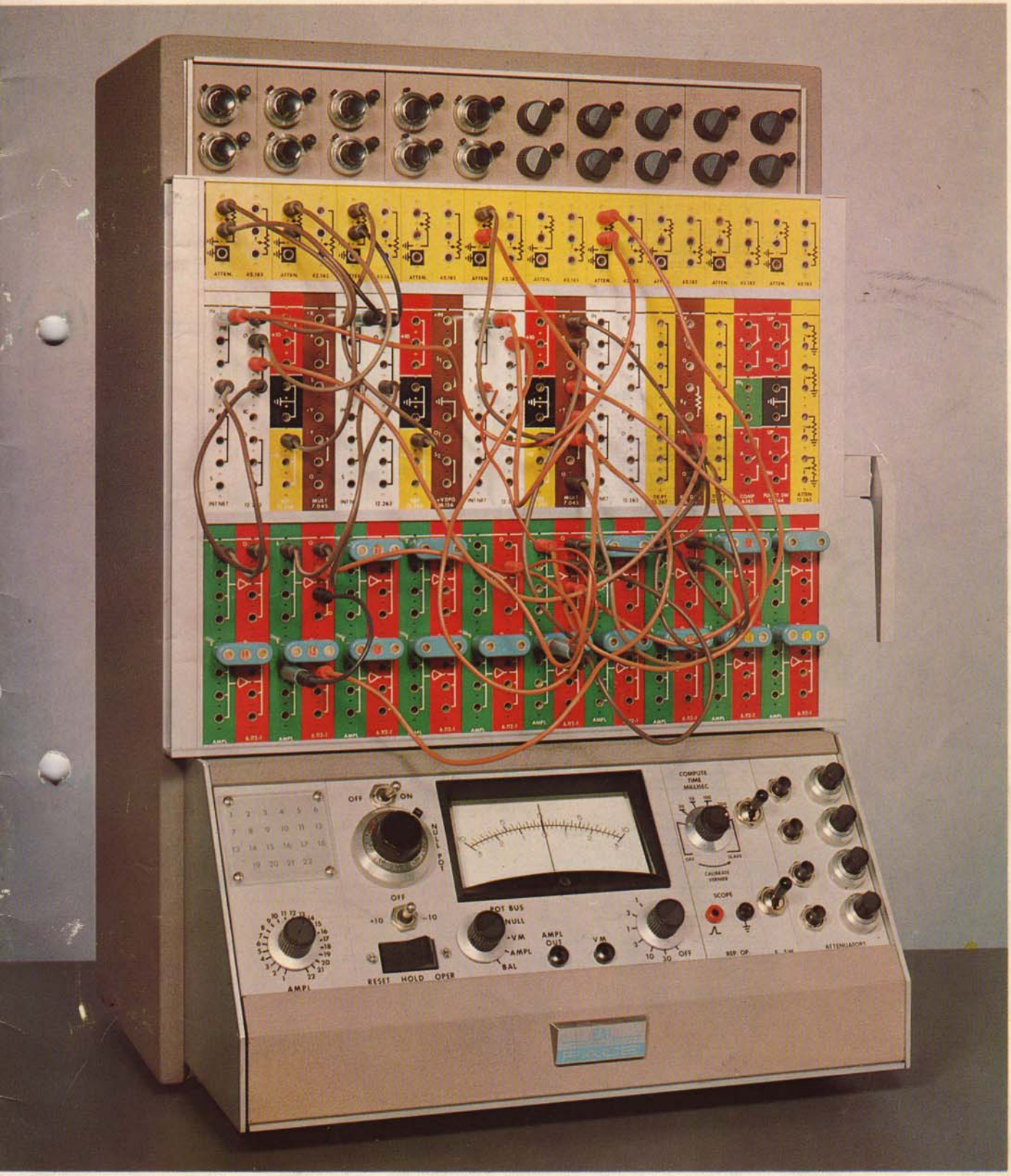
1

PACE TR-10 *analog computer*



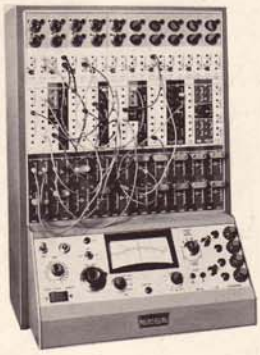
EAI ELECTRONIC ASSOCIATES, INC. *Long Branch, New Jersey*

New EAI computer puts the advantages of analog computation right at your desk. Accurate up to 0.1%, it is capable of performing the mathematical operations of *summation, integration, sign changing, multiplication, division,* and *function generation;* those operations required in the solution of most of your routine engineering problems. Differential equations, basic to most engineering problems, can now be solved with surprising rapidity. Even if you have never seen a computer before, you can learn to operate the TR-10 as easily as you learned to use a slide rule.

You simply turn a knob to feed in design parameters. The computer provides an instant-by-instant dynamic picture of the effect of each change. You can study the relationships of heat, pressure, flow, vibration, torque or any other variable. And you can visually compare one with the other. This new insight into the behavior of differential equations helps you to arrive at solutions faster . . . easier.

PACE TR-10

eliminates drudgery . . . stimulates creativity . . . cuts engineering time and costs



Because of its unique portability, this compact computer can become your personal tool. Carried right to your desk, it can be used to solve your day-to-day problems, saving you time and eliminating the drudgery of repetitive hand calculations. By allowing you to spend more of your time on creative engineering, it can enhance your value as an engineer.

You can experiment with new ideas that formerly were too costly or time consuming to try. You can perfect your design and work out all the "bugs" right on the computer . . . before building pilots or protoypes. It can drastically reduce design time and costs.

Companies who already have large analog computer installations will find the PACE TR-10 can be used to solve smaller problems and eliminate tie-ups and excessive waiting time for large equipment. It is ideal for breaking-in new engineers to the advantages and techniques of analog computation.

This dependable new tool is completely solid-state and consumes no more power than a 60 watt light bulb. Transistorized circuits assure highest reliability and long trouble-free life. The design is backed by the experience of EAI's Computer Engineering Department, which has developed designs for 70% of the general purpose analog computers in use today.

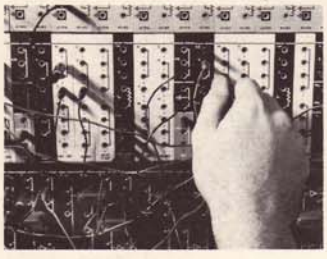
5 *steps to the solution of your routine engineering problems . . .*

STEP 1 — PROBLEM ANALYSI

Problem is translated into a mathematical description usir algebraic and differential equations.

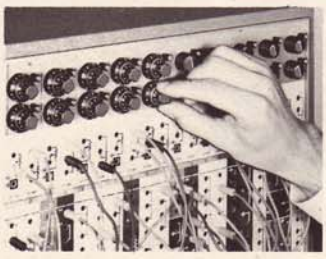
STEP 2 — PROGRAMMING

An information flow sheet is prepared using a block diagram to represent the various computer elements and their interconnections.



STEP 3 — PATCHING

Following this diagram, the patch cord connections are made between the various computer elements.



STEP 4 — INSERTION OF PROBLEM PARAMETERS

Coefficient potentiometers are adjusted to provide design parameter inputs.

STEP 5 — SOLUTION

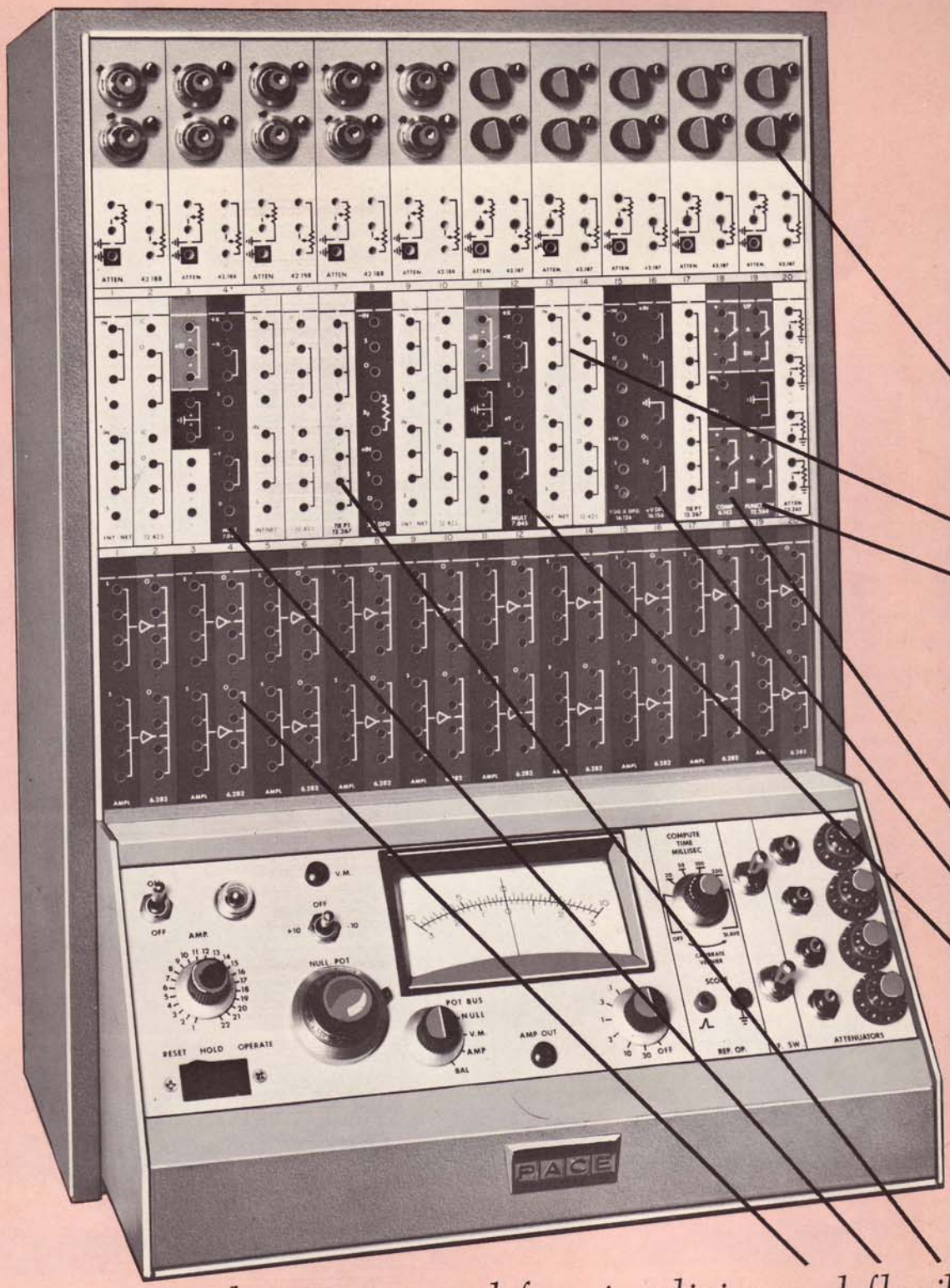
The computer solution is performed in the exact manner prescribed by the mathematical equations. Solutions are presented on an XY plotter, strip chart recorder or on an oscillograph.

ATTENUATOR ROW

NON-LINEAR ROW

AMPLIFIER ROW

CONTROL PANEL



PACE TR-10 *quality engineered for simplicity and flexibility*

Plug-in components may be replaced easily and quickly for expansion or servicing.

Non-linear components fit most non-linear row positions. Number of configurations is limited only by the number of components kept on hand.

Basic Computer is pre-wired and can be expanded simply by plugging in desired components—no additional wiring necessary.

Draws less power than 60 watt bulb. Operates from 115V, 60 cycle outlet.

Bus bar power distribution eliminates complex cabling and simplifies maintenance.

Solid state design — instant warm-up—no cooling problems.

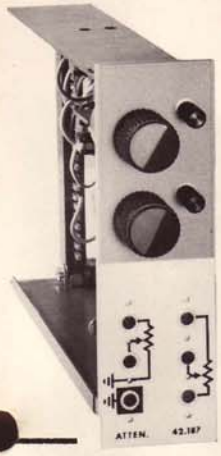
Human engineered control panel is inclined for easy, finger-tip control.

Push button potentiometer readout system speeds set-up — reduces errors.

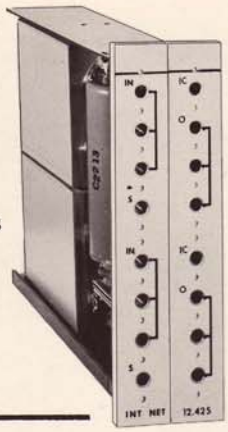
Built-in null voltmeter provides direct reading or precision null reading.

Color coded patching modules and accessories promote programming efficiency.

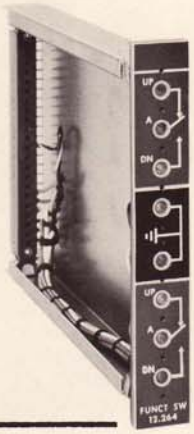
Interchangeable, plug-in components add flexibility, make expansion easy



COEFFICIENT SETTING POTENTIOMETERS
for inserting equation coefficients or problem parameters into computer.



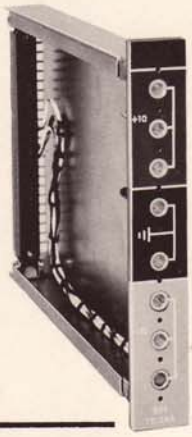
INTEGRATOR NETWORKS
enable operational amplifiers to perform integration.



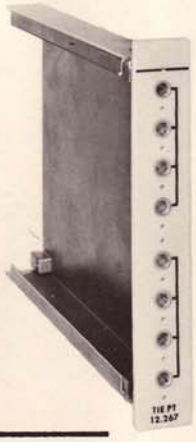
FUNCTION SWITCHES
provide for manually interchanging components without reprogramming or repatching.

COMPARATORS
compare a variable input voltage to an arbitrary bias voltage and cause a switching operation to be performed.

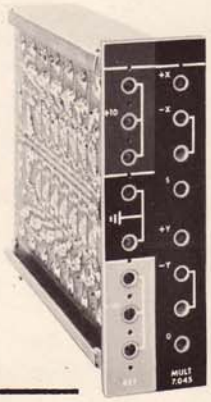
FUNCTION GENERATORS
electronically generate analytic, as well as arbitrary functions of one variable.



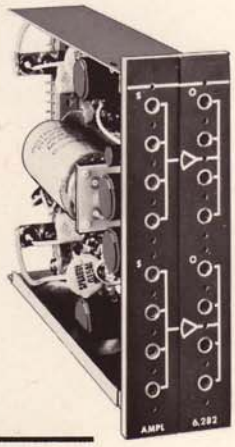
REFERENCE PANEL
makes available accurate reference voltages required for problem solution.



TIE POINT PANELS
provide additional patch panel terminations for components inputs or outputs.

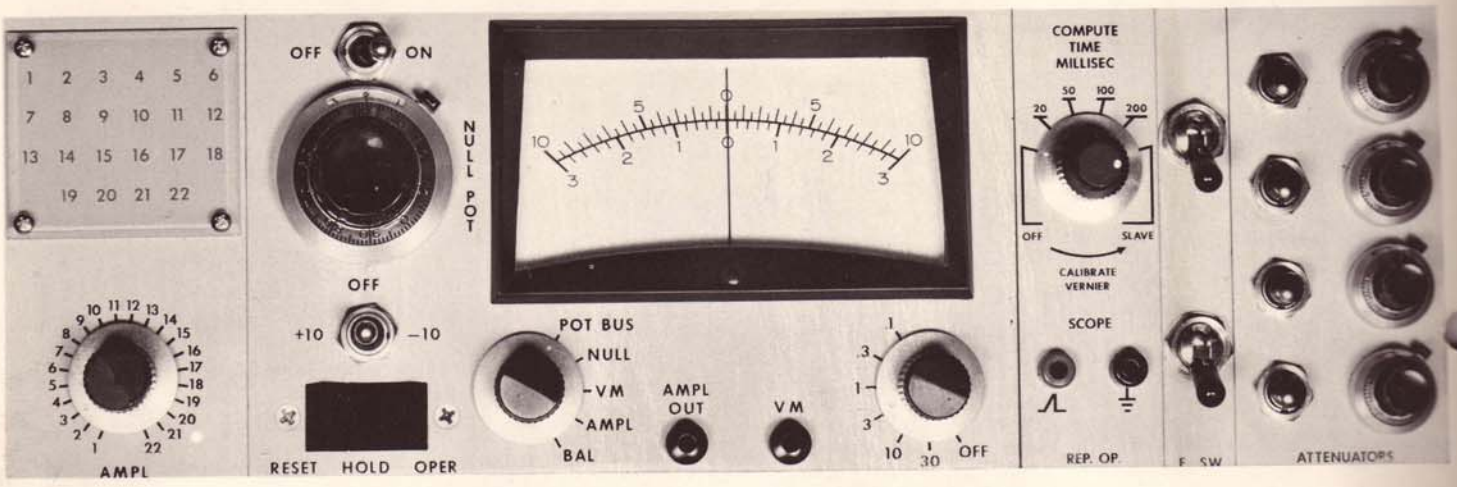


MULTIPLIERS
electronically multiply two variables of either sign.



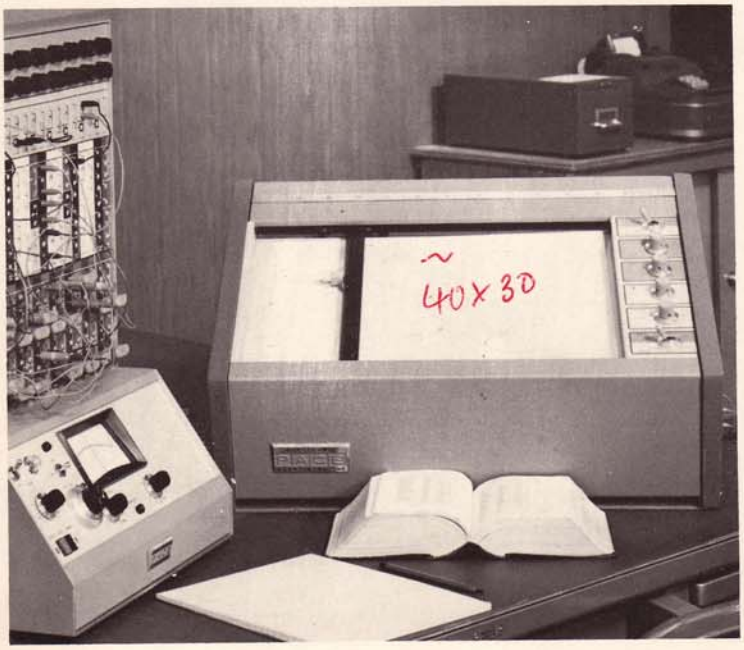
OPERATIONAL AMPLIFIERS
are high-gain, low-drift, chopper-stabilized DC amplifiers used for addition, subtraction, integration and inversion. With other components, they also perform a variety of non-linear operations.

TR-10 *Control Panel is human engineered for ease of operation...*



CONTROL PANEL has been designed for ease of operation. All knobs, buttons and switches are clearly marked and entire panel is inclined to make elements easier to see and reach. Human engineered control panel is employed in setting coefficient potentiometers, reading out problem variables, controlling computer operating mode (i.e.—hold —operate—reset), controlling primary power to computer and periodic manual balancing of operational amplifiers. An important feature of the panel is the Individual Overload Indicator on the left side which immediately identifies any amplifier that is in an overload condition so that programming errors can be located with mimimum delay.

NULL METER — Built into TR-10 control panel, it is designed for precise measurement of fixed voltages. A precision potentiometer is provided with the nulling system whereby output signals can be read to three-place accuracy (0.1%). Null Meter is also used for setting coefficient potentiometers to accuracy of 0.1%.



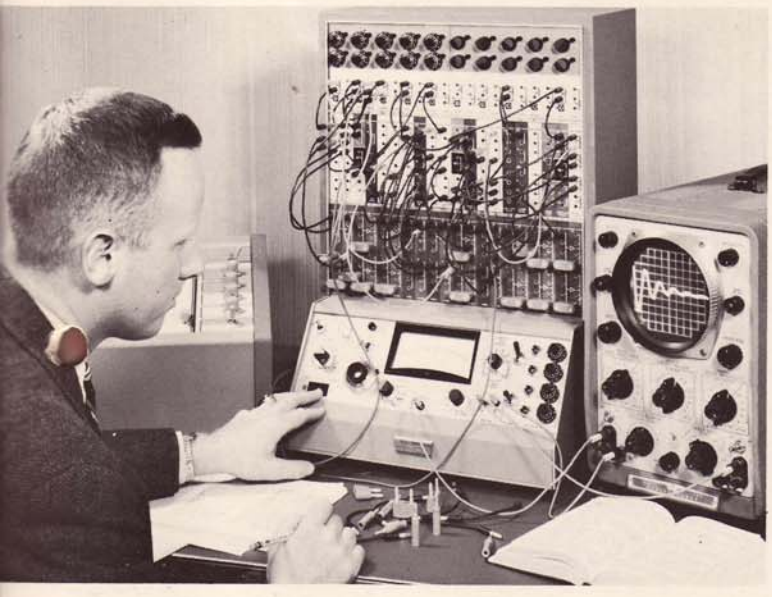
external read out equipment for use with the TR-10

X-Y PLOTTER — Model 1100E Variplotter provides highly accurate recording of any two problem variables, one as the function of the other. Re-runs can be easily made with different parameter values for comparison studies. The plotter may also be used as a time-base recorder or function generator with accessories. Write for further details.

TWO-CHANNEL, STRIP-CHART RECORDER — For use in dynamics problems where a permanent record of any two simultaneously recorded outputs against time is required. Write for additional information.

TR-10 *Becomes even more versatile with the addition of* HIGH SPEED REPETITIVE OPERATION

Accessory Group, Type 2.246



The High Speed Repetitive Operation Accessory permits the PACE TR-10 to be operated alternately as a real time or high speed repetitive computing device . . . utilizes the wide bandwidth of the TR-10 Computing Components . . . with no loss in real time computing accuracy, changing the computer operation from real time to high speed repetitive operation is accomplished by a single control . . . *without any reprogramming or repatching of the problem.*

These outstanding features of the Type 2.246 Accessory Group add to the problem solving capabilities of the TR-10 Computer.

- Selection of real time or repetitive operation of the computer by a single control . . . requires no repatching or reprogramming . . . allows immediate, permanent recording of selected solutions.
- Computing times of from 20 to 500 milliseconds per solution.
- Switched control of solution times at fixed values of 20, 50, 100, and 200 milliseconds per solution.
- Continuous control of solution times between fixed values . . . by as much as 2.5 times the fixed value.
- All solid state timing unit.
- Precision polystyrene feedback capacitors.
- SLAVE feature for control of two repetitively operated TR-10 Computers from either computer.

In REPETITIVE OPERATION the computer is continuously recycled between the *RESET* and *COMPUTE* mode of operation. The problem is, therefore, solved over and over at some predetermined repetition rate, usually often enough to allow its presentation on an oscilloscope.

TYPICAL USES OF HIGH SPEED REP OP

Users of the PACE TR-10 Analog Computer will find the High Speed Repetitive Operation Accessory a valuable aid to the solution of a variety of computing problems. The high problem solution rates possible with the repetitively operated TR-10 makes it possible to almost instantaneously view the effect of varying the parameters of a problem. This unique ability provides a powerful and economical computational tool for solving those problems requiring multiple solutions of the problem equations.

Typical problem areas are:

System Optimization . . . the selection of parameter values which give the best overall performance.

Boundary Value Problems . . . the solution of differential equations in which the problem is to find the initial conditions for specified solutions of the equation.

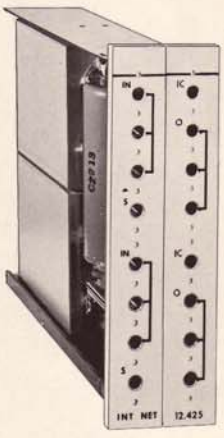
Model Building . . . the problem of determining a mathematical representation for a system of known response.

OTHER USES of High Speed Repetitive Operation . . . rapid exploratory studies to conserve computing time . . . rapid approximation of optimum system parameters and determination of stability regions of control systems . . . approximate computation and display of integral transforms, such as Fourier integrals, superposition integrals, and correlation functions . . . statistical studies requiring many solutions . . . plus a wide variety of routine computational problems requiring numerous solutions.

REP OP

INTEGRATOR NETWORK,

(Type 12.425)



This network *replaces* the real time, Type 12.263 Integrator Network in those TR-10 Computers equipped with the REP OP Accessory. Each REP OP Integrator Network contains the precision feedback capacitors, provisions for introducing initial conditions, and switching relays required to connect and operate two operational amplifiers as either real time or repetitive integrators. Patching interconnections are the same as those for the real time integrator networks.

here's how PACE TR-10

the BASIC TR-10 *is capable of solving linear problems*

PROBLEM

Solve the second order linear differential equation:

$$\frac{1}{\omega_n^2}\frac{d^2x}{dt^2} + \frac{2\zeta}{\omega_n}\frac{dx}{dt} + x = k(t) \qquad 1)$$

with the initial conditions $(t=0)$

$$\frac{dx}{dt} = \dot{x}_0 = +2.5\omega_n, \quad x = x_0 = -4.0$$

and parameters

$\zeta = 0.3, 0.6, 1.2$

$\omega_n = 1.0, 2.0, 3.0$

$k = 2.0$, a constant.

For computer solution it is appropriate to write the equation in the form:

$$\frac{1}{\omega_n}\frac{d^2x}{dt^2} = k\omega_n - 2\zeta\omega_n\left(\frac{1}{\omega_n}\frac{dx}{dt}\right) - \omega_n x \qquad 2)$$

The problem variables, x and its derivatives, are represented on the computer by voltages, amplitude scaled within the ±10 volt allowable range by including a suitable scale factor . . .

$$\frac{\text{max. allowable voltage}}{\text{max. value of variable}} = \text{scale factor (volts/unit)}$$

scale factor × variable = scaled voltage

variable	estimated max. value	scale factor	scaled voltage
x	5	2	$[2x]$
$\frac{1}{\omega_n}\frac{dx}{dt}$	5	2	$\left[\frac{2}{\omega_n}\frac{dx}{dt}\right]$

Substituting the scaled voltages into eq(2) and adjusting the coefficients to maintain equality . . .

$$\left[\frac{2}{\omega_n}\frac{d^2x}{dt^2}\right] = 2\omega_n k - 2\zeta\omega_n\left[\frac{2}{\omega_n}\frac{dx}{dt}\right] - \omega_n[2x] \qquad 3)$$

Further adjustment of coefficients enables each term to be expressed as a product of integrator gain, potentiometer coefficient setting and scaled computer voltage . . .

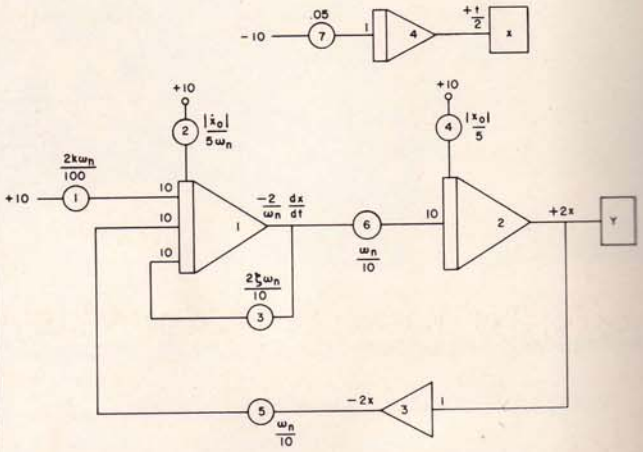
$$\left[\frac{2}{\omega_n}\frac{d^2x}{dt^2}\right] = 10\left(\frac{2k\omega_n}{10\cdot 10}\right)[10] - 10\left(\frac{2\zeta\omega_n}{10}\right)\left[\frac{2}{\omega_n}\frac{dx}{dt}\right] - 10\left(\frac{\omega_n}{10}\right)[2x] \qquad 4)$$

In this equation the terms inside the square brackets represent voltage outputs from the computer components, such as the output of an amplifier or from the reference source. The terms inside the parenthesis represent pot settings, and the factors without parenthesis or brackets indicate the required input gain to the first integrator.

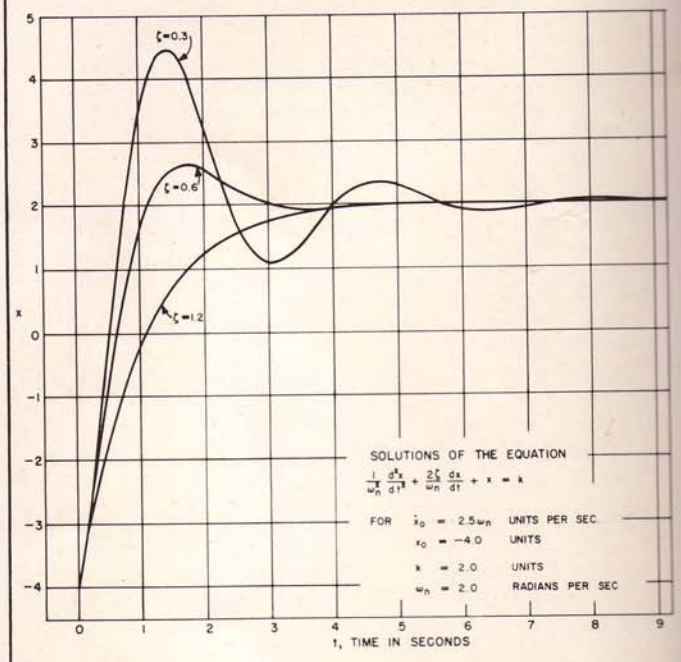
COMPUTER PROGRAM

The computer circuit diagram is obtained by

1) Integrating the highest derivative (L.H.S. of eq.4) twice to produce $\frac{2}{\omega_n}\frac{dx}{dt}$ and $2x$
2) Instrumenting the R.H.S. of eq.4 to complete the loops.
3) Providing a time-base generator by integrating a constant voltage in integrator 4.



SOLUTION



solves engineering problems . . .

by adding non-linear components to the BASIC TR-10 *non-linear problems can be solved*

PROBLEM

Solve the normalized form of Van der Pol's equation:

$$\frac{d^2x}{dt^2} - \lambda(1-x^2)\frac{dx}{dt} + x = 0 \qquad 1)$$

for initial conditions $(t = 0)$

$$\frac{dx}{dt} = \dot{x}_0 \qquad -5 < \dot{x}_0 < +5$$

$$x = x_0 \qquad -5 < x_0 < +5$$

and values of λ

$$0.1 < \lambda \leq 2.$$

Plot a phase plane diagram.

The problem variables, x and dx/dt, are amplitude scaled within the ±10 volt allowable range by including a suitable scale factor . . .

$$\frac{\text{max. allowable voltage}}{\text{max. value of variable}} = \text{scale factor (volts/unit)}$$

variable × scale factor = scaled voltage

variable	estimated max. value	scale factor	scaled voltage
x	5	2	$[2x]$
$\frac{dx}{dt}$	10	1	$\left[\frac{dx}{dt}\right]$

Solving for the highest derivative . . .

$$\frac{d^2x}{dt^2} = \lambda\frac{dx}{dt} - \lambda x^2\frac{dx}{dt} - x \qquad 2)$$

Substituting the scaled voltages into eq.2 and adjusting the coefficients to maintain equality . . .

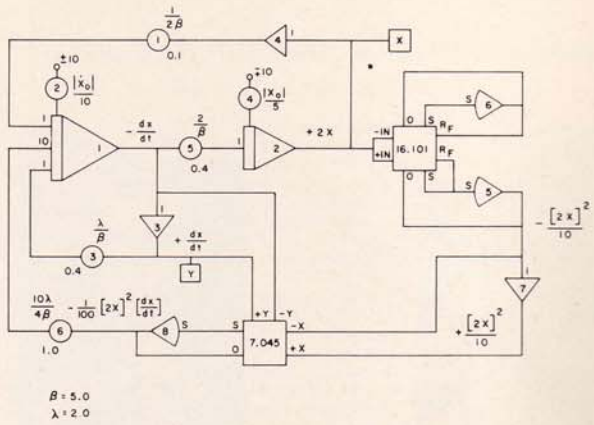
$$\left[\frac{d^2x}{dt^2}\right] = \lambda\left[\frac{dx}{dt}\right] - \frac{100\lambda}{4}\left[\frac{\frac{[2x]^2}{10}\left[\frac{dx}{dt}\right]}{10}\right] - \frac{1}{2}[2x] \qquad 3)$$

Factors of 10 are included in the nonlinear term for they are produced automatically in the computer voltage representing this term.

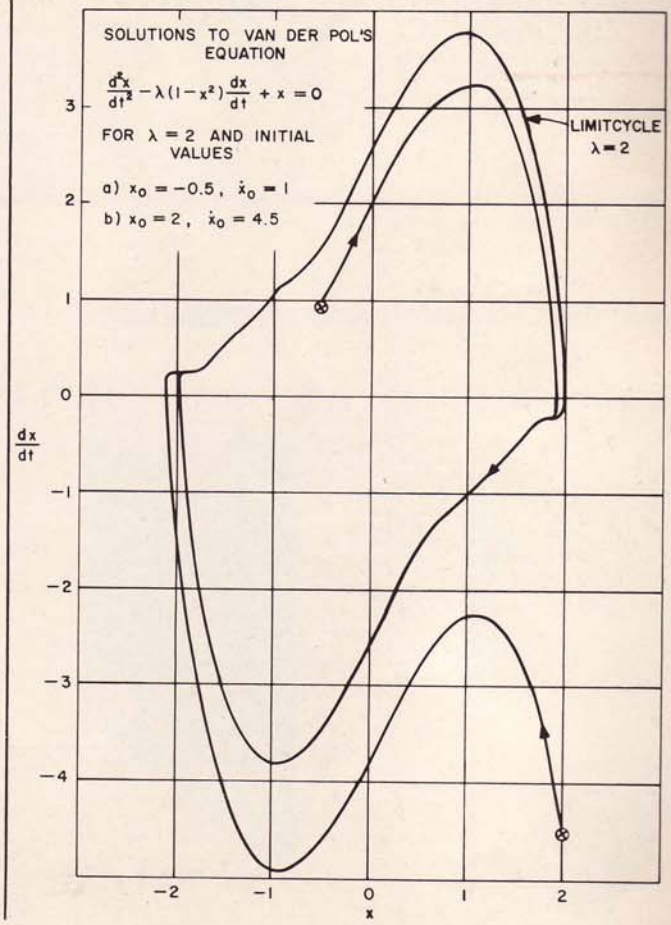
COMPUTER PROGRAM

The circuit diagram shows the computer mechanization of eq.3

A time scale factor β is included in all the inputs to all the integrators to permit changes in the speed with which the solution is produced.

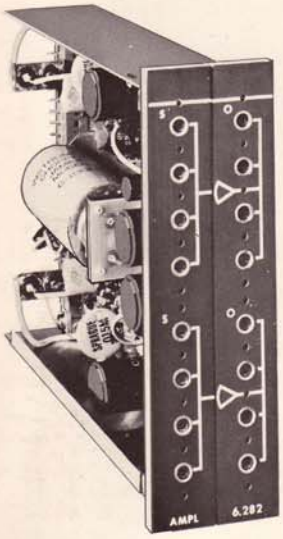


SOLUTION



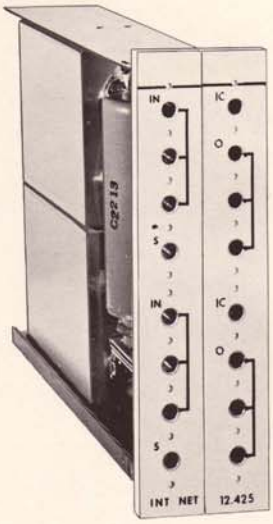
component specifications and descriptions . . .

DUAL OPERATIONAL AMPLIFIER (Type 6.282)



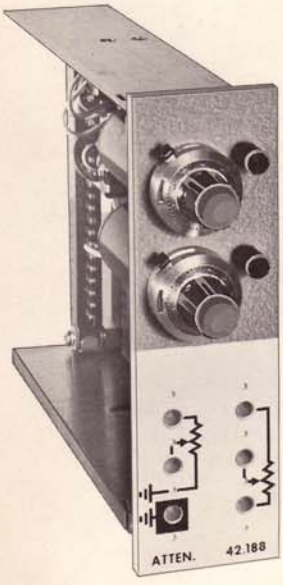
- Consists of two amplifiers packaged in a single metal chassis which is easily inserted into front of console.
- Each computing amplifier is individually chopper stabilized to reduce drift to a negligible amount.
- Simple remote adjustments are provided to facilitate manual balancing of amplifiers.
- Summing junctions of all amplifiers are available at the patch panel so that any amplifier may be used for a variety of mathematical operations.
- All amplifiers utilize single-ended inputs and outputs.
- Fully transistorized for increased reliability.
- Patch panel dimensions: 5 inches high by 1½ inches wide. Color code: Green (inputs), Red (outputs).

DUAL INTEGRATOR NETWORK (Type 12.425)



- Each network contains the precision capacitors that enable any operational amplifier to perform the mathematical operation of integration.
- Contains all relays necessary for switching the computer to various modes of operation; i.e., IC (Initial Condition), Hold, Operate. Relay operation is controlled by computer mode switch on control panel.
- A simple, two patch cord connection converts any integrator network to any operational amplifier, thus converting it to an integrator.
- The integrator initial condition voltages may be introduced from any potentiometer into the "IC" termination on the integrator network patch panel. All integrators may thus receive non-zero initial conditions, if required.
- 10 mfd ±0.1% Polystyrene capacitors used throughout to reduce drift and assure high dynamic accuracy.
- Patch panel dimensions: 5 inches high by 1½ inches wide. Color code: White.

DUAL COEFFICIENT SETTING POTENTIOMETER (Types 42.187 & 42.188)

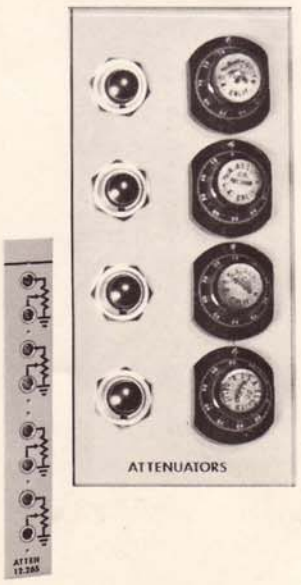


- Used for setting of problem coefficients, initial and boundary conditions, as well as problem inputs. Two types of potentiometers are available.

  Type 42.187 — Includes two ten-turn 5000Ω carbon potentiometers, with adjusting knobs and push-button switch for rapid setting of coefficients.

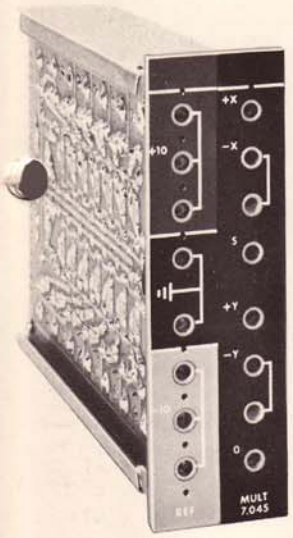
  Type 42.188 — Includes two ten-turn 5000Ω wire-wound potentiometers, with a ten-turn calibrated adjusting dial and push-button switch for rapid setting of coefficients.
- Dual potentiometer patch panel terminations are available with one potentiometer bottom-end-grounded and one bottom-end-ungrounded and terminated at the patch panel. All pot modules have top and arm of pot terminating at the patch panel.
- A ground termination is located on the patch panel module so that ungrounded potentiometers may be conveniently grounded, if desired.
- Push button switch connects reference to top of potentiometer and allows coefficient setting to be monitored by null meter.
- Patch panel dimensions: 5 inches high by 1½ inches wide. Color: code Brown (control knob area), Yellow (patching area).

QUAD COEFFICIENT SETTING POTENTIOMETER GROUP (Type 2.128)



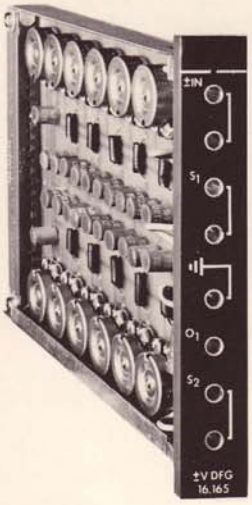
- Provides four additional potentiometers which may be used for setting problem coefficients, initial conditions, as well as problem inputs.
- Consists of Quad Coefficient Setting Potentiometer Patching Module, Type 12.265 and a Quad Coefficient setting Potentiometer Assembly, Type 42.185 (the latter being located on the control panel area).
- Two-hole terminations are provided on the patch panel for four attenuators. The bottom ends of all four potentiometers are internally grounded.
- Four wire-wound, 5000Ω ten-turn potentiometers are located on the mounting panel, each equipped with calibrated adjustment dials. They provide an indication of the coefficient setting and permit accurate resetting and recording of dial reading.
- Push button switch connects reference to top of pot and allows coefficient setting to be monitored by null meter.
- Patch panel dimensions: 5 inches high by ¾ inches wide. Color code: Yellow. Control panel width: 2¼ inches.

MULTIPLIER (Type 7.045)



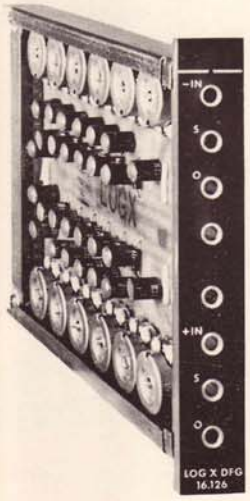
- A completely solid state device which makes use of the quarter-square technique of multiplication.
- It is used in conjunction with an operational amplifier to produce a product — XY/10 from inputs of +X, −X, +Y and −Y.
- Output polarity may be easily reversed by interchanging +X, −X, +Y, −Y inputs.
- Division of two variables may be readily performed.
- Only the right half of the patch panel on the multiplier chassis is used for multiplier terminations. The left half provides reference and ground terminations for use as required for problem solution.
- Patch panel dimensions: 5 inches high by 1½ inches wide. Color code: Brown (inputs, outputs), Black (ground), Red (plus reference), Yellow (minus reference).

VARIABLE DIODE FUNCTION GENERATOR (Types 16.165, 16.156, 16.154)



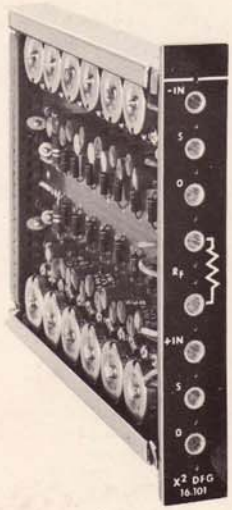
- A fixed breakpoint diode function generator composed of completely solid state components.
- Three models of the VARIABLE DFG available:
  1. Type 16.165 (± input voltage) — when used in combination with two transistorized operational amplifiers a function whose input varies from −10 to +10 volts DC can be represented by 11 straight line segments.
  2. Type 16.156 (+ input voltage) — when used in combination with two transistorized operational amplifiers a function whose input varies from 0 to +10 volts DC can be represented by 10 straight line segments.
  3. Type 16.154 (− input voltage) — when used in combination with two transistorized operational amplifiers a function whose input varies from −10 to 0 volts DC can be represented by 10 straight line segments.
- Output voltages range ±10 volts DC for all models of VARIABLE DFG. Adjustments of the VARIABLE DFG to produce a desired function is made by screwdriver from the side of DFG chassis when mounted in Service Shelf, Type 51.039. NOTE: Set-up Attenuator Unit Type 42.243 facilitates the DFG set-up.
- Fully electronic to provide wide computing bandwidth.
- Patch panel dimensions: 5 inches high by ¾ inches wide. Color code: Brown.

LOG DIODE FUNCTION GENERATOR (Types 16.126 & 16.133)



- A dual fixed diode function generator composed of completely solid state components.
- Two types of LOG DFG available . . .
  1. Type 16.126 — when used in combination with external transistorized operational amplifiers it produces an output of 5 $\text{Log}_{10}(10X)$ for an X input.
  2. Type 16.133 — when used in combination with external transistorized operational amplifier it produces an output of 2.5 $\text{Log}_{10}(10X)$ for an X input.
- One dual chassis of each type of LOG DFG is capable of the following operations:
  - A. When operating in combination with an external operational amplifier it will yield a Log_{10} X output for an X input of one polarity.
  - B. When operating in combination with an external operational amplifier for each channel it will yield outputs of $\text{Long}_{10}X_1$ and $\text{Log}_{10}X_2$ when both X_1 and X_2 are unipolar and of opposite sign.
  - C. An exponential output may be obtained by using the LOG DFG in the feedback of an external operational amplifier.
- Accepts inputs in the range of ±10 volts DC, provides outputs in the range of ±10 volts DC.
- Fully electronic to provide wide computing bandwidth.
- Patch panel dimensions: 5 inches high by ¾ inches wide. Color code: Brown.

DUAL X^2 DIODE FUNCTION GENERATOR (Type 16.101)

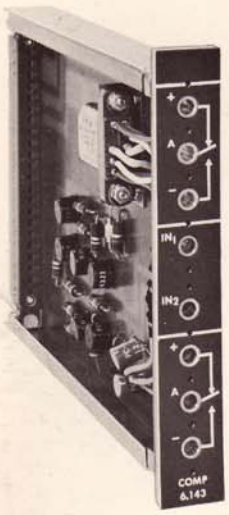


- A dual fixed diode function generator composed of completely solid state components.
- One dual chassis is capable of the following operations:
  - A. When operating in combination with an operational amplifier, it will yield an X^2 output for an X input of one polarity.
  - B. When operating in combination with two operational amplifiers, it will deliver outputs of $(X_1)^2$ and $(X_2)^2$ when both X_1 and X_2 are unipolar and of opposite sign.
  - C. When operating in combination with two operational amplifiers, it will deliver an output of X^2, with the input X varying both plus and minus in sign.
  - D. A square root output may be obtained by using the X^2 DFG in the feedback loop of an operational amplifier.
- Accepts input to ±10 volts, provides outputs ±10 volts.
- Fully electronic to provide wide computing bandwidth.
- Patch panel dimensions: 5 inches high by ¾ inches wide. Color code: Brown.

NOTE: Other commonly encountered fixed functions are available.

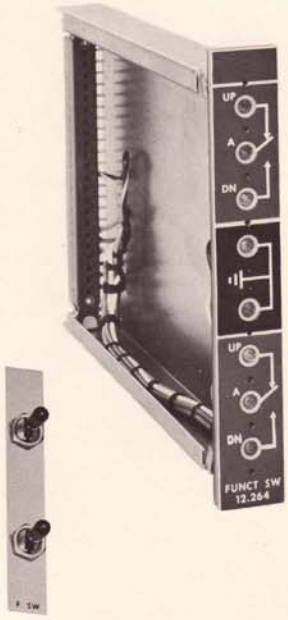
component specifications and descriptions . . .

COMPARATOR (Type 6.143)



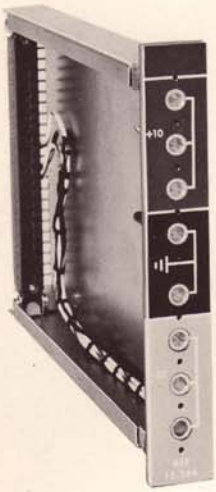
- Compares a variable input voltage to an arbitrary bias voltage and causes a switching operation to be performed.
- Consists of a three-stage, transistor amplifier and a high-speed, double-pole-double-throw relay.
- When the algebraic sum of input variable and bias voltage is positive, the relay will assume one position and, when this sum is negative, it will assume the other.
- Patch panel dimensions: 5 inches high by ¾ inches wide. Color code: Green (inputs), Red (relay contacts).

DUAL FUNCTION SWITCH GROUP (Type 2.127)



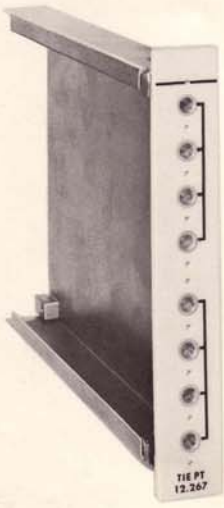
- Provides two independent, single-pole double-throw, center-off, function switches for performing manual switching operations.
- Consists of Function Switch Patching Module, Type 12.264 and a Dual Function Switch Mounting Panel, Type 20.366 (the latter being located in the control panel area).
- Two ground terminations are also provided on the patch panel for gener use in problem solution.
- Switch contacts are rated at 120 volts, 1.0 amps resistive load.
- Patch panel dimensions: 5 inches high by ¾ inches wide. Color code: Red (switch contacts), Black (ground).
- Control panel dimensions: ¾ inches wide.

REFERENCE PANEL (Type 12.266)



- This unit makes ±10 volt reference available at the patch panel. A similar panel is also included as a part of Multiplier, Type 7.045, and used for the same purpose. Computers that do not use the Multiplier, Type 7.045, will use the Reference Panel, Type 12.266, for obtaining the necessary reference terminations.
- Patch panel dimensions 5 inches high by ¾ inches wide. Color code: Red (plus reference), Yellow (minus reference), Black (ground).

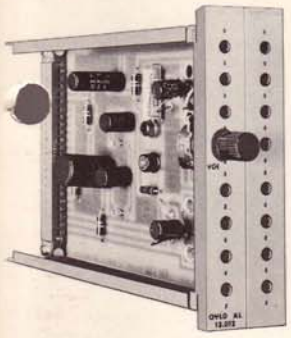
DUAL TIE POINT PANEL (Type 12.267)



- Provides two four-hole tie points for multiple interconnections of patch cords or for increasing the number of output terminations of various computing components.
- Patch panel dimensions: 5 inches high by ¾ inches wide. Color code: White.

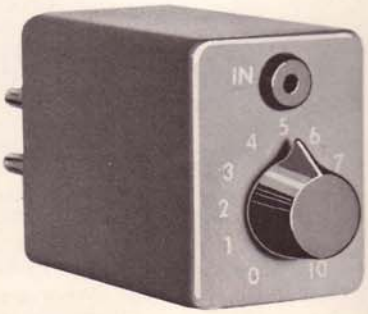
TR-10 *accessories . . .*

OVERLOAD ALARM (Type 13. 012)



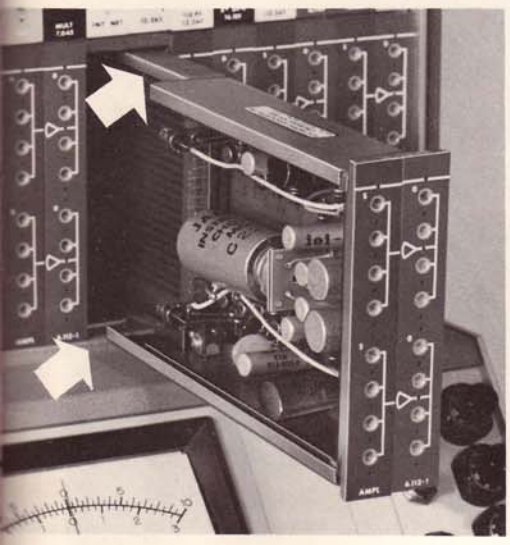
- Provides an audible warning signal when an overload occurs in any of the operational amplifiers.
- Tone of warning signal adjustable
- Fully transistorized.
- Mounts in rear of computer adjacent to Reference Regulator.
- Housed in standard TR-10 component chassis; 5 inches high by 1½ inches wide. Color code: Yellow.

SET-UP ATTENUATOR UNIT (Type 42.243)



- Facilitates the set-up of functions on the VARIABLE DFG.
- When plugged into an operational amplifier and with reference voltage patched to its input it provides a precision voltage divider for the convenient setting of VARIABLE DFG break-point voltages.
- Amplifier output voltage can be stepped in increments of 1 volt by rotary switch on front of Attenuator Unit.
- Polarity of voltage output determined by polarity of reference voltage patched to input.

PATCHING ACCESSORIES . . .



- Service Shelf (Type 51.039)
  Facilitates maintenance of any plug-in computing component under normal operating conditions.

Feedback Resistor

Input Resistor

Multiple Block

Patch Cords

- Feedback Resistors
  Type 646.010 — 10,000 ohms; Code: Red Dot
  Type 646.021 — 100,000 ohms; Code: Yellow Dot
  Wire-wound ±0.1% resistors supplied in Blue molded plugs, designed for patching between summing junction and output terminations of any operational amplifier.
- Input Resistors
  Type 646.005 — 1,000 ohms; Color Code: Red Band
  Type 646.006 — 10,000 ohms; Color Code: Orange Band
  Type 646.007 — 100,000 ohms; Color Code: Yellow Band
  Type 646.088 — 1 megohm; Color Code: Green Band
  Supplied as epoxy-encapsulated, wire bound ±0.1% resistor — male end plugs into amplifier summing junction terminations, female end accepts patch cord plug.
- Resistor Set (Type 5.134)
  Includes the following quantities of Input and Feedback Resistors:
  15 each Type 646.006 — 10K Input
  10 each Type 646.007 — 100K Input
  10 each Type 646.010 — 10K Feedback
- Diode Unit (Type 614.051)
  A WHITE banded, epoxy-encapsulated silicon diode for limiting the output of computing components or generating non-linear effects.
- Multiple Block (Type 542.605)
  Provides a six hole, off-the-patch-panel tie point for interconnecting patch cords or increasing the number of output holes of computing components.
- Patch Cord Set (Type 5.133)
  Includes the following:
  10 each Type 510.043-0, 6" long, Color — Black
  15 each Type 510.043-1, 12" long, Color — Brown
  10 each Type 510.043-2, 18" long, Color — Orange
  5 each Type 510.043-3, 30" long, Color — Blue

PACE TR-10 *can be ordered in almost an infinite variety of computing component configurations*

BASIC TR-10 *is versatile, expandable*

The *Standard Basic* TR-10 provides an economical desk-top analog computer with all of the quality engineered features of the expanded TR-10 Computer . . . and expansion capabilities are built right in. The Basic Computer is completely wired to accept a full complement of computing components . . . monitoring and control facilities for a fully expanded computer are incorporated. Expansion of the computer to enable it to solve more complex problems is accomplished simply by plugging in the desired number and type of computing components . . . no additional wiring is necessary.

The *Standard Basic* TR-10 contains the following:

1 Pre-wired Console
1 Reference System
1 Power Supply
1 Overload Alarm
5 Dual Coefficient Setting Potentiometers (Type 42.187)
5 Dual Transistorized Operational Amplifiers
2 Dual Integrator Networks (Type 12.263)
1 Dual Tie Point Panel
1 Service Shelf
1 Reference Panel
1 Patch Cord Set
1 Multiple Block
1 Resistor Set
1 Diode Unit

The Standard Basic *TR-10 is capable of solving up to two second-order differential equations plus associated linear algebraic operations.*

system design of PACE TR-10 *allows unlimited computing flexibility . . .*

The component complement of the TR-10 is limited only by the number of components kept on hand. The use of standardized, plug-in, solid-state computing components together with a unique design concept allows considerable flexibility in selecting the complement of non-linear computing components. All components plug into the computer console from the front of the computer . . . the computer patch panel is automatically formed by the color coded patching modul forming the front of each component. This feature, coupled with the ability to place different types of computing components into the same console position, permits a flexibility in arranging different equipment complements, both initially and for later expansion.

That portion of the TR-10 Computer Console which accepts plug-in computing components is divided into four areas:

ATTENUATOR ROW — This is the top row of computing components. It has been wired to accept and has positions to accommodate up to a maximum of 10 Dual Coefficient Setting Potentiometer plug-in modules (20 poteniometers).

NON-LINEAR ROW — This is the middle row of computing components. It is wired to accept a variety of interchangeable linear and non-linear computing components.

AMPLIFIER ROW — This is the bottom row of computing components. It is wired to accept and has positions to accommodate up to a maximum of 10 Dual Operational Amplifier Modules (20 amplifiers).

CONTROL PANEL — This is the area on the right side of the Control Panel. Three (3) positions are available (numbered left to right) to accept the following accessory equipment:

POSITION CP1 — High Speed Repetitive Operation Control Panel.

POSITION CP2 — Type 20.366 Function Switch Assembly.

POSITION CP3 — Type 42.185 Quad Coefficient Setting Potentiometer Assembly.

Non-linear computing components (Multipliers, DFG'S, etc.) are housed in full-width (1½ inches) or half-width (¾ inches, plug-in modules that are interchangeable in the NON-LINEAR ROW. This row consists of twenty ¾ inch positions numbered to correspond to the numbering strip across the top of the row. It has the capacity for mounting twenty (20) half-width modules or ten (10) full-width modules or any combination of both which does not exceed the total capacity of the row. Full-width modules occupy two adjacent odd and even numbered position pairs, i.e., #1 and #2, #5 and #6, etc.

The NON-LINEAR ROW makes provisions for the following inter-changeable components in any combination providing that the total capacity of the row is not exceeded.

INTEGRATOR NETWORKS. Up to nine (9) Type 12.263 or Type 12.245 Dual Networks can be accommodated in positions #1 through #18. Each dual network occupies adjacent position pairs as for example positions #1 and #2, #5 and #6 ,etc.

MULTIPLIERS. Up to nine (9) Type 7.045 Quarter Square Multipliers can be accommodated in positions #1 through #18. Since the multiplier is housed in a full-width module it also occupies adjacen position pairs.

VARIABLE DFG. Any of the three available models of the VARIAGLE DFG; Type 16.154, Type 16.155, or Type 16.165, can be accommodated in any *even* numbered position with the exception of position #20.

X^2 DFG. The Type 16.101 function generator can be mounted in any *even* numbered position with the exception of position #20.

LOG DFG. Any of the two available models of the LOG DFG; Type 16.126 or Type 16.133, can be positioned in any *even* numbered position with the exception of position #20.

REFERENCE PANEL. The Type 12.266 REFERENCE PANEL can be positioned in any *even* numbered position with the exception of position #20.

DUAL TIE POINT PANEL. This unit can be positioned in any position in the NON-LINEAR ROW.

COMPARATOR. The Type 6.143 COMPARATOR may be positioned in position #18 only.

FUNCTION SWITCH PATCHING MODULE. The Type 12.264 Patching Module may be mounted in position #19 *only*.

QUAD POTENTIOMETER PATCHING MODULE. The Type 12.265 Patching Module may be mounted in position #20 *only*.

NOTE: The above assignment of computing components applies to the standard TR-10 Console. Special computers may be supplied with provisions for mounting DFG's or REFERENCE PANEL in the odd numbered positions (with the exception of position #1) or for accommodating more than one COMPARATOR.

PACE TR-10 *versatility allows one computer to do the work of several . . .*

or two TR-10's *can be slaved together to solve larger problems*

With the TR-10 you need never worry about your problems becoming too complex. From the standpoint of problem solving capabilities the TR-10, is in many respects, a combination of several computers. If your problem is too large or complex for the *STANDARD BASIC* TR-10 you simply expand the computer by plugging in the needed computing components. Problems requiring an extra integrator or multiplier need no longer go unsolved. You simply remove an unneeded component from the expanded computer and replace it with the proper computing component. If your problem becomes too large for a single expanded TR-10 then you slave two TR-10's together. With the TR-10 Computer you are not limited to fixed equipment complements . . . the combination of computing components is easily changed to satisfy your problem requirements.

STANDARD BASIC TR-10 . . . provides an economical desk-top analog computer which is ideal for instructional purposes or for the solution of less complex problems.

STANDARD BASIC TR-10 *plus specific components* . . . allows you to solve those "smaller" physical problems which are complicated by the presence of non-linearities.

STANDARD NON-LINEAR EXPANDED TR-10 . . . provides a desk-top analog computer with sufficient computing components to solve several complex equations simultaneously. Allows you to make a more detailed analysis of your design problem.

STANDARD NON-LINEAR EXPANDED TR-10 *plus spare non-linear components* . . . effectively provides several computers in one TR-10 Console. By purchasing additional non-linear components beyond the console non-linear capacity you can achieve unusual computing flexibility.

SLAVING TWO TR-10 *COMPUTERS* . . . provides an analog computer with sufficient capacity to solve complete system problems in some detail. With the TR-10 SLAVE feature you have complete control of your problem solution . . . from either computer. TR-10 Computers are easily SLAVED . . . or disconnected to permit the solution of two individual problems simultaneously.

Experience has shown that the complement of computing components provided in the Standard Non-Linear Expanded TR-10 will satisfy the computing requirements of typical engineering design problems. This unit contains the following component complement:

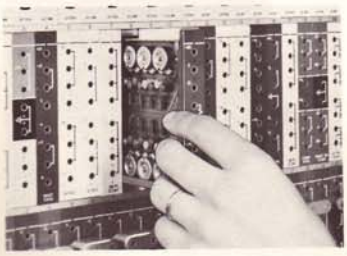
COMPONENT	STANDARD NON-LINEAR EXPANDED COMPUTER TR-10-3
Pre-wired Console	1
Power Supply	1
Reference System	1
Overload Alarm	1
Dual Coefficient Pots (Type 42.187)	10
Quad Coefficient Pots	1
Dual Operational Amplifiers	10
Dual Integrator Networks (Type 12.263)	4
Multiplier (Type 7.045)	2
VARIABLE DFG (Type 16.165)	1
X^2DFG (Type 16.101)	1
Set-Up Attenuator Unit	1
Comparator	1
Dual Tie Point Panel	3
Dual Function Switch Group	1
Service Shelf	1
Patch Cord Set	3
Multiple Block	1
Resistor Set	2
Diode Unit	1
optional . . .	
High Speed Rep Op Group	1

PHYSICAL DESCRIPTION

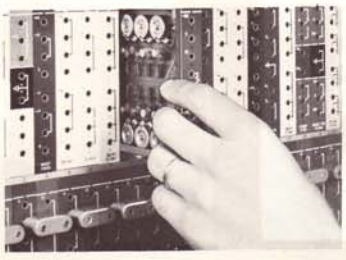
Width	16"
Height	24"
Depth	15"
Weight	95 lbs., approx. (fully expanded)
Power Source	115 volts, 50-60 cycle
Power Requirement	under 50 watts (fully expanded)

changing the equipment complement is easy with the TR-10

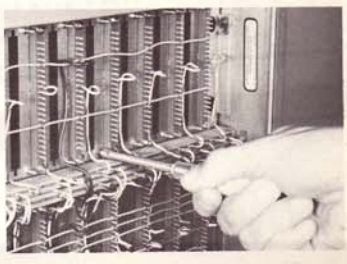
At the rear of the console remove the two retaining nuts which secure the component to be replaced.



Pull the component out of the computer.



Plug the desired component into the empty position. No wiring is necessary.

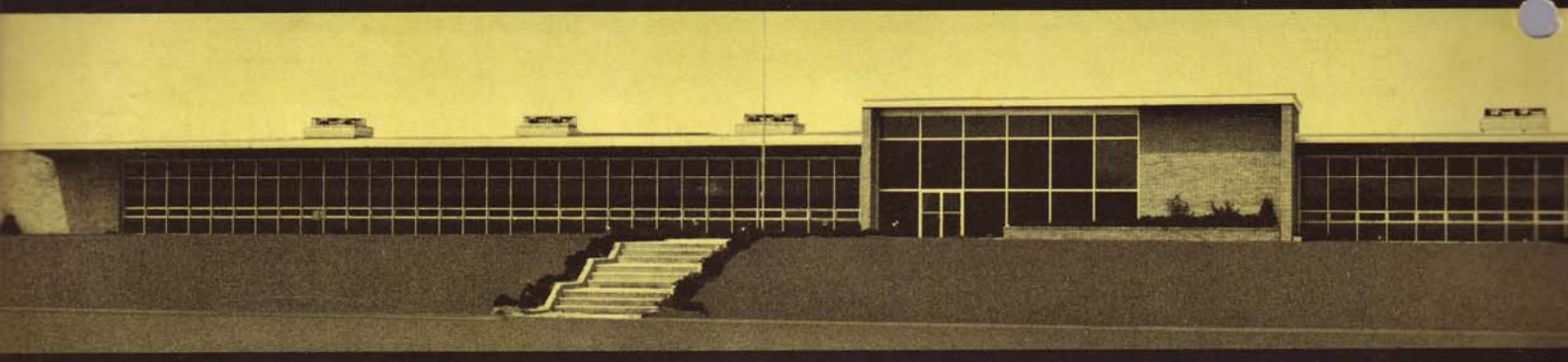


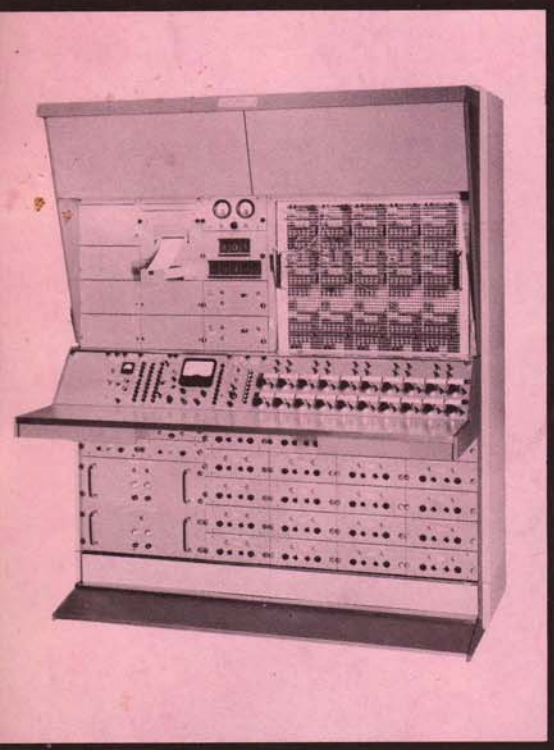
Replace the retaining nuts and secure the component in the position. You effectively have a new computer.

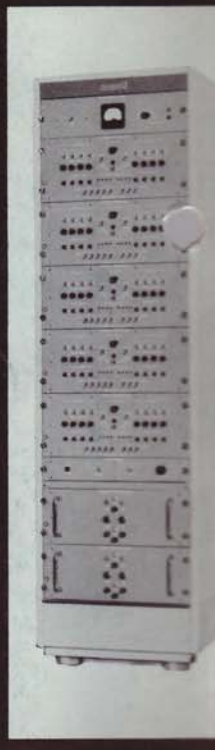
PACE TR-10

is backed by the unmatched experience of EAI

Electronic Associates has designed and built more general purpose analog computers than any other company in the world. In addition, it operates three computation centers where EAI analog equipment is in constant use solving problems for industry. It is this unmatched experience and know-how that has gone into the design and development of the PACE TR-10.







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