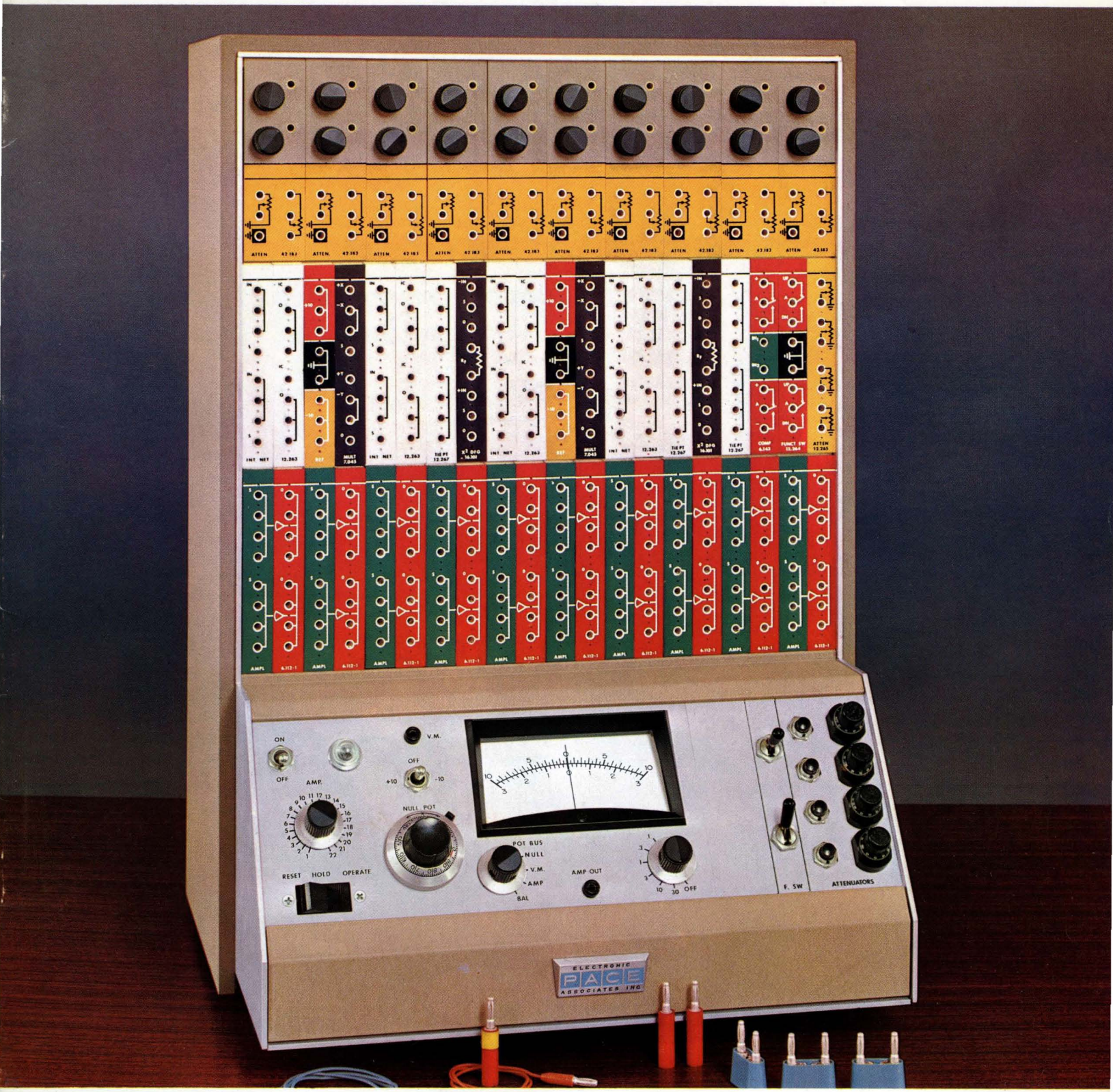
PACE® TR-10 *analog computer*

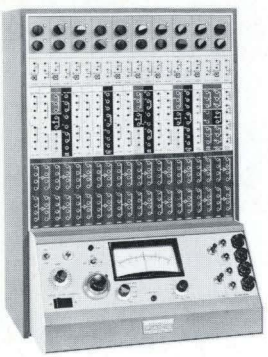


EAI ELECTRONIC ASSOCIATES, INC. *Long Branch, New Jersey*

New EAI computer puts the advantages of analog computation right at your desk. Accurate to 0.1%, it is capable of performing the mathematical operations required in the solution of 95% 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.

NEW PACE® TR-10



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

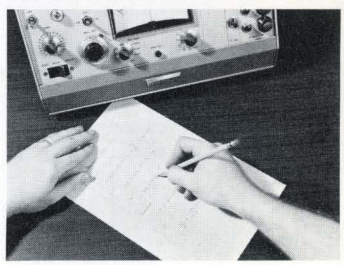
Because of its unique portability, this compact computer can become your personal tool. Carried right to your desk, it can be used to solve your day-to-day problems, saving you time and eliminating the drudgery of repetitive hand calculations. By allowing you to spend more of your time on creative engineering, 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 prototypes. It can drastically reduce design time and costs.

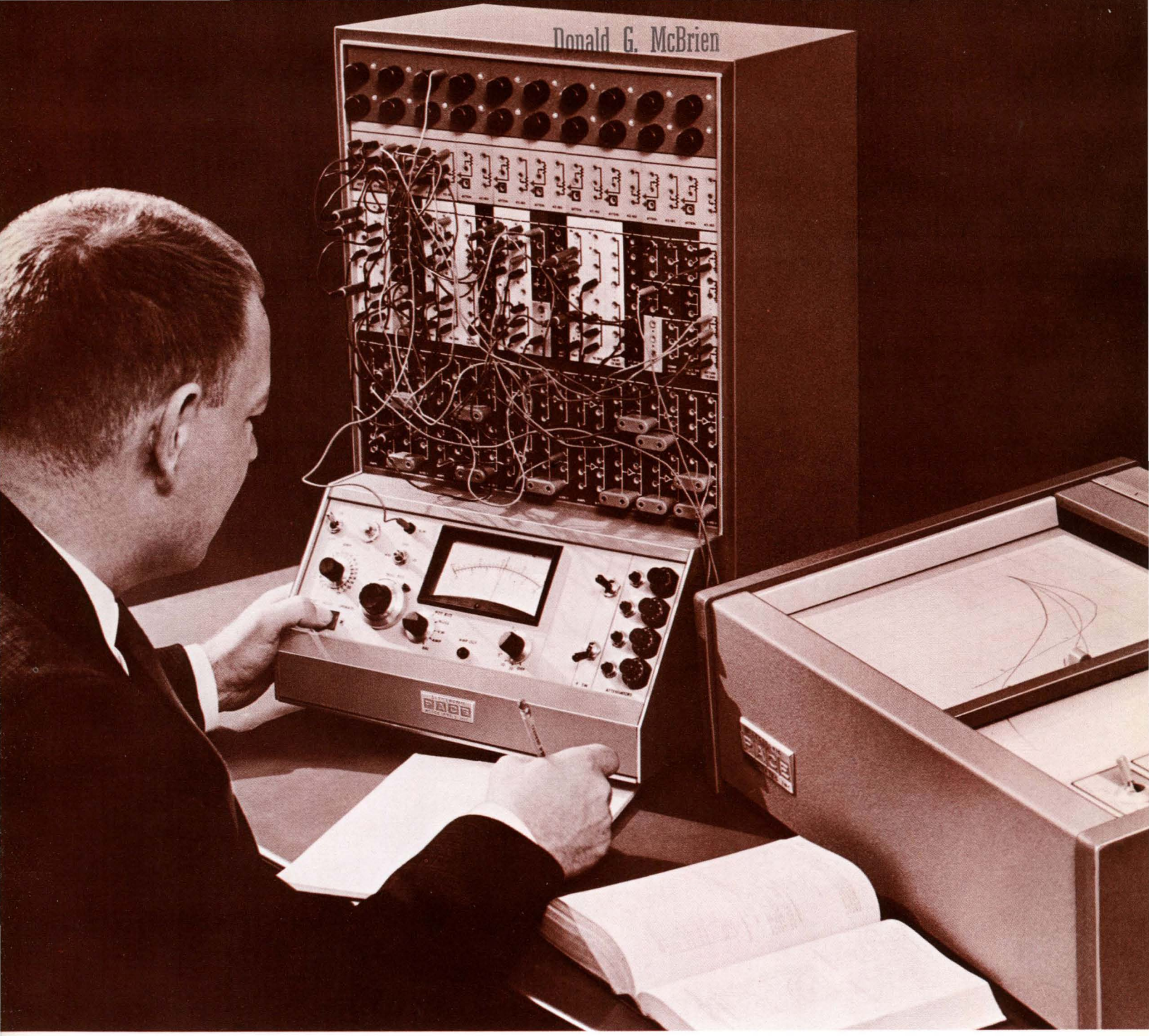
Companies who already have large analog computer installations will find the PACE TR-10 can be used to solve smaller problems and eliminate tie-ups and excessive waiting time for large equipment. It is ideal for breaking-in new engineers to the advantages and techniques of analog computation.

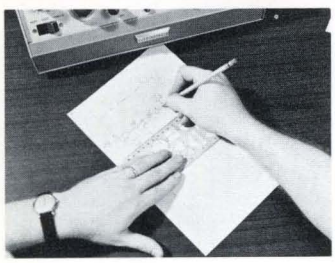
This dependable new tool is completely solid-state and consumes no more power than a 60 watt light bulb. Transistorized circuits assure highest reliability and long, trouble-free life. The design is backed by the experience of EAI's Computer Engineering Department, which has developed designs for 70%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

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



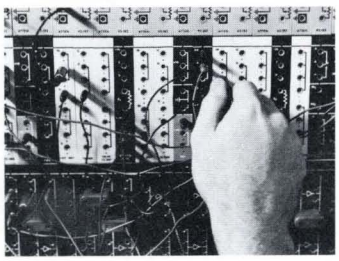
STEP 1 — PROBLEM ANALYSIS
Problem is translated into a mathematical description using algebraic and differential equations.





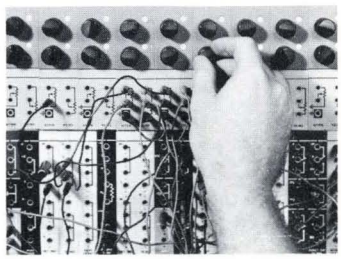
STEP 2 — ***PROGRAMMING***

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



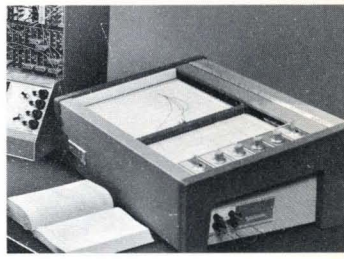
STEP 3 — ***PATCHING***

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



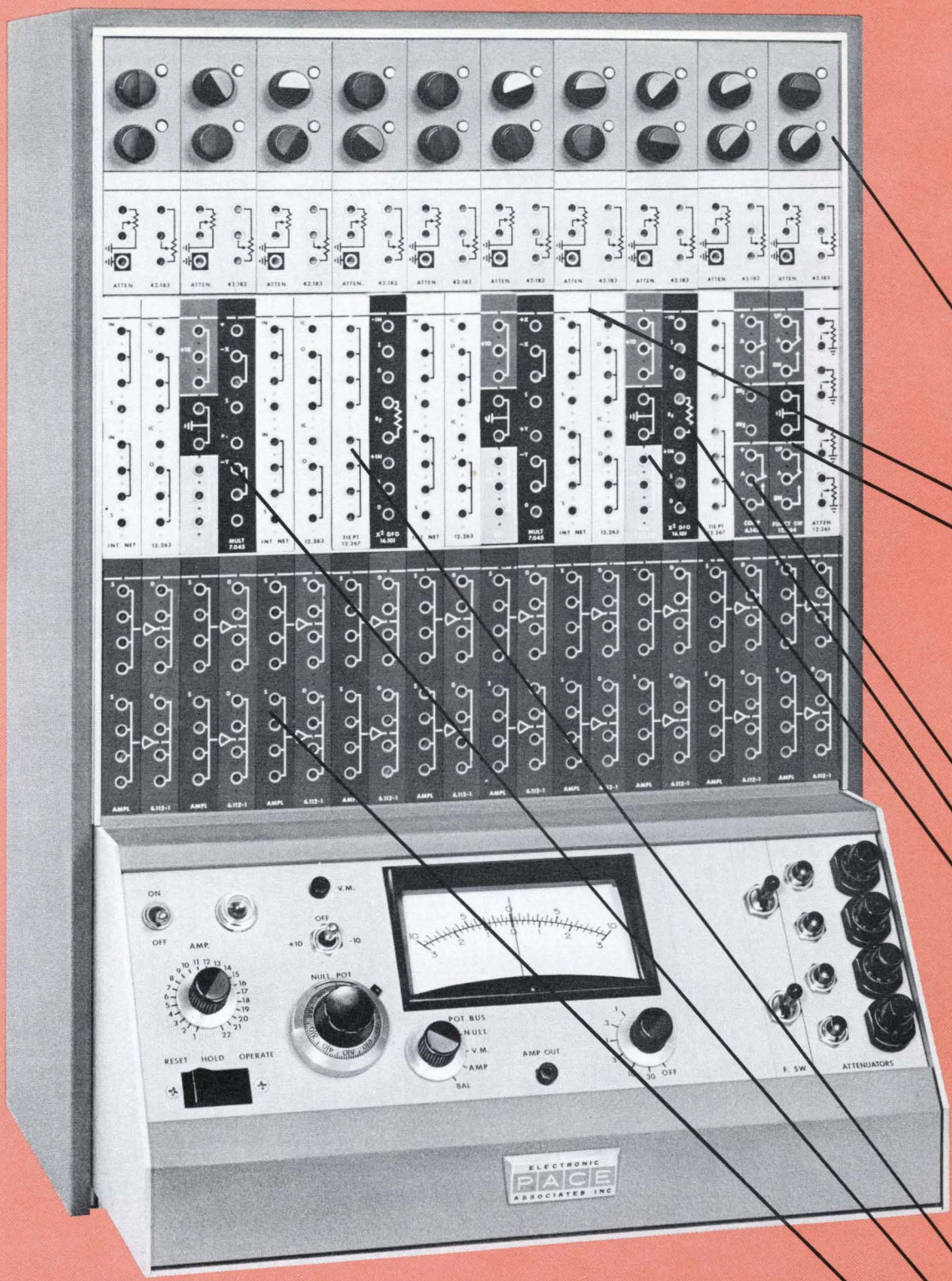
STEP 4 — ***INSERTION OF PROBLEM PARAMETERS***

Coefficient potentiometers are adjusted to provide design parameter inputs.



STEP 5 — ***SOLUTION***

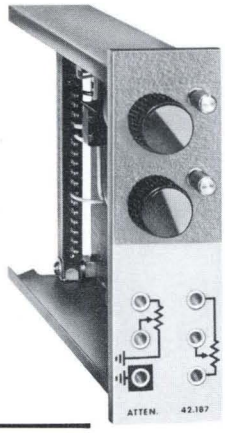
The computer solution is performed in the exact manner prescribed by the mathematical equations. Solutions are presented on an XY plotter, strip chart recorder or on an oscillograph.



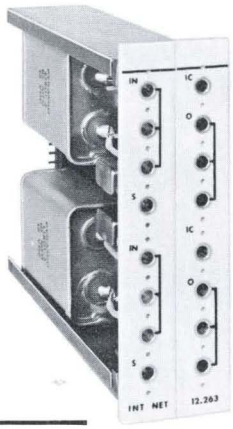
PACE® TR-10 *quality engineered for simplicity and flexibility*

- **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.

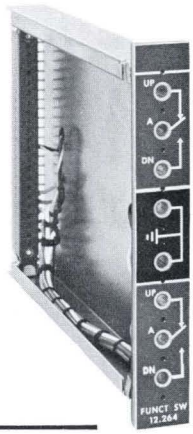
Interchangeable, plug-in components add flexibility, make expansion easy



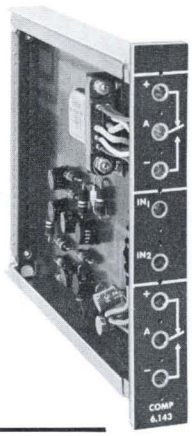
COEFFICIENT SETTING POTENTIOMETERS
for inserting equation coefficients or problem parameters into computer.



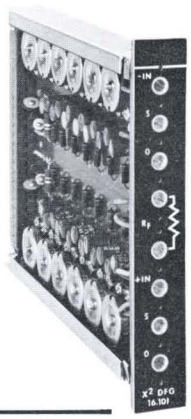
INTEGRATOR NETWORKS
enable operational amplifiers to perform integration.



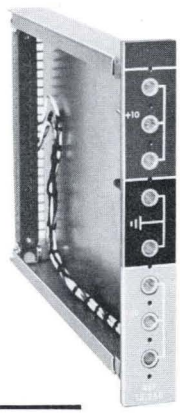
FUNCTION SWITCHES
provide for manually interchanging components without reprogramming or repatching.



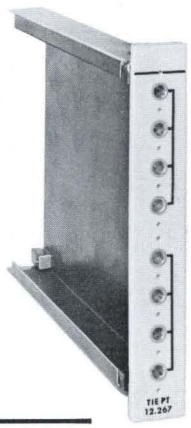
COMPARATORS
compare a variable input voltage to an arbitrary bias voltage and cause a switching operation to be performed.



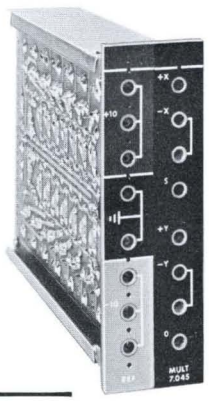
FUNCTION GENERATORS
electronically generate analytic, as well as arbitrary functions of one variable.



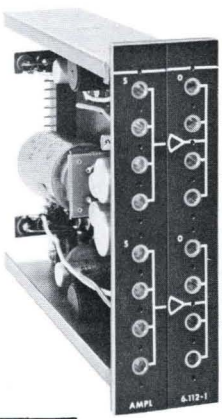
REFERENCE PANEL
makes available accurate reference voltages required for problem solution.



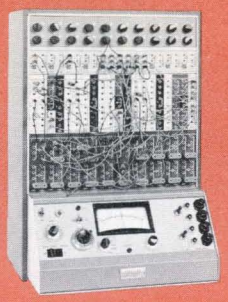
TIE POINT PANELS
provide additional patch panel terminations for components inputs or outputs.



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.



here's how PACE® TR-10 *solves engineering problems...*

PROBLEM

The equation to be solved is a second order linear differential equation...

$$50\frac{d^2x}{dt^2} + 120\frac{dx}{dt} + 112.5\,x = 25y$$

with the initial conditions

$$\left.\frac{dx}{dt}\right|_{t=0} = +2.3$$

$$x_{t=0} = -3.8$$

and the following expected maximum values of the problem variables and parameters

$$x_{max} \approx 9.0$$

$$\left.\frac{dx}{dt}\right|_{max} \approx 10.0$$

$$y_{max} < 40$$

The problem variables are amplitude scaled within the ±10 volt allowable range by applying a suitable scale factor to the maximum value..

(variable) (scale factor) = (scaled voltage)

$$\left.\frac{dx}{dt}\right|_{max} \cdot 1.0 = \left[\frac{dx}{dt}\right]$$

$$x_{max} \cdot 1.0 = [x]$$

Solving for the highest derivative

$$\frac{d^2x}{dt^2} = -\frac{120}{50}\frac{dx}{dt} - \frac{112.5}{50}x + \frac{25}{50}y$$

Substitute scaled voltages and adjust coefficients to maintain a correct equation. The equation becomes...

$$\frac{d^2x}{dt^2} = -\frac{120}{50}\left[\frac{dx}{dt}\right] - \frac{112.5}{50}[x] + \frac{25y}{50\cdot 10}[10]$$

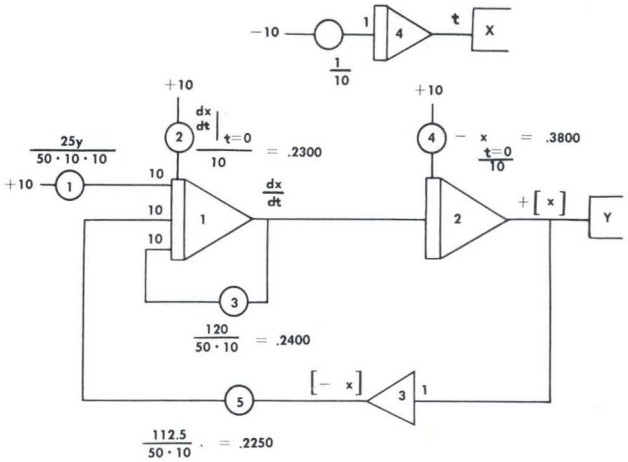
Further adjustment of coefficients enables each term to be expressed as a product of integrator gain, potentiometer coefficient setting and scaled computer voltages...

$$\frac{d^2x}{dt^2} = -10\left(\frac{120}{50\cdot 10}\right)\left[\frac{dx}{dt}\right] - 10\left(\frac{112.5}{50\cdot 10}\right)[x] + 10\left(\frac{25y}{50\cdot 10\cdot 10}\right)[10]$$

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 and/or brackets indicate the required input gain to the dx/dt integrator. The signs, of course, must be adhered to.

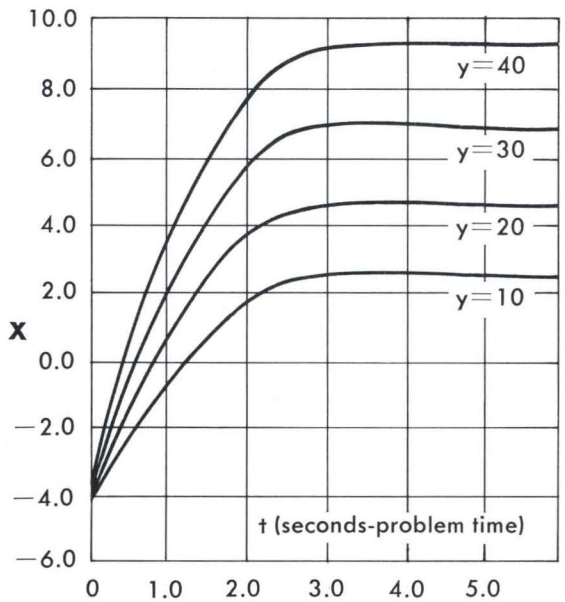
COMPUTER PROGRAM

Representing the equation as a computer circuit showing the interconnection of components...



Parameter	Pot 1 Setting
y	25y/5000
10	.0500
20	.1000
30	.1500
40	.2000

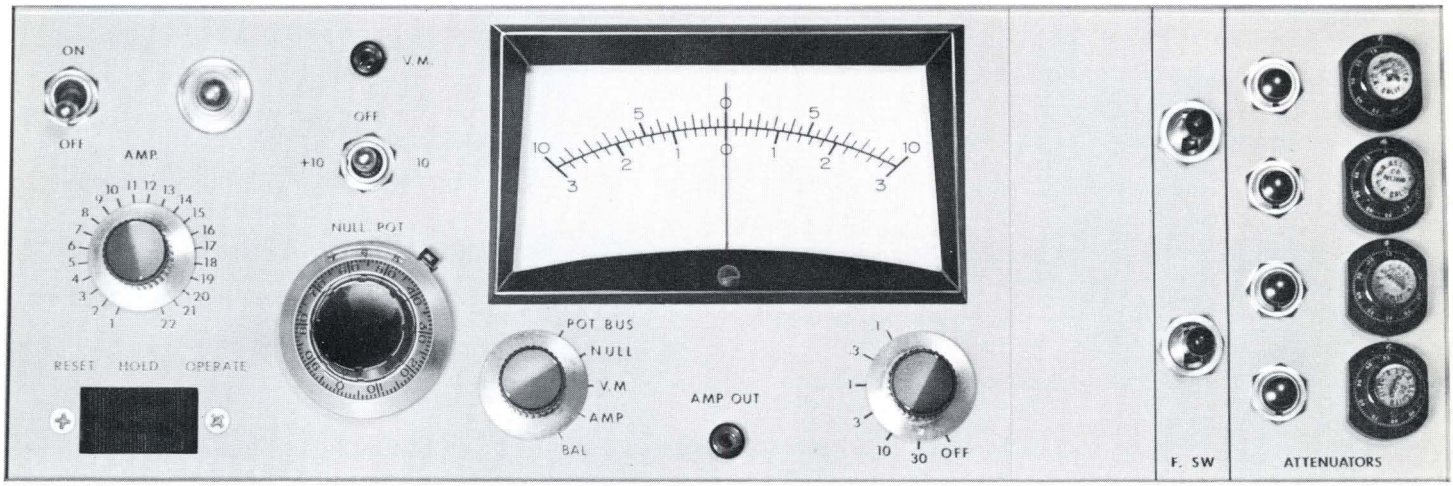
SOLUTION



Typical solutions are shown in the graph.

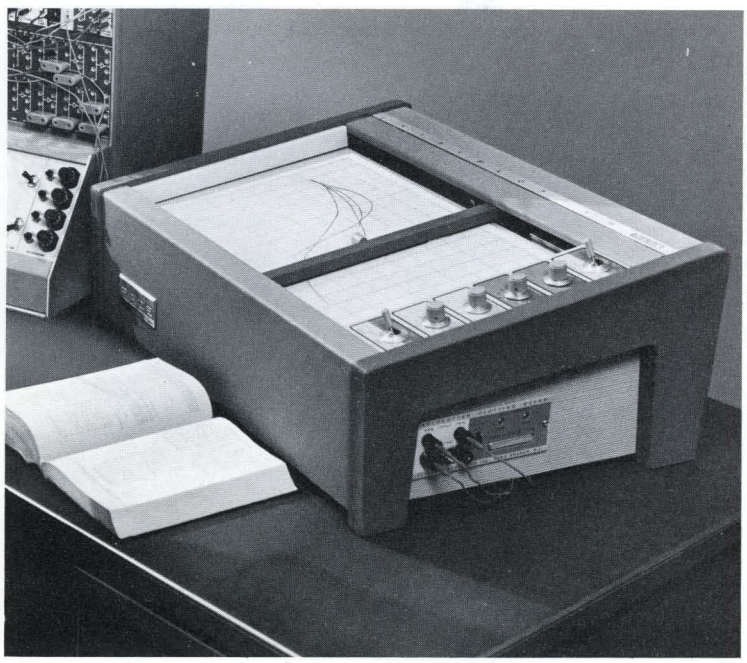
Note: *Where problems involve values which exceed the capacities of various computing components or when it is desired to run solutions in other than real time, simplified scaling techniques are applied. These are fully described in the TR-10 Operator's Handbook provided with each computer.*

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.

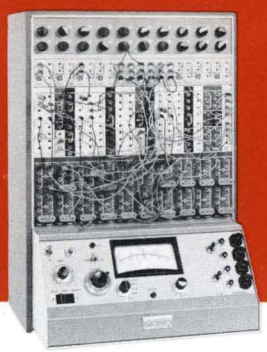
NULL METER — Built into TR-10 control panel, it is designed for precise measurement of fixed voltages. A precision potentiometer is provided with the nulling system whereby solutions can be read to three-place accuracy (0.1%). Null Meter is also used for setting coefficient potentiometers to accuracy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



external read out equipment for use with the TR-10

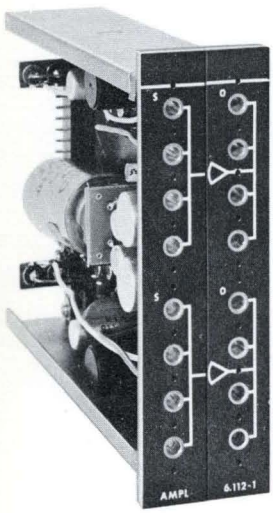
X-Y PLOTTER — Model 1100E Variplotter provides highly accurate recording of any two problem variables. Re-runs can be easily made with different parameter values for comparison studies. The plotter may also be used as a time-based recorder or function generator. Write for further details.

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.



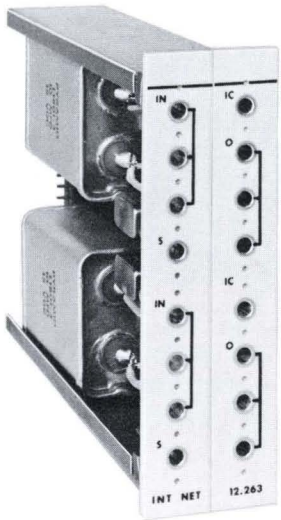
component specifications and descriptions...

DUAL OPERATIONAL AMPLIFIER, (TYPE 6.112-1)



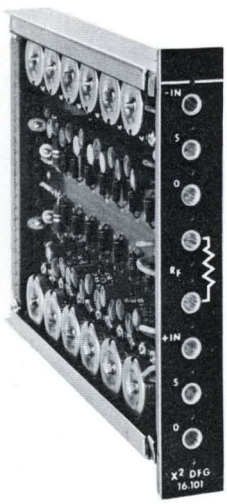
- Consists of two amplifiers packaged in a single metal chassis which is easily inserted into front of console.
- Each computing amplifier is individually chopper stabilized to reduce drift to a negligible amount.
- Simple, remote adjustments are provided to facilitate manual balancing of amplifiers.
- 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 12.263)



- 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 ties 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 X^2 DIODE FUNCTION GENERATOR (TYPE 16.101)

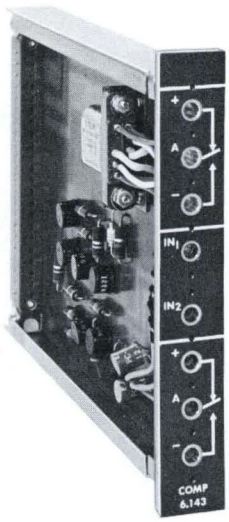


- A dual fixed diode function generator composed of completely solid state components.
- One dual chassis is capable of the following operations:
  - A. When operating in combination with an operational amplifier, it will yield an X^2 output for an X input of one polarity.
  - B. When operating in combination 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 bandwith.
- Patch panel dimensions: 5 inches high by ¾ inches wide. Color code: Brown. NOTE: Other commonly encountered fixed functions are also available.

MULTIPLIER (TYPE 7.045)

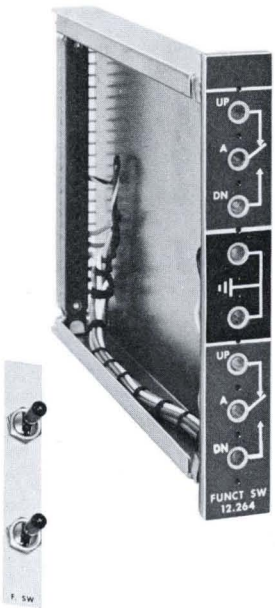
- A completely solid state device which makes use of the quarter-square technique of multiplication.
- It is used in conjunction with an operational amplifier to produce a product − XY/10 from inputs of +X, −X, +Y and −Y.
- Output polarity may be easily reversed by interchanging +X, −X, or +Y, −Y inputs.
- 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).

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)

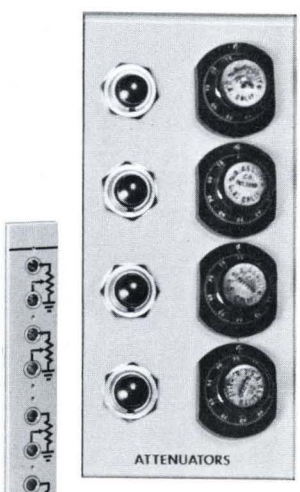


- Provides two independent, single-pole, double-throw, center-off, function switches for performing manual switching operations.
- Consists of patch panel module and a dual switch mounting panel (the latter being located in the control panel area).
- Two ground terminations are also provided on the patch panel for general 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.

DUAL COEFFICIENT SETTING POTENTIOMETER

- 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 pot 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).

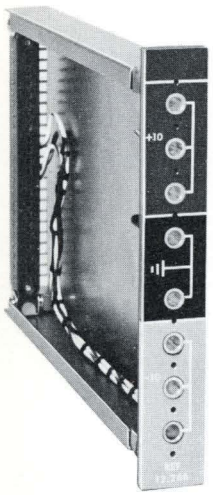
QUAD COEFFICIENT SETTING POTENTIOMETER GROUP (TYPE 2.128)



- Provides four additional potentiometers which may be used for setting problem coefficients, initial conditions, as well as problem inputs.
- Consists of patch panel module and a potentiometer mounting panel located in the control 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.

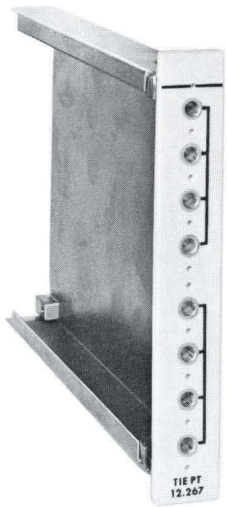
component specifications and descriptions...

REFERENCE PANEL (TYPE 12.266)



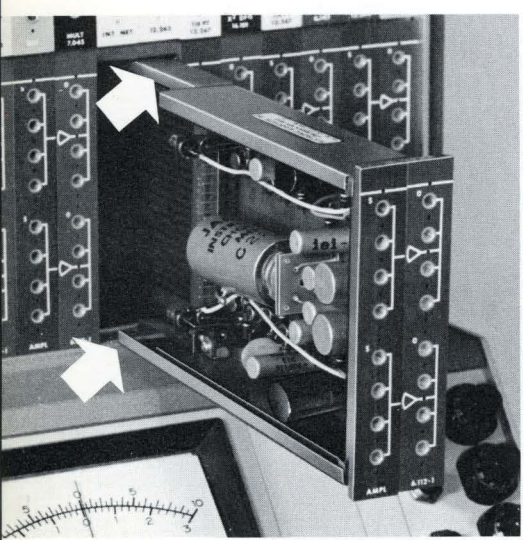
- This unit makes ±10 volt reference available at the patch panel. A similar panel is also included as a part of Multiplier, Type 7.045, and used for the same purpose. Computers that do not use the Multiplier, Type 7.045, will use the Reference Panel, Type 12.266, for obtaining the necessary reference 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)

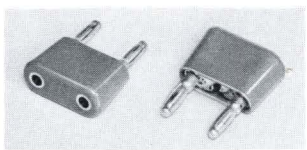


- Provides two four-hole tie points for multiple interconnections of patch cords or for increasing the number of output terminations of various computing components.
- Patch panel dimensions: 5 inches high by ¾ inches wide. Color code: White.

ACCESSORIES

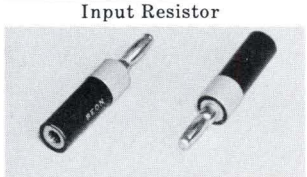


- Service Shelf (Type 51.039)
  Facilitates maintenance of any plug-in computing component under normal operating conditions.

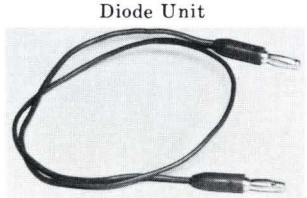


Feedback Resistor

Input Resistor



Diode Unit



Patch Cord

- Feedback Resistor
  Type 646.010 – 10,000 ohms, ±0.1% wire-round resistor; supplied in a *BLUE* molded plug, is designed for patching between summing junction and output terminations of any operational amplifier.
- Input Resistors
  Type 646.006 – 10,000 ohms, ±0.1%., an *ORANGE* banded epoxy-encapsulated, wire-wound resistor – male end plugs into amplifier summing junction termination, female end accepts patch cord plug.
  Type 646.007 – 100,000 ohms, ±0.1%, a *YELLOW* banded, expoxy-encapsulated, wire-wound resistor – male end plugs into amplifier summing junction termination, female end accepts patch cord plug.
- Resistor Set (Type 5.134)
  Includes the following quantities of Input and Feedback Resistors described above:
  15 each Type 646.006 (see above)
  10 each Type 646.007 (see above)
  10 each Type 646.010 (see above)
- Diode Unit (Type 614.051)
  A *WHITE* banded, epoxy-encapsulated silicon diode for limiting the output of computing components or generating non-linear effects.
- Patch Cord Set (Type 5.133), includes the following:
  10 each Type 510.033-0, 6″ long, Color – Black
  15 each Type 510.033-1, 12″ long, Color – Brown
  10 each Type 510.033-2, 18″ long, Color – Orange
  5 each Type 510.033-4, 30″ long, Color – Blue
- 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 various computing components.

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

PACE® TR-10 *is versatile, expandable*

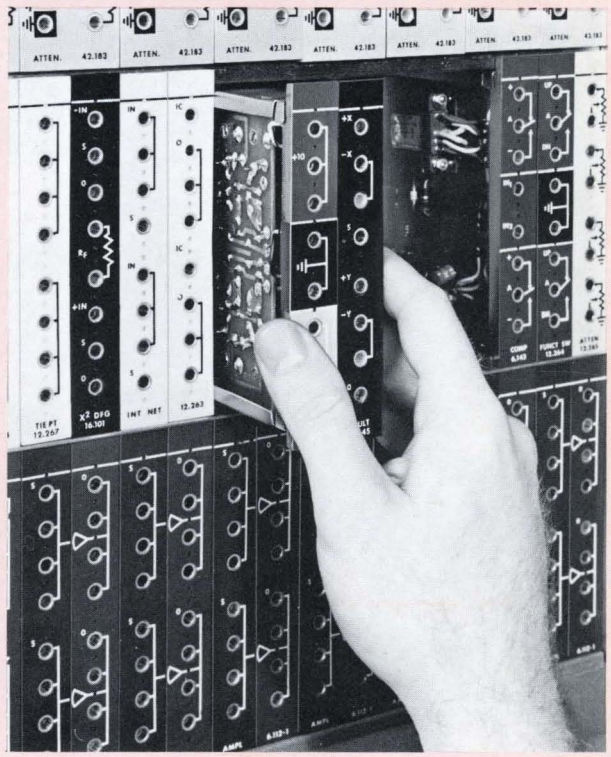
STANDARD BASIC TR-10

The *Standard Basic* TR-10 is capable of solving up to two second-order differential equations, plus associated linear algebraic computations. It is the smallest model available and contains the following:

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

For handling more complex problems the *Standard Linear Expanded* and *Standard Non-Linear Expanded* computers are suggested. These units contain the following:

COMPONENT	STANDARD LINEAR EXPANDED TR-10-1	STANDARD NON-LINEAR EXPANDED TR-10-2
Pre-wired Cabinet	1	1
Power Supply	1	1
Reference System	1	1
Dual Coefficient Setting Potentiometer (Type 52.187)	10	10
Quad Coefficient Setting Potentiometer Group	1	1
Dual Operational Amplifier	10	10
Dual Integrator Network	4	4
Multiplier	—	2
Dual X^2 Diode Function Generator	—	2
Comparator	—	1
Dual Tie Point Panel	2	3
Dual Function Switch Group	1	1
Service Shelf	1	1
Reference Panel	2	—
Patch Cord Set	2	3
Multiple Block	1	1
Resistor Set	2	2
Diode Unit	1	1



Naturally, you are not limited to these configurations and may choose the combination of components that best meets your needs. Since all units are plug-in and all positions are pre-wired, you can achieve unusual flexibility by purchasing additional non-linear components beyond the cabinet non-linear capacity. These components can then be easily interchanged to handle a wide variety of problems.

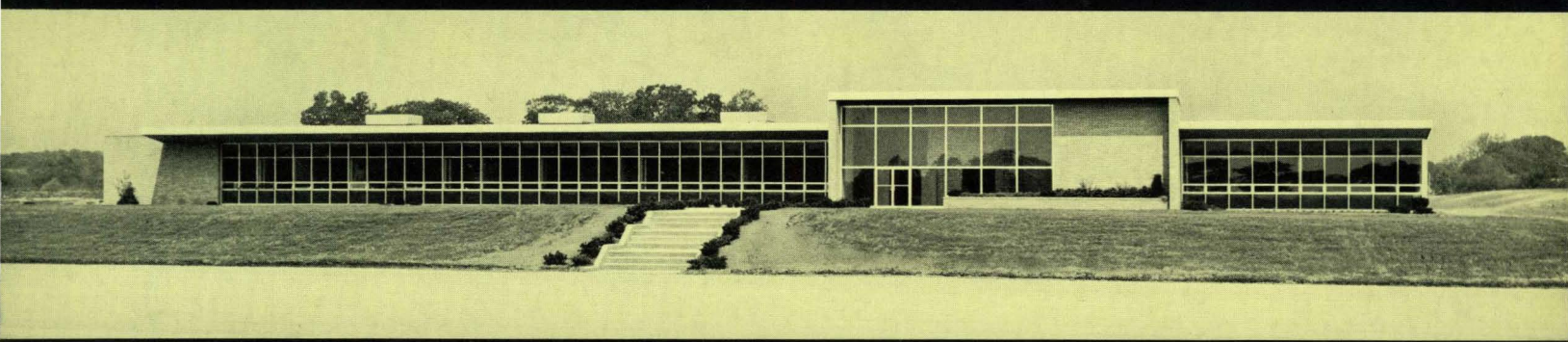
PHYSICAL DESCRIPTION

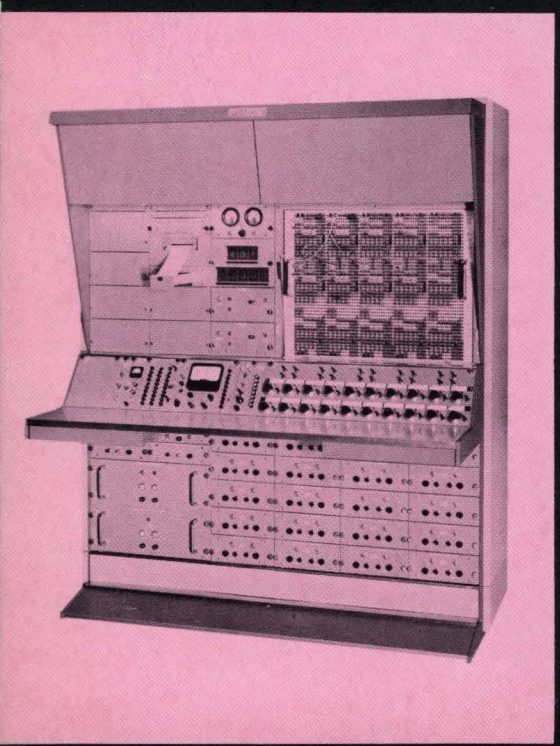
Width	16″
Height	24″
Depth	15″
Weight	93 lbs. (fully expanded)
Power Source	115 volts, 60 cycles
Power Requirement	under 50 watts (fully expanded)

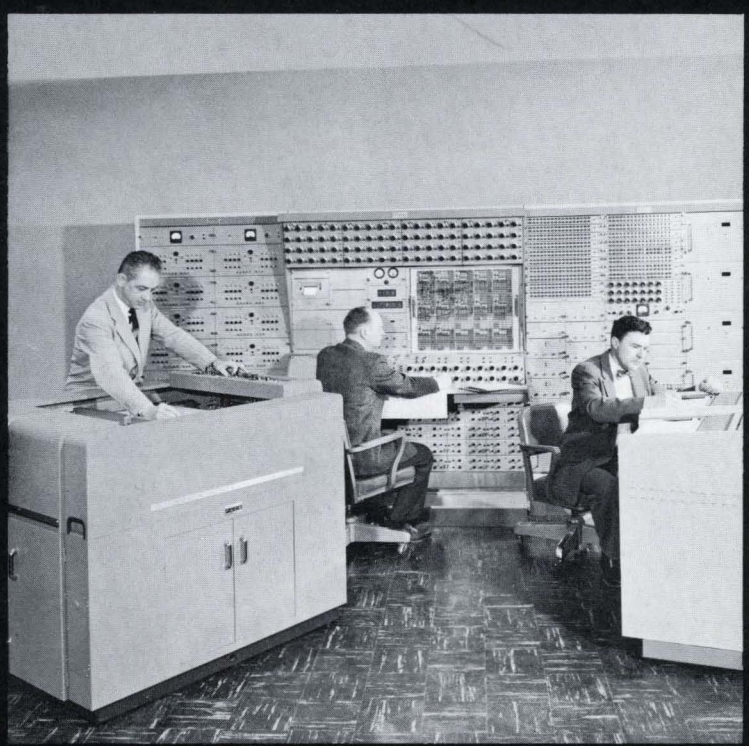
PACE® TR-10

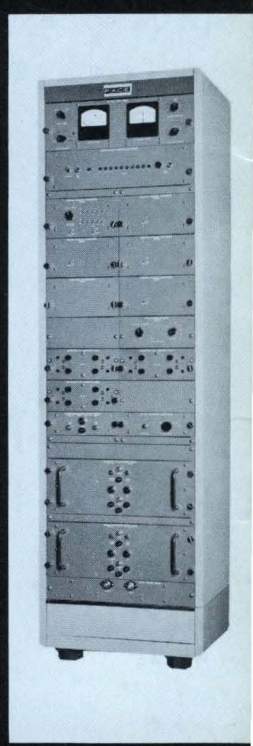
is backed by the unmatched experience of EAI

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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