INSTITUTE OF HIGH ENERGY PHYSICS, SERPUKHOV
Report IFVE 70 - 50

SCINTILLATION HODOSCOPE WITH LIGHT CODING

A.P. Burgorskij, A.A. Borisov, A.A. Derevshchikov,
Yu.A. Matulenko, A.P. Meshchanin, S.B. Nurushev,
V.L. Solov'yanov, L.F. Solov'ev, E.V. Smirnov,
V.V. Siksin and I.M. Shalashov

Serpukhov 1970

Translated at CERN by R. Luther
(Original: Russian)
Not revised by the Translation Service

(CERN Trans. 71-27)

Geneva
January 1971

1. DESIGN OF THE HODOSCOPE

In experiments to investigate the elastic scattering of particles, it is sufficient to record just one particle passing through the device. When developing a hodoscope for those experiments, the amount of electronic equipment may be reduced by introducing optical or electrical information coding techniques[1]. Figure 1 shows the optical coding circuit for a hodoscope with 16 scintillation elements (counters). Each photomultiplier simultaneously scans 4 scintillators. Eight photomultipliers are required altogether. Of these the first 4 (at the top of the diagram) are termed photomultiplier "units" and the other 4 (at the bottom of the diagram) are termed photomultiplier "groups". When a particle passes through any counter in the "units" or "groups", the photomultipliers are triggered one by one. By knowing their numbers, the element through which the particle has passed may be determined unambiguously.

Figure 2 illustrates the design of a hodoscope comprising 16 vertical and 16 horizontal elements with their respective screens. Three hodoscopes were prepared and designated H 1, H 2 and H 3 with scintillators of 5 mm, 3 mm, and 2 mm thickness respectively. The designs were otherwise identical. The scintillators were 3 mm wide with an initial length of 100 mm. Their tips were heated in liquid petrolatum and then curved to specific angles. The type of coding selected enables the 4 elements to be fully interlinked: their light is collected at one photomultiplier and an extremely efficient type of light-guide can be used for light collection. The scintillators themselves were wrapped in thin aluminium-coated mylar (only the ends were left exposed). This prevented light from penetrating through the lateral face to the adjacent elements. The design does not prevent light from passing through the scintillators' end faces when light is reflected from the photocathode, but this effect is not very great under working conditions. The hodoscopes' photomultipliers were initially selected for gain by means of a pulsed light source.

Subsequently, the characteristics of each photomultiplier were checked under working conditions in a particle beam. The difference in gain between each hodoscope's photomultiplier does not exceed a factor of two. The photomultipliers are secured in frames of soft iron and have individual dividers. Each photomultiplier is provided with a pulsed light source made from silicon carbide which can illuminate the photomultiplier's photocathode. The hodoscope's counters are powered by two VS-28 rectifiers.

In addition to hodoscopes H 1, H 2 and H 3, which have a working area of 48 × 48 mm (the total area covered by the vertical and horizontal screens), hodoscope H 4 was constructed, with a working area of 108 × 108 mm. It comprises 36 vertical and 36 horizontal elements. The scintillators' thickness is 5 mm, width 3 mm and initial length 210 mm. Each screen contains 12 photomultipliers. Otherwise, its design is identical to the others.

2. MEASUREMENT OF THE HODOSCOPES' CHARACTERISTICS

The hodoscopes' characteristics were studied on a 40 GeV/sec particle beam with the aid of a "Minsk 22" digital computer. The beam intensity reached 5×10^5 part/cycle. The length of cycle varied in the range 0.2-0.5 sec. The number of recorded events per cycle did not exceed 2×10^3 and was limited by the digital computer's storage capacity. The gating circuit in the data channels was triggered by a signal from the monitor counter. If an event is recorded, then the following are possible:

1) there is one signal in each "unit" or "group" channel. The number of these events as a fraction of the number of triggerings monitored is expressed by m_{11};

2) there are no signals either in the "unit" or "group" channels, or simultaneously in both channels (m_{01}, m_{10}, m_{00});

3) there are three or more signals. For example, there is one signal in the "units" and two in the "groups" (m_{12}). The main characteristic of the hodoscope is the value m_{11}. For H 1 ($3 \times 5 \times 48$ mm^3) this value rises as the voltage increases, reaches a maximum ($\sim$ 0.9) at 2.75 kV and then drops (Fig. 3). The m_{11} value depends on background loading and the beam characteristics. At the same time these factors lead to an increase in the number of m_{12}, m_{21} and m_{22} events (Fig. 4). As regards m_{01}, m_{10} and m_{00} events, these describe the inefficiency of the "unit" and "group" channels and decrease with a rise in voltage (Fig. 5). It should be pointed out that the minimum attainable m_{00} value is determined by the size of the gap between the scintillators.

In hodoscopes H 2, H 3 and H 4, when U = 3 kV, the maximum m_{11} value is 0.88, 0.73 and 0.7 respectively.

Figure 6 illustrates the behaviour of $m_{\alpha\beta}$ values for the vertical plane of the H 1 hodoscope when it is rotated through its vertical axis at 2.8 kV. The m_{00} value reaches a maximum at approximately 1°. In this case, the hodoscope is positioned in such a way that the maximum possible section of beam passes through the slit between the scintillators. Values m_{12}, m_{21}, and m_{22} are then at a minimum and m_{11} at a maximum. No variations are detected in the horizontal plane characteristics during these rotations.

CONCLUSION

During these measurements the H 1 hodoscope ($3 \times 5 \times 100$ mm^3) displayed the greatest efficiency (m_{11} = 0.88-0.91). The other hodoscopes were less efficient ($m_{11} \simeq 0.80$).

Hodoscopes H 2 ($3 \times 3 \times 100$ mm^3) and H 3 ($3 \times 2 \times 100$ mm^3) are convenient for use in experiments where it is essential to have a minimum amount of material in the beam.

The construction of the H 4 hodoscope ($3 \times 5 \times 210$ mm) represents an attempt to apply the optical coding method described above using wide screens (108×108 mm). Further advances in this direction lead to serious difficulties in designing systems to collect light from the scintillators at the photomultiplier's cathode.

Finally the authors wish to thank Yu.A. Solomatin and V.A. Kormilitsin for their considerable efforts in preparing the scintillators and light-guides, M.V. Kuchina and V.S. Postovik for their assistance with the design, the staff of the TsEM for the high standard of their metal-work, and the staff of the OE for installing the radio equipment.

REFERENCES

1) E. Heer, Proceedings of International Conference on Instrumentation for High Energy Physics, p. 62 (1960).

2) A.E. Belotsvekov, L.V. Belyaevskij, A.A. Derevshchikov, V.D. Zhil'chenkov, Yu.A. Matulenko, Yu.V. Mikhailov, E.V. Smirnov, V.L. Solov'yanov, P.T.E. No. 1, 92 (1970).

Figure captions

Fig. 1 : Information coding circuit for a hodoscope consisting of 16 vertical and 16 horizontal elements. The actual coding system is shown in the upper part of the figure.

I "units"
II scintillating elements
III photomultiplier
IV "groups"

Fig. 2 : Design of a hodoscope with 16 vertical and 16 horizontal elements.

Fig. 3 : Dependence of m_{11} on the supply voltage:

a) for the vertical and horizontal screens of the H 1 hodoscope;

b) for the vertical and horizontal screens of the H 2 hodoscope;

c) for the vertical and horizontal screens of the H 3 hodoscope;

d) for the vertical screen of the H 4 hodoscope.

Fig. 4 : Dependence of m_{12}, m_{21} and m_{22} on the supply voltage for vertical hodoscope screens:

a) H 1 hodoscope,
b) H 2 hodoscope,
c) H 3 hodoscope,
d) H 4 hodoscope.

Fig. 5 : Dependence of m_{10}, m_{01} and m_{00} on the supply voltage for vertical hodoscope screens:

a) H 1 hodoscope,
b) H 2 hodoscope,
c) H 3 hodoscope,
d) H 4 hodoscope.

Fig. 6 : Dependence of $m_{\alpha\beta}$ on rotation around the vertical axis of the H 1 hodoscope's vertical screen:

a) dependence of m_{11} on rotation;

b) dependence of m_{00}, m_{12}, m_{21} and m_{22} on rotation.
1. - degrees.

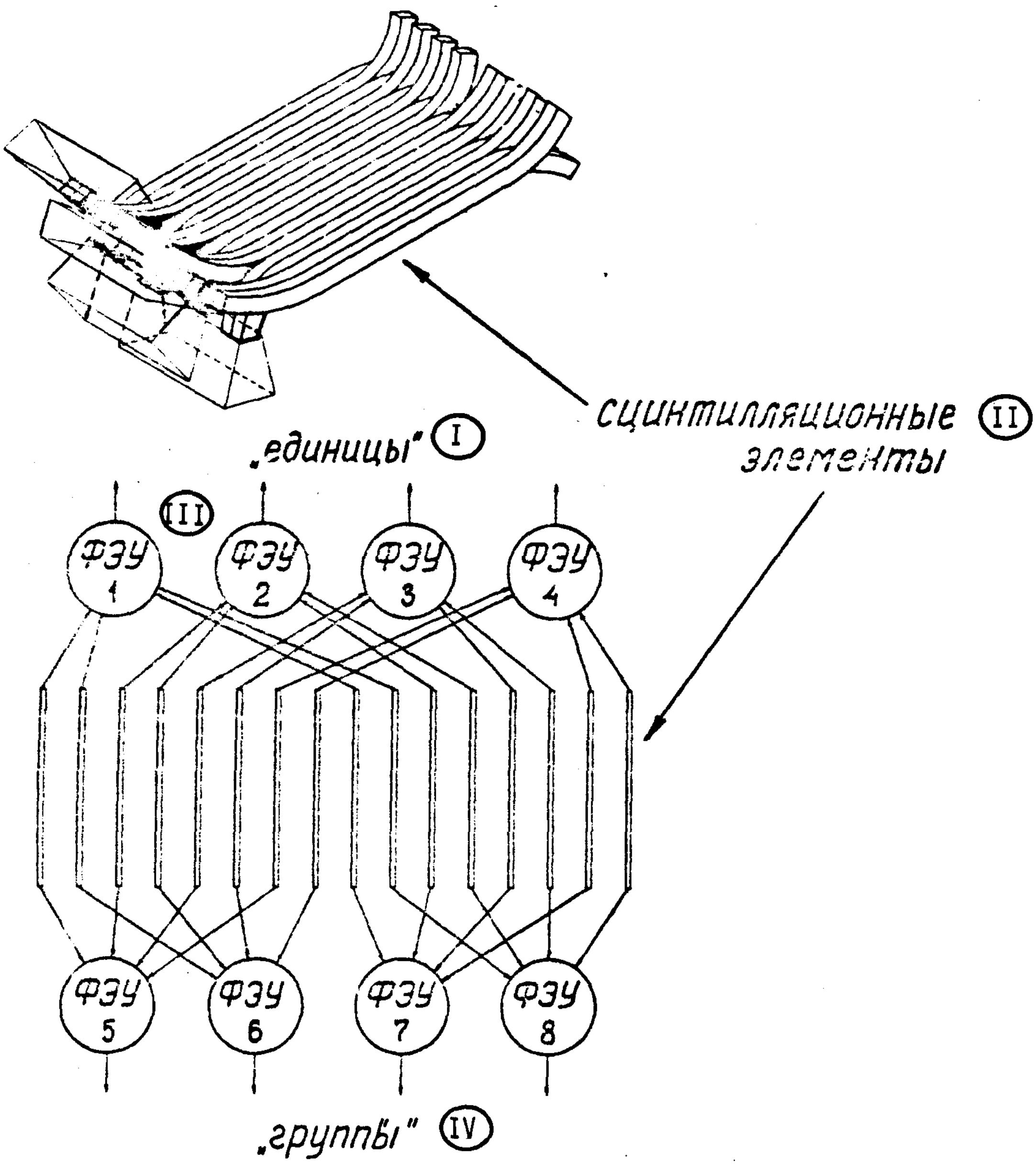

сцинтилляционные элементы (II)
"единицы" (I)
(III)
ФЭУ 1
ФЭУ 2
ФЭУ 3
ФЭУ 4
ФЭУ 5
ФЭУ 6
ФЭУ 7
ФЭУ 8
"группы" (IV)

Fig. 1

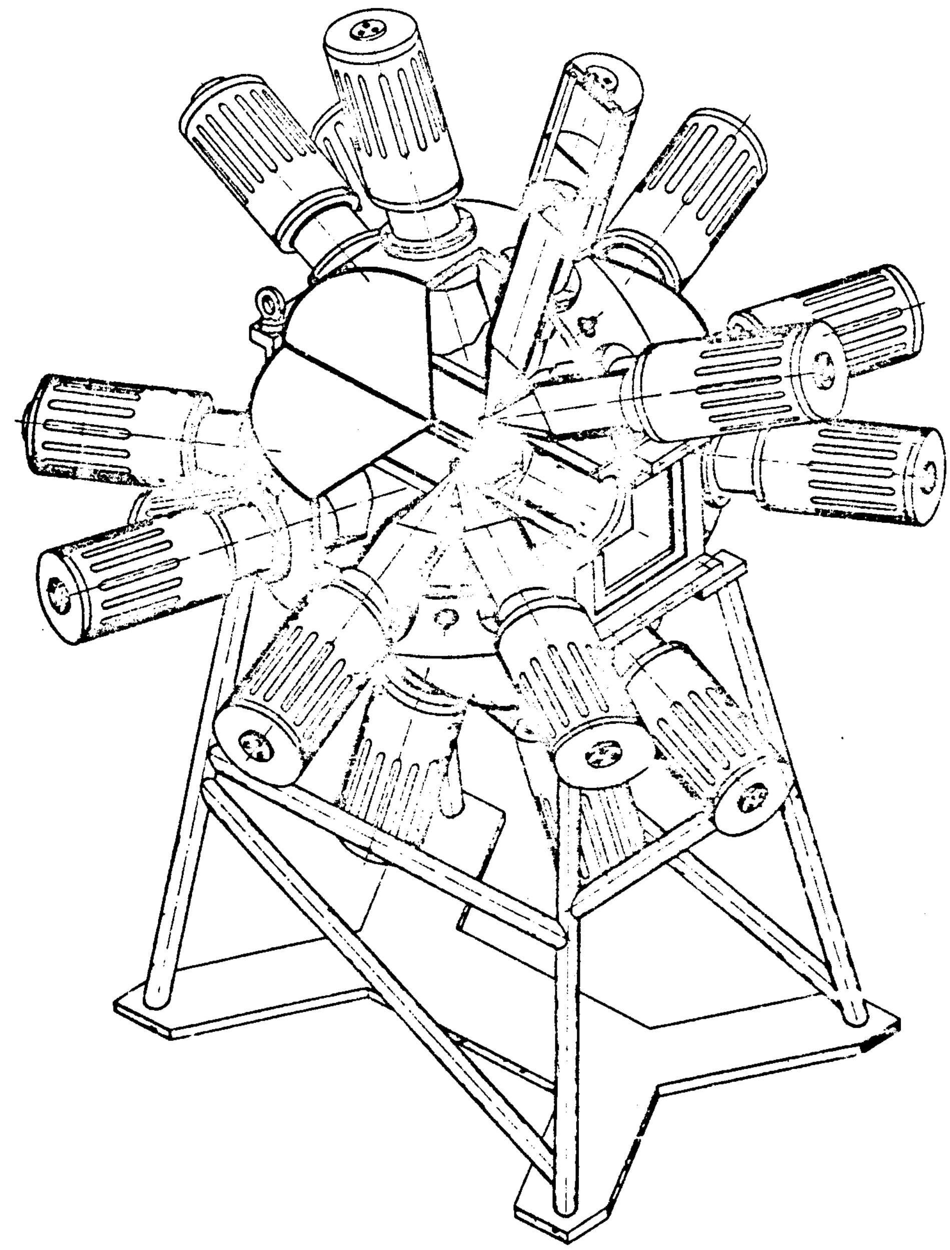


Fig. 2

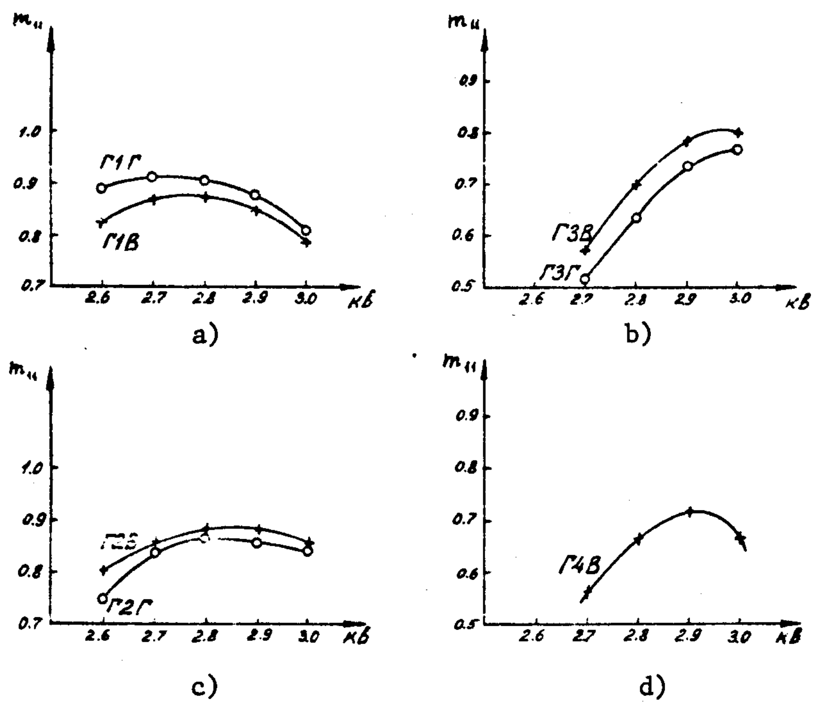


Fig. 3

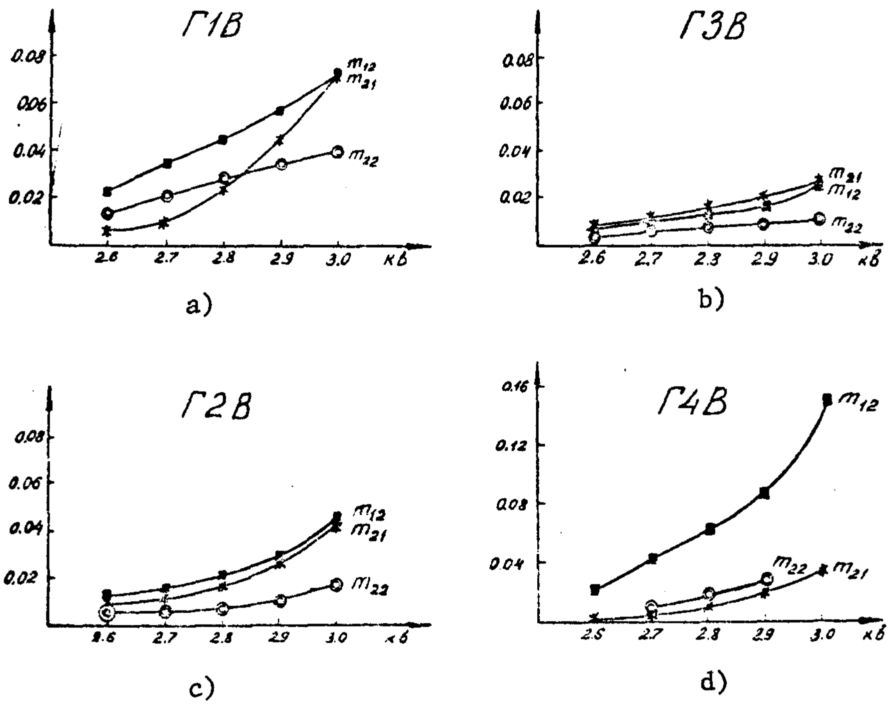
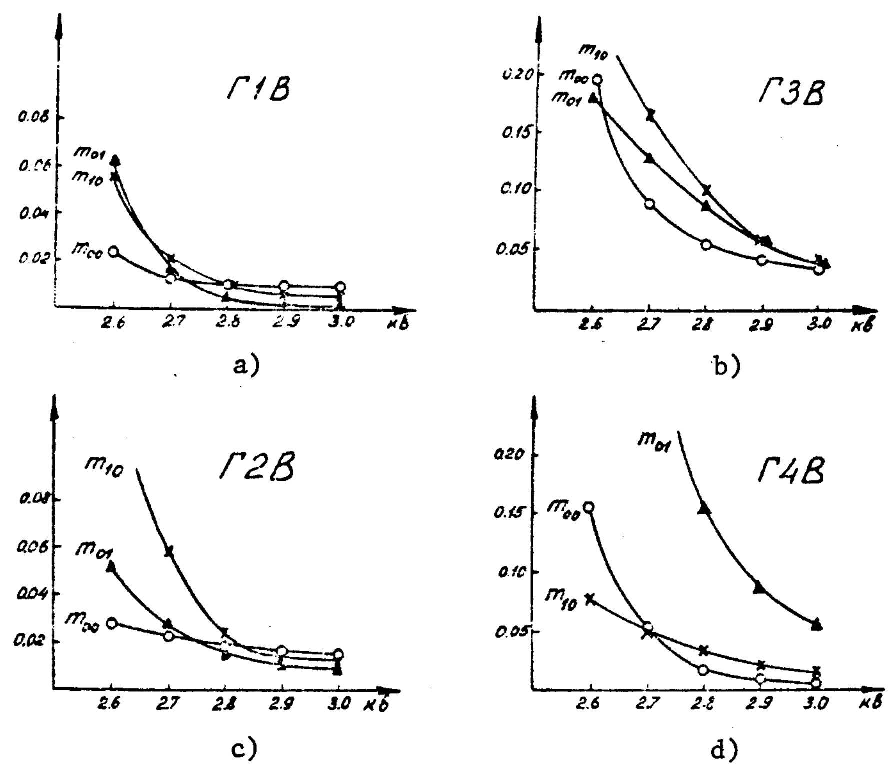
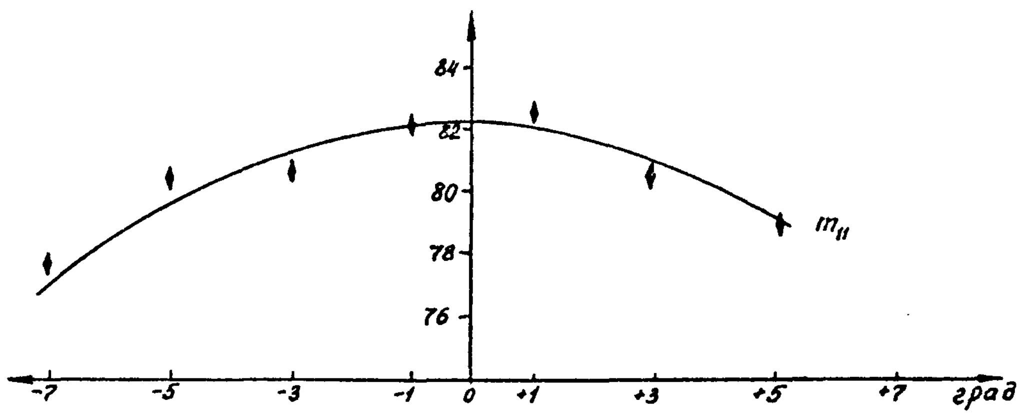

Г1В
0.08
0.06
0.04
0.02
2.6
2.7
2.8
2.9
3.0
кв
m12
m21
m22
a)
Г3В
0.08
0.06
0.04
0.02
2.6
2.7
2.8
2.9
3.0
кв
m21
m12
m22
b)
Г2В
0.08
0.06
0.04
0.02
2.6
2.7
2.8
2.9
3.0
кв
m12
m21
m22
c)
Г4В
0.16
0.12
0.08
0.04
2.5
2.7
2.8
2.9
3.0
кв
m12
m22
m21
d)

Fig. 4



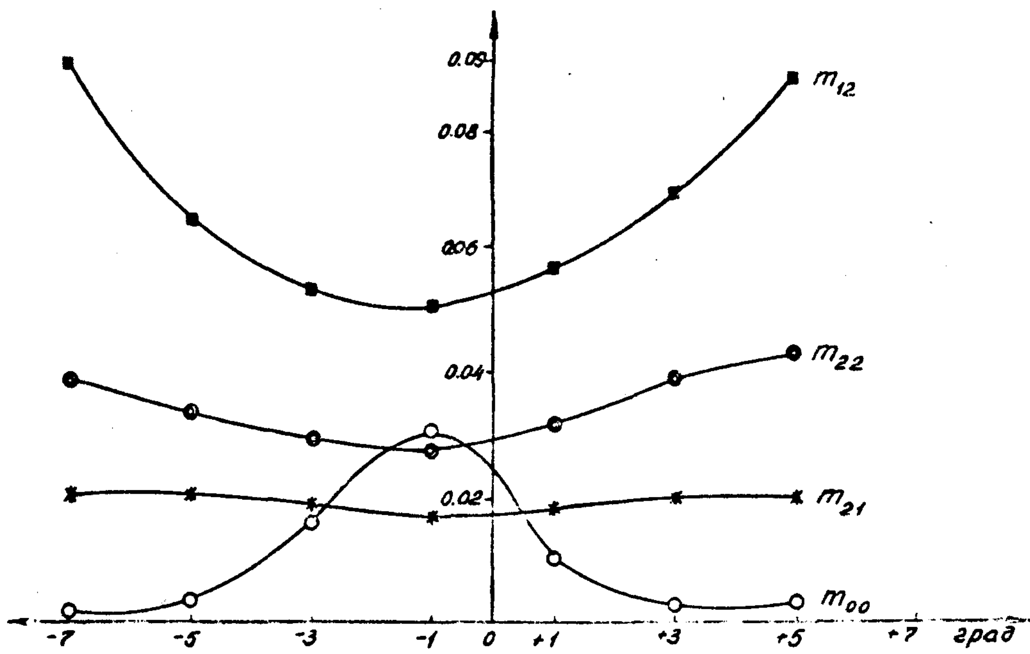
Г1В
Г3В
Г2В
Г4В
m01
m10
m00
кв
2.6
2.7
2.8
2.9
3.0
0.02
0.04
0.06
0.08
0.05
0.10
0.15
0.20
a)
b)
c)
d)

Fig. 5



84
82
80
78
76
m_{11}
-7
-5
-3
-1
0
+1
+3
+5
+7
град

a)



0.09
0.08
0.06
0.04
0.02
m_{12}
m_{22}
m_{21}
m_{00}
-7
-5
-3
-1
0
+1
+3
+5
+7
град

b)

Fig. 6