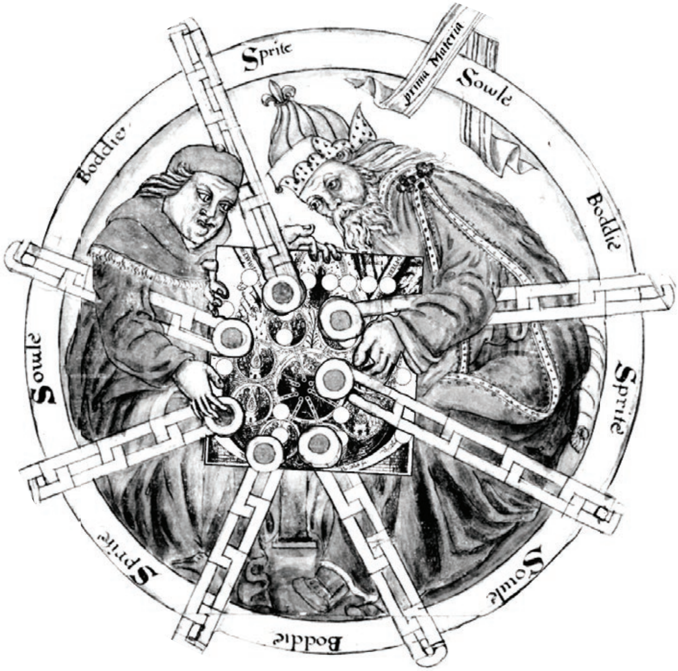
🜃

Which Venom kills, and saveth such as
Venom chance to take.

ERD/TOAD is produced in Hangzhou and Berlin by various machinic toads and hands in an edition of 100.

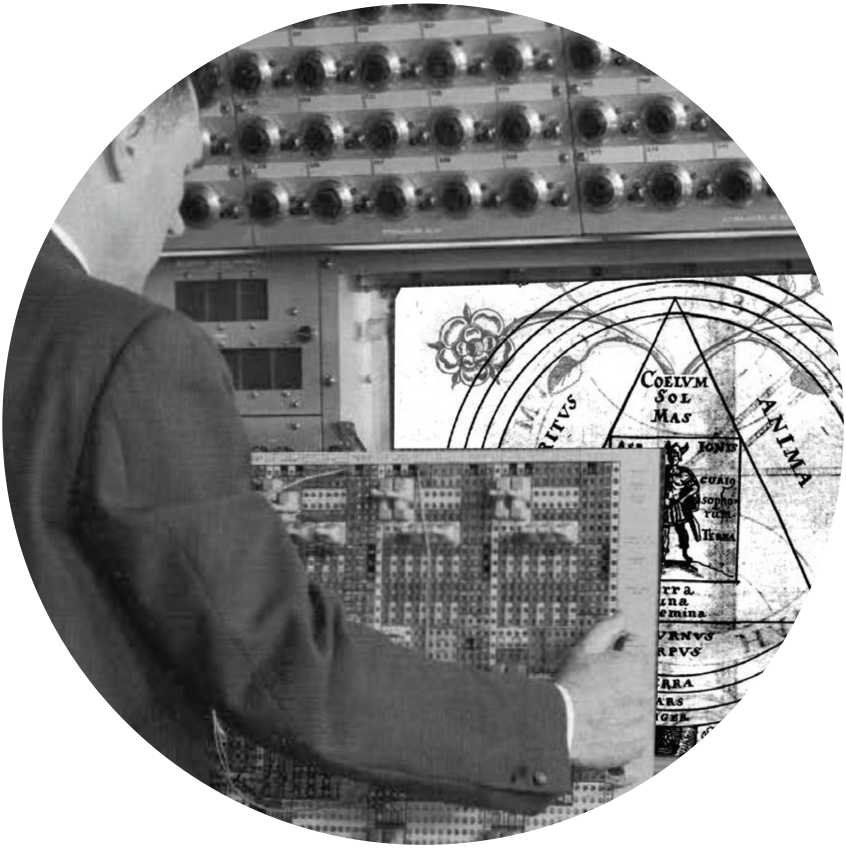
This module is numbered ......



A Toad full ruddy I saw.

ERD/TOAD is an hermaphroditic analogue computer driven by the times of pulses and slopes, designed to model both physical and imaginary processes underlying the vocal emissions of various twinned lunar and solar creatures (such as ravens and toads). Ruddy, bursting and overcharged, running by turns hot and cold, breaking and stretching tracts and redefining pulses and control as the venomous spots on the belly of a bulky blackened TOAD, they bring forth all the rarest colours.

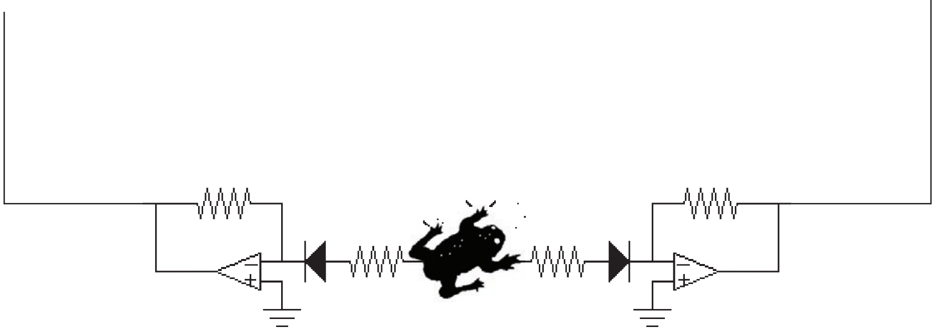
By default TOAD re-implements physicist Gabriel B. Mindlin’s ouroboric differential equation which models the mechanisms of birdsong production, computing oscillations within the bird’s syrinx, or sound producing organ. TOAD’s analogue computing elements are normed to follow this model and generate oscillations; only a clock signal (normed to multipliers and all clocks) needs to be supplied to generate audio. This signal can be any changing signal or pulse (it is converted to a clock internally).



With a few connections, TOAD can also be used to model chaotic equations from J. C Sprott's "A New Class of Chaotic Circuit," producing oscillations and filtering incoming signals in the audio domain.

TOAD can compute any number of audible physical and less-than-physical models using three switched capacitance integrators, a square function, three inverters, one signum function and seven multipliers (some of these are embedded within other functions).

When busie at my Book I was upon a certain Night,
This Vision here exprest appear'd unto my dimmed sight:
A Toad full Ruddy I saw, did drink the juice of Grapes
so fast,
Till over-charged with the broth, his Bowels all to brast:
And after that, from poyson'd Bulk he cast his Venom fell,
For Grief and Pain whereof his Members all began to swell;
With drops of Poysoned sweat approaching thus his secret Den,
His Cave with blasts of fumous Air he all bewhited then:
And from the which in space a Golden Humour did ensue,
Whose falling drops from high did stain the soyl
with ruddy hue.
And when his Corps the force of vital breath began to lack,
This dying Toad became forthwith
like Coal for colour Black:
Thus drowned in his proper veins of poysoned flood;
For term of Eighty days and Four he rotting stood
By Tryal then this Venom to expel I did desire;
For which I did commit his Carkass to a gentle Fire:
Which done, a Wonder to the sight, but more to be rehearst;
The Toad with Colours rare through every side was pierc'd;
And White appear'd when all the sundry hews were past:
Which after being tincted Ruddy, for evermore did last.
Then of the Venom handled thus a Medicine I did make;
Which Venom kills, and saveth such as Venom chance to take:
Glory be to him the granter of such secret ways,
Dominion, and Honour both, with Worship, and with Praise.
Amen.



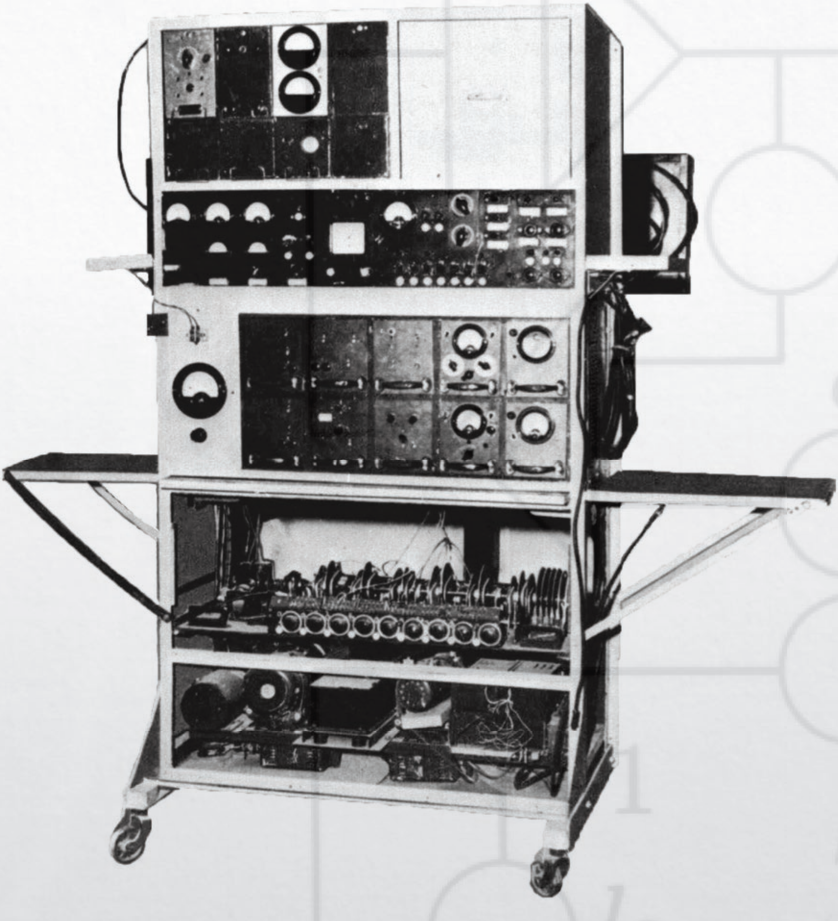


Fig. 1.6. Helmut Hoelzer's general purpose analog computer after World War II

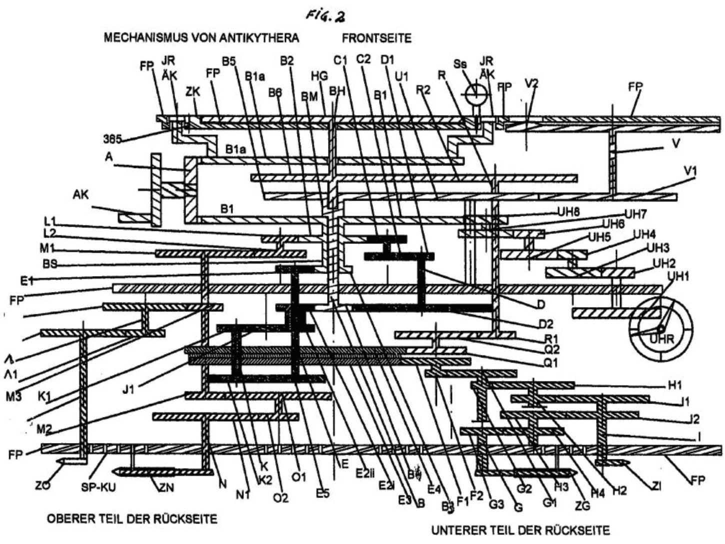
Did drink the juice of Grapes.

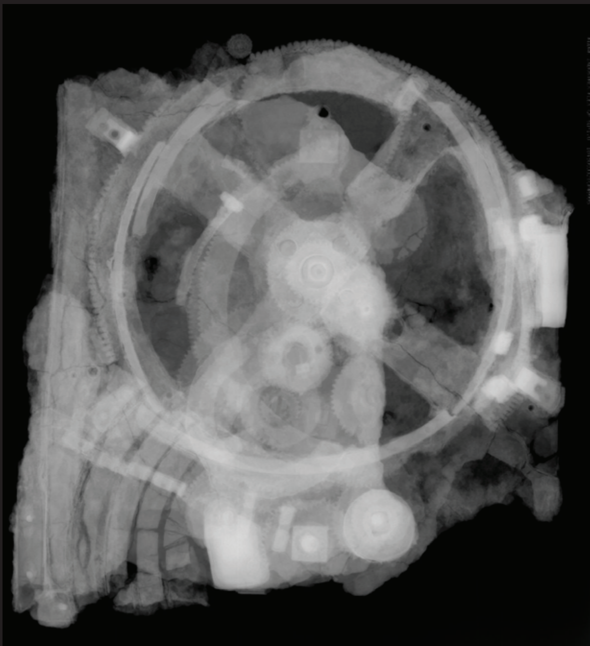
[analog/ue computing]

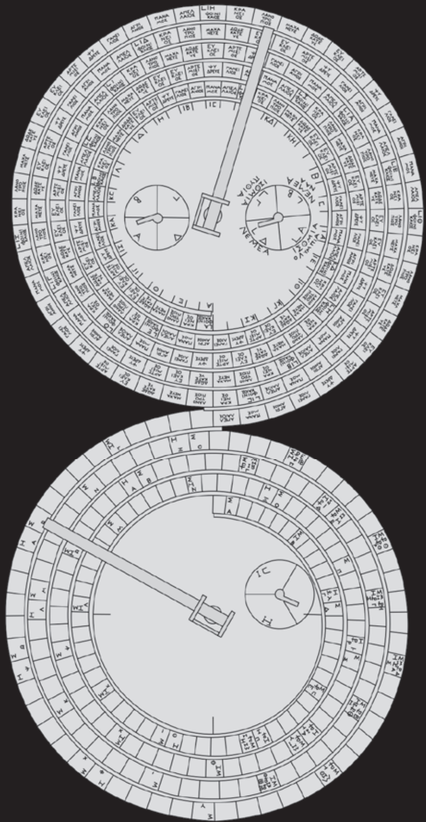
Analog computing is about modelling dynamic systems, i.e., systems that change over time according to known relationships. Examples include market economies, the spread and control of diseases, population dynamics, nutrient absorption, nuclear chain reactions, and mechanical systems. Models of dynamic systems are useful similarly to how architectural models are useful in building design and crash test dummies are useful in car safety engineering. They offer insights into matters that would be too difficult, laborious, expensive, or harmful to study directly. Analog computing can serve a variety of purposes. It may help understand what is (models of), or it may help bring about what should be (models for). It may be used to explain in educational settings, to imitate in gaming, to predict in the natural sciences, and to control in engineering – or it may be pursued for the pure joy of it. Analog computing is also a great way to learn about calculus, science, and engineering. Analog computers are modular and analog computer "programming" is a process of translating the behaviour of a given system into patched connections between computing elements – the modules that make up an analog computer. As intermediate steps, this process requires that temporal behaviour be described mathematically in the form of differential equations and, in turn, that these equations be converted into patch diagrams. While solutions of algebraic equations are single values, solutions of differential equations are functions – i.e., relationships that can be presented as graphs. Consequently, analog computers produce output in the form of (typically two-dimensional) graphs. All differential equations can be modelled with just a few kinds of computing elements: inverters, summers, multipliers, and, crucially, integrators.

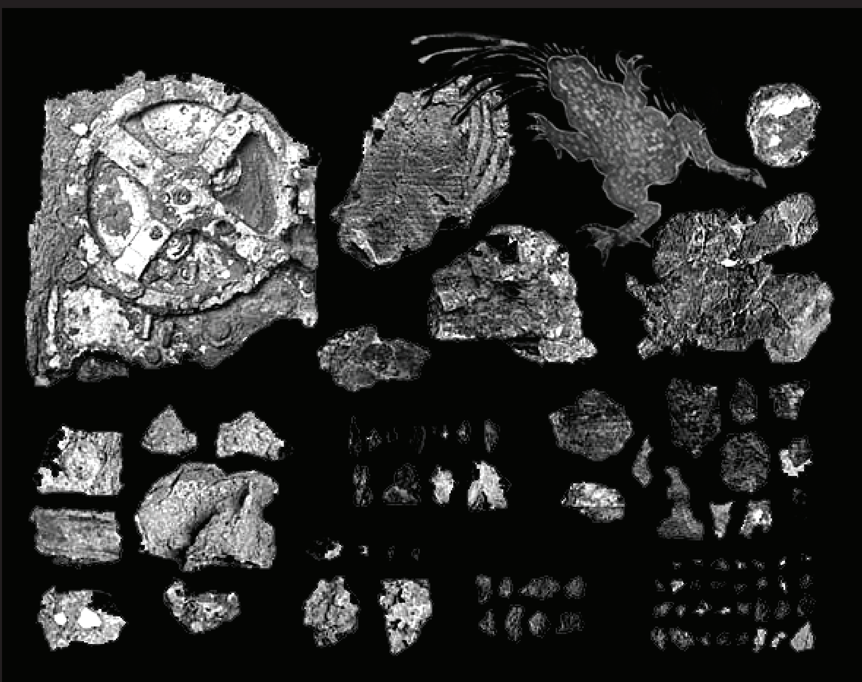
The idea of analog computing is, of course, much older than today's predominantly algorithmic approach. In fact, the very first machine that might aptly be called an analog computer is the Antikythera mechanism, a mechanical marvel that was built around 100 B. C. It has been named after the Greek island AntikÔjhra (Antikythera), where its remains were found in a Roman wreck by sponge divers in 1900. At first neglected, the highly corroded lump of gears aroused the interest of Derek de Solla Price, who summarized his scientific findings as follows: "It is a bit frightening to know that just before the fall of their great civilization the ancient Greeks had come so close to our age, not only in their thought, but also in their scientific technology." Research into this mechanism, which defies all expectations with respect to an ancient computing device, is still ongoing. Its purpose was to calculate sun and moon positions, to predict eclipses and possibly much more. The mechanism consists of more than 30 gears of extraordinary precision yielding a mechanical analogue for the study of celestial mechanics, something that was neither heard of or even thought of for many centuries to come.

[The Analog Thing. First Steps]









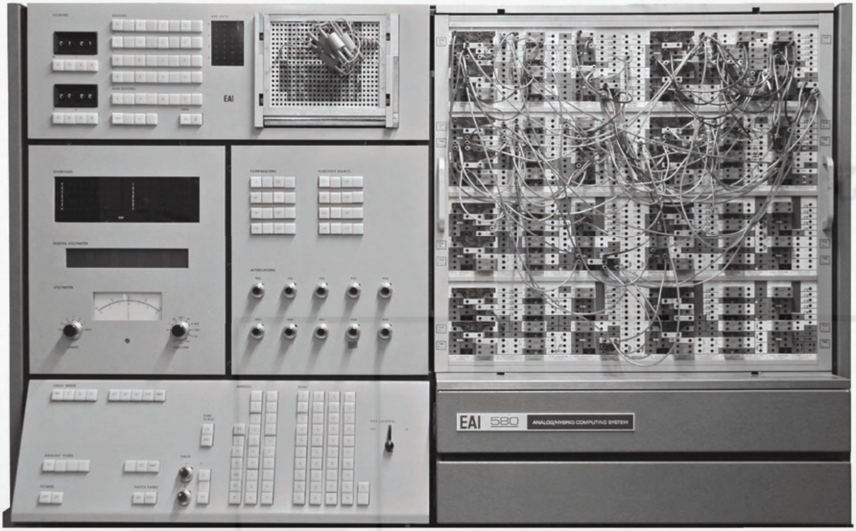


Fig. 3.1. EAI-580 analog computer

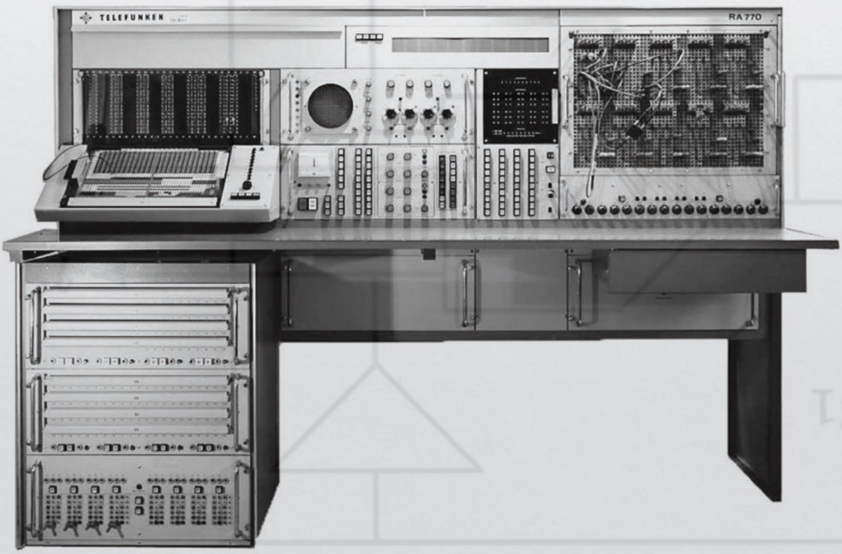


Fig. 3.2. Telefunken RA 770 precision analog computer

$$x' = y,$$

$$y' = -\epsilon x - Cx^2y + By,$$

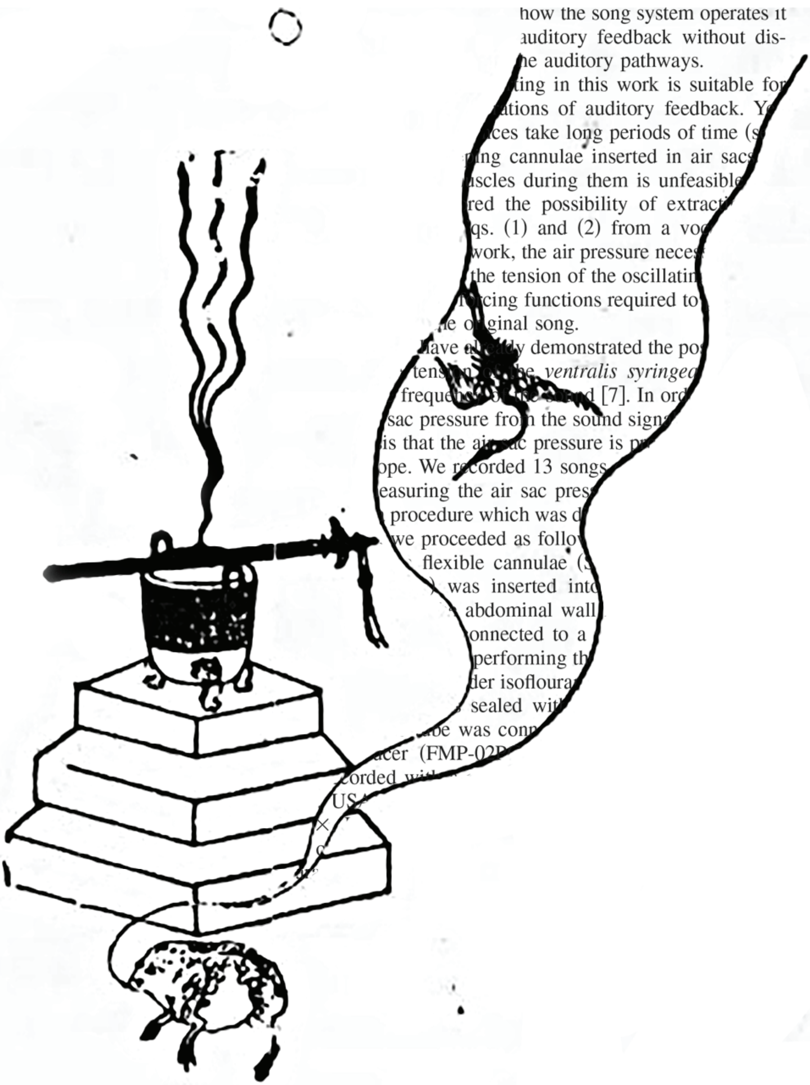
An analogue computer is a piece of equipment whose component parts can be arranged to satisfy a given set of equations, usually simultaneous ordinary differential equations. If a physical system whose properties are to be studied can be described by such a set of equations, the study may be carried out on the analogue computer.

In the electronic analogue computer variables are represented by continuously variable voltages, and integration is performed by a physical process involving the accumulation of electric charge on a capacitor (switched across in this implementation).

[...]

The analogue computer, by its ability to solve equations which can be expressed in terms of addition, multiplication, integration etc., and so simulate different physical systems on different occasions, is a development of the much older idea of using scale models such as model ships in a water tank, in the design of ocean-going vessels, or model aircraft in wind-tunnels when designing full-scale aircraft. With models, the two systems are similar physically; with analogues they are only similar in that they both obey the same equations. However, the analogue computer is more flexible than a direct model for it can represent quite different physical systems on different occasions.

[Schematic Analogue Computer Programming,
A.S. Charlesworth, J.R. Fletcher]


how the song system operates it
auditory feedback without dis-
he auditory pathways.
ting in this work is suitable for
ations of auditory feedback. Y
ces take long periods of time (s
ing cannulae inserted in air sacs
scles during them is unfeasible
red the possibility of extract
qs. (1) and (2) from a voc
work, the air pressure neces
the tension of the oscillatin
rcing functions required to
ginal song.
demonstrated the pos
ventralis syringea
[7]. In ord
sac pressure fro the sound sign
is that the pressure is p
ope. We recorded 13 songs
easuring the air sac pres
procedure which was d
we proceeded as follo
flexible cannulae (S
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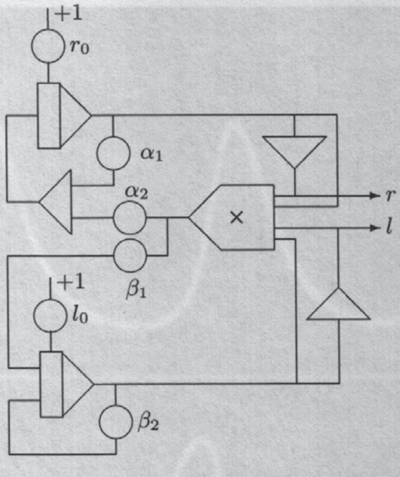


Abb. 5.36: *Gesamtschaltung des ausgeführten Räuber-Beute-Systems*

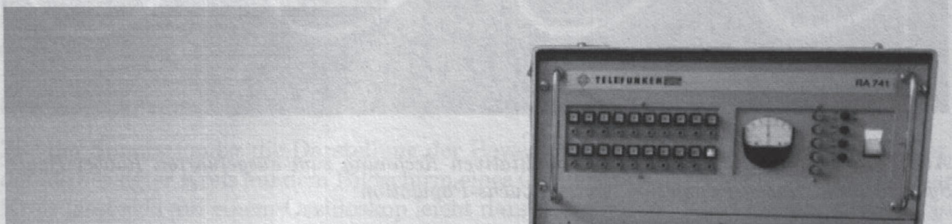


Abb. 5.37: *Die ausgeführte Rechenschaltung*

So fast.

[the elements]

The single collector (or summer) row of jacks at the top of the module constitutes our **prima materia.** The collector combines or collects signals and routes these to the first **TOAD** twinned output, and in the normed/default configuration into the first integrator. The summer yields a negative (inverted) output, and combines two signals (two jacks far right), with three sets of multiplied signals (X*Y). There are thus three multipliers in the collector, additionally one as part of each of the three integrator cells, and one as part of the square function below. The multipliers multiply inputs supplied to their inputs. In the default configuration all the parts of the equation are routed into this summer/ collector.

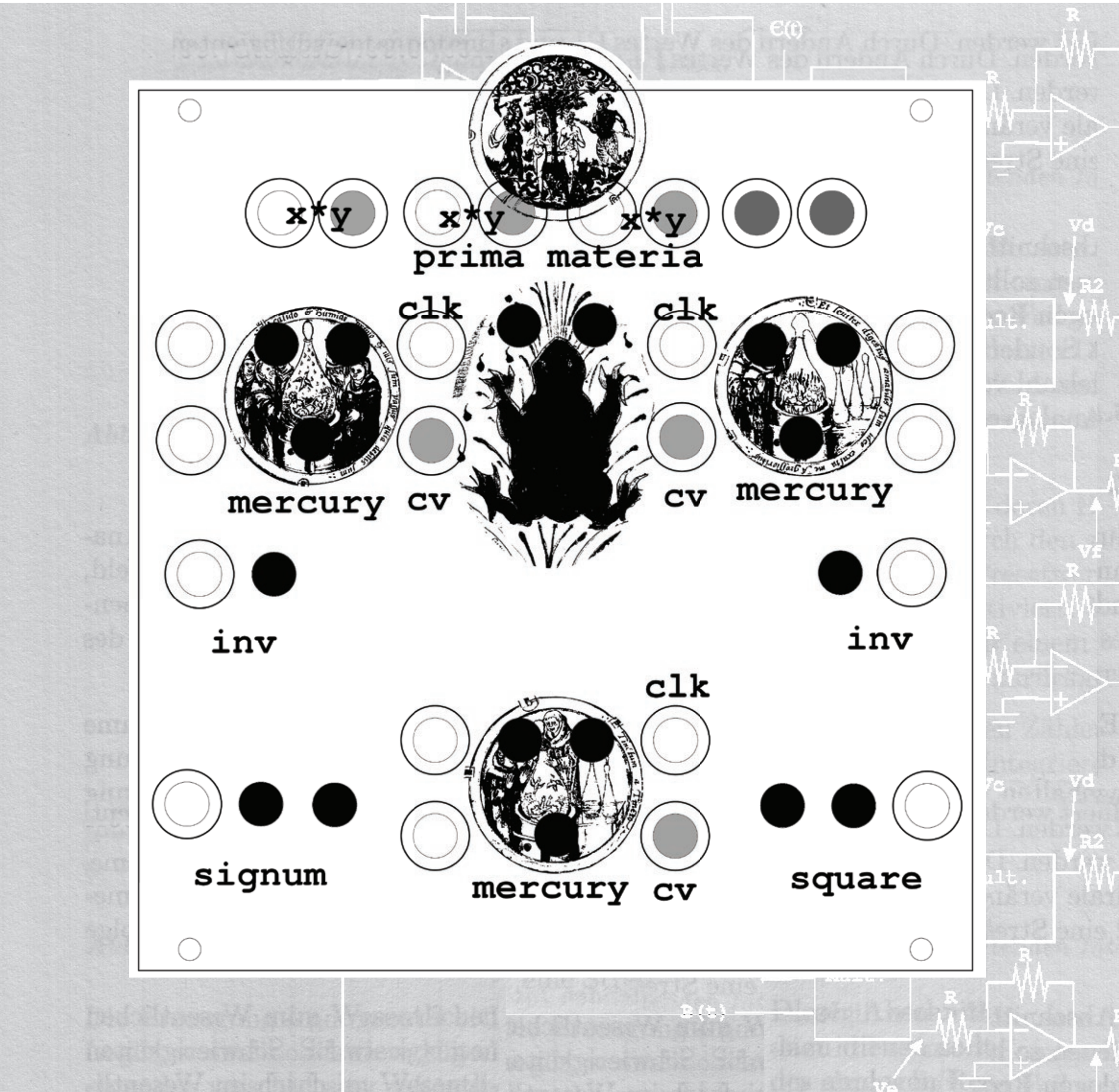
A trinity of switched capacitance integrator cells (left, right and lower) substantiate our **mercury.** These are the core of TOAD, combining a four-quadrant analogue multiplier (with two inputs, and one multiplier CV), followed by a simple switched capacitor filter (accepting one CLK signal which is rendered as a pulse internally so can be any kind of changing signal). There are three outputs (all the same signal). Within the normed configuration the three cells are arranged one after the other in a chain which returns to the collector in the order left to right and below. In the default configuration the third integrator is unused.

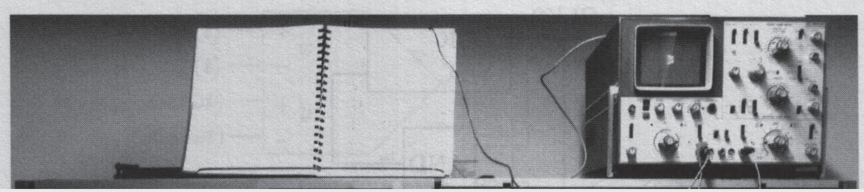
A **SIGNUM** function (bottom left) which inserts non-linearity and follows part of J.C Sprott's chaos inducing equation as G(x)= -Bx + Csgn(x). There are two (same signal) outputs. In the default configuration this element is not used.

A **square** function (bottom right) which also adds non-linearity - producing an attenuated square of the two inputs to a single output. There is one input and two identical outputs.

Two **inverters** which simply invert a signal (negative to positive and vice versa). There is one input and one output. As above, so below. The right hand interpreter (mirrors the left) is unused in the default normed patch.

These elements are combined according to the chosen equation, laboratory, model or schematic - or, more simply, reflect, try things out: make new connections and hear what happens. On the following diagram, all inputs are marked with an outer circle, and all outputs are darkened circles. Left and right repeating elements (such as inverters, SIGNUM/SQUARE, left and right integrators) are mirrored.





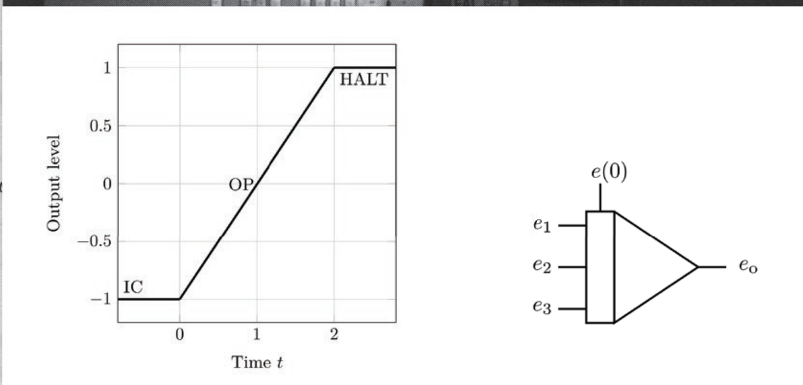
Integrator:

The behavior of an integrator is described by

$$e_o = -\left(\int_0^t \sum_{i=1}^{n} a_i e_i \mathrm{d}\tau + e(0)\right)$$

with the weights a_i being typically 1 or 10 times the time scale factor. The integrator is reset to its initial condition $e(0)$ by activating IC-mode. The actual integration with respect to time takes place during OP-mode. An integration can be temporarily halted by switching the computer to HALT.

Abb. 5. *ierenden drei-*
dimensi



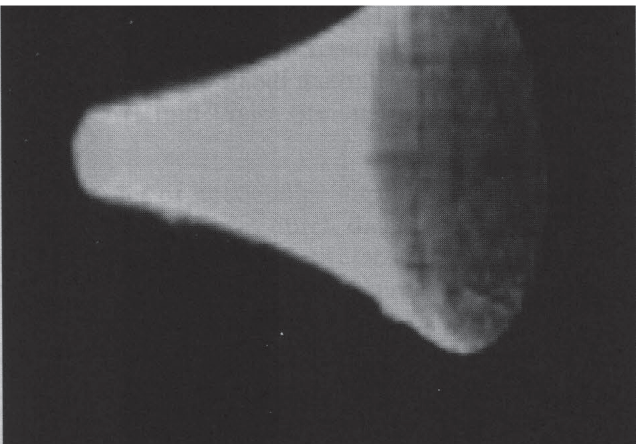


Abb. 5.61: *Darstellung der dreidimensionalen Spirale auf dem Oszilloskop bei festgehaltenem Drehwinkel*

Abb. 10.81: *Für das Project Mercury von den Bell Laboratories entwickelter Simulator (nach [121][S. 569])*

Till over-charged with the Broth, his Bowels all to brast.

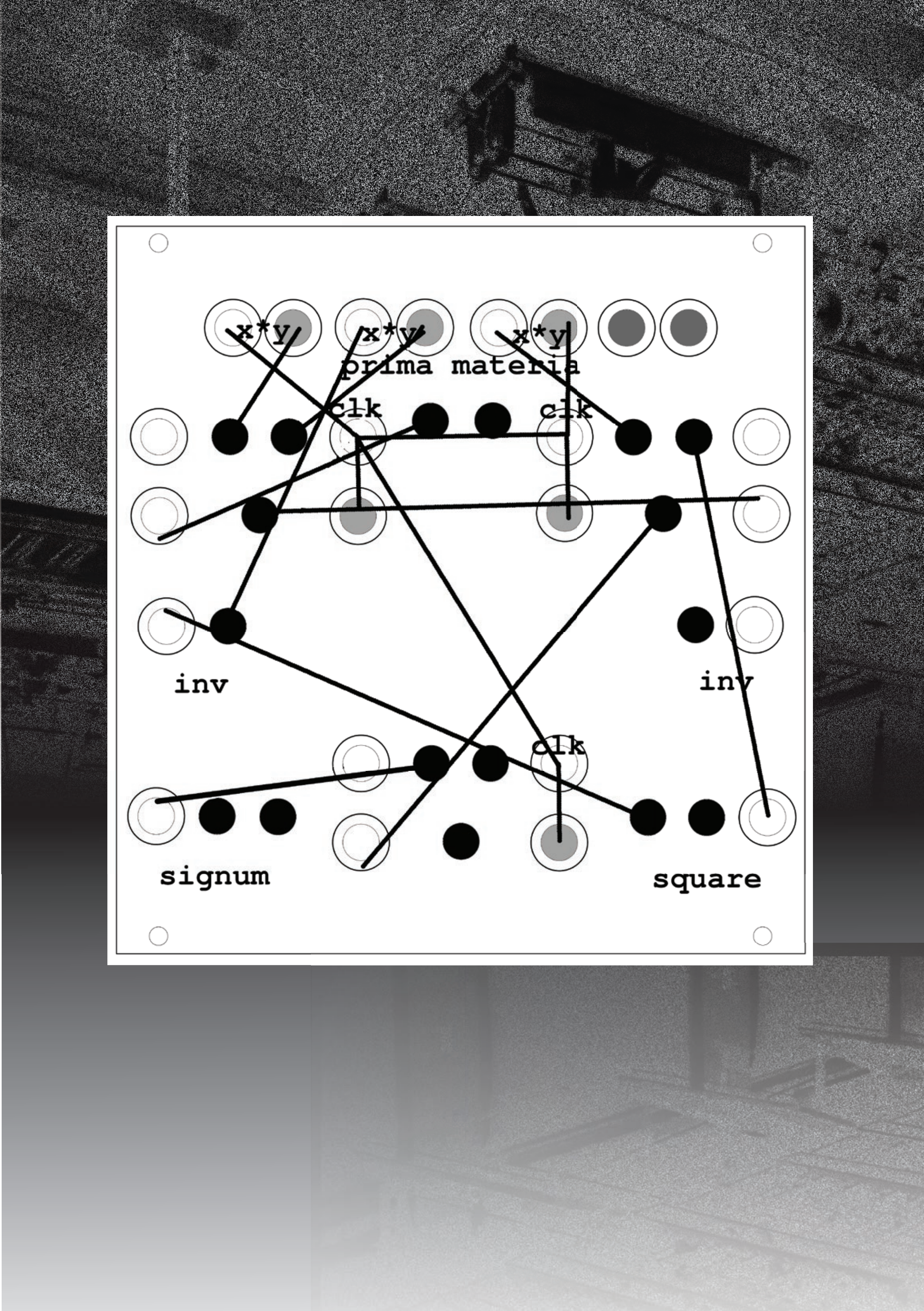
[the default setup]

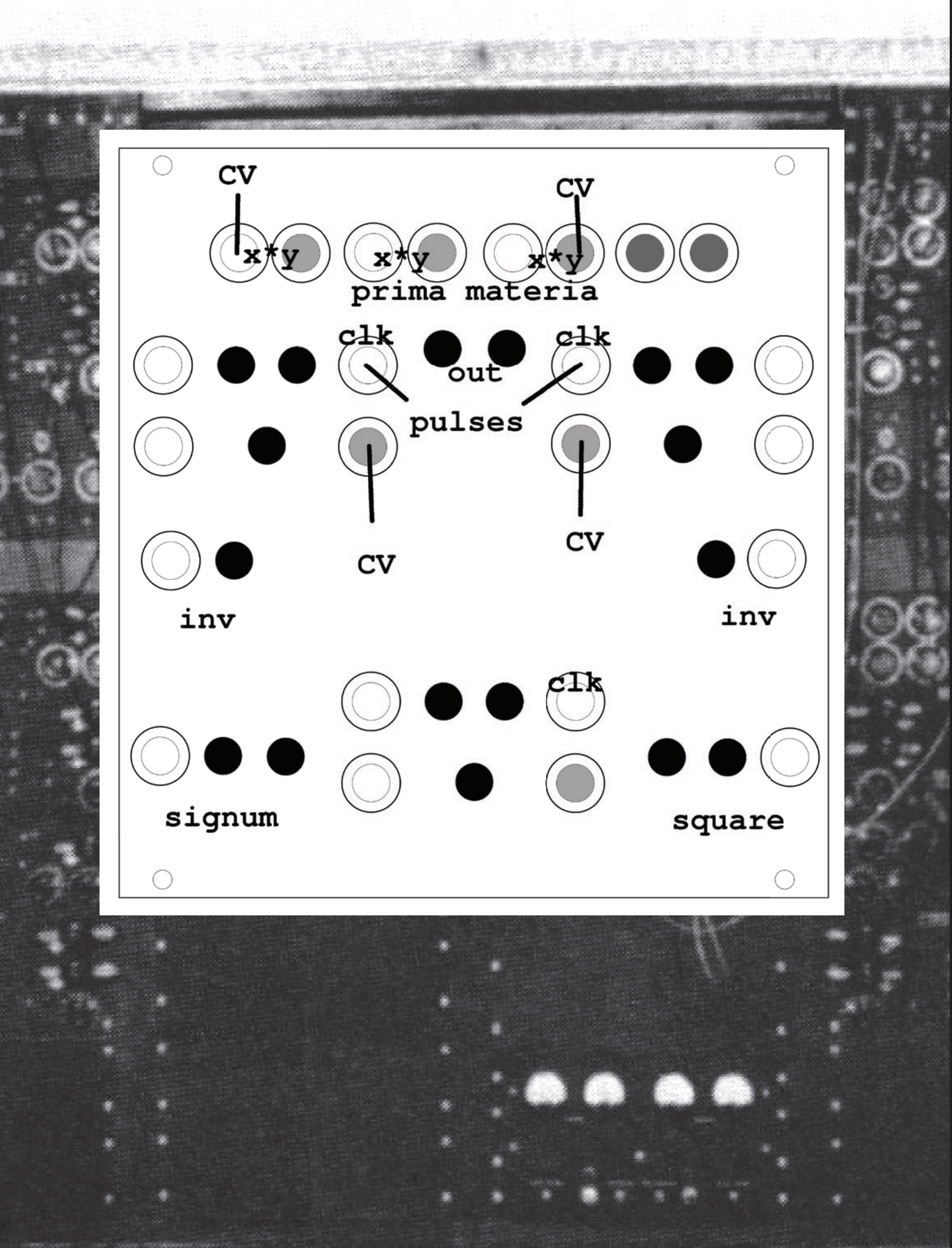
The default or normed TOAD is configured after Gabriel B. Mindlin's differential equation which models the mechanisms of birdsong production, computing oscillations within the bird's syrinx, or sound producing organ. Mindlin computed a pair of differential equations to model the midpoint of a labium x and its velocity y as follows:

$$x' = y,$$
$$y' = -E(t)x + (B(t) - b)y - cx^2y,$$

Where E(t) and (B(t)-b) are slowly varying temporal functions, with offsets, which are supplied by CVs for the collector multipliers. The normed setup(see right) models this equation and thus only uses the collector, the first two integrators, the square and the leftmost inverter.

Starting with this default configuration (see second diagram), supply a single clock to the first integrator cell. This signal is also supplied/normed to the clock of the second integrator and to the multiplier CV of both integrators, so sound will be produced with just one single input. Audio/control outs can be taken from the central TOAD outs, and from any output from any element in use (in this case, the first and second integrators, and the square). Additional CV signals should be supplied to the far left collector multiplier input, and the far right collector multiplier (supplying E(t) and B(t)), as shown in the diagram. CV signals can also be supplied to the integrator cell multipliers. So for the default model, ideally four CVs (which could come from ERD/acquisitio by way of ERD/VIA or caput draconis) can be supplied, and one or two pulses, changing signals (from caput draconis or All Colours). It is advised to add offsets to CV inputs.


x*y
x*y
x*y
prima materia
clk
clk
inv
inv
clk
signum
square



CV
CV
x*y
x*y
x*y
prima materia
clk
out
clk
pulses
CV
CV
inv
inv
clk
signum
square

Anhängende Zeichnungen

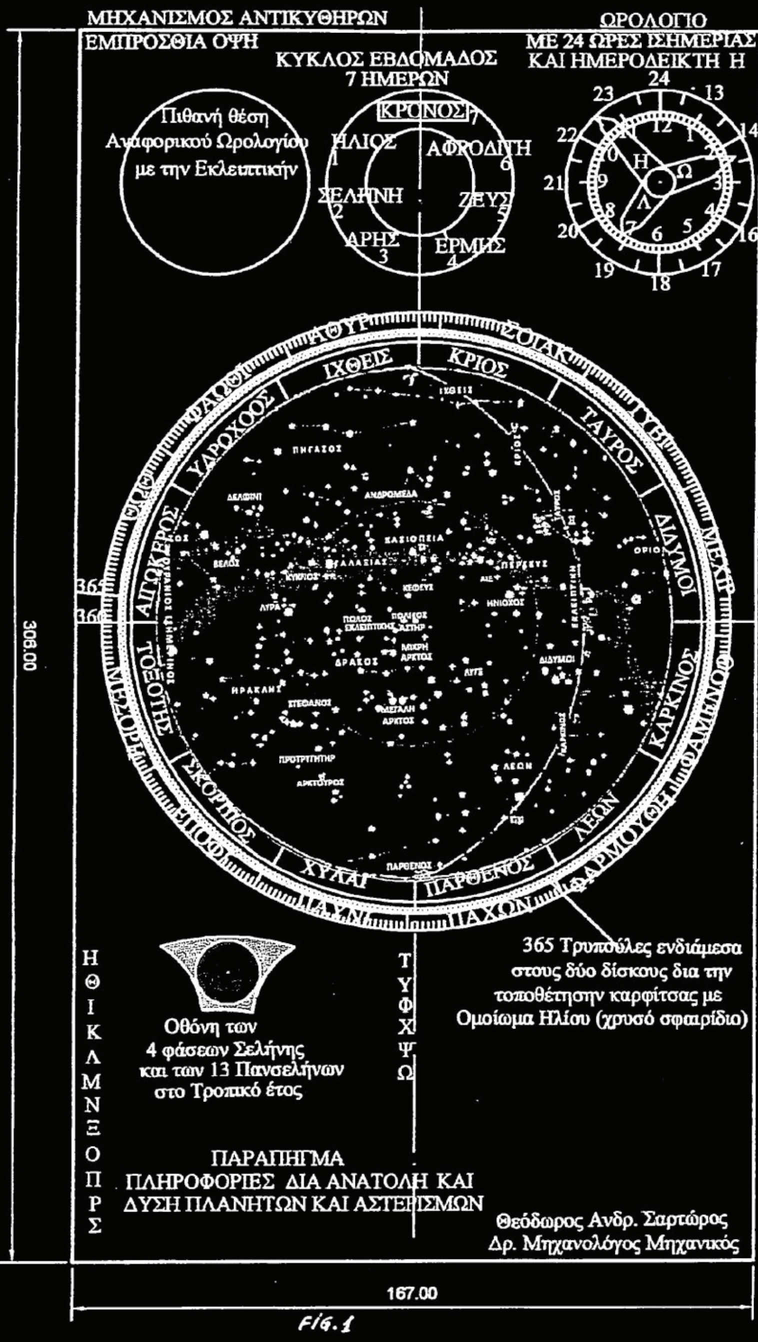


FIG. 1

And after that, from poysoned bulk he cast his venom fell.

[the sprott setup]

TOAD can be used to model one (or more) of the chaotic equations from J. C Sprott's "A New Class of Chaotic Circuit," producing oscillations and filtering incoming signals in the audio domain. The equation is defined in this instance as:

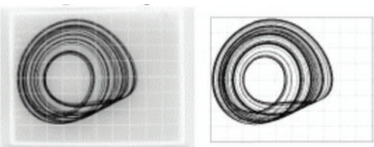
$$x''' + Ax'' + x' = G(x) \quad \text{- where: } G(x) = -Bx + C\,\mathrm{sgn}(x)$$

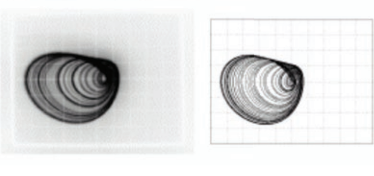
which can be re-worked as:

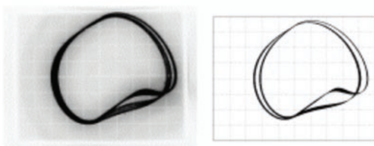
$$x''' = (-Bx + C\,\mathrm{sgn}(x)) - Ax'' - x'$$

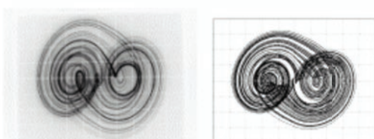
This equation uses our custom SIGNUM function and our three integrator cells and can be set up quite simply as in the following diagram with a few patch cables (the SQUARE function is not used in this case). Note that as the first integrator cell's CLK is normed to the second and third, you do not need to supply three CLKs unless you wish to experiment in this way.

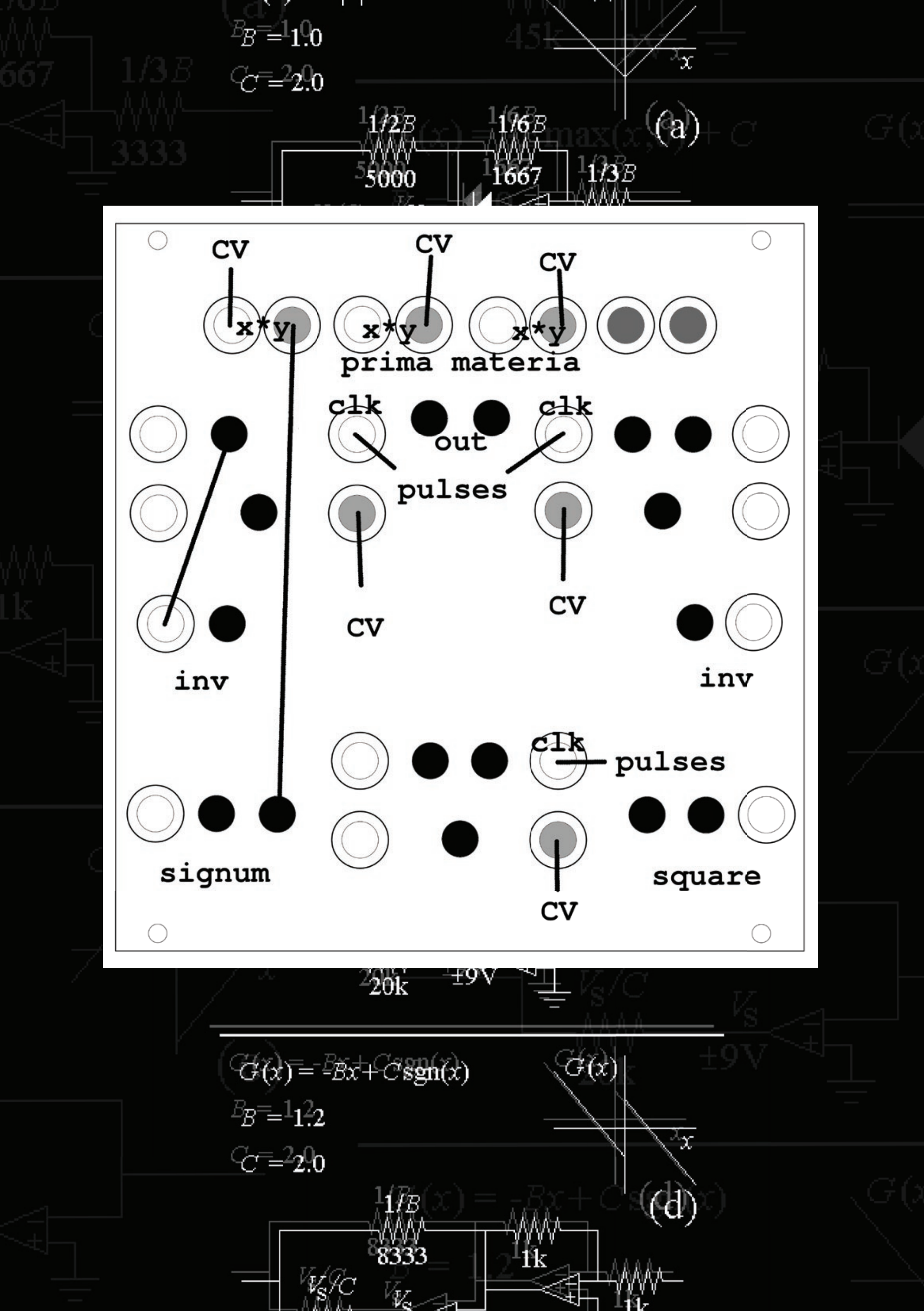
For the Sprott model, ideally six CVs (some of which could come from ERD/acquisitio, ERD/VIA or caput draconis) can be supplied, and one or two pulses (from caput draconis, or All Colours), changing signals.


(a)


(b)


(c)


(d)


CV
CV
CV
x*y
x*y
x*y
prima materia
clk
out
clk
pulses
CV
CV
inv
inv
clk
pulses
signum
square
CV
G(x) = -Bx+Csgn(x)
B = 1.2
C = 2.0
(d)
B = 1.0
C = 2.0
(a)

For grief and pain whereof his members all began to swell.

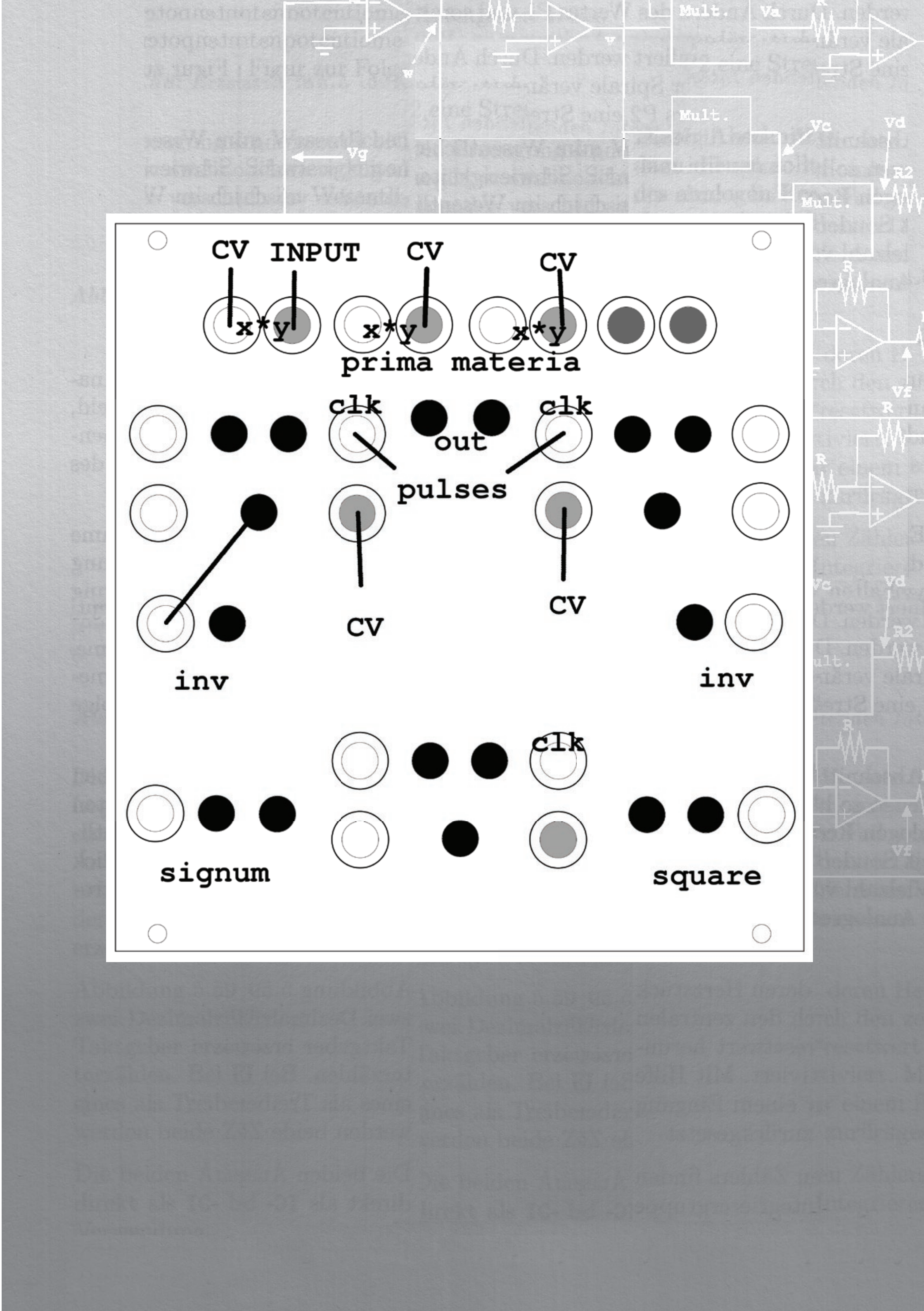
——————[the mass-spring-damper model]

TOAD can also model a mass-spring-damper system, or series of damped oscillations, which also can be used as a state variable filter.

Here the equation is: $x''=1/m(-(Dx' + sx)$ with m as mass, D as damping coefficient and s as springiness. This is a simple equation to begin with, and can produce resonant, clanging and metallic sounds.

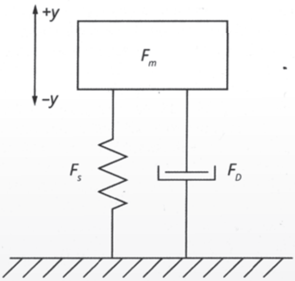
x represents the vertical displacement of the spring, x' is the first derivative of x (which would be speed) and x'' is the second derivative (which would be acceleration). We patch the equation by feeding the lower derivatives (x' and x) produced by the first two integrators into the collector. Paying attention to norms, this can be seen in the next diagram. We can use the first multiplier pair as VCA for our input

For the spring model, ideally four CVs (which could come from ERD/acquisitio by way of ERD/VIA or caput draconis) can be supplied, and one or two pulses, changing signals (from caput draconis or All Colours).


CV
INPUT
CV
CV
x*y
x*y
x*y
prima materia
clk
clk
out
pulses
CV
CV
inv
inv
clk
signum
square

8.2 MASS-SPRING-DAMPER SYSTEM

Vehicle suspensions absorb bumps in the road to provide comfortable and safe rides. A typical suspension system includes a spring and a damper, which support the mass of the vehicle, its passengers, and cargo. By selecting the ideal spring and damper settings for a given mass and impact force, suspensions systems are *tuned to a* "sweet spot" called critical damping. In this condition, the suspension absorbs as much impact energy as possible and returns to equilibrium without overshooting and oscillating. Testing suspension characteristics for varying masses and impact forces tends to be infeasible in the field, which makes analog computer modeling an excellent alternative. As a first step, this requires a description of the system of interest in the form of one or more differential equations arranged such that the highest derivative is isolated on the left of each equation. To describe a suspension system in this way, we start by noting that the sum of the forces exerted by mass, spring, and damper is zero at all times:



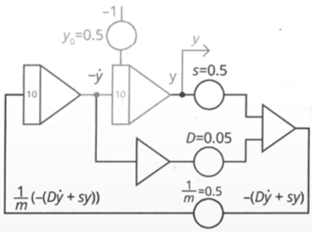
$$F_m + F_s + F_D = 0$$

According to Newton's second law of motion, F_m is mass m times acceleration a. The force with which the damper resists movement F_D is a damping coefficient D times the speed v of its vertical displacement. The force exerted by the spring F_s is a spring coefficient s times its vertical displacement y. The speed v is the first derivative of vertical displacement over time, which we denote by $\dot{y}$, and the acceleration a is the second derivative of vertical displacement over time, which we denote by $\ddot{y}$. This yields $m\ddot{y} + D\dot{y} + sy = 0$ or, resolved for the highest derivative $\ddot{y}$:

$$\ddot{y} = \frac{1}{m}(-(D\dot{y} + sy))$$

Developing a patching diagram from this second-order differential equation takes advantage of the equality of both sides of the equal sign. Assuming that $\ddot{y}$ is known, we model the term on the right of the equal sign using two integrators and feed the resulting lower derivatives, with coefficients applied and summed, back to the input of the first integrator, as shown in the diagram on the top right.

Run the patch in REPF (repeat fast) mode at 80 ms OP-time to view a flicker-free image on the display system. As the patch runs, change the settings of coefficient potentiometers 1 through 4 and observe the suspension dynamics change. This patch also applies to damped oscillators in scenarios other than vehicle suspension tuning, for example in earthquake safety engineering and electronic circuit design.



Output: displacement of an underdamped suspension

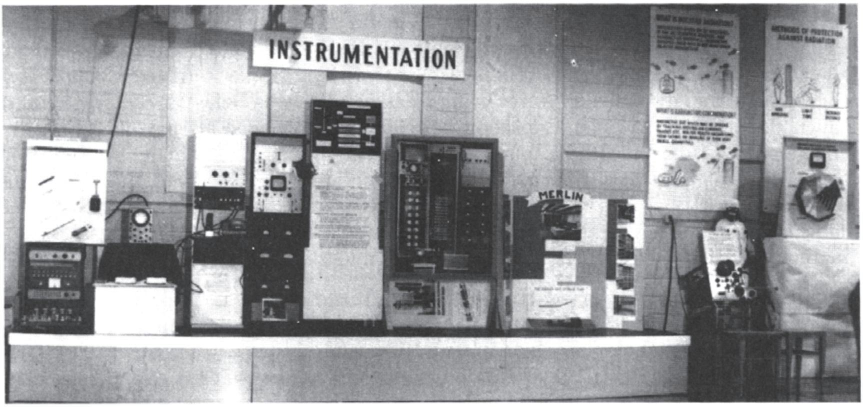


Abb. 10.86: *Tag der offenen Tür der Brookhaven National Laboratories im Jahre 1958 – hier wurde erstmals* Tennis for two *einer größeren Öffentlichkeit vorgestellt (mit freundlicher Genehmigung der Brookhaven National Laboratories)*

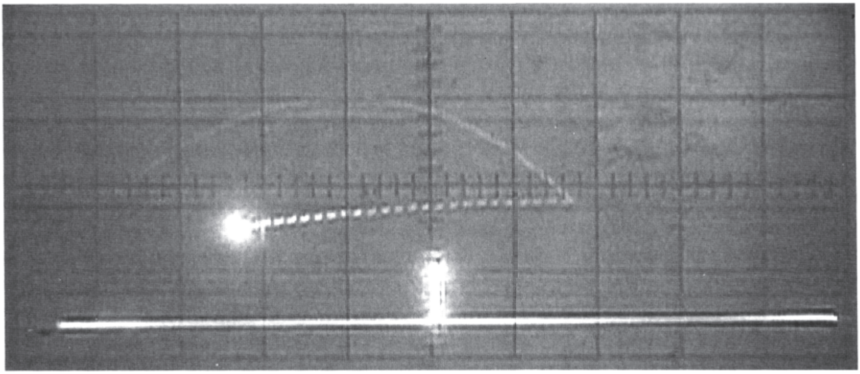


Abb. 10.87: *Erste interaktive Simulation eines Tennisspieles,* Tennis for two *(Quelle: Brookhaven National Laboratory, mit freundlicher Genehmigung)*

4.5 Mass-spring-damper system

Apart from the amplitude stabilization scheme shown in section 4.2, the problems shown so far have exhibited oscillating behavior with no damping. The next example introduces damping using the simple mass-spring-damper system shown in figure 4.18. In this example y denotes the vertical position of the mass with respect to its position of rest. Neglecting any gravitational acceleration acting on the mass, there are three forces to be taken into account:

- The force due to the moving mass, $F_{\mathrm{m}} = ma = m\ddot{y}$,
- the force caused by the spring which is assumed to depend linearly on the strain applied to the spring, $F_{\mathrm{s}} = sy$, and
- the force due to the velocity-linear damper, $F_{\mathrm{d}} = dv = d\dot{y}$.

$$F_{\mathrm{m}} + F_{\mathrm{d}} + F_{\mathrm{s}} = 0$$

$$m\ddot{y} + d\dot{y} + sy = 0$$

Fig. 4.18. Simple mass-spring-damper system

Since this is a closed physical system all forces add up to zero yielding the following second order differential equation, which describes the dynamic behavior of this mass-spring-damper system:

$$m\ddot{y} + d\dot{y} + sy = 0 \tag{4.8}$$

Here, m denotes the mass, d is the damper constant, and s the spring constant. Without the damping force F_{d} this would just be an undamped harmonic oscillator, as in the previous examples.

4.5.1 Analytical solution

This mechanical system is still simple enough to be solved analytically, which is useful as this solution can be compared later with the solutions obtained by means of an analog computer. Dividing (4.8) by m yields

$$\ddot{y} + \frac{d}{m}\dot{y} + \frac{s}{m}y = 0. \tag{4.9}$$

With the following definitions of the damping coefficient

$$\beta := \frac{d}{2m}$$

and the (undamped) angular *eigenfrequency*[51]

$$\omega_0 = \sqrt{\frac{s}{m}},$$

this can be rewritten as

$$\ddot{y} + 2\beta\dot{y} + \omega_0^2 y = 0. \tag{4.10}$$

---

51 The eigenfrequency, sometimes also called *natural frequency*, is the frequency at which a system oscillates without any external forces acting on it.

A classic approach to tackle such a differential equation is the exponential function. "Guessing"

$$y = a\mathrm{e}^{\mu t}$$

yields

$$\dot{y} = \mu a\mathrm{e}^{\mu t} \text{ and } \ddot{y} = \mu^2 a\mathrm{e}^{\mu t}.$$

Substituting these into (4.10) yields

$$\mu^2 a\mathrm{e}^{\mu t} + 2\beta\mu a\mathrm{e}^{\mu t} + \omega_0^2 a\mathrm{e}^{\mu t} = 0.$$

Dividing by $a\mathrm{e}^{\mu t}$ results in the following quadratic equation

$$\mu^2 + 2\beta\mu + \omega_0^2 = 0,$$

which can be readily solved by applying the quadratic formula

$$\mu_{1,2} = -\frac{p}{2} \pm \sqrt{\frac{p^2}{4} - q}$$

with $p = 2\beta$ and $q = \omega_0^2$ yielding the solutions

$$\mu_{1,2} = -\beta \pm \sqrt{\beta^2 - \omega_0^2}. \tag{4.11}$$

With the definition of

$$\omega^2 = \omega_0^2 - \beta^2$$

(4.11) can be rearranged to

$$\mu_{1,2} = -\beta \pm \mathrm{i}\omega.$$

The solution of (4.9) is thus given by the linear combination

$$\begin{aligned} y &= a\mathrm{e}^{\mu_1 t} + b\mathrm{e}^{\mu_2 t} \\ &= a\mathrm{e}^{-(\beta+\mathrm{i}\omega)t} + b\mathrm{e}^{-(\beta-\mathrm{i}\omega)t} \\ &= a\mathrm{e}^{-\beta t}\mathrm{e}^{\mathrm{i}\omega t} + b\mathrm{e}^{-\beta t}\mathrm{e}^{-\mathrm{i}\omega t} \\ &= \mathrm{e}^{-\beta t}\left(a\mathrm{e}^{\mathrm{i}\omega t} + b\mathrm{e}^{-\mathrm{i}\omega t}\right). \end{aligned} \tag{4.12}$$

As known from complex analysis[52]

$$\begin{aligned} \mathrm{e}^{\mathrm{i}\omega t} &= \cos(\omega t) + \mathrm{i}\sin(\omega t) \text{ and} \\ \mathrm{e}^{-\mathrm{i}\omega t} &= \cos(\omega t) - \mathrm{i}\sin(\omega t). \end{aligned}$$

Applying this to (4.12) yields

$$y = \mathrm{e}^{-\beta t}\Big(a\big(\cos(\omega t) + \mathrm{i}\sin(\omega t)\big) + b\big(\cos(\omega t) - \mathrm{i}\sin(\omega t)\big)\Big)$$

52 The function $\cos(\varphi) + \mathrm{i}\sin(\varphi)$ is sometimes denoted by $\mathrm{cis}(\varphi)$ in the literature.

$$= \mathrm{e}^{-\beta t}\big((a+b)\cos(\omega t) + \mathrm{i}(a-b)\sin(\omega t)\big). \tag{4.13}$$

The $\mathrm{e}^{-\beta t}$ term is the damping term of this oscillating system while $a+b$ and $a-b$ are determined by the initial conditions. If it is assumed that the mass has been deflected by an angle α_0 at $t=0$, this will obviously be the maximum amplitude of its movement. If the mass is then just released at $t=0$ without any initial velocity given to it, the following initial conditions hold:

$$\alpha(0) = \alpha_0 \text{ and}$$
$$\dot{\alpha}(0) = 0.$$

From $\cos(\omega t) = 1$ and $\sin(\omega t) = 0$ for $t = 0$ it follows that

$$\alpha(0) = (a+b) = \alpha_0.$$

Differentiating (4.13) with respect to t and applying the same arguments yields

$$\dot{\alpha}(0) = (a-b)\mathrm{i}\omega = 0$$

and thus $a-b=0$ for this case. So a mass released from a deflected position at $t=0$ with no initial velocity given to it, is described by

$$y = \mathrm{e}^{-\beta t}\alpha_0\cos(\omega t),$$

which is exactly what would have been expected from a practical point of view. The position of the mass follows a simple harmonic function and its amplitude is damped by an exponential term with negative exponent.

The term

$$\omega = \sqrt{\omega_0^2 - \beta^2},$$

describing the angular eigenfrequency, yields

$$T = \frac{2\pi}{\omega}$$

for the period and is quite interesting as three cases have to be distinguished with respect to ω_0 and β:

$\omega_0 > \beta$: *Subcritical damping*, (*underdamped*) the mass oscillates.

$\omega_0 = \beta$: *Critical damping* – the systems returns to its position of rest in an exponential decay movement without any overshoot.

$\omega_0 < \beta$: In this case the system is said to be *overdamped*. It will return to its position of rest without any overshoot but more slowly than with critical damping.

It should be noted that the damped eigenfrequency ω is always lower than ω_0 depending on the amount of damping, which can be observed directly when the system is simulated on an analog computer, as shown in the following section.

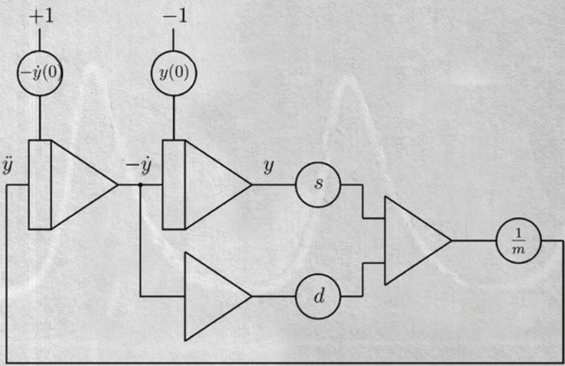
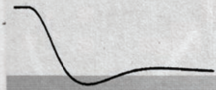
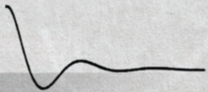


Fig. 4.19. Mass-spring-damper system

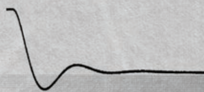


Fig. 4.20. $s = .2$, $d = .8$ **Fig. 4.21.** $s = .6$, $d = .8$ **Fig. 4.22.** $s = .8$, $d = .6$ **Fig. 4.23.** $s = .8$, $d = 1$

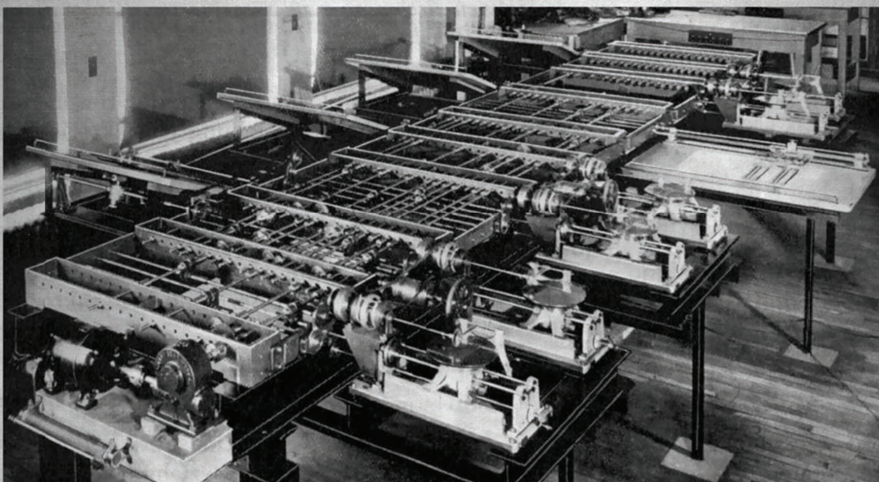
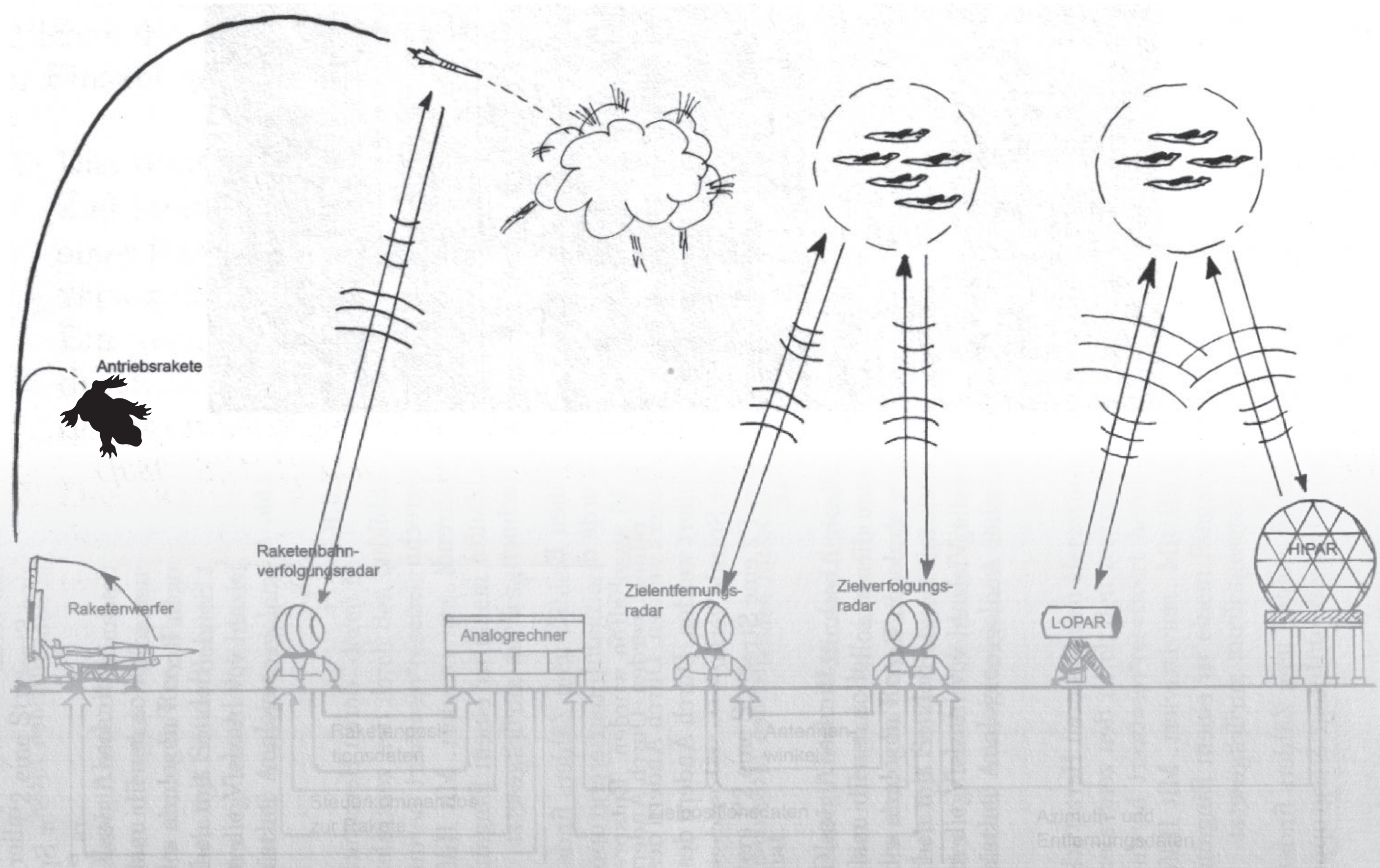


Fig. 1.3. VANNEVAR BUSH's mechanical differential analyzer (source: [Meccano 1934, p. 443])


Antriebsrakete
Raketenbahn-
verfolgungsradar
Raketenwerfer
Analogrechner
Zielentfernungs-
radar
Zielverfolgungs-
radar
LOPAR
HIPAR
Raketenposi-
tionsdaten
Steuerkommandos
zur Rakete
Antennen-
winkel
Zielpositionsdaten
Azimuth- und
Entfernungsdaten

With drops of poysoned sweat, approaching thus his secret Den.

[some tips and suggestions]

Use extra VCAs between elements and before element outputs reach the collector. You can use the VCA portions of ERD/acquistio in this case. Use ERD/amissio to also toggle feedback connections.

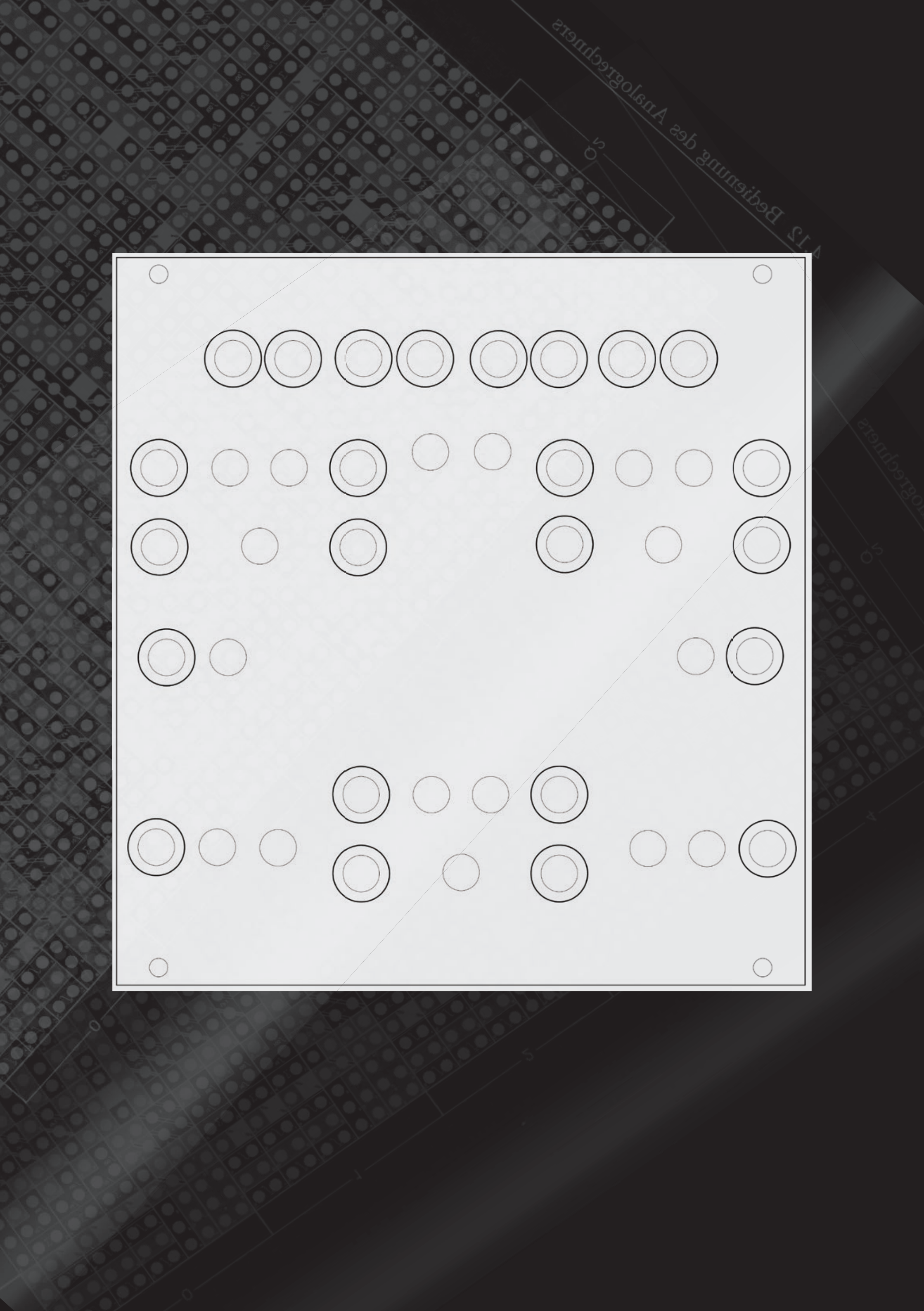
Place other modular elements (such as filters, parts of All Colours) between integrator cells, or before entry into the collector. Explore feedback by/through TOAD.

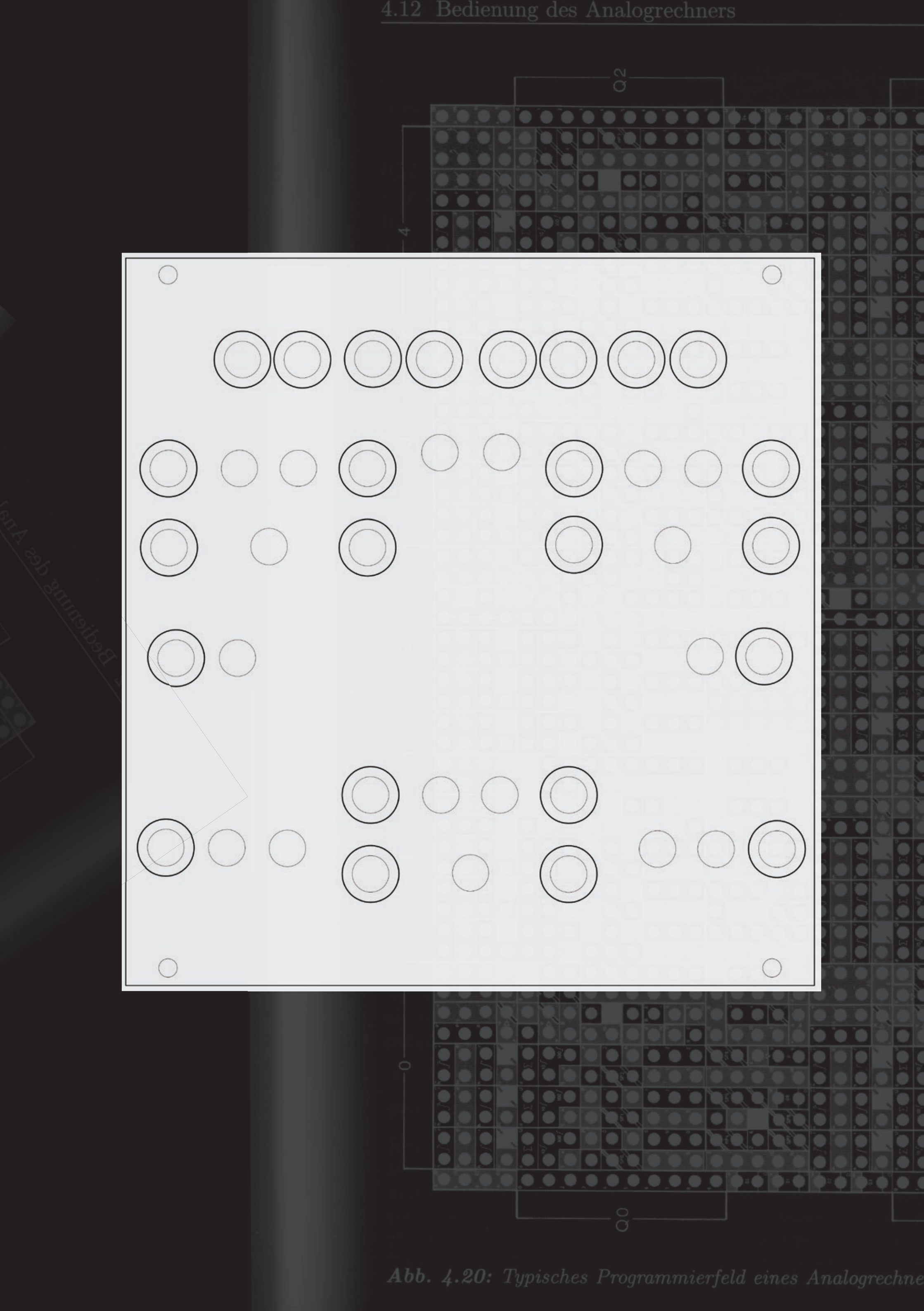
Add fixed offsets to elements (using any offset module or ERD/acquisitio).

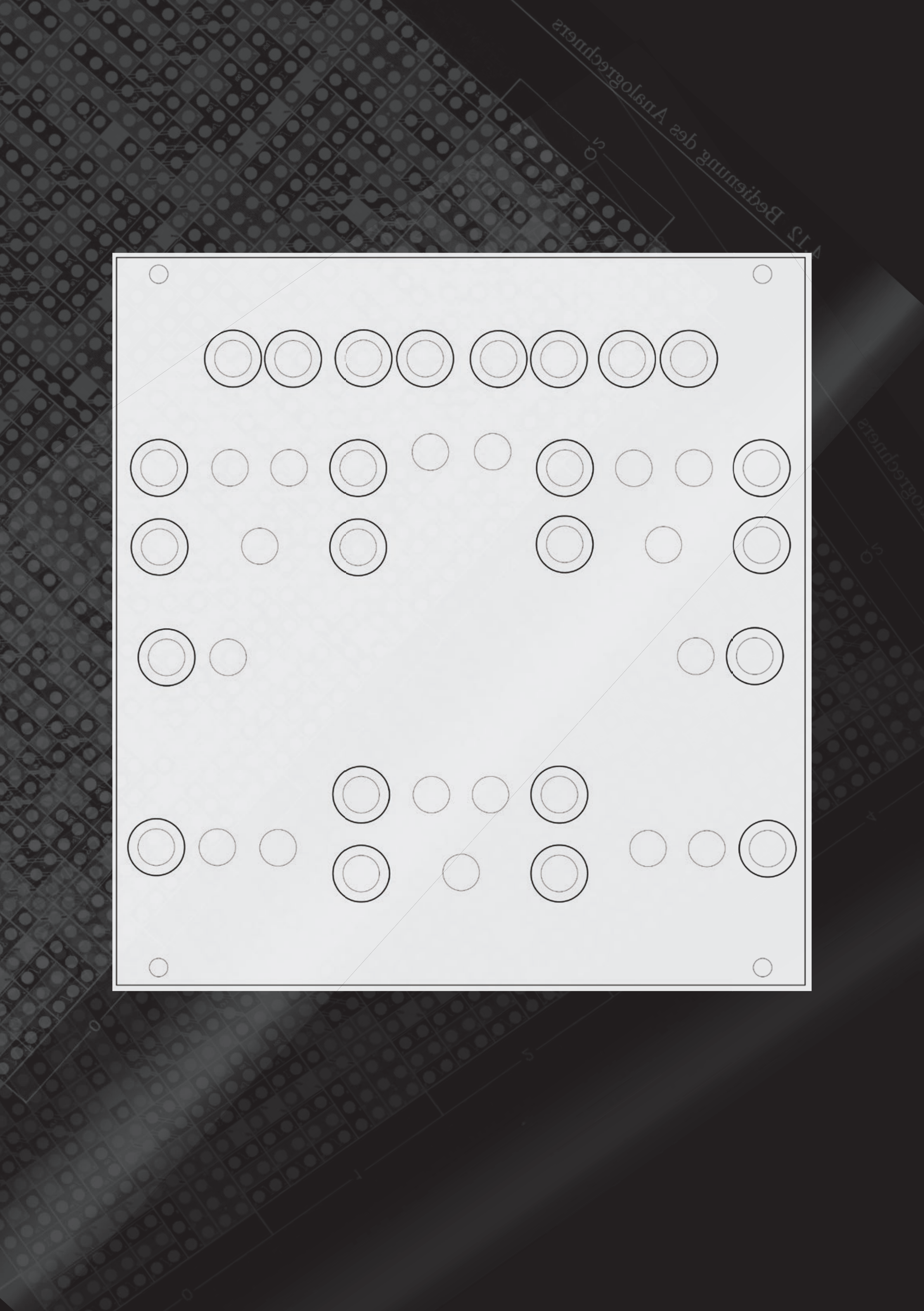
Sometimes you might need to dispose of an unwanted normed input - just plug in an unconnected patch cable.

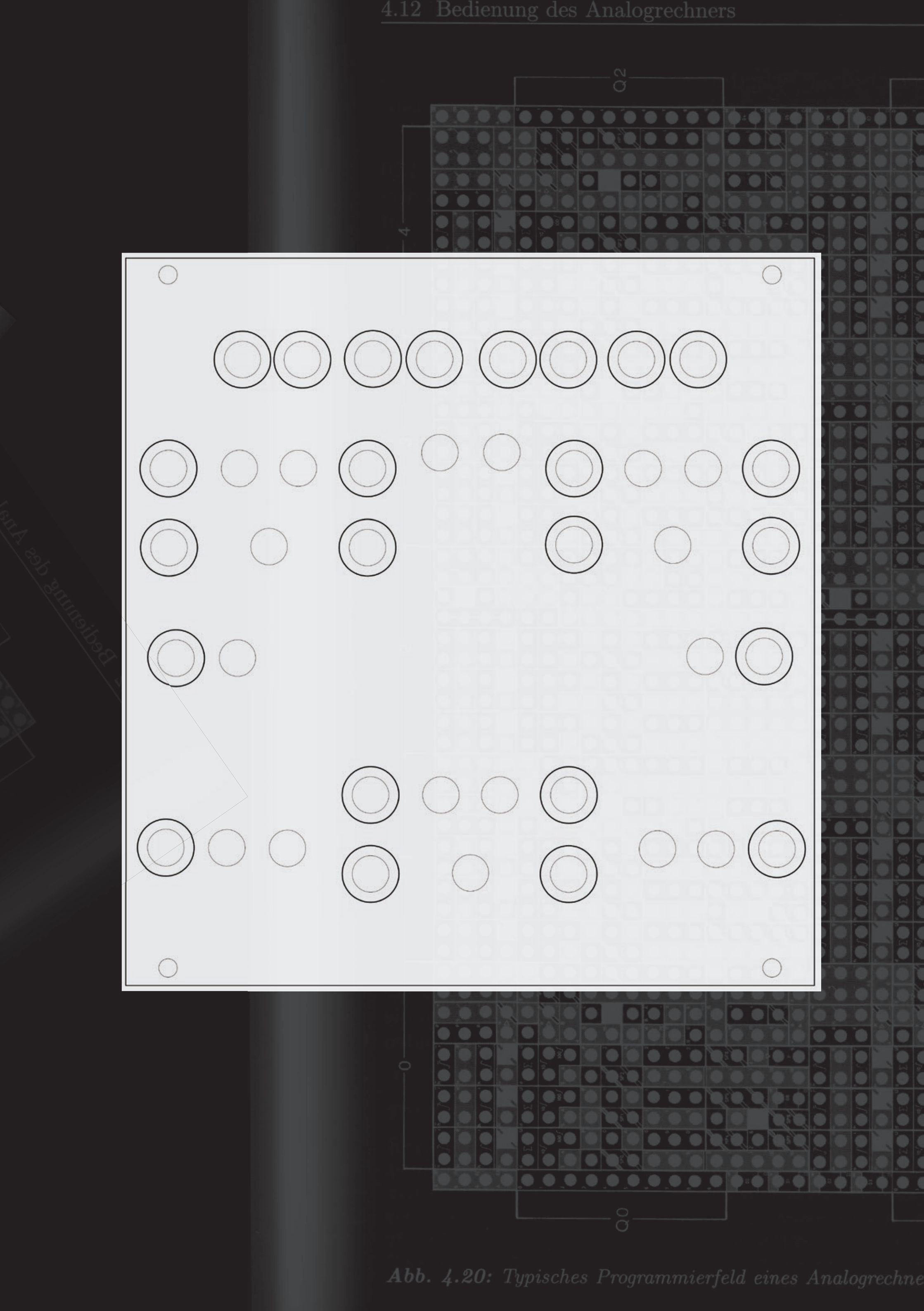
Use high (beyond audio) frequencies for the clock inputs to the integrator cells. For example, the clock outputs of All Colours (particularly in the final mode - far right mode on All Colours).

Make use of other modules (summers, inverters, multipliers, non-linear elements, VCAs, ERD/conjunctio) as analogue computing elements. ERD will soon release extended elements for this purpose.




4.12 Bedienung des Analogrechners
Q2
4
0
Q0
Abb. 4.20: Typisches Programmierfeld eines Analogrechne




4.12 Bedienung des Analogrechners
Q2
4
0
Q0
Abb. 4.20: Typisches Programmierfeld eines Analogrechne

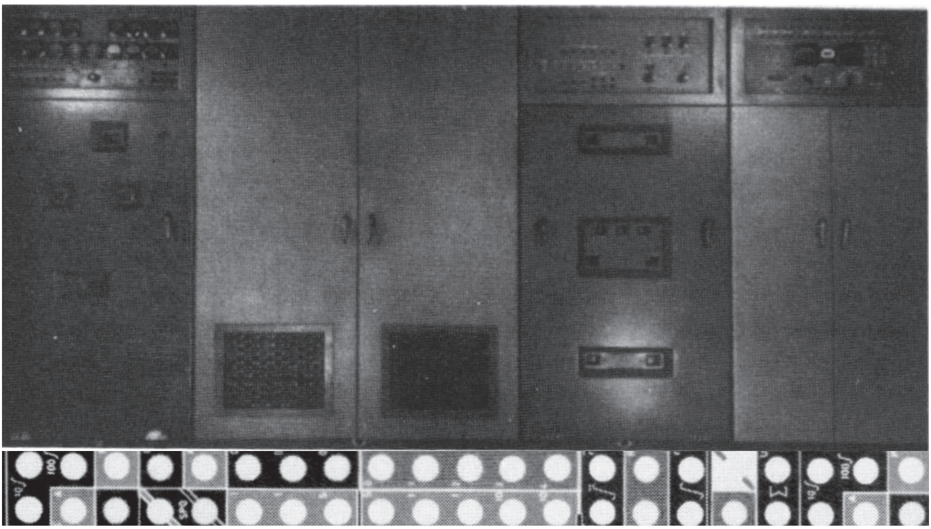
His Cave with blasts of fumous Air, he all bewhited then.

[usage and technical]

Red stripe or -12V DOWN towards the bottom of the unit.

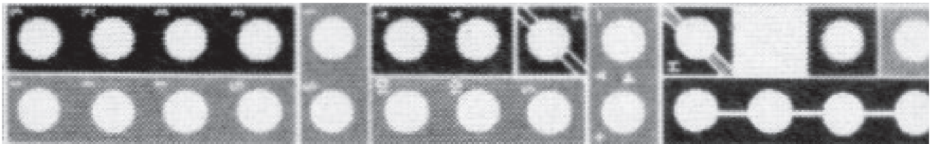
Connect power connector (red/-12v down) as indicated, connect an output, CVs and pulses as indicated in the patch diagrams. Pulses can be any changing signal as there are internal comparators on all pulse inputs. All signals can go up to 10V. Output signals can be as hot as this too.

The design is open hardware and can be accessed at:
https://github.com/microresearch/allcolours/tree/master/TOAD

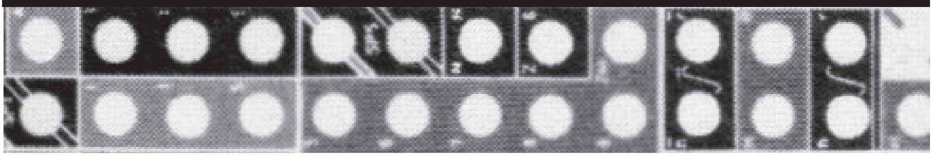


And from the which in space
a Golden Humour did ensue.

[the specifications]



[24HP, 100mA at +12V,
100mA at -12V,
0mA at 5V, 20mm deep.]



Whose falling drops from high did stain the soyl with ruddy hue.

[the credits]

Now God only is the Dispenser of these glorious Mysteries: I have been a true Witness of Nature unto thee,and I know that I write true, and all Daughters of Art shall by my Writings know that I am a Fellow-Heir with them of this Divine Skill. To the Ignorant I have wrote so plain as may be, and more I had written if the Creator of all things had given me larger Commission. Now to Her alone, as is due, be all Honour, and Power, and Glory, who made all things, and giveth knowledge to whom she listeth of her Servants, and conceals where she pleaseth: To Her be ascribed, as due is, all Service and Honour. And now, Sister, whoever enjoyeth this rare Blessing of God, improve all thy strength to do her service with it, for she is worthy of it, who hath created all things, and for whose sake they were and are created.

TOAD acknowledges the key inspirational research, implementations and equations of J.C. Sprott, Jan Hall and Gabriel B. Mindlin. We would also like to thank Peter Blasser for sprotted inspiration, and the work of Bernd Ulmann and anabrid (with their THAT Analog thing bringing analogue computing to the mass springers). No affiliation, attribution or direct contribution is implied and any copyrights are maintained.

Manual design by Melissa Aguilar.

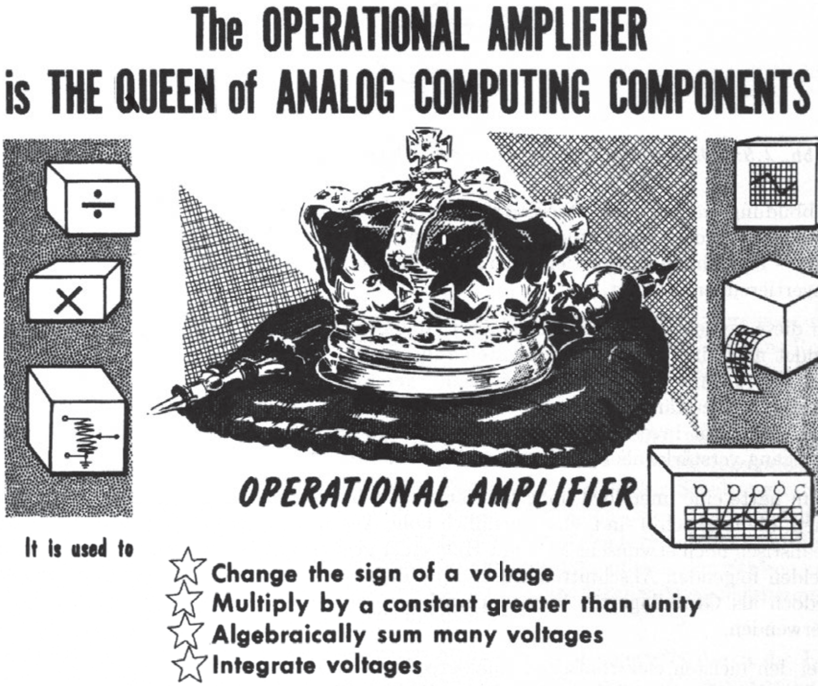


Abb. 4.2: Der Operationsverstärker als „König" des Analogrechners (nach [577][S. 2-58])

And when his Corps the force of vital breath began to lack.

[the references]

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B. Ulmann: Analog Computer Programming
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J.C. Sprott, A New Class of Chaotic Circuit:
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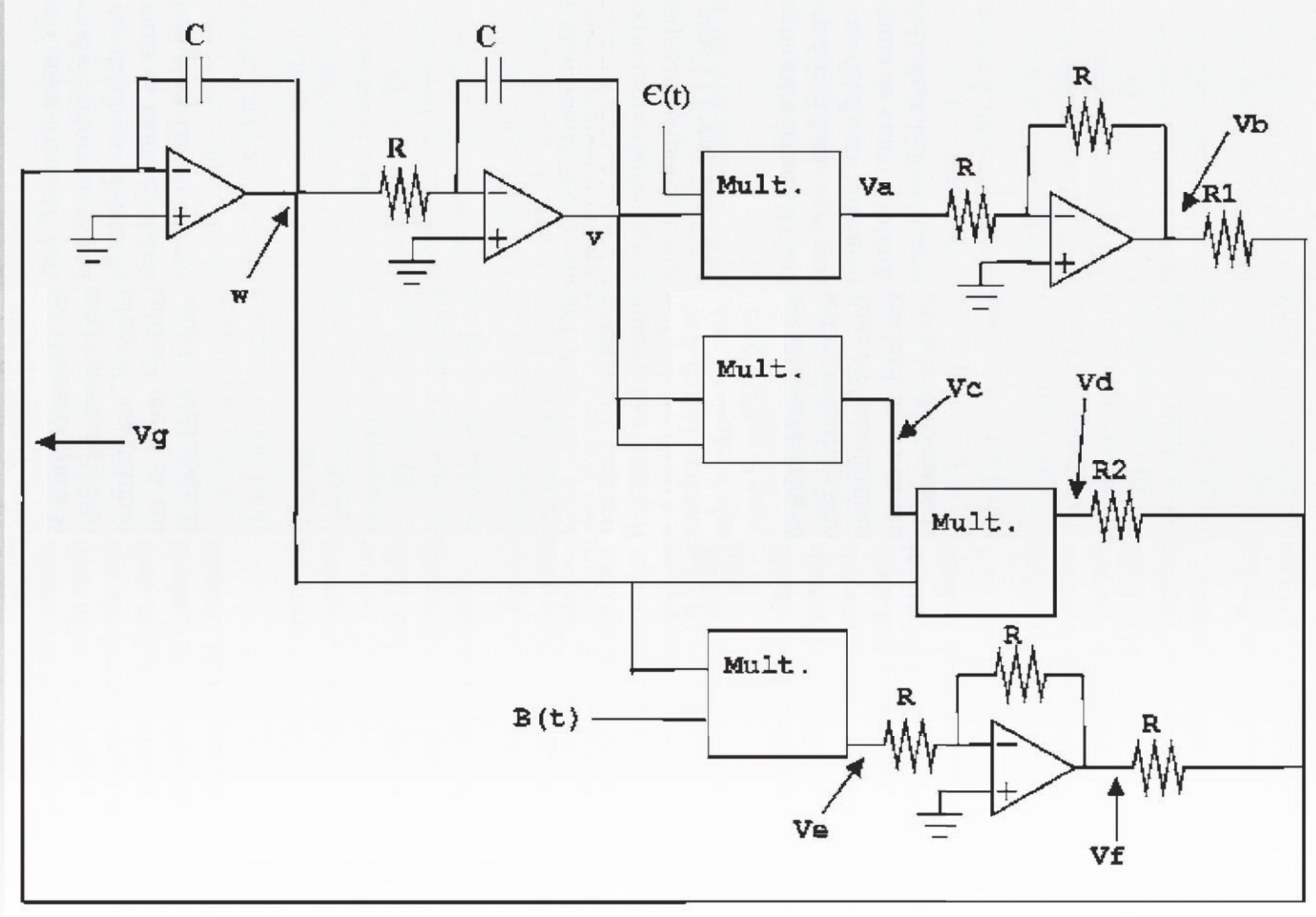
R.T. Prinke, Hunting the Blacke Toade:
https://www.alchemywebsite.com/toad.html

Philalethes exposition of Ripley's Vision:
http://www.levity.com/alchemy/rpvision.html

This dying Toad became forthwith
like Coal for colour black.


C
C
R
Є(t)
Mult.
Va
R
R
Vb
R1
w
v
Mult.
Vc
Vd
Vg
R2
Mult.
R
Mult.
R
B(t)
R
Ve
Vf

Sweet are the uses of adversity;
Which like the toad, ugly and venomous,
Wears yet a precious jewel in his head.


prima Materia
Sow