

COMMON SYSTEMS
"O" & "ON" CARRIER TELEPHONE
OB1, OC1, OD1 GROUP RECEIVING
OR
REPEATER AMPLIFIER CKT.
AND
ON1 & ON2 GROUP RECEIVING CKT.

CHANGES

B. CHANGES IN APPARATUS

B.1 Added (Optional)

Fig. 7

- 1 - Filter (FL2), 530AB
- 1 - Filter (FL2), 530AC
- 1 - Filter (FL2), 530AD
- 1 - Filter (FL2), 530AE
- 1 - Filter (FL2), 530AF

B.2 Superseded

Superseded by

In Fig. 1

- 1 - Varistor (CR1), 45A
- 1 - Varistor (CR1), 45G

D. DESCRIPTION OF CIRCUIT CHANGES

D.1 Fig. 7 was added to include the filters covered in B.1 above, for options "AB," "AC," "AD," "AE," and "AF."

D.2 Notes 101A, 101E and 106 were extended to include references to ON2 carrier and Fig. 7.

D.3 Connecting information was extended to include references to ON2 carrier.

D.4 In Fig. 1, the leads connected to capacitor (C1) were previously designated "D1" in error.

D.5 In Fig. 1, a designation "D3" previously associated in error with the amplifier ground lead was moved to apply to the lead connected to the bottom end of resistor (R9).

D.6 The "EQUIPMENT INFO" previously read J98703G-() in error.

D.7 The title was extended to include reference to ON2 carrier.

All other headings under Changes, no change.

1. PURPOSE OF CIRCUIT

1.1 This circuit provides the group amplification, regulation, and frequency shift for the receiving portion of a terminal, or provides the amplification, regulation, frequency shift and inversion for one direction of transmission of a repeater.

2. WORKING LIMITS

2.1 None.

3. FUNCTIONS

3.01 At a terminal or repeater and at an ON1 junction OW; provides means for selecting from or delivering to the open-wire line the high group (60-76 kc) and low group (40-56 kc) frequencies in the OB1 group, or the high group (100-116 kc) and low group (80-96 kc) frequencies in the OC1 group, or the high group (140-156 kc) and low group (120-136 kc) frequencies in the OD1 group.

3.02 Receives the low group frequencies or high group frequencies at a variable level, and provides a variable gain amplifier in order to deliver these frequencies to the modulator at a constant level.

3.03 At a repeater; provides a modulator to frequency shift and invert the low group frequencies to the high group frequencies or vice versa.

3.04 At a junction or at a terminal; provides a modulator to frequency shift and invert either the low group frequencies or the high group frequencies to the base band frequencies, (180-196 kc).

3.05 At a repeater; provides a fixed amount of amplification for the modulated signals, in either the low group band or high group band.

3.06 At a junction or at a terminal; provides a fixed amount of amplification for the modulated signals in the base band frequency range (180-196 kc).

3.07 Provides means for adjusting the gain of the amplifier over a 3 db range as a factory adjustment.

3.08 Amplifies and rectifies a portion of the output in order to provide automatic gain control for regulation.

3.09 Provides means for injecting a masking noise source into the transmission path at a terminal.

3.10 Provides means for measuring space current of three of the four tubes.

3.11 Means are provided so that the filaments of the tubes may be operated off either the -48 or +130V office battery.

4. CONNECTING CIRCUITS

4.1 At a Repeater:

4.11 Application Schematic "O1" Carrier Repeaters - SD-95155-01

4.12 O1 Repeater Osc, Misc Osc ON1 & ON2 Misc. Osc Ckt. - SD-95158-01

4.2 At a Terminal:

4.21 Application Schematic O1, ON1 & ON2 Carrier Terminal - SD-95150-01

4.22 OBI, OCI, ODI, ON1, & ON2 Group Transmitting Ckt. - SD-95153-01

4.23 O1 Terminal Group Oscillator ON1 & ON2 Group Oscillator Ckts., - SD-95154-01

4.24 O1, ON1 & ON2 Twin Channel Carrier Ckt. - SD-95151-01

4.25 ON1 or ON2 Combining Network and Oscillator Ckt. - SD-95198-01

4.3 At a Junction:

4.31 Application Schematic for ON1 Junction Group 1 - SD-95196-01

4.32 Application Schematic for ON1 Junction Groups 2 & 3 or Groups 4 & 5 - SD-95197-01

4.33 O1 Terminal Group Oscillator and ON1 Group Oscillator Ckts. - SD-95154-01

4.34 O1 Repeater Oscillator and Misc Osc and ON1 Misc Osc Ckts. - SD-95158-01

DESCRIPTION OF OPERATION

5. GENERAL

5.1 This subunit (Fig. 1), when used in conjunction with Figs. 2 and 3, and combined with a similar unit and a repeater oscillator circuit forms a two-way repeater for either the OBI, OCI or ODI group. Figs. 2 and 3 when plugged into Fig. 1, as covered in circuit notes, establishes the unit as either a low-to-high repeater (low group frequencies received from the line and high group frequencies retransmitted to the line) or a high-to-low repeater (high group frequencies received from the line and low group frequencies retransmitted to the line).

5.2 Fig. 1 when used in conjunction with Fig. 2 and Figs. 4 or 5 and with the Group Oscillator Ckt. forms a group receiving circuit for either the OBI, OCI, or ODI group. Fig. 2 and either Figs. 4 or 5 when plugged into Fig. 1, as covered in circuit

notes, establishes the unit as either a low group receiving circuit (low group frequencies received from the line) or a high group receiving circuit (high group frequencies received from the line).

5.3 Fig. 1 when used in conjunction with Fig. 2 and Figs. 4 or 5 and with the Group Oscillator Ckt. forms a group receiving circuit for the open-wire side of the ON1 junction for groups 1, 2, 3, 4, and 5. Fig. 2 and either Figs. 4 or 5 when plugged into Fig. 1 as covered in circuit notes, establishes the unit as either a low group receiving circuit or a high group receiving circuit of an OB, OC, or OD system to work with the open-wire line.

5.4 Fig. 1 when used in conjunction with Fig. 6 and Figs. 4 or 5, and with the ON1 Misc. Osc. Ckt., forms a group receiving circuit for the cable side of the ON1 junction for groups 1, 2, 3, 4, and 5. Figs. 4 or 5 when plugged into Fig. 1, as covered in circuit notes, establishes the unit as either a low group receiving circuit or a high group receiving circuit for the group required.

5.5 Fig. 1 when used in conjunction with Fig. 6 and Figs. 4 or 5 and with the Group Oscillator Ckt. forms a group receiving circuit for the ON1 terminal for groups 1, 2, 3, 4, and 5. Figs. 4 or 5 when plugged into Fig. 1, as covered in circuit notes, establishes the unit as either a low group receiving circuit or a high group receiving circuit for the group required.

5.6 When used in the ON1 junction OW the circuit may be used as either low group receiving or high group receiving. The previous two paragraphs apply.

5.7 When used in the ON1 junction CA or in the ON1 or ON2 terminal, the receiving group connector (Fig. 6) is plugged into Fig. 1 in place of (FL1) so there is no directional selectivity. Otherwise the previous paragraphs apply.

5.8 Fig. 1, when used in conjunction with Fig. 6 and Fig. 7 and with a group oscillator circuit of appropriate frequency, forms a group receiving circuit for the ON2 terminal for groups 1, 2, 3, 4, 5, or 6.

6. FILTER CIRCUIT (FIG. 2)

6.1 The input signal is applied to the line side of (FL1) which provides attenuation to the unwanted line frequencies lying above and below either the OBI frequency group (40-76 kc), the OCI frequency group (80-116 kc), or the ODI frequency group (120-156 kc). This filter (FL1) acts as a directional filter.

When used in a low-to-high repeater or a low group receiving unit, filter (FL1)

will be plugged into Fig. 1 as indicated on the schematic. Under this condition the low group frequencies are received from the line and are applied through transformer (T1) to resistors (R1), (R2) and (R3). High group frequencies from either the output of the other repeater unit or the group transmitting circuit are applied to the line through the other section of (FL1).

When used in a high-to-low repeater or a high group receiving unit, filter (FL1) is reversed and plugged into Fig. 1. Under this condition the high group frequencies are received from the line and are applied through transformer (T1), to resistors (R1), (R2), and (R3). The low group frequencies from either the output of the other repeater unit or the group transmitting circuit are applied to the line through the other section of (FL1).

6.2 Filter (FL1) is equipped with two capacitors to provide impedance correction for transformer (T1). The filter used for the OD1 group has in addition resistors connected in parallel with the capacitors for further impedance correction in the OD1 frequency range. Due to the plug and jack arrangement either one or the other of these capacitors (or capacitors and resistors) will be bridged across (T1) whether (FL1) is plugged in normally or reversed.

7. REGULATOR, FILTER, AND DEMODULATOR CIRCUIT (FIGS. 1, 3, 4, 5, & 7).

7.1 Transformer (T1) is used as an isolating transformer to eliminate any ground loops that may result in noise or cross-talk difficulties when OB, OC, and OD systems are operated on the same open wire pair. Resistors (R1), (R2), and (R3) are arranged as a 135 to 3000 ohm, (22 db loss) pad which attenuates the input signals to the proper level for the regulating amplifier and provides impedance matching for (FL2).

7.2 Jacks (IN) & (GRD) provide test connections to the input circuit and to ground. The output of the pad is applied to either the (A) or (B) sections of filter (FL2), Figs. 3, 4, 5, or 7 depending on the required use. Section (A) of (FL2) is a band-pass filter providing additional attenuation to signals outside the low group band. Section (B) of (FL2) is a band-pass filter providing additional attenuation outside the high group band.

7.3 For a low group receiving circuit the output of the pad connects to the input of the (A) section of (FL2), Fig. 4 and its output is applied to the first grid of electron tube (V1), operated as a regulating amplifier, thus providing more selectivity for the received low group signals.

7.4 For a high group receiving circuit the output of the pad connects to the input of the (B) section of (FL2), Fig. 5, whose output is applied to the first grid of tube (V1), providing additional selectivity for the received high group frequencies.

7.5 For a low-to-high repeater Fig. 3 is connected to Fig. 1, as indicated on the schematic, and the output of the pad connects to the (A) section of (FL2), whose output is applied to the first grid of tube (V1). This provides better selectivity for the received low group frequencies.

7.6 For a high-to-low repeater Fig. 3 is reversed and plugged into Fig. 1. Under this condition the output of the pad connects to the (B) section of (FL2), Fig. 3, whose output is applied to the first grid of tube (V1). Thus more selectivity is provided for the received high group frequencies. Electron tube (V1) is operated as a regulating amplifier providing automatic gain control in order to maintain a fixed level at the input to the modulator.

7.7 The regulating amplifier consists of electron tube (V1) operated as a two-stage amplifier whose gain is inversely proportional to its input level. The gain control is obtained by amplifying and rectifying a portion of the group receiving unit or repeater output and applying the resultant dc voltage as bias to the grids of both stages of the regulating amplifier. Resistor (R4) provides a 135-ohm termination for the output of either the (A) or (B) section of (FL2) and capacitor (C1) and resistor (R5) couple this output to the first stage grid of tube (V1). The output of the first stage of (V1) is resistance-capacitance coupled to the grid of the second stage of tube (V1) by means of resistor (R6), capacitor (C6) and resistor (R8). Transformer (T2) couples the plate of the second stage of tube (V1) to the modulator. Plate power is supplied through plate filters composed of resistor (R7) and capacitor (C5), and resistor (R10) and capacitor (C7). Both cathodes are grounded and the variable grid bias is applied through a filter consisting of resistor (R9) and capacitors (C2), (C3), and (C4) to the two grid return resistors (R5) and (R8). The combination of resistor (R9) and capacitors (C2), (C3), and (C4) provide the proper time constant for the regulator circuit. The ac signal path to ground for both stages of tube (V1) is through the parallel capacitors (C2), (C3), and (C4).

8. MODULATOR AND FILTER CIRCUIT (FIGS. 1, 3, 4, and 5)

8.01 Transformer (T2) couples the output of the regulating amplifier (high side of (T2)) to a copper-oxide-varistor modulator

(low side of (T2)) consisting of varistor (CR1). Resistor (R11) tends to reduce variations of the regulating amplifier output impedance. Signals during one-half cycle of the carrier frequency flow directly to repeating coil (T3) through 1-2 and 4-5 of the varistor, while on the alternate half-cycle of the carrier the poling is reversed so that signals flow through 6-5 and 3-2 of the varistor unit and in an opposite direction through repeating coil (T3). This poling reversal at carrier frequency rate causes the impedance of the pairs of the varistor disks to have alternately low and high impedance at the carrier rate and produces lower and upper sidebands which appear at the output of (T3). The carrier for this operation is supplied from the repeater oscillator for the O repeater, from the group oscillator for the low group or high group O terminal, or ON terminal or the OW side of the ON Junction, and from the misc. oscillator for the CA side of the ON Junction. This carrier is introduced at the midpoints of the (T2) and (T3) transformer windings facing the varistor unit. With this modulator configuration the input signals are, to the degree of balance realized, excluded from the output branch; certain orders of modulation products are excluded from the input branch; certain other orders of modulation products are excluded from the output branch, and the carrier is excluded from both the input and output branches being balanced out in the local path through transformers (T2) and (T3) and the varistor unit. Of the modulation products produced by the varistor, the lower sideband is selected by either the (A), (B), (D1), or (D2) section of filter (FL2), Fig. 3, 4, 5, or 7 depending on whether the required use is (1) a type "O" low-to-high or high-to-low repeater, or (2) a type "O" low group or high group receiving circuit, or (3) depending on the "ON" group employed.

8.02 Sections (A) and (B) of (FL2) have been previously described. Sections (D1) and (D2) of (FL2), Figs. 4, 5, & 7 are band-pass filters designed to attenuate frequencies above and below the base band frequencies (180-196 kc). The (D1) and (D2) sections differ in that they have attenuation peaks corresponding to the different carrier frequencies used in order to reduce carrier oscillator leak at the output of the modulator.

8.03 For a type "O" low group receiving circuit the output of the modulator is connected to the input of the (D1) section of (FL2), Fig. 4, the output of this filter being connected to transformer (T4). The (D1) section of (FL2) selects the lower side-band product (180-196 kc) of the low group input frequencies (40-56, 80-96, or 120-136 kc) modulated by the 236, 276, or 316 kc oscillator.

8.04 For a Type "O" high group receiving circuit the output of the modulator is connected to the input of the (D2) section of (FL2), Fig. 5, the output of this filter being connected to transformer (T4). The (D2) section of (FL2) will select the lower side-band product (180-196 kc) of the high group input frequencies (60-76, 100-116, or 140-156 kc) modulated by the 256, 296, or 336 kc oscillator.

8.05 For a Type "O" low-to-high repeater the output of the modulator is connected to the input of the (B) section of (FL2). Fig. 3, the output being connected to transformer (T4). With a carrier frequency of 116, 196, or 276 kc being applied to the modulator, the (B) section of (FL2) will select the lower side-band product (60-76, 100-116, or 140-156 kc) of the low group line frequencies (40-56, 80-96, or 120-136 kc) modulated by the oscillator.

8.06 For a Type "O" high-to-low repeater, by virtue of reversing Fig. 3 in its jack, the output of the modulator is connected to the input of the (A) section of filter (FL2), the output being connected to the input of transformer (T4). Since the carrier frequency is 116, 196, or 276 kc, the (A) section of (FL2) will select the lower side-band product (40-56, 80-96, or 120-136 kc) of the high group input frequencies (60-76, 100-116, or 140-156 kc) modulated by the oscillator.

8.07 For the group receiving circuit of the ON1 Terminal or of the CA side of the ON1 Junction the following information applies:

ON1 Group	Input Band	Group Osc. Freq.	Output Band	Equiv. Type "O" Term.
1	120-136kc	316kc	180-196kc	OD(LG)
2	100-116	296kc	180-196kc	OC(HG)
3	80-96	276kc	180-196kc	OC(LG)
4	60-76	256kc	180-196kc	OB(HG)
5	40-56	236kc	180-196kc	OB(LG)

Information of the previous paragraphs applies.

The group receiving circuits of the OW side of the ON1 Junction are similar to standard O1 Terminals. The output bands are 180-196kc. The modulator oscillators are the same as standard O1 Terminals. Each of groups 1 to 5 may be an OD (HG or LG), OC (HG or LG), OB (HG or LG) or OA (HG or LG) terminal. In the latter case, of course, the group receiving circuit of this drawing is not used. In the first three cases, information of the previous paragraphs applies.

8.08 For the group receiving circuit of the ON2 terminal, the following information applies:

ON2 Group	Input Band	Group Osc. Freq.	Output Band	Equiv. Type "0" Term.
1	116-132kc	312kc	180-196kc	-
2	100-116	296kc	180-196kc	OD(HG)
3	84-100	280kc	180-196kc	-
4	68-84	264kc	180-196kc	-
5	52-68	248kc	180-196kc	-
6	36-52	232kc	180-196kc	-

8.09 At a terminal the noise voltage generated in the associated group transmitting unit is bridged across the transmission path at the output of the modulator (terminals 6 and 4 of (T3)) via a strap within the (FL2) filter, (Figs. 4 or 5).

At a Type "0" repeater the noise leads are not used and are short circuited to ground to prevent crosstalk via these leads between adjacent repeater circuits.

8.10 The (A) and (B) sections of (FL2), Fig. 3, when used at the modulator output, use a pad and capacitors to reduce the impedance irregularities of the modulator and the amplifier input transformer. This is a 3 db pad for the OB and OC filters and 1.5 db for the OD filter. In addition, the OD filter has resistors connected across the capacitors for further impedance correction. Each resistor introduces 1.5 db loss. The (A) and (B) sections of (FL2), when used at the regulating amplifier input, work between good resistance terminations and no pads or capacitors are required. However, since the (A) section of (FL2), Fig. 3, is also used at the modulator output (high to low repeater) it must also be equipped with a pad and a capacitor (or capacitor and resistor).

8.11 The (D1) and (D2) sections of (FL2) use a 1.5 db pad at the filter input to reduce impedance irregularities of the modulator. An additional 1.5 db loss is introduced by the bridging on of the noise leads. (FL2), Figs. 4, 5, and 7 are also equipped with capacitors, as in the case of the OC and OD groups, and ON1 groups 1 and 2, and ON2 groups 1, 2, and 3, a resistor, to bridge across the low winding of (T4) in order to provide a better termination for the (D1) or (D2) section of (FL2).

9. AMPLIFIER (FIG. 1)

9.1 The amplifier circuit is a two-stage feedback amplifier employing hybrid feedback on the output and series feedback on the input. This circuit provides amplification for either the low-to-high repeater or for the high-to-low repeater and the low group or high group receiving circuit. The signal and masking noise received from the

output section of (FL2) is stepped up by the input transformer (T4). Resistor (R12) provides a suitable termination for the transformer. The high winding is connected directly to the control grid of tube (V2) and ground. Resistor (R16) provides cathode bias of the first stage, while resistor (R17) and capacitor (C9) provide plate filtering. The output of the plate filter is fed directly to the screen, and capacitor (C9) places the screen of (V2) at ac ground potential. Plate voltage is fed to the tube through inductor (L1). The output of (V2) is impedance coupled to the grid of the second stage (V3) by means of inductor (L1), capacitor (C10), and resistor (R18). Resistor (R19) provides cathode bias for the second stage. The plate of the second stage tube, (V3), delivers power to the line through transformer (T5) whose high side winding is arranged to provide hybrid feedback. The signal voltage appearing across terminal 5 and ground of (T5) is fed back to the cathode of (V2) through resistor (R20) and capacitor (C11). Capacitor (C11) also blocks the dc voltage, present at terminal 5 of (T5), from the low resistance path to ground provided by the parallel combination of (R13), (R14), and (R15). The feedback, or Beta, circuit controls the gain of the amplifier and includes:

(a) The hybrid winding of transformer (T5) and resistor (R21) which is the terminating network for the hybrid transformer. Resistor (R21) in conjunction with the ratio of the turns on the high side of transformer (T5), and the step down ratio of transformer (T5) determine the output impedance of the amplifier.

(b) Resistors (R20), (R13), (R14), and (R15), control the amount of voltage fed back to the cathode of the first stage, and thus the amplifier gain. Resistors (R13) and (R14) are provided to obtain one db changes in gain for manufacturing gain adjustments. Capacitor (C8) blocks the dc cathode current of electron tube (V2) from resistors (R13), (R14), and (R15).

9.2 DC voltage is fed to the screen of (V3) through inductor (L2) and resistor (R21). Capacitor (C12) provides ac ground for both the screen of (V3) and one side of (R21). Inductor (L2) prevents an ac short across the feedback path. DC voltage is fed through inductor (L2), and the high side winding of transformer (T5) to the plate of (V3). Resistor (R22) in series with capacitor (C13) provides for correction of the high frequency mu-beta phase and gain of the amplifier.

9.3 The space currents for each stage can be determined by voltage measurements between test jacks (K2), and (K3) and ground. Test jack (OUT) is connected to terminal 3 of transformer (T5) and is used to measure the signal level at the output of the amplifier.

9.4 Capacitor (C20) connected across terminals 3 and 1 of (T5) improves the output impedance. Capacitor (C19) connected between terms 16 and 11 of Fig. 1 provides additional capacitance when the unit is used at an OB repeater. Wiring on the associated jack of the repeater frame will connect capacitor (C19) in parallel with capacitor (C20).

10. CONTROL AMPLIFIER-RECTIFIER (FIG. 1)

10.1 The control amplifier-rectifier stage is essentially a single stage feedback amplifier whose output is rectified and compared against a dc reference voltage, the sum of these two voltages being applied as bias to the grids of the regulator tube (V1). A portion of the signal at the plate of (V3) is applied to the input of the control amplifier-rectifier through capacitor (C14) and resistors (R23) and (R24). Resistors (R25) and (R27) and the (OUT) potentiometer are in the cathode circuit and since grid return resistor (R23) is connected to the junction of (R25) and the (OUT) potentiometer, series feedback is obtained. Bias for the tube is provided by resistor (R25). Varying potentiometer (OUT) changes the amount of signal voltage fed back to the grid circuit thereby varying the gain of the control amplifier. Resistor (R27) in conjunction with jack (K4) provides means for measuring the space current of electron tube (V4). Resistor (R24) functions to prevent lockup of the control amplifier in the event of a high transient at the output of the amplifier.

10.2 The output of (V4) is fed through transformer (T6) to a voltage doubler-rectifier circuit composed of capacitor (C16), varistors (CR2), (CR3), (CR4), (CR5); resistor (R31) (when used as a repeater) and capacitor (C8). When the voltage across terminals 1 and 3 of (T6) is poled so that 3 is positive, varistors (CR4) and (CR5) conduct, charging capacitor (C16) to approximately the peak value of the voltage. On the alternate half-cycle varistors (CR4) and (CR5) block, while varistors (CR2) and (CR3) conduct, charging capacitor (C18) to a voltage which is the sum of approximately the peak voltage across terminals 1 and 3 of (T5) and the charge previously developed across (C16). Capacitor (C18) also acts as a filter capacitor holding the dc voltage developed across load resistor (R31) at a constant value.

10.3 A voltage divider composed of resistors (R29) and (R30) provides a dc reference voltage which is positive with respect to ground. Since the dc output voltage of the doubler-rectifier is in series with a dc reference voltage but of opposite polarity the algebraic sum of the two voltages is fed as a bias to the grids of tube (V1) through resistor (R9). Since the dc output of the doubler-rectifier is larger than the dc reference voltage the result is a negative bias on the grid. Resistor (R9) and capacitors (C2), (C3), and (C4) in parallel provide the desired time constant for the regulator.

10.4 Regulation is obtained as follows: an increase in signal input to the unit increases the output at the plate of (V3) of the fixed gain amplifier, which results in more dc output of the rectifier. This makes the bias on the grids of the regulating tube (V1) more negative reducing the gain and restoring the output of the unit close to its former value. A decrease in input will result in the opposite effect; therefore, the regulator tends to maintain a constant level input to the modulator and since the amplifier is fixed gain, a constant level at the unit output.

10.5 When the unit is used as a group receiving unit, load resistor (R31) will be replaced by the winding of an alarm relay and a resistance.

10.6 Plate supply is filtered by (R28) and capacitor (C15) and is fed through winding 4 and 6 of (T6) to the plate of (V4). The output of the plate filter is connected directly to the screen of (V4), and capacitor (C15) maintains the screen at ac ground potential. Capacitor (C17) places one side of the doubler-rectifier circuit at ac ground potential and filters the dc reference voltage.

11. HEATER CIRCUIT

11.1 The electron tube heater supply may be obtained from a -48V or +130V office battery. Proper strapping for either battery is indicated on the terminal or repeater application schematics. In the case of the -48V office battery a resistor external to this circuit will drop the voltage to approx. -38.5V.

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