INSTRUCTION MANUAL

MODEL 220

"AUDIO LEVEL OPTIMIZER"

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INOVONICS
INCORPORATED

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I. GENERAL INFORMATION

The Inovonics 220 is a gated, automatic audio level controller intended primarily for use in radio and television broadcasting. The 220 functions to unobtrusively increase average modulation and to provide protection from program peaks.

Features of the 220 include:

A fully gated Compression/Limiting function with choice of GAIN HOLD, HOLD AND RELEASE, or HOLD AND FADE modes.

Selection of Peak or Peak + Average limiting characteristics.

Adjustable peak limiting symmetry for full AM carrier modulation.

A separate frequency-selective limiting option to prevent high frequency overmodulation in FM and TV audio.

A frequency-weighted gating threshold to discriminate against non-program input signals.

Very low distortion, even at low frequencies, is assured by unique open-loop gain control and ripple-cancelling circuitry.

INOVONICS 220
SPECIFICATIONS

Frequency Response: ±0.5dB, 20Hz - 20kHz

Noise Level: better than 70dB below output program level

Distortion (with Ripple-Cancelling circuit enabled):

	50Hz - 200Hz	200Hz - 20kHz
Peak Limiter		
SLOW Release:	0.5%	0.3%
FAST Release:	0.8%	0.4%
Averaging Function:	(no contribution)	
Frequency-Selective Limiter:	-	0.5%

Below Limiting Threshold: 0.15%, 20Hz - 20kHz at +23dBm

Clipping Level: >+24dBm

Limiter Timing:

Peak Limiter
Attack: <1 µs / dB-limiting
Release: continuously variable between 30ms / dB-limiting (SLOW) and 6ms / dB-limiting (FAST)

Averaging Function
Attack and Release approx. 25ms / dB-limiting

Frequency-Selective Limiter
Attack: <1 µs / dB-limiting
Release: 50ms (max) for any degree of reduction

Peak Limiting Symmetry: A series of straps on the circuit board permits setting the value of positive peaks to 100% (symmetrical), 105%, 110%, 115%, 120%, or 125% of the negative peak value.

Stereo Coupling: Two or more units may be interconnected for ganged gain reduction.

Input: the 20k-ohm, bridging input, transformer-isolated, adjusts to accommodate input program levels between -20 and +15dBm.

Output: Transformer-coupled line output feeds 600-ohm line or bridging inputs at program levels between 0 and +15dBm.

Power Requirement: 105 - 130VAC (230V available) 50/60Hz, 10 watts.

Size and Weight: 3½" X 19" X 6"; 12 lbs.

Accessories:

75 µs FM / TV audio Freq. Sel. Limiting Insert
Remote Compression Meter

II. INSTALLATION

Upon receipt of the equipment, inspect at once for shipping damage. Should any such damage be observed, notify the carrier immediately; if not, proceed as outlined below. It is suggested that the original shipping carton and materials be saved should future re-shipment become necessary.

Mounting

The Inovonics 220 is packaged to mount in a standard 19-inch equipment rack, requiring 3½ inches of panel space per channel. As the unit generates negligible heat, and itself is quite temperature insensitive, no special precautions need be taken to insure more than normal convection ventillation.

RFI

Although the 220 is designed for a high-RF environment, care should be taken to situate the unit away from abnormally high fields, and to provide a suitable chassis ground.

Connection

A screw-terminal barrier strip provides connections for the Input, Output, and optional Remote Compression Meter, if used. An additional jack permits interconnecting two or more units for ganged gain reduction.

Termination

No output line termination is necessary, as the very low source impedance obviates any shift in characteristics, whether or not the output is terminated in 600 ohms. Should the equipment which feeds the 220 require output loading, an external 600 ohm resistor may be placed across the 220 input terminals; otherwise the input is a nominal "bridging" input.

Polarity

In AM broadcast applications it is important that the 220 output polarity be observed. The output terminal marded "+" will be positive-going on positive modulation peaks.

III. OPERATION AND FUNCTIONAL DESCRIPTION

Interface

The Inovonics 220 will accept a "0 VU" input program level between -20 and +15dBm. The output level can be adjusted between 0 and +15dBm.

Operational Considerations

Operation of the Inovonics 220 Audio Level Optimizer in the PEAK LIMIT mode, and with the PEAK RELEASE control fully clockwise will result in the greatest preceived program loudness; HOWEVER, the attendant high degree of dynamic range compression may be objectionable in many programming formats. To reduce the audible effects of compression, the PEAK RELEASE timing may be increased (toward SLOW), or the unit may be operated in the PEAK LIMIT & AVG. COMPRESSION mode. Judicious use of the gating feature will greatly aid in reducing undesirable dynamic compression side-effects.

Initial Setup

1. Set the FUNCTION A switch to GATING OFF; FUNCTION B to PEAK LIMIT.
2. Apply a 1kHz test signal from the 'board at a "0 VU" level. Adjust the INPUT GAIN (COMPRESSION) control for an indicated compression of 5 to 10dB.
3. Reduce the 1kHz signal from the 'board to -15 VU. Turn the FUNCTION A switch to HOLD GAIN. Rotate the GATING THRESHOLD control fully clockwise, so

that the GATE OPEN indicator is extinguished, and then slowly counterclockwise until the indicator just comes on.

4. With normal program material fed from the 'board, adjust the 220 OUTPUT LEVEL control for desired maximum modulation (incidence of 100% peaks), as indicated by a calibrated Modulation Monitor.

NOTE: Listening tests and experimentation may suggest alternate control settings. The above instructions are intended for preliminary adjustment, and should result in satisfactory initial operation.

Panel Controls

Although front panel controls and indicators are identified, a brief description of the function of each may help eliminate ambiguities and aid in adjustment.

The FUNCTION B switch controls AC power to the unit, and selects between PEAK LIMIT (only) or PEAK LIMIT & AVG. COMPRESSION limiting/compression modes; that is whether gain reduction will be solely a peak limiting function, or whether gain will be controlled also as a product of average level. The latter choice results in a less compressed "sound".

The FUNCTION A switch selects between an ungated mode (GATING OFF), or normal HOLD GAIN operation. Further, it provides for a "fade down" (HOLD & FADE) or "fade up" (HOLD & RELEASE) should the input signal fall below the gating threshold for a period in excess of 10 seconds.

GATING THRESHOLD sets the point at which an input signal will open the gate and permit gain reduction to follow variations in the input signal. It is by the proper choice of this control setting that "breathing" or "pumping" effects are eliminated by holding gain constant in the absence of a valid input signal.

OUTPUT LEVEL adjusts the 220 output to match the transmitter input requirement for maximum desired modulation.

INPUT GAIN (COMPRESSION) sets the amount of signal gain prior to limiting, and establishes the level of input signal which will result in maximum modulation, and above which input signals will be reduced to the output "ceiling" value. The setting of this control will typically result in an indicated average compression of 5 to 10dB.

PEAK LIMIT RELEASE adjusts the peak limiter recovery time; typically set at about mid-rotation as the best compromise between a high average level and freedom from undesirable dynamic effects.

Indicators

These include GATE OPEN, indicating that the input signal has exceeded the gating threshold; PEAK REDUCTION, to indicate that a program peak has been reduced to the "ceiling" value; and AVERAGE LEVEL COMPRESSION, indicating that the gain reduction in effect is a product of the average program level,

as well as the peak value.

The Compression Meter displays either true average level compression, or an equivalent amount of average compression when the 220 is set in the PEAK LIMIT (only) mode.

Assymetrical Peak Limiting

It is customary in AM broadcast practice to exceed "100% modulation" on positive program peaks. The Inovonics 220 Audio Level Optimizer is equipped with a series of circuit board terminals, which can be strapped to permit positive peaks to assume up to 125% of the negative peak value. The strapping arrangement is shown in Fig. 3-1.

Ripple-Cancelling Circuitry

Nearly all automatic gain-controlling devices employ a program-derived DC control signal to effect gain reduction. Filtering time constants must necessarily be fairly short in order for the DC signal to follow program level variations; thus at low frequencies, a greater portion of the input signal appears as "ripple" in the DC control signal. This results in generation of harmonic distortion.

The Inovonics 220 incorporates a novel ripple-cancelling circuit which can reduce the generation of harmonics to a very low value. This is accomplished, however, at the expense of a very slight increase in peak output level beyond the "ceiling" value. If the peak modulation is being run very close to 100%, use of the option will

For:	Strap:
100% (symmetrical)	A-B-C-D
105% pos. peaks	B-C-D
110% " "	A-B & C-D
115% " "	C-D
120% " "	A-B
125% " "	(no straps)

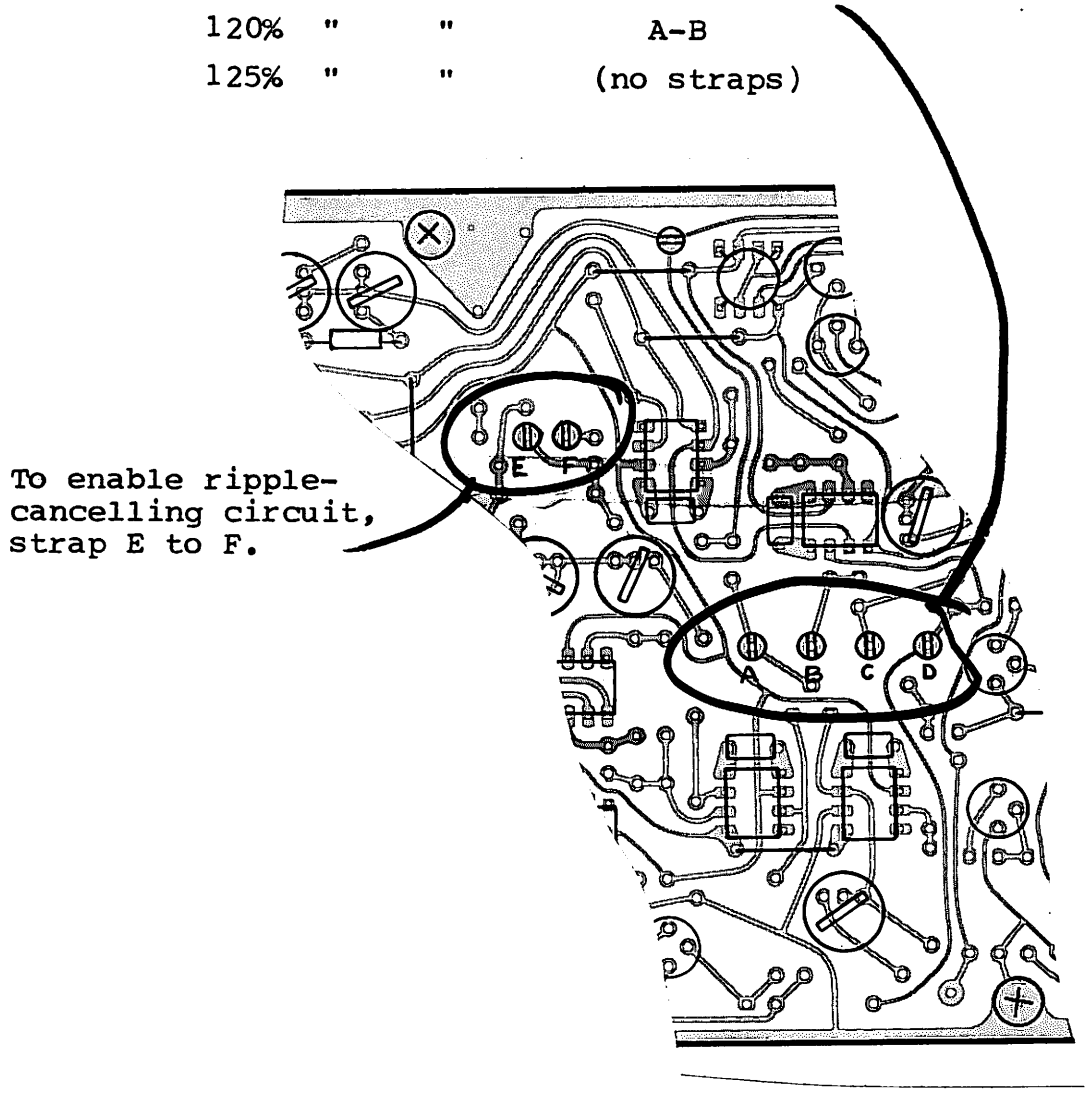


Fig. 3-1

Circuit Board Strapping

have to be weighed against the small sacrifice in average transmitted level. A test with and without the ripple-cancelling circuit in use (see Fig. 3-2) will determine whether or not its use is justified.

Frequency-Selective Limiting Option

FM and TV audio transmission employ a 75μs pre-emphasis time constant for signal-to-noise improvement. This means, however, that a transmitter audio input level which results in 100% modulation at 1kHz will cause overmodulation at 10kHz. Since much program material contains a respectable amount of high frequency energy, the limiter "ceiling" must decrease as frequency increases.

The Inovonics 220 can be supplied with an optional plug-in "insert" which will complement the 75μs pre-emphasis characteristic. In this case, high frequencies are <u>independently</u> limited. Unlike a "DE-ESSer", or limiter with a pre-emphasis network in its sampling circuit, the 220 does not reduce overall broadband gain when a high frequency overload is encountered; rather, it reduces only the offending highs, resulting in virtually inaudible operation

IV. CIRCUIT DESCRIPTIONS

Unlike most conventional limiters operating in a closed-loop configuration, the "knee" or "breakaway point" of the Inovonics 220 Audio Level Optimizer is not abrupt; rather, it is a gentle transition from a linear to a limited condition. (See Fig. 4) The increasing-ratio-compression prior to the infinite ratio afforded by the opimally-flat output "ceiling" of the Inovonics 220, is characteristic of "open-loop" operation, and responsible for the reduced audibility of gain control action.

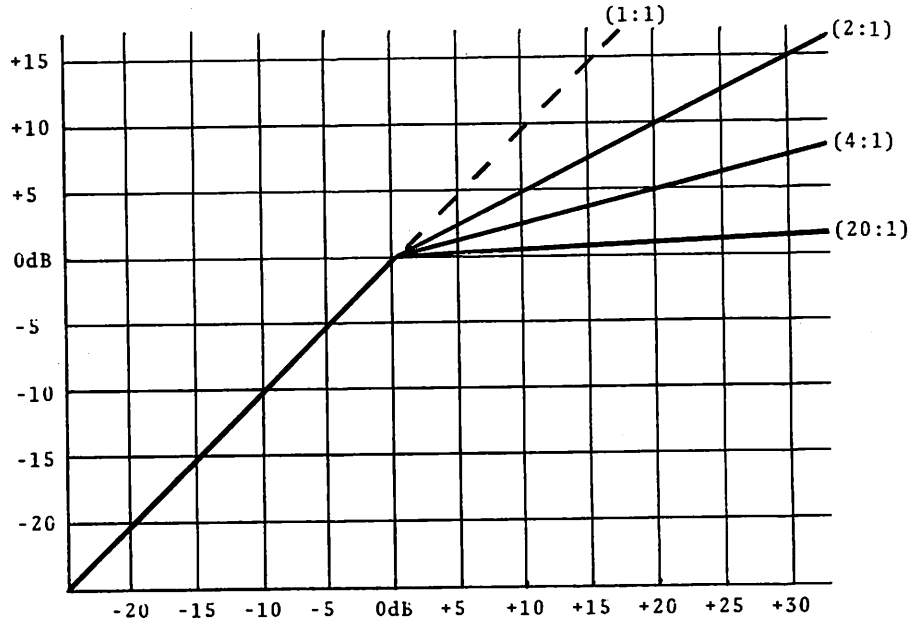
Signal Path

Referring to the 220 schematic, Fig. 5, input signals are coupled by transformer T 102 to input amplifier IC 4. Gain of this stage is determined by the INPUT GAIN (COMPRESSION) control, R 102.

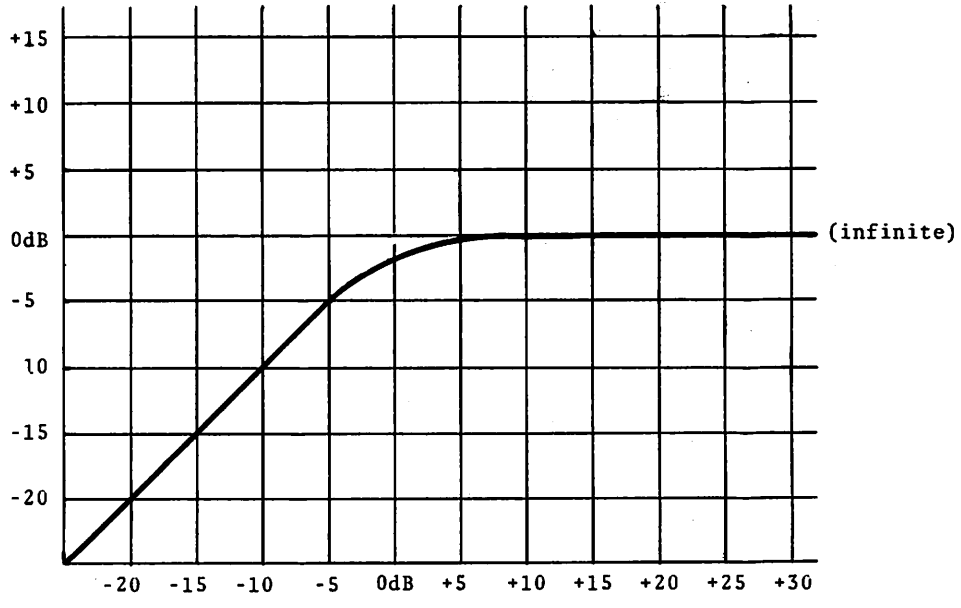
From IC 4, signals pass to the Gain Control Module, which provides the required degree of broadband or frequency-selective signal attenuation. The OUTPUT LEVEL control, R 101, is included in the feedback loop of the output amplifier (integral within the Gain Control Module). Transistors Q 1 and Q 2, the output drivers, are short-circuit protected by diodes CR 5 and CR 6. Output transformer T 101, a near-unity-gain unit, isolates the 220 from its load.

DC Control Signal Derivation

A portion of the signal from input amplifier IC 4 is



Transfer Characteristic of Conventional (closed-loop) Limiter



Transfer Characteristic of Inovonics 220 "Audio Level Optimizer"

Fig. 4

routed to a precision full-wave rectifier composed of IC 8, IC 9, and related components. By adjusting R 43, the rectifier circuit can be trimmed for equal rectification of symmetrical positive and negative peaks; however, circuit board terminals A, B, C, and D may, at the user's discretion, be jumpered such that positive program peaks may assume up to 125% of negative peak values. (See Fig. 3-1) Transistors Q 6 and Q 14 provide the high peak current necessary for charging filter capacitor C 17 at the very rapid rate required for fast program peak reduction. C 17 discharges through Q 5 at a rate determined by the setting of the PEAK RELEASE control, R 104, when the GATE is open, or when the gating function is disabled. IC 11 is a unity-gain "buffer" amplifier to isolate C 17 from subsequent circuit loading, preventing discharge when the GATE is closed.

The peak-derived DC control signal is integrated by R 66 and C 24 to obtain a voltage roughly representing the quasi-VU "average" level of the input signal. This voltage, buffered by IC 13, is available in the PEAK & AVG. mode to effect a secondary "averaging" gain control function, in addition to normal peak limiting.

IC 14 compares the "average"-derived DC control voltage with a fixed reference to light the AVERAGE COMPRESSION indicator when this mode of operation is employed. IC 12 compares the peak-derived control signal with the integrated value to give an indication of PEAK REDUCTION.

Ripple-Cancelling Circuitry

The peak- and average-derived DC control voltages are applied to the DC control input of the Gain Control Module through R 20 and the "linearity" trimmer, R 79. This same signal drives the front panel Compression Meter and Remote Compression Meter through scale-expansion networks.

This same DC control signal is also phase-inverted by IC 10, and AC coupled through C 16 to a diode clamp, consisting of CR 21 and CR 22. The object of this circuit is to extract the AC ripple component of the DC control signal, and re-introduce it out of phase, to effectively cancel itself and significantly reduce the generation of distortion.

Gating Circuit

A portion of the 220 input signal is routed via the GATING THRESHOLD control, R 103, to amplifier IC 5. This stage is bandwidth-limited, with -3dB points at 300Hz and 3kHz. This insures that most of what will appear at the output of IC 5 is legitimate program material and not spurious noises. IC 6 is a unity-gain inverter which, with diodes CR 14 and CR 15, forms a full-wave rectifier.

In the gated mode of operation, C 12 is charged by current through R 31. When input signals reach the predetermined threshold value, Q 3 begins to conduct, discharging C 12. IC 7 adds hysterisis to the circuit, insuring complete discharge of C 12 whenever input signals exceed the threshold. The output of IC 7,

normally positive when C 12 is charged, assumes a negative potential when an input signal opens the "gate". Q 4 turns on the GATE OPEN indicator, and Q 5 saturates, enabling compression release by permitting C 17 to discharge through RELEASE control, R 104. Q 15 serves to clamp overall gain at the level of previous average compression when the gate closes.

Saturation of Q 5 also discharges C 21, driving the output of IC 15 positive. When the input signal falls below the gating threshold, however, Q 5 turns off, and C 21 again begins to charge through R 64. Approximately 10 seconds later, if the input signal has remained below threshold, C 21 has charged sufficiently to drive the output of IC 15 negative. With the FUNCTION A switch in HOLD & FADE, this negative voltage slowly charges C 17, through R 70, to reduce gain and fade input noise, etc., down. Alternately, in the HOLD & RELEASE mode, the negative voltage from IC 15 saturates Q 8, slowly discharging C 17 through R 67. In this case, the input signal will fade up from its previously compressed value to an uncompressed, "wide open" figure.

Frequency-Selective Limiter

A portion of the 220 output signal is applied to a frequency-weighting network on the Frequency Insert, where a 75 μs pre-emphasis is imparted. The weighted signal passes, via a calibration trimmer, R 4, to an amplifier / rectifier composed of IC 1, IC 2, and related components. IC 3 provides additional post-rectification DC gain to the resultant control signal, which is passed on to the Gain Control Module

A separate gain-reduction element within the Gain

Control Module works in conjunction with additional networks on the Frequency Insert to separately control only the high frequency energy when it exceeds the limit imposed by the 75μs FM/TV audio curve.

Power Supplies

Zener diode CR 37 and transistors Q 10 and Q 11 form the zener-stabilized positive power supply. Similarly, CR 38, Q 12, and Q 13 form the negative supply regulator. Rectifier diodes CR 39 through CR 42 are circuit-board-mounted, while the power transformer, T 103, and filter capacitors C 101 and C 102 are chassis-mounted.

V. ALIGNMENT AND CALIBRATION

Equipment Required

AUDIO SIGNAL GENERATOR - H.P. 200CD, or equivalent
AC V.T.V.M. - H.P. 400E, or equivalent
DISTORTION ANALYZER - H.P. 330-B, or equivalent
OSCILLOSCOPE - DC to 100kHz bandwidth, 0.1V/division sensitivity
V O M - 1000 ohms-per-volt or greater

Procedure

A. Preliminary

Set all variable panel controls fully counter-clockwise. Switch the FUNCTION A switch to GATING OFF, the FUNCTION B switch to PEAK LIMIT.

B. Power Supply Check

Apply primary power and check the positive and negative regulated supplies for 19v, ±1v. (The metal cans of the finned passer transistors are convenient monitor points.

C. Compression Linearity

1. Apply 500Hz to the 220 input and monitor the output with the VTVM.
2. Increase the generator output from minimum. The 220 output will follow until it reaches a point at which the output "levels", and then once again follow the input increase. (See Fig. 5-1)
3. Adjust R 79 so that the 220 output remains maxi-

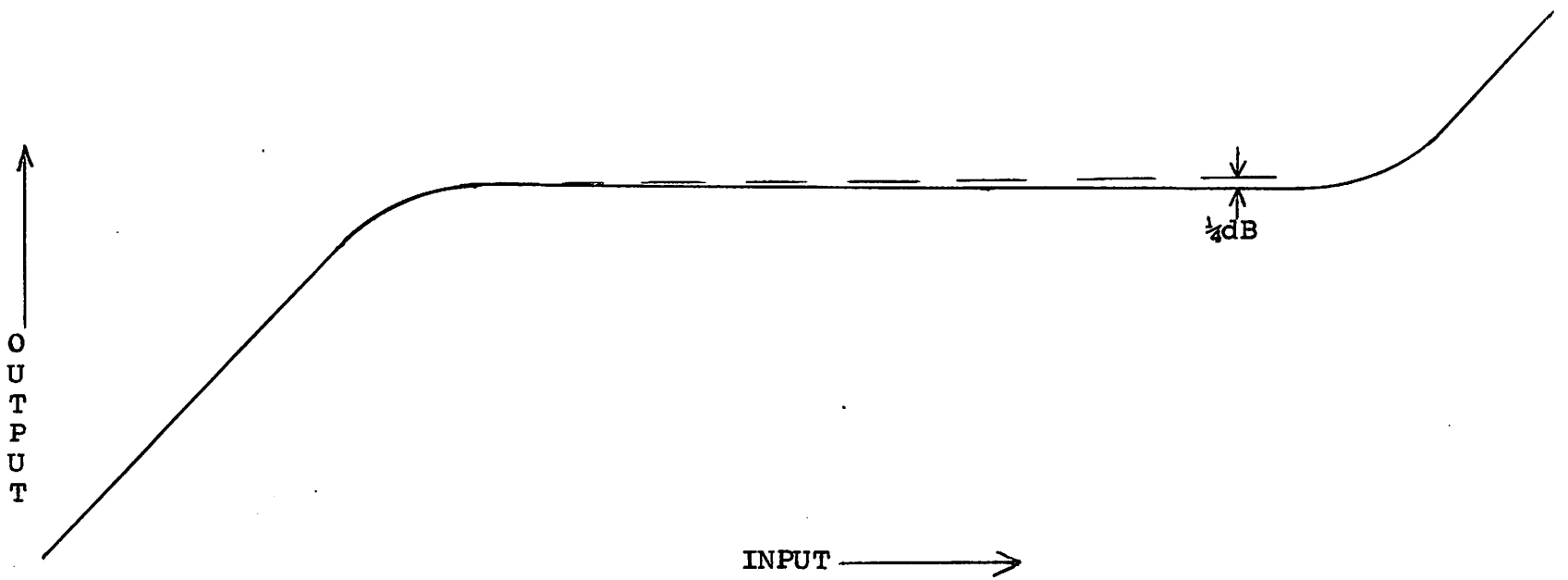


Fig. 5-1 "Linearity" Adjustment

mally flat over the "level" portion of the input/output transfer characteristic. An optimum adjustment will result in the droop of about 0.25dB, as shown in Fig. 5-1.

D. Meter Calibration

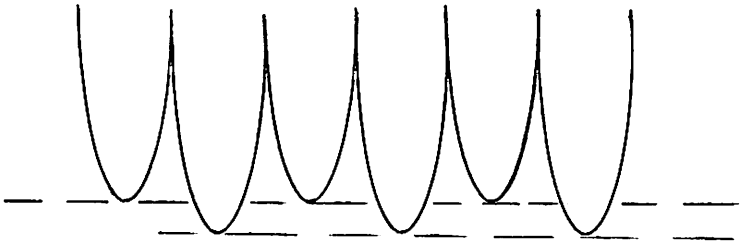
1. Reduce the generator amplitude so that the 220 output measures about -10dBm. Measure the generator level, then adjust the 220 OUTPUT LEVEL control so that the 220 output is the same as the generator.
2. Increase the generator output until the generator level is 20dB above the 220 output level. Adjust R 22 for a front panel meter reading of 20dB, and R 21 for a Remote Compression Meter (if used) reading of 20dB.

E. Peak Symmetry Calibration

1. Solder a jumper across the A - B - C - D terminals on the circuit board.
2. Apply 500Hz at a level to indicate 10 to 15dB compression.
3. Monitor the cathode of CR 24 with the oscilloscope, and adjust R 43 for equal ripple peaks. (See Fig. 5-2)

F. Distortion Null

1. Install a temporary (clip lead) jumper between terminals E and F on the circuit board.
2. Set the PEAK LIMIT RELEASE control fully clockwise.
3. Set the generator frequency to 50Hz, generator level to yield an indicated compression of 15dB.
4. Monitor the 220 output with the Distortion Anal-



WRONG

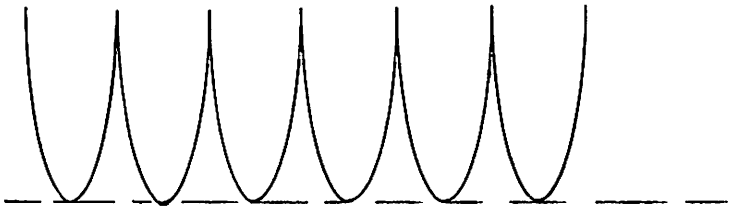


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Fig. 5-2

Peak Symmetry Calibration

yzer, and adjust R 18 for minimum indicated distortion.

5. Remove the E-to-F jumper (unless the option is to be utilized) and reset the PEAK LIMIT RELEASE control to approximately mid-rotation.

G. Frequency-Selective Limiting Option Calibration

NOTE: This step must follow those above.

1. Apply 500Hz to the 220 input at a level that will yield an output exactly 2dB below the "ceiling" value.
2. With a 75μs FM / TV insert installed, increase the generator frequency to 2.3kHz.
3. Adjust R 4 for an output level exactly 3dB below the "ceiling" value.
4. Sweep the generator frequency upward. The 220 output should fall at approximately 6dB-per-octave. (10kHz output 6dB below the 5kHz output.)

SCHEMATIC REF. NO.	PART NUMBER	DESCRIPTION	MFG.	MANUFACTURER PART NUMBER
	118700	PCB Assembly		
C 1,3,16,26,29	0901	Capacitor, 5 uF, 25V	Sprague	TE 1202
C 2,4,7,9,10,11, 18,23	0801	" 10 pF, mica	Elmenco	DM15-100J
C 5,15,19,20, 22,25,28	0803	" 22 pF, mica	Elmenco	DM15-220J
C 6,31	0810	" 100 pF, mica	Elmenco	DM15-101J
C 8	0858	" 0.0047 uF, 100V	Sprague	225P47291
C 12	0867	" 0.1 uF, 100V	Sprague	225P10491
C 13,17	1050	" 4.7 uF, 35V Tantalum	Kemet	K4R7C35K
C 14	0906	" 100 uF, 3V	Sprague	TE 1059.5
C 21,24	1052	" 22 uF, 35V	Kemet	K22C35K
C 27,30	0904	" 25 uF, 25V	Sprague	TE 1207
CR 1-37,44-47	1100	Diode, Silicon, 1N4009	Fairchild	
CR 38,39	1101	" , Zener, 20V, 5%	Motorola	1N5250B
CR 40-43	1125	" , Rectifier	ITT	1N4005
IC 1-10,12-15	1300	Integrated Circuit	Signetics	N5748V
IC 11	1305	" "	Motorola	MC 1456 CG
Q 1,3,11,14,15	1204	Transistor, 2N3567		
Q 2,4-9,13,16	1205	" 2N3645		
Q 10	1212	" 40319	RCA	
Q 12	1200	" 2N2102	NSC	

SCHEMATIC REF. NO.	PART NUMBER	DESCRIPTION	MFG.	MANUFACTURER PART NUMBER
R 1	0172	Resistor, ¼W, 10%, 8.2 k		
R 2	0174	" " " 12 k		
R 3,10,13,23,24	0161	" " " 1 k		
R 9,11,31, 57,68,80	0185	" " " 100 k		
R 5,12,30,34,35, 37,38,54,55,56 69,71,19,20,51, 45	0173	" " " 10 k		
R 6,7,32,33,47	0083	" " 5% 10 k		
R 4,53	0563	Resistor, Variable, 100 k	Helipot	91AR 100K
R 8,70	0209	Resistor, ¼W, 10%, 10 Meg		
R 29,36,61	0149	" " " 100 ohms		
R 14,17,41	0168	" " " 3.9 k		
R 15,16	0137	" " " 10 ohms		
R 18,21,22,79	0559	Resistor, Variable, 10 k	Helipot	91AR 10K
R 25,26	0080	Resistor, ¼W, 5%, 7.5 k		
R 27,28	0055	" " " 620 ohms		
R 39	0164	" " 10%, 1.8 k		
R 40,42,59,73	0176	" " " 18 k		
R 43	0558	Resistor, Variable, 5 k	Helipot	91AR 5K
R 44,46	0089	Resistor, ¼W, 5%, 20 k		
R 48	0045	" " " 240 ohms		
R 49	0052	" " " 470 ohms		
R 50	0051	" " " 430 ohms		

SCHEMATIC REF. NO.	PART NUMBER	DESCRIPTION	MFG.	MANUFACTURER PART NUMBER
R 52	0181	Resistor, ¼W, 10%, 47 k		
R 58,72	0180	" " " 39 k		
R 60	0372	" ½W, " 100 ohms		
R 62	0175	" ¼W, " 15 k		
R 63,76,77	0169	" " " 4.7 k		
R 64	0191	" " " 330 k		
R 65	0379	" ½W, " 390 ohms		
R 66	0177	" ¼W, " 22 k		
R 67	0197	" " " .1 Meg		
R 74	0375	" ½W, " 180 ohms		
R 75,78	0165	" ¼W, " 2,2 k		
		CHASSIS		
C 101,102	0910	Capacitor, 500 uF, 50V	Sprague	TVA 1315
C 103-109	1064	" 0.005 uF, 1000V	Sprague	5GA-D50
I 101	2002	Lamp Ass'y, Amber	Dialco	507-3918-1433-600
I 102	2001	" Red	Dialco	507-3918-1431-600
I 103	2010	" Green	Dialco	507-3918-1432-600
I 104,105	2000	Meter Lamp, #388		

SCHEMATIC REF. NO.	PART NUMBER	DESCRIPTION	MFG.	MANUFACTURER PART NUMBER
R 101	0602	Resistor, Variable, 10 k	Allen-Brad	JA1L040S103UC
R 102-104	0603	" " 100 k	Allen-Brad	JA1L040S104UC
S 101,102	1811	Switch, Rotary, 2 pole	Centralab	PA 1002
T 101	109000	Transformer, Output		
T 102	1502	Transformer, Input	UTC	O-37
	1503	Shield	UTC	O-17
T 103	1503	Transformer, Power	Triad	F 91x