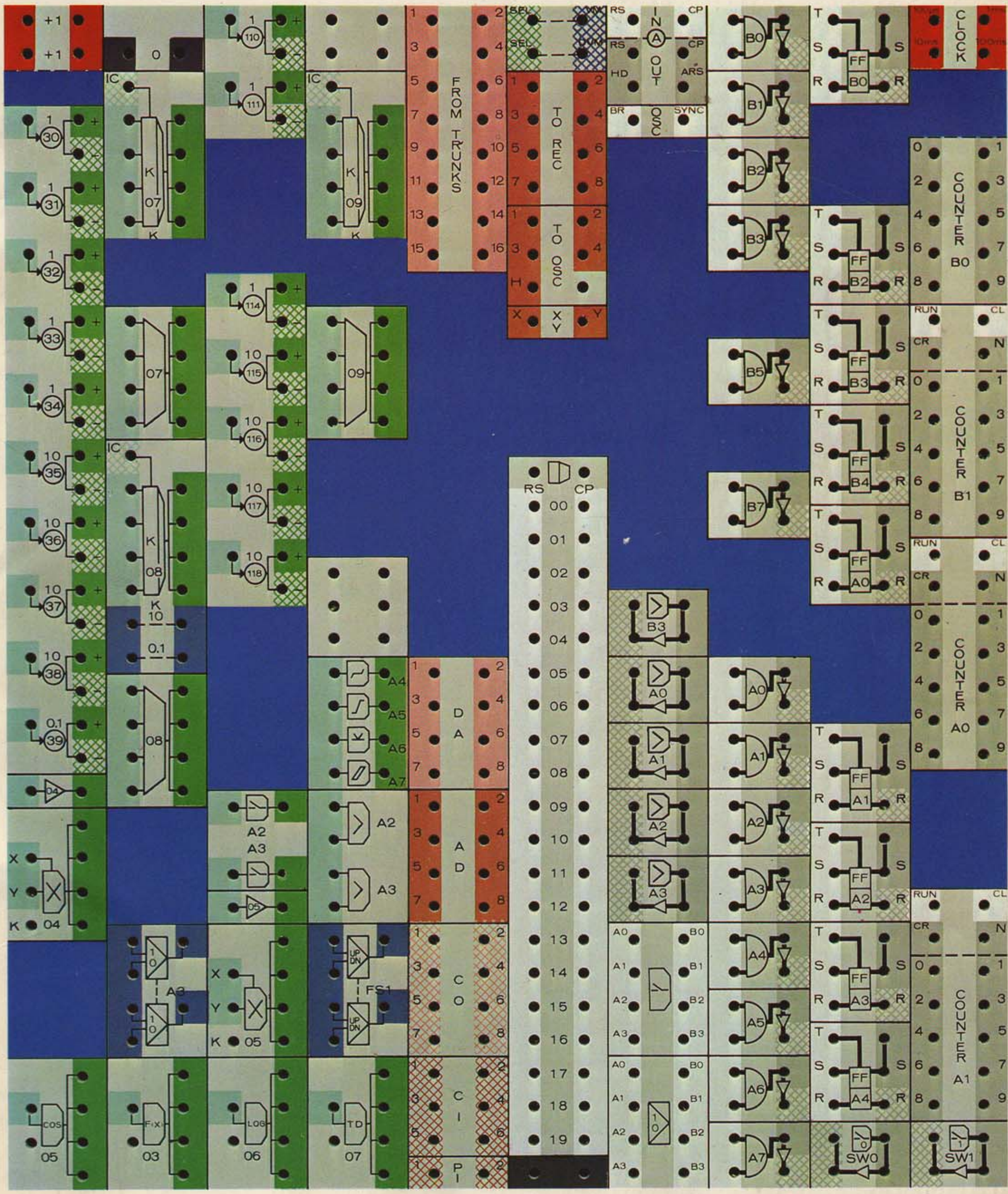
HITACHI ANALOG/HYBRID COMPUTER

HITACHI-200X



HITACHI

Hitachi Electronics, Ltd.

You Need Not Be an Electronic Specialist· Write an Equation and Patch It As a Marking Guide···

The HITACHI-200X Translates It and Calculates Everything

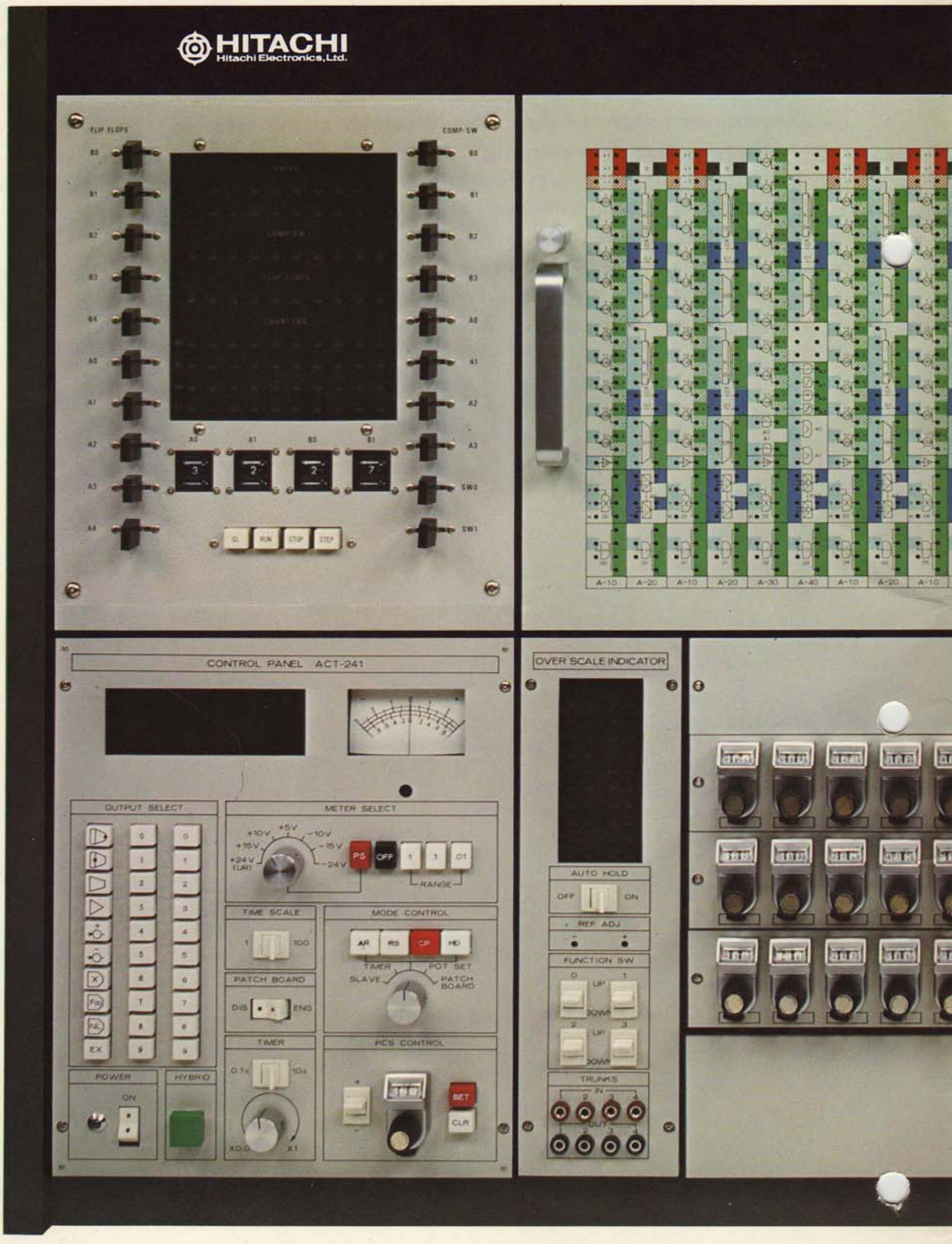
Hitachi's reevaluation of "What an analog computer should be" resulted in a really easy-to-operate machine...the HITACHI-200X.

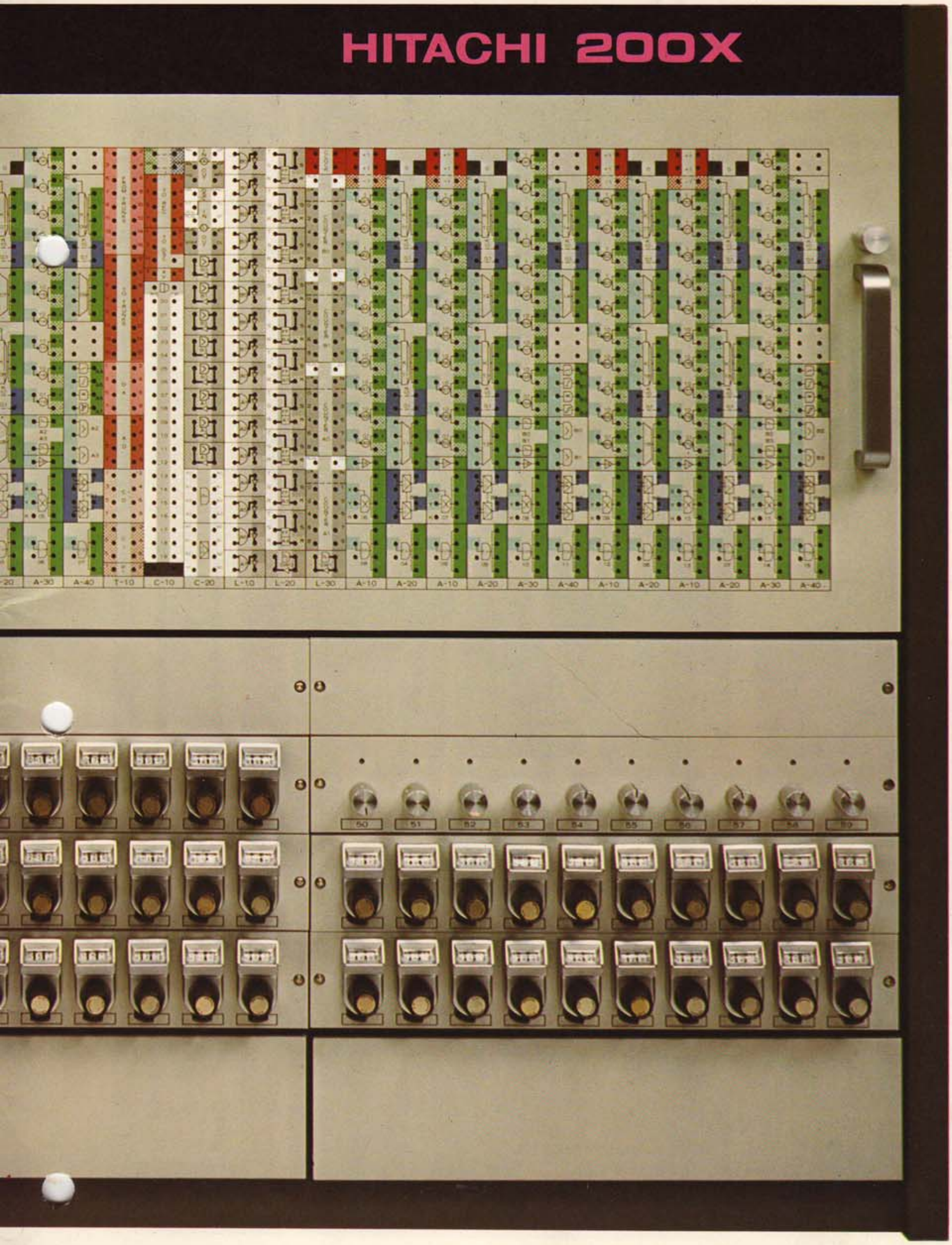
Conventional analog hybrid computers seem to require the user to have a considerable knowledge or electronics, rather than knowledge of their own profession. In this sense, a digital computer is easier to operate. Hitachi believes an analog hybrid computer must allow the user to draw a required block diagram directly — and exactly — on its patch board. It must not require the user to translate mathematical matters into electronic ones. The computer must COMPUTE all of what is given in the form of a patched block diagram.

The HITACHI-200X has no special electronic terms on its patch board. You can draw a block diagram on a problem, with very basic common knowledge on representation, and patch it on the patch board as markings guide.

Design and specifications are subject to change without notice.

Front Panel


HITACHI
Hitachi Electronics, Ltd.
CONTROL PANEL ACT-241
OVER SCALE INDICATOR
OUTPUT SELECT
METER SELECT
RANGE
TIME SCALE
MODE CONTROL
PATCH BOARD
TIMER
PCS CONTROL
POWER
HYBRID
AUTO HOLD
REF ADJ
FUNCTION SW
TRUNKS

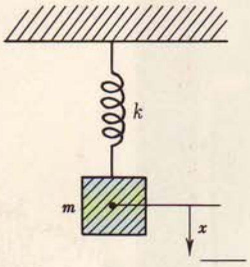

HITACHI 200X

HITACHI-200X simplifies solving differential equations

Example 1. Linear 2nd order differential equation

• Problem

This is a spring oscillation problem. One end of a spring is fixed to a position, and its elastic modulus is k. A substance (mass m) is suspended at the other end of the spring. Motion of the center of gravity of the substance can be given, if mass of the spring is neglected, as follows:

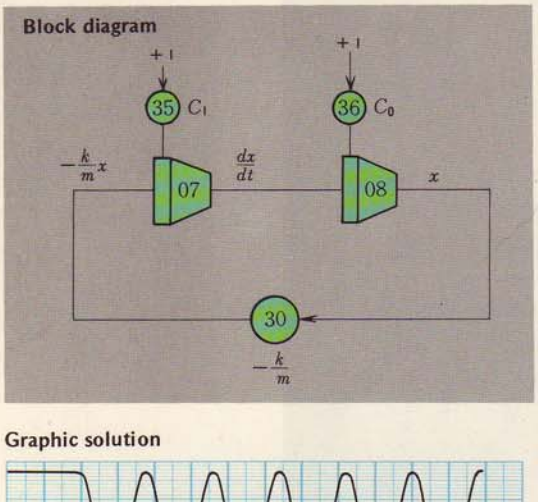


$m\frac{d^2x}{dt^2}+kx=0$ and, at $t=0$

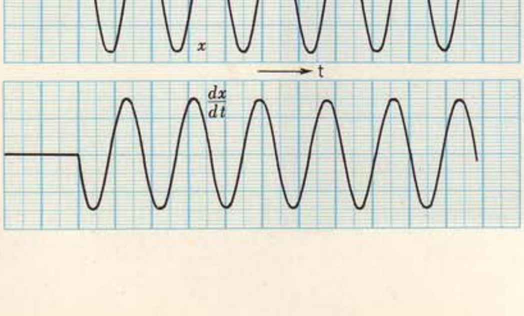
$x=C_0,\quad \frac{dx}{dt}=C_1$

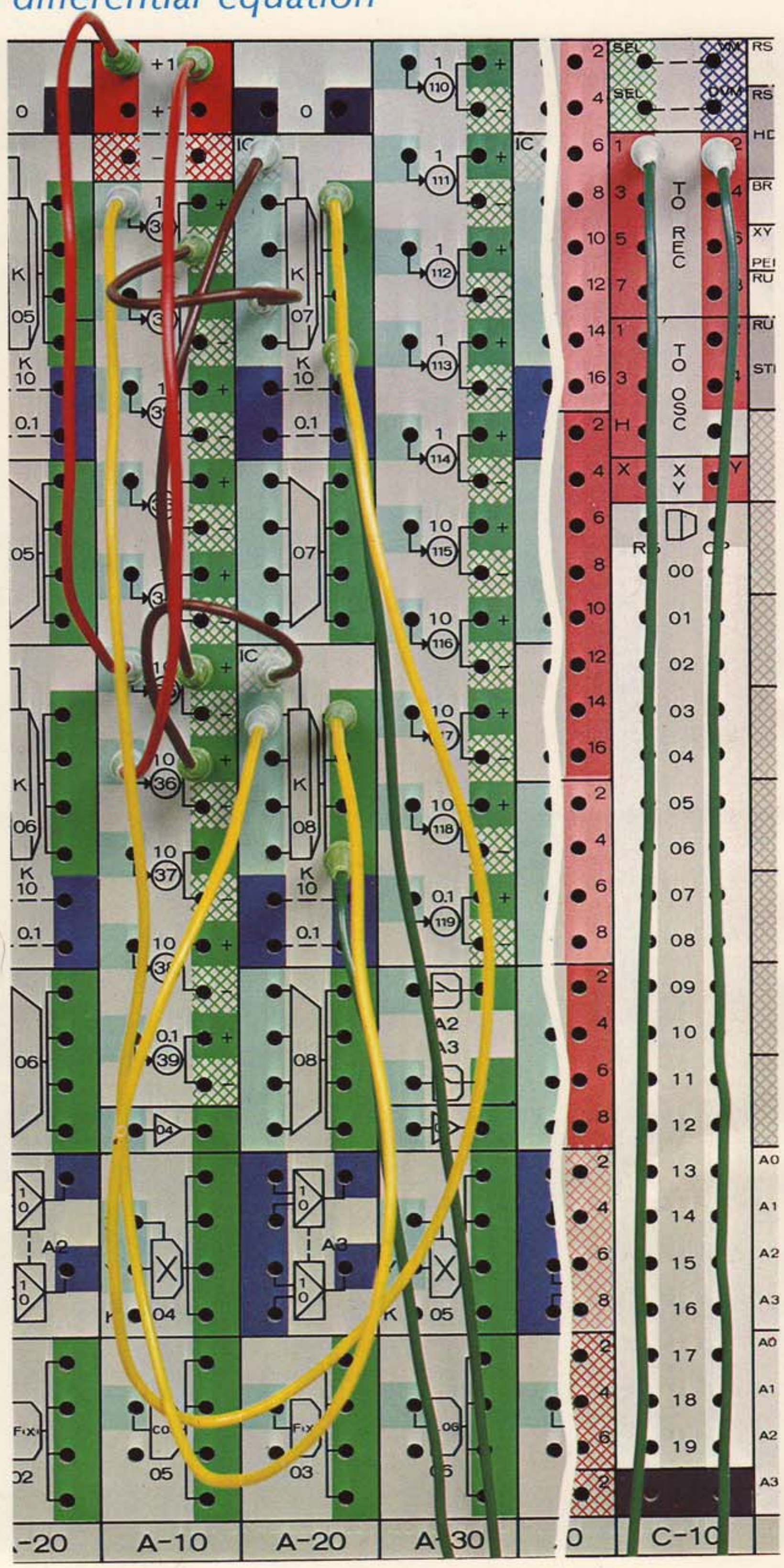
• Solution

By transforming the equation $-\frac{d^2x}{dt^2}=-\frac{h}{m}x$



Graphic solution



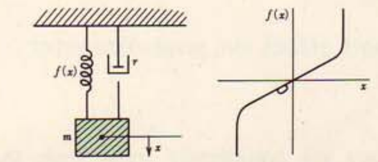


Example 2. Nonlinear 2nd order differential equation

• Problem

Consider the nonlinearity of a spring constant in the vibration system in Example 1. A damper (damping factor r) is added to the system.

The equation of motion is given as follows, and the spring characteristics f (x) is given in the above figure –



Spring characteristics f (x) Spring characteritics

$$m\frac{d^2x}{dt^2}+\frac{dx}{dt}r+f(x)=0 \qquad \text{At } t=0,$$

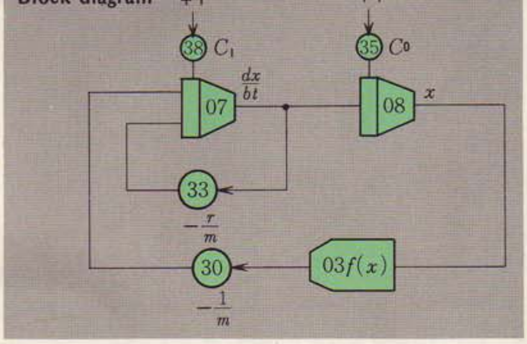
$$x=C_0, \quad \frac{dx}{dt}=C_1$$

• Solution

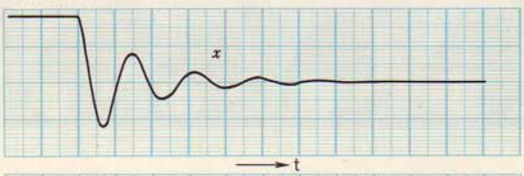
By transforming the equation –

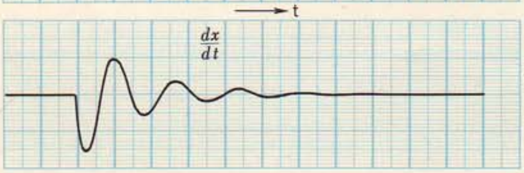
$$\frac{d^2x}{dt^2}=-\frac{r}{m}\frac{dx}{dt}-\frac{1}{m}f(x)$$

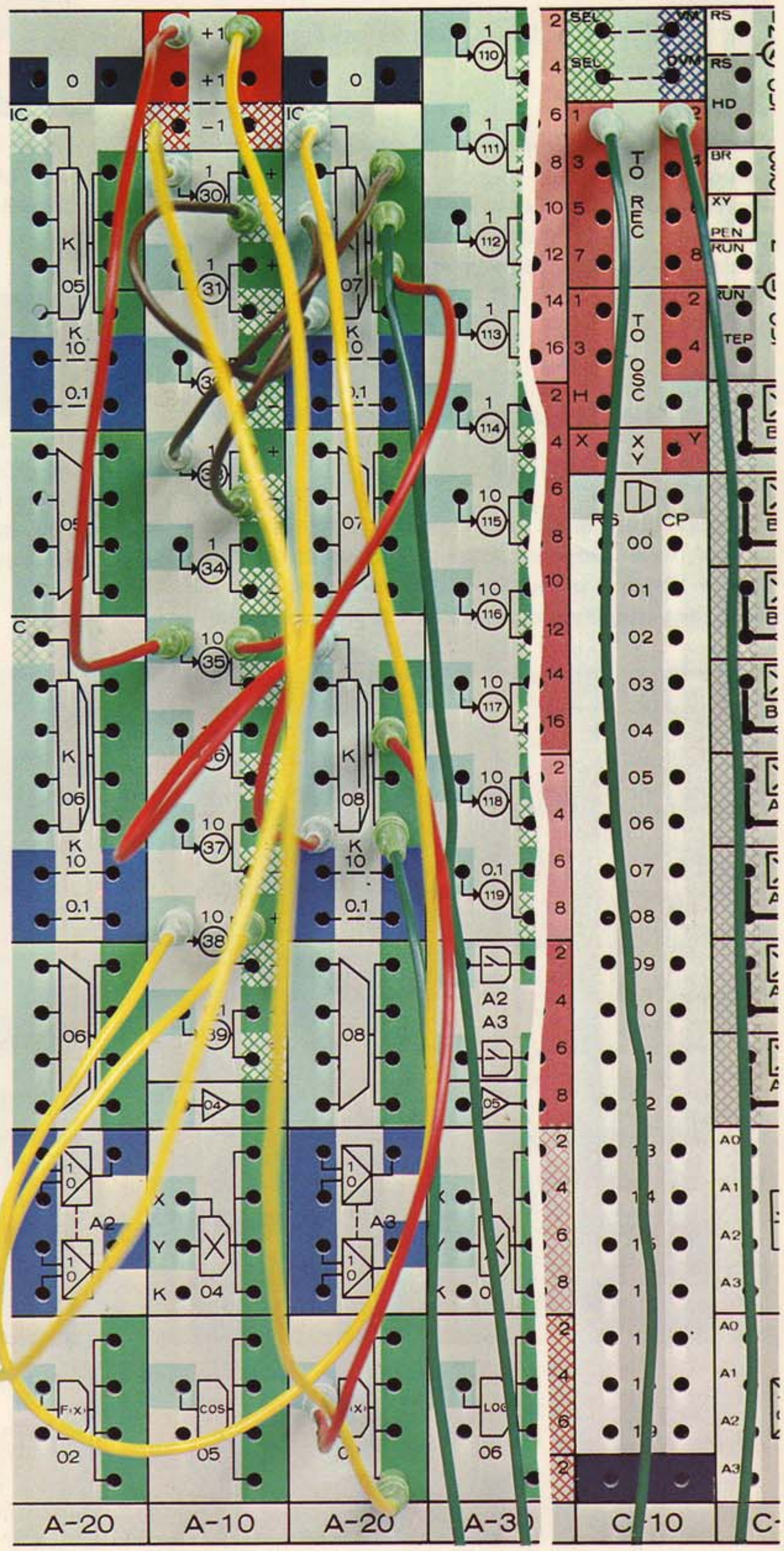
Block diagram



Graphic solution







The HITACHI-200X boasts many innovative features

1 Direct programming as set forth by equation

The Operational element has an equal sign at input and output.
It eliminates the trouble to inverse polarity of the signals in preparing a block diagram. You can draw the diagram directly as your equation sets forth.

2 No particular electric terms on panel

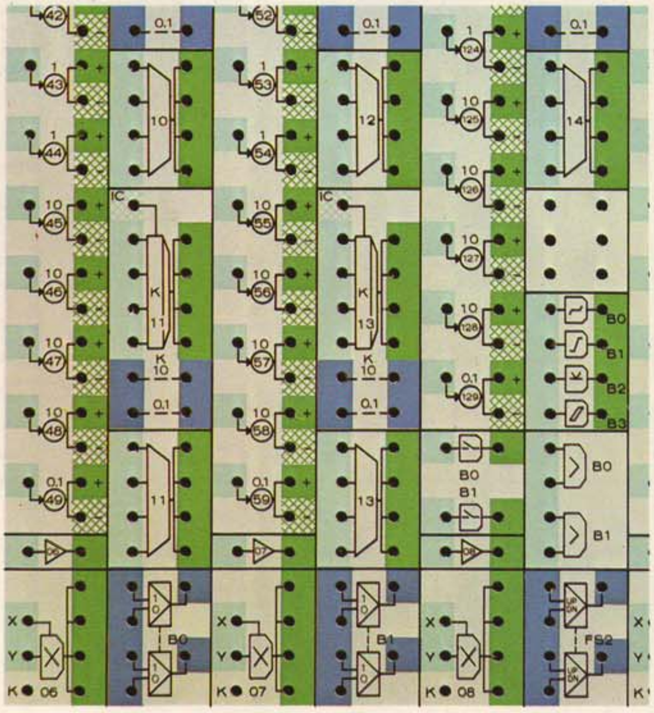
The patch board is not marked in electric terms; rather it is marked with common codes for an operational block diagram. Patch it as your block diagram shows.
Now, the analog/hybrid computer is at your command!

3 Three types of potentiometers (potentiometer at a conventional computer) Increased degree of freedom of setting range

Three types of potentiometers cover a very wide range with high accuracy. They cover the ranges of −0.1 to 0.1, −1 to 1, and −10 to 10.

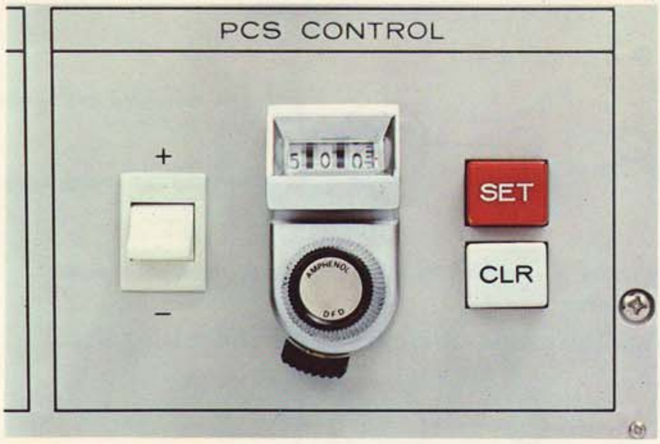
4 No load effect on potentiometer

The potentiometers are completely freed from the loading effect of operational element. No compensation for setting is required. Dialed values give accurate coefficients. You need not make compensation for setting, such as the troublesome zero-method.



5 Simplified program debugging thanks to the PCS function (Program Check System)

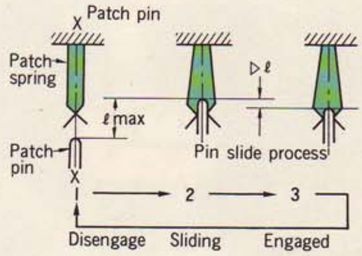
Functioning of the operational element and operation block is readily checked for your patched program, without requiring further operation. You need not prepare a debugging program.

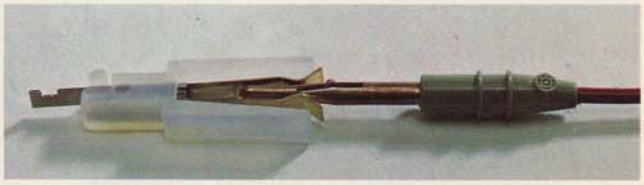


6 Dual point-contact system for patch pins. Perfect shielding between springs.

• Dual-point contact system

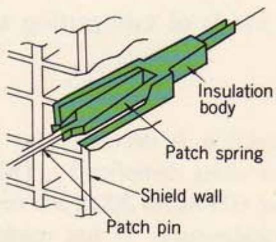
The patch pin and patch spring ensure perfect contact at two points. The patch pin is inserted in more than the normal position and returns to it when engaging is established. Sliding motion of the patch spring cleans the contacts and keeps the patching free from defective contact.

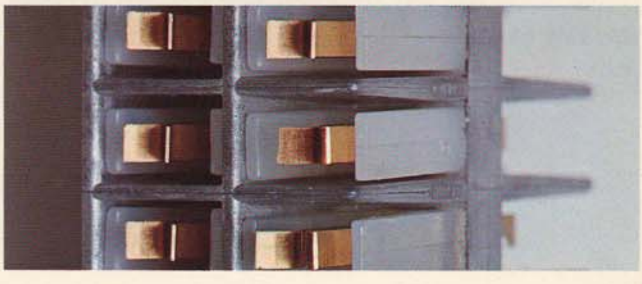




• Perfect shielding

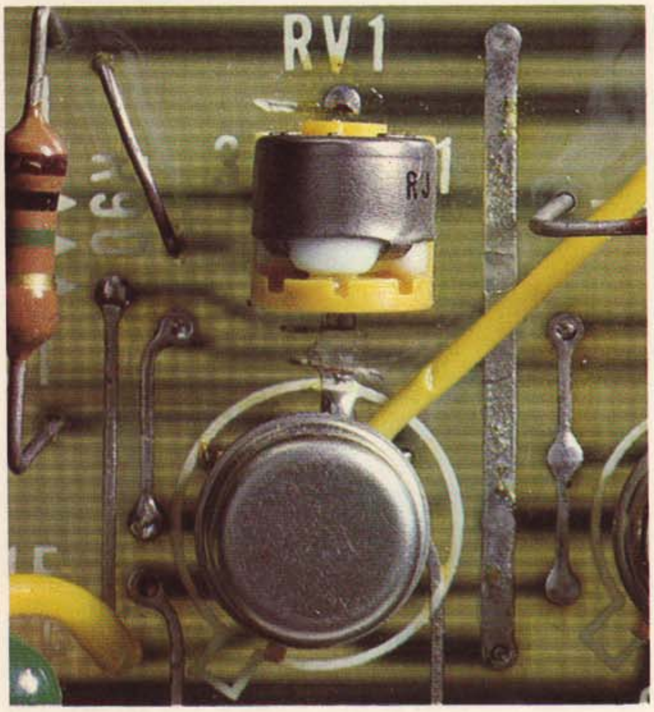
Patch springs are mounted inside the shielded wall. There is no mutual induction of error voltages. The shielded walls also protect the pins and springs from dust deposits.





7 Abundant use of Integrated Circuits (IC)

All operational amplifiers are composed of IC modules, guaranteeing the highest reliability of operation.



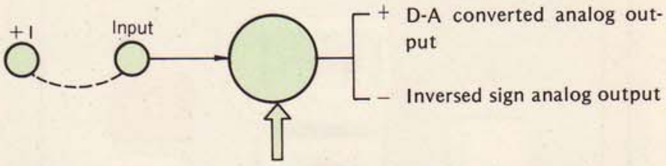
8 All kinds of computing element

No universal function is necessary for operators, merely rendering user handling complicated. This is Hitachi's idea! Operators of the HITACHI 200X are complete with function for their assignment. It has made the dead space limiter, hysteresis, and other nonlinear elements incomparably easy to operate.

9 Digital coefficient amplifiers for facilitating application to a hybrid system

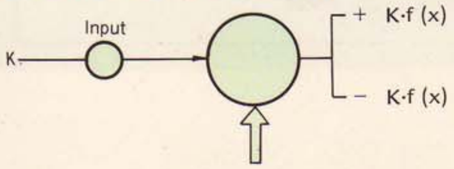
Electronic digital coefficient amplifiers provide the following two operation speeds: high operation speed of 10msec and superhigh operation speed of 50 μsec.
For example, they allow the following hybrid applications:

D-A conversion



(Setting is controlled by a digital signal from the digital computer.)

Multiplication of digital signal and analog signal



(Setting is controlled by a digital signal f(x) from the digital computer.)

10 Software service HIDASP is available.

The software package HIDASP (Hitachi Digitally-Aided Scaling Program) readily prepares scale-converted (output conversion and time axis conversion) operational formulas and a patching list for an original equation (no electric development of equation is required). The digital solution obtained from the support will aid in checking the final solution.

- **Example of assistance by HIDASP**

$\ddot{x} + \dot{x} + 7x + y = 0$

$\ddot{y} + 0.7\,\dot{y} + 4y - 5.6x = 0$

Initial condition $\dot{x} = 0, x = 2, \dot{y} = 0 \quad y = 0$

```
*** HIDASP SOURCE PROGRAM LIST ***
1* D2X -DIX-7.0* X-Y                  Source program
2* D2Y -0.7* D1Y-4.0*Y + 5.6*X        D2X : ẍ
3* D1X INT (D2X, 0.)                  D1X : ẋ
4* X    INT (D1X, 2.0)                X   : x
5* D1Y INT (D2Y, 0.)                  D2Y : ÿ
6* Y    INT (D1Y, 0.)                 D1Y : ẏ
7*      OUT (D1X, X, D1Y, Y)          Y   : ÿ
8*      FIN (T, 20.0)                 FIN (T, 20.0)
9*      END                           Calculate the program for 20 seconds.
```

```
*** COMPILATION FINISHED ***
*** SCALE FACTOR ***
TSF  = .20000E00
D1X  = .50000E01     Scale-converted values
X    = .50000E01     TSF: Time scale factor
D1Y  = .10000E02
Y    = .50000E01
```

This software service is only available when the digital computer is furnished with 16KW core memory and disc memory.

11 Software service DASC also available

The software package DASC (Digital Automatic Setting and Checking Program) provides man-machine communication with a digital computer for the PCS (Program Check System) function.

- **Example of assistance by DASC**

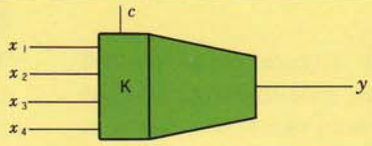
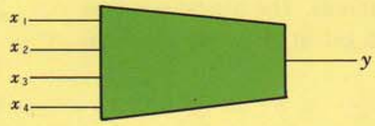
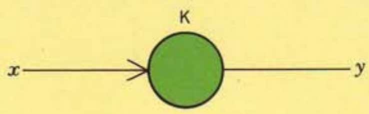
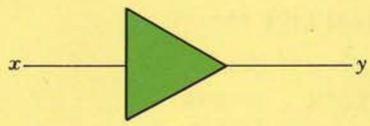
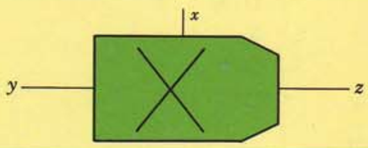
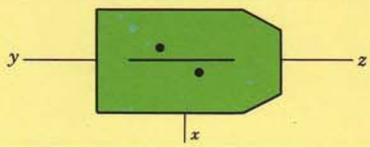
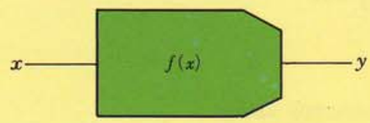
Test functioning of integrators No. 1 through No. 10 and adders No. 1 through No. 3.

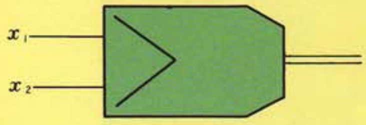
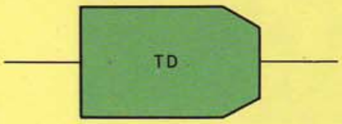
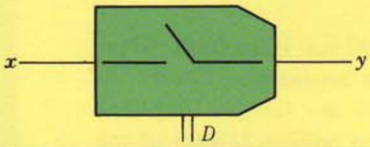
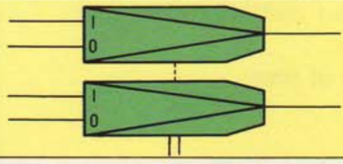
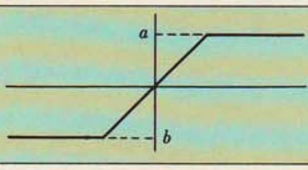
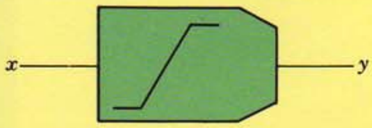
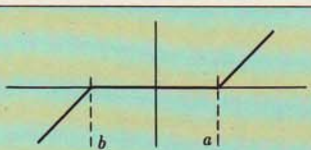
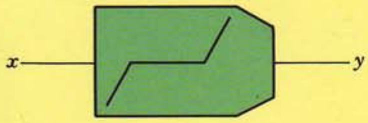
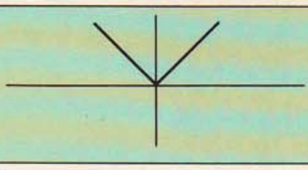
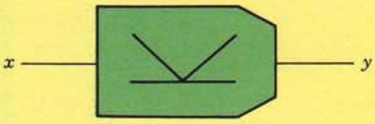
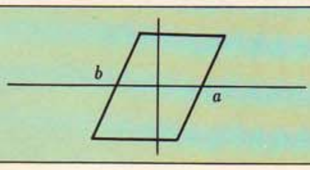
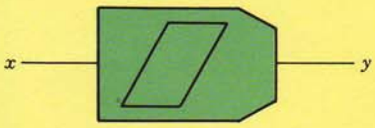
```
I/0 MACHINE
IN(0)0-10     Source program
CA(0)1-3      The device No. of analog computer is
RUN           parenthesized.
              IN:  Integrator
              CA:  Adder
STATEMENT RUN
IN TESTING                      Result of test
HAD=0 TAD=10 AC=0               HAD: No. of head element
0    9                          TAD: No. of tail element
CA TEST OK                      AC:  Device No. of analog
HAD=1 TAD=3 AC=0                     computer
RUN END                         Result: Integrators 0 and 9
                                        are defective.
```

**Refer to the Programming Manual for details of HIDASP and DASC.*

Operation formula and symbols for operational elements

Symbols of the elements are quite unique, but they said your patching "as written in an equation."

Computing Element	Operation formula	Symbol	Condition
Integrator	$y=k\ \ (x_1+x_2+x_3+x_4)l+C$		$K=0.1$、1、10 or (10、100、1000) $-1<y<1$
Summer	$y=x_1+x_2+x_3+x_4$		$-1<y<1$
Coefficient potentiometer	$y=kx$		$0<K<0.1$ or $0<K<1$ or $0<K<10$ $-0.1<K<0$ or $-1<K<0$ or $-10<K<0$
Inverter	$y=-x$		$-1<y<1$
Multiplier	$z=x\cdot y$		$-1<z<1$
Divider	$z=\frac{y}{x}$		$-1<z<1$
Variable function generator	$y=f(x)$		$-1<y<1$
Sine function generator	$y=\sin(\pi\cdot x)$		$-1<y<1$
Consine function generator	$y=\cos(\pi\cdot x)$		$-1<y<1$

Designation	Operation formula	Symbol	Condition
Logarithmic function generator	$y = \log_{10}(10 \cdot x)$		$-1 < y < 1$ If $-0.01 < x < 0.01$, $y = 0$
Comparator	"1", if $x_1 + x_2 > 0$ "0", if $x_1 + x_2 < 0$		
Transfer delay element	$y = e^{-st}$		t: delay time, 100μs to 10s
Electronic switch	$y = x$, if D = "1" $y = 0$, if D = "0"		D: control signal
Relay	Wiper and contact 1 are closed, if D = "1" Wiper and contact 0 are closed, if D = "0"		D: control signal
Limiter			$0 < a < 1$ $-1 < b < 1$ Gradient 1
Dead zone element			$0 < a < 1$ $-1 < b < 0$ Gradient 1
Absolute value			$y = \lvert x \rvert$ Gradient 1
Hysteresis			$0 < a < 0.5$ $-0.5 < b < 0$ Gradient 1

Here are actual examples you can use with the analog hybrid computer.

Example 1. Spreading rate of infectious disease

• Problem

A town's total population of 1,000 has 10 patients suffering from an epidemic. 900 people are sensitive against the epidemic, while the remaining 90 are immune from the disease. On the average, a patient infects 1/1000 of the infectious people per day. Infected patients recover and become immune from the epidemic.

Obtain the following as a function of time;

(1) No. of infectious people X
(2) No. of patients Y
(3) No. of people having become immune Z

• Solution

Formulas for this problem are –

$\frac{dx}{dt}=-\frac{1}{1000}xy \quad \frac{dy}{dt}=\frac{1}{1000}xy-\frac{1}{14}y \quad \frac{dz}{dt}=\frac{1}{14}y$

At $t = 0$, $x = 900$, $y = 10$ and $z = 90$.

Assuming the estimated maximum value for x, y, and z as 1,000, the following equations (scale converted ones) are obtained –

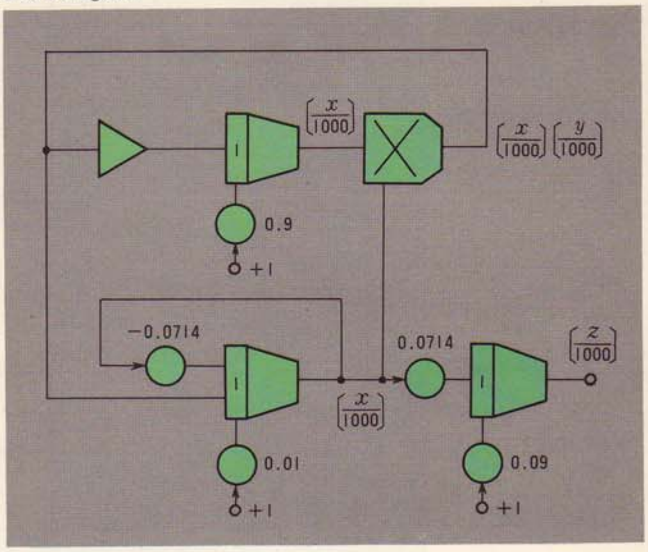
$$\left[\frac{\frac{dx}{dt}}{1000}\right]=-\left[\frac{x}{1000}\right]\left[\frac{y}{1000}\right]$$

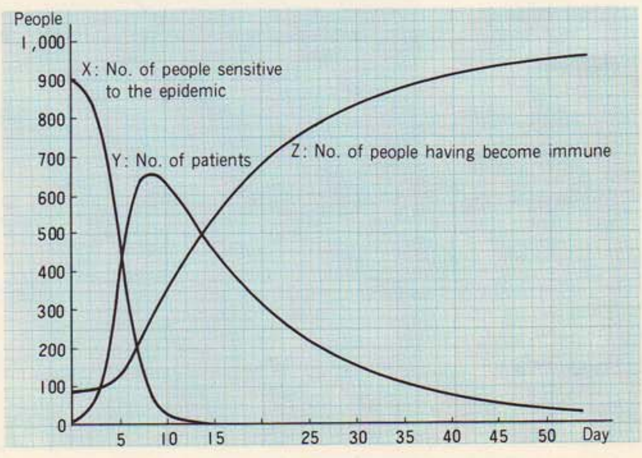
$$\left[\frac{\frac{dy}{dt}}{1000}\right]=\left[\frac{x}{1000}\right]\left[\frac{y}{1000}\right]-0.0714\left[\frac{y}{1000}\right]$$

$$\left[\frac{\frac{dz}{dt}}{1000}\right]=0.0714\left[\frac{y}{1000}\right]$$

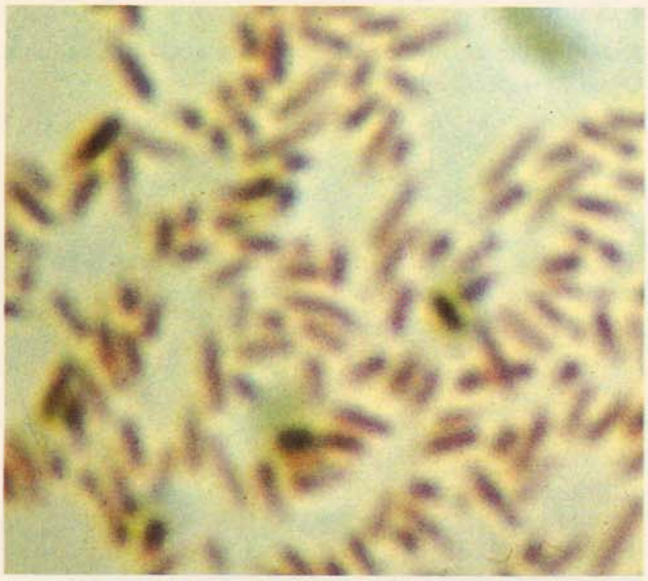
At $t = 0$, $\left[\frac{x}{1000}\right]=0.9 \quad \left[\frac{y}{1000}\right]=0.01 \quad \left[\frac{z}{1000}\right]=0.09$

Block diagram





Example 2. Germs in polluted water



• Problem

A disinfectant was sprayed over a puddle which contained three types of germs. The life characteristics of germs are exponential. In the first minute, 50% of germ 1, 30% of germ 2, and 20% of germ 3 died. Assuming the number of each type of germ was 10^5/ml, obtain the number of germs as a function of time. Also, obtain the total number of live germs.

$$X = X_{\circ}e^{-\lambda xt} \quad Y = Y_{\circ}e^{-\lambda yt} \quad Z = Z_{\circ}e^{-\lambda zt}$$

• Solution

Since 50% of the germs are killed within a minute,

$\frac{X_0}{X_1} = \frac{100}{50} = e^{0.693}$ (0.5 is equal to $e^{0.696}$)

$\frac{Y_0}{Y_1} = \frac{100}{70} = e^{0.358}$ $\quad \frac{Z_0}{Z_1} = \frac{100}{80} = e^{0.223}$

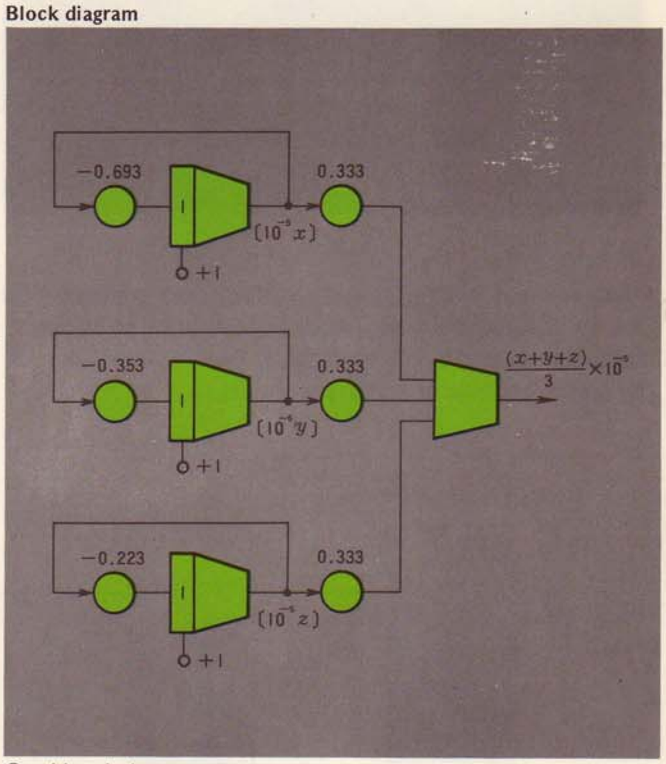
Thus, $\lambda x = 0.693$, $\lambda y = 0.358$ and $\lambda z = 0.223$

Differentiating these figures,

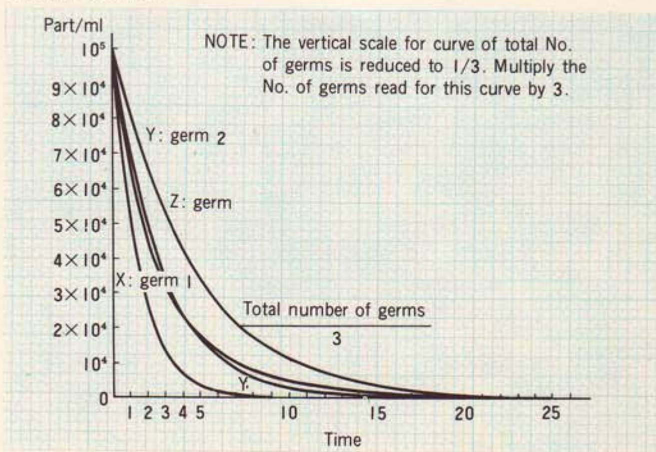
$\frac{dx}{dt} = -0.693x \quad \frac{dy}{dt} = -0.358y \quad \frac{dz}{dt} = 0.223z$

At $t = 0$, $x = y = z = 1$

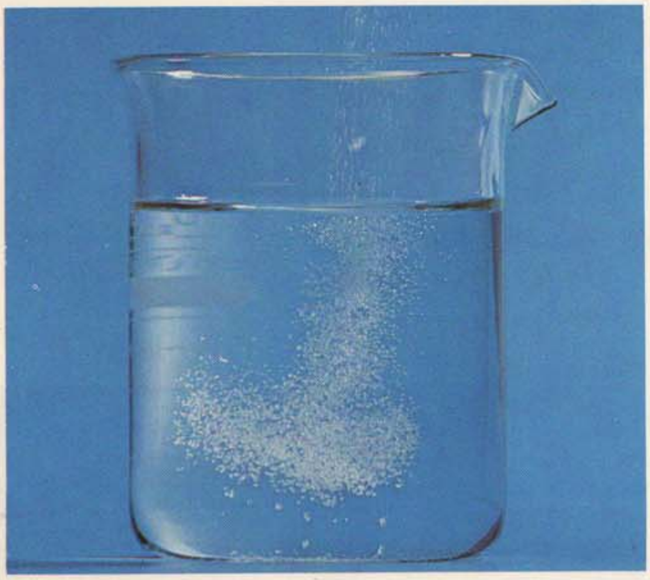
Block diagram



Graphic solution



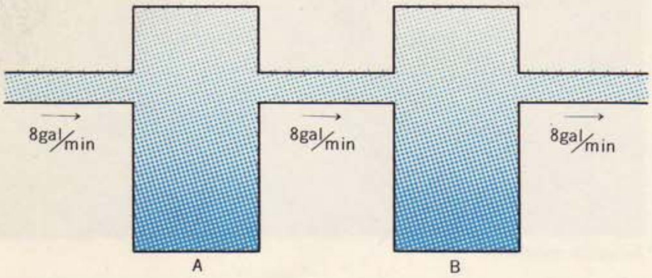
Example 3. Solution regarding salt



• Problem

Tank A stores a 50-gal. water solution of salt containing 50 lbs. of salt. Calculate the amount of salt to be overflown to tank B as a function of time, when fresh water is supplied to tank A at a rate of 8 gals. per minute.

Chemical Problem



• Solution

Assuming the amount of salt contained in tanks A and B as Q and R, respectively –

$$\frac{dq}{dt}=\left(\frac{8gal}{min}\right)\left(\frac{q\,lb}{50\,gal}\right)$$

$$\frac{dr}{dt}=\left(\frac{8gal}{min}\right)\left(\frac{q\,lb}{50\,gal}\right)-\left(\frac{8gal}{min}\right)\left(\frac{r\,lb}{50\,gal}\right)$$

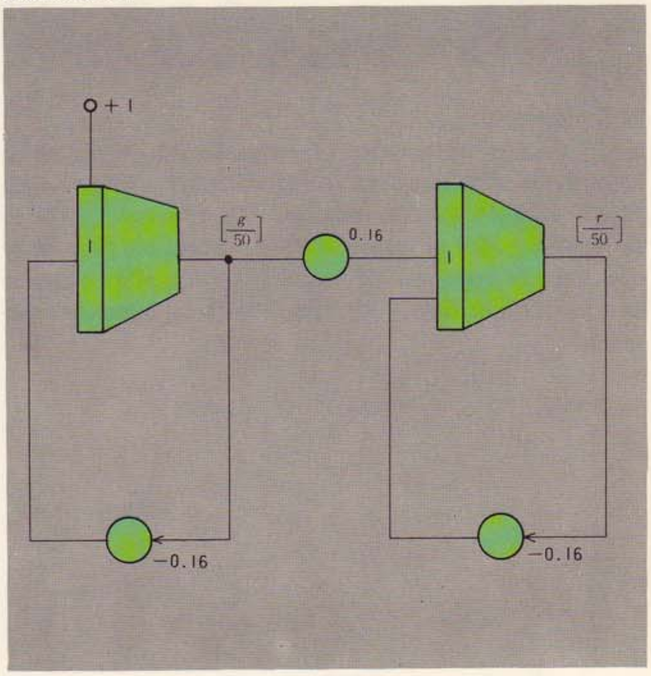
At t = 0, q = 50, and r = 0.

The following formuls can be obtained by assuming 50 for the maximum value of q and r;

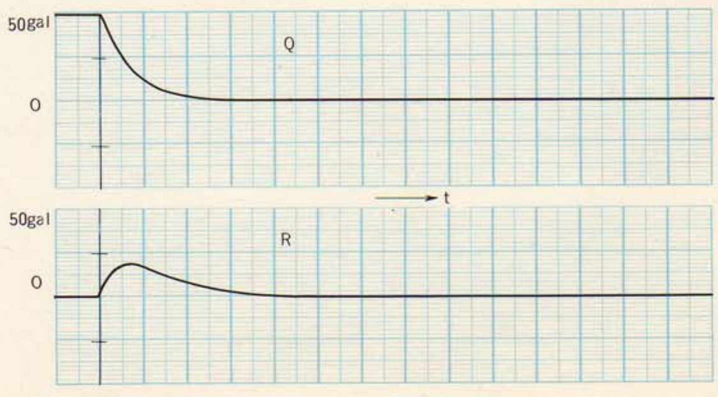
$$\left[\frac{\frac{dq}{dt}}{50}\right]=-0.16\left[\frac{q}{50}\right] \quad \left[\frac{\frac{dr}{dt}}{50}\right]=0.16\left[\frac{q}{50}\right]-0.16\cdot\left[\frac{r}{50}\right]$$

At $t=0$, $\left[\frac{q}{50}\right]=1$ and $\left[\frac{r}{50}\right]=0$

Block diagram



Graphic solution



Example 4. Earthquake response of a building

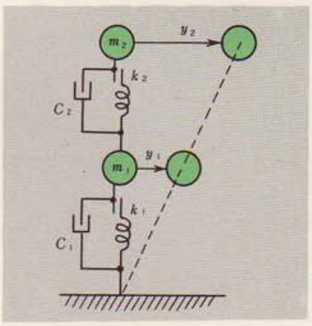
If we consider the vibration characteristics of a building up to its plastic region, analysis by an analog computer will be suitable for the purpose, because a certain nonlinearity is contained in the earthquake response of the building.

An analysis is to be made to obtain response of the building for horizontal swing by earthquake. The building can be simulated on a concentrated constant basis, by concentrating the mass of each story at the center of gravity of each story. Thus, the building can be modeled as shown in Fig. 1.

Fig. 1 is a simulation of a two mass-point system which is equivalent to a 2-story building. Substituting composite characteristics of two stories for a mass point in Fig. 1, the figure can simulate a 4-story building.

The correspondence of mass points and number of stories is not fixed; rather, it is rich in flexibility.

Fig. 1 Model of a Two Mass-point System Building



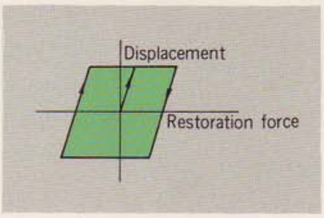


Fig. 2 Relationship in Displacement and Restoration Force

The spring constant of posts k1 and k2 shows the displacement-to-restoration force relation given in Fig. 2.

Compliance of posts C1 and C2 are assumed to be constant.

• Equations

The building in Fig. 1 can be simulated by the following equation;

$$m1\frac{d^2y_1}{dt^2}+C1\frac{dy_1}{dt}+C2\left(\frac{dy_1}{dt}-\frac{dy_2}{dt}\right)+k1\cdot y1+k2\,(y1-y2)=$$
$$m1\cdot\alpha(t)$$

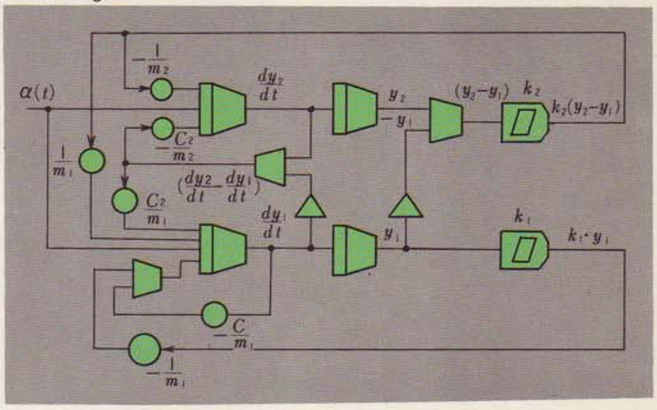
$$m2\frac{d^2y^2}{dt}+C2\left(\frac{dy_2}{dt}-\frac{dy_1}{dt}\right)+k2\,(y2-y1)=m2\cdot\alpha(t)$$

The condition for spring constants k1 and k2 is given in Fig. 2.

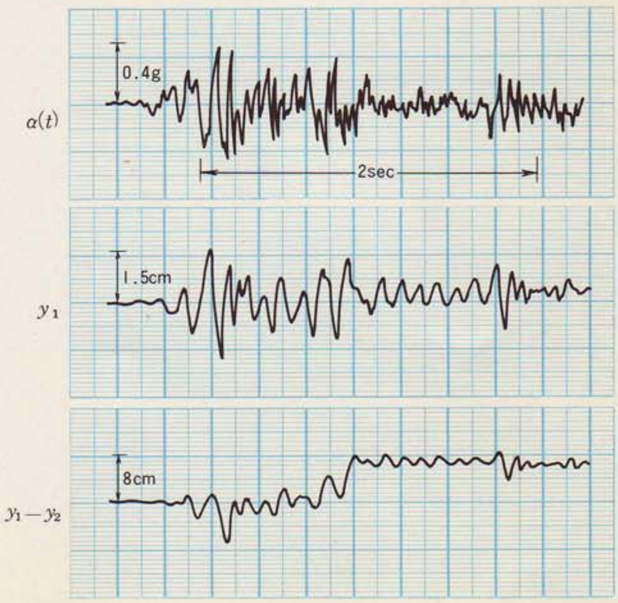
In the equation, the earthquake wave is given by α (t) which is applied at the dimension of acceleration.

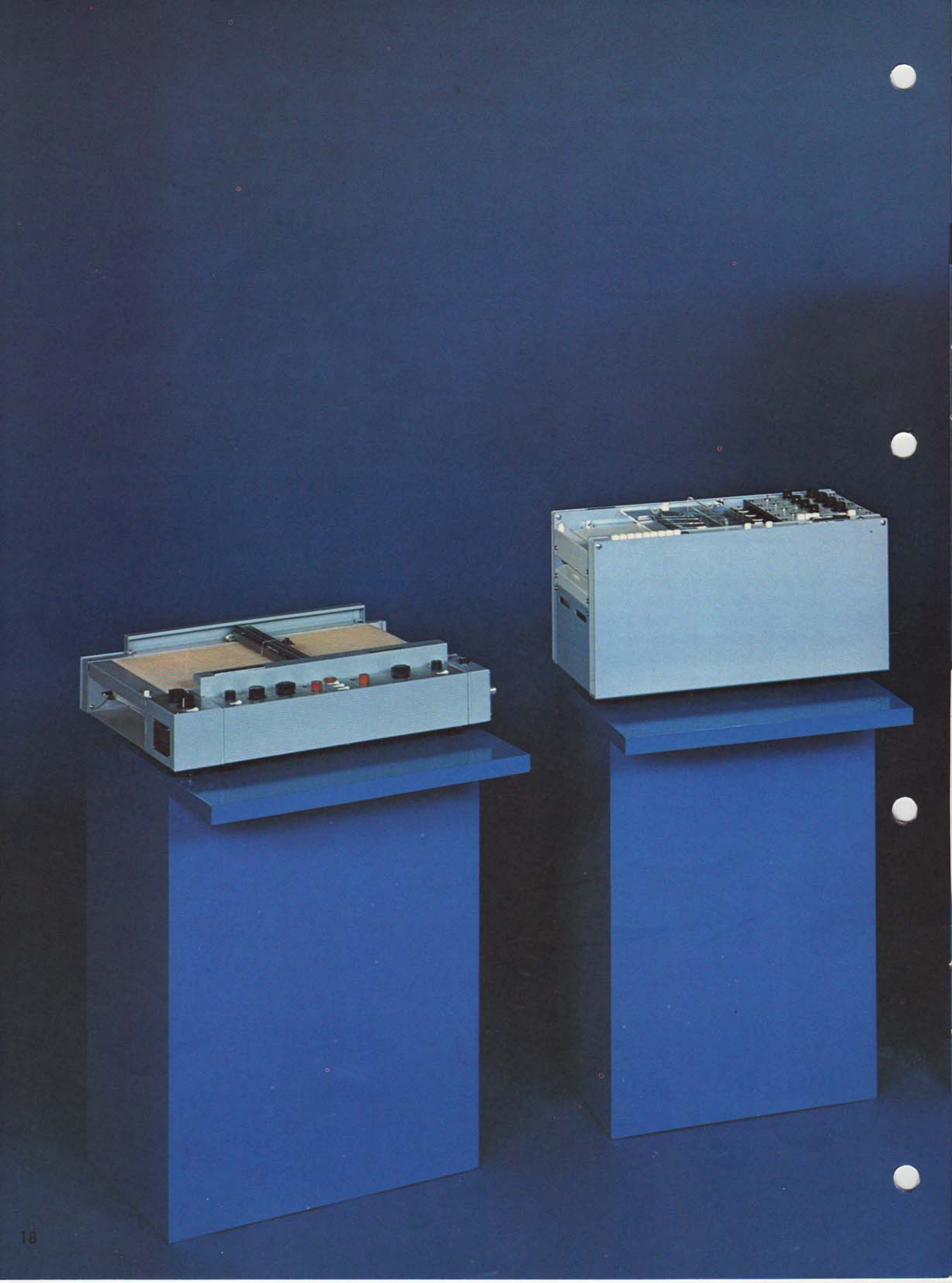
$$\begin{cases}\dfrac{d^2y_1}{dt^2}=-\dfrac{c^1}{m^1}\cdot\dfrac{dy_1}{dt}-\dfrac{c_2}{m^1}\left(\dfrac{dy_1}{dt}-\dfrac{dy_2}{dt}\right)-\dfrac{k_1}{m^1}\cdot y1-\dfrac{k_2}{m^1}(y1-y2)+\alpha(t)\\ \dfrac{d^2y^2}{dt^2}=-\dfrac{c_2}{m_2}\cdot\left(\dfrac{dy_2}{dt}-\dfrac{dy_1}{dt}\right)-\dfrac{k_2}{m_2}(y2-y1)+\alpha(t)\end{cases}$$

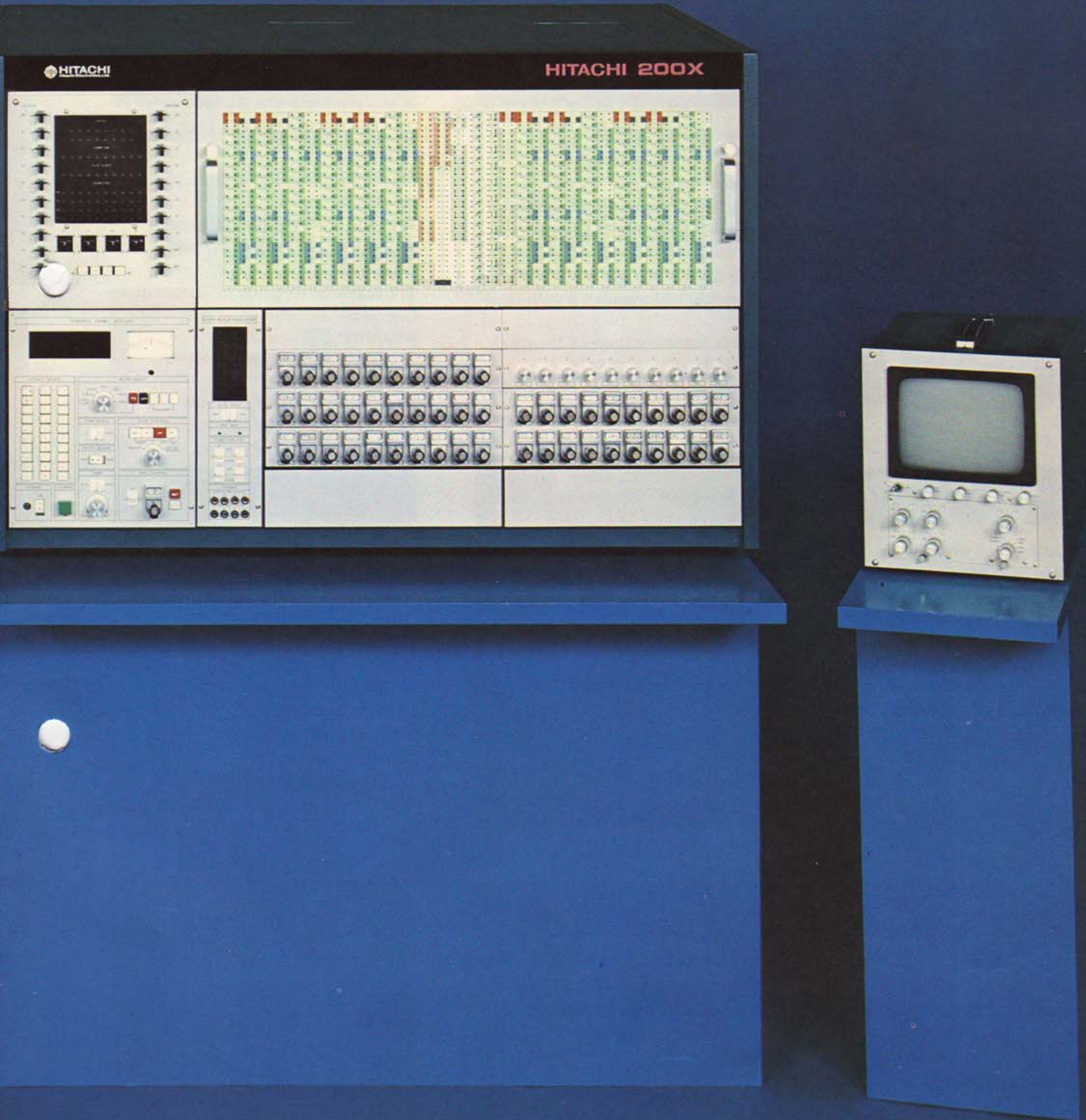
Block diagram



Graphic solution



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Application field of analog/hybrid computer, further expanded by the HITACHI-200X

Chemical industry

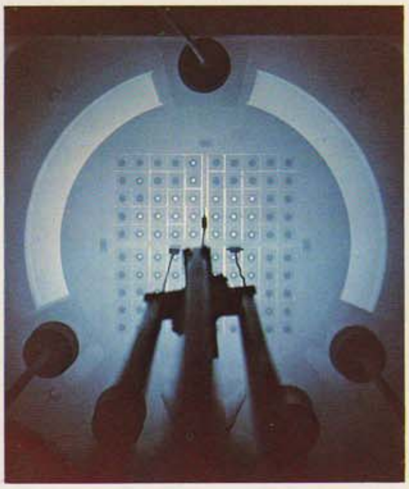
Process control analysis
Chemical reaction analysis
Dynamic property of plants
Transmission function measurement
Frequency response of thermal systems
Condensation refrigerator design
Process control associated with time delay
Graphic representation of chemical reactor dynamic property
Static property of chemical reactors

Electric power, electronics, and communications

Acceleration of ions by cyclotron resonator
Matching analysis of electric wave absorption wall
Analysis of electroluminescence
Analysis of phase shift caused by particle scattering
Transmission function of servomotors
Characteristic analysis of magnetic amplifiers
Transient response of inductive circuits
Simulation of water turbines
Dynamic analysis of step motors
Dynamic analysis of boilers

Nuclear energy industry

Dynamic analysis of reactors
Examination of reactor control systems
Output distribution of boiling water reactors
Trouble analysis of critical reactors
Effect analysis of reactor-scrum
Dynamic analysis of marine reactors



Aircraft and ship industry

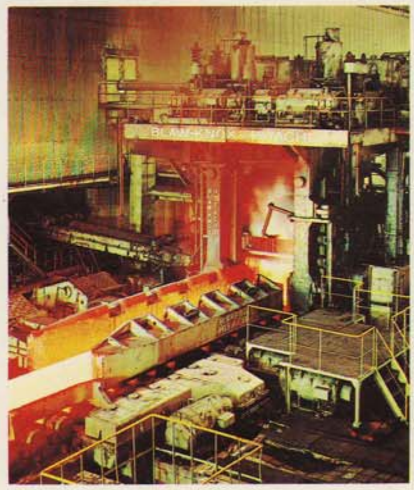
Gas turbine control
Analysis of aircraft unstability in gliding
Analysis of ship body rolling
Guided flight simulator
Analysis of parabolic motion considering resistance and buoyancy
Landing control
Flight simulator research
Aircraft body motion
Jet gas turbine simulator

Automobile and railway industry

Analysis of bicycle ride
Compressor rippling simulator
Transient response of vehicle dynamic damper
Snaking motion of ralway cars
Body vibration analysis

Steel mill

Speed control of continuous hot rolls
Convergence of time-shared operation
Partial differential equation
Analog simulation of mobile boundary problem in thermal condition equation
Heat conduction in molds



Automatic control

Phase plane analysis of nonlinear optimum control systems
Operation analysis of relay control systems
Automatic tracking of dynamic property using a model method

Medical field

Analysis of red-blood corpuscles maintenance systems
Simulation of vocalization mechanism
Analysis of nervous system
Simulation of muscular control system
Simulation of kidney activity
Pathological analysis of circulation system

Mathematics

Polynominal linear equation
Wave equation
Algebraic equations of high order
Polynominal high order equations

Machinery industry

Natural oscillation of beams
Automatic control of hydraulic universal testers

Management

Good wine equations
Business games

Architecture and civil engineering

Analysis and tracking of floods
Architectural response against earthquakes
Flood control calculations
Blending of cement materials
Vibration analysis of high-storied buildings
Earthquake response of building structures

Others

Analysis of mathemetic equations
Analysis of phisical phenomena
Automatic control theory in electric systems
Analysis of transmission functions
Research of mechanical motions and vibrations

HITACHI-200X, Example of Composition

Computing element	ALS-200X										
	Type	1	2	2S	2LS	3	3S	3LS	4	4S	4LS
● Linear unit											
Analog unit	A-10	2	4	4	4	6	6	6	8	8	8
Analog unit	A-20	2	4	4	4	6	6	6	8	8	8
Analog unit	A-30	1	2	2	2	3	3	3	4	4	4
Analog unit	A-40	1	2	2	2	3	3	3	4	4	4
Potentiometer	APT-241	2	2	2	2	3	3	3	4	4	4
Potentiometer	APT-242		2	2	2	3	3	3	4	4	4
● Detail											
Integrator		5	10	10	10	15	15	15	20	20	20
Summer		5	10	10	10	15	15	15	20	20	20
Sign changer		3	6	6	6	9	9	9	12	12	12
Potentiometer		20	40	40	40	60	60	60	80	80	80
Function switch		1	2	2	2	3	3	3	4	4	4
● Nonlinear unit											
Multiplier	AEM-001										
Multiplier	AEM-002	2	4	4	4	4	4	4	6	6	6
Sine function generator	ASI-001					1	1	1	1	1	1
Cosine function generator	ACO-001					1	1	1	1	1	1
Variable function generator	AFG-061A		1	1	1	1	1	1	2	2	2
Variable function generator	AFG-061B		1	1	1	1	1	1	2	2	2
Variable function generator	AFG-062					1	1	1	2	2	2
Variable function generator	AFG-067									1	1
Logarithmic function generator	ALG-001			1	1		1	1		2	2
Comparator	ACP-001			2	2		3	3		4	4
Electronic switch	AES-001			2	2		3	3		4	4
Relay	ARL-001			2	2		3	3		4	4
Special nonlinear element	ASN-001			1	1		2	2		2	2
Transfer delay element	ATD-001			1	1		2	2		2	2
● Basic unit											
Cabinet		1	1	1	1	1	1	1	1	1	1
Digital volt meter		1	1	1	1	1	1	1	1	1	1
Analog mount	AMA-001					1	1	1	1	1	1
● Accessories											
Pre-patch board	PP-200	1	2	2	2	3	3	3	3	3	3
Patching kit	PK-200	2	3	3	3	5	5	5	5	5	5
Recorder connector											
● Display devices											
CRT oscilloscope (4CH)	OS-242AS										
Strip chart recorder (4CH)											
Strip chart recorder (6CH)											
X-Y recorder	WX-411H										
● Logic units											
Logic control panel	BL-240				1			1			1
Logic mount	AML-001				1			1			1
Logic unit	L-10				1			1			1
Logic unit	L-20				1			1			1
Logic unit	L-30				1			1			1
● Detail											
Gate					16			16			16
Flip-flop					10			10			10
Counter					4			4			4
● Analog trunks											
Analog trunks	T-10	1	1	1	1	1	1	1	1	1	1
Linkage trunks	Required to compose a hybrid system										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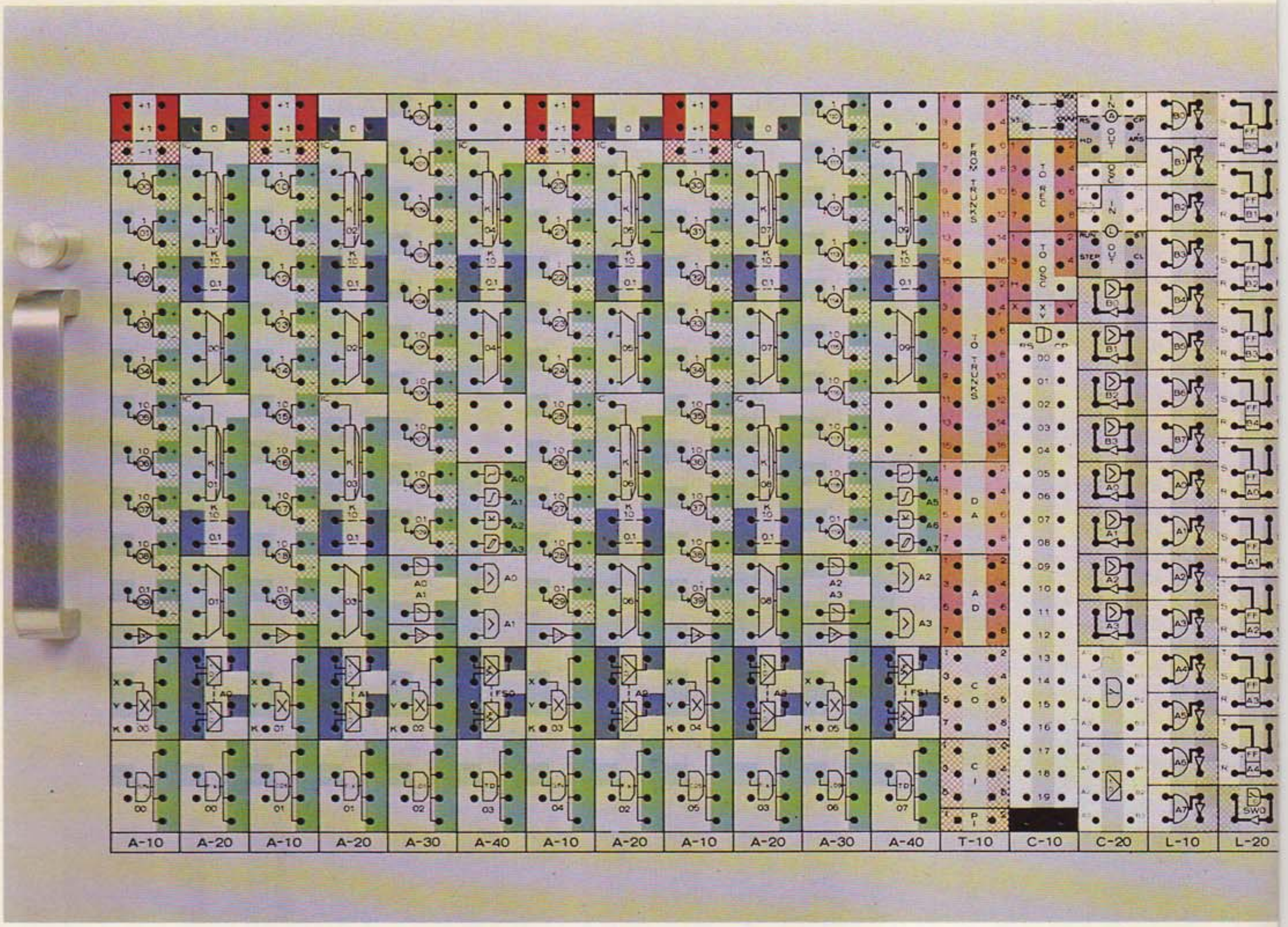
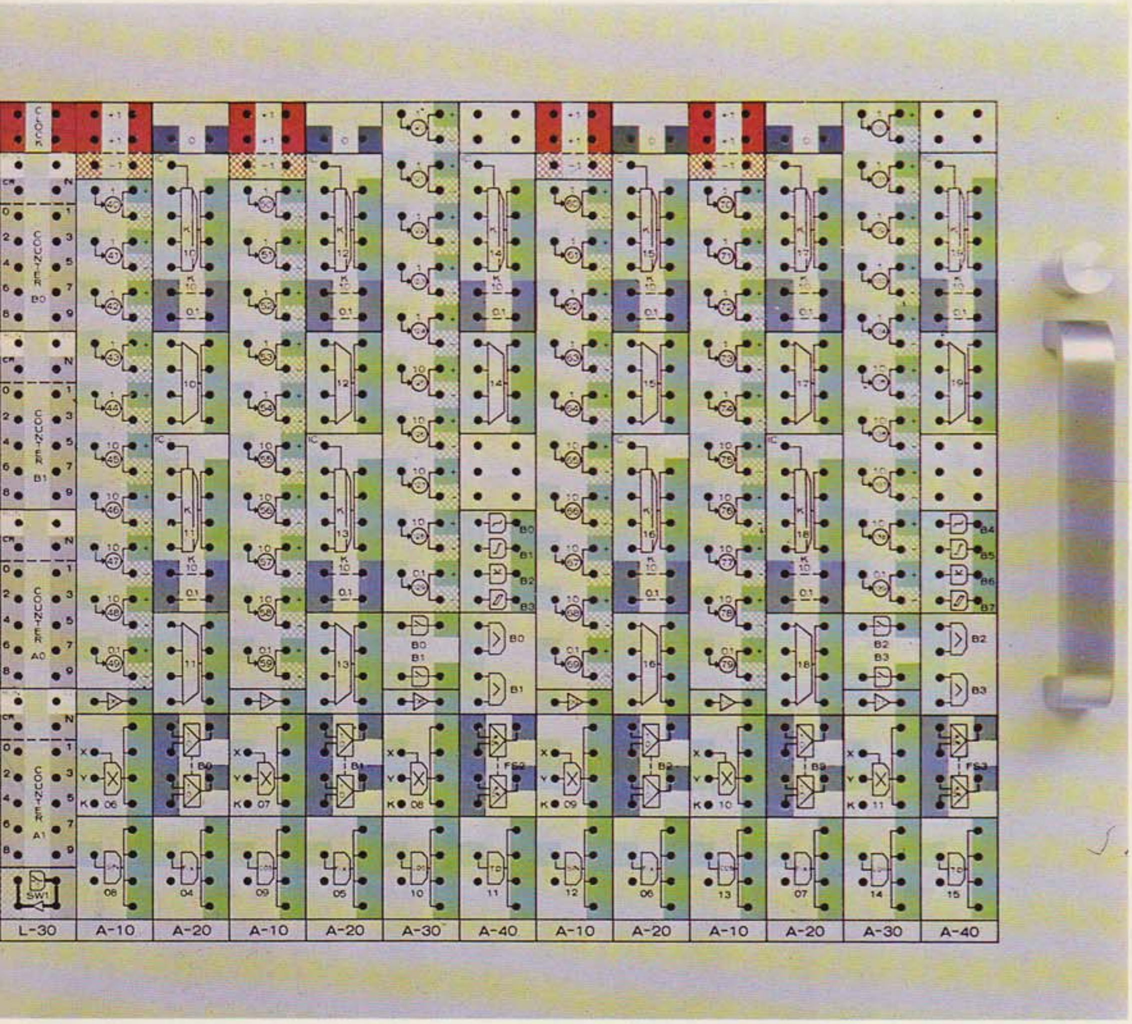
Computing element layout



The mount is contained in the basic unit

		A-10	A-20	A-10	A-20	A-30	A-40	A-10	A-20	A-10	A-20	A-30	A-4
Integrator		–	2	–	2	–	1	–	2	–	2	–	1
Summer		–	2	–	2	–	1	–	2	–	2	–	1
Inverter		1	–	1	–	1	–	1	–	1	–	1	–
Potentiometer		10	–	10	–	–	–	10	–	10	–	–	–
Function switch		–	–	–	–	–	1	–	–	–	–	–	1
Precision-type multiplier	AEM-001	1	–	1	–	1	–	1	–	1	–	1	–
Standard-type multiplier	AEM-002												
Sine function generator	ASI-001	1	–	–	–	–	–	1	–	–	–	–	–
Cosine function generator	ACO-001	–	–	1	–	–	–	–	–	1	–	–	–
Variable function generator (fixed break points)	AFG-061A	–	1	–	1	–	–	–	1	–	1	–	–
Variable function generator (fixed break points)	AFG-061B												
Variable function generator (fixed break points)	AFG-062												
Variable function generator (variable break points)	AFG-067												
Logarithmic function generator	ALG-001	–	–	–	–	1	–	–	–	–	–	1	–
Comparator	ACP-001	–	–	–	–	–	2	–	–	–	–	–	2
Electronic switch	AES-001	–	–	–	–	2	–	–	–	–	–	2	–
Relay	ARL-001	–	1	–	1	–	–	–	1	–	1	–	–
Special nonlinear element	ASN-001	–	–	–	–	–	1	–	–	–	–	–	1
Transfer delay element	ATD-001	–	–	–	–	–	1	–	–	–	–	–	1
Potentiometer (10-turn)	APT-241	1	–	1	–	–	–	1	–	1	–	–	–
Potentiometer (1-turn)	APT-242												

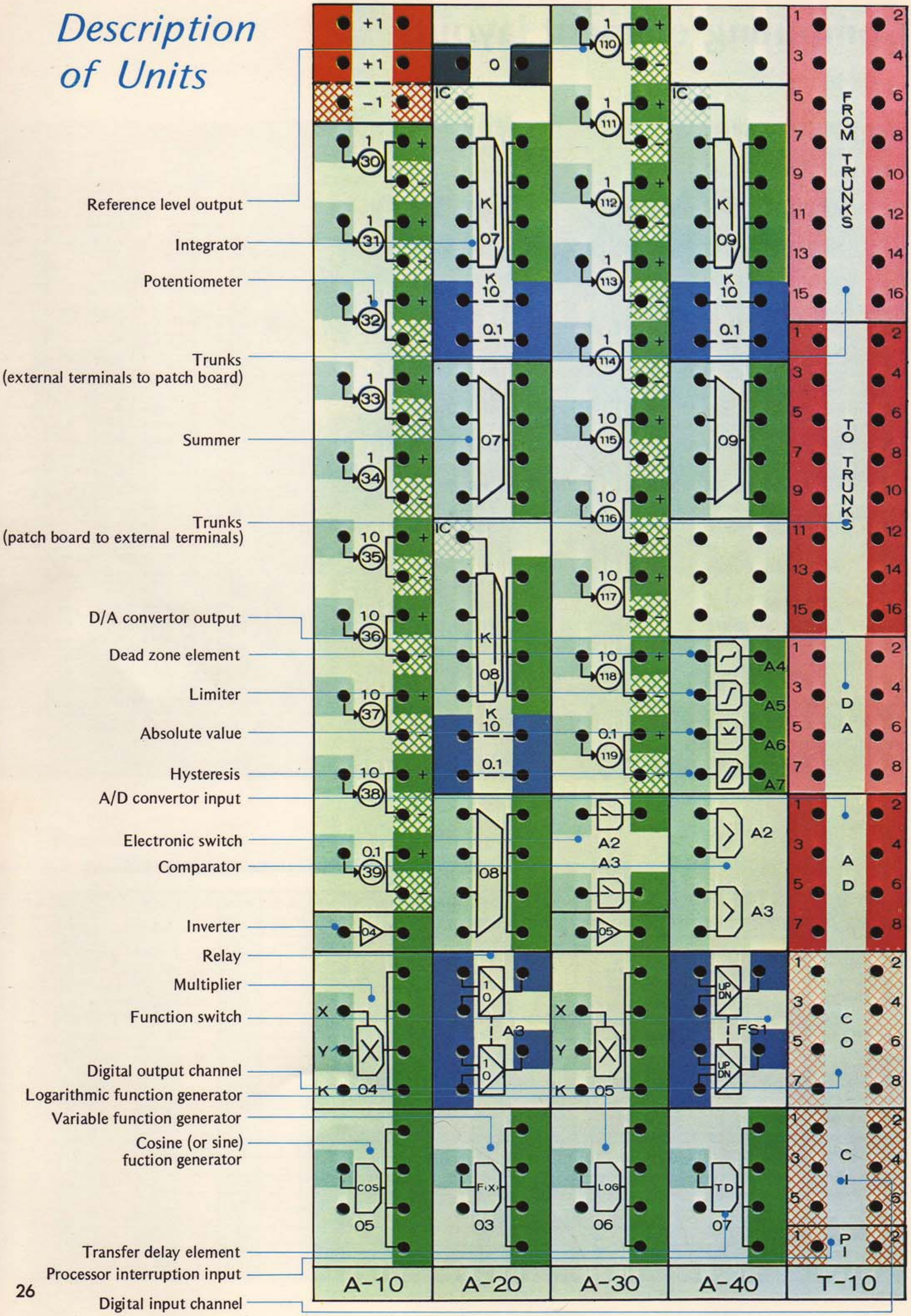


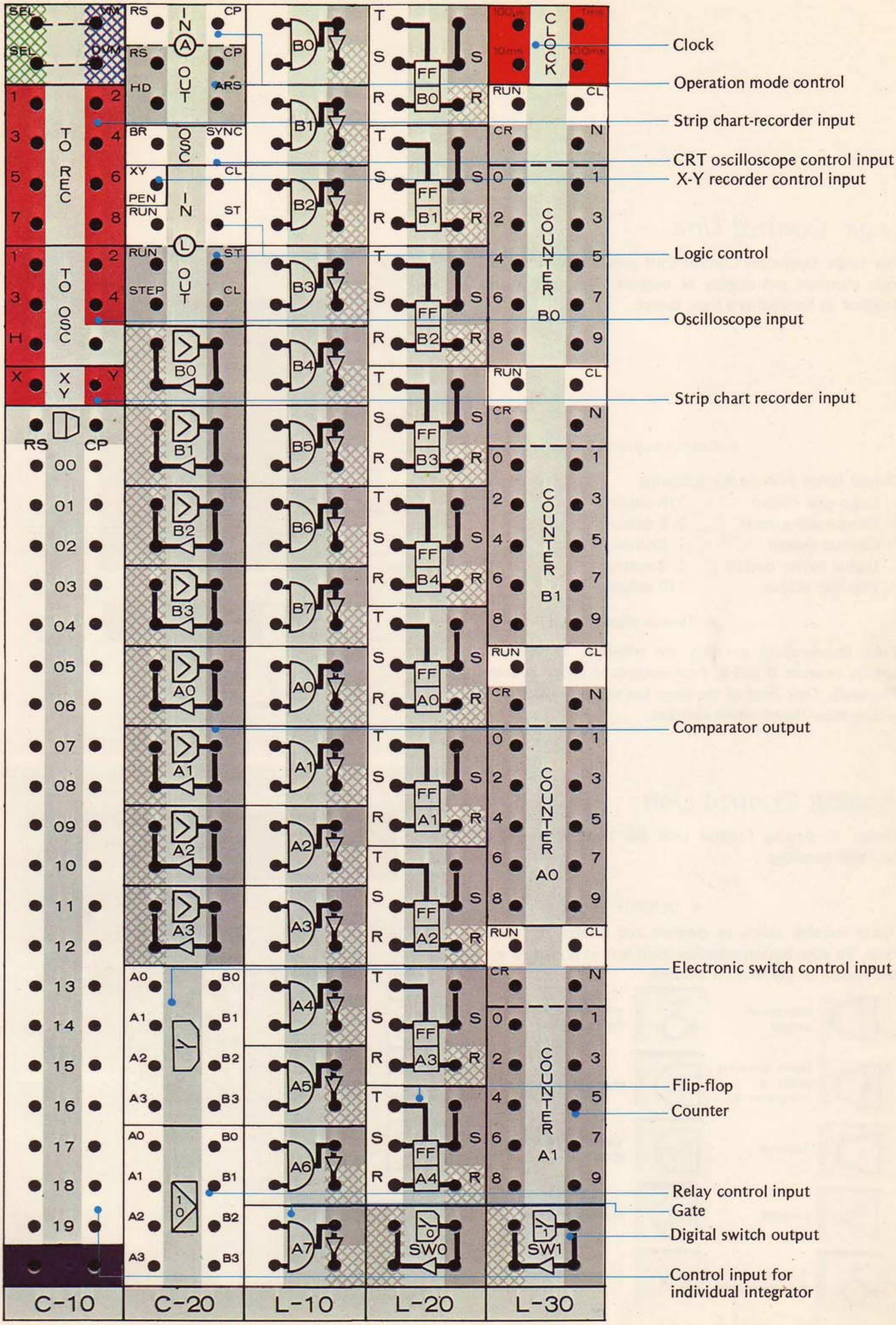
Logic mount AML-001 required ⟵⟶ Analog mount AMA-001 required

C-10 & C20 (contained in basic unit)
T-10 Trunks
Input 16CH
Output 16CH
Linkage trunks
AD 8 CH, CI 6 CH
PI 2 CH, DA 8 CH,
CO 8 CH
L-10
Gate/16
L-20
Flip-flop/10
Digital switch/1
L-30
Counter/4
Clock/4 intervals {0, 1 ms; 1 ms; 10 ms; 100 ms}
Digital switch/1
NOTE:
Potentiometer
APT-241 (10-turn x 10)
APT-242 (1 turn x 10)

A-10	A-20	A-10	A-20	A-30	A-40	A-10	A-20	A-10	A-20	A-30	A-40	Total
–	2	–	2	–	1	–	2	–	2	–	1	20
–	2	–	2	–	1	–	2	–	2	–	1	20
1	–	1	–	1	–	1	–	1	–	1	–	12
10	–	10	–	–	–	10	–	10	–	–	–	80
–	–	–	–	–	1	–	–	–	–	–	1	4
1	–	1	–	1	–	1	–	1	–	1	–	12
1	–	–	–	–	–	1	–	–	–	–	–	4
–	–	1	–	–	–	–	–	1	–	–	–	4
–	1	–	1	–	–	–	1	–	1	–	–	8 Up to 2, for AFG-067.
–	–	–	–	1	–	–	–	–	–	1		4
–	–	–	–	–	2	–	–	–	–	–	2	8
–	–	–	–	–	–	–	–	–	–	2	–	8
–	1	–	1	–	–	–	1	–	1	–	–	8
–	–	–	–	–	1	–	–	–	–	–	1	4
–	–	–	–	–	1	–	–	–	–	–	1	4
1	–	1	–	–	–	1	–	1	–	–	–	8

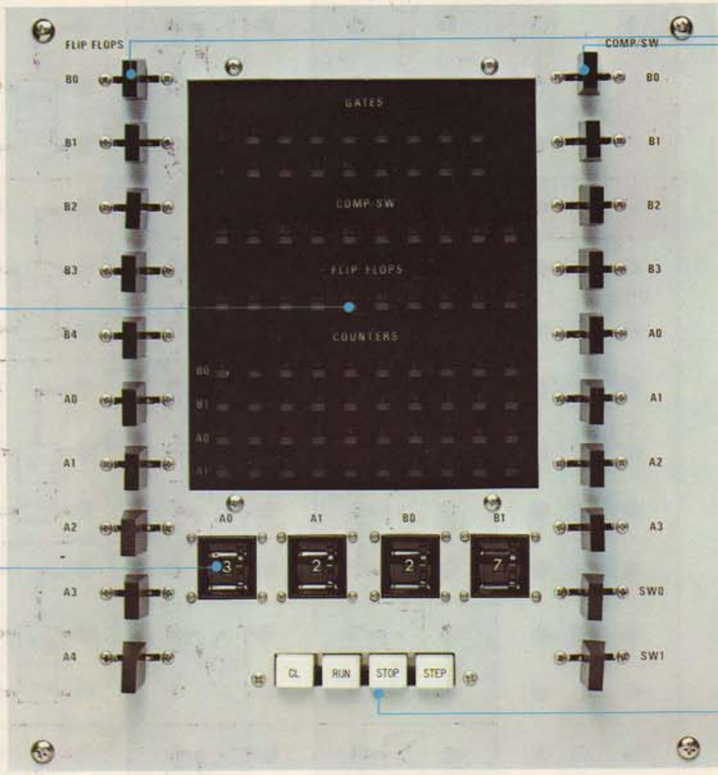
Description of Units




Clock
Operation mode control
Strip chart-recorder input
CRT oscilloscope control input
X-Y recorder control input
Logic control
Oscilloscope input
Strip chart recorder input
Comparator output
Electronic switch control input
Flip-flop
Counter
Relay control input
Gate
Digital switch output
Control input for
individual integrator
TO REC
TO OSC
CLOCK
COUNTER B0
COUNTER B1
COUNTER A0
COUNTER A1
SW0
SW1
C-10
C-20
L-10
L-20
L-30

Logic Control Unit

The Logic Operation Control Unit provides presetting of logic elements and display of outputs. This unit is also designed to be used as a logic trainer.



• Output indication lamp

Output lamps indicate the following

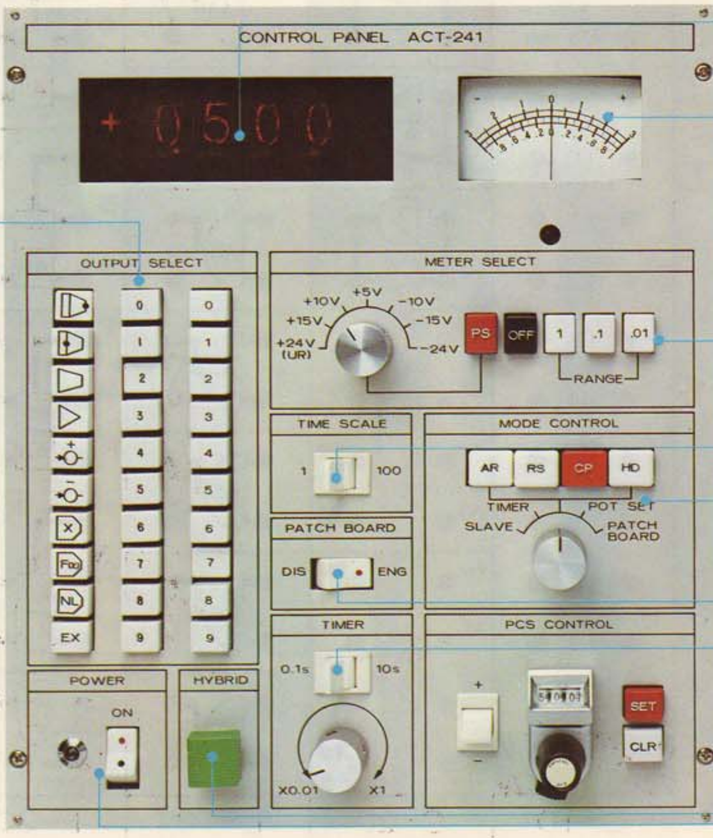
Logic gate output	: 16 outputs
Comparator output	: 8 outputs
Counter output	: Decimal, 4 sets
Digital switch output	: 2 outputs
Flip-flop output	: 10 outputs

• Thumb-wheel switch

Four thumb-wheel switches are provided to select an output between 0 and 9, from outputs of digital counters (decimal). Time limit of the timer can be easily changed by setting these thumb-wheel switches.

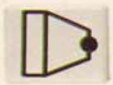
Analog Control Unit

Design of Analog Control Unit has been improved to facilitate handling.



• OUTPUT SELECT

These buttons select an element and display its output level. To ease button selection, each button is marked with the symbol of the relevant element.

	Intergrator output		-output of Potentiometer
	Input summing point of integrator at		Multiplier
	Summer		Variable function generator
	Inverter		Nonlinear element
	+ output of Potentiometer		External output

• Control switch

These key switches are used for manual setting or resetting of the logic element. The switches are useful to debug the function of logic elements.

Flip-flop control switch	:	10
Comparator control switch	:	8
Manual digital switch	:	2

• Logical control switch

These switches control overall operation of the logic circuit.

- CL .... Clears logic circuit.
- RUN .... Actuates a built-in clock generator (0.1ms, 1ms, 10ms or 100ms).
- STOP .... Stops the clock generator.
- STEP .... Generates a single pulse.

• METER

• METER SELECT

• TIME SCALE

Used for checking of power supply voltages or others.

- 1 Real-time operation (as programmed).
- 100 1/100 of programmed time.

• MODE CONTROL

A switch for selecting operation mode.

- AR (all reset) .... A mode for entering initial condition to all integrators working under individual control.
- RS (reset) .... A mode for entering initial condition to a integrator.
- CP (compute) .... The computing operation mode.
- HD (hold) .... A mode for holding operation at an interim state.
- SLAVE .... A mode for operating the computer under control of other system.
- TIMER .... Used to start timer-controlled operation.
- POT SET .... A mode for allowing changing of potentiometer setting.
- PATCH BOARD .... Operation of the computer is controlled by a patched mode-control input.

• ENG To engage the motor-driven patch panel.

• POWER The power ON/OFF switch.

• DIGITAL VOLT METER

The digital volt meter displays output level of an element selected by the OUTPUT SELECT, or a coefficient being set at potentiometer adjustment.

For accurate setting of the coefficient, display of the decimal point has been improved so that the decimal point location will be automatically changed with the type of coefficient amplifier being used.

Coefficient range between 0 and 0.1 (0.0500 is displayed)

Coefficient range 0 to 1 (0.500 is displayed).

Coefficient range 0 to 10 (05.00 is displayed).

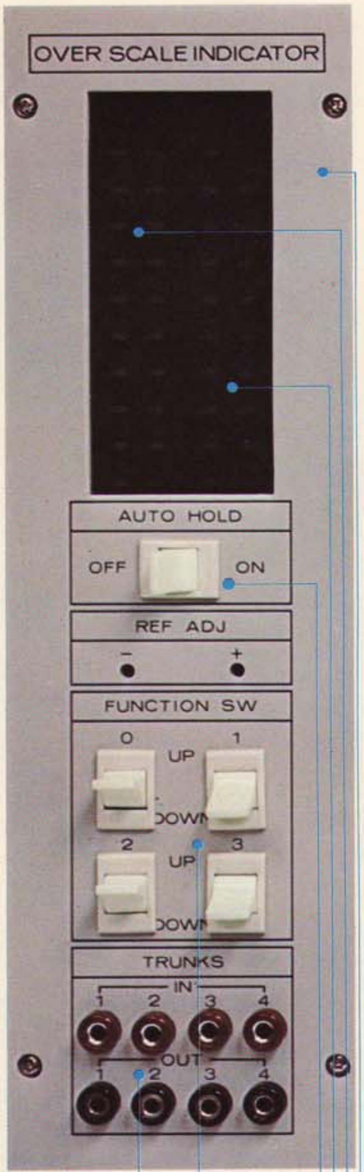
(5-digit digital meter is available on request.)

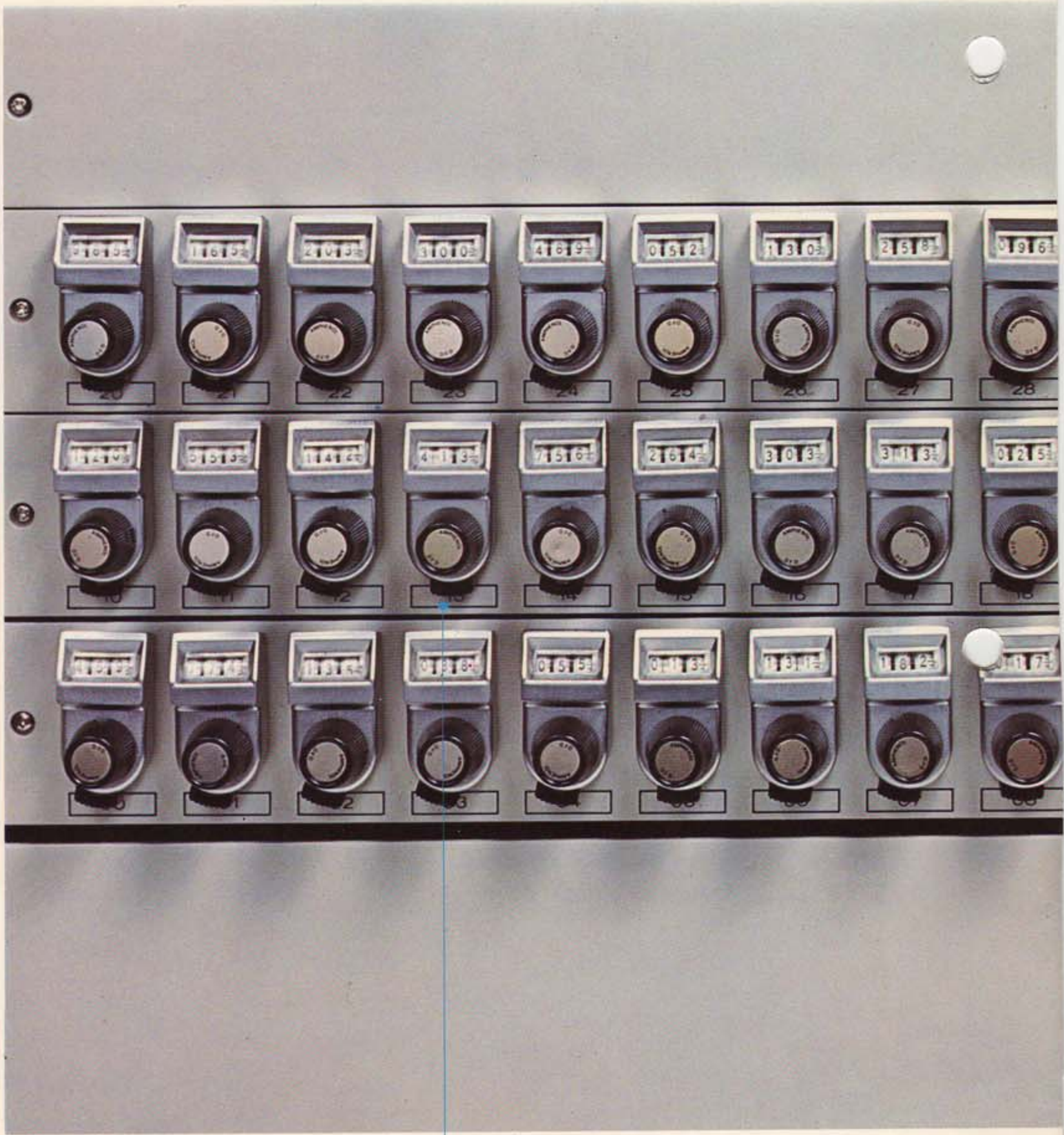
• TIMER

The timer is used for repetitive operation.
The following timers are built-in –
RESET time approx. 1 msec.; COMPUTE TIME approx. 1 msec. to 100 msec.
RESET time approx. 100 msec.; COMPUTE time approx. 100 msec. to 10 sec.

• HYBRID

This mode is used for hybrid operation in a hybrid system.





Potentiometer Panels

• Overscale indicator

INT .... 00 to 19
Indicate overscale of the integrators

ADD ..... 00 to 19
Indicates overscale of the summer

AUTO HOLD

ON .... When overscale of an element is detected, "HOLD" mode is selected automatically

OFF... The selected operation mode even when overscale of an element is sensed

FUCTION SWITCH

Manual control switches

TRUNKS

Interface to external devices

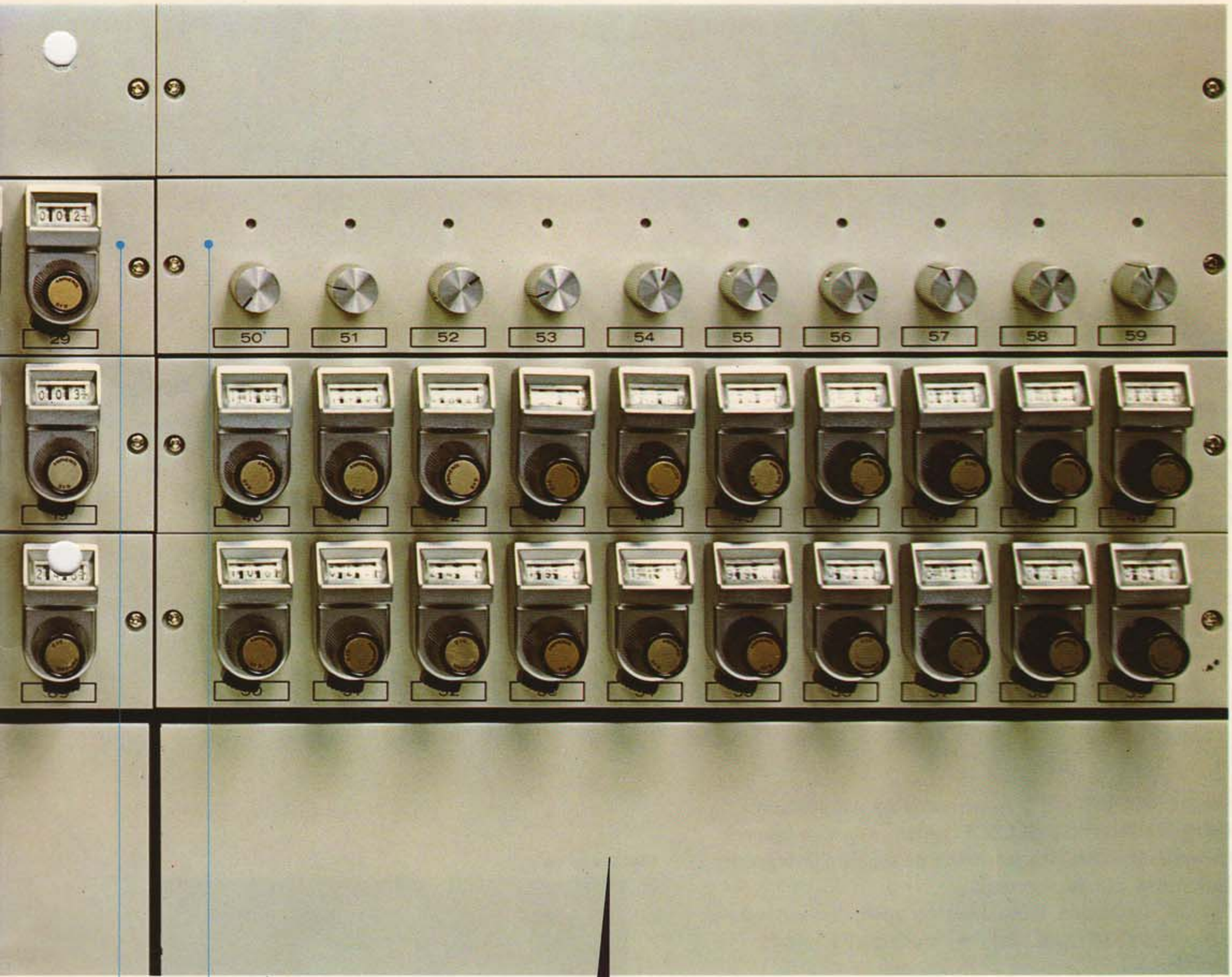
• Potentiometer

APT-241 Ten-turns potentiometer, ten pieces

APT-242 Single-turns potentiometer, ten pieces

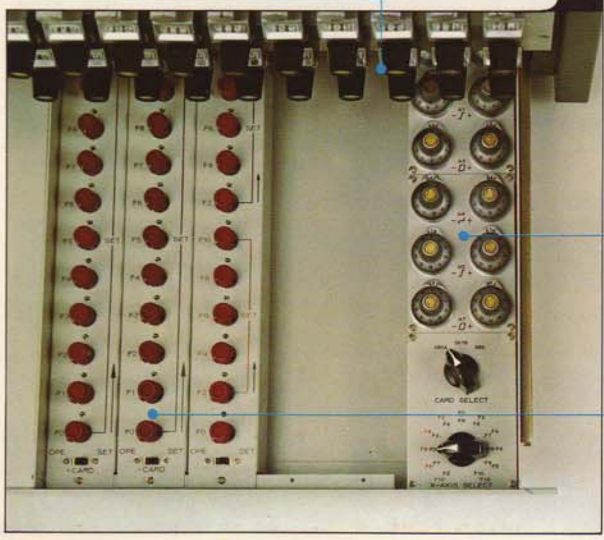
Accessories: Patching kit PK-200

Cord color	Cord length	Quan. per kit
Brown	10 cm	15
Red	20 cm	30
Yellow	40 cm	30
Green	60 cm	15
Violet	80 cm	10
		100 cords per kit.



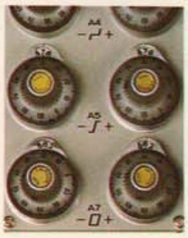
- **Transfer Delay Setting Panel**

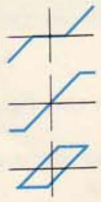
This panel selects the desired delayed time.



- **Special Nonlinear Element Panel**

These controls preset breakpoints for the following non-linear elements.





Dead zone

Limiter

Hysteresis

\+ breakpoint in position direction

\- breakpoint in negative direction

NOTE: Gradient of curves is 1 for all elements.

- **Variable Function Generator Panel**

AFG-061A	(10 segments in positive direction)
AFG-061B	(10 segments in negative direction)
AFG-062	(5 segments in both positive and negative directions)

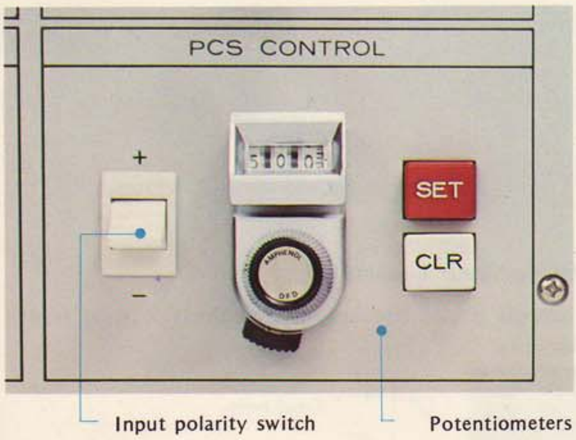
These variable function generators are of fixed break point.

AFG-067	(10 segments, with variable break point)

Example of Program Cheek System (PCS)

The Program Check System (PCS) is provided with two functions: (1) checking the computing element function and (2) checking the programming on the prepatch board. For example, the optionally selected elements can be tested and mistakes in patching can be checked by supplying an optional signal level to a selected element and by computing it with a theoretical value.
These check operations can be performed by accessing the Control Panel (when the computer is used in a hybrid mode, the simulation is more simplified by accessing the circuit from a digital computer which is combined).

1. Set the MODE CONTROL switch to the AR position.
2. Using the OUTPUT SELECT switch, select an element to which the checking input will be supplied (integrators and adders can be selected).
3. Set the simulation input level by using the potentiometer PCS CONTROL and the input polarity switch.



(In this figure, −0.5 is set.)

4. Supply the checking input to the element by depressing the SET switch of PCS CONTROL.
5. Select the other element to be checked by the OUTPUT switch and reach the signal level displayed by the digital volt meter and analog meter indicator. Compare the displayed level and analog meter indicator. Compare the displayed level and theoretical value to check the element functioning and patching.
6. After the test is completed, clear the circuit by depressing the CLR button of PSC CONTROL.
   Repeat steps 2 to 6, above, for all circuits in the prepared block.

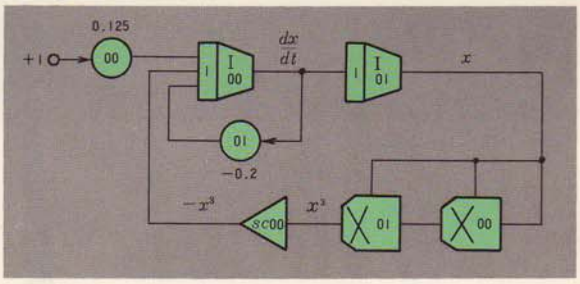
Problem: $\frac{d_2 x}{dt_2}+0.2\frac{dx}{dt}+x^3=0.125$

At $t = 0,\ \frac{dX}{dt} = X = 0$

Solution: Transforming the equation –

$$\frac{d^2x}{dt^2}=-0.2\frac{dx}{dt}-x^3+0.125$$

Block diagram



1. Supply checking input +1 (equivalent to $\frac{dX}{dt}$ = 1, x = 0) to integrator 100.

Test point	Theoretical	Patching tested by the check	Setting levels to be covered by the check
Input summing point to I 00	(−0.2+0.125) − 0.075	I 00→P01→I 00 + 1 →P00→I 00	P 00 P 01
Input summing point to I 01	+ 1	I 00→I 01	

Check points for trouble- shooting

2. Supply a PCS simulation input +0.5 to integrator I 01.

Test point	Theoretical	Patching test by the check	Setting or accuracy tested by the check
X 00 output	(0.5 x 0.5) 0.25	I 01 → X 00 X input Y input	Accuracy of X 00
S C 00 output	−(0.25x0.5) − 0.125	I 01 → X 01 X 00 → X 01 →S C 00	Accuracy of X 01
Input summing point to I 00	(−0.125+0.125) 0	SC 00→I 00 +1 →P 00 →P 00 →I 00	P 00

Specifications

1. General Specifications

Type of operations	Low-speed operation, high-speed repetitive operation, high-speed automatic operation, automatic mixed operation of low and high speeds, multitime axis operation, analog and digital hybrid operation.
Range of numeric values	-1 to +1
Time scale	1, 100
Repetition time	1 msec to 10 sec (standard) and 1 msec to 100 sec (optional)
Operation modes	RESET, COMPUTE, HOLD, ALL-RESET, POT SET, REP-OP (by timer), and AUTO HOLD
Pre-patch board	Color-coded pre-patch board
Patch pins	Dual contact point system with perfect shielding
Structure	
Computing element	Unit structure of identical configuration. Coefficient amplifier and variable function generators are mounted in the panel system.

Console	Desk-top type
Dimensions and weight	733 (H) x 1,135 (W) x 780 (D) mm Approx. 110 kg
Ambient Conditions	
Temperature	Rated performance guaranteed at 23°C ± 3°C Operable temperature range 5 to 35°C
Humidity	Rated performance guaranteed at 65 ± 10% R.H. Operable range 30 to 85% R.H.
Vibration	Within allowable limit to ordinary measuring instruments.
Gas	No corrosive gas permitted.
Power Requirements	
Voltage	100/110/120V ± 10%, 200/220/240V ± 10%* Single phase AC
Frequency	50/60 Hz
Power consumption	Approx. 700 VA

*According to the user's specification, the power circuit is wired to a specific voltage range before delivery.

2. Individual Specifications

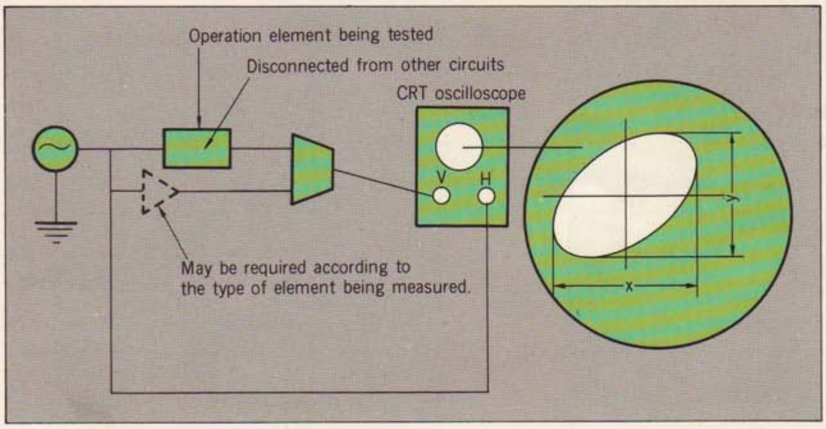
Conventionally, specifications for an analog/hybrid computer are given in terms of static accuracy, frequency response, phase characteristics, and so on. However, Hitachi believes that the user may require, in the most practical sense, to acknowledge computer actual accuracy at the actual operation speed (natural angular velocity ω inherent in an equation being used).

For Analog Computer 200X, Hitachi offers specifications in the term of TIDE (Total Instanteous Dynamic Error) which reflects what the analog/hybrid computer does in actual operation.

TIDE is represented by a sum of static error and dynamic error.

In the measurement setup shown in the figure (for an summer and for ω = 100), TIDE is given as;

$$\text{T,I,D,E} = \frac{y}{10x} \times 100\ (\%)$$

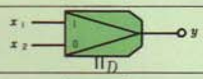
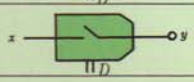
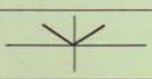
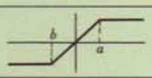
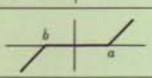
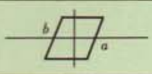


Specifications for Individual Computing Element

Computing element		Model	T.I.D.E (Total Instantaneous Dynamic Error) ω = 100	ω = 1,000	ω = 10,000	Output noise	No. of analog inputs	No. of analog outputs
Integrator						±0.005% (at reset mode)	4	4
Summer			± 0.04%	± 0.08%	± 0.13%	± 0.05%	4	4
Inverter			± 0.04%	± 0.08%	± 0.13%	± 0.005%	1	1
Potentiometer		APT-241 APT-242	± 0.04%	± 0.08%	± 0.13%	± 0.005%	1	1 - positive 1 - negative
Multiplier		AEM-001	± 0.15%	± 0.25%	± 0.35%	± 0.01%	2	4
		AEM-002	± 0.3%	± 0.4%	± 0.5%	± 0.01%	2	4
Variable function generator		AFG-061A	± 0.25%	± 0.3%	± 0.5%	± 0.02%	1	4
		AFG-061B	± 0.25%	± 0.3%	± 0.5%	± 0.02%	1	4
		AFG-062	± 0.25%	± 0.3%	± 0.5%	± 0.02%	1	4
		AFG-067	± 0.6%	± 0.8%	± 1%	± 0.05%	1	4
Sine function generator		ASI-001	± 0.35%	± 0.55%	± 0.75%	± 0.02%	1	4
Cosine function generator		ACP-001	± 0.35%	± 0.55%	± 0.75%	± 0.02%	1	4
Logarithmic function generator		ALG-001	± 0.35%	± 0.45%	± 0.55%	± 0.05%	1	4
Comparator		ACP-001	± 0.00025 (min. sensitivity)				2	4
Relay		ARL-001	–	–	–	–	2	4
Electronic switch		AES-001	± 0.04%	± 0.08%	± 0.13%	± 0.005%	1	1
Transfer delay element		ATD-001	–	–	–	± 0.005%	1	4
Special nonlinear elements	Absolute value	ASN-001	± 2.0%	± 2.5%	± 3.0%	± 0.01	1	1
	Limiter		± 2.0%	± 2.5%	± 3.0%	± 0.01%	1	1
	Dead zone		± 2.0%	± 2.5%	± 3.0%	± 0.01%	1	1
	Hysteresis		–	–	–	± 0.01%	1	1

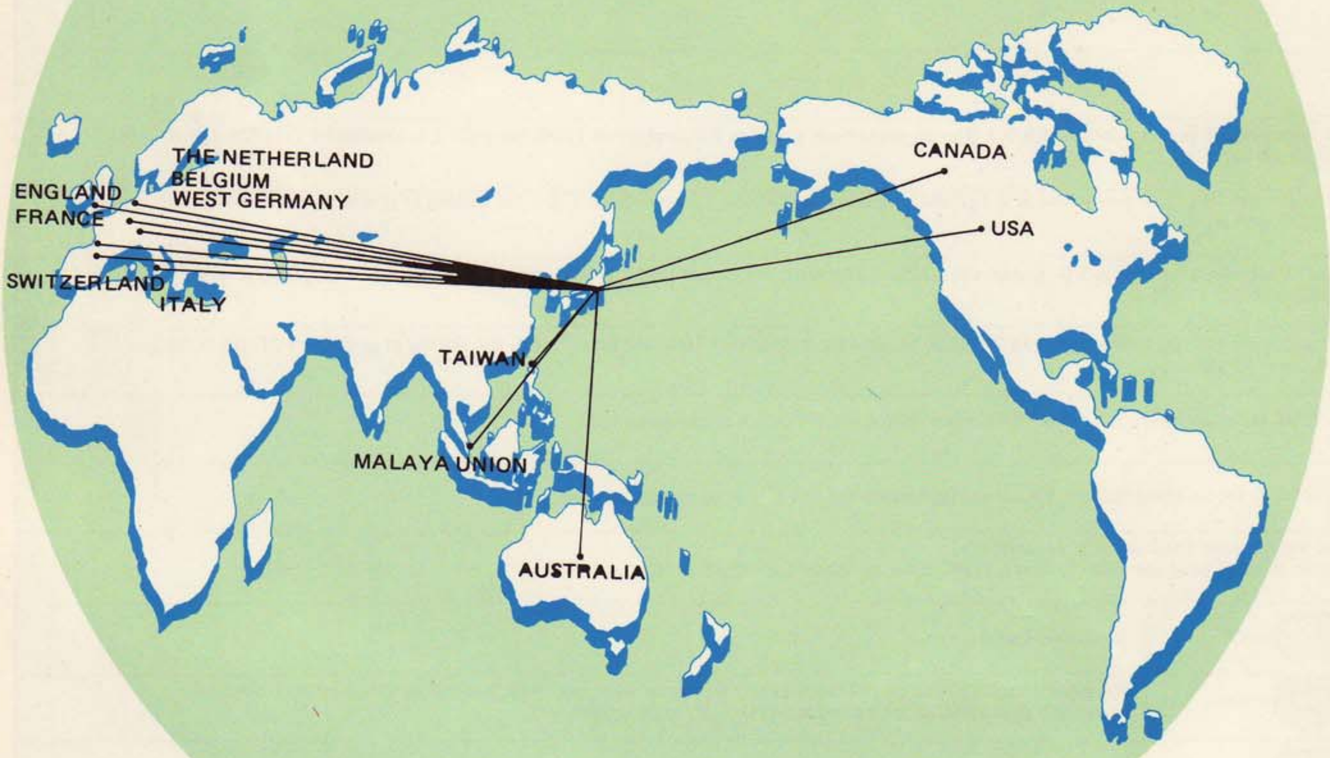
NOTE: Accuracy shall be determined against full scale (–1 to +1).

Others

	Circle test; 0 to -0.04% for $\omega = 1$, 0 to -0.04% for $\omega = 100$; 0 to $\pm 0.1\%$ for $\omega = 100$, 0 to $\pm 0.8\%$ for $\omega = 1000$ — Reset time; 1 ms for $\omega = 1$, 50 μs for $\omega = 100$ — HOLD drift (at 0V input); 0.025%/min — Every Integrator can be RESET or COMPUTE individually
	The potentiometer panel is provided with a potentiometer K = 1, 5 potentiometer K = 1, and 4 potentiometer K = 10. 10-turn potentiometer for APT-241, and single turn potentiometer for APT 242.
	No. of segments 10 (+), segment width 0.1 (fixed), maximum gradient 2.5, and given TIDE for setting at gradient 1 (TIDE is for an input $0.5 + 0.05 \sin \omega t$).
	No. of segments 10 (–), segment width 0.1 (fixed), maximum gradient 2.5, and given TIDE for setting at gradient 1 (TIDE is for an input $-0.5 + 0.05 \sin \omega t$)
	Number of segments 5 (+) plus 5 (–), segment width 0.2 (fixed), maximum gradient 2.5, and given TIDE for setting at gradient 1 (TIDE is for an input $0.5 + 0.05\ \omega t$)
	No. of segments 10, segment width 0 to 2 (variable), maximum gradient 100, and given TIDE for setting at gradient 1 (TIDE is for an input $0.5 + 0.05 \sin \omega t$)
	Given TIDE is for an input $0.2 + 0.05 \sin \omega t$ (generator for $\sin \frac{\pi}{2} x$ is an optional item).
	Given TIDE is for an input $0.2 + 0.05 \cos \omega t$ (generator for $\cos \frac{\pi}{2} x$ is an optional item).
	Output will be zero until input X exceeds 0.1. The input X must be larger than 0. Given TIDE is for an input $0.2 + 0.05 \sin \omega t$.
	Response speed 5 μs.
	No directionality (may be operated as $y \rightarrow x_1, x_2$ or as $x_1\ x_2 \rightarrow y$). Switching speed 10 ms (relays of operation speed 500μs are optional item). D: logic signals
	
	Transfer delay (τ): 0.1 to 10 sec. (0.1 sec. steps); error ±2% of max. value 0.01 to 1 sec. (0.01 sec. steps); error ±2% of max. value. 0.001 to 0.1 sec. (0.001 sec. steps); error ±10% of max. value. 0.0001 sec. to 0.01 sec. (0.0001 sec. steps); no rating for error.
	
	a and b preset by individual dial; gradient 1.
	a and b preset by individual dial; gradient 1.
	a and b preset by individual dial; gradient 1, $0 < a < 0.5$ and $-0.5 < b < 0$.

Experienced in World-Wide Operations

Hitachi Electronics, Ltd. exerts energetic efforts in producing the most reliable and finest electronic computers available. In leading universities, laboratories, companies, government offices... it seems that no matter where you go, Hitachi analog/hybrid computers are in full operation. You'll find them in Europe, the U.S.A., Canada, Australia, Southeast Asia, and other areas. Truly, Hitachi might be labeled "computer supplier to the six continents"!



Hitachi Electronics,Ltd.
23-2, 1-chome, Kanda-Suda-cho, Chiyoda-ku, Tokyo 101, Japan
Cable: ELCOHITACS TOKYO Telex: J24178 JAPAN
Tel.: (03) 255-8411

Hitachi Electronics, Ltd.