INSTRUCTION MANUAL

NTC SERIES

PROGRAMMING INTERFACE

KEPCO INC.
An ISO 9001 Company.

MODEL
NTC SERIES
PROGRAMMING INTERFACE

ORDER NO.	REV. NO

NOTE: This on-line version of the Technical Manual includes only installation and operating instructions. For the complete manual, please contact Kepco.

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THE POWER SUPPLIER™

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TABLE OF CONTENTS

PARAGRAPH PAGE

LIST OF ILLUSTRATIONS

FIGURE

LIST OF TABLES

TABLE

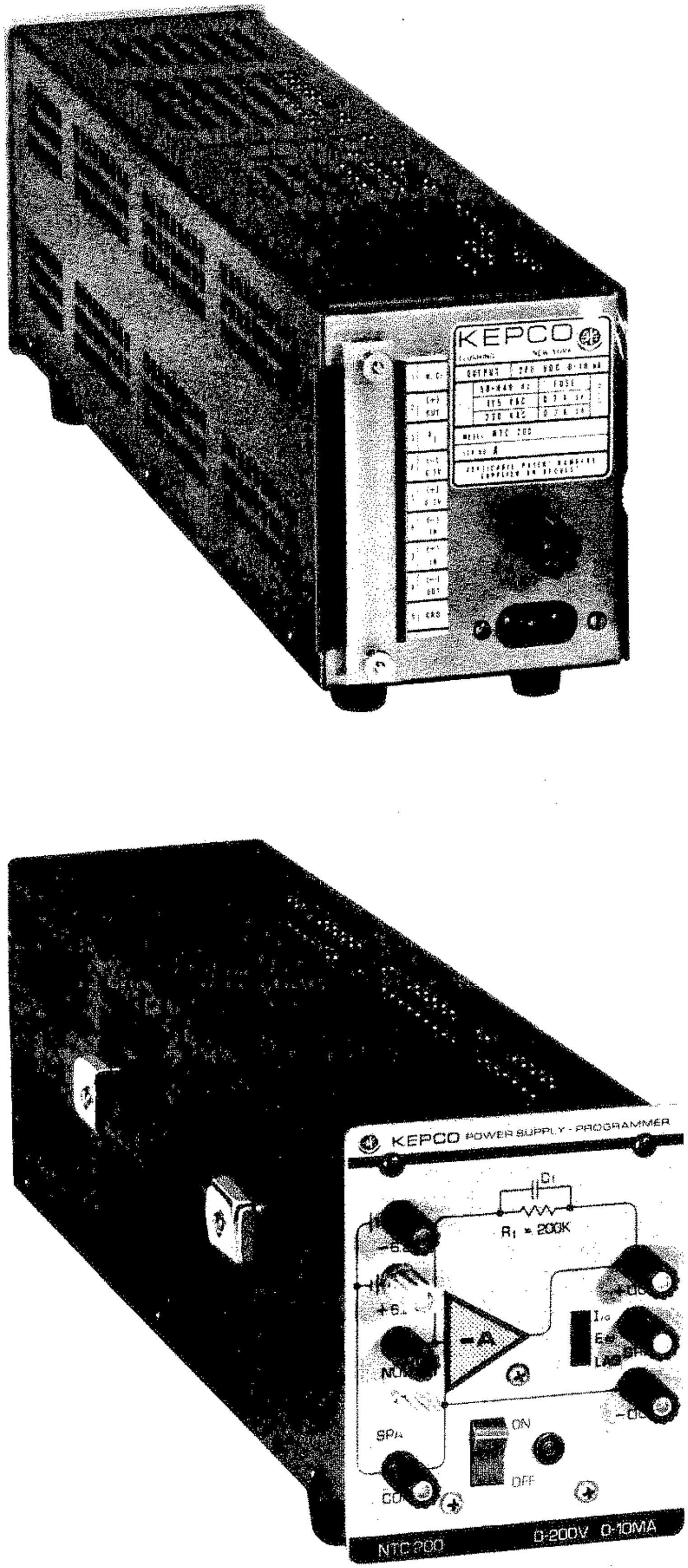


FIG. 1-1 NTC POWER SUPPLY, TYPICAL FRONT AND REAR VIEWS.

SECTION I – INTRODUCTION

1-1 SCOPE OF MANUAL

1-2 This instruction manual contains information for the installation, operation and maintenance of the Kepco NTC Power Supply-Programmers.

1-3 GENERAL DESCRIPTION

1-4 Kepco NTC Power Supply-Programmers are interface devices, designed to be used in conjunction with power supplies whose "common" terminal is the positive output. NTC Power Supply-Programmers provide a convenient way to reverse the polarity of the programming signal, making the power supply's negative output "common" to the signal source.

1-5 NTC Power Supply-Programmers are completely self-contained voltage supplies with built-in d-c reference sources, fixed feedback resistor, compensated amplifier and shunt regulator stage. All necessary programming terminations are provided on front panel binding posts as well as on a rear barrier-strip.

1-6 NTC Power Supply-Programmers are constructed in a "quarter-rack" or "half-rack" configuration, depending on the model number. The main chassis and the wrap-around cover are from cold-rolled steel; the front panel material is aluminum. Refer to "Mechanical Outline Drawing" (FIG. 1-2) for dimensions and finish.

1-7 ACCESSORIES

a) HALF-RACK UNITS:
   1) RACK ADAPTER (for single unit): Kepco Model RA–24, with filler panel, Kepco Model RFP 24–2, or RACK ADAPTER Kepco Model RA–32 with filler panel RFP–1, RFP–2 or RFP–3.
   2) RACK ADAPTER (for two units): Kepco Model RA–24.

b) QUARTER-RACK UNITS:
   1) RACK ADAPTER (FOR FOUR UNITS): KEPCO MODEL RA–24. Fits standard EIA rack dimensions, or RACK ADAPTER (for two units): Kepco Model RA–32 with filler panels RFP–1, RFP–2 or RFP–3.
   2) FILLER PANELS to cover empty slots if adapter is used for less than its capacity (for RA–24):
      KEPCO MODEL RFP 24–1, to cover one (1) empty slot.
      KEPCO MODEL RFP 24–2, to cover two (2) empty slots.
      KEPCO MODEL RFP 24–3, to cover three (3) empty slots.

1-8 SPECIFICATIONS, GENERAL

a) INPUT REQUIREMENTS: 105 to 125V a-c or 210 or 250V a-c (selectable), 50 to 65 Hz, single phase. A-C input source current approximately 0.3A at 125V a-c, power factor: 0.9.

b) AMBIENT OPERATING TEMPERATURE: –20°C to +65°C.

c) AMBIENT STORAGE TEMPERATURE: –40°C to +85°C.

d) ISOLATION: Output is isolated from the chassis:
   1) MODEL NTC–2000: A maximum of 1000 volts (d-c or p-p) may be connected between either output terminal and ground. Common mode current, output/ground = 30 μA rms, 300 μA p-p.
   2) MODEL NTC–200: A maximum of 500 volts (d-c or p-p) may be connected between either output terminal and ground. Common mode current, output/ground = 5 μA rms, 50 μA p-p.

   Note: Common mode current measured at 115V a-c, 60 Hz.

e) PROGRAMMING: May be controlled by external voltage or current signals. The NTC is a 3-terminal device, producing a positive output for a negative input with reference to the common (negative).

f) MAXIMUM CAPACITIVE LOADING: 0.001 microfarads. Excess capacitance slows the response time and may cause instability or high-frequency oscillations at the output.

g) CURRENT LIMIT: Output current is limited to approximately 110% of the rated value when operating into a short circuit. Recovery is automatic when overload is removed.

h) INPUT OFFSETS: The fixed (initial) part of the input offset voltage (E_{io}) and the input offset current (I_{io}) can be nulled by means of the built-in panel controls. The variable parts of the input offsets ($\Delta E_{io}, \Delta I_{io}$) are specified in TABLE 1-2. These offset errors (and any input or bias source used) contribute to the output voltage change (ΔE_o). Since the total output voltage error is also dependent on the input and feedback resistors used, ΔE_o is calculated for each application using the error equation:

$$\Delta E_o = \pm \Delta E_i \ (R_f/R_i) \ \pm \Delta E_{io} \ (1 + R_f/R_i) \ \pm \Delta I_{io} R_f,$$

where R_f and R_i are the feedback resistor and the input resistor respectively.

1-9 SPECIFICATIONS, PERFORMANCE

a) OUTPUT: (See TABLE 1-1.)

MODEL	d-c OUTPUT RANGE VOLTS	d-c OUTPUT RANGE mA	OUTPUT IMPEDANCE dc OHMS + SERIES L	SLEWING RATE
NTC–200	0–200	0–10	3.4Ω + 10 μH	1V/μsec.
NTC–2000	0–2000	0–1	334Ω + 100 μH	3V/μsec.

TABLE 1-1 OUTPUT SPECIFICATIONS

b) INPUT OFFSET SPECIFICATIONS: (See TABLE 1-2.)

INFLUENCE QUANTITY		VOLTAGE AMPLIFIER OFFSETS ΔE_{io}	VOLTAGE AMPLIFIER OFFSETS ΔI_{io}	REFERENCE ± 6.2V
SOURCE: 105–125/210–250V a-c		<100 μV	<10 nA	0.0005%
LOAD: No load – full load		<1 mV	<10 nA	———
TIME: 8-hours (drift)		<20 μV	<5 nA	0.005%
TEMPERATURE: Per °C		<20 μV	<5 nA	0.005%
UNPROGRAMMED OUTPUT DEVIATION(1) Ripple and noise	rms	<0.01% or 5 mV(3)		———
	p-p(2)	<0.05% or 50 mV(3)		———

(1) One terminal grounded, or connected so that common mode current does not flow through the load.
(2) 20 Hz to 10 MHz. (3) Whichever is greater.

TABLE 1-2 OFFSET AND REFERENCE SPECIFICATIONS.

c) OPEN LOOP D-C GAIN: >0.5 X 10^6 volts per volt.

d) OUTPUT SLEWING RATE: Refer to TABLE 1-1. The maximum SLEWING RATE is measured (in volts per microseconds) on the exponential output response to a square wave input signal. It is the fastest rate of change which can be obtained by overdriving or "forcing."

e) SINUSOIDAL FREQUENCY RESPONSE: Calculate by means of the equation:

$$f_{max.} = \frac{\text{SLEWING RATE}}{\pi E_{pp}}$$

where E_{pp} is the peak-to-peak magnitude of the programmed output voltage.

f) PROGRAMMING TIME CONSTANT: Given by the RC product of the built-in feedback resistances/capacitances.
Model NTC–200: R_f = 200K, C_f = 350 μμF.
Model NTC–2000: R_f = 2 M, C_f = 100 μμF.

1-10 SPECIFICATIONS, PHYSICAL

a) Refer to "Mechanical Outline Drawing" (FIG. 1-2).

SECTION II – INSTALLATION

2-1 UNPACKING AND INSPECTION

2-2 This instrument has been thoroughly inspected and tested prior to packing and is ready for operation. After careful unpacking, inspect for shipping damage before attempting to operate. Perform the preliminary operational check as outlined in paragraph 2-11 below. If any indication of damage is found, file an immediate claim with the responsible transport service.

2-3 TERMINATIONS

a) FRONT PANEL: Refer to FIG. 2-2 and TABLE 2-2.

b) REAR: Refer to FIG. 2-3 and TABLE 2-3.

c) INTERNAL ADJUSTMENTS (Refer to FIG. 2-1 and TABLE 2-1.)

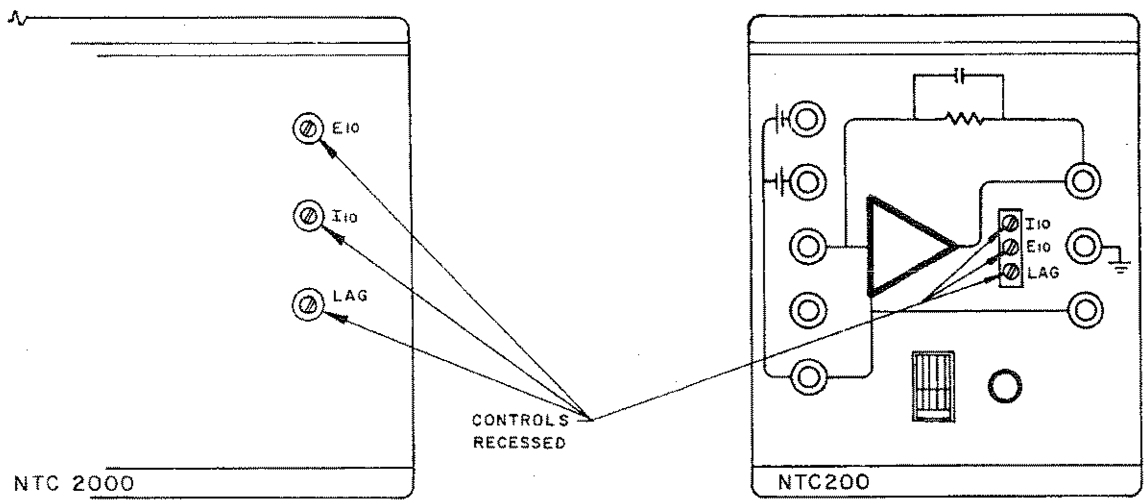


FIG. 2-1 LOCATION OF INTERNAL CONTROLS.

REFERENCE DESIGNATION	CONTROL	PURPOSE	ADJUSTMENT PROCEDURE
R12	E_{io} Null	Offset Voltage Zero Adjustment	Par. 3-4
R15	I_{io} Null	Offset Current Zero Adjustment	Par. 3-4
R9	Lag	A-C Stability Adjustment	Par. 3-14

TABLE 2-1 INTERNAL CONTROLS.

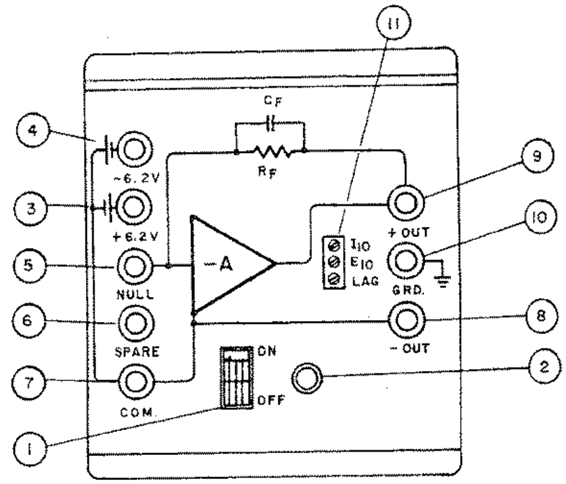


FIG. 2-2 CONTROLS AND TERMINATIONS, FRONT.

NO.	CONTROL OR TERMINATION	FUNCTION
1	A-C POWER SWITCH	TURNS POWER "ON" OR "OFF"
2	A-C LINE INDICATOR	INDICATES LINE POWER "ON" WHEN ENERGIZED
3	PLUS REFERENCE SOURCE	PROVIDES (+) 6.2V WITH RESPECT TO COMMON
4	MINUS REFERENCE SOURCE	PROVIDES (−) 6.2V WITH RESPECT TO COMMON
5	NULL JUNCTION	INPUT TO AMPLIFIER (INVERTING)
6	SPARE TERMINAL	MECHANICAL SUPPORT FOR INPUT COMPONENTS
7	COMMON	COMMON INPUT/OUTPUT TERMINAL
8	(−) OUTPUT	LOAD CONNECTION (COMMON) TO POWER SUPPLY BEING PROGRAMMED
9	(+) OUTPUT	LOAD CONNECTION TO POWER SUPPLY BEING PROGRAMMED
10	GROUND	CHASSIS CONNECTION, RETURN TO A-C GROUND
11	RECESSED ADJUSTMENTS	OFFSET ZEROING, LAG ADJUSTMENT

TABLE 2-2 CONTROLS AND TERMINATIONS, FRONT.

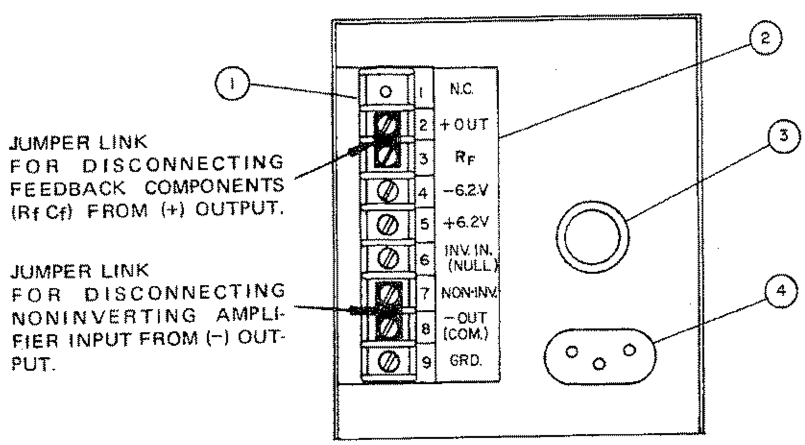


FIG. 2-3 TERMINATIONS, REAR

NO.	TERMINATION	FUNCTION
1	REAR BARRIER-STRIP	REAR TERMINALS DUPLICATE ALL FRONT PANEL TERMINAL FUNCTIONS, AND PROVIDE SPECIAL FUNCTIONS: SEE NOTES IN FIG. 2-3.
2	DECAL	TERMINAL DETAILS FOR REAR BARRIER-STRIP
3	FUSE	PROTECTS PRIMARY OF MAIN TRANSFORMER
4	LINE INPUT	SOCKET FOR (SUPPLIED) SAFETY LINE CORD

TABLE 2-3 TERMINATIONS, REAR.

2-4 A-C POWER REQUIREMENTS

2-5 The Kepco NTC Power Supply-Programmer is normally delivered for operation on a single phase, 105 to 125V a-c line, 50 to 65 Hz. For operation on 210 to 250V lines, the jumper connections on the main transformer (T201) must be changed as shown in FIG. 2-4.

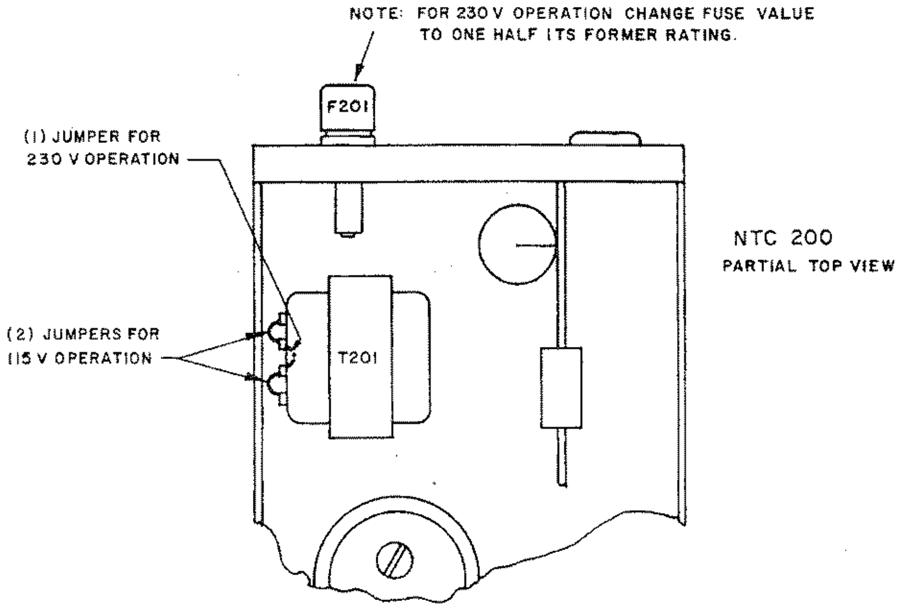


FIG. 2-4 TRANSFORMER CONNECTIONS FOR 115V A-C AND 230V A-C OPERATION.

2-6 GROUNDING

WARNING

2-7 THE HIGH VOLTAGES PRESENT IN THIS EQUIPMENT MAKE IT IMPERATIVE THAT THE CASE IS KEPT AT GROUND POTENTIAL AT ALL TIMES. If the 3-wire line cord with 3-prong safety plug (supplied with this equipment) is used in combination with a properly grounded outlet, this is taken care of automatically. If an adapter for an ungrounded outlet is used, however, the case must be grounded separately.

2-8 It is good practice to ground one side of the output at all times. The NTC has been specifically designed such that the NEGATIVE (COMMON) terminal can be operated at ground potential. Where circuit requirements do not permit grounding of either side of the output, additional precautions against dangerous electrical shocks must be taken. Equipment used in conjunction with high voltage operational power supplies must be able to withstand the operating voltage of the latter. Properly insulated wires are essential.

2-9 COOLING

2-10 The Kepco NTC Power Supply-Programmer is designed for adequate convection cooling through the wrap-around, perforated case under specified operating conditions. Sufficient space around the unit must be allowed for free air circulation. If the instrument must be mounted into confined spaces, forced-air cooling may be necessary to keep the surrounding air within the specified ambient temperature limits.

2-11 OPERATIONAL CHECK

2-12 After unpacking the instrument and before permanent installation, an operational check should be performed as described below.

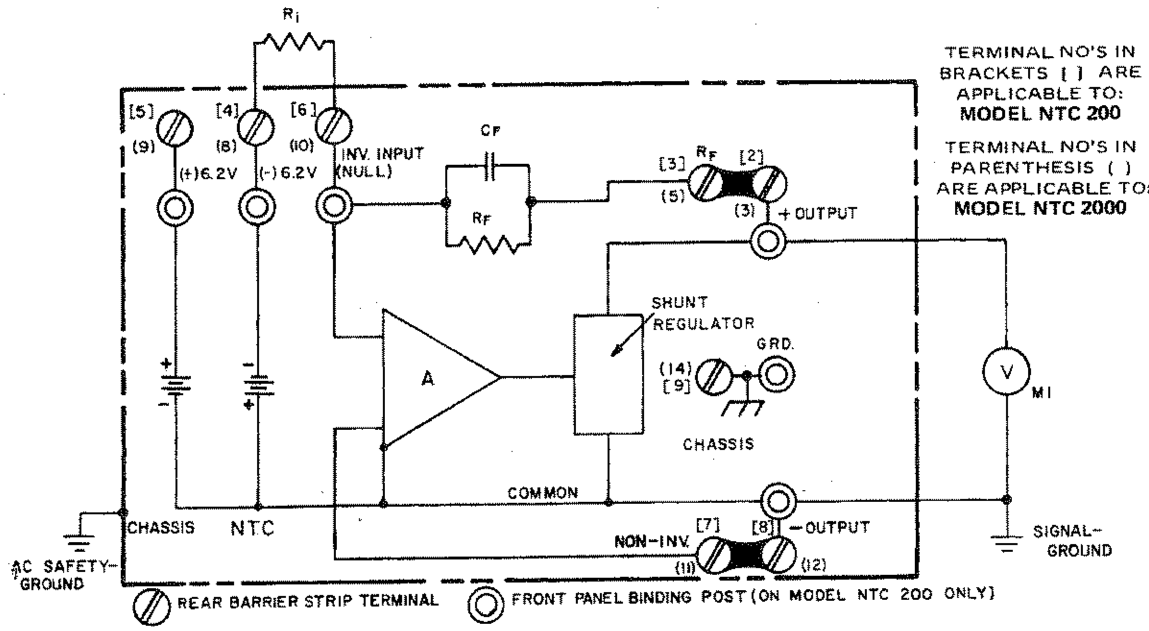


FIG. 2-5 PRELIMINARY CHECK SETUP.

a) The NTC is operated as a unipolar operational power amplifier using the internal reference source and a suitable input resistor R_i. Selection of R_i may proceed according to the operational equation:

$$-E_o = E_r \frac{R_f}{R_i}$$

EXAMPLE FOR NTC–2000: Since E_r = 6.2V and R_f = 2 megohms are given,* we may select the test voltage on the basis of the meter (M1) available. Assuming E_o = 1000V, we can calculate the input resistor required by:

$$R_i = \frac{6.2V\ (2 \times 10^6\ \Omega)}{1000V} = 12.4 \times 10^3 \text{ ohms.}$$

A 12.4 K ohm resistor will therefore produce approximately 1000 volts at the output. Connect components as shown and turn unit "on." Observe output voltage at M1. This concludes the preliminary test.

b) EXAMPLE FOR NTC–200: Since E_r = 6.2V and R_f = 200 K ohms are given,* for a test voltage of 200 volts, the input resistor (R_i) must be:

$$R_i = \frac{6.2V\ (2 \times 10^5\ \Omega)}{200V} = 6.2 \times 10^3 \text{ ohms.}$$

A 6.2 K ohm resistor for R_i (metal film or w.w. 1/2W) will produce the selected output voltage of 200 volts. Connect components as shown in FIG. 2-5 and turn NTC "on". Observe output on the voltmeter (M1). This concludes the preliminary test.

*The built-in feedback resistor (R_f) and the internal reference source (E_r = 6.2V nominal) are used for this test.

SECTION III – OPERATION

3-1 GENERAL

3-2 a) MODEL NTC–2000: This model is of hybrid design, using a vacuum tube in a shunt regulator configuration. A built-in thermal time delay of approximately 30 seconds is activated by turning the unit "on." Output is available after the delay.

b) MODEL NTC–200: This model has a power transistor in the shunt regulator stage. Ouput is therefore immediately available.

c) BOTH MODELS: Before critical adjustments or applications, a warm-up period of about 30 minutes should be allowed to insure thermal equilibrium of all critical components.

3-3 EXTERNAL CONNECTIONS

WARNING

THIS INSTRUMENT IS CAPABLE OF PRODUCING LETHAL VOLTAGES. ALL CONNECTIONS TO AND FROM THE UNIT MUST BE MADE WITH THE A-C INPUT POWER CORD REMOVED FROM THE UNIT.

a) Input and output connections may be made either at the front panel or at the rear barrier-strip (TB201) where all front panel terminations are duplicated. (Refer to FIG. 3-1.) Extra terminals are provided at the rear barrier-strip for disconnecting the feedback components (R_f, C_f) from the (+) output and to make the noninverting amplifier input available for special applications.

NOTE: **Front panel binding posts provided on Model NTC–200 only.**

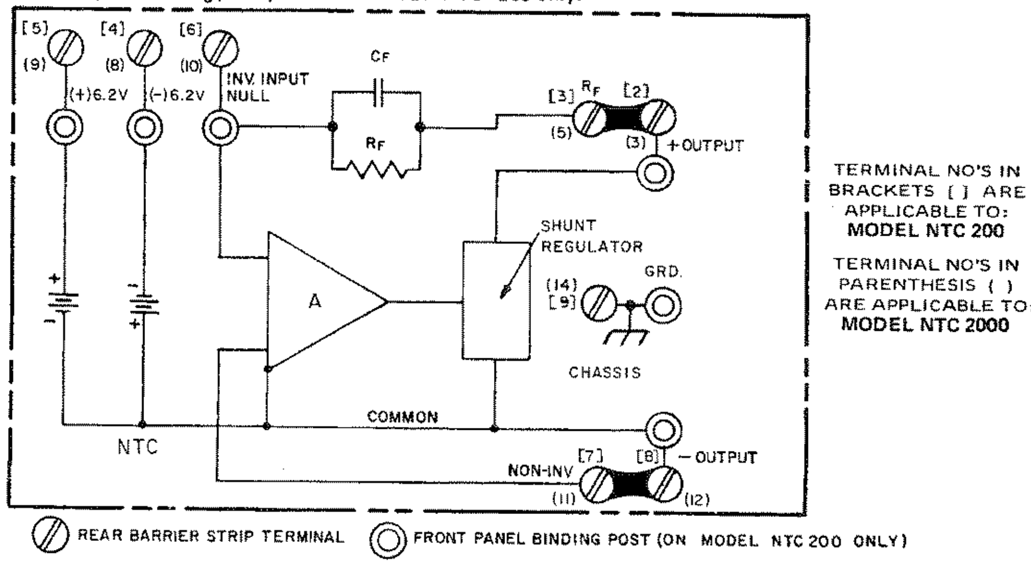


FIG. 3-1 FRONT AND REAR CONNECTIONS, NTC MODELS.

b). Connecting wires or cables must be properly insulated and terminated to make accidental touch impossible.

c) The maximum output voltage of the NTC appears also at the feedback terminals (between NULL and plus [+] OUTPUT). Consequently, any additional components connected to these terminals must be rated to withstand at least the maximum rated output voltage.

d) Refer to Section II (par. 2-6) for grounding instructions.

3-4 INITIAL ADJUSTMENTS

3-5 GENERAL. Built-in trim rheostats provide for the nulling of the fixed or initial offsets at the amplifier inputs. The procedure outlined below should precede each application to insure programming accuracy and to minimize errors.

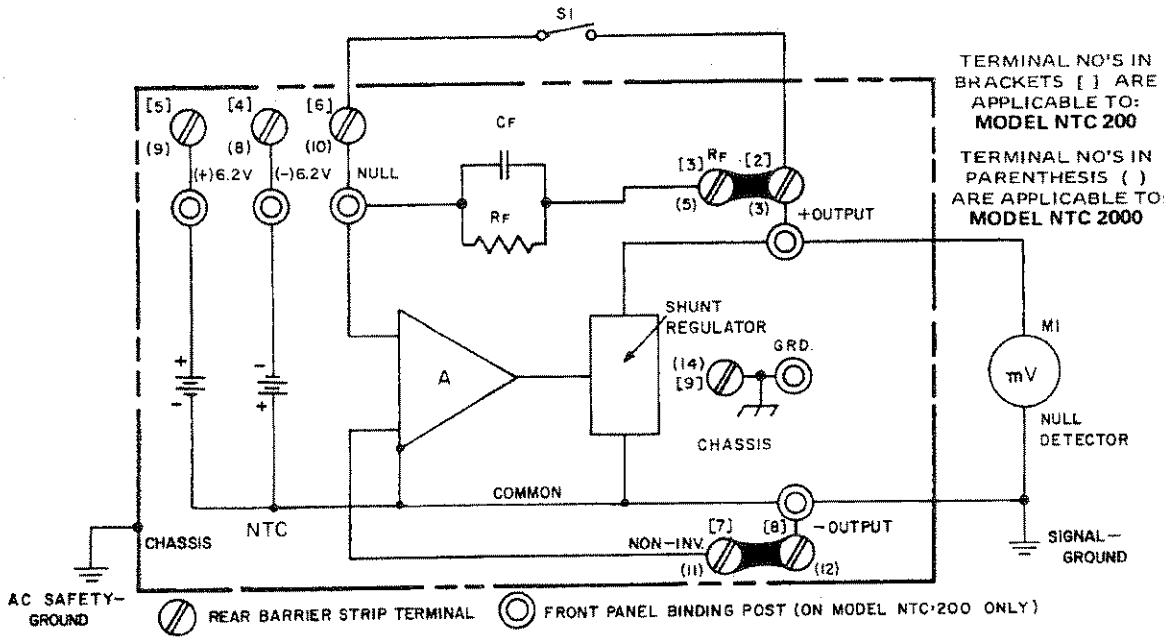


FIG. 3-2 OFFSET NULLING CIRCUIT.

3-6 PROCEDURE

a) Connect external components as shown in the diagram. (Refer to FIG. 3-2.) The "Null Detector" (M1) should be a sensitive instrument such as the MILLIVAC Model MV–07C or a digital meter. The shorting switch (S1) may be replaced by a shorting wire.

b) OFFSET VOLTAGE NULLING (S1 CLOSED). Turn NTC "on" and allow sufficient warm-up time until instruments have reached thermal equilibrium. Locate the offset controls. (Refer to Section II, FIG. 2-1.) Observe the "Null Detector" (M1) at the output and gradually increase the sensititivity of the meter. Adjust "E_{io} Null" (R12) until the "Null Detector" (M1) reads "zero."

c) OFFSET CURRENT NULLING (S1 OPEN). Observe the "Null Detector" (M1) and increase its sensitivity while adjusting "I_{io} Null" (R15) to "zero."

d) The adjustment may shift slightly as the NTC and the "Null Detector" are reaching thermal balance. Repeat adjustments as necessary.

3-7 PROGRAMMING WITH THE NTC (NEGATIVE GOING INPUT SIGNAL)

3-8 After the offset adjustments have been completed, the NTC is ready for interconnection with the associated power supply in the system. The setup diagram (FIG. 3-3) shows a complete programming system with all necessary interconnections.

3-9 Notice that all equipment cases are safely connected to a-c ground, and that a single signal or system ground point is established by grounding the NEGATIVE output of both the NTC and the associated power supply. The signal source POSITIVE is also connected to this common signal ground so that the signal source can now be operated close to ground potential.

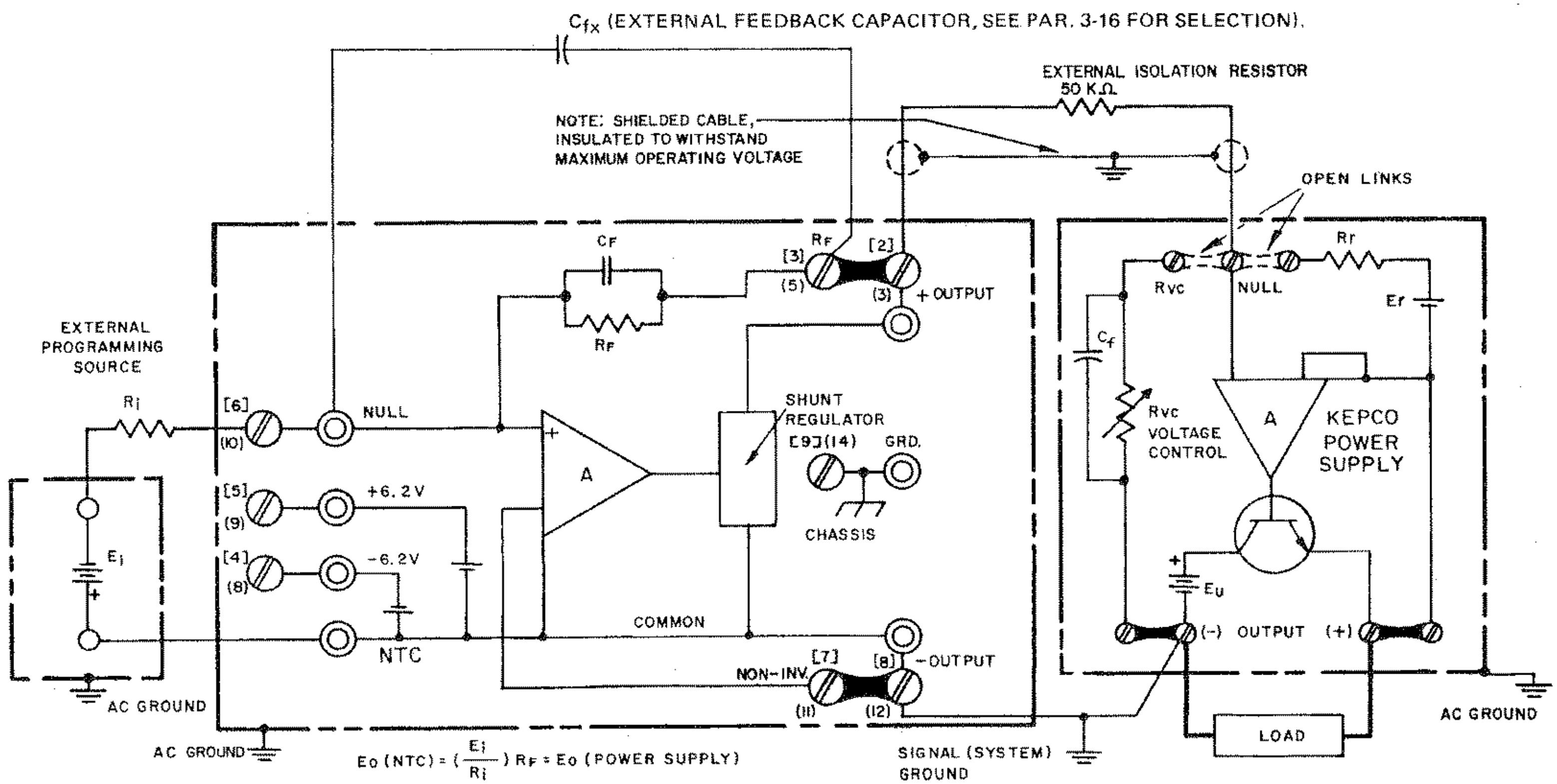
3-10 All suitable programming examples which are described in the individual instruction manual for the associated power unit are fully applicable. All equations for the calculation of programming components can be used, except that the input polarity of the signal source and the output polarity of the power supply are reversed. The total transfer functions for the system can be expressed by:

$$E_o \text{ (Power Supply Unit)} = E_o \text{ (NTC)} = (-) \left(\frac{E_i}{R_i}\right) R_f \text{ where:}$$

E_i = Programming voltage (Negative with reference to COMMON)

R_i = Input resistance

R_f = 2 megohms for NTC–2000, 200 K ohms for NTC–200

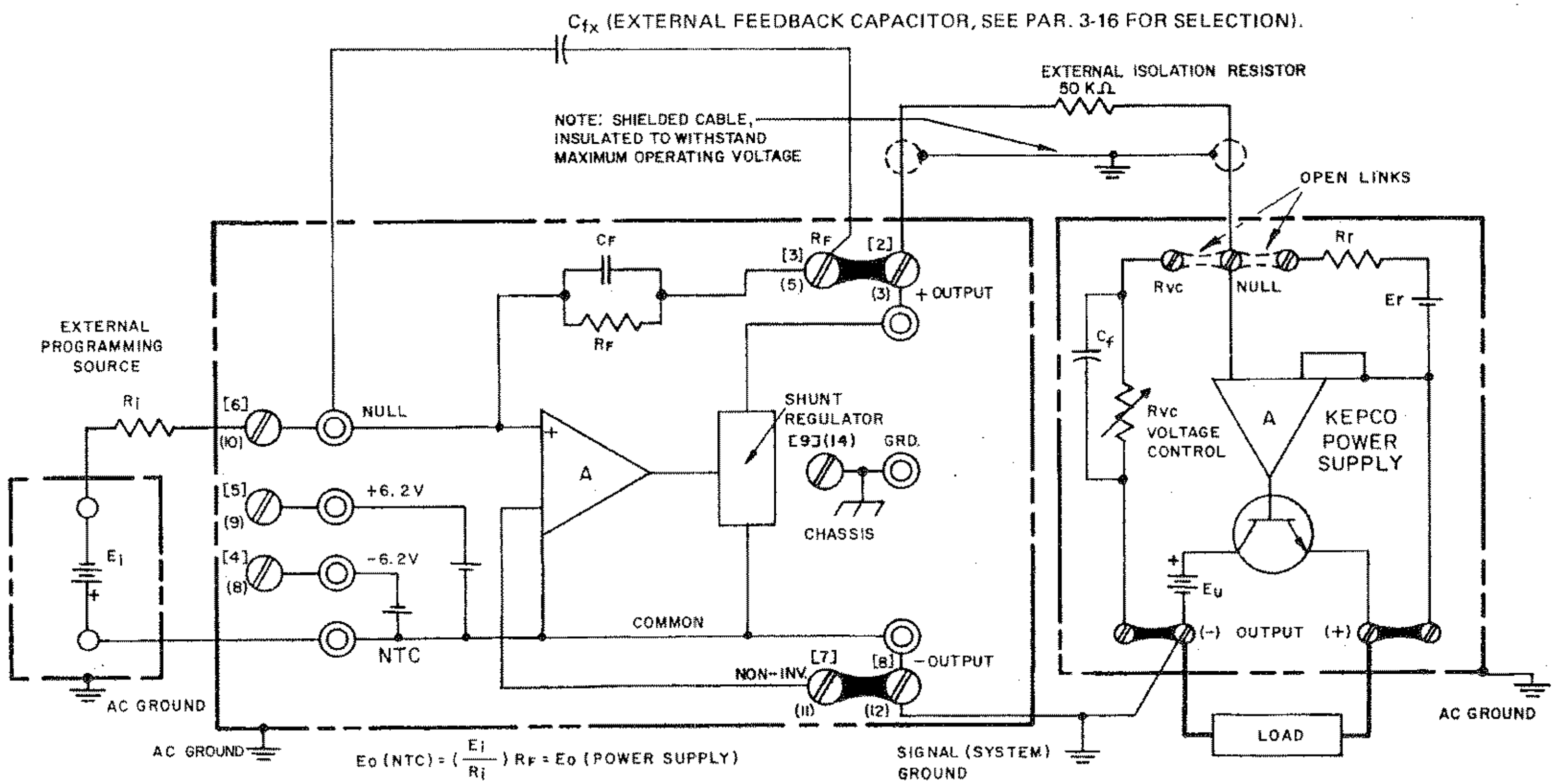


TERMINAL NO'S IN BRACKETS [ ] ARE APPLICABLE TO:
MODEL NTC 200

TERMINAL NO'S IN PARENTHESIS ( ) ARE APPLICABLE TO:
MODEL NTC 2000

NOTE: Front panel binding posts provided on Model NTC–200 only.

FIG. 3-3 COMPLETE PROGRAMMING SET-UP (NEGATIVE GOING INPUT SIGNAL).



TERMINAL NO'S IN BRACKETS [ ] ARE APPLICABLE TO:
MODEL NTC 200

TERMINAL NO'S IN PARENTHESIS ( ) ARE APPLICABLE TO:
MODEL NTC 2000

NOTE: Front panel binding posts provided on Model NTC—200 only.

FIG. 3-3 COMPLETE PROGRAMMING SET-UP (NEGATIVE GOING INPUT SIGNAL).

3-11 PROGRAMMING WITH THE NTC (POSITIVE GOING INPUT SIGNAL)

3-12 For applications where the polarity of the available input signal is POSITIVE with respect to COMMON (-output), the noninverting input of the NTC can be used to achieve the desired results (refer to FIG. 3-4). The transfer function for the system (connected as shown in FIG. 3-4) can now be expressed by the equation:

$$E_o \text{ (Power Supply)} = E_o \text{ (NTC)} = E_i \, (1 + R_f/R_i),$$

where: E_i = Programming Voltage (POSITIVE with reference to COMMON).
R_i = Input resistance, depending on the magnitude of E_i and to be calculated by the equation above.
R_f = 2 megohoms for NTC–2000, 200 K ohms for NTC–200.

3-13 Example for calculating R_i: Let the input be a positive going sawtooth wave with an amplitude of 10V, and let the desired power supply output be 150V. Then E_i = 5V, E_o = 150V, R_{VC} = 200 K (NTC–200), so that:

$$E_o/E_i = 30 = 1 + \frac{200K}{R_i}, \text{ and } R_i \approx 6.9 \text{ K ohm.}$$

NOTE: The input voltage (E_i) for programming the noninverting input of the NTC must be restricted to ***positive*** voltage signals with a maximum peak value of 5 volts.

3-14 A-C STABILITY ADJUSTMENT

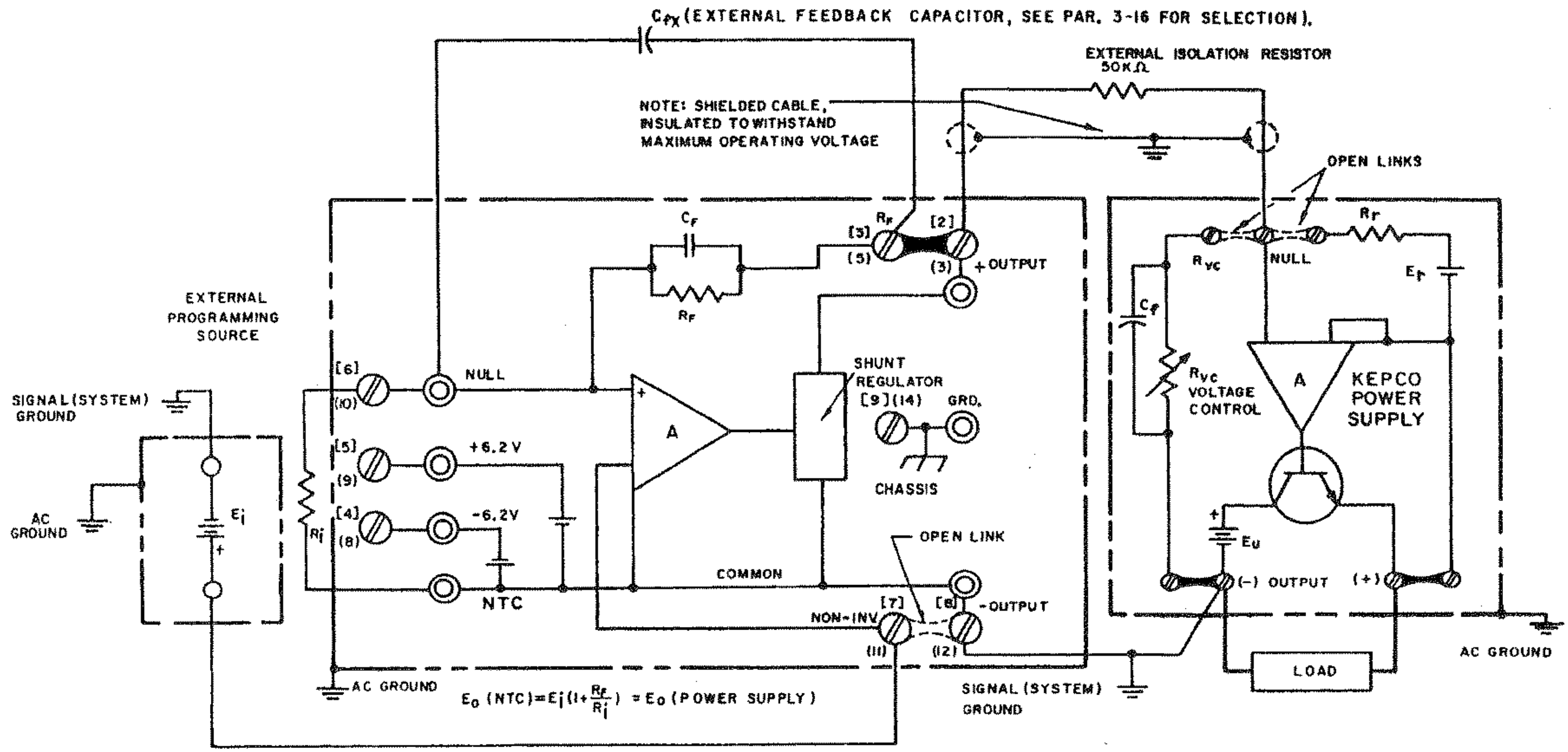
3-15 All NTC models are equipped with an "A-C Stability" adjustment, accessible through the slot on the front panel. In case of dynamic instability (oscilliation) as observed with an oscilloscope across the load, this control should be adjusted to restore stable output.

3-16 PROGRAMMING "SLOW SPEED" POWER SUPPLIES

3-17 When a "slow speed" power supply is programmed via the NTC device, an additional, external feedback capacitor and/or an isolation resistor must be connected as indicated in FIG. 3-3 and FIG. 3-4 to avoid dynamic instability. The reason for this behavior is that the internal feedback capacitor (C_f) of the power supply capacitively loads the NTC interface device. If this capacitive load exceeds the maximum specified for the NTC, instability will result The capacitive load, must therefore, be isolated and/or compensated by the external capacitor (C_f external) and/or the external isolating resistor. The isolation resistor should be connected first. If instability persists, connect the external capacitor. The external capacitor should be selected experimentally for the lowest value which will stabilize the output. NOTE: For the NTC–2000, the capacitor must have voltage rating of at least 2000 volts (200 volts for NTC–200).

3-18 NTC WITH EXTERNAL FEEDBACK

3-19 The built-in feedback resistor (R_f) together with the feedback capacitor (C_f) may be disconnected from the positive output terminal (+ OUT) of the NTC. The NTC may then be used with other values of feedback resistance, or it may be operated in an "open loop" configuration. A new value of feedback capacitor (C_f) must be selected and connected for every new value of feedback resistance (R_f). The new value of (C_f) should be determined experimentally.



TERMINAL NO'S IN BRACKETS [ ] ARE APPLICABLE TO: **MODEL NTC 200**

TERMINAL NO'S IN PARENTHESIS ( ) ARE APPLICABLE TO: **MODEL NTC 2000**

NOTE: Front panel binding posts provided on Model NTC–200 only.

FIG. 3-4 COMPLETE PROGRAMMING SET-UP (POSITIVE GOING INPUT SIGNAL).