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THE USE OF A BEAM SHUTTER MAGNET IN THE M3 BEAM

Introduction

In the last experiments with the Saclay HBC 81 a pulsed magnet was used to reduce the statistical fluctuations of the number of particles per picture. This was especially useful since the normal fluctuation was increased by beam sharing with rather bad stability.

The magnet was placed one meter before the second mass slit of the M2 beam.[1) The particles entering the chamber were counted by a telescope. After a preset number of particles the magnet was pulsed. All particles arriving later were deviated vertically and missed the slit.

The magnet

The magnet is a long air coil (fig.1) consisting of four layers of copper 60 x 3 mm^2. The open height is 30 mm, thus giving a useful area of 6 x 3 cm^2; the length is one meter. The particles pass parallel to the bars; they enter and leave by apertures at the ends. The copper layers are insulated by 0,1 mm Mylar foils. The copper surfaces were carefully smoothed from irregularities which damage the insulation when sudden forces are applied by pulsing the magnet. The mechanical forces, which are equivalent to an internal pressure of 1 kg cm^{-2}, are not very serious and are taken by plates of Resocel bolted together by stainless steel bolts. The inhomogenity of the matnetic field in this coil is 40 o/o in the x - direction and 10 o/o in the y - direction (fig. 1).

The electrical circuits

The electrical circuit (fig.3) is a conventional pulse circuit with crowbar operation,[2) ignitrons being used as switches. The only particular requirements were:

a) a rise time short compared to the average delay between subsequent particles (50 μsec)

b) a decay time longer than the duration of the machine burst (500 - 1000 μsec).
The rise is roughly given by the oscillation of the circuit

$$i_r = U\ (0) \sqrt{\frac{C}{L}}\ \sin\ (\cancel{2\pi}\, t/\sqrt{LC}) \qquad (\pi t)$$

and the decay by

$$i_d = i_{max}\ \exp\ \left(- \frac{R}{L}\ t\right)$$

That means that the circuit should combine a high frequency with a very low resistance, the latter being mainly the ignitron resistance plus the dc - resistance of the coil since skin effect is neglectible for the decay. The actual data are: (see fig. 2)

L	7 μH	U (0)	3000 V
C	90 μF	i_{max}	8000 A
R	3,5 mΩ	stored energie	400 J
T_{osc}	150 μsec	min field in	
T_{shut}	20 μsec	useful area	1700 Gauss
$T_{decay}\ (\frac{1}{e})$	2 μsec	max field	3750 Gauss
		particle deviation	10 mrad

The block diagram for the electronic circuits is shown in fig. 3
Ignitron 1 discharges the condensor through the magnet and ignitron 2 is fired after a delay of a quarter oscillation period when the maximum current is reached.

In fig. 4 the firing circuits for both ignitrons are shown. Hydrogen thyratrons were chosen to obtain a short delay between the trigger pulse and the building up of the ignitron current. This delay finally was 1.5 μsec with a jitter of about 0,2 μsec.

Fig. 5 shows the circuit for counting the number of particles. Pulses coming from a pulse shaper are stored in a capacitor. At a preset level a Schmitt trigger is fired which in turn fires the first ignitron.

Measurements

Measurements when operating the magnet with the bubble chamber are plotted in fig. 6. Curve A shows a normal fluctuation of the number of tracks per picture for an average of 12 tracks. Curve B shows the distribution when using the magnet. Of course the beam intensity was higher in this case.

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1) Un faisceau d'usage général a deux étages de séparation électrostatique au PS. J. Goldberg, J.M. Perreau, CERN 63-12.

2) See for example: On the fast extraction of particles from a 25 GeV Proton Synchrotron. B. Kuiper, G. Plass, CERN 59-30.

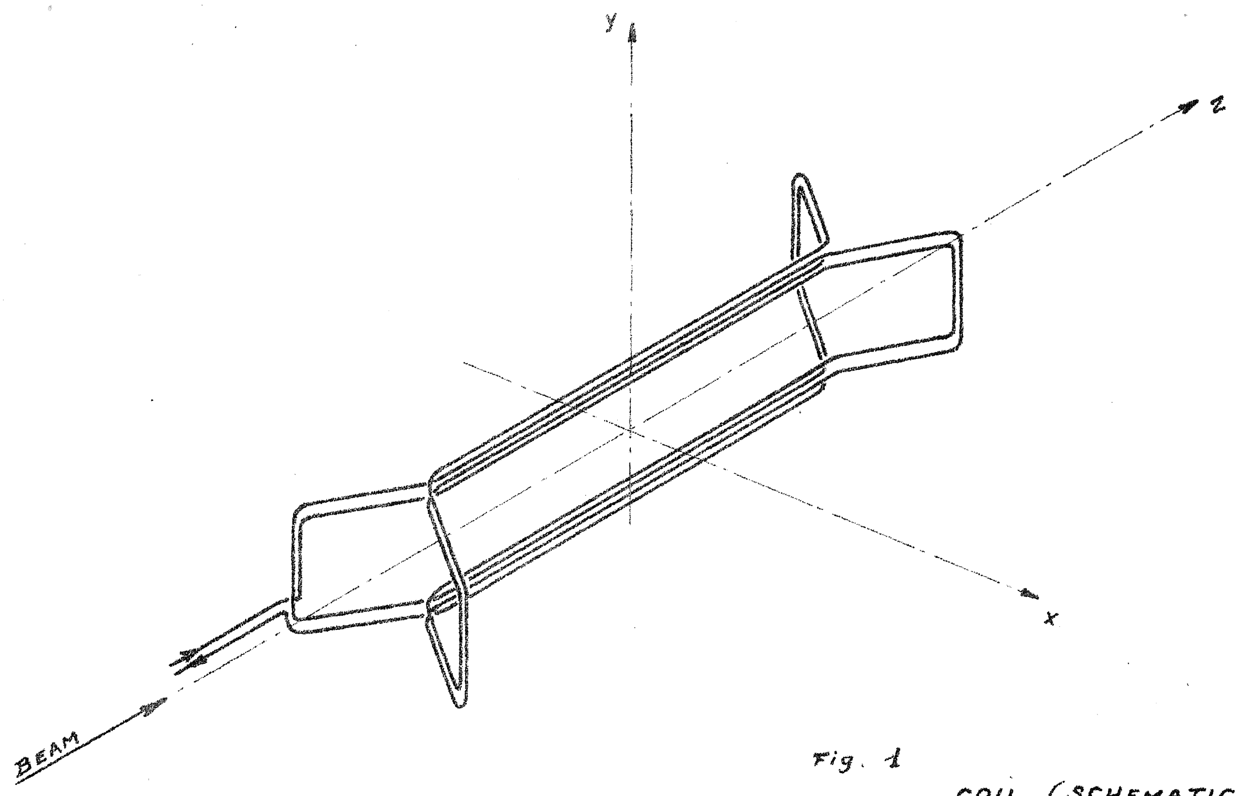

Fig. 1

COIL (SCHEMATIC).

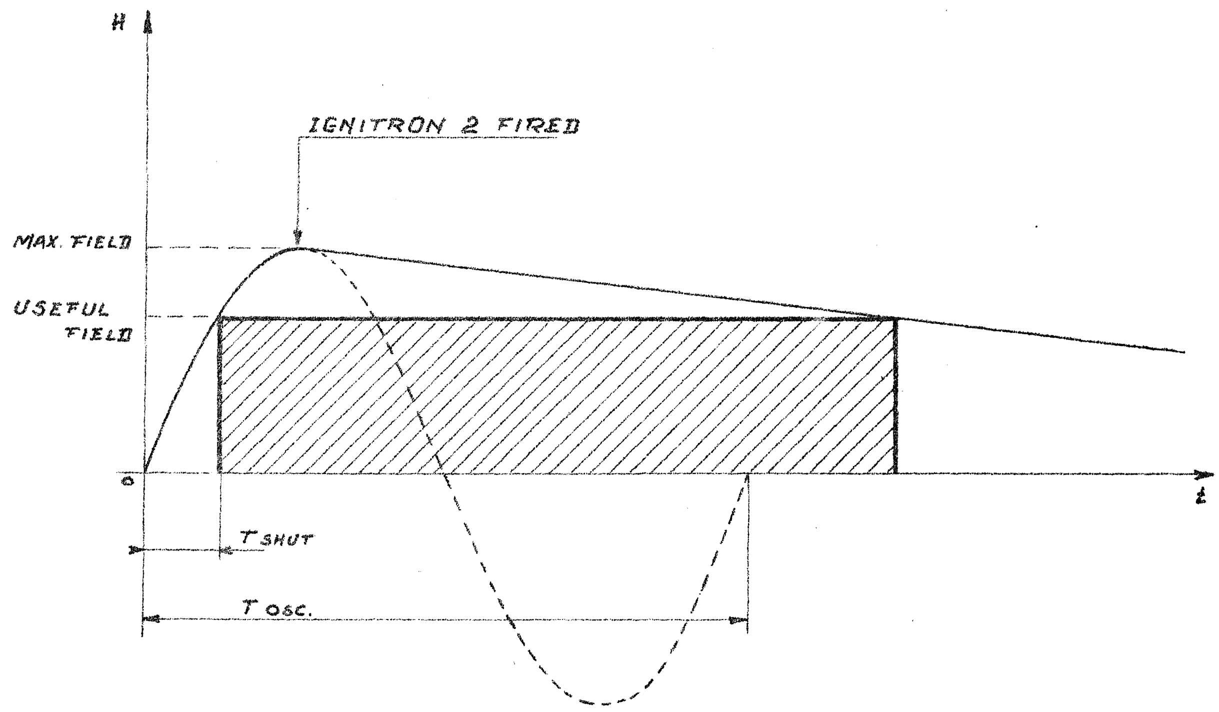

Fig. 2

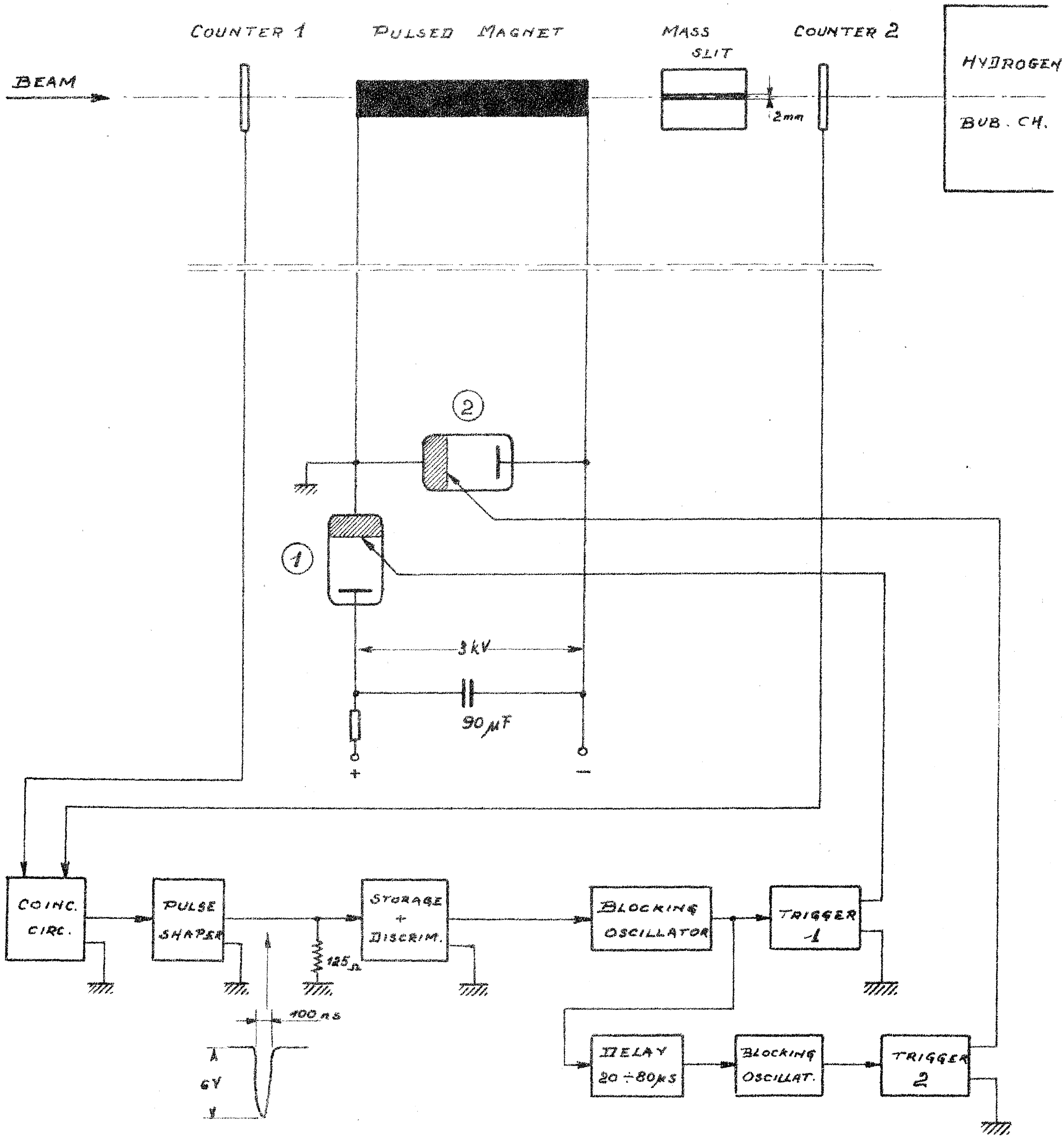

Fig. 3

BLOCK DIAGRAM OF THE ELECTRONIC CIRCUITS.

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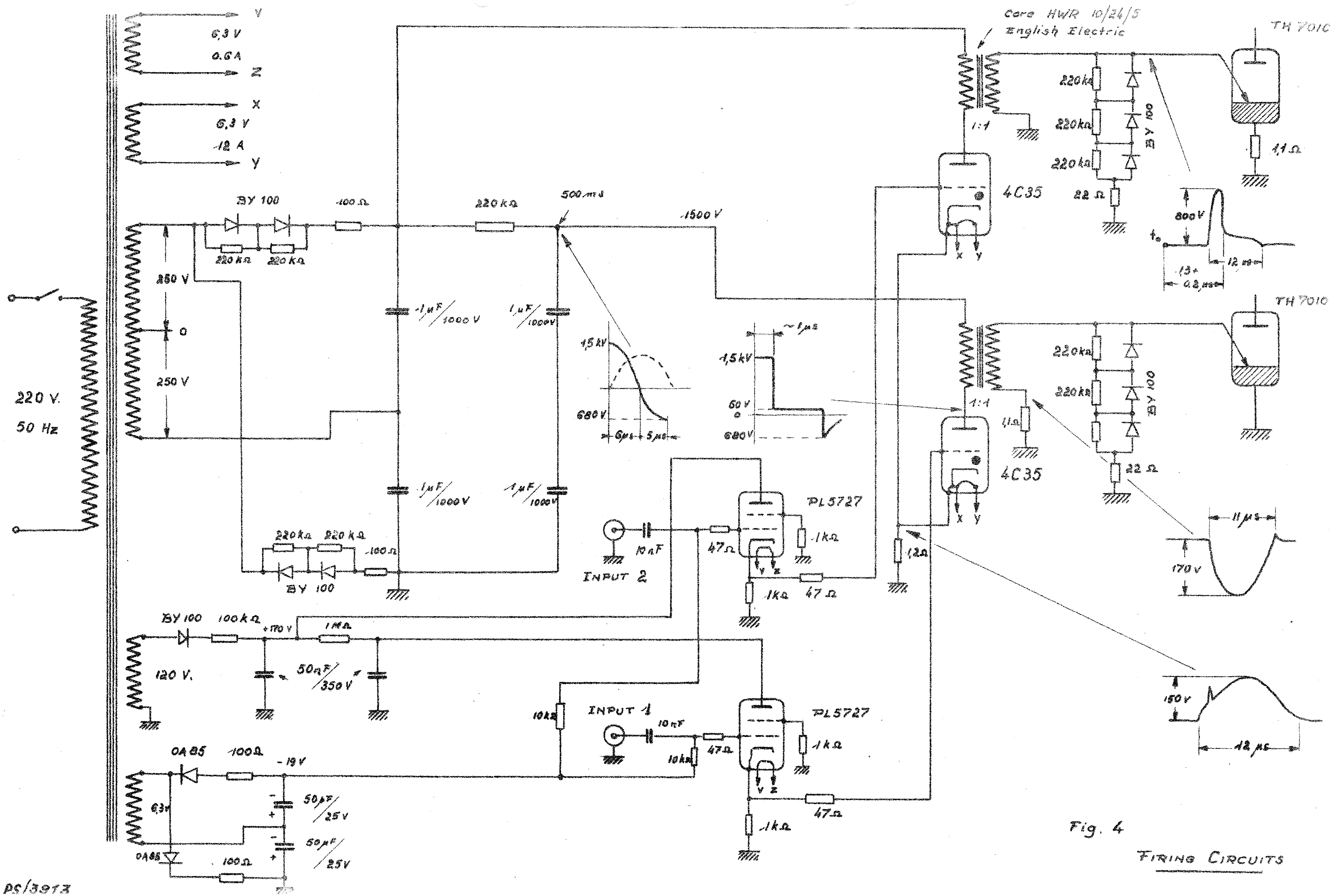

Fig. 4

FIRING CIRCUITS

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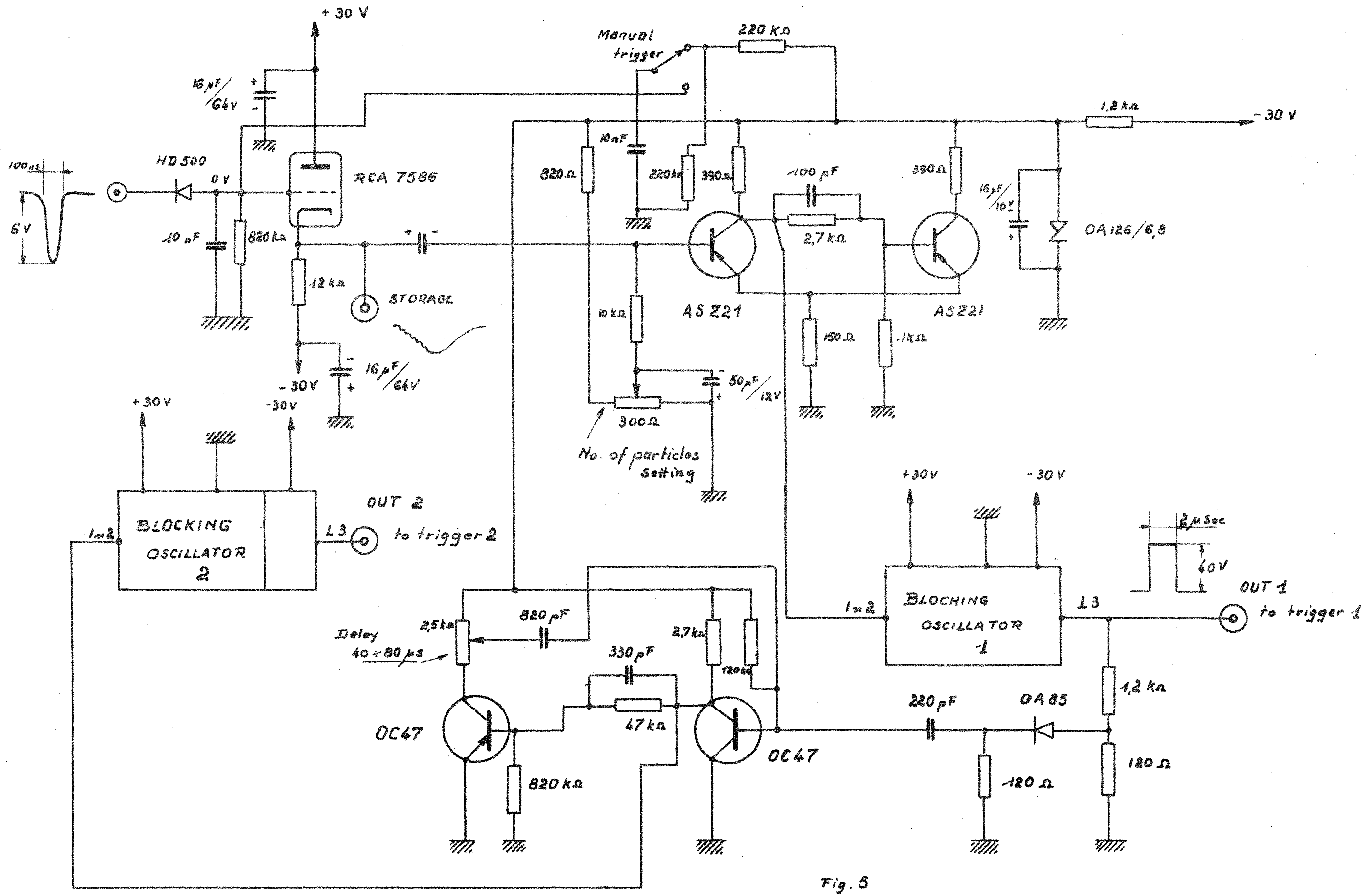

Fig. 5

COUNTING CIRCUIT.

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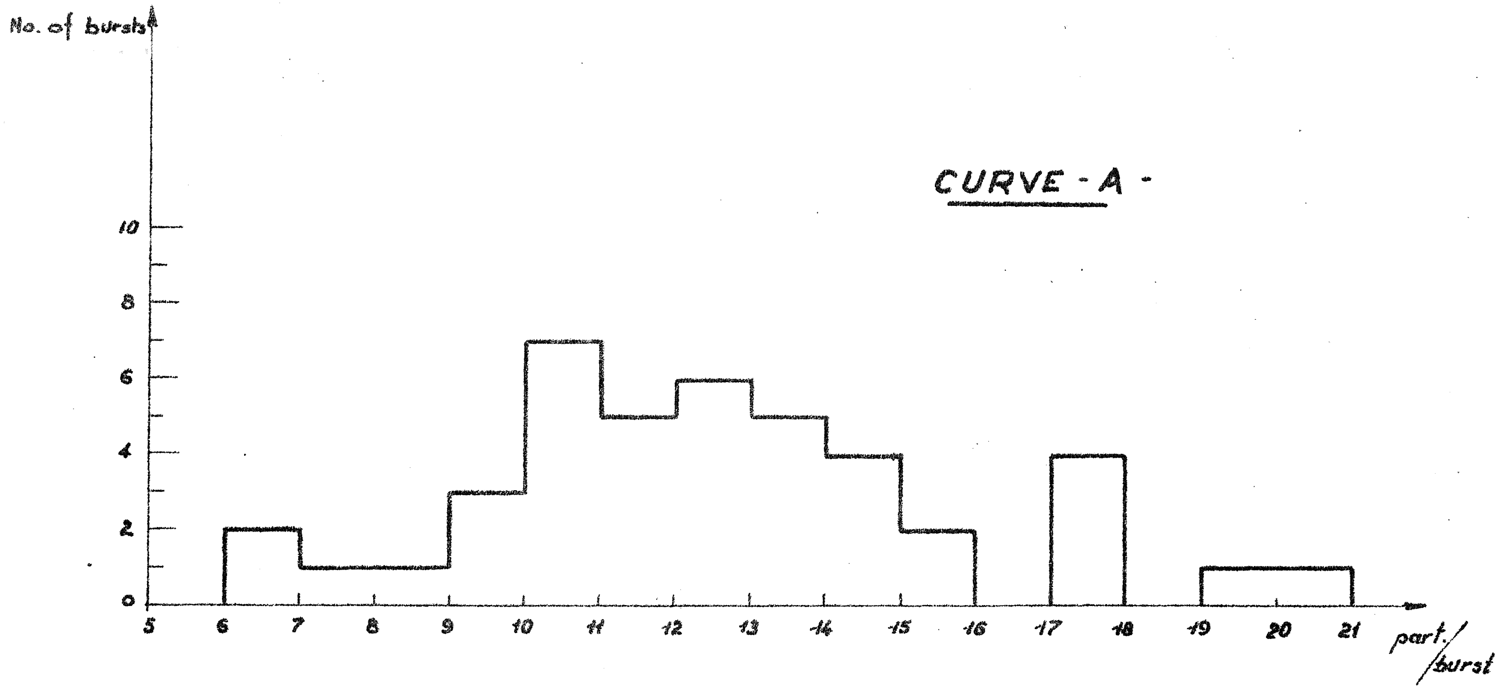
No. of bursts
CURVE - A -
0
2
4
6
8
10
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
part./burst

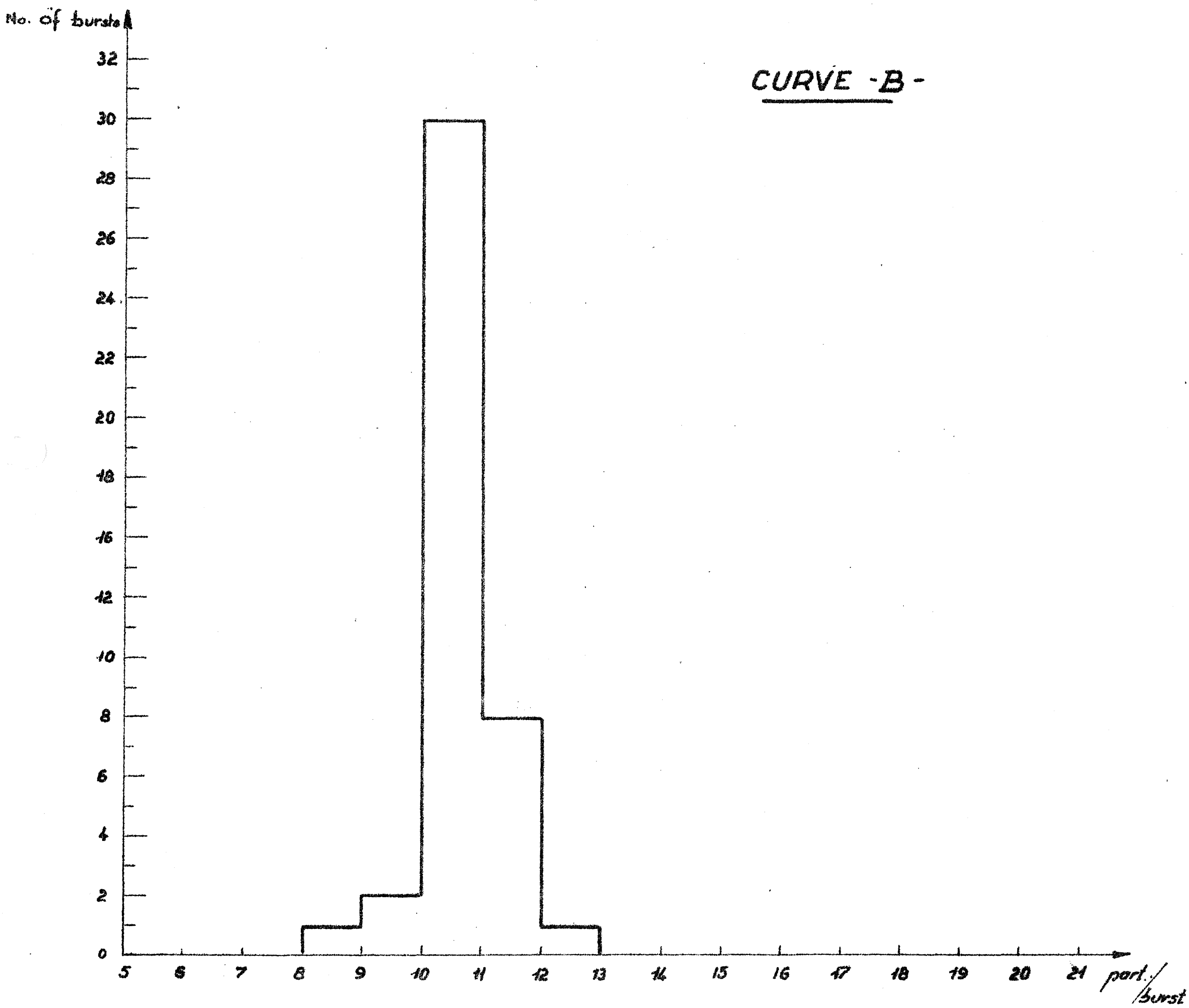
No. of bursts
CURVE - B -
0
2
4
6
8
10
12
16
18
20
22
24
26
28
30
32
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
part./burst

Fig. 6

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