PROPOSED HYDRAULIC PROGRAMME GENERATOR

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1. INTRODUCTION

During ejection, the mobile septum magnet is placed in front of the beam. In order to minimize the beam losses on the septum and its radioactivity, the magnet is placed in a standby position out of the beam before and after ejection. The displacement of the septum magnet from the standby position into the working position and back is controlled by an electrohydraulic servomechanism. The servosystem is driven by an electrical signal of the programme generator. The programme generator allows for up to six distinct displacements during an acceleration cycle corresponding to three shots of the ejection system (see Report TN-49, Fig. 5.2).

The timing of the ejection bursts is programmed by the C-ejection units of the timing system. There are pre- and post-pulses to trigger the power supplies and the pulse generators. As an example, the charging and discharging of the pulse forming network of the septum magnet is triggered by C-pre-pulses. In a similar way, the movement of the septum magnet could be triggered by timing pulses to lock the hydraulic movement to the ejection bursts. If the ejection timing had to be changed, the hydraulic programme would be time shifted automatically and no operator would have to change the hydraulic programme. A new programme generator for the hydraulic system is proposed herewith to cope with the flexibility of the timing system.

A pre-pulse, generated in due time before ejection, starts the displacement of the septum magnet from the standby position into the working position in front of the beam. The movement is smoothed by an analogue function generator in such a way that the acceleration of the magnet and the pressure of the hydraulic servosystem never exceed the safety levels of the mechanical construction. The duration of the displacement can be chosen by a helipot from 0.1 to 1 sec. The position of the septum in front of the beam is programmed by a digital switch within the stroke of 200 mm. The digital switch comprises three decades, which yield a resolution of 0.2 mm for the programmed position in front of the beam.

After the ejection, the septum magnet is removed from the beam. The movement is triggered by a timing pulse.

The duration of the movement is programmed by a separate helipot ranging from 0.1 to 1 sec. The new standby position is programmed by a separate digital switch.

As indicated in Fig. 1, the movement of the septum magnet is composed of halfs of sine waves of individual amplitude and time duration T_1, T_2 ... T_6. Every individual sine wave movement is triggered by a timing pulse arriving at t_1, t_2 ... t_6. After completion of the displacement, the magnet stays in position y_1, y_2 ... y_6, till the next displacement is initiated by a timing pulse. The sequence of displacements is arbitrary. Figure 1a represents a triple ejection; Fig. 1b shows the sequencing of the same ejection at intervals of 10 sec.

The standby and working positions are programmed on the programme selector chassis (Fig. 2), which consists of six identical programme plug-ins with a digital pre-selection of the position and a helipot for the time duration of the displacement. The function generator chassis collects the signals from the programme selector chassis and compiles the composed movement of the septum magnet. Several programme selector chassis can be connected to the same function generator chassis to generate more complex functions, when fast ejection channel B will come into operation.

The features of the proposed hydraulic programme generator can be summarized as follows:

1. obvious and easy operation -- operator proof!
2. compatible with timing philosophy;
3. high accuracy and resolution of the programmed position ± 0.2 mm;
4. adequate and reliable electronic design principles -- easy servicing;
5. optimum signal shape avoiding excessive acceleration and pressure shocks in the servoactuator;
6. simple interface with computer;
7. further extension possible for ejection in channel B at Serpukhov.

2. CIRCUIT DESCRIPTION (Fig. 3)

The programme selector receives the timing pulses for each individual displacement of the septum magnet. Every displacement is defined by the pre-selected position y_i and the transition time T_i. The timing pulse triggers a triangle generator (Fig. 4), whose sweep time T_i is selected by a helipotmeter on the front panel (Fig. 2). The analogue triangle signal is transmitted to the function generator.

The preselected digital position y_i is shifted by the timing pulse from the programme selector plug-in into the register A of the function generator. The previous position y_{i-1} is shifted into the register B. Register B memorizes the start position of the displacement, register A contains the end position of the displacement. Both positions are converted in an analogue signal by the digital/analogue converters A and B. The difference of the two positions is measured by the operational amplifier Δ, and the sign of the displacement is defined by the analogue comparator.

The triangle signal of the programme selector chassis is amplified by a summing amplifier Σ and converted into a sinusoidal function. Analogue sine function generators of excellent performance are commercially available from different manufacturers for Sw.Fr. 700 ... 1500. The output signals of the sine function generator and the difference amplifier Δ are multiplied by another analogue device, the multiplier module X. Multiplier modules of high accuracy are available from several manufacturers for about Sw.Fr. 500. The product signal at the output of the multiplier X defines the programmed ram velocity y.

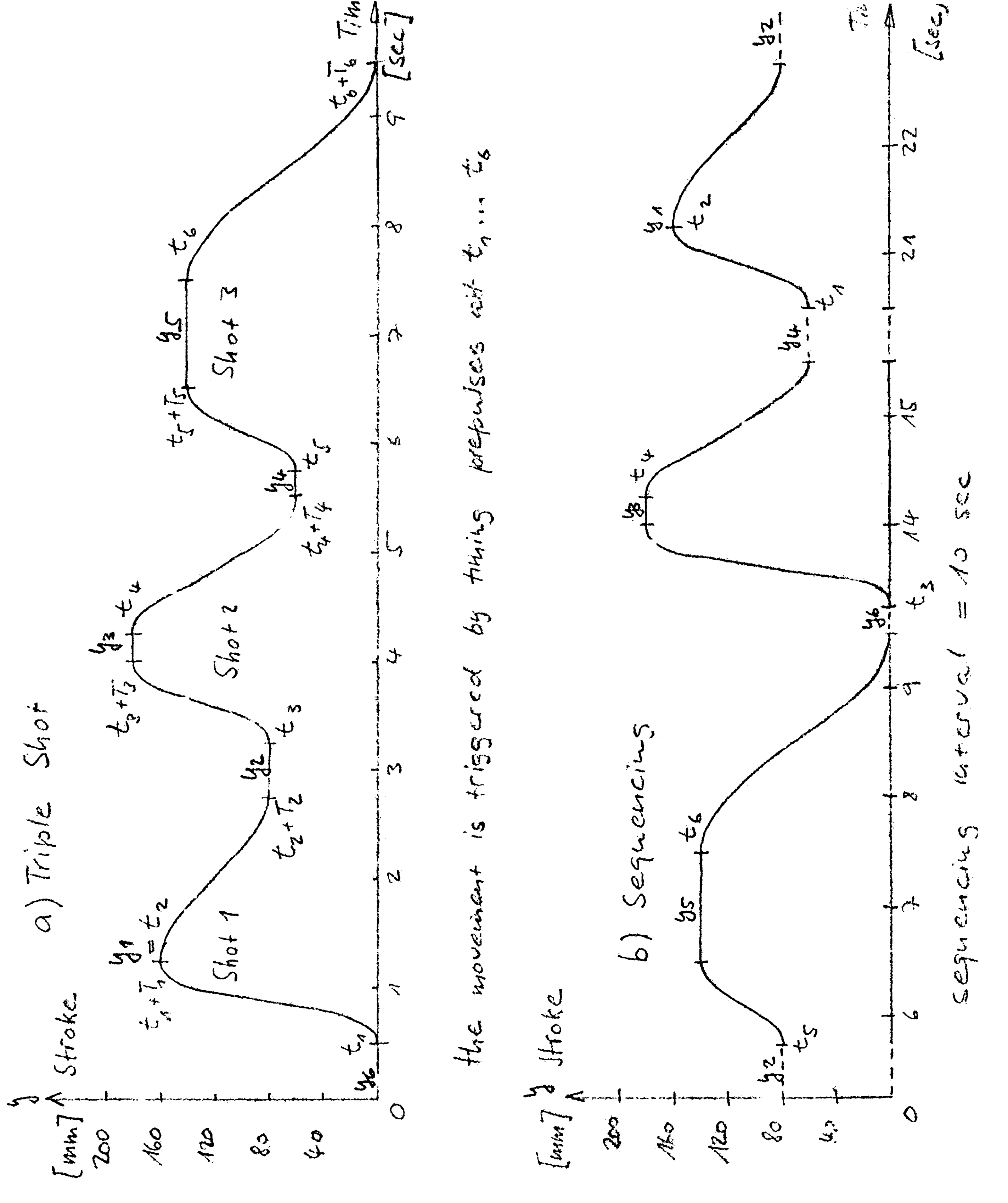
Figure 5 shows the difference for programming the velocity $\dot{y}(t)$ as a triangle function (Fig. 5a) and as a sine function (Fig. 5b). With a triangle generator only (Fig. 5a) we get a parabolic function for the displacement $y(t)$ of the magnet. Its derivative $\ddot{y}(t)$ represents the acceleration of the magnet, which is stepwise constant. The inconvenience of acceleration steps are pressure peaks in the servoactuator, which lead to high frequency oscillations in the servosystem, which fatigue the material. The sinusoidal function generator $\dot{y}(t)$ avoids such acceleration and pressure shocks (Fig. 5b). Ram acceleration $\ddot{y}(t)$ and servoactuator pressures $p_1(t)$ and $p_2(t)$ on both sides of the piston follow harmonic oscillations without higher harmonics. The sinusoidal function generator provides the most adequate control signal for the servosystem.

The analogue velocity signal of the multiplier X controls the voltage/frequency converter V/f, which generates a pulse train of variable frequency $f(t)$ proportional to the analogue input signal $\dot{y}(t)$. High precision voltage/frequency converters are commercially available for about Sw.Fr. 3400. The pulse train $f(t)$ is counted by the integrating up/down counter. The sign of the digital up/down counter is controlled by the analogue comparator. The content of the integrating counter represents the digital position of the magnet: $y(t) = \int \dot{y}\, dt = \int f\, dt$. If the counter reaches the programmed digital position, the input gate is closed by the digital comparator, and the counter stays on the programmed position. The position y(t) is memorized in digital format till the subsequent displacement is started.

The digital content of the counter is converted into an analogue signal by a precision digital/analogue converter of high accuracy $< 10^{-3}$. For operational purposes, the output signal of the digital/analogue converter can be attenuated by a precision output amplifier. The baseline of the programme voltage is added to the output amplifier.

The output of the hydraulic programme generator can be switched either to the output amplifier of the sinusoidal function generator or to the manual sweep potentiometer, but only if both signals are at zero level.

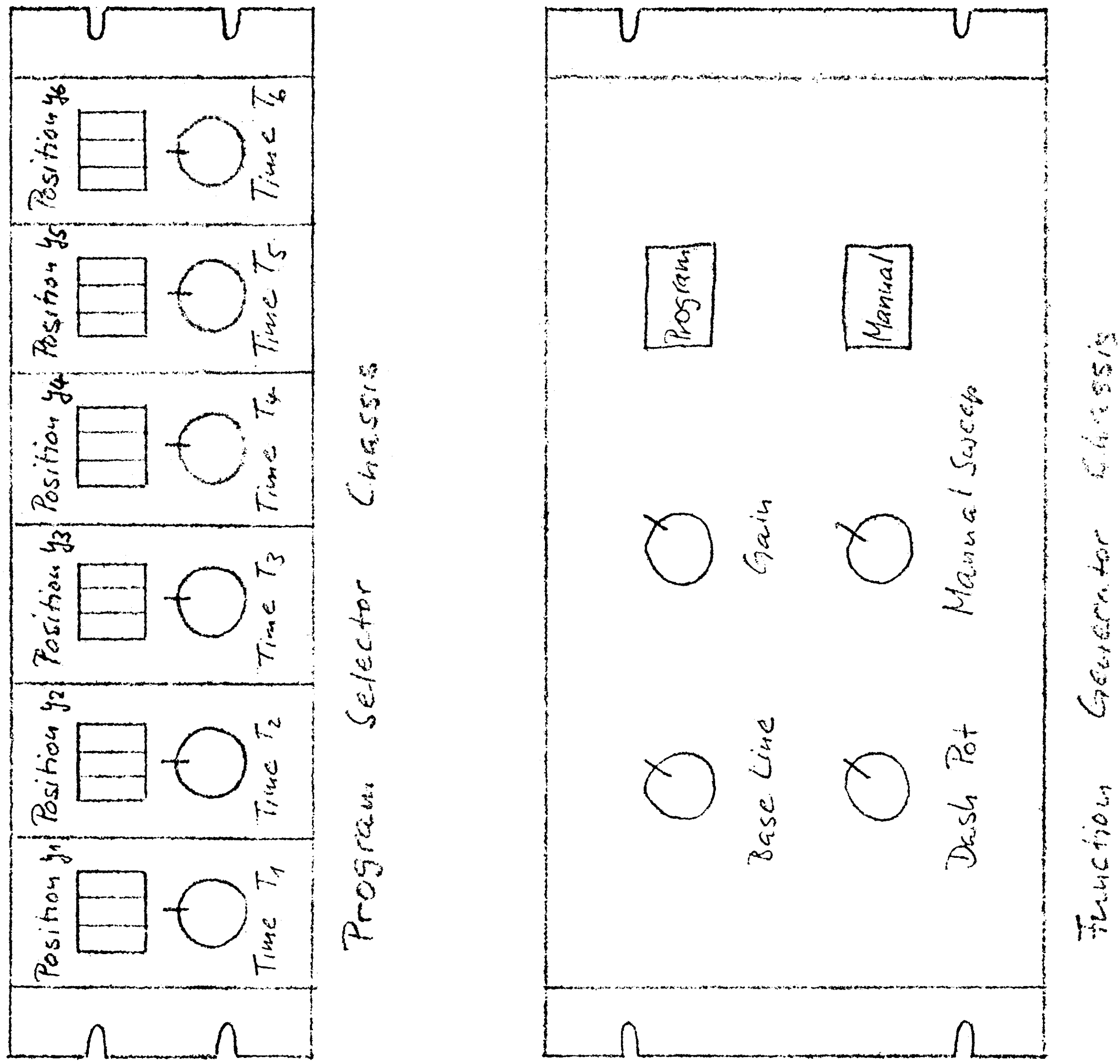
Summarizing the circuit description of the hydraulic programme generator (Fig. 3), we can say that the ram velocity is programmed by a flexible analogue device. The ram position is controlled with digital precision depending only on the accuracy of the digital/analogue converter and of the output amplifier.



Hydraulic Program Generator fig. 1.

Composed Movements 379-000-4

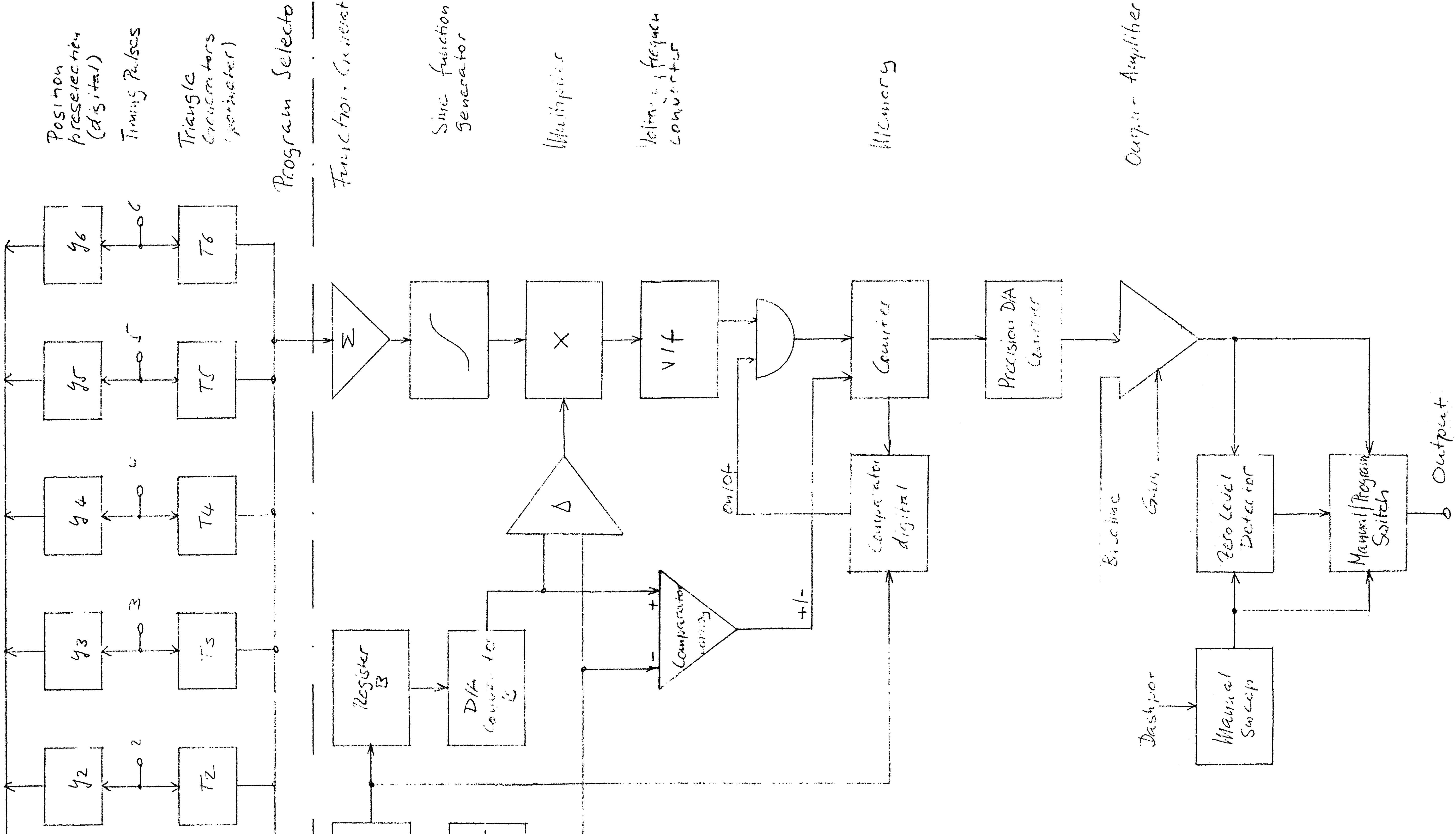
Mobile Septum Magnet BR 23.10.69



Hydraulic Program Generator fig. 2

Proposed Front Panels of 379-300-4

Function Generator BR 22.10.69



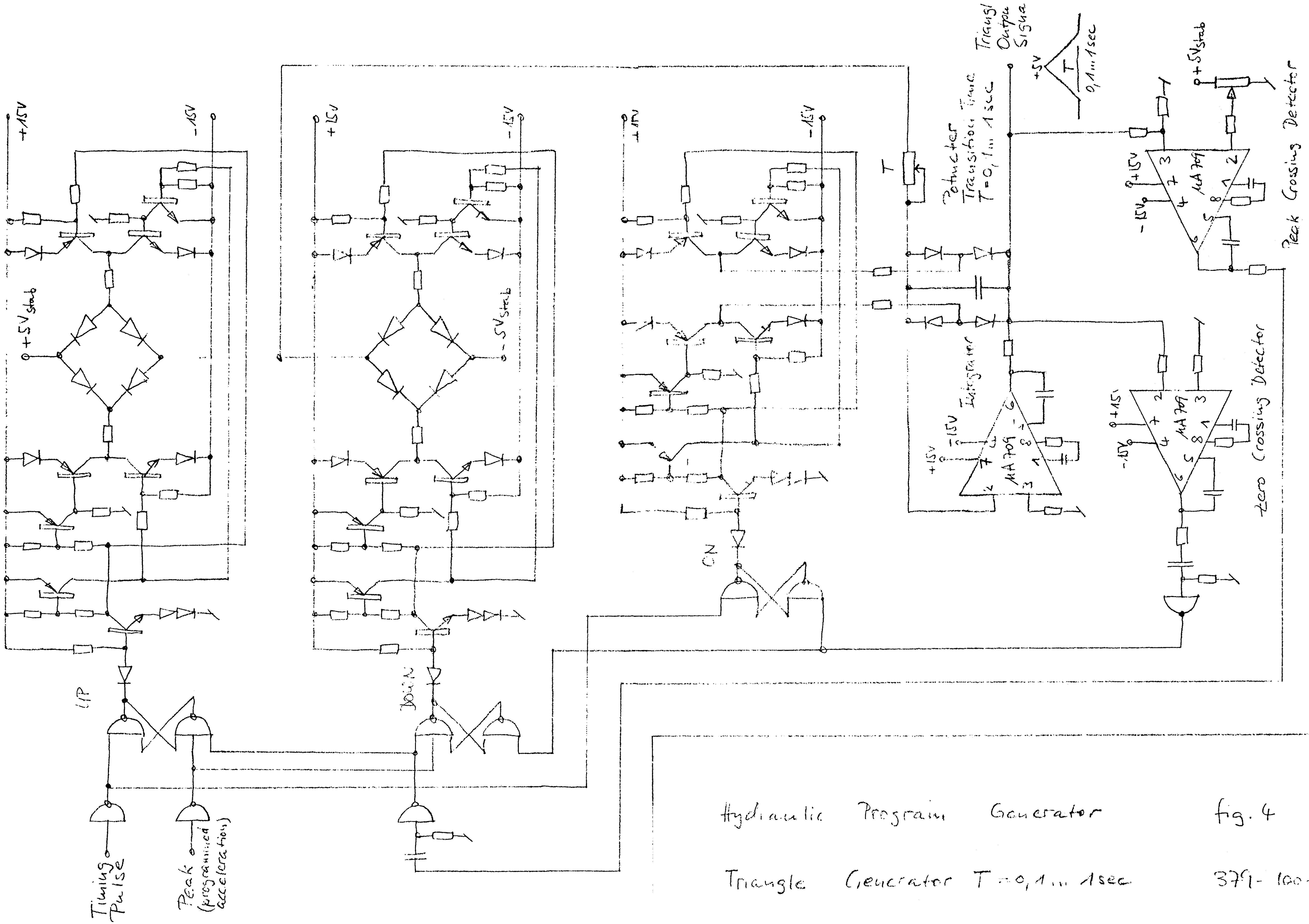
Hydraulic Program Generator

fig. 3

379-001-3

Proposed Block Diagram

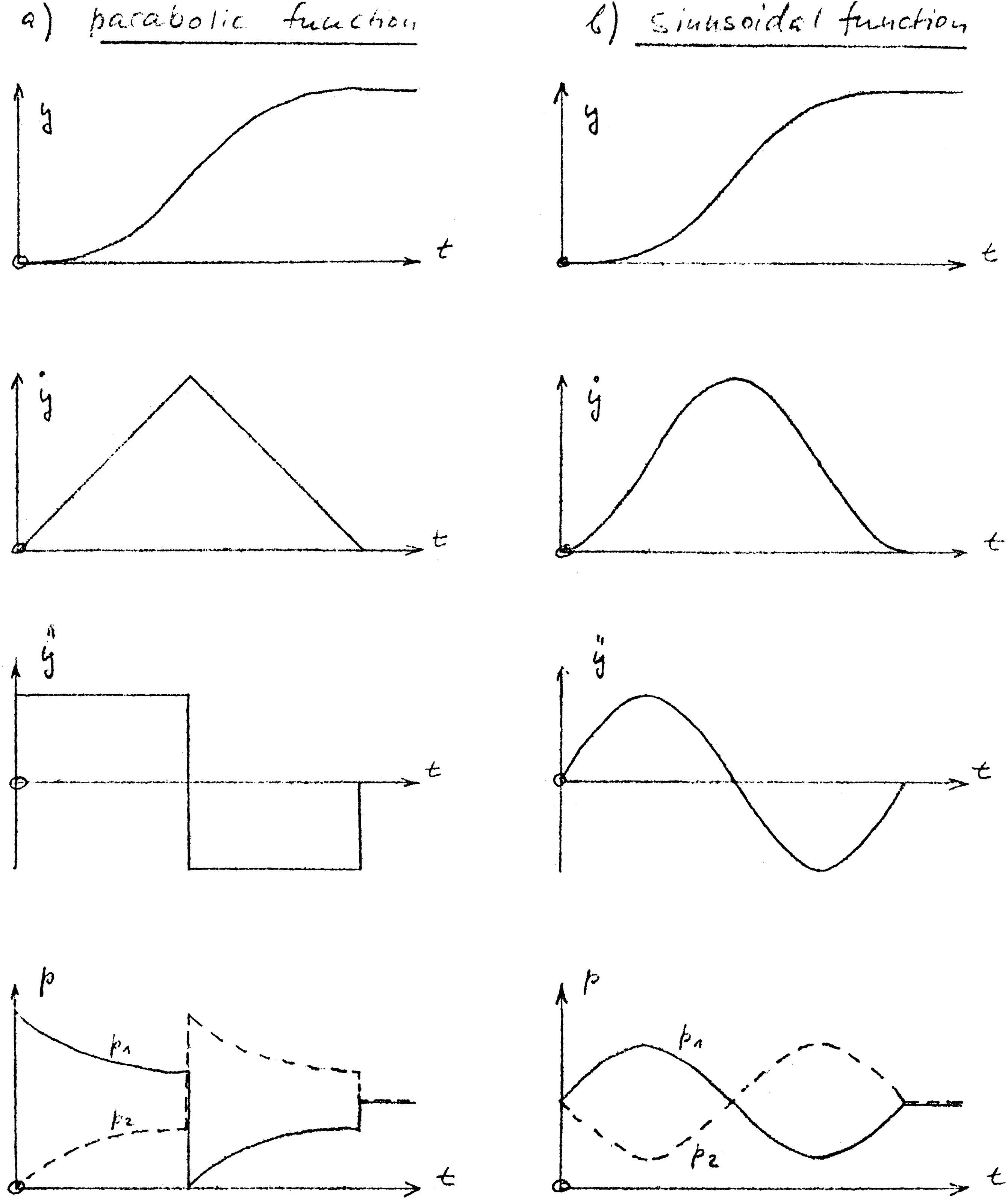
BR 21.10.61



Hydraulic Program Generator fig. 4

Triangle Generator T = 0,1 ... 1sec 379-100-3

Circuit Diagram BR 26.10.69



Hydraulic Program Generator fig. 5

Servoactuator's pressure [p] 379-002-4
versus
time [t] and ram velocity [ẏ] BR 29.10.69