass circuit; e.g., patch jacks 50L to jacks 81D, etc. In making these patches what terminations would be necessary and what precautions would you take in using the patch cords?

(b) Referring to Figs. 2, 3 and 4 attached, give a list of errors, if any, in each circuit. Supporting reasons for any necessary corrections are required.

A.—(a) Patching connections required at Nelson office:—

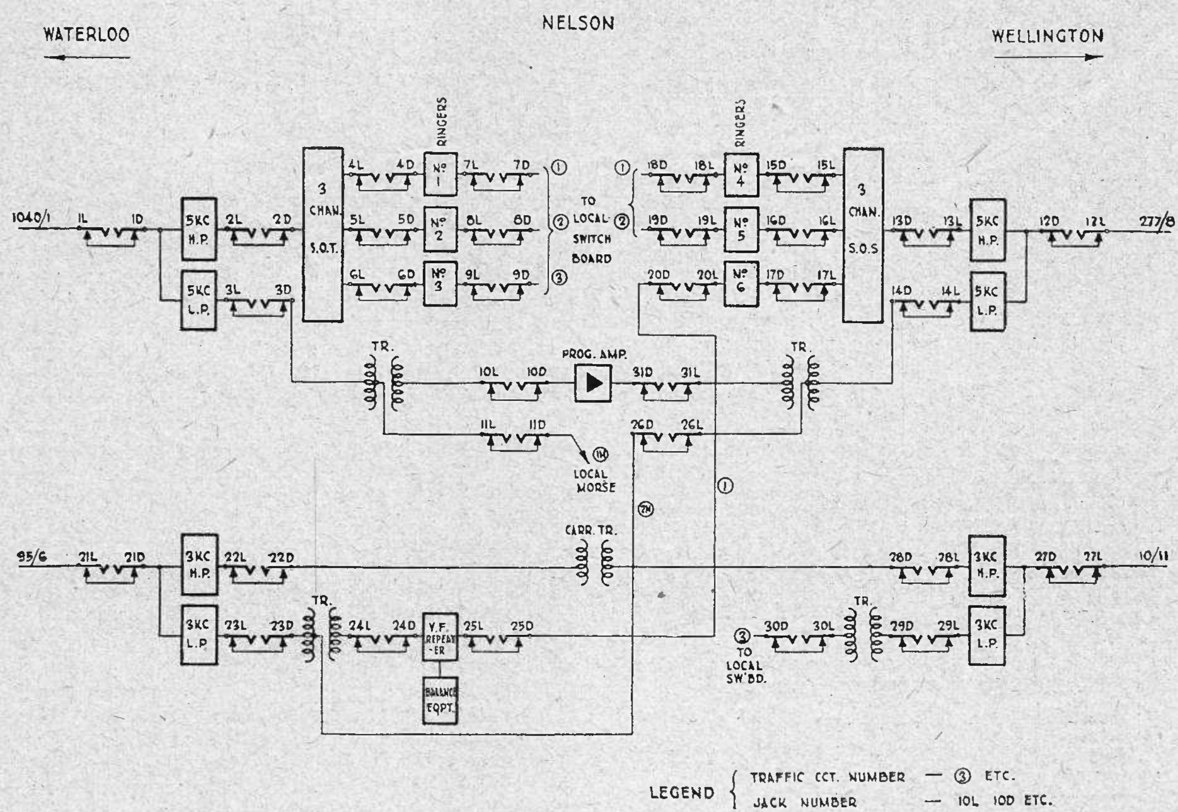
(1) Patch A and B wires from jacks 21L to jacks 1D. This transfers the three-channel S.O.T. system and physical program circuit to line 95/6.

(2) Patch A and B wires from jacks 6L to jacks 17L. This provides a carrier circuit for the Nelson-Waterloo section of the Wellington-Waterloo No. 1 circuit in place of the physical

circuit which was disconnected when No. 1 patch was made.

(3) Patch from jack 11L to jack 26L (single wire) to restore Cailho Morse No. 2.

(4) Place 600 ohm terminations in jacks 24D and 25L to prevent V.F. repeater from singing.



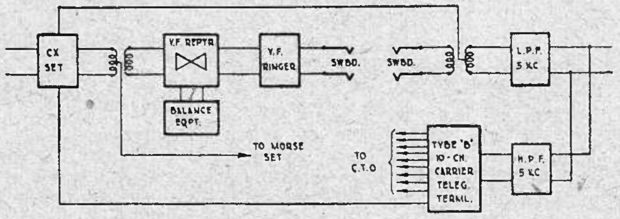
Q. 4, Fig. 1.

Precautions:

(i) Ensure that all patching cords are in good condition.

(ii) In using the patch cords for (1) and (2) above, it would be necessary to ensure that the A and B sides of the lines are not reversed.

(iii) Patches 1, 2 and 3 should be done simultaneously, with similar appropriate patches at Waterloo by arrangement with the officer concerned at that station.

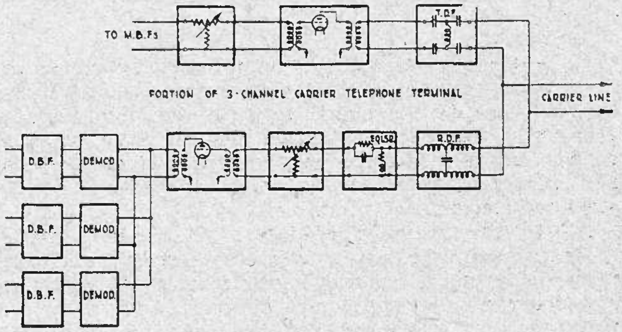


Q. 4, Fig. 2.

(b) **Fig. 2.** (1) The line filters shown should be 3 kC/s in lieu of 5 kC/s. A type "B" carrier telegraph system transmits a band of frequencies of 3.3 to 5.5 kC/s in the B-A direction and 6.5 to 10.25 kC/s in the A-B direction. The 5 kC/s filter group shown would cut off most of the frequencies in the B-A direction.

(2) The cailho telegraph circuit shown in conjunction with the C.X. set is incorrect. The C.X. set allows the use of each leg of the line as an earth return telegraph circuit and consequently prevents the use of the cailho circuit for D.C. operation.

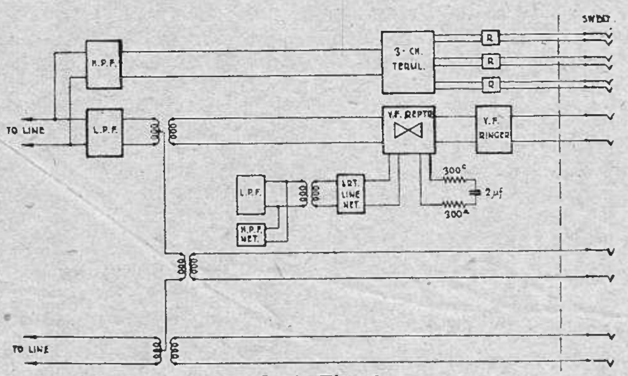
(3) The duo-directional channel of the type "B" telegraph system should be connected through a telegraph repeater for duplex working via the C.X. set.



Q. 4, Fig. 3.

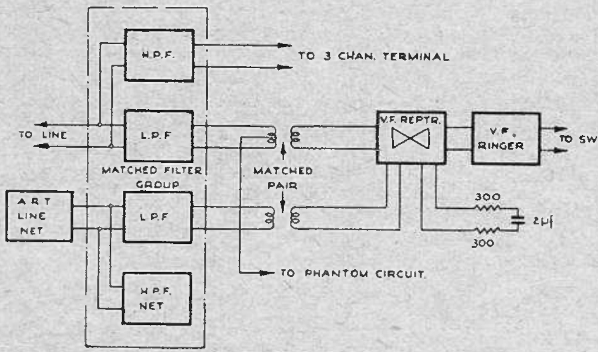
Fig. 3. (1) The demodulators and demodulator band filters (D.B.F.) are reversed in position. It is necessary to separate the three-channel frequency bands by means of the D.B.F.'s before demodulation takes place.

(2) A transformer should be inserted between the R.D.F. and the equaliser. The equaliser is of the unbalanced type and the transformer is necessary to isolate the equaliser from the line and provide a correct termination for the R.D.F.



Q. 4, Fig. 4.

Fig. 4. (1) The balance network on the line side of the V.F. repeater is shown incorrectly. In order to obtain an accurate balance of the line equipment and the line, the elements comprising the network should bear the same relationship to the hybrid coil as the line equipment. The correct method of connection is shown in Fig. 5.



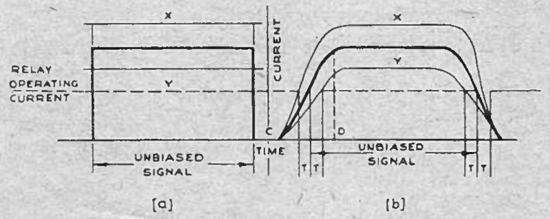
Q. 4, Fig. 5.

(2) A filter group or equivalent network to match the filter group shown is required on the second line comprising the phantom group in order to balance the phantom circuit.

Q. 5.—In any voice frequency telegraph channel why is it necessary to control, within fairly close limits, the received carrier signal level at the input to the detector? Describe the action of the A.V.C. feature of any amplifier detector with which you are familiar and illustrate your answer with a diagram of the essential elements of the circuit.

A.—In carrier telegraph transmission where carrier is transmitted during a marking element and suppressed during a spacing element the equivalent of single current transmission is obtained, and the receive relay requires a bias (either mechanical or electrical) in order to restore its tongue to the spacing contact on cessation of a marking signal. As the restoring force is fixed when the channel is lined up for operation by reversals transmitted from the distant terminal, any subsequent variations in received signal level will result in bias distortion.

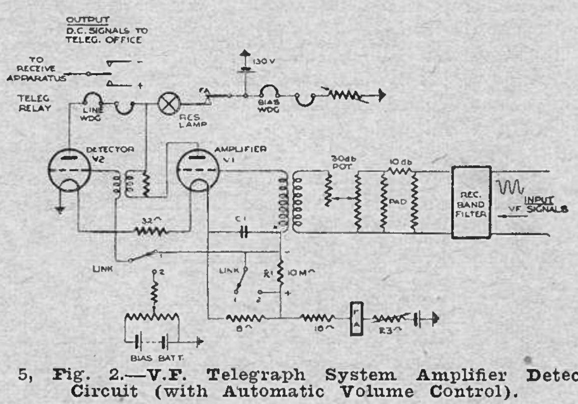
In V.F. telegraph working the necessity for maintaining constant amplitude of the received signals is dependent upon the shape of the signal envelope. If the signal were square topped in form, as shown in Fig. 1 (a), the bias distortion introduced by small changes in amplitude would be zero, whereas when the signal envelope is of sinusoidal shape small changes in amplitude are sufficient to cause considerable distortion.



Q. 5, Fig. 1.

The signal applied to the channel band pass filters takes a definite time to build up to a steady state value. The extent of the building-up time is largely a function of the filter characteristics and increases with reduction of filter bandwidth. This building-up time causes the applied signal to be tapered and the resultant effect of line-level variations on the rectified current is shown in Fig. 1 (b), where the horizontal dotted line represents the steady bias condition and indicates the point where the incoming signal strength is sufficient to operate the receive relay from space to mark. With respect to the normal line-up signal, the effective mark signal (X) commences earlier and finishes later, whereas signal (Y) commences later and finishes earlier, with a resultant distortion in either case equal to 2T. (It will be appreciated that in Fig. 1 (b) one particular fixed bandwidth having a constant building-up time represented by C, D, is dealt with and, therefore, any change in the amplitude of the applied signal will produce a change in the slope of the signal envelope as indicated.)

It is evident, therefore, that some form of regulation is necessary in order that signals of constant amplitude are applied to the receive relay. This can be achieved either by ensuring that the telephone bearer circuit is held regulated to very close limits or by incorporating a level control feature in the telegraph system.



Q. 5, Fig. 2.—V.F. Telegraph System Amplifier Detector Circuit (with Automatic Volume Control).

The essential elements of the A.V.C. feature of a typical amplifier detector is shown in Fig. 2. The unit comprises a high-gain amplifier tube, V1, followed by a detector, V2, and links 1 and 2 provide for the A.V.C. to be disconnected from the circuit. When the links are in the position as shown, the input level to the detector determines the grid bias of the amplifier stage. In this position the bias for both tubes is derived from point X in the sketch so that, under static current conditions, the normal bias on the detector will be 12 volts with respect to the filament, whilst that on the amplifier will be approximately 2 volts.

A normal signal amplified by V1 makes the grid of V2 slightly positive, with the result that grid current flows in V2 via resistor R1. This flow of current through R1 causes a voltage drop across it which increases the negative bias across V1 and thus reduces the amplification of this tube. This negative bias will be reduced to a more normal value during an interruption to the incoming carrier, provided that the interruption is of sufficient duration to allow condenser C1 to discharge through R1. The capacity of C1, however, and the resistance R1 ensure that C1 will hold its charge for a time at least equal to the time length of the maximum telegraph spacing signal. The flow of detector grid current through R1 also affects the grid bias voltage of V2 slightly, but the change from its normal value of 12 volts is not large enough to move its operating point appreciably and, therefore, the effect on the signals delivered is negligible. If the level of the signal input to V1 increases, the grid bias on V1 is further increased and the gain is reduced accordingly. On the other hand, if the incoming signal decreases, the grid current through R1 is reduced, the condenser C1 discharges slightly, and the gain of the amplifier tube is increased.

By this means a constant output is obtained from V2 over a wide working range.

EXAMINATION No. 2473.—ENGINEER—LINE CONSTRUCTION

J. W. Pollard, B.Sc.

GROUP 1—GENERAL

Q. 1.—Tabulate the principal likely causes of deterioration of underground cable sheathing under the following headings only:—

(i) Electrolysis.
(ii) Chemical Corrosion.
(iii) Intercrystalline Fracture (fatigue).

A.—(i) Electrolysis.

(a) Stray traction currents from railway and tramway services.
(b) Currents from D.C. power supply systems.
(c) Fire-alarm systems.
(d) Telephone exchange currents such as P.B.X. and R.A.X. battery charging.
(e) Telegraph and signalling currents.
(f) "Galvanic" or "long-line" currents due to differences in soil conditions.
(g) Local action in a cell composed of an iron pipe and a lead cable sheath and with an alkaline solution as electrolyte.

(ii) Chemical Corrosion.

(a) Acetic acid from decaying wood.
(b) Contact with fresh cement.
(c) Drainage from stables or other contaminated sources.
(d) Ashes and cinders.
(e) Corrosive soils, both alkaline and acidic.

(iii) Intercrystalline Fracture (fatigue).

(a) Excessive handling and bending of cable.
(b) Vibration of ducts in roadway or on bridges due to heavy traffic.
(c) Expansion and contraction of lead sheath when exposed to direct rays of the sun, such as on walls.
(d) Vibration of aerial wires transmitted to cable on cable head poles and affecting cable underneath the cable box.
(e) Continued rocking of cable head pole causing fatigue at foot of pole.
(f) Transport of cable on drums for long distances.

Q. 2.—Detail the methods of preservative treatment you would recommend for the following items of line plant:—

(i) Wooden Crossarms.
(ii) Steel Bolts and Spindles.
(iii) Wooden Poles.
(iv) Steel Poles, namely—rails, girders and pipes.

Explain briefly the principal causes of deterioration you would require to guard against in each case, assuming average city and country atmospheric conditions.

A.—(i) Wooden Crossarms.

Deterioration of wooden crossarms is caused mainly by decay and fungus growths and chiefly occurs around the section where the arm is in contact with the pole. This deterioration can be largely prevented by the use of creosote, which is fairly cheap, readily obtainable and easy to apply. Before issue from the store the arms shall be creosoted and except in dry areas all cut faces and bolt holes should be treated with creosote. After cutting the joggle in the pole, creosote is applied to the pole before fitting the arm. In addition to preventing decay and fungus growths, creosoting will also prevent attack by termites.

(ii) Steel Bolts and Spindles.

The chief cause of corrosion in this case is rusting due to atmospheric conditions. In some cases, such as beside the sea, chemical corrosion will also occur. To prevent this corrosion, all steel fittings are galvanized by the hot-dip process.

(iii) Wooden Poles.

As for wooden arms the main causes of deterioration are decay, fungus growths and termite attack. Wooden poles erected in wet areas are more liable to attack by decay than those in drier localities, and consequently such conditions call for more effective treatment to obtain the maximum life from the poles. The severity of termite attack varies in different districts and is dependent on the species found in the locality. In bad areas attack is very severe and can quickly weaken a pole, so that constant inspection and treatment are necessary.

The preservative used is creosote and is effective in preventing poles from decay, and except in extreme cases from termite attack.

The treatment can be divided into two sections—

(a) before and during erection of the pole;
(b) standing poles.

Where poles can be treated in main depots, the most suitable method is the hot and cold tank process and consists of immersing about 6′ of the butts of the poles for about 4 hours in a tank containing creosote heated to about 200°F. The tank is then allowed to cool and when the temperature is about 100°F. the poles are removed.

Although the penetration of creosote in hardwood poles is mainly confined to the sapwood, this layer of treated wood will prevent decay or termite attack for up to 10 years or more.

If it is not possible to apply the hot and cold tank method the pole should be placed over the hole and creosote either brushed or poured over the butt to a point which will be about 18″ above the ground when the pole is erected. When applied by this method, the creosote does not penetrate the sapwood to any great depth and re-treatment soon becomes necessary.