

ORTEC

100 MIDLAND ROAD, OAK RIDGE, TENNESSEE, 37830

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TWX 810-572-1078

INSTRUCTION

MANUAL

438

BASELINE

RESTORER

ORTEC[®]

INSTRUCTION MANUAL

MODEL 438 BASE LINE RESTORER

Serial No. _____

Purchaser _____

Date Issued _____



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OAK RIDGE, TENNESSEE 37830
Telephone (615) 483-8451
TWX 810-572-1078

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STANDARD WARRANTY FOR ORTEC ELECTRONIC INSTRUMENTS

DAMAGE IN TRANSIT

Shipments should be examined immediately upon receipt for evidence of external or concealed damage. The carrier making delivery should be notified immediately of any such damage, since the carrier is normally liable for damage in shipment. Packing materials, waybills, and other such documentation should be preserved in order to establish claims. After such notification to the carrier, notify ORTEC of the circumstances so that we may assist in damage claims and in providing replacement equipment when necessary.

WARRANTY

ORTEC warrants its electronic products to be free from defects in workmanship and materials, other than vacuum tubes and semiconductors, for a period of twelve months from date of shipment, provided that the equipment has been used in a proper manner and not subjected to abuse. Repairs or replacement, at ORTEC option, will be made without charge at the ORTEC factory. Shipping expense will be to the account of the customer except in cases of defects discovered upon initial operation. Warranties of vacuum tubes and semiconductors, as made by their manufacturers, will be extended to our customers only to the extent of the manufacturers' liability to ORTEC. Specially selected vacuum tubes or semiconductors cannot be warranted. ORTEC reserves the right to modify the design of its products without incurring responsibility for modification of previously manufactured units. Since installation conditions are beyond our control, ORTEC does not assume any risks or liabilities associated with the methods of installation, or installation results.

QUALITY CONTROL

Before being approved for shipment, each ORTEC instrument must pass a stringent set of quality control tests designed to expose any flaws in materials or workmanship. Permanent records of these tests are maintained for use in warranty repair and as a source of statistical information for design improvements.

REPAIR SERVICE

ORTEC instruments not in warranty may be returned to the factory for repairs or checkout at modest expense to the customer. Standard procedure requires that returned instruments pass the same quality control tests as those used for new production instruments. Please contact the factory for instructions before shipping equipment.



ORTEC[®]

MODEL 438

**BASELINE
RESTORER**

MODE
ACTIVE



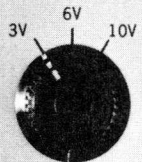
PASSIVE

OUTPUT
POS.



NEG.

OUTPUT RANGE



D.C. LEVEL
ADJUST FINE



COARSE



INPUT

$Z_0 \approx 1\Omega$



OUTPUT

$Z_0 \approx 93\Omega$



OUTPUT



INSTRUCTION MANUAL
ORTEC 438 BASELINE RESTORER

1. DESCRIPTION

The 438 BASELINE RESTORER is a precision instrument designed to restore the undershoot of a nuclear pulse amplifier output to a dc baseline prior to presenting such signals to analysis equipment such as multichannel analyzer ADC's. By this means, the BASELINE RESTORER allows precision analysis of signals at a much higher count rate than may be tolerated under previous conditions. The 438, by way of restoring the undershoot in ac-coupled amplifiers, reduces pile-up distortion caused by pulses falling on the tail (long-term component) of previous pulses. An in-depth treatment of the advantages of dc restoration is contained in the literature.^{1) 2) 3)} This instrument may be used to restore any type of signal to a dc baseline, even though it was specifically designed to restore signals from linear amplifiers in nuclear spectrometry systems. The use of the dc restorer allows linear amplifiers to be ac-coupled with arbitrary time constants and yet have the output signal as a pulse displacement from a fixed dc level. This dc level may, in this case, be adjusted to be either plus or minus from zero volts by a specified amount.

The 438 will restore bipolar signals as well as unipolar signals to a dc baseline. For bipolar signal restoration (which is not recommended), the 438 must be operated in the PASSIVE mode.

Output gain selection is provided to allow a full range output of 3V, 6V, and 10V for an input span of 10 volts. This versatility, in conjunction with the ability to obtain either positive or negative output signals, increases the 438's ability to interface with all analysis equipment.

The 438 is a single-width standard NIM module, and obtains its power via an ORTEC 401A/402A modular Bin and Power Supply.

¹ Chase, R. L. and Poulou, L. R., IEEE Trans. Nucl. Sci. NS-14 (1): 83 (February 1967)

² Gere, E. A. and Miller, G. L., IEEE Trans. Nucl. Sci. NS-14 (1): 89 (February 1967)

³ Williams, C. W., "Reducing Pulse Height Spectral Distortion by Means of DC Restoration and Pile-Up Rejection," to be published in IEEE Trans. Nucl. Sci. NS-15 (1) (February 1968)

2. SPECIFICATIONS

Input: 0-10V, positive, unipolar or bipolar, (only positive portion of bipolar pulse analyzed)

Note: Bipolar signal operation is not recommended; see Section 4.

Outputs: 2 separate, $Z_o = 1$ ohm and $Z_o = 93$ ohms

Polarity: Switch selectable, positive or negative

Voltage Range: Selectable, 3-position switch (0-3V, 0-6V, 0-10V) for 0-10V input

DC Level Adjustment: Selectable, 2-position switch, Fine or Coarse

Fine — $\pm 1\%$ full scale

Coarse — $\pm 20\%$ full scale

Nonlinearity: $\leq \pm 0.1\%$ of range over full rated output

Temperature Stability: $\leq \pm 100$ ppm/ $^{\circ}$ C (0-50 $^{\circ}$ C)

Count Rate Stability*: Centroid Shift $\leq \pm 0.1\%$, for count rates up to 50k cts/sec with time constants of 1 μ sec equal RC integrate and differentiate, count rate selector on HIGH

Resolution: The noise contribution is a function of the noise spectrum at the input and therefore has many external contributing variables, such as detector capacity and shaping time constant. The 438 is specified to contribute $< 2\%$ linewidth broadening to a system consisting of a detector with 20 pF capacitance, an ORTEC 109A Preamplifier, and an ORTEC 410 or 440A shaping amplifier with time constants of 2 μ sec equal RC integrate and differentiate and with 438 Count Rate Selector on LOW and using the PASSIVE Restoration Mode.

* The centroid of a monoenergetic pulser spectrum at 80% of range of the 438 or full scale of the monitoring instrument is modulated by variable count rate random signals from a 661 keV gamma source incident on a 2" x 2" NaI (Tl) detector with a corresponding maximum energy of 70%. (See Section 6.1.5)

Controls (Front Panel):

Output Amplitude: 3 position switch

Restoration Mode: 2 position switch (ACTIVE - PASSIVE)

Output Polarity: 2 position switch (POSITIVE - NEGATIVE)

Output DC Level: 2 position switch (FINE - COARSE)
25-turn potentiometer

Controls (Rear Panel):

Count Rate Selector: 2 position switch,
HIGH (>25 kHz) - LOW (<25 kHz)

Power Requirements: +24V — 25mA +12V — 30mA
 -24V — 40mA -12V — 20mA

Dimensions: Standard single width module (1.38 x 8.714 inches) per TID-20893 (Rev.)

Weight (Shipping): 4 pounds 1 ounce

Weight (Net): 3 pounds 5 ounces

3. INSTALLATION INSTRUCTIONS

3.1 General

The 438, used in conjunction with the ORTEC 401A/402A Bin and Power Supply, is intended for rack mounting, and therefore it is necessary to ensure that vacuum tube equipment operating in the same rack has sufficient cooling air circulating to prevent any localized heating of the all-transistor circuitry used throughout the 438. The temperature of equipment mounted in racks can easily exceed the recommended maximum unless precautions are taken. The 438 should not be subjected to temperatures in excess of 120° F (50° C).

3.2 Connection to Power - Nuclear Standard Bin, ORTEC 401A/402A

The 438 contains no internal power supply, and therefore must obtain power from a Nuclear Standard Bin and Power Supply such as the ORTEC 401A/402A. It is recommended that the bin power supply be turned off when inserting or removing modules. The ORTEC 400 Series is designed so that it is not possible to overload the bin power supply with a full complement of modules in the bin; however, this may not be true when the bin contains modules other than those of ORTEC design. In this case, power supply voltages should be checked after the insertion of modules. The 401A/402A has test points on the power supply control panel to monitor the dc voltages.

3.3 Connection Into A System

3.3.1 General

Normally, the 438 should be connected into the analysis system as the last function performed prior to pulse height analysis. If there is a nonlinear element such as a biased amplifier in the system and that biased amplifier does not contain a dc restoration circuit, then it is necessary to dc couple the nonlinear element up to the nonlinear bias point and also dc restore prior to it in order to obtain good pulse height resolution. Of course, this means that if the output of that nonlinear element is again ac coupled, it is necessary to again dc restore before entrance to the pulse height analysis system, e.g., multichannel analyzer, if the best pulse height resolution versus count rate is to be obtained. These precautions are not necessary with the ORTEC 408 Biased Amplifier at moderate rates, since it contains a dc restoration circuit.

Of course it is necessary that the pulse height analysis system be dc coupled following the dc restorer.

Some of the analog to digital converters associated with multichannel analyzers are not dc coupled at their normal input and contain no method of dc restoration;

however, some of these analyzers do allow direct access to their linear gate circuitry in the so-called Mossbauer analysis mode. Other ADC's have a built-in dc restorer capable of restoring the long time constant associated with the ac-coupling capacitor in the ADC prior to the dc restorer point. In these cases, one may obtain reasonably high count rate, i.e., in the order of 10,000 to 15,000 counts per second, of high resolution data by dc restoration externally and coupling direct into the ADC in the normal mode. This means that there are two steps of dc restoration. If, however, very high count rates are to be encountered, one should assure dc-coupling in these ADC's as well and dc restore externally by means of the 438.

There are many ADC's in use in nuclear research and the variety of input requirements is almost as broad as the variety of ADC's used. Below are listed some specified ADC's and block diagrams outlining methods of connecting the 438 into the system in such a way that it may perform its function and supply an analysis signal to the ADC through a dc coupled network. It should be noted that in some cases it is necessary to feed two signals to the ADC. One of these, which is the dc coupled signal to be analyzed, goes directly to the gate circuit, while the second signal goes to the normal input and is used merely as a trigger signal to initiate analysis since some of the ADC's pick off the trigger signal to initiate analysis from the normal, i.e., 0-10V, input.

3.3.2 Methods of Connection to Various Analyzers

Below is listed a number of various manufacturers of multichannel analyzers along with the manufacturer's recommended method of dc coupling of specific ADC's. Figure 1 applies where no trigger is needed, and Figure 2 applies where an external trigger is indicated. If information in excess of that given is necessary, contact the analyzer manufacturer for further details.

A. RIDL (Model 3412)

PACKARD INSTRUMENTS

INTERTECHNIQUE

Direct access available via the dc or Mossbauer input (trigger required).

B. NORTHERN SCIENTIFIC

Direct access available on all models (no trigger required).

C. NUCLEAR DATA

ADC Model	Direct Input Volts	Modification	Trigger Condition
ND-120 ND-130	-3 -3	Short out 0.01 μ f capacitor on ADC board, base of T-1	None Req.
ND-110	-2.5	None (use Mossbauer Input)	None Req.
ND-160F	-3	None (use Direct)	None Req.
ND-161F	-3	Short out 0.018 μ F capacitor on ADC board, base of T-1	None Req.
ND-2200	-5	Short out capacitor 09D8 on ATC board.	No trigger required if operated in open gate
ND-3300	+10	Short out 0.01 μ F capacitor on ALG board	Trigger required

D. TMC ANALYZER AND ADC DIRECT INPUT REQUIREMENTS

Model No.	Signal Required	Modifications
102 Analyzer	0 to -4 volts	Yes (1)
213 ADC	0 to +8 volts	Yes (2)
401D Analyzer	0 to -4 volts	Yes (1)
404C Analyzer	0 to -4 volts	Yes (1)
461 ADC	0 to -8 volts	No
1001 Analyzer	0 to -4 volts	Yes (3)
1004 Analyzer	0 to -4 volts	Yes (1)

Model No.	Signal Required	Modifications	
1010 Analyzer	0 to -4 volts	Yes	(3)
217B ADC	0 to -4 volts	Yes	(3)

(1) Add signal input and trigger input for Linear Gate

(2) Add signal input and special trigger input

(3) Add signal input to Linear Gate circuit

E. TULLAMORE (Victoreen) signal 0 to +10V

Model No.	Modification	Trigger	DC Level
PIP-400	Short C-203	None	~+1.5V
SCIPP Series	Short C-403	None	~+1.5V
ICADC	None	None	~0V

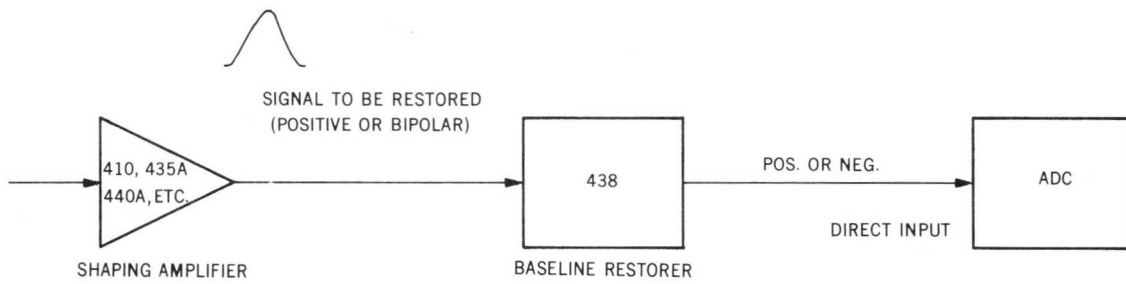


FIG. 1 CONNECTION BLOCK DIAGRAM FOR SELF-TRIGGERED ADC'S

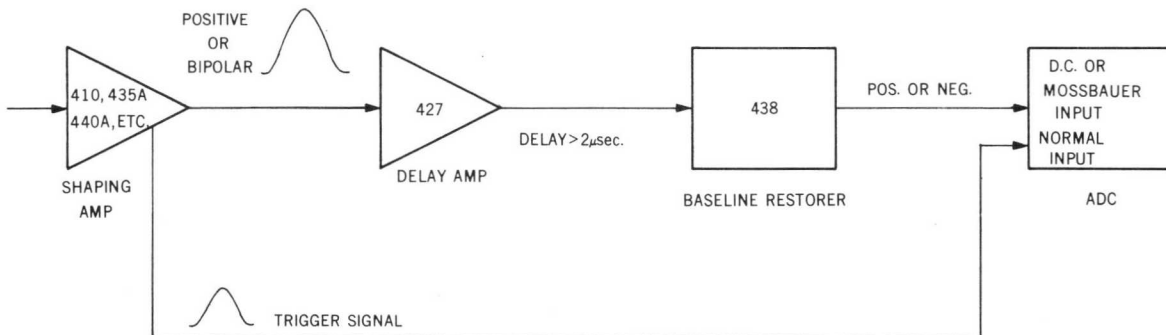


FIG. 2 CONNECTION BLOCK DIAGRAM FOR ADC'S REQUIRING EXTERNAL TRIGGER

3.4 Linear Output Signal Connections and Terminating Impedance Considerations

Source impedances of the 0-10V standard linear outputs of most ORTEC 400 Series modules are approximately one ohm and 93 ohms. Interconnection of linear signals to the 1-ohm output is thus noncritical since the input impedance of circuits to be driven is not important in determining the actual signal span, e.g., 0-10V volts, delivered to the following circuit. Paralleling several loads on a single output is, therefore, permissible while preserving 0-10 volt span. Short lengths of interconnecting coaxial cable (up to approximately four feet) need not be terminated. However, if a cable longer than this is necessary on a linear output, it should be terminated in a resistive load equal to the cable impedance. Since the output impedance is not purely resistive and is slightly different for each individual module, when a certain given length of coaxial cable is connected and is not terminated in the characteristic impedance of the cable, oscillations will generally occur. These oscillations can be suppressed for any length of cable by properly terminating the cable at the receiving end of the line by way of a shunt termination. To properly terminate the cable at the receiving end, it may be necessary to consider the input impedance of the driven circuit and choose an additional parallel resistor to make the combination produce the desired termination resistance.

If series termination of the cable is desired, one may use the output labeled 93-ohm on the modules and coaxial cable of this impedance. When series terminating at the sending end, full signal span, i.e., amplitude, is obtained at the sending end only when it is essentially unloaded or loaded with an impedance many times that of the cable. It must be remembered that when the series output impedance is in series with the driven load and for the case where the driven load is 900 ohms, a decrease in signal span of approximately 10% will occur when the 93-ohm output is used. If this output is used with a 93-ohm cable and that cable is receiving end terminated also, a 50% loss in signal amplitude will occur.

BNC connectors with internal terminators are available from a number of connector manufacturers in nominal values of 50, 100, and 1000 ohms. ORTEC stocks a limited quantity both of 50 and 100 ohm BNC terminators. These terminators are quite convenient to use in conjunction with BNC tees.

4. OPERATING INSTRUCTIONS

The operation of the 438 in the system is quite straightforward. The OUTPUT RANGE SWITCH (S3) selects the span of the output voltage to be 3V, 6V, or 10V for an input voltage range of 0-10V. This, in conjunction with the output polarity selection of positive or negative signal by means of S2, allows a matching to all ADC inputs. On some ADC's, the input has a zero offset adjust, which feeds a dc level on to the input in the normally operating ac coupled mode; however, when the direct access is used, this dc offset adjust is to some degree disabled by the output impedance of the driving amplifier (in this case, the 438) which controls the amount of that dc voltage. For this reason, the 438 provides two ranges of output dc level adjust. The range is selected by S4, the FINE-COARSE selector. This voltage level may be adjusted by R24 to be either positive or negative up to 20% of full scale.

The MODE switch (S1), which has two positions, ACTIVE and PASSIVE, selects the method of dc restoration. In the PASSIVE mode, the restoration is by way of a simple diode restorer. This mode should be used for signals which are bipolar* and in those instances where the count rate is moderate and best energy resolution (least noise width contribution) is required. The ACTIVE mode provides a very much higher restoration rate and therefore a very much higher count rate capability for the same amount of pile-up distortion and therefore should be used whenever high count rates (approximately ≥ 10 kcts/sec) are to be encountered. The active mode should not be used to restore bipolar type signals. The restoration rate is so fast with the active mode that restoration is to the point of most negative signal, and therefore the baseline is shifted to the point of most negative excursion of the input pulse. This is obviously undesirable.

The COUNT RATE switch (S5) located on the rear panel, determines the restore capacitor which allows optimum resolution at all count rates.

*Bipolar input operation is not recommended because the restorer performs the function of maintaining the baseline, and, since the pulse width is \geq a factor of two wider for bipolar, the count rate tolerated is lower.

5. CIRCUIT DESCRIPTION (See Drawings 438-0101-B and 438-0101-S)

The 438 essentially consists of three circuits. They are: the input amplifier, the dc restorer element, and the output amplifier. The input amplifier is a dc coupled operational amplifier stage consisting of transistors Q1 through Q5. It serves as an input buffer and driver circuit for the restorer capacitor C2.

The dc restorer proper consists of capacitor C2 charged by the constant current generated by Q6 or Q7 when the MODE SELECTOR switch (S1) is in the PASSIVE position. This, of course, utilizes the two diodes, D1 and D2, in the standard "Robinson" diode restorer network. When the MODE SELECTOR (S1) is in the ACTIVE mode position, restoration is performed by way of the closed loop amplifier of Q8 and Q7, which very rapidly restores the charge to capacitor C2 or C21. The mode balance control balances the offset voltage between the base of Q8 and Q9 in the active and passive modes. The adjustment of this control will be covered in Section 6. The resistor R14 performs the function of dc zero; i.e., it is adjusted to obtain dc voltage of zero at TP3. The signal from emitter of Q8 is fed by way of Q11 to TP3, which is also the input to the output amplifier loop.

The output amplifier consists of transistors Q13 through Q21 and is a high power driver to drive the coaxial cable or whatever impedance is imposed on the output. Provision is made for switching the output polarity from positive to negative by means of the POLARITY switch S2. Also, provision is made for adjusting the level of the output voltage. This is done by way of the DC LEVEL adjustment R25, which is shunted by means of a FINE-COARSE switch (S4) with a 10-ohm resistor to change the range of adjustment of the dc level. The gain of the output stage is controlled by feedback, switched by means of the OUTPUT RANGE control switch S3. This allows an output amplitude full range of 3V, 6V, or 10V.

6. MAINTENANCE INSTRUCTIONS

6.1 Testing Performance

6.1.1 Introduction

The following test descriptions are intended as an aid in the original installation and any succeeding checkout of the 438.

6.1.2 Test Equipment

The following test equipment, or its equivalent, may be used to perform each of the tests described.

1. Linear Shaping Amplifier, ORTEC 410, 435A, or 440A
2. ORTEC 419 Test Pulse Generator
3. ORTEC 427 Delay Amplifier (A delay of greater than 2 μ sec is necessary with some analyzers, notably the RIDL-3412 and the similar analyzer manufactured by Intertechnique and Packard Instruments).
4. Multichannel Pulse Height Analyzer, or alternatively, a Tektronix 540 Series or 580 Series oscilloscope with a Type W plug-in unit

With this equipment, routine diagnostic tests may be performed. Specialized tests mentioned later will involve other test equipment not mentioned here.

6.1.3 Preliminary Procedures

1. Visually check module for possible damage due to shipment.
2. Connect ac power to the Nuclear Standard Bin, e.g., ORTEC 401A/402A.
3. Plug module into bin and check for proper mechanical alignment.
4. Switch on ac power and check the dc power voltages at the test points on the 401A power supply control panel.

6.1.4 Operational Pulse Tests

These tests are to ensure that the circuit is functioning properly. Connect the pulse generator to the input of the shaping amplifier, and connect the output of the shaping amplifier to the input to the 438. Connect the output of the 438 to the input of an oscilloscope (dc coupled). Set the shaping switches on the shaping amplifier to obtain $RC = CR = 1 \mu$ sec. Set the amplifier gain switches to obtain 8V at the output. By means of a scope probe, observe the signal input to the 438 and note the amount of undershoot and the time that the signal remains below the baseline. Next, monitor the output of the 438 with the scope

and again note the amount of undershoot and the time duration of that undershoot. The undershoot should be virtually non-existent at the output of the 438 if the circuit is operating properly. Once this is observed, the 438 controls may be varied to check the circuit for positive or negative output and output signal amplitude by means of the output range selector switch; and if desired, the output zero level may be varied by means of the front panel switch and control. Normally, this level should be set to 0.00 volts. Switch the ACTIVE-PASSIVE MODE switch and determine if the dc level moves when the switch is moved from one position to the other. If this level changes, see Section 6.2.1 under calibration.

6.1.5 Count Rate Tests

Of course the most desirable test to be used for count rate of the 438 is the experiment in which it is to be used; however, if its operational characteristics are in question, it should be connected into a system shown in the block diagram, Figure 3, from which its count rate characteristics may be determined. For this test, it is suggested that a Tektronix type oscilloscope with a Type W unit be used in preference to a multichannel analyzer, since it is very difficult to separate the baseline shifting and peak spreading effects of what may be observed as the 438 - multichannel analyzer ADC combination. Some ADC's do exhibit both baseline shift and channel smear under high count rate conditions even though they are dc coupled. The extent of this smearing and shifting of the ADC may be determined by removing it from the system and observing the system function alone by means of the oscilloscope.

To perform the test, connect the system as shown, set the gains on the amplifier and pulse generator such that the pulse generator signal appears at approximately 80% of full scale, i.e., 8V on the 10-volt output range. Arrange the photo-multiplier high voltage and amplifier gain such that the maximum energy of the gamma ray from the NaI appears below the peak of the pulser, i.e., approximately 70% of full scale. Since the oscilloscope is triggered by the pulse generator, only the pulses from the pulse generator will be observed on the scope trace. These pulses will, of course, be modulated by the high count rate from the gamma source. This count rate may now be varied at will to observe the shifting or spreading of the pulser peak. Also, one may immediately observe any baseline shifting which might be contributed by count rate by the same method.

Once it is determined that this system is operating correctly, the oscilloscope may be replaced by the multichannel analyzer ADC, and the same type tests performed again to determine the overall capability of the total system including the ADC.

Figure 4 exhibits the type of operational improvement obtained when the 438 is used in a very high resolution x-ray spectrometer system compared to the same system without the 438. In this instance, the ADC used is one of the best modern units utilizing an internal dc restorer. The superiority of the 438 is readily evident.