N3 CARRIER TELEPHONE SYSTEM
DOUBLE-CHANNEL REGULATOR UNIT
J99300AC AND J99300CA
DESCRIPTION

CONTENTS PAGE

1. GENERAL

A. Scope

1.01 This section describes the J99300AC and the J99300CA double-channel regulator units which are part of the receiving channel equipment in the N3 and N3-L Carrier Telephone Systems.

1.02 This section is reissued to include the J99300CA, List 9 and 10 regulator units which replace List 1 and 2, now manufacture discontinued. Since this is a general revision, arrows are not used to indicate changes.

B. Description

1.03 The J99300CA double-channel regulator replaces the manufacture discontinued J99300AC regulator. The J99300CA, List 9 and 10 units feature further improvements in design to eliminate a high frequency sing condition in the ground paths of the circuit. Each double-channel regulator is a single plug-in assembly occupying one modular space in an N3 terminal or Type C N3-L Junction. The Type B N3-L Junction uses the J99331BC low-level regulator unit to perform the same functions. See Section 362-925-100.

1.04 As shown in Fig. 1 and 2, the J99300AC and J99300CA double-channel regulators differ slightly in physical appearance. A major difference is in the front panels, where the TH BIAS test jack has been eliminated in the J99300CA unit.

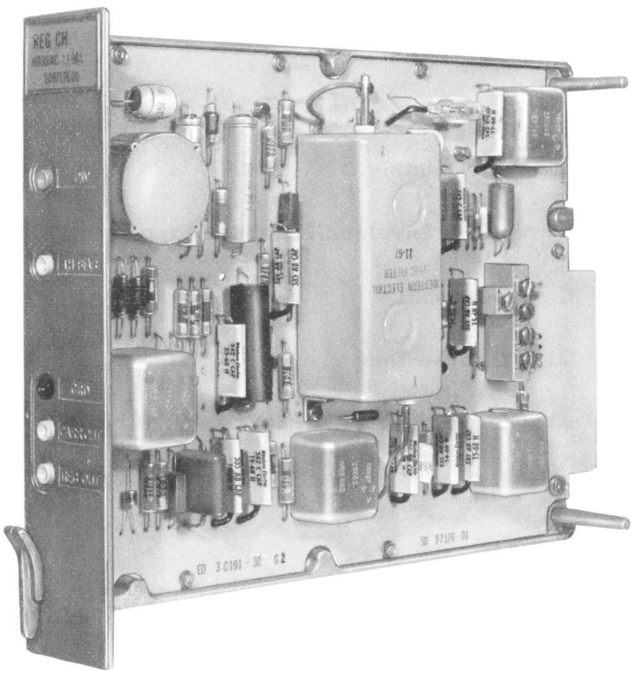

Fig. 1—J99300AC Double-Channel Regulator with Filter (List 9)

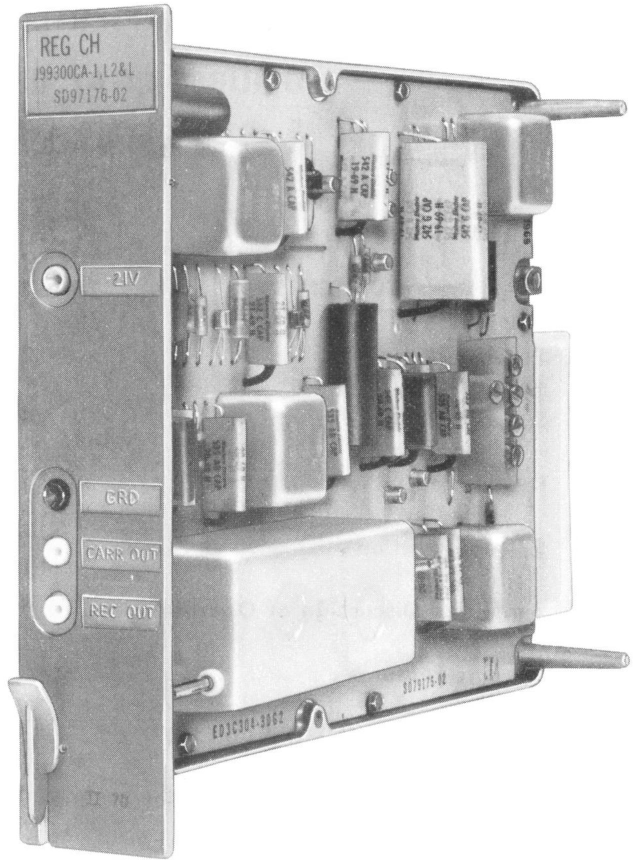

Fig. 2—J99300CA Double-Channel Regulator with Filter (List 2 or 10)

1.05 Circuit components for both types of regulators are mounted on a printed wiring board, surrounded by a die-cast frame which includes the front panel. All interconnection to and from the double-channel regulator is made via a 20-pin plug integral with the printed wiring board at the rear of the unit. A mechanical latch for locking the unit in position is also located on the front panel.

C. System Function

1.06 The double-channel regulator compensates for variations in the received carrier signal level, thereby providing nearly constant input signal levels to the associated channel demodulators. Since the N3 Carrier Telephone System transmits only the even-channel carriers, adjacent odd and even channels are regulated by the even-channel carrier.

1.07 In the N3-L System, a 96-kHz spurious frequency, originating in the L multiplex, beats with the 256-kHz N3-L modulating frequency creating a 160-kHz difference frequency. This difference frequency interferes with the 160-kHz channel 4 carrier of the N3 System, which is ordinarily used to regulate channels 3 and 4. A double-channel regulator with three outputs has been developed to avoid the use of the channel 4 carrier. Thus in N3-L Systems, channels 1, 2, and 3 are regulated from the channel 2 carrier and channels 4, 5, and 6 from the channel 6 carrier. The dotted lines in Fig. 3 indicate output connections for this application.

1.08 In addition to regulated signal outputs, the double-channel regulator provides the received even-channel carrier for use in demodulating the even-numbered channels. This output requires the use of a double-channel regulator for channels 3 and 4 in the N3-L System. See Fig. 3.

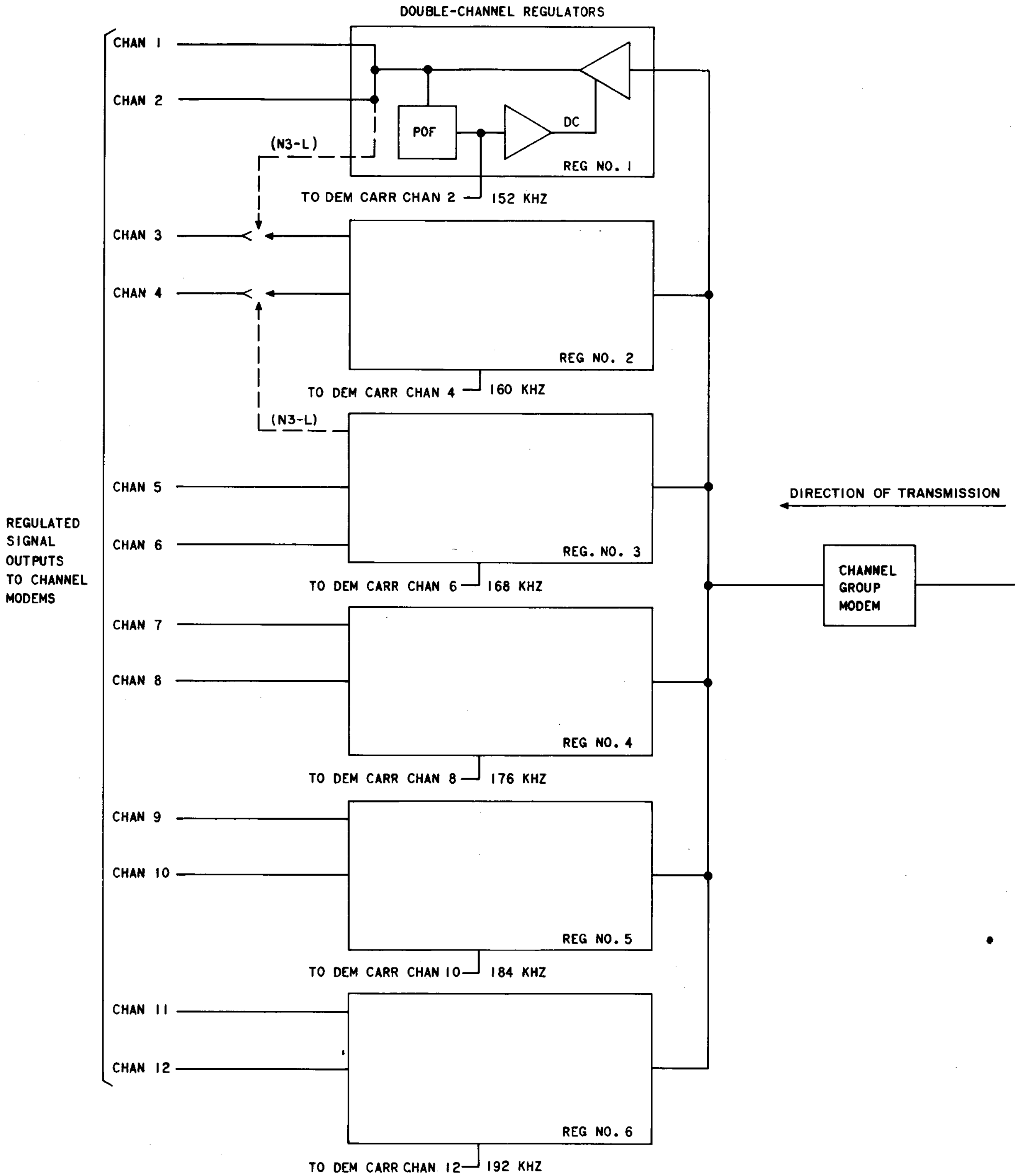

Fig. 3—Double-Channel Regulators in an N3 or N3-L System

D. Simplified Discussion of Operation

1.09 The operation of the double-channel regulator is described with the aid of Fig. 4. This block diagram is greatly simplified for explanation and is applicable to both the J99300AC and J99300CA double-channel regulators, although these units have somewhat different circuitry. The heavy lines show the forward transmission signal path and the lighter lines, the envelope feedback path.

1.10 The six even-numbered channel carriers and all twelve channel sidebands are contained in the input signal from the channel group modem. The signal follows the forward transmission path through the variable attenuator, the fixed gain μ amplifier, and the output transformer to an odd-channel and an even-channel demodulator.

1.11 In the envelope feedback path, the pick-off filter blocks all the frequencies present in the input signal except the carrier for the particular even channel to be regulated. This carrier is amplified by the constant gain β amplifier, rectified, and fed to the dc amplifier where it is compared to a dc reference voltage. The output of the dc amplifier is essentially the difference between the rectified carrier and reference voltage. This difference voltage controls the resistance of the variable attenuator.

1.12 When the even-channel carrier input level increases, the difference voltage increases causing the attenuator resistance to decrease. The decrease in attenuator resistance shunts the signal fed to the constant gain μ amplifier and returns the output level of the double-channel regulator to its nominal value. The output level is similarly regulated when the carrier level decreases.

1.13 As previously discussed, all the carriers and channel sideband signals in the 12-channel group are present at the input and output of the regulator. The even-channel carrier corresponding to the pick-off filter frequency is centered between the odd and even sidebands which correspond to

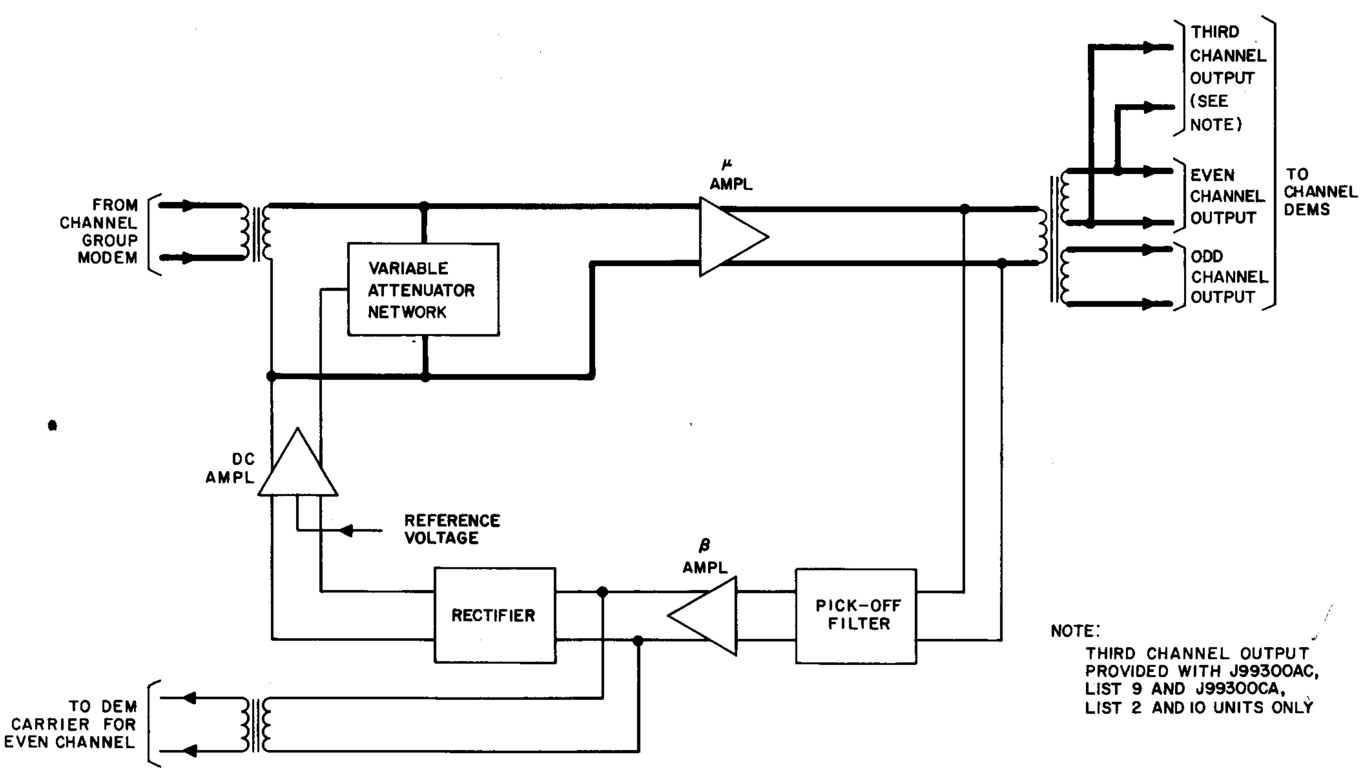

Fig. 4—Block Diagram of Double-Channel Regulator

the channel demodulators connected at the output. The channel bandpass filters in the demodulators select only the desired, regulated channel signal from the 12-channel signals present.

1.14 Another output of the regulator is the even-channel carrier frequency, taken from the β amplifier and fed to the corresponding modem for use as the demodulating carrier.

E. Specific Features

1.15 In general, the J99300AC and the J99300CA double-channel regulators are interchangeable plug-in units with the same transmission characteristics, power drain, and system functions. However, specific list-numbered units are required in particular channel regulator positions to furnish pick-off filters corresponding to the even-channel carrier frequency.

1.16 The main difference between the J99300AC and J99300CA units is in the variable attenuator component. The manufacture discontinued J99300AC double-channel regulator contains a thermistor, while the J99300CA unit has a field-effect transistor. This modification of the associated control circuits has reduced the cost of these units.

1.17 The N3-L System requires triple-channel regulators in certain positions (1.07). The J99300AC, List 9 and J99300CA, List 2 and 10 regulator units contain screw switches to set the output for either two or three outputs for use in N3-L Systems. The output can also be terminated by means of the screw switches. This feature is used in regulator number 2 of the N3-L System, where the regulator provides only the demodulating carrier for channel 4.

1.18 A complete N3 terminal requires 12 double-channel regulators, six for each 12-channel group. A Type C N3-L Junction requires six regulators for the terminal channel group. Refer to Section 362-909-501 for J and List number requirements and installation of the pick-off filter.

1.19 The Type B N3-L Junction requires J99331BC low-level regulator units instead of double-channel regulators. The low-level regulator is described in Section 362-925-100. Maintenance and installation information is contained in Section 362-925-501.

2. FORWARD TRANSMISSION CIRCUIT

A. Forward Transmission μ Amplifier

2.01 The μ amplifier is slightly different in the J99300AC and J99300CA double-channel regulator units.

2.02 In the J99300AC unit, the μ amplifier (Fig. 5) employs four transistor stages and provides an overall gain of approximately 30 dB. The preamplifier, or first stage (Q1) has the common-emitter configuration and provides an input impedance greater than 10,000 ohms. The second and third stages (Q2 and Q3) are also operated in the common-emitter configuration, while the last stage (Q4) has the common-collector configuration. The negative feedback path around the last three stages is shunt connected at the output of Q4 and series connected at the input of Q2. The output impedance of the μ amplifier is less than 5 ohms.

2.03 As shown in Fig. 6, the J99300CA unit employs a preamplifier consisting of transistors Q1 and Q8 in a series feedback arrangement. The output of Q8 is directly coupled to transistor Q2, and the remainder of the μ amplifier circuit operates as described in 2.02.

2.04 In both configurations, the negative feedback path has been designed to avoid instability at high frequencies and minimize intermodulation distortion. One intermodulation product (2A-B) is shown in Fig. 7. The gain is constant in the operating frequency range from 148 to 196 kHz.

B. Input and Output Circuits

2.05 The six balanced 135-ohm primary windings of the double-channel regulators for one channel group are connected in parallel by the N3 or N3-L bay wiring (Fig. 3). The impedance at this point is therefore 135 divided by 6 or 22.5 ohms, which matches the output impedance of the channel group demodulator.

2.06 Two types of output circuits are available. When regulating two channels, the output circuit is split to provide separate outputs for transmission to the odd- and even-channel modems (Fig. 8). This is accomplished by the two secondary windings of output transformer T2 via plug P1, pins 9 and 10, and 7 and 8, respectively. Resistors

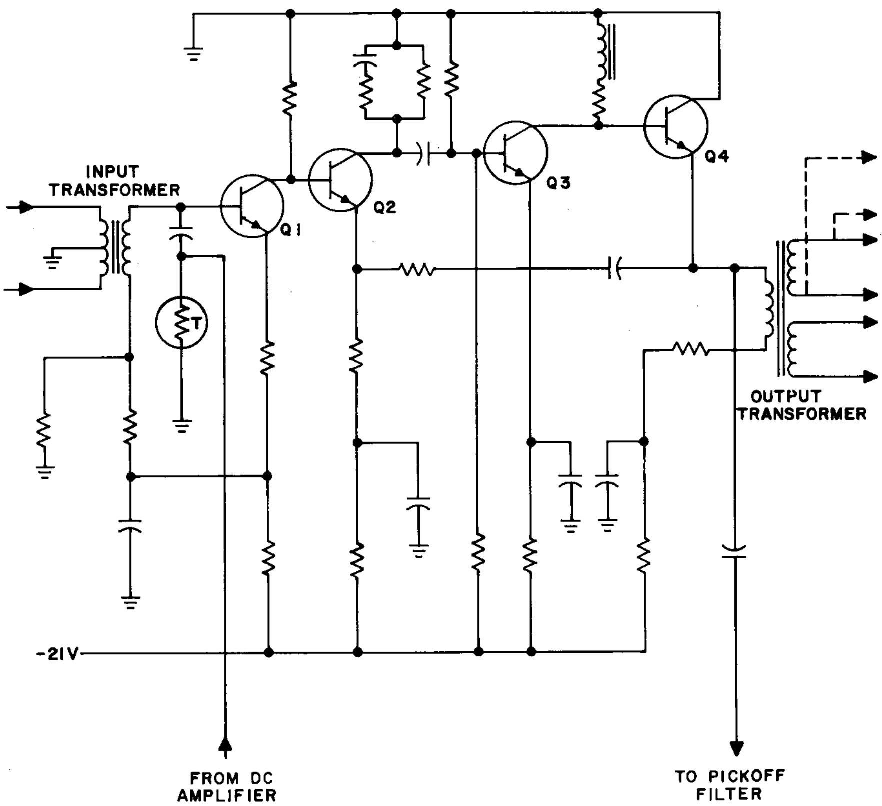

Fig. 5—μ Amplifier in the J99300AC Regulator

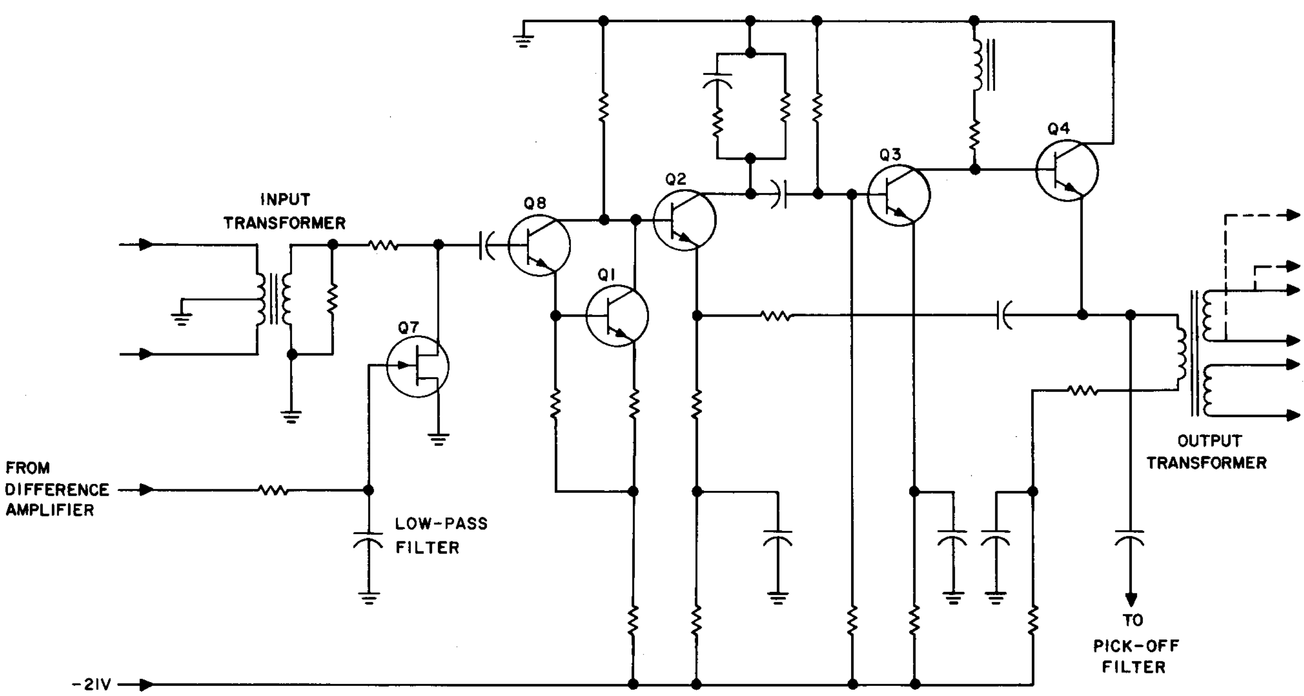

Fig. 6—μ Amplifier in the J99300CA Regulator

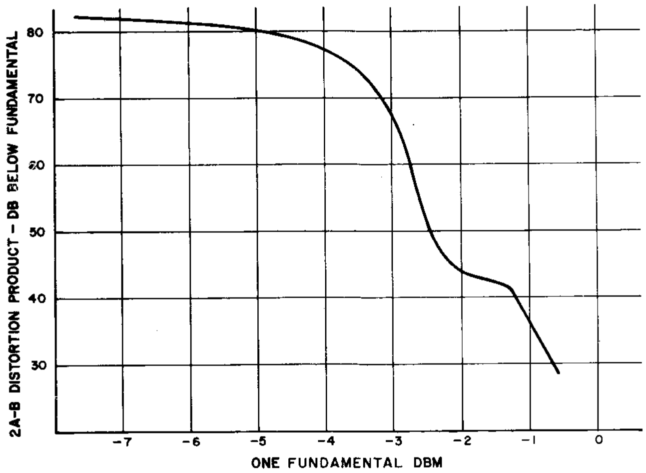

Fig. 7—Intermodulation Distortion

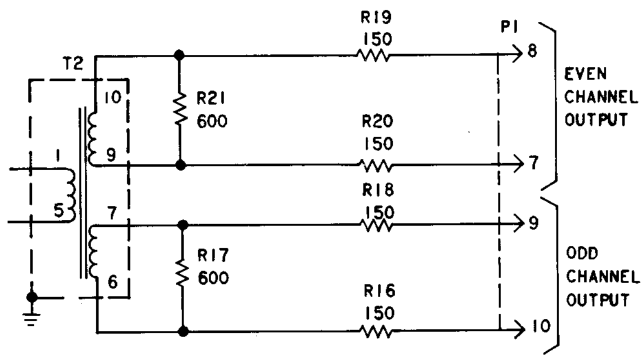

Fig. 8—Output Circuit (J99300AC, List 1 and 8 and J99300CA, List 1 and 9)

R16, R17, and R18 provide isolation in the odd-channel output while resistors R19, R20, and R21 perform the same function in the even-channel output. The isolation provided by these resistors is such that removal of one channel demodulator causes only a 0.1-dB change in the other channel.

2.07 As shown in Fig. 9, separate outputs can also be provided for transmission to three channel modems. The even-channel output is through closed screw switches S7 and S8 and pins 7 and 8 of plug P1. The odd-channel output is through closed screw switches S5 and S6, and pins 9 and 10 of plug P1. The third channel output is provided through pins 14 and 15 of plug P1. Resistors R47, R48, and R49 provide isolation in the odd-channel output while resistors R50, R51,

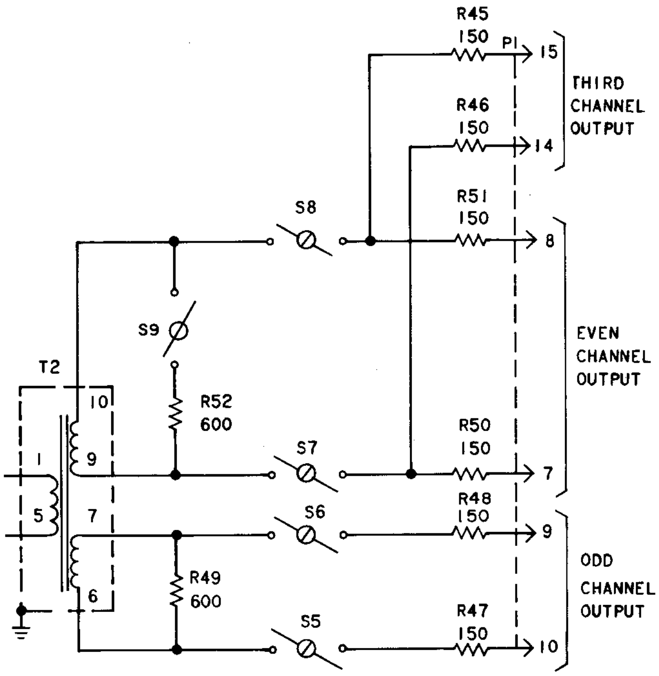

Fig. 9—Output Circuit Switching Arrangement (J99300AC, List 9 and J99300CA, List 2 and 10)

and R52 perform the same purpose in the even-channel output. Isolation for the third-channel output is provided by resistors R45 and R46. When the third-channel output is used, screw switch S9 must be opened to provide the proper termination. When used only as the demodulating carrier for channel 4, switch S9 is closed and switches S5, S6, S7, and S8 are opened. The J99300AC, List 9 or J99300CA, List 2 and 10 units may be used in N3 terminal or N3-L Type C Junctions in regulator position 4, 5, or 6 by setting switches S5, S6, S7, S8, and S9 to the closed position. These units should not be used in regulator position 1, 2, or 3 except in N3 terminals associated with N3-L Systems (1.07).

C. Shunt Thermistor (J99300AC Double-Channel Regulator)

2.08 The directly heated shunt thermistor (Fig. 5) is connected across the input to the μ amplifier. The resistance of the thermistor is exponentially proportional to the current through it. The output of the dc amplifier is used to drive the thermistor and control its resistance. The regulating action of the shunt thermistor is described as follows. Assume that the carrier signal, present at the input transformer, increases above the nominal level. This causes the control current from the dc amplifier to increase. An increase in control current causes the thermistor resistance to decrease; thus more attenuation is applied to the carrier input signal, and the overall result is a nearly constant level at the output transformer.

2.09 With a nominal −32 dBm carrier signal at the primary of the input transformer, the thermistor resistance is approximately 300 ohms at an ambient temperature of 80°F and the dc control current is approximately 4 mA.

2.10 Deviations from nominal of the carrier input signal level can be conveniently monitored by measuring the dc voltage between the TH BIAS jack (+) and the −21V jack (−). A typical curve showing thermistor voltage versus input signal level deviation is shown in Fig. 10.

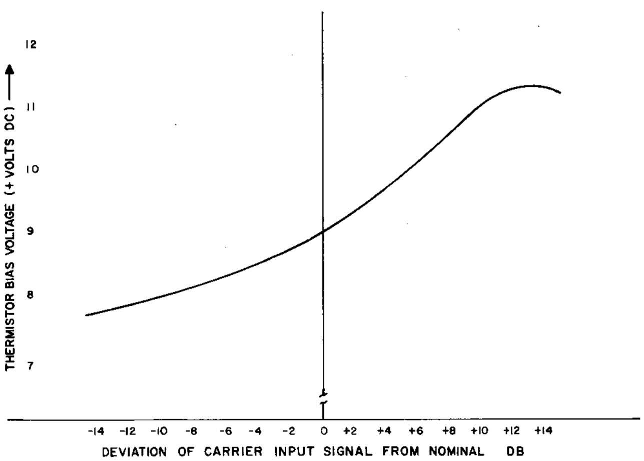

Fig. 10—Thermistor Bias Voltage Versus Deviation of Carrier Input Signal from Nominal

2.11 With negligible control current, the thermistor resistance can be expected to range from approximately 45,000 ohms at an ambient temperature of 80°F to approximately 12,000 ohms at an ambient temperature of 140°F.

2.12 The thermistor has a negative temperature coefficient of approximately −2.5 percent per degree Fahrenheit at 80°F.

2.13 The thermistor has a time constant of approximately 20 seconds.

2.14 A capacitor provides dc isolation between the thermistor and the first stage of the μ amplifier.

D. Field-Effect Transistor (J99300CA Double-Channel Regulator)

2.15 The field-effect transistor (Fig. 6) is connected across the input to the forward transmission preamplifier. The resistance of the transistor varies with voltage applied to its gate through the low-pass filter by the difference amplifier. This voltage is essentially the difference between a reference voltage and the sum of the rectified carrier and the emitter junction voltage of the difference amplifier transistor.

2.16 An increase in carrier input will increase the rectified voltage, causing a smaller difference voltage to be applied to the gate of the field-effect transistor. This will decrease the resistance of the transistor resulting in an increase of attenuation of the signal applied to the forward transmission preamplifier circuit. A decrease in carrier input will similarly increase the resistance of the field-effect transistor and decrease the attenuation of the signal.

2.17 The field-effect transistor and its associated fixed resistors form a variable attenuation network which varies inversely with the level of the received carrier. Thus the received signal is regulated to a nearly constant level at the input to the forward transmission preamplifier.

3. ENVELOPE FEEDBACK LOOP

A. Pick-Off Filter

3.01 Any one of six pick-off filters may be used in the double-channel regulator. The choice of filter depends upon which pair of channels is to be regulated. When the pick-off filter is in the circuit, it accepts the desired transmitted carrier and rejects all other carriers and sidebands. There is a pick-off filter for each of the following transmitted carrier frequencies: 152, 160, 168, 176, 184, and 192 kHz. ***The filters, coded 659A through 659F, are fragile crystal filters which should be handled carefully to avoid damage.***

3.02 The pick-off filter is a narrow bandpass crystal filter which bridges the last stage of the μ amplifier. Variations in the bridging effect on the forward transmission over a ± 4 kHz band are held to less than 0.05 dB. In the passband the pick-off filter is flat to within ± 0.05 dB over the C ± 2 Hz band where C is the frequency of the transmitted carrier. The output of the pick-off filter is coupled to the first stage of the β amplifier. A typical discrimination characteristic curve for the pick-off filter is shown in Fig. 11.

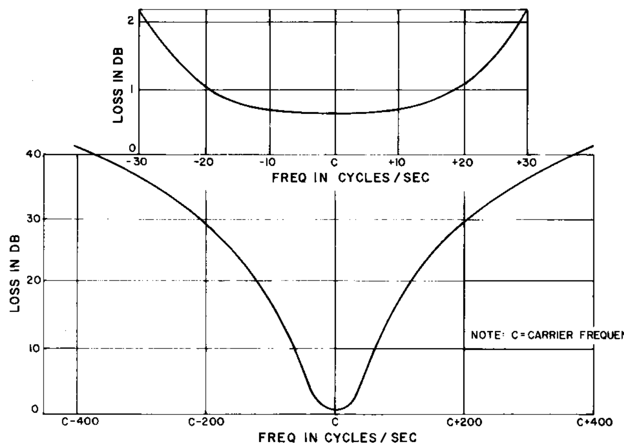

Fig. 11—Typical Discrimination Characteristic of the Pick-Off Filter

B. Carrier-Frequency Feedback β Amplifier

3.03 The β amplifier (Fig. 12) uses two transistor stages to obtain a gain of approximately 30 dB. Approximately 25 dB of negative feedback is applied to minimize gain variations. Nominal phase margins of 63 degrees for the low-frequency gain crossover at approximately 2100 Hz and 51 degrees for the high-frequency gain crossover at approximately 5 MHz ensure loop stability within the amplifier.

3.04 A positive temperature coefficient resistor (approximately 0.3 percent per degree Fahrenheit) is used at the input to the β amplifier to compensate for temperature variations in the regulator circuitry including the pick-off filter.

3.05 The β amplifier employs series input feedback; therefore, the input impedance is approximately 36,000 ohms.

3.06 Adjustment of the gain of the β amplifier is made as part of a factory test by cutting straps in the feedback loop. The forward transmission gain of the overall regulator, as measured at the secondary of the output transformer of the μ amplifier, is decreased 0.6 dB for each strap cut.

3.07 The β amplifier has two outputs. One output is simply the continuation of the envelope feedback loop. The β amplifier output impedance, as seen at the input to the rectifier, is approximately 3000 ohms. The other output supplies the demodulating carrier frequency for the even-channel demodulator.

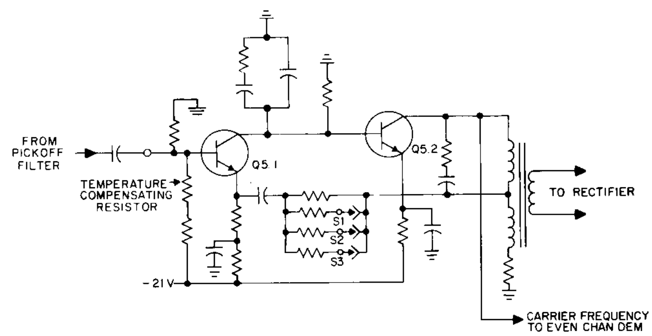

Fig. 12—β Amplifier

C. Carrier Rectification and Regulation in the J99300AC Double-Channel Regulator

3.08 A full-wave diode bridge rectifier with transformer input and resistance output terminations feeds a low-pass filter where considerable smoothing of the rectified signal takes place (Fig. 13). The value of the rectified carrier signal is close to the average value of the carrier sine wave. This reduces the effect of unwanted sideband energy affecting the regulation level.

3.09 The dc amplifier has two transistor stages. The input voltage to the first stage is the output of the low-pass filter. The common-collector configuration of the first stage provides a high input impedance of over 30,000 ohms. The output voltage of the first stage is compared to the reference voltage established at the emitter of the second stage by the avalanche diode voltage drop, and the difference or error voltage is amplified by the common-emitter second stage.

3.10 Small changes in the low-pass filter output voltage cause proportionally large changes

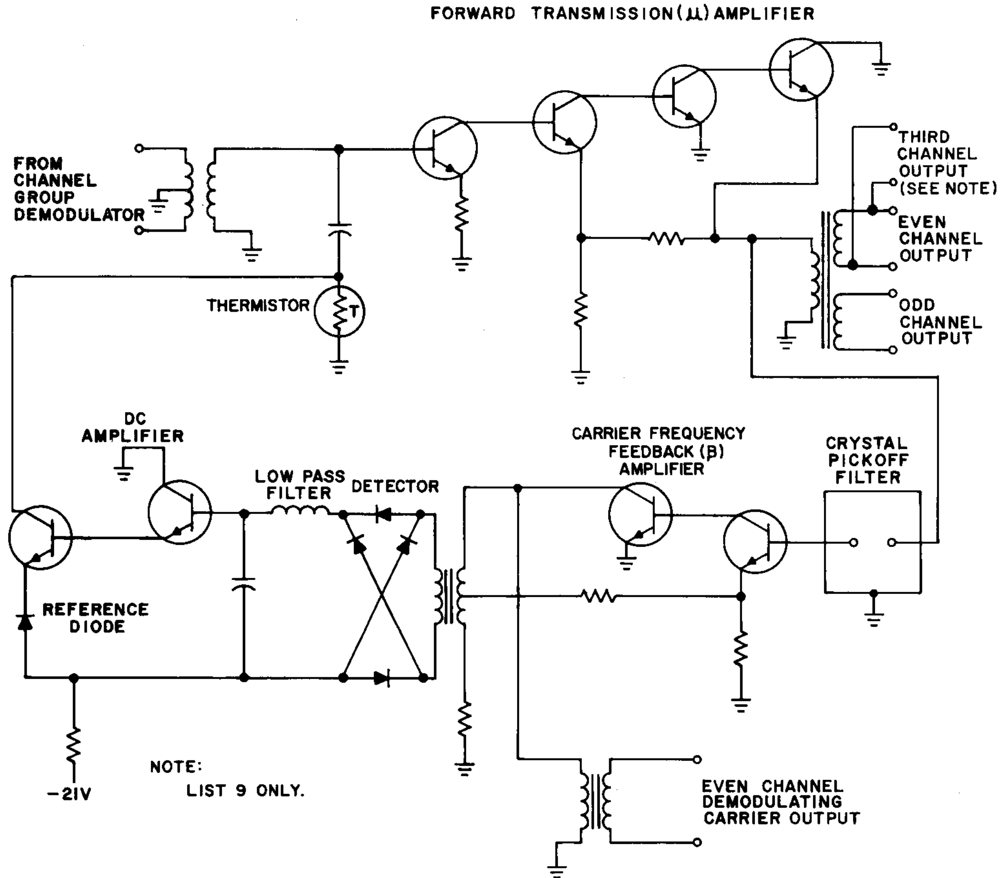

Fig. 13—Essential Components of the J99300AC Double-Channel Regulator

in the error voltage. The principle upon which the operation of the regulator is based is described as follows. Assume that initially the output voltage of the first stage of the dc amplifier is 6.1 volts and the reference voltage is 6.0 volts. Then the error voltage will be 0.1 volt. If the desired transmitted carrier were to increase in level, the output of the first stage would also increase. For this example, assume the new voltage to be 6.3 volts. The error voltage now will be 0.3 volt, which is an increase of 300 percent at the input to the second stage, whereas the output of the first stage changed only 5 percent.

3.11 An increase in carrier signal from the nominal level causes an increased signal level in the envelope feedback loop and, therefore, a larger difference voltage when this signal is rectified and compared to the reference voltage. The new difference signal causes more current in the thermistor, resulting in a decrease of thermistor resistance. A decrease in thermistor resistance causes less signal to be applied to the μ amplifier, thereby automatically regulating the output signal. A similar automatic increase in thermistor resistance will occur for a decrease in carrier signal.

D. Carrier Rectification and Regulation in the J99300CA Double-Channel Regulator

3.12 The output of the carrier-frequency feedback amplifier is transformer coupled to a half-wave rectifier as shown in Fig. 14. The ac component of the rectified signal is shunted by a capacitor and the dc component is applied to the base of the difference amplifier transistor.

3.13 Another diode provides a constant reference voltage derived from the −21 volt power supply. This reference voltage is applied between the emitter and base of the difference amplifier transistor through a bias resistor.

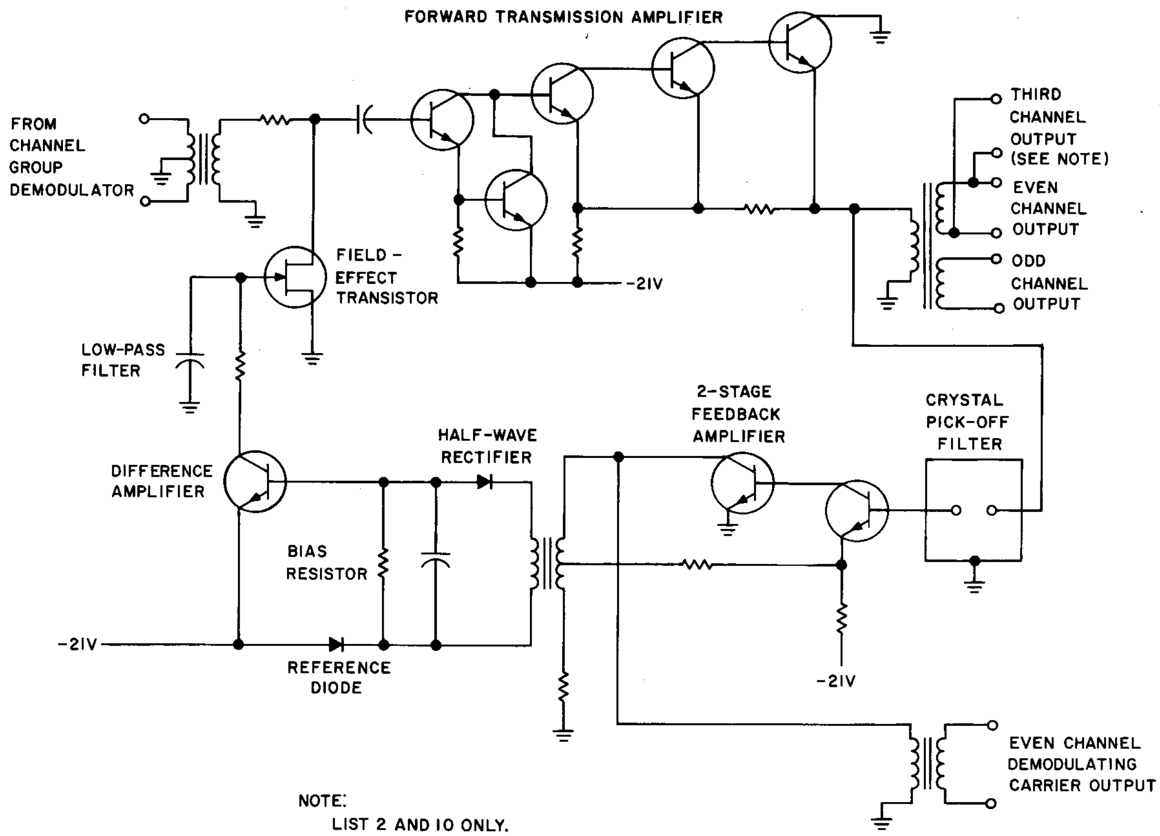

Fig. 14—Essential Components of the J99300CA Double-Channel Regulator

3.14 The difference between the rectified carrier voltage and the reference voltage controls the conduction of the difference amplifier, and the difference voltage will vary as the rectified carrier level varies. In the collector circuit, the difference voltage is amplified and fed to the gate of the field-effect transistor through a resistive-capacitive low-pass filter. The filtered voltage controls the resistance of the field-effect transistor as described in 2.16.

3.15 An increase in carrier signal from the nominal level causes an increased signal level in the envelope feedback loop and a larger difference voltage when this signal is rectified and compared to the reference voltage. The larger difference voltage is amplified and creates a decrease in field-effect transistor resistance which increases signal attenuation. A decrease in the received carrier causes a similar automatic decrease of the attenuation, so that a constant input to the forward transmission μ amplifier is maintained.

4. OVERALL PERFORMANCE

A. Power Supply

4.01 Variations of one volt from the nominal -21 volts cause negligible changes in the regulator output (approximately 0.02 dB). Under normal operating conditions, the regulator current drain is approximately 93 mA.

B. Overall Envelope Feedback Loop

4.02 Because of the envelope feedback characteristic, the response of the double-channel regulator sharply attenuates low-frequency variations in the carriers (beat signals). A 1-Hz variation is reduced approximately by a factor of 2. Similarly, a 2-Hz variation is reduced approximately by a factor of 4.

C. Input Limits

4.03 The output level of the N3 channel group modem is required to be -32.0 dBm ± 7.0 dB.

This is the input to the double-channel regulator, which will regulate this 14-dB variation in the input to an output as shown in Fig. 15.

D. Response Time

4.04 The response time of the double-channel regulator is a function of the initial input signal level and the magnitude of the input signal level change. The maximum possible response time results when a regulator at room temperature is plugged into the bay. Regulation time for this condition can be as much as two minutes.

5. ASSOCIATED DRAWINGS (NOT ATTACHED)

5.01 The following schematic drawings provide detailed information related to the double-channel regulator.

NUMBER	TITLE
SD-97176-01	Common Systems, N3 Carrier Telephone, Double-Channel Regulator Circuit, J99300AC
SD-97176-02	Common Systems, N3 Carrier Telephone, Double-Channel Regulator Circuit, J99300CA
SD-97185	Common Systems, N Carrier Telephone, N3 Terminal Circuit, N3-L Type B and C Junction (Shop Wired)
SD-97188	Common Systems, N Carrier Telephone, Application Schematic For Packaged N3 Terminals, N3-L Type B and C Junctions

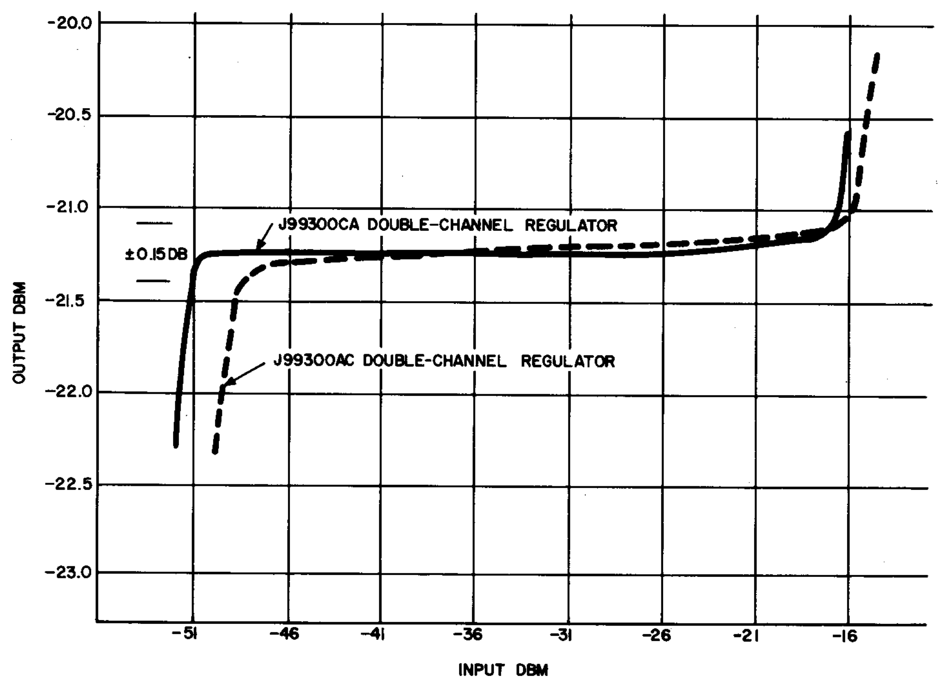

Fig. 15—Regulation Characteristic