ОБЪЕДИНЕННЫЙ
ИНСТИТУТ
ЯДЕРНЫХ
ИССЛЕДОВАНИЙ
Дубна

E10 - 4179

J.Bystrický , J.Čech , P.Horváth , F.Lehar

AUTOMATIC SCANNING DEVICE FOR SEVERAL TYPES OF OPTICAL SPARK CHAMBER EXPERIMENTS

ЛАБОРАТОРИЯ ЯДЕРНЫХ ПРОБЛЕМ

1968

E10 - 4179

J.Bystrický*, J.Čech**, P.Horváth***, F.Lehar**

AUTOMATIC SCANNING DEVICE FOR SEVERAL TYPES OF OPTICAL SPARK CHAMBER EXPERIMENTS

*) On leave of absence from the Institute of Computing Techniques of the Czechoslovak Academy of Sciences, Praque.

**) On leave of absence from the Nuclear Research Institute of the Czechoslovak Academy of Sciences, Řež.

***) On leave of absence from the Faculty of Electronics, Technical University, Bratislava, Czechoslovakia.

1. Introduction

In the last few years a large amount of papers has been published, concerning the completely automatized scanning of pictures from spark and bubble chambers/1-5/. All such scanning devices transform the information contained in the pictures into data for electronic computers.

In general the work of the computer can be devided into three stages:

a) Reconstruction of the tracks in a given picture.

b) Treatment of the "useful" events.

c) Analysis of the treated events.

The most universal devices (e.g. HPD, Luciol, etc.) pose very few conditions on the form of the tracks, their amount, etc. In such cases a large amount of information arrives to the computer from each picture. The reconstruction of the tracks demands a high speed of computing and a great memory capacity, as well as good soft ware of the computer.

In many cases it is possible to make certain assumptions concerning the shape of the track, its direction, length, multiplicity, etc. Starting from these assumptions it is possible to construct a scanning device for tracks coming from certain types of physical experiments. This considerably simplifies the reconstruction of tracks in the computer, so that the demands on its memory capacity and cycle time are considerably lower.

We see that it is useful to construct specialized automatic scanning devices for pictures, obtained in large amount in certain typical experiments.

In this paper we suggest a method of completely automatized scanning of pictures from spark chamber experiments on nucleon-nucleon or pion-nucleon scattering.

It should be noted that the suggested device can also be used for other types of measurements in which tracks are formed, consisting of direct parts.

2. Formulation of the Problem

A typical spark chamber track is shown in Fig.1. in two projections. The device described in this paper is constructed for tracks from spark chamber with thin electrodes and several scatterers (T_1, T_2) in predetermined places. The electronic triggering of the spark chamber enhances the probability of one single track originating in the chamber. All other cases form the background and must be excluded.

A track is considered to be "useful" if it satisfies the following criteria:

1) The entrance angle of the track lies within the limits given by the geometry of the experiment/6/.

2) The scattering angle is no larger than 30^{o}x).

3) The continuations of the ingoing and outgoing parts of the tracks intersect in the region which does not considerably differ from that of the scatterer (this is to exclude multiple scattering).

---

x) In the whole energy region of 50-700 MeV the scattering cross section on the used analyzers (e.g. Al, C) is very small for scattering angles larger than 30^{o}(in the laboratory system), the role of inelastic scattering increases considerably and the elastic scattering polarization is small.

The purpose of the scanning is to measure the scattering angles in the useful tracks and to exclude all false events. The angles (θ_1 and θ_2 on Fig.1) should be measured with an accuracy better than that of a semiautomatic device/7/.

The conditions mentioned above serve as the requirements for the completely automatized device.

3. Scanning by Means of a Mask

A spark chamber picture is shown in Fig.1. Parts 11,12, 13 and 21, 22, 23 of the track correspond to two projections of the particle path in the spark chamber. If we neglect the microstructure of the track, these parts are straight lines. Each of them lies in a quite definite region of the picture (this is due to the construction of the spark chamber and of the projecting device). It is sufficient to describe the piece of the track by a given y and ϕ in the previously chosen coordinate system and by the number of the region in which it is located.

It follows that tracks satisfying the above assumptions can be measured with the help of a mask.

A mask having the form of a straight slot of the corresponding width can be rotated and translated so as to coincide with the image of a definite part of the track. As soon as the two coincide both coordinates must be written down. The mask can be made to move with respect to the picture by means of a follow-up motor or it can move permanently so as to scan the whole picture. The second method is simpler and sufficient for the considered type of pictures.

The mask can be realized mechanically, optically or by means of TV. The motion of the mask with respect to the picture can be realized by means of various combinations of rotations and translations of the mask or the picture.

4. Rotation and Translation of the Mask

The mask is realized as a rotating disk with a radial slot. The centre of the rotation of the disk lies on the y axis (Fig.2) and moves up and down along this axis. The scanned part of the track is projected (positively) on to the disk and detecting photomultiplier is placed under the disk, so as to register the light flux through the slot. The disk rotates rapidly and its centre moves relatively slow between y_{min} and y_{max}. During this motion we can find a position in which the slot transmits a maximum of light to the photocathode of the photomultiplier. Measuring the position of the centre of the disk and the direction of the slot at this maximum, we obtain the two coordinates y and ϕ.

Scanning the whole picture in this manner, we obtain a set of the coordinates y_i and ϕ_i (cf.Fig.3), which together with the number of the corresponding part of the track $i = 1,\ldots,n$, completely charcterizes the given picture for calculations on a computer.

5. The Scanning Speed and the Accuracy of the Measured Coordinates

The scanning speed, i.e. the time necessary to measure one picture, depends on the mechanical design of the device mainly on the number of rotations of the disk per time unit. The angular velocity ω of the disk is related to the linear velocity v of the centre. The ratio ω/v can be determined from the requirements on the accuracy of y_i and ϕ_i.

The moment when the slot coincides with the measured part of the track is always determined with a certain time delay ΔT , which can be separated into a systematic and statistic parts

$$\Delta T = \Delta T_{st} + \Delta T_{syst}$$

This time delay causes the errors Δy and $\Delta\phi$ in the determination of the coordinates

$$\Delta y = v \cdot \Delta T_{syst} + v \cdot \Delta T_{st} + 2\Delta$$

$$\Delta\phi = \omega \cdot \Delta T_{syst} + \frac{v}{r} \Delta T_{st} + 2\partial ,$$

where Δ is the basic unit of the y-coordinate scale and ∂ is that of the ϕ-scale.

After choosing ω, Δy and $\Delta\phi$ we can determine v, Δ and ∂ .

The systematic deviations Δy_{syst} and $\Delta\phi_{syst}$ are measurable constants for the given device, and they can be excluded by introducing the corresponding corrections when treating the data on a computer.

When the spark chamber detects an event with a large scattering angle a, so-called, "step-like" track is produced (Figs.4,5), in this case we cannot measure the correct coordinates y and ϕ using the described method. They will be measured with a further systematic deviation, the size and direction of which depends on the angle between the direction of the track and the axis of the spark chamber (the angle ϕ) and on the direction of the motion of the centre of the disk. The particle trajectory of Figs.4,5 is indicated by a dashed line. Straight lines $\overline{11}'$ and $\overline{22}'$ determine two directions which can be measured by our method. One of them corresponds to the motion from y_{min} to y_{max} and the other one to the reverse. The systematic deviation from the correct direction ϕ is $+\Delta_1\phi$ in one case and - $\Delta_2\phi$ in the other. These deviations can be calculated or measured and corresponding corrections can be introduced into the computer prior to further treatment.

6. Recording of Information

Practically any output device - a puncher, a tape - recorder or directly the operative memory of a computer can be used to record information.

In the described scanning device with a rapidly rotating disk and relatively slow moving centre the slot scan the whole picture during one cycle. During the motion of the centre of the disk from one boundary position to the other, all parts of the tracks in the picture can be scanned, i.e. the direction of all parts of the track can be made to coincide with the direction of the slot. Naturally the information does not arrive uniformly during the scanning and sometimes the slot can coincide with two parts of the track simultaneously. For this reason it is either necessary to stop the scanning till the slow output device is ready to accept further information, to apply several cells of a rapid buffer memory, or to use a rapid recording in the form of fast memory.

6. Experimental Arrangement

We shall test the suggested method by scanning pictures taken in the spark chamber with two scatterers (cf. Fig.1).

The mechanical part of the equipment is shown schematically in Fig.6. This is a projecting device with a mechanism for shifting the pictures (CH), the measuring disk (D) is rotated by a high velocity motor (MR). The motor together with the disk moves along rails (along the y-axis). This motion is controlled by a follow-up motor which regulates the speed of the motion along the y-axis. The photomultiplier block (PM) with the light guides is placed under the disk. This block divides the picture into the necessary number of parts so that each photomultiplier detects its own definite projection of a part of the track. The scale (S) of the agnle ϕ is drawn in the periphery of the disk and a scale S_y is along the y-axis.

A block diagram of the electronics is given in Fig.7. The probes P_ϕ and P_y ensure continuous measuring of the angle ϕ of the slot and of the ordinate y of the centre of the disk. These data are transmitted to the counting registers R_ϕ and R_y. The light from the track falls on the photocathode of the photomultiplier through the slot and forms electric pulses on the output, the amplitude of which depends on the position of the centre of the disk.

The amplitude of the pulses is maximal if the slot coincides with the measured part of the track. This moment is determined in the block of coincidences CL. The output pulse from the CL writes the number of the region ,in which the coincidence occurred,(i.e. the number of the photomultiplier)into the register R_N. Simultaneously it stops the registers R_ϕ and R_y and gives the order for the data y, ϕ and N to be read off.

Conclusion

In this paper the method of the fully automatic measurement of spark chamber pictures is described. This method is suitable for scanning tracks, which can be devided into a few direct parts. Such a special device is useful if a great number of pictures has to be treated. Output data from this device are treated by a computer. The main parts of this device have been tested. From these tests it follows, that the scanning rate of about one picture per second can be achieved.

Acknowledgement

The authors express their deep gratitude to A.F.Pisarev, Yu.M.Kazarinov for useful discussions and to P.Saxlova, J.Saxl and J.Skurovà for help in our work.

References

1. R.A.Bowen, H.E.Davies, P.Zanella. The Automatic Scanning of Spark Chamber Pictures to Determine the Parity of the Ξ^- and Σ^+ Particles. Preprint CERN-DD/DP/65/11 December 1965.
2. R.A.Bowen, E.H.Davies, J.C.Lassalle, J.Wilson, P.Zanella. Preprint CERN DD/DP/67/5, February 1965.
3. T.F.Anderson, P.M.Blackall, J.Daub, A.E.Heat, M.B.Metcalf, V.J.Weights. Preprint CERN DD/DP/67/4, February 1967.
4. P.Zanella. Preprint CERN DB/DP/66/5, October 1966.
5. I.Pless. Proceedings of the Purdue Conference on Instrumentation for High Energy Physics, May 12-14, 1965.
6. Z.Janout, Yu.M.Kazarinov, F.Lehar, A.F.Pisarev, Yu.N.Simonov. Preprint E-2560,Dubna, (1966).
7. F.Lehar, M.Maly, O.Shon. PTE, 5, 78 (1966).
8. I.Bystricky, F.Lehar, J.Cech, Z.Janout. Preprint P10-3910, Dubna (1968).
9. A.F.Pisarev. Theses. Dubna 1964.
10. J.Cech. Preprint P10-3122, Dubna, (1967).

Received by Publishing Department on December 2, 1968

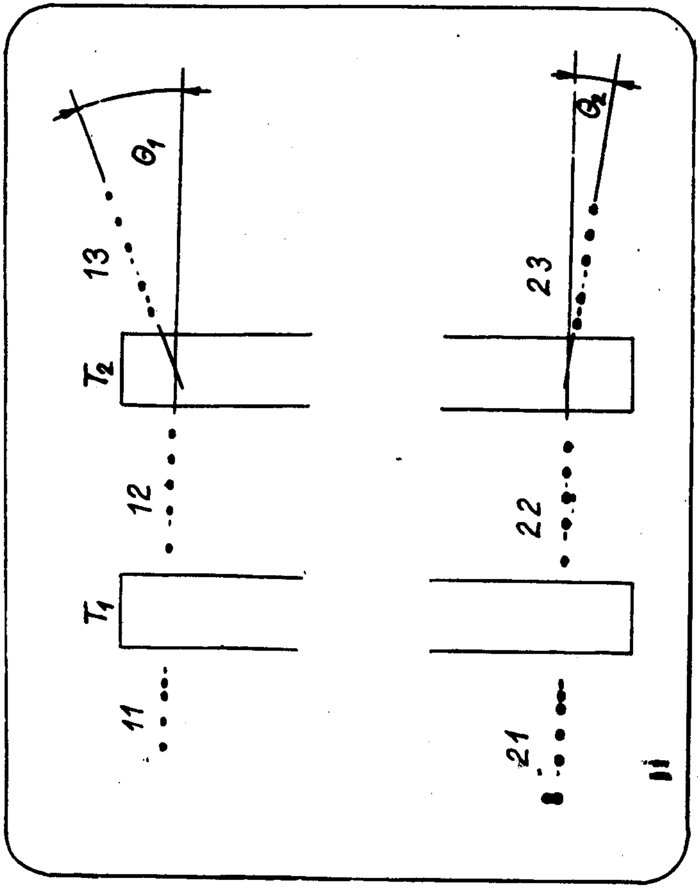


Fig.1

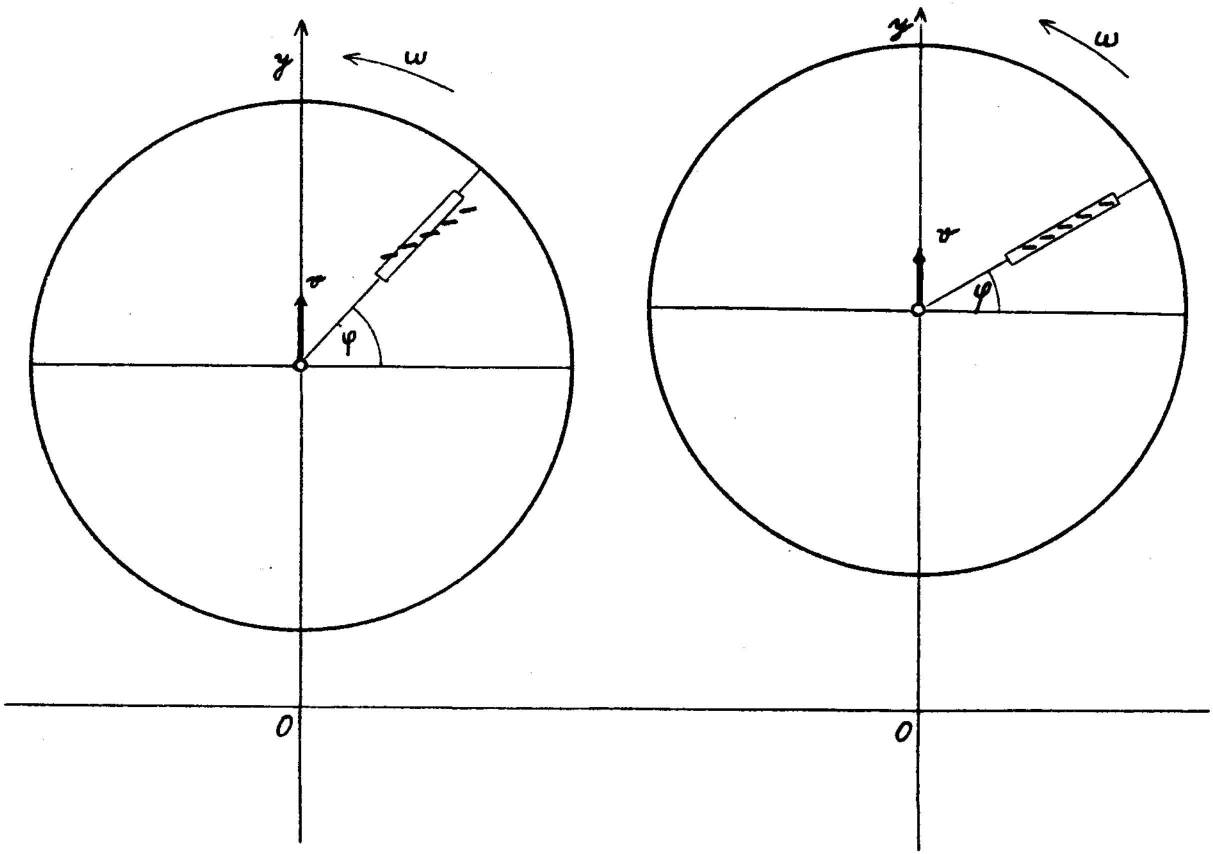


Fig.2.

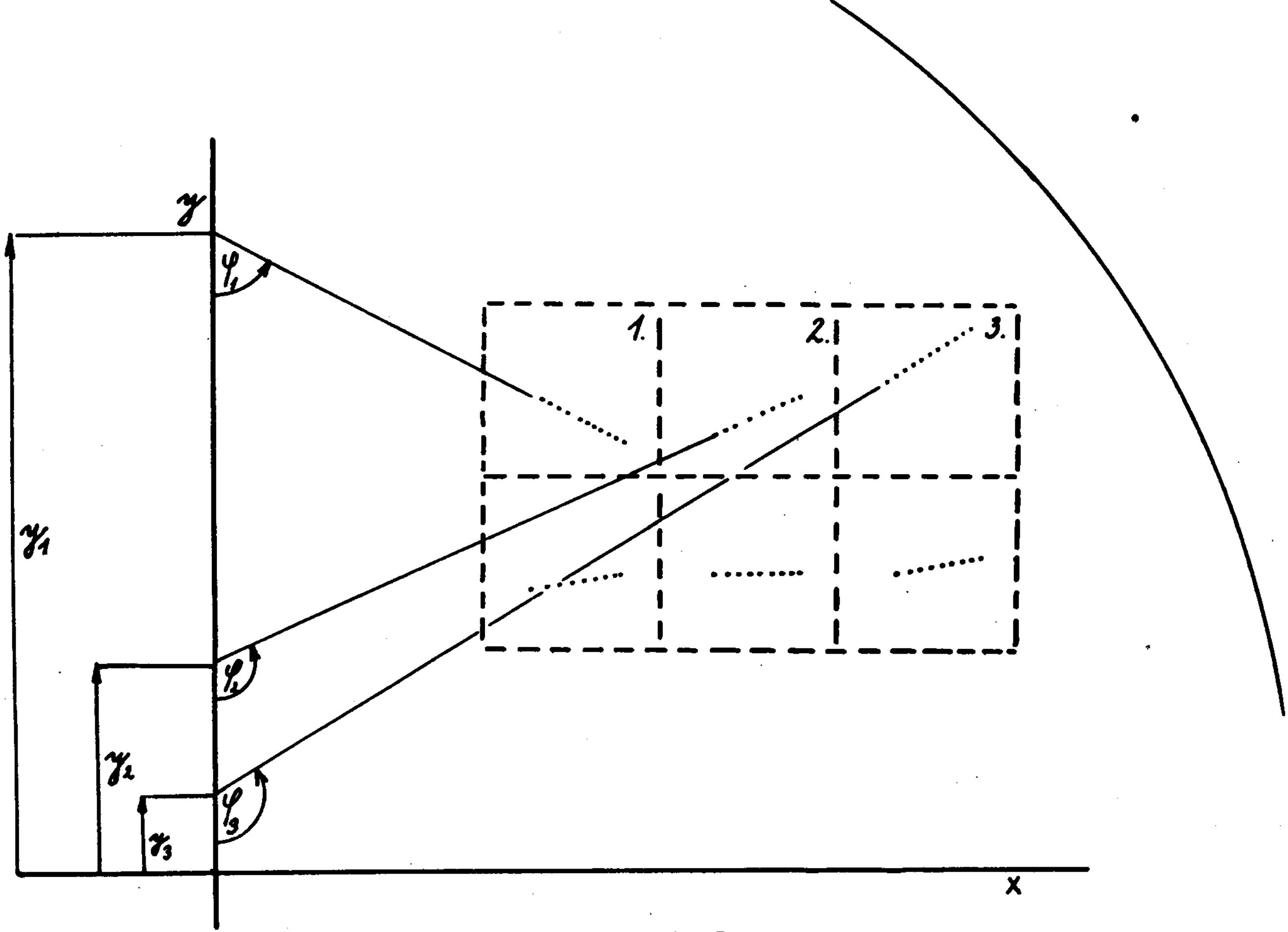


Fig.3.

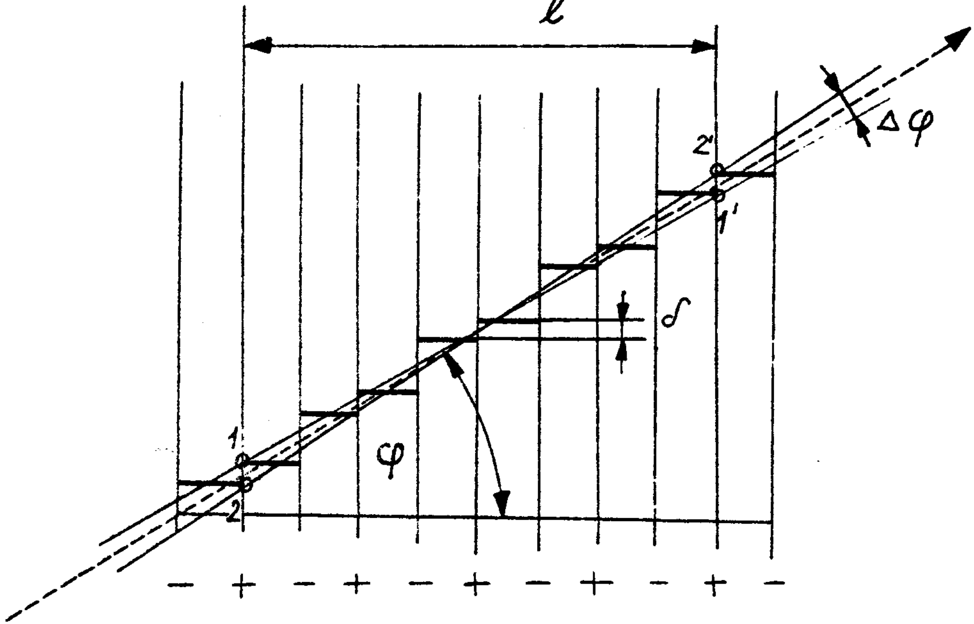
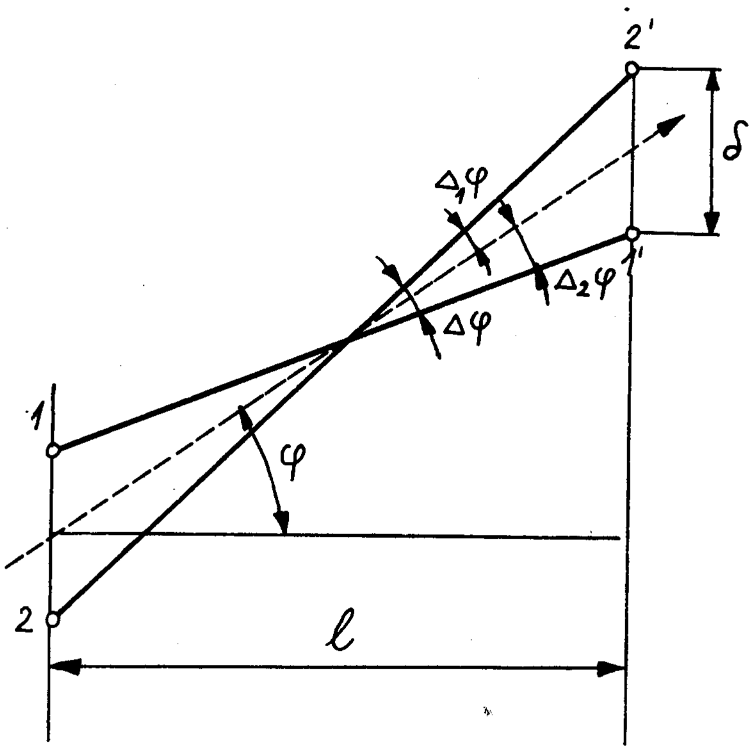


Fig.4.



2'
δ
$\Delta_1\varphi$
$\Delta_2\varphi$
1'
$\Delta\varphi$
1
φ
2
ℓ

Fig.5.

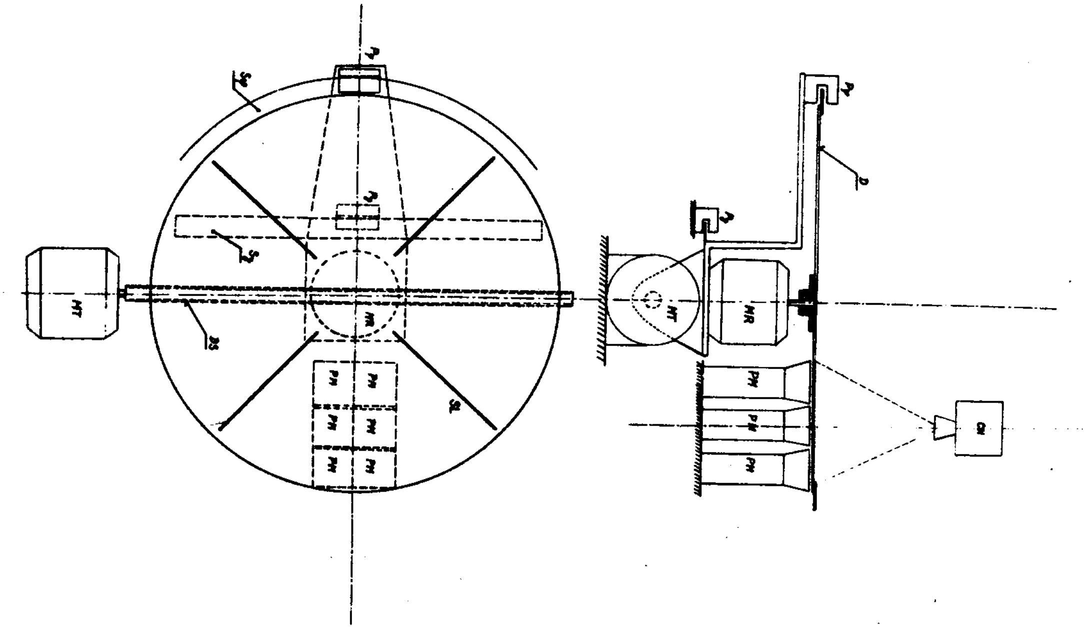


Fig.6.

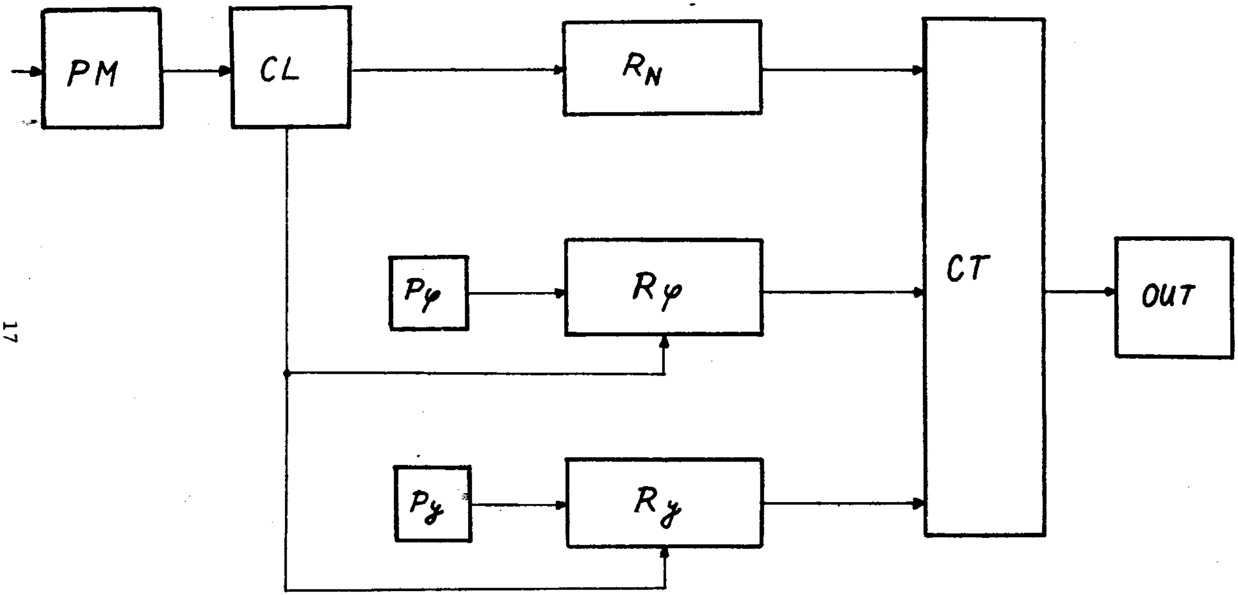


Fig.7