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EXPERIMENTAL INVESTIGATION OF BIOLOGICALLY INDUCED ENERGY TRANSPORT ANOMALIES

Hungarian Academy of Sciences

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EXPERIMENTAL INVESTIGATION OF BIOLOGICALLY INDUCED ENERGY TRANSPORT ANOMALIES

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ABSTRACT

The subject of the paper is an experimental investigation of biologically induced energy and momentum transport anomalies, as well as electric conductance anomalies. The test methods are detailed in the first and second part of the paper, the artefact effects discussed in the Appendix. The paper contains a sample of successful and unsuccessful test results.

АННОТАЦИЯ

Предметом настоящей статьи является экспериментальное исследование биологически индуцированных аномалий переноса энергии и момента, а также электрической проводимости, наблюдаемых при интенсивной работе головного мозга. Описываются проведенные эксперименты, излагаются возможные причины ошибок измерения и оценивается их величина. Приложенные фотографии показывают успешно проведенные и неудачные эксперименты.

KIVONAT

A tanulmány tárgya egy olyan energia, momentum és elektromos vezetőképességi anomália kisérleti vizsgálata, ami intenziv emberi agytevékenység esetén regisztrálható. A tanulmány a kisérletek ismertetésével kezdődik, majd részletesen ismerteti a mérési hibák lehetséges okait és nagyságát. A cikk végén több fényképen sikertelen és sikeres kisérletek láthatók.

C O N T E N T S

Introduction

Developments in physics and technology have always contributed to research in biology. The discovery of the microscope rendered possible the discovery of the cellular structure of living beings, the application of radioactive elements revealed important biochemical phenomena, and the application of X-rays is indispensable in diagnostics.

Recent technological achievments like computers rendered possible the development of X-ray and positron tomography, and the structure of DNA was revealed by a method developed by physicists.

Cooperation between physics, engineering and biology is indispensable, although at first sight the connection may seem to be loose. There is, for instance, no need to prove the importance of the electrocardiograph, which applies knowledge gained from electrical phenomena to biology, or to be more precise to biophysics. Magnetic phenomena are not as yet utilized to any great extent, but it would seem that they have important potential applications in medicine [1] - though there is a need for further work in this area.

Energy transport methods and boundary layer theory — fundamental areas in technology — have been applied only marginally in biology up till now.

The purpose of the present paper is to demonstrate, with the help of energy and momentum transport methods, the existence of a hitherto unknown effect. This area is practically a white spot on the map of science, but it seems likely that important knowledge could be found at the borders of transport phenomena.

Living beings make use of extremely sophisticated "designs" in their work, and by no means all of them are understood clearly at present.

This present work is purely experimental, its purpose being to examine a strange energy transport anomaly. Its physical nature is far from being understood, but testing is possible by means of our present knowledge of experimental methods.

The phenomenon to be investigated is rather simple: liquid rotates slowly in the proximity of the hands of some individuals as a consequence of hard mental effort and concentration. This movement is caused by an unknown effect, and it is reliably separable from the effects of artefacts such as vibration of the hands, air currents, etc.

Without doubt, the movement of the liquid is definitely caused by some sort of energy and momentum transport, and it is anomalous because its source has not been identified so far. In the given test series the source of this anomalous effect is an unidentified biophysical process, therefore this phenomenon will be termed "Biologically induced energy transport anomaly" (BETA) in the paper.

It is not known at this stage what function this phenomenon has in the human organism, it is not known how and why it is generated, nor whether it is a fundamental effect or a side effect. But it is certain that mental effort is necessary to induce it, therefore it might be of interest to neurophysiology.

When the experiments were designed it was kept in mind that they should be as simple as possible. The physical features of this anomalous effect should be investigated on a simple and well-known object, on which the cause of any change can be precisely identified and separated. For this reason and for additional technical considerations, liquid in a cylindrical Petri-dish was chosen for the target or the sensor of the test, and the changes on the sensor induced by the unknown effect are to be measured.

At a later stage of the experiments it was found that this energy (and momentum) transport anomaly is associated with an electric conductance anomaly as well. It does not seem unreasonable that further explorations could lead to the finding of additional anomalous effects as well, in view of which the extension of the research activity might be worth while.

About 500 experiments have been carried out so far, so some conclusions can be drawn, but the whole study is exploratory; further work is needed to improve the test methods. It is clear by now that the nature of the problem involves several branches of science, such as electrodynamics, hydrodynamics, physiology (neurophysiology) and psychology as well.

The apparent lack of link between these branches may explain the fact that this region has not been investigated. There is another reason as well: the effect is usually barely noticeable, so the chance of accidental discovery has been slim. The aim of this study has been to investigate a natural phenomenon, and no immediate practical application is intended; nevertheless, its practical use cannot be ruled out in the long run.

The effect was repeatable, but not every test subject was able to produce it, and those who could produce it were able to repeat it only when they were not tired.

Most of the technical details are described in the Appendix in order to make the report easy to read.

Acknowledgement

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Part I.

The subject of the paper is an experimental investigation of a Biologically Induced Energy Transport Anomaly (BETA). The existence of the above effect and its physical nature are not generally accepted. In view of this, it is essential to conduct an experimental investigation which satisfies the following criteria:

a.) The results should be repeatable;

b.) The experiment should be deterministic, free of unknown artefacts;

c.) The explanation of the results should rule out multiple interpretation of the cause of the results;

d.) The test results should be documented, and usable for subsequent analysis by other investigators.

The experimental method is the following: The test subject places his/her hands above a Petri-dish filled with water, and is asked to rotate the liquid without moving the hands and without touching either the Petri-dish or the water. A detailed description of the test method together with the documentation of the experimental setup is given in the Appendix. The experiments were carried out under a glass box to rule out ambient air currents. The effect of possible thermal, mechanical, vibrational, electrostatic, etc. artefacts is discussed in the Appendix.

The test subjects were all 15-17 year-old high school students. Three groups were selected for the tests:

Group 1: Mostly girls, majoring in arts and humanities, living in Szentes,

Group 2: Mostly boys, majoring in mathematics and physics, living in Budapest

Group 3: Mixed students of average academic achievement living in Szerencs.

With one exception the tests were carried out on Mondays, Tuesdays and Wednesdays; the students in Groups 1 and 2 were boarders at the high school living in the hostel of the high school (boarding school). They were selected and accepted by their school after a tough entrance examination (usually only one out of 10 applicants was able to pass the exam). The lifestyle, the food, and the requirements of both groups were similar. However, Groups 1 and 3 were located in the countryside, with a slower pace of life, whereas Group 2 was in the middle of Budapest, where the air pollution is perhaps the highest in Europe. There were significant differences in the weather as well, and not always the same person conducted the experiments.

Group 3 was selected from average students living with their parents, and only very few of them could meet the requirements of Groups 1 and 2. Some of the most important data are collected in Fig.1.

The major conclusions were the following:

a.) A significant proportion of the students were able to rotate the liquid.

b.) There was no single parameter which could be correlated with success or failure; however, there were very good indications for the important internal and external factors. These are the following:

1.) Internal features of a successful subject:

Extrovert, popular among classmates, easy-going; favourite subjects: humanities, good school performance; good marks in sports, athletics. Not tired at the time of the test, interested in the experiment, had had a chance to try it before.

2.) Internal features of an unsuccessful subject:

Introvert, shy, pessimistic about the outcome of the test and his/her abilities; favourite subject: natural sciences; not interested in sports. Tired at the time of the test, had never had a chance to try the test before.

3.) External features of a successful test:

Good weather, and a helpful, encouraging experimenter; calm, quiet surroundings.

4.) External features of an unsuccessful test:

Bad weather, noise, cold, rain, teacher-like experimenter. (It might seem strange, but when the author was the experimenter, the performance was usually weaker than with other experimenters).

It should be noted that statistics leading to comparison of performance might be misleading. Generalization is not yet possible, the database is not wide enough. In addition this method is not statistical: a single successful

case can prove the reality of the phenomena.
The performances of the subjects are plotted in Figs. 2-5. The performance is measured as the rotation angle during a given time, viz. 90-120 sec.
The performance of Group 1 was filmed using a 16 mm movie camera. However, the control measurements filmed during Feb.1985 were badly underexposed, and therefore discarded.
The performances of Groups 2 and 3 were photographed with a still camera (using 24x36 mm black-and-white 12 ASA film).
This method is very much less expensive, but less informative as well.

The shutter of the camera is opened for 120 seconds, with a 1/16 aperture. Longer exposure is not possible because the film becomes overexposed. The marker's movement leaves a white-grey path on the plate during the exposure. However, the better the movement, the poorer the picture. This is an inherent problem of the still photography method. The alternative would be a series of photographs, about 30 sec/frame. However, even the soft click of the shutter worried, upset, or disturbed some subjects, and they pulled out their hands immediately (those tests were considered unsuccessful). The usage of an automatic winder is therefore not recommended, or sound screening should be applied.

The other major problem with still photography is that it is inappropri - ate as a means of detecting the rotation of the markers around their axis, the variation of speed, and the direction of the movement.

Test procedure

a.) The whole class (25-35 students) is briefed about what is to be done, what hand position is to be used, and what is to be expected. The students are divided into teams of 6-8 persons, in alphabetical order.

b.) Before the test, the students' data are recorded: name, age, favourite subject, marks in gymnastics, and level of fatigue.

c.) During the test, only the experimenter is present in the room with the subject. The subject is given 2-3 minutes for a "warmup". For Group 1, only the successful tests were filmed. The other groups (with still photogra-

phy) were photographed regardless of the results. The shutter was usually opened after 180 sec and, in the case of an unsuccessful test, closed after 90-120 sec, whereas in the case of successful runs after 120 sec. The movie film was shot for 90 sec.- with the exception of the first and second runs, which took 180 sec.
The second run was filmed right from the start. Nothing happens for about 100 sec, then the rotation starts slowly and it gets quicker and quicker. However, this method consumed so much film that only 20-30 trials could have been filmed. Therefore, later on only successful runs were filmed, and even those were only partially filmed. Nobody in Groups 2 and 3 was allowed more than 180 sec warmup time, and no more than 300 sec was given for Group 1. Therefore the tests were quite continuous for the last two groups, and time is plotted on the performance chart.
In the case of Group 1, this was impossible due to the technical difficulties of the movie making, i.e. the frequent technical breaks. Therefore time is not plotted on the performance chart of Group 1.
The subject is asked to put his/her hands carefully into the glass box, through the curtain. On no occasion did this movement cause a visible marker movement. During the tests no immediate movement was ever observed, the quickest results came after about 60-100 sec.
The experimenter started filming after the rotation was more than 30^0, or started photography after a visible movement, or after 180 sec following the start of the experiment, but not before the 100^{th} sec.
During the photographic sessions, the experimenter recorded the angle of rotation, the exposure time, and the direction of the movement, and any special events were noted.

d.) After the test the palm temperature was taken along with the palm size, except in the case of the December 1984 tests.

General remarks

The students were told at the start that they would not be rewarded if successful, and they would definitely not be punished if unsuccessful. It was explained that concentration and full attention were necessary, and that the test is similar to that when a sportsman attempts to break a high jump record.

Neither the real nature nor the basic issue of the experiment was explained. In the case of Group 1, they were not very interested in the technical details, they just wanted a good performance. The subjects of Group 2, were generally interested in the technical and physical details, and several of them stated that the task was impossible. They wanted to know as much about it as possible, and they knew physics quite well, but obviously lacked information on the details of the Maxwell equations. None of those could perform successfully who expressed doubts about the phenomenon. (However, some of the author's skeptical fellow workers performed quite successfully, but these results are not on record). In Group 3, the interest was mixed. One class (III.b) - having the worst reputation among the teachers - was selected as an additional test group. Their performance was the best. A group of friends happened to be in a team, starting with No.66. They made high performance a matter of prestige and a burst of good results came as the outcome. In this case the experimenter was allowed to continue the test, so the camera was rewound, while the subjects continued without pulling out their hands. In this case the test period was about 300 seconds. Other subjects, apart from Nos. 67 and 72, were not allowed to prolong the test.

The subjects were asked to have their hands in the "L" position. There were two exceptions to that. During the control tests of Group 1, "T" positions were maintained, and the last class in Group 3 was asked to have a reverse "L" position (subjects Nos. 91-116).

There was one exceptional class in Group 3 (Nos. 1-30). The first class in that school was not told what result to expect. While the briefing was usually held on the day before of the test, this class was briefed on the very morning of the experiment, and the first team immediately came to do the test. As they were first in the tests they had no information about the expected outcome. However, there was a major problem - the pouring rain. Only one subject, a boy, could perform successfully, and also a teacher during a break (not listed in the test results).

The exceptionally poor performance continued for the second class as well, who were already told what to expect. Their performance suddenly improved when the rain stopped. (The same phenomenon occurred in Group 1 on the second day. As long as it was pouring with rain there was no visible marker movement).

This phenomenon clearly shows that statistical comparison, without stating the conditions, is misleading.

Technical issues of the experiment

A linear phenomenon is the best means of detecting the presence of a mechanical force field. Laminar liquid flow is appropriate for this purpose because there is no minimum force field density threshold (to overcome surface friction).

Due to the low viscosity of water, a very small force field density is enough to cause a visible motion, deformation. (Some organic solvents have lower density, and smaller viscosity, but all of them have an unpleasant odour. As the measurements were always carried out in a closed room, their usage was ruled out).

A circular motion was chosen instead of a linear one because in this way a smaller mass is involved in the movement, and the movement tracking is easier technically. Finally, liquid movement was chosen,

, because in this way it is possible to map the field properties of the BETA force whereas for a solid body it is impossible. Besides, due to the smaller density of water compared with most solids, larger, quicker movements were expected for the same force density.

It is seldom noted that a mechanical force (regardless of its cause) has inherent field properties. Sometimes force/area - (pressure, mechanical tension) is used, but usually force/volume - force density is used. Force never acts through a dimensionless point, it is always a simplification. In the experiment the field properties are of crucial importance because one can assume that in the case of an average subject this mechanical force field (the consequence of BETA) has a very small density.

It is possible to map the azimuthal force field distribution in a cylindrical dish, but not the axial one, and only partially the radial component. The homogeneous radial force field distribution will not cause motion, only the shape of the liquid surface will change; inhomogeneous distribution could cause motion in a liquid.

Given a steady or transient mechanical force field distribution in a liquid (or gas), hydrodynamics is capable - in principle - of solving or determining the resultant liquid movement. The chances of successful solution are higher in the case of laminar flow. Even in this case the steady, linear movement is preferable. However, in our case it was not the mathematical, but the technical simplicity that was the primary objective, therefore the mathematical solution is not going to be simple.

The time-dependent, three-dimensional mapping of the flow velocity distribution is not a simple task. Due to several financial limitations, the Baker method [2] could not be implemented in the first stage of the work. Therefore at the initial stage of the tests the flow velocity measurements were restricted to only two spots on the surface. Small circular or triangular markers were placed on the surface of the liquid, preferably at half-radius distance from the centre, opposing each other.

Thus two velocities could be recorded simultaneously. The edges of the markers were immersed in the liquid so that their velocities were identical to that of the surrounding water. The shape of the markers and the usual velocity distributions are shown in Fig.6. It seems that the velocity has a singularity in the centre, which always causes mathematical complications.

Concluding remarks

The test series showed that liquid BETA is quite repeatable; however, this repeatability is different from in the case of machines. When the control measurements were carried out in Group 1 in Feb.1985, the same subjects who performed very well in Dec.1984 were unable to repeat it. That is, the whole phenomenon is not a "switch on-off" type process. It is not easy to achieve repeatability because the ambient and internal conditions (weather, noise, physical and mental fitness) cannot be repeated.

The marker method for velocity measurement has severe limitations; it is inappropriate for the numerical evaluation of the process. It is very difficult to compare two cases: when one subject rotated the whole liquid say 30^0, and the other only a part of the liquid, but 180^0.

Due to these problems, any statistical comparison is to be considered with extreme caution. Other parameters, such as the experimenter's personality, his/her effect upon the subject's performance, may further complicate the issue.

The hands frequently covered the marker movement, and it was annoying when the filming was terminated during this period. The movement should be filmed from under, if possible, or with two cameras. Any further improvement requires a definite technical complication and a cost increase.

If smaller Petri-dishes are used during the experiments, higher speeds are expected in principle. However, then the hands cover proportionally a larger area, therefore a 14 cm dish was always used.

(During the long, repetitious, thermal artefact measurements a rather strange thing happened twice. Due to a sudden, loud, sharp, outside noise I became frightened for a moment, and the angular velocity of the movement accelerated. While the angular velocity had not been higher than 6^0/min for any artefact (see Appendix), during these events the angular velocity became 12^0/min. I was about 1 meter from the Petri-dish, which was covered with the glass box as usual. The room was closed, there was no way for measurement error because the data (the marker position versus time) were taken continuously. The sudden noise made me tremble, but the measurement was continued. This observation is unrepeatable because the emotional change was caused by an unexpected event, while experiments deal with expected events. The case is mentioned only in order to pinpoint that BETA could perhaps be detected in different circumstances as well.

The result (12^0/min) is higher than any artefact-produced effect, but lower than the minimum accepted value for the experiments (-15^0/min).).

Unfortunately a printed paper cannot describe properly a movement but Plates 1-8 might be of some assistance to the reader, they might help towards a better understanding of the measurement methods and the results. The results were taken from the Group 3 tests.

The filmed results of Group 1 were edited and can be seen under the title "Bioelectricity". (Here its meaning is more general than in the usual sense.)

The sequence of the film is the following:

1.) The neighbourhood of Szentes high-school is shown.

2.) Subject No.1 walks in, touches the electrically grounded lukewarm radiator, sits down, starts the experiment.

3.) The rotation of the liquid is shown.

4.) A group of subjects - the best ones - are shown, and the data collection.

5.) The experiment on subject No.2 is shown, along with the camera, the timer, and the start button.

6.) Artefact experiments. The effect of different temperatures, highly charged ebony and glass rods.

7.) The MHD analogy is shown with polarity reversal, and the effect of different force field densities. In a smaller dish the magnetic and electric field densities are higher, and the angular velocity is higher as well. The bubble generation on the electrodes is visible as well.

8.) The glass box of the experimental arrangement is shown. At first a metal strip is placed, which electrically connects the two metal grid-covered hand supports. The coordinate system is placed on this, later the Petri-dish, which is then filled with water. The markers are placed on the surface, then the glass lid is replaced.

9.) The results of the experiments are shown.

Part II.

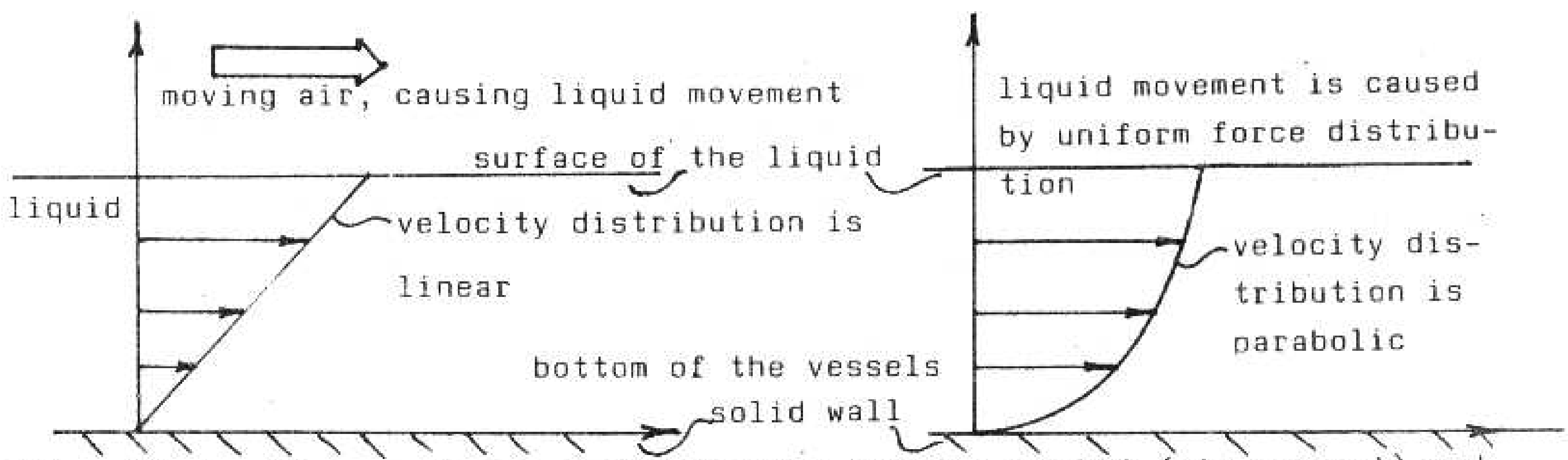
Application of an electrochemical method for velocity distribution measurements.

It was mentioned earlier that the BETA effect is usually barely noticeable, only a part of the target liquid is rotated by the subject. In this case the floating marker may not indicate movement at all.

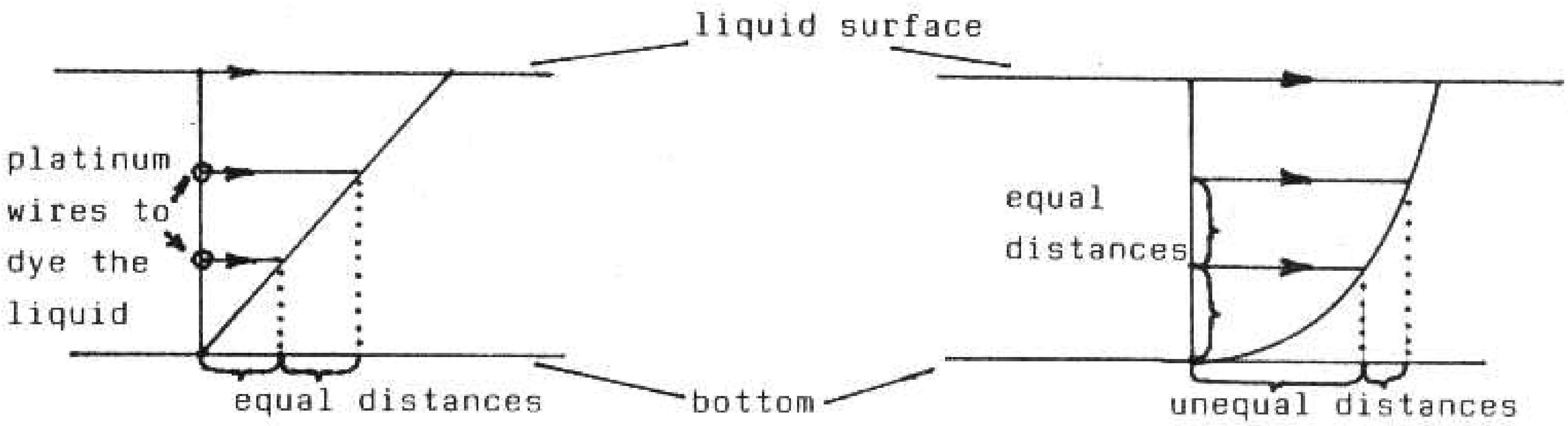
Ideally every point in the liquid target should be marked and traced, but this is technically unsolvable. A good compromise is to dye a region of the liquid so the movement of the liquid is detectable. The liquid movement should be detected at least at two cross sections, (along two perpendiculār diameters in a cylinder) and at different axial distances. This problem has been solved in the present work by an electrochemichal method, the liquid in a Petri-dish is dyed along thin platinum wires, so the movement became fairly detectable. (The technical details will be discussed in the Appendix).

This method renders possible the experimental investigation of the liquid velocity at different depths, so apart from the local velocity distribution even the type of the flow can be determined. This is very useful because it is directly related to the force distribution (field) which is the cause of the movement.

To put it simply: if the cause of the liquid movement is a thermal artefact, the velocity distribution is linear (Couette flow, see sketch below), but when the force distribution is uniform, the velocity distribution is parabolic (Hartmann type flow, see sketch below)



This effect offers a chance to distinguish between artefact (air current) and genuine BETA movement. Due to the parabolic distribution, the distance between the dyed liquid filaments will be smaller than for the case of linear distribution, as shown in the following sketch:



The flow is more complicated in our case because it is not a simple translational flow but a rotating one. However, as a crude approximation this method is acceptable.

In principle the flow distribution could be detected more precisely with more than two wires at a cross section. In this case, however, only one dyeing pulse could be used as the second impulse would generate an overlying structure, which would be too complex for evaluating the measurement. An additional reason for the two-wire solution is that the stained dyed liquid has a certain thickness (due to diffusion) and when the edges of the dyed filaments are near to each other, the test results are hard to evaluate.

When the liquid velocity is small, only one or two impulses are required otherwise the picture of the filaments becomes blurred. There are additional advantages of the electrochemichal method: changes in the dye generating current can be measured, and plotted.

It has been found during a very successful pilot test that despite the presence of the dying current (a small LED flashed) there was only a marginal amount of dye, as if there were a short circuit between the platinum electrodes. Therefore later the dying current was measured with a portable ammeter.

The process and the results of the measurements:

This method has been tested by three groups. There were twelve adults in the first group, but the test procedure was initially marred by technical difficulties: there was no ammeter in the circuit at this stage, the film winder jammed after the 20th picture, so only some of the experiments were documented. Despite the problems these tests helped to determine the "teething" problems of the method, and it helped to develope the test method. There were two very good test results: one subject was able to influence the direction of the flow, and the other had a very high velocity performance. The other participants did not produce significant results. (This test series was not more than a pilot study, and its results are not shown in this report).

Hereafter the test procedure was as follows:

a.) The subjects's hands are placed into the glass box through the curtains, beside the Petri-dish - now filled with the aqueous solution of the chemical indicator.

b.) The test subject attempts to rotate the liquid in the Petri-dish (without touching it).

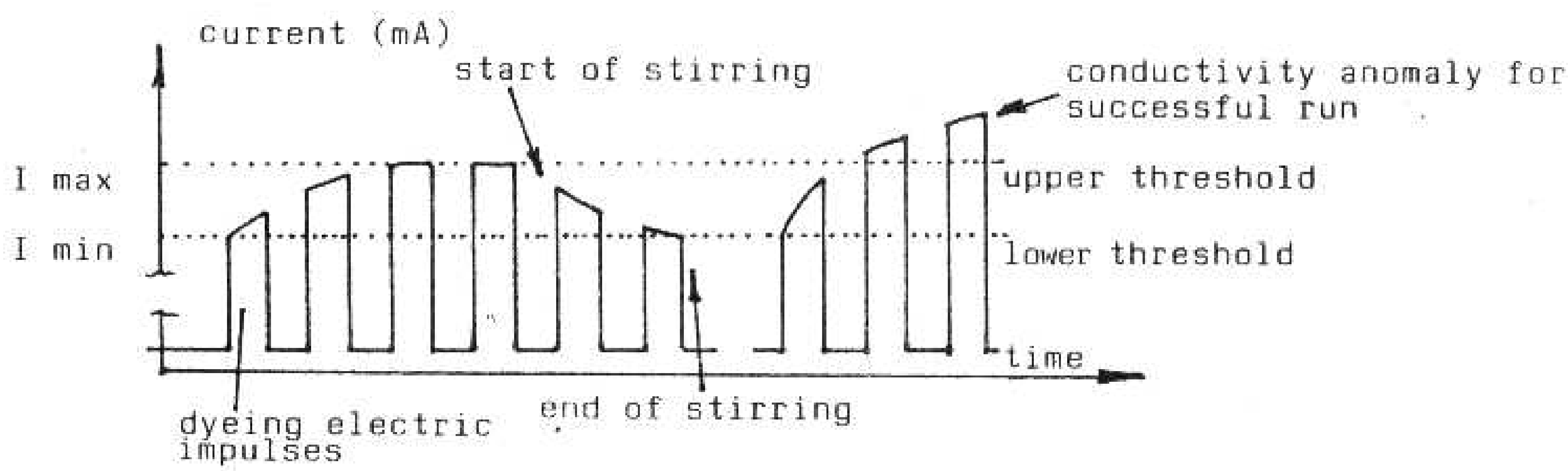
c.) When the experimenter observes the movement of the liquid (a small floating marker moves on the surface) the dyeing current is switched on. Depending on the liquid's angular velocity, the current is switched off after a while. In the case of slow velocity only 4-5 impulses are used, for higher velocities (better performances) 5-8 impulses were applied. The current of the dyeing impulses was measured and plotted continuously on a paper strip. (In order to eliminate the disturbing noise of pencils on the paper strip, this apparatus was taken to another room.) The duration of a dyeing impulse was ~ 15 sec, and the next one followed it by 15-30 sec.

In the case of the UNSUCCESSFUL RUNS the experimenter photographed the Petri-dish from above no later than one minute after the termination of the dyeing impulses. This one minute upper limit is due to technical reasons, the dye is dissipated in the liquid quite quickly, the stained liquid filament is no longer continuos after a minute, and therefore unusable.

With SUCCESSFUL RUNS the photographs were taken as soon as a noticeable liquid velocity appeared, and it took 5-10 seconds after a dyeing impulse. This short duration was necessary in order to have thick painted liquid filaments having strong contrast on the photographs. (The constrast of the filaments is noticeably weaker after about 15 seconds). This technical limitation is a definite drawback to the velocity estimation when a still camera is used. The experimenter had to watch for the start of the movement, switch the current on and off and take the photograph during the 5-10 second period; all this quite a demanding task. In addition, the experimenters had no previous experience in these test so the velocity estimation is less reliable in this case. This source of error makes the velocity measurements quite unrealiable, but fortunately previous measurements with the floating marker are quite reliable.

In the case of totally unsuccessful attempts the experimenter usually did not switch on the dyeing. After a successful run, a 5 min delay time had to be maintained in order to allow for the liquid to come to rest. After about every fifth test a control test was carried out without a subject in order to test the conductivity of the target liquid since in principle, changes could take place due to dissolved CO_2 content and temperature fluctuations. During the control tests the electronical contacts were checked as well.

Mention is made that the electric resistance of the target liquid is not constant because of electrochemical effects. The electrical resistance continuously decreased to a threshold value, thus the measured current reached a peak value. However, when the liquid was stirred, the electrical resistance of the electrolyte increased again to a threshold level. (This effect is shown in Fig. a). Any change apart from these values is due to some other unknown effect, see skech below):



Anomalies detected during the tests

During most of the tests, no anomalies were detected, there was no liquid movement apart from the known thermal effect, and the dyeing current was the same as during the control run.

However during some of the tests, the liquid started to rotate—locally, or in the whole dish— and an anomaly appeared in the conductivity as well. With small local rotations, (which are the majority of the successful runs) the electrical conductivity anomaly is barely noticeable.

When the whole liquid was rotated in the Petri-dish, the conductivity anomaly became more pronounced, see sketh above. This increment of electrical conductivity is considered to be an anomaly because the stirred liquid had a smaller conductivity during the control tests.

In principle two different effects may cause this result

1.) a temporary change in the conductivity of the electrolyte (this seems to be the most likely cause)
2.) electric current appeared temporarily from an unknown source during the period of a successful run.

In principle both effects could appear simultaneously but the present experiments were not designed to solve this issue, just to detect it. There was a causal relationship between the angular velocity and the conductivity anomaly.

The correlation is simple: the higher the angular velocity, the higher the conductivity of the liquid. The registered change in the conductivity was 5-7 % higher than the upper threshold value. This is not a very spectacular change, but it is detectable reliably (see Fig.b-d).

Such a conductivity anomaly has never been found without a detectable high speed liquid rotation, and true vice versa. But as was mentioned earlier, with small rotations the electrical conductivity anomaly is barely noticeable.

Test results of the second and third groups

96 students of the József Attila University, Szeged, comprised the second group. A still camera was to register movement of the liquid. On the first day of the tests black-and-white film was used, and some successful and unsuccessful results are shown on plates.

The results were generally rather poor, however local liquid rotations were visible from time to time.

On the second day colour slides were used for documentation, and the results were even worse. This was partly because the students did not have a rest on Saturday night, but the cloudy rainy weather might have contributed to the weak results as well.

None of the students had taken part in the experiment previously, and most of them were sceptical about their ability to carry out a successful test. The third group consisted of 69 pupils of the Horváth Mihály High School, Szentes, all of them had participated in the previous tests.

A 16 mm movie camera was used for the documentation partly with colour partly with black-and-white negatives.

This group proved to be quite successful, compared with the second group; occasionally an angular velocity of 180^{o}/min was achieved. The strongest electrical conductance anomalies were achieved and recorded in this group.

Unfortunately, most of the films were underexposed, but three successful tests were properly filmed.

Technically, the measurements were rather cumbersome, but the experimenter had a less complicated task.

The main technical difficulty was caused by the fact that the dyeing current power and the movie camera motor were plugged into the same electric socket, and this caused a noticeable, but separable effect upon the registered dyeing current.

Appendix

Experimental arrangement

The experimental arrangement consists of a Petri-dish under a glass box. Two sides of the box are covered with curtain where the subject of the experiment puts his/her hands inside the box. A piece of either wood or plastic of the same thickness as the depth of the Petri-dish is placed at one side of the dish and another piece is placed at the opposite side. The subjects's hands are placed on these. We have also carried out measurements in which each of these hand-supports was covered with a thin metal net and the two nets were connected to each other by a metal strip. The reason for this was to eliminate any electrostatic potential difference.

Beneath the Petri-dish was a coordinate system to facilitate the tracing of the movement of the small markers on the surface of the fluid. Various objects can be used as markers, e.g. sawdust, thin metal foil or possibly paint drops.

We compromised by using thin circular or triangular markers floating on the surface of the fluid. However, the disadvantage of this is that it is possible to register the velocity of about two points only. Because of the surface tension, the markers stick to each other or to the wall of the dish if they approach each other or the wall closer than a critical distance. If the marker is triangular and aluminium foil is used with water and a glass dish, then it is possible to prevent the marker from sticking to the glass wall.

Since the movement caused by surface tension is typical, always radial, it can be distinguished from BETA effects.

The most important part of the series of tests was a 16 mm film camera equipped with telephoto lenses and a timer. Thus the movement could be photographed from above at a distance of about 1.8 m and at a previously given time interval.

The experiment

The study was carried out with secondary school students, 14 to 17 years old. The subjects were mainly girls, from all parts of the country.

First we briefly explained the aim of the experiment and showed the position in which they should keep their hands. We asked them to try to concentrate as much as they could, but told them that it would not cause any problem if no result appeared. The subjects then entered the experimental room in groups of five, to give the following data: name, age, school achievements, mark in gymnastics, favourite subject, and present feeling of fatigue. They then left the room and were asked to return individually to carry out the experiment under the guidance of the experimenter whose main function was to control carefully the position of the hands and to watch the movement of the markers. As the movement started the timer was released and the camera worked automatically for 90 seconds.

The presence of the experimenter was necessary because we wished to avoid the need for the subject having to push a button with the foot and thus distract his/her attention. In spite of this, the movement was interrupted several times because the noise of the camera abruptly broke the silence.

Instead of the usual shutter speed of 24 frames/sec, speed one quarter of it, 6 frame/sec, was used. Thus, when projecting the film, the movement is shown four times quicker than it actually was.

Carrying out a measurement

On entering the room, the subject placed his/her hands for a very short time on the central-heating radiator in order to remove static electricity. After this, he/she sat down and put his/her hands through the curtains at the sides of the glass box above the Petri-dish. Two hand positions were used in the measurements: one of them the so called "L" position, the other being the "T" position.

Generally at least 2-3 minutes were necessary for a noticeable movement to be started. The camera was released only after this, and after 90 seconds the movement generally ceased quickly because the subject felt that the experiment was successfully completed. There were some subjects, however, who repeated this test successfully several times, without being photographed, but generally each subject had only one chance because our aim was to perform the experiment with as many subjects as possible.

The camera was released only when the markers were displaced by at least 30^0. The experiment was qualified as being unsuccessful if the displacement of the markers was less than 30^0 or if there was no displacement at all. In a considerable number of the cases - about one third - we were unable to observe any noticeable movement.

The students participating in the tests were specializing in drama, that is, they were taking special courses in acting. This is the only school providing this possibility in the country, and this was a major standpoint when the selection of the test subjects was considered. They had to pass a tough entry examination to be admitted to this school, in view of which they cannot be termed as "average" high school pupils. Their favourite subjects were poetry, drama, music and history; only one student was interested in physics.

They were extremely cooperative, helpful, cheerful and open - apart from one or two individuals - and they competed with each other in order to achieve better results. Interestingly, their school achievements were all more or less the same, generally the standard was "good". Definite conclusions cannot be drawn because of the fairly small number of subjects. However, it seems that students who are better achievers academically and who are also better at sports performed better in the tests than those of worse achievements in learning and in sports.

Movements of the floating markers

In general, the movements were tangential, but not always; i.e. the markers did not move along regular circles, but sometimes along irregular curves. It was interesting to observe that the deformation of the path happened mainly when one of the markers came close to one hand. It could also be observed that in the given "T" or "L" position the movement was generally clockwise, but sometimes counter-clockwise, too. A feature of particular interest was that the movement generally started counter-clockwise, then it quickly reversed to become a steady clockwise movement.

It is also interesting that nobody was able to control the direction of the movement for a given hand position. The subject could at most stop the movement, but without being able to reverse its direction.

Generally, the hands of the subject were 1-5 cm above the surface of the liquid, and they neither touched the liquid, nor the glass dish. In only one case were the subject's hands about 15 cm above the surface of the liquid, but even so there was a well detectable movement, about 360^0/minute. The subject in this case was a 27 - year - old female physician doing sports regularly, and she was very relaxed and mentally alert.

Analysis of thermal artefacts

Careful study of all possible artefacts is perhaps more important than the BETA effect itself, due to the debatable nature of the issue. As the hands were inside the glass box, their possible thermal, electrical and mechanical disturbance was analysed experimentally and theoretically.

The most obvious possibility of an artefact is the thermal effect. Heat and perspiration conducted through several layers of the dermis and epidermis could cause a disturbance through combined heat and mass transfer to the air under the glass box. In order to simulate these effects properly, the physical properties of the skin must be known.

Therefore the thermal physiological properties of human skin were studied before the hand simulators were built [5-17].

The most important conclusions were the following:

1.) The thermal conductivity coefficient (λ) is a function of the given layer (dermis, epidermis, etc.) The data are rather scattered. In Cohen's review [9] the lowest value is 7.5 $\frac{\text{cal}}{\text{sec}\ {}^{o}\text{C cm}} \cdot 10^{-4}$, (cold in vivo dermis) while 67 is the highest one for warm living skin. In most papers the thermal diffusivity coefficient is measured, $a=\lambda/\rho c$, [6,7,8,10], and the data calculated for λ are scattered between these limits.

2.) The internal heat transport capability depends on the thermal gradients and the convection heat transport through blood circulation [11,13,14,16]. The bulk temperature of the body is usually 37°, and the surface on the palms is usually 32 °C.

3.) The evaporation rate has a significant scattering again [15] and the important parameters are ambient temperature, humidity and stress. In the case of profound sweating, the skin is completely covered with evaporating sweat.

4.) The maximum skin temperature is limited because the denaturation of lipids (coagulation of proteins) starts at 40 °C, and increases at 45 °C [13]. Therefore 45 °C will be the upper limit of the surface temperature in our considerations.

5.) Transients in the skin temperature are rather slow due to the large thermal inertia and poor conductivity [17]. Nevertheless, to be on the safe side, this limitation will not be considered.

Thermal simulation of the hands

It is essential that the simulator instrument should behave thermally in the same manner as the original. The simplest way of simulation is a 1:1 geometry and temperature distribution. Fortunately there is no problem in constructing hand simulators that correspond to the usual sizes. The following sizes were chosen:

Man's left hand	right hand, "L" shape, two pieces
19x9x3 cm	12x9x2.5 cm plus 7x9x2.5 cm

Material: 1.5 mm thick aluminium plate.

Girl's left hand	right hand, "L" shape, two pieces
16x8x2 cm	Two identical pieces 8x8x2 cm

Material: 0.2 mm thick copper plate.

The sizes were chosen according to the maximum hand size. (The simulator of the girl's hand, due to its smaller surface, yielded proportionally smaller effects, so only the results from the simulator of the man's hand will be discussed further.)

The most important parameter after the size and shape is the thermal resistance of the walls. It should be much lower than that of the hands. The hand.surface temperatures are simulated simply by pouring warm water into the metal boxes, and measuring the temperature in the liquid, with a mercury thermometer.

Reliable measurement of outer wall temperatures is cumbersome - and expensive. However, if the thermal resistance of the wall is low, the outer wall temperature will differ very little from the internal temperature. The thin aluminium (and copper) plates have negligible thermal resistance so the internal temperature is taken during the measurements as the temperature of the hand surface.

In the case of skin, the thermal conduction coefficient - at its peak value - is 2.4 kcal/mh ^{0}C, while it is 190 kcal/mh ^{0}C for aluminium.

That is, the internal body temperature is always higher than the surface temperature due to the lower heat conduction coefficient. (The thermal resistance is δ / λ, where δ is the thickness of the wall. As the average skin thickness is about 1.5 mm on the human palm, the resistances are proportional to λ.)

The 2 cm internal thickness of the box is enough to allow internal convection, i.e. a uniform liquid temperature.

The evaporation effect could be simulated as well. When the boxes were covered there was no evaporation at all. When the boxes were open at the top, there was significant evaporation (partial evaporation). The evaporation maximum was achieved by covering the sides of the boxes with wet linen with the upper end of the linen strips immersed in the warm water in the box. Actually this caused a slow leakage of the warm liquid out of the boxes, but it ensured a completely wet surface. This high evaporation rate caused condensation on the internal side of the glass box lid. (This has never been observed with the subjects.)

The sides of the boxes could be covered with any heat insulation material to have different temperatures; however, this difference is not significant (1-2 ^{o}C) for the subjects.

Air movement due to heat and mass transfer

As it is well known thermal differences cause the formation of air currents. This phenomenon is thoroughly studied in engineering [18-21], theoretically as well as experimentally. These studies render possible the understanding of the nature of the heat and mass transfer phenomenon. The most important features are the following:

1.) The air currents will be laminar because the product of Gr.Pr (Grashof and Prantl number) is $2.58.10^6$ for air at 25 ^{o}C temperature difference, and $1.5.10^6$ for 15 ^{o}C temperature difference.
   (The turbulent motion starts at Gr.Pr $>2.10^7$; i.e. one order of magnitude higher if $\Delta t > 150$ ^{o}C.)
2.) The heat transfer mechanism is therefore laminar, free convection; the maximum thickness of the thermal boundary layer is about 2.2 cm at maximum,

while the maximum thickness of the velocity boundary layer is about 3 cm. The heat transfer coefficient (α) is 4.5 kcal/m^2 h ^{0}C at Δ t=25 ^{0}C, and α =3.97 for Δ t=15 ^{0}C. For the velocity and temperature distribution, see Fig.8.

3.) The air flow is external for the heated wall (hands), and internal for the glass box.

Within the boundary layers the situation could, in principle, be described mathematically. For a two dimensional flow (Fig.8):

$$\rho u\frac{\partial u}{\partial x}+\rho v\frac{\partial u}{\partial y}=g_x\beta\rho_\infty(T-T_\infty)\frac{\partial}{\partial y}(\eta\frac{\partial u}{\partial y})$$

will be the momentum equation, with the standard notation, and the energy equation will be

$$u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}=a\frac{\partial^2 T}{\partial y^2}$$

where T is the temperature, u and v are the vertical and horizontal air velocity components, x and y the space variables, ρ the air density, η the gas viscosity, and β the volumetric expansion coefficient of the gas.

Outside of the boundary layers the frictionless Bernoulli equations should be used.

The above partial differential equations of momentum and energy transfer are usually transformed into non-dimensional ordinary differential equations, and solved numerically.

It is very important to note that they are <u>linear</u> for the velocity and temperature distributions; that is, their solution will behave accordingly.

Unfortunately, our situation is not so simple for the following reasons:

1.) As the heat transfer problem occurs within a closed box, the flow is three dimensional.

2.) The heated wall has a three dimensional geometrical arrangement, this is another reason for the three dimensional calculation, it cannot be simplified.

3.) The liquid in the Petri-dish could move, and this moving boundary complicates the velocity specification at the boundaries.

4.) There is a possible mass transfer effect, and the simultaneous calculation of three dimensional laminar heat and mass transfer with moving boundary for internal - external flow is very complicated. Only a numerical solution is possible, therefore the most inexpensive and reliable solution for the problem is experimental simulation.

Simulation of combined heat and mass transfer

The simulation was preceded by "cold runs", i.e. when the glass box contained only the Petri-dish. Hours of observation could show no trace of movement (in a closed room). The result was the same when empty hand-simulator boxes were placed into the box.

During the simulation experiments the markers were placed about 3 cm from the centre, and the rotation angle was observed as a function of time.

The "L" arrangement was always used during the control tests. The duration of a test varied between 10 and 30 minutes.

An additional control test has been carried out to simulate the thermal artefact effect. As the shape of the metal boxes was not identical to that of the human hands, rubber gloves were used for hand simulation.

The gloves had a solid internal frame made of thin copper and steel wires. Then the openings of the gloves were stuck, except a small opening where the lukewarm water was poured in. The rubber was about 0.1 mm thick, its thermal resistance is similar to that of the human skin.

Results for even and uneven temperatures

Even temperatures

1.) Warm dry runs (boxes covered) $\omega_{max}=2^{0}/min$. $t_{max}=40\ ^{0}C$ (ω denotes the angular velocity $^{0}/min$).
2.) Warm, partial evaporation (open box) $t_{max}=45\ ^{0}C$, $\omega_{max}=4^{0}/min$, but usually if $t<40\ ^{0}C$, $\omega<3^{0}/min$.
3.) Warm, full evaporation, completely wet surfaces. $t_{max}=40\ ^{0}C$, $\omega_{max}=4^{0}/min$ (same as above).

Uneven temperatures

The hypothetical case when one hand temperature is markedly different from that of the other, was also simulated.

1a) Warm, partial evaporation

left box empty (20 ^{o}C), right hand boxes full of 35 ^{o}C water, i.e. the temperature difference is 15 ^{o}C. $\omega_{max}=6^{o}$/min. (The highes value observed).

1b) Left box full, right hand side empty. $\Delta t=15$ ^{o}C, $t=35$ ^{o}C. $\omega_{max}=4^{o}$/min.

2.) Warm, full evaporation, completely wet surfaces. $\Delta t=20$ ^{o}C left hand side empty, right hand side warm, wet. $\omega_{max}=4^{o}$/min.

The runs were repeated at lower initial temperature, 35 ^{o}C, 30 ^{o}C results were always weaker. The ambient temperature (including the water in the Petri dish) varied between 18 and 20 ^{o}C. When one side of the boxes was covered with thin aluminium foil, the results were weaker - but not significantly. Transient temperature changes do not play an important role due to the linearity of the equations. A temperature transient will cause a smaller movement during the same time interval as a steady state run.

Due to the above results, the criterion for a marginally successful run was set to $\omega_{min}=15^{o}$/min. This arbitrary value was chosen in order to leave some safety margin. It is important to note that the best performances had about 180 ^{o}/min angular velocity, which is an order of magnitude higher than the max. thermal artefact value.

However, apart from the significantly different angular velocity values, there are other major points to consider:

1.) Palm temperatures are usually between 30 and 32 ^{o}C, which is lower than in the control cases, i.e. in reality the 3-4 ^{o}/min is high for thermal artefacts. A number of unsuccessful runs showed no movement whatsoever during the whole run (Plates 3,4).

2.) The heat transfer is proportional to the palm temperature and surface; however, the palm temperature of the subjects did not show correlation with the performance, with one exception - subjects with cold hands $t<27$ ^{o}C) always performed poorly. Boys having larger palms tended to have a worse peak performance than girls.

Group 2 students (the worst general performers) had similar temperature distribution as the other two groups. During the rain, when the temporary performance was the lowest, palm temperatures were not lower than usual. The effect of heat transfer induced rotation appears right after the pouring of warm water into the simulator boxes. In the case of BETA induced flow, there was always a delay period, and sometimes quick, small scale local rotations appeared, which never occurred in heat induced flows. The artefact thermal effect test results were the same in the case of the rubber gloves as that of the metal boxes.

That is, not only the velocity scale but usually also the flow pattern is different.

For the above reasons, the conclusion is clear. In the case of the successful tests the observed movement cannot be explained by heat and mass transfer induced phenomena and the safety margin is at least one order of magnitude.

Ambient and internal air currents

Apart from the thermally induced air currents, the effect of hand-shaking induced air currents has to be considered as well. It should be noted that the momentum transfer between the air and liquid depends on the ratio of velocities, and densities of the interacting fluids (air and water). The coupling is very weak in the case of separated parallel flow, due to the three-order of magnitude difference in densities, and one order of magnitude difference in viscosity.

The hand shaking is an oscillation, which seldom resulted in any movement. On Plate 4, an unsuccessful attempt is shown, where the contours of the fingers are blurred due to hand shaking. In the case of visible hand shaking, the result was considered unsuccessful to avoid any doubt. Artificial "hand shaking tests" showed negligible marker movements and even those were not regular, cicular movements. Analysis of the successful experiments showed that most of them were free of visible hand motion.

The sides of the glass box were covered with a 2 mm thick broad cloth to avoid external air currents. Before the test, the effect of a strong draught and air jet was tried. The draught had no effect whatsoever but the strong air jet caused some movement, about 30 ^{o}/min. However, the jet was simulated by a vacuum cleaner, which is a far cry from any experimental situation. The doors and windows were closed during the experiments, and the subjects were told to put their hands very slowly and carefully into the glass box. The air current-induced flow will cause a Couette type (linear) velocity distribution in the liquid, while the BETA induced flow should have a Hartmann type liquid velocity boundary layer [22]. The measurement of the velocity distribution could itself verify the cause of the liquid movement.

For the above reasons, marker rotation and dye movement cannot be considered as an effect of air current.

<u>Electrodynamic and electrostatic effects</u>

The flow of electric current through conducting liquids in an ambient magnetic field induces a fluid motion (MHD effect). However, there are significant differences, and these will be described later in the paper. The flow of electric current through the hand - air - liquid - air - hand cycle is ruled out because the resistance of the air is extremely high. The electrical insulation breaks down if the potential difference exceeds a critical threshold.

If the hands are approximated by two 1 cm diameter spheres 5 cm apart, V_{min}=12800 V. Even then a spark would be between the hands through the air, and not through the liquid. As the subject touched a grounded metal object at first, then the electrically connected hand support, the dynamic effect can be ruled out.

Electrostatic effects were eliminated by the above method but their possible effect was simulated as well. Highly charged ebony and glass rods were held near the marker, and if the rod was quite near, it caused a slight, but definitely radial movement. Apart from two cases, which were not filmed and were considered unsuccessful, such radial movement has not been observed, the movement was azimuthal, i.e. perpendicular to the radial direction. (Even in the case of those two radial movements it is hard to explain it by normal electrostatics because the effect appeared after a long delay period.)

During the application of electrochemical method the whole circuit has been grounded, and the electrolyte was slightly conducting. This setup eliminated the possibility of strong electrostatic field build-up.

Electrostatic effects do not cause sustained rotational movements, therefore their possible effects can be eliminated.

As none of the possible artefact effects could explain the characteristic rotational liquid movement and its relatively high angular velocity, the effect is ostensibly induced by BETA.

Method of data analysis

In our case, in principle a 3-dimensional velocity distribution can be measured and, via analysis of the movement - in principle - the cause of the movement, a mechanical force field distribution, can be mapped. It is a further problem to find the cause of the mechanical force field - to establish the nature of the BETA. The experiment was designed on the basis of the multidimensional electrodynamics hypothesis [3].

The first part of the problem is the following:

Given: a transient, laminar, quasi-cylindrical, open-surface flow with velocity singularity, three-dimensional velocity distribution.

To be determined: the cause of the movement, a transient, cylindrical, three-dimensional mechanical force distribution. (Indirect problem).

This problem is rather unusual in fluid mechanics: usually the cause of the movement is given and known, and the resultant liquid movement is to be determined. (Direct problem).

The solution of reserve, (inverse) problems is possible in principle, at least approximately. However, at first the original problem, the mechanical force field velocity distribution task must be solved.

Analytically, the following direct problem can be solved: given a mechanical force field which yields a steady state, laminar, cylindrical, closed surface, non-singular, three-dimensional fluid flow.

The differences in singularity can be circumvented so that the place of singularity is replaced by a wall of small radius which does not disturb the flow significantly. The open surface problem can be circumvented in the case of low velocity. The surface plane is selected as a

$$\left.\frac{\partial V}{\partial z}\right|_{z=\text{ half height}} = 0 \text{ local velocity}$$

maximum, it will represent a symmetry plane for the flow in the axial direction. In this way the original flow-channel height is doubled, but only the lower half of the solution is of interest to us. The transient flow is more complicated to tackle, however, it can be represented as the sum of a series of steady flow problems, with approximate methods.

Within fluid mechanics, magnetohydrodynamics tackles the problems of our interest. Given an electrically conducting liquid, with the help of ambient magnetic and electric fields, and with the help of Lorentz forces, it is possible to produce a wide variety of mechanical force field distributions.

The nearest case to our problem is the following: given a hollow cylindrical channel (Fig.6) with electrically insulating top and bottom plates, and conducting inner and outer axial walls, there is a radial electric current flow distribution between these electrodes, and the channel is in a homogeneous axial magnetic field.

The governing equations are the following [4]:

rot $\bar{H} = \bar{J}$ for the electric current /1/

rot $\bar{E} = 0$ for the electric field /2/

div $\mu_0 \bar{H} = 0$ for the total magnetic field /3/

$\bar{J} = \sigma(\bar{E}+\bar{V}\times\bar{B})$ the electric current density /4/

$\rho(\bar{v}\ \mathrm{grad})\ \bar{v} = -\mathrm{grad}\ p + \eta\Delta\bar{v} + \bar{f}(\bar{r})$ /5/

Relation (5) is the Navier-Stokes equation for the liquid with friction:

div $\bar{v} = 0$ conservation of mass for the liquid /6/

$\bar{j} = \bar{J} \times \bar{B}$ mechanical force density distribution /7/

where $H = H(\bar{r})$ magnetic field distribution

$J = J(\bar{r})$ electric current distribution

$v = v(\bar{r})$ velocity field distribution

$f = f(\bar{r})$ mechanical force field distribution due to Lorentz forces

$p = p(\bar{r})$ pressure distribution.

σ, μ, η are specific conductance, magnetic permeability and viscosity of the liquid, respectively. Due to the symmetry of the flow, H and v are independent of ϕ, the velocity has only a tangential (azimuthal) component

$$V_\phi = V_\phi(r,z)$$
$$V_z = 0$$
$$V_r = 0$$

and $H_Z = H_0$ is the ambient axial component, and the tangential component $H_\phi = M_\phi(r,z)$ is to be determined also. In the case of small current densities and high Mo, $H_0 \gg H_\phi$.

The system of equations (1-7) will be transformed into a cylindrical coordinate system with the above-mentioned simplifications as follows:

$$\frac{\partial^2 H_\phi}{\partial z^2} + \sigma\mu_o H_o \frac{\partial v}{\partial z} = 0 \qquad /8/$$

$$\frac{\partial^2 v(r,z)}{\partial z^2} + \frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial v(r,z)}{\partial r}\right) - \frac{v}{r} + \frac{\mu_o H_o}{\eta} \cdot \frac{\partial H_\phi}{\partial z} = 0 \qquad /9/$$

$$\frac{\partial p}{\partial r} = \rho\frac{v^2}{r} \qquad /10/$$

$$\frac{\partial}{\partial z}(p+\frac{1}{2}HB)=0 \qquad /11/$$

The solution is the simplest for a hollow coaxial cylinder geometry, with a square flow channel cross-section (see Fig.6).

The boundary conditions for the walls are the following:

$$v=0 \text{ if } r=\begin{cases} r_1 \\ r_2 \end{cases} \text{ and } -a \le Z \le a \text{ inner and outer walls} \qquad /12/$$

$$v=0 \text{ if } z=\begin{cases} a \\ -a \end{cases} \text{ and } r_1 \le r \le r_2 \text{ top and bottom} \qquad /13/$$

Now Eqs./8/ through /11/ are to be solved with the boundary conditions of /12/ and /13/.

The solution, neglecting the intermediate steps, is in the form of a sum of the terms of a series.

The velocity distribution will be:

$$v(r,z) = -\frac{1}{2\pi\sigma\mu_o H_o r_1^2} \sum_{i=1}^{\infty} \frac{\omega_i}{\lambda_i} \frac{ch\omega_i z - ch\omega_i a}{sh\omega_i a - (\frac{\lambda_i}{\alpha})^2 \omega_i a ch\omega_i a}$$

$$\frac{Z_o(\lambda_i r_2) - Z_o(\lambda_i r_1)}{k^2[Z_o(\lambda_i r_2)]^2 - [Z_o(\lambda_i r_o)]^2} \; Z_1(\lambda_i r) \qquad /14/$$

where

$$\alpha = \mu_o H_o \sqrt{\frac{\sigma}{\eta}} \qquad /15/$$

and $$Z_o = J_o(\lambda_i r) - \frac{J_1(\lambda_i r_i)}{N_1(\lambda_i r_i)} N_o(\lambda_i r)$$ /16/

similarly $$Z_1 = J_1(\lambda_i r) - \frac{J_1(\lambda_i r_1)}{N_1(\lambda_i r_1)} N_1(\lambda_i r)$$ /17/

where J_o, J_1 and N_o, N_1 are respectively Bessel and Neumann functions of zero and first order, and λ_i is obtained from Eq./18/:

$$J_1(X).N_1(Xk) - J_1(kX).N_1(X) = 0$$ /18/

where $x_1, x_2, \ldots x_i$ are the roots of Eq./18/,

and $k = \frac{r_2}{r_1}$ $\lambda_1 = \frac{x_1}{r_1}; \ldots \lambda_i = \frac{X_i}{r_1}$

Finally: $\omega_i = \alpha^2 + \lambda_i^2$ /19/

Actually we need only a part of the velocity distribution, the lower half of it, which is symmetric to the distribution of the upper half.

This is what mathematical physics can offer in a more or less compact form of direct solution, for a steady-state case, with a homogeneous axial ambient magnetic field.

The transient inverse solution (what we need) does not exist in closed form to the knowledge of the author, but in principle it is possible to have a numerical solution.

However, Eq./14/ is very important because the velocity distribution to be measured will have a similar form.

The calculation procedures will be different for the MHD and BETA induced flow, but they contain several identical or similar aspects.

Calculational methods and aspects of MHD and BETA induced flows:

MHD flow	BETA induced flow
The task is usually direct. Given: an electrical current (J) and ambient magnetic field Ho distribution. The resultant mechanical force field distribution is to be calculated.	The task is always indirect. Given: a velocity field distribution. The cause of the movement - the mechanical force field - is to be calculated.
The flow is nonsingular (because there is an electrode at the singularity point) and rotational	The flow is singular, rotational (the artificial omittance of flow singularity is permissible.)
The problem could be steady state or transient	The problem is always transient
The calculation of the mechanical force field density $\bar{f}=\bar{J}\times\bar{B}$ is unambiguous.	The cause of the force density $\bar{f}(\bar{r})$ is not known, due to different BETA interpretations. The result of the calculation is the field $\bar{f}(\bar{r})$, it is to be used in BETA research. $\bar{f}(\bar{r})$ is not necessarily unambiguous.

The surface flow is problematic for both MHD and BETA cases but it can be circumvented by considering only the lower half of the flow in a closed channel.

The velocity distribution field (Eqs. /14/-/19/) is similar in both cases as is the mechanical force field distribution.

Using this mutual correspondence it is possible to simulate BETA induced flow with MHD flow, or vice versa.

This correspondence is important, it could provide a crucial element in BETA study because in this way it will be possible to analyse numerically the results of BETA experiments, this being a basic requirement in a rigorous study.

While keeping in mind the analogies, it is important to note that there are very definite and clear differences between the physical appearance of the MHD flow and the BETA induced flow:

MHD flow	BETA induced flow
Only an electrically conducting liquid will rotate (e.g. salty water), there is no movement with tap water or distilled water.	Any liquid will rotate, including distilled or tap water.
An ambient magnetic field is necessary.	There is no need for an ambient magnetic field (in the conventional sense)
An electric field is necessary, the electrodes must be immersed into the liquid.	There is no electric field in the conventional sense, there are no electrodes, the liquid and the glass dish are not touched.
There is an accentuated O_2 and H_2 generation on the electrodes during liquid movement when salty water is used.	There is no bubble generation.
When the polarities of the electrodes are reversed, or the direction of the magnetic field is reversed, the flow direction is always reversed.	When the hand positions are reversed, the flow direction is usually reversed, but not always.
With the given arrangement (Fig.7) the direction of the mechanical force field is tangential, and independent of ϕ, z, but depends on the radius.	The mechanical force field is frequently quite inhomogeneous, not only tangential, but rarely radial, $\bar{f}=\bar{f}(r,\phi,z)$

The last difference is rather unfortunate because strong inhomogenity makes the calculations more difficult, or it requires simplifications. During the measurements it frequently occurred that small, persistent whirls were generated, and the liquid was calm at a slight distance a bit off from the vortex. The marker method is unfortunately inadequate to map the velocity distribution in these cases. Only the Baker method (or photochemical Laser--beam method) could provide at least a good qualitative velocity distribution picture.

Results of the calculations

Based on the previously discussed analogy between the BETA flow and the MHD flow, it is possible to calculate the inducing fields, and the resultant velocity distributions. The velocity distribution of a BETA flow is shown in Fig. 6/a. Within the dish will be a point of zero velocity causing a singularity. This singularity cannot be simulated by calculations: it has to be replaced by a cylinder of radius r_1 (see Fig.6/c). Radius r_1 could be quite small, in which case more terms of the sum have to be used so the calculation will be quite lengthy.

In our calculations we used the following geometric parameter: r_1=1.4 cm, r_2=7 cm, a=0.21 cm(a being the height of liquid in the Petri dish). Five terms were used in the sum, thus an accuracy of about 20 % was obtained. Obviously this level of accuracy is not very good but it is nonetheless, suitable for an order of magnitude estimation.

It should be noted that the calculation yields velocity distribution, and not movement distribution, but their relation is linear for steady state problems. The fields of the anologous MHD problem are shown in Fig.7, but only the velocity field will be calculated below. As has been stated earlier, it is possible to induce liquid rotation by the MHD effect if there are electrodes in the liquid. Control calculations were performed for the following two cases:

a.) Normal conditions

The purpose of the calculation is to evaluate the maximum liquid velocity, where the input data are taken as they occur in nature, that is, the ambient magnetic field is that of the Earth's geomagnetic field 4.7×10^{-5} Vsec/m^2 and the specific conductivity σ is 7.7×10^{-6} 1/Ohm m. (Measured value of the target liquid.) The net current is taken to be 2.2×10^{-2} A, which is the maximum possible,otherwise it is fatal, or seriously harmful.

The maximum liquid velocity is 1.58×10^{-2} mm/sec (at the top of the liquid surface), which is a negligible value. If a smaller, more realistic current is chosen, the velocity is further reduced.

b.) Simulated conditions

During the tests the angular velocity of the marker exceeded 180^0/min a number of times, i.e. the velocity maximum was about 2-3 mm/sec. This speed can be simulated by higher conductivity and stronger ambient magnetic field. V_{max}=1.6 mm/sec is obtained if $B=5.10^{-3}$ Vsec/m^2 is chosen (hundred-fold increment) with $\sigma=7.7 \times 10^{-4}$ 1/Ohm m (hundred fold increment). The net current was of the same value ($I=2.2 \times 10^{-2}$ A).

It is easy to grasp that these B and σ values are very high and therefore the liquid could not have been rotated in the experiments by the MHD effect. It has to be added that in the experiments the movement was faster at the start, thus the force, inducing the liquid movement had to overcome the inertia of the liquid. Therefore a stronger force was needed than in the case of the above-mentioned steady state calculations.

Technical details of the electrochemical method

The electrodynamical velocity measurement method was developed by James Baker [2], and only minor modifications were used during the implementation of the method. These were the following:

a) A small amount of alcohol had to be used to accelerate the dissolution of the thymol blue,

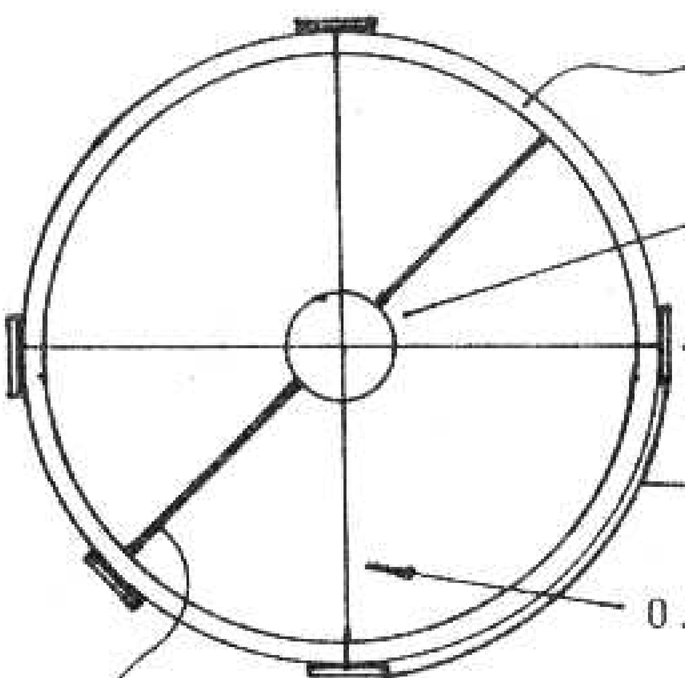
b) About 10 drops of concentrated NaCl solution were added to increase conductivity, thus the contrast of the dye increased. This slightly increased the density of the dye filaments so they were not perfectly free-floating. A better quality movie camera with more sensitive film, or video, would obviously yield satisfactory pictures from weak contrasts as well.

Higher voltage and current should be avoided due to the disturbing effect of bubble formation on the electrodes and heating of the target liquid.

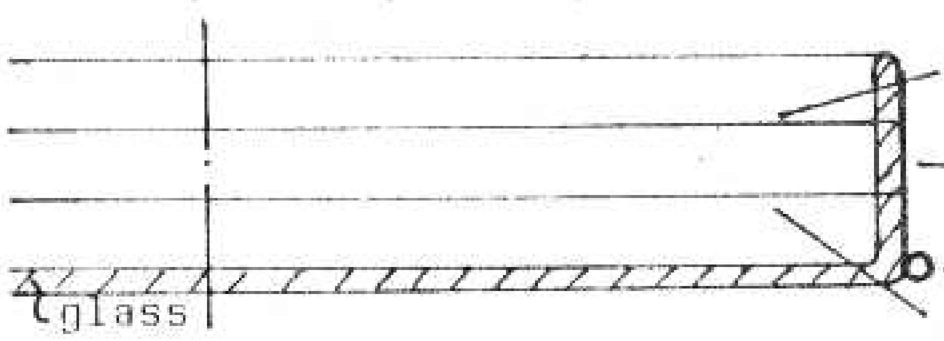
Homogeneous current density should be used in order to have uniform contrast during dye formation. This is very hard to achieve in a cylindrical arrangement, only the peak values could be cut off.

The following electrode arrangement was used:

from above

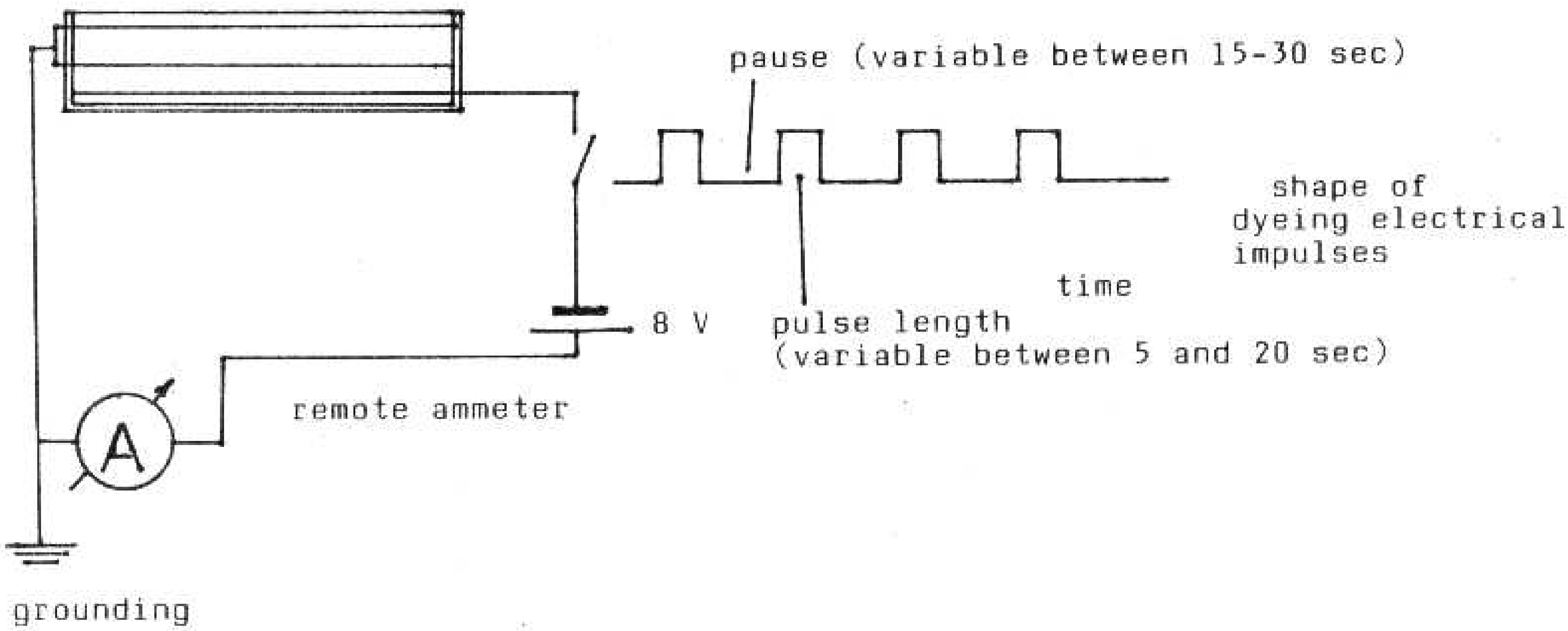


side view (cut, enlarged)



The thick electrode is on the bottom, it is not shown here. The liquid is usually filled within 1-2 mm of the top of the 18 mm high Petri-dish. The diameter of the dish is 140 mm. This electrode arrangement was chosen to reduce net radial current during dyeing and to facilitate adequate velocity mapping.

The electric circuit for liquid dyeing:



Possibilities for technical improvements of the test method

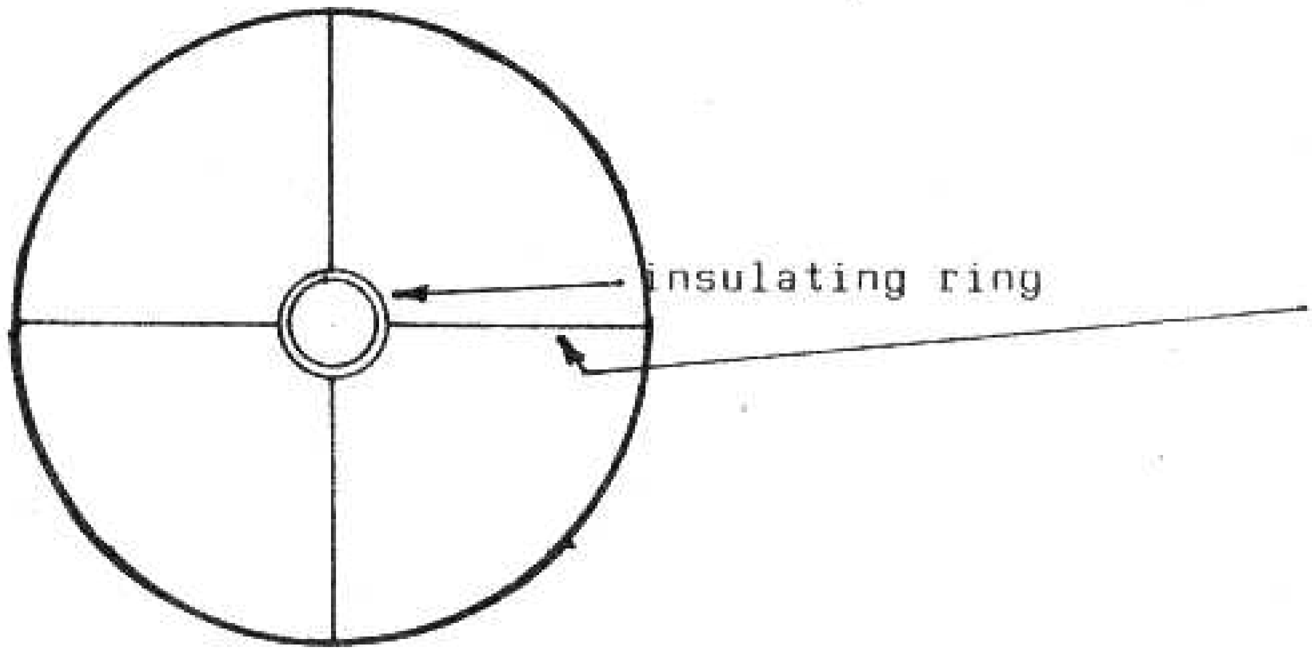
There are several possibilities for improvements both technically and in the test methods.

The most important technical step would be to construct an "energy microscope". While the present method applies only a single electric circuit for the conductance anomaly measurement, the liquid target provides a fine force field mapping. In other words, during the present measurements the appearance of BETA effect can be localized but the conductance anomaly cannot. However, the conductance anomaly could also be localized by the application of several electrical circuits (and ammeters). Even the presently used 4 - wire electrode system can be converted into an 8 - circuit "energy microscope" without the increment of hydraulic resistance, without a major change in the geometric arrangement. This would enable a local conductance anomaly to be localized, and it should coincide with a local rotation due to BETA effect.

Obviously the application of an 8 - circuit ammeter is more cumbersome, but it is frequently applied for EEG equipment and only minor modifications would be necessary.

The local coincidence of the BETA and conductance anomalies would be important because it could pave the way to detailed quantitative studies of the phenomena, significant information can be learned via this method.

Only a minor change in the thin electrode system would be necessary: instead of the continuous thin wires used at present, the length of a single wire would be half of the present one. See sketch below:



Instead of the full diameter, the sensing electrode would be about the length of the radius.

Two identical grids are placed one above the other.

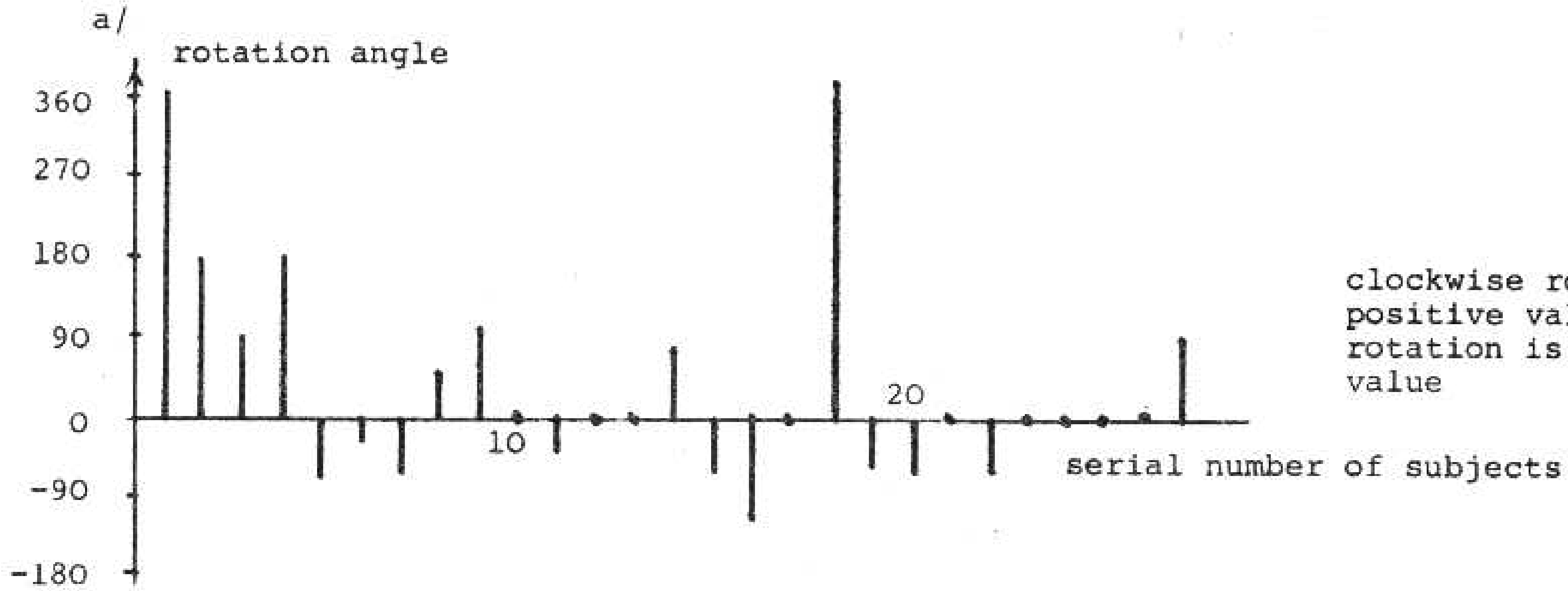
There is no change in the hydraulic resistance, but the sensitivity increases locally. In principle more than 8 circuits could be used, but the increment is limited by the hydraulic resistance, dye diffusion length (the dyed filaments become indistinguishable if too many of them are used), and data acquisition difficulties.

Certain aspects of the BETA effect suggest that these anomalies are basically electromagnetic in nature, therefore magnetic anomalies are expected to occur as well. But these are most probably very weak and hard to detect by the usual portable laboratory equipment. Nevertheless it might be considered at a later stage.

Group, date	Date	Experimenter	number of test subjects	boys	girls	successful boys	successful girls	Weather	Remark
Group 1 Szentes, drama [illegible] students	9^{th} Mon.	M. Dus	45	12	33	6	20	10 °C, sunny	morning+afternoon sessions
	10^{th} Tues.	M. Dus	28	4	24	2	5	10 °C rainy sunny	during rain no results
Dec. 1984.	11^{th} Wedn.	M. Dus	20	3	17	2	10	10 °C sunny	morning sessions only
Febr. 1985.	11^{th} Mon.	G. Egely	31	7	24	2	4	-20 °C stormy	generally poor results
	12^{th} Tues.	G. Egely	18	7	11	2	3	-20 °C stormy	
16 mm movie film		Same subjects as in Dec. 1984, but not everybody							
Group 2 Budapest, Math-Phys. students, still photography April 1985.	22^{nd} Mon.	M. Dus	34	21	13	10	1	20 °C sunny	polluted air, weak results, good weather for each day
	23^{rd} Tues.	G. Egely	31	20	11	5	1	20 °C sunny	
	24^{th} Wedn.	G. Egely K. Bartha	32	22	10	5	1	20 °C sunny	The results improved when Kati Bartha was the experim.
Group 3 Szerencs, average students, still photography May 1985.	3^{rd} Fri.	Z. Smajda	46	17	29	2	7	18 °C rainy	during rain very poor results
	6^{th} Mon.	E. Gyomlai	43	21	22	10	6	20 °C sunny	good results
	7^{th} Tues.	K. Szarka	25	10	15	7	10	25 °C sunny	good results

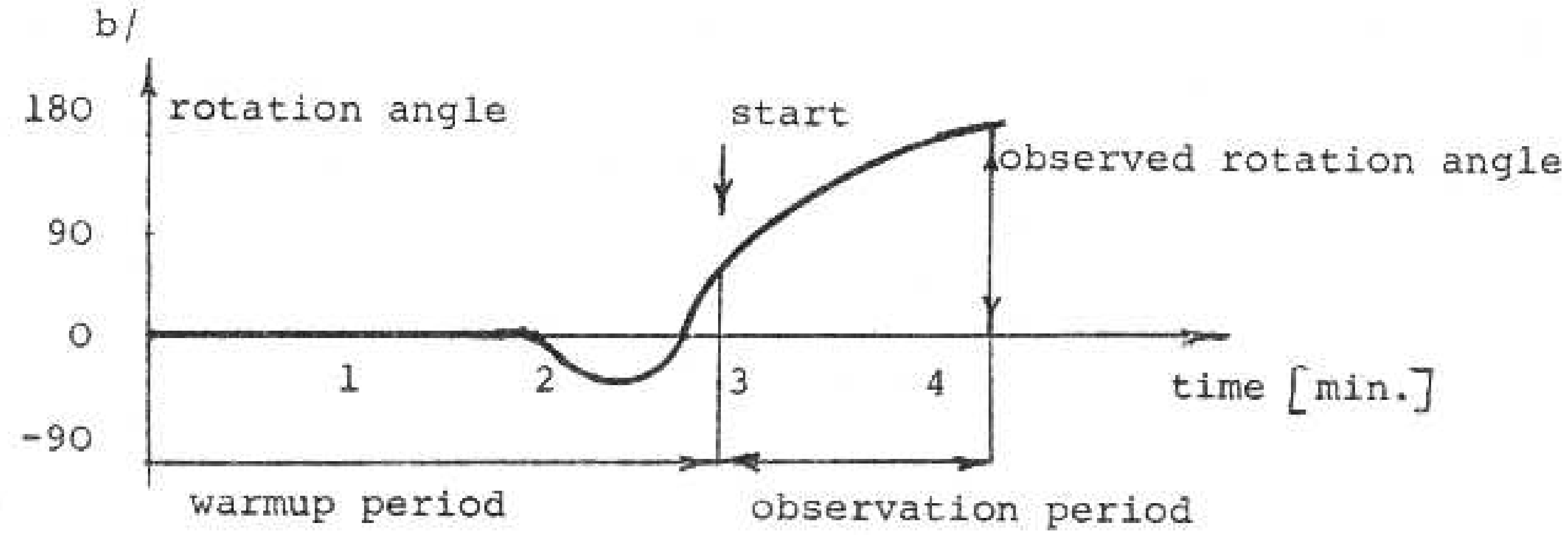
Figure 1.: Statistical evaluation of the tests. The criterion of success: angular velocity $> 15\ ^{o}/min$.
/A different criterion would yield a different success rate./

a/



clockwise rotation is plotted as a positive value, while anticlockwise rotation is plotted as a negative value

b/



An individual performance diagram. The marker position is plotted as a function of time. The two markers do not always have identical angle-time plot, i.e. their velocity could be different. On the performance charts the larger movement is plotted.

Figure 2. a/ Performance chart of a part of Group 1, Szentes. The first ten subjects had several trials at home, they were experienced. The observation period has been 90 sec, except with subjects No 1 and 2. The plotted results are of 9 Dec. 1984, morning session, the best results of the whole test series.

b/ The position of a marker as a function of time. The small "kink" appeared quite frequently, but not always.

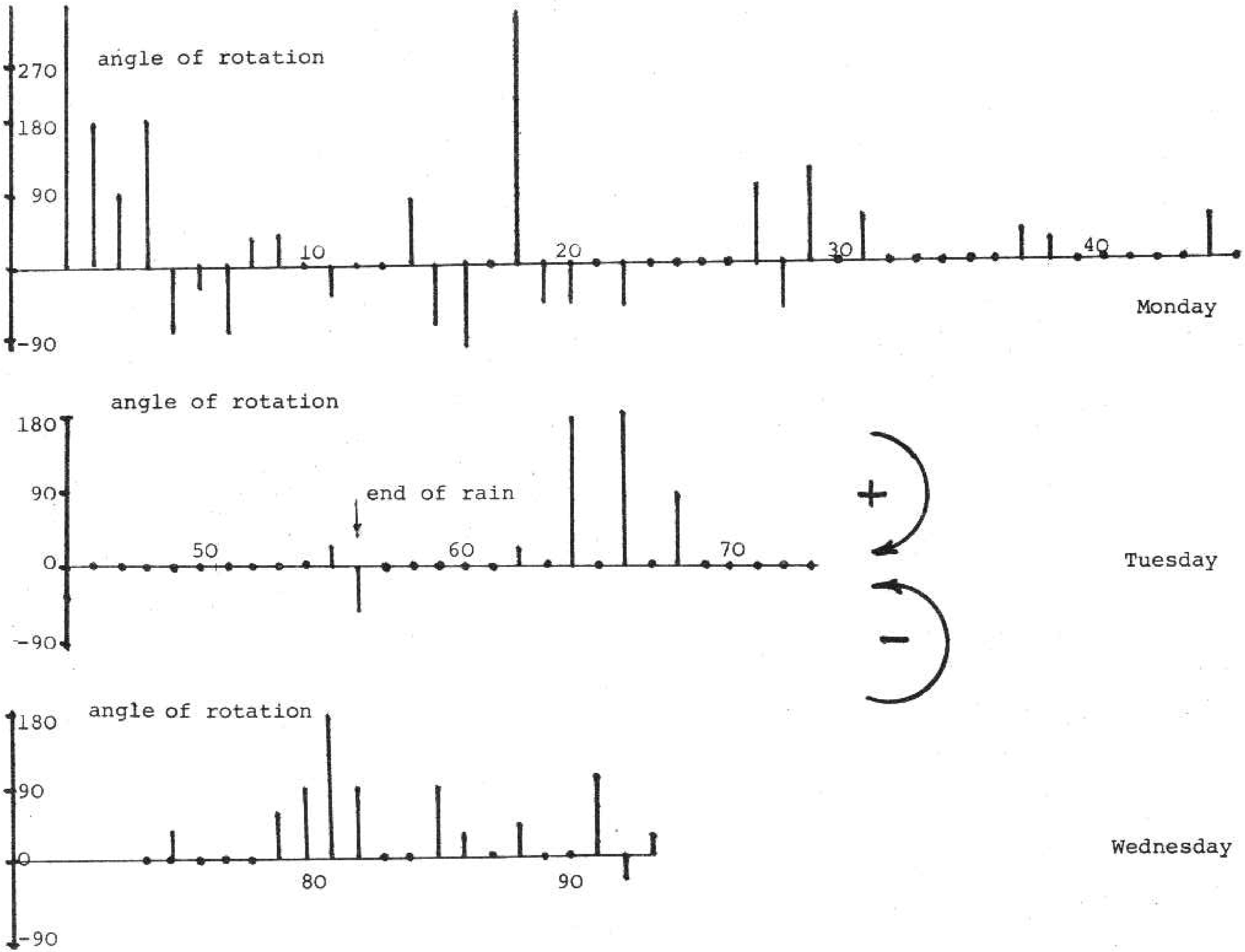


Figure 2/c. Performance chart of Group 1, Szentes. Test days: 9, 10, 11 Dec. 1984. Observation period 90 sec, except subjects N° 1, 2, where it was 180 sec. The performance was poor on Tuesday morning during the rain.

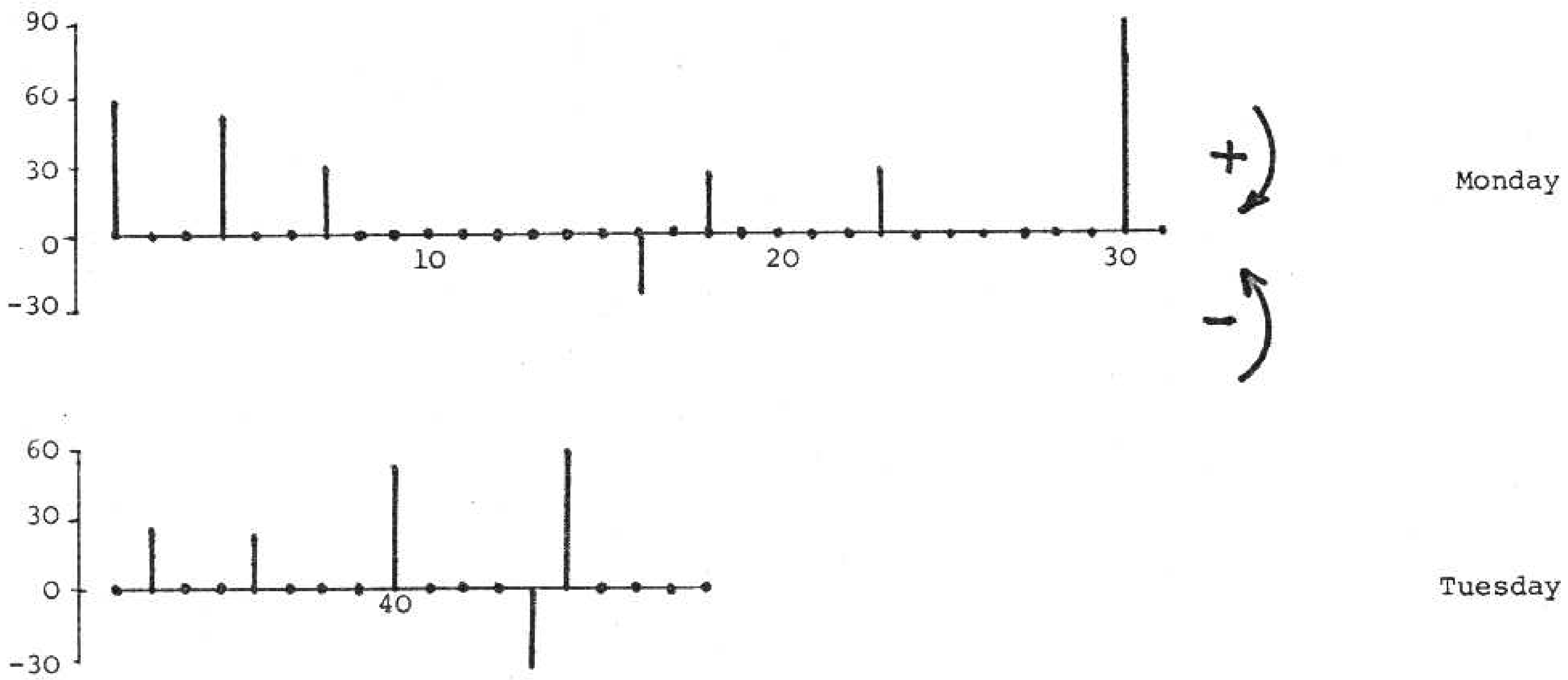


Figure 3. Performance chart of Group 1 during the control test series of February 1985. The performance is markedly worse than that during the Dec. 1984 experiments. The subjects used a "T" position in the first 42 tests, then the "L" test for the last seven trials. Due to the poor performance and technical difficulties the experiments were canceled. The observation period was 90 sec. The film camera broke down, and the pictures became underexposed. The liquid rotation was similar for both the "L" and the "T" tests.

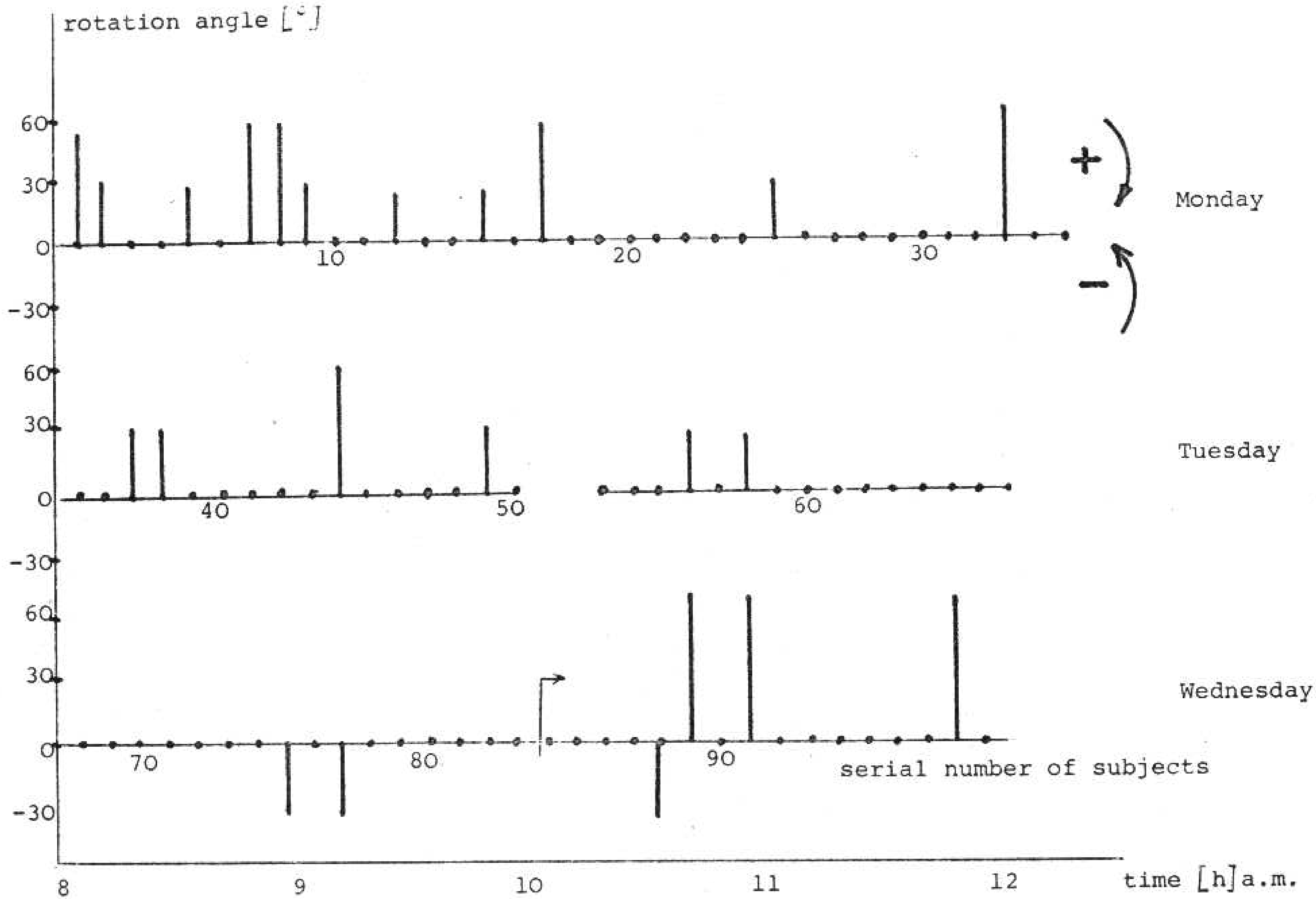


Figure 4. Performance chart of Group 2, Budapest. Test days: 22, 23, 24 Apr. 1985
The observation period is 120 sec, "L" position.
The experimenter was K. Bartha from run No. 84.

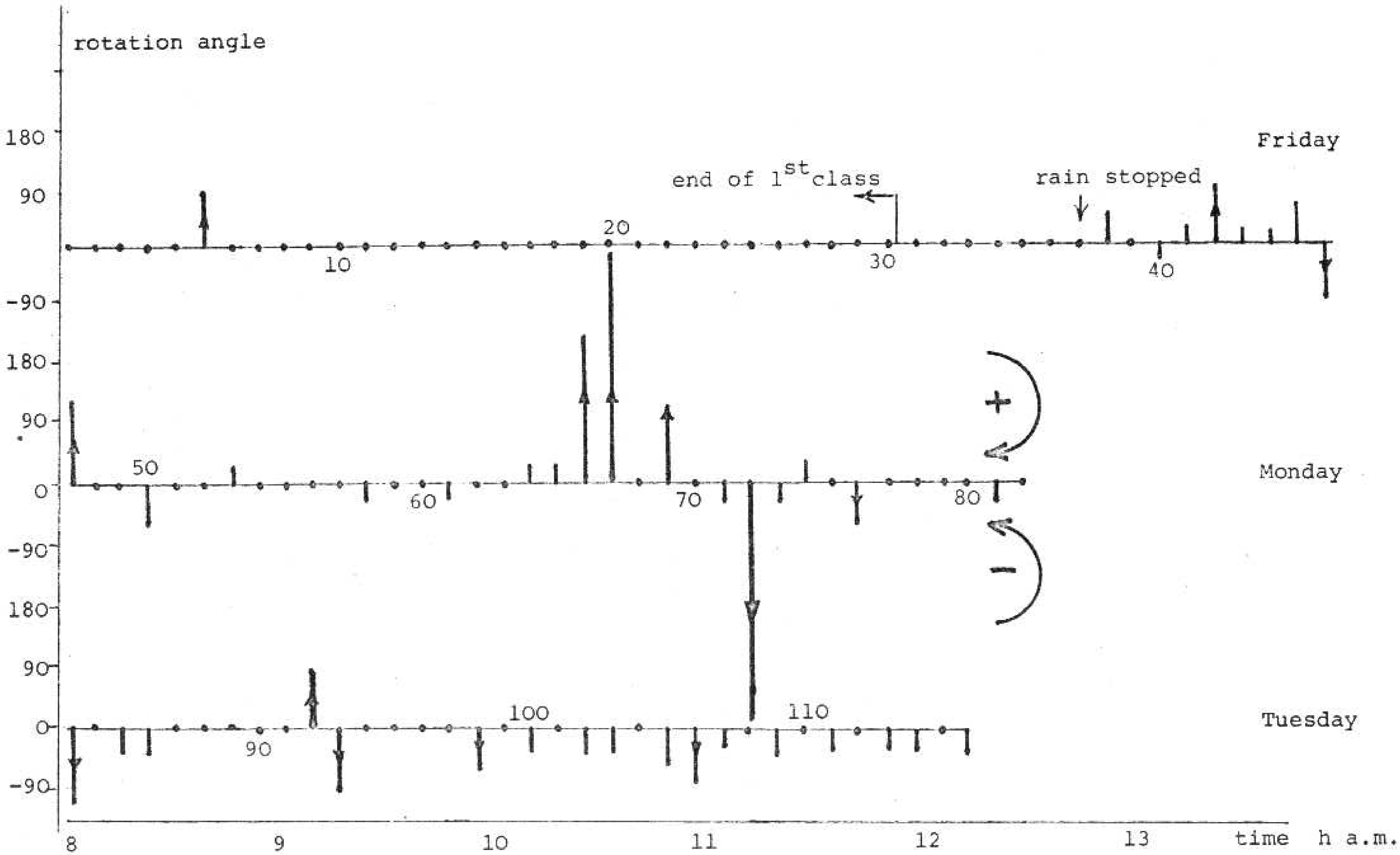
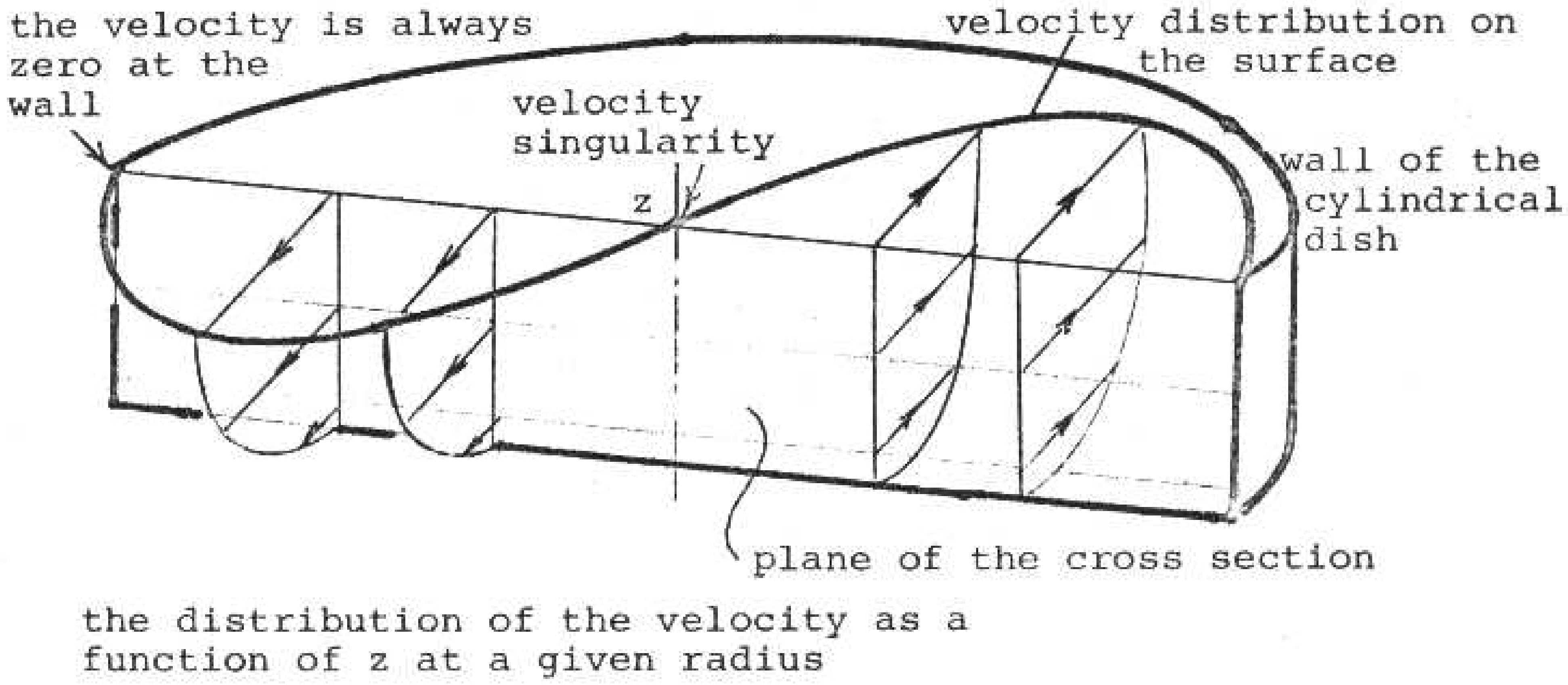
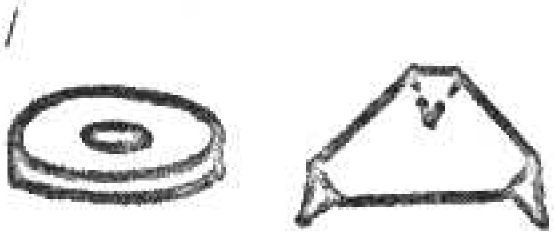


Figure 5. Performance chart of Group 3, Szerencs. Test days: 3, 6, 7 May 1985.
Observation period 120 sec, except with subjects No. 67 and 72, where it was 300 sec.
Note the change in the scale of the rotation angle.

a/



b/



c/

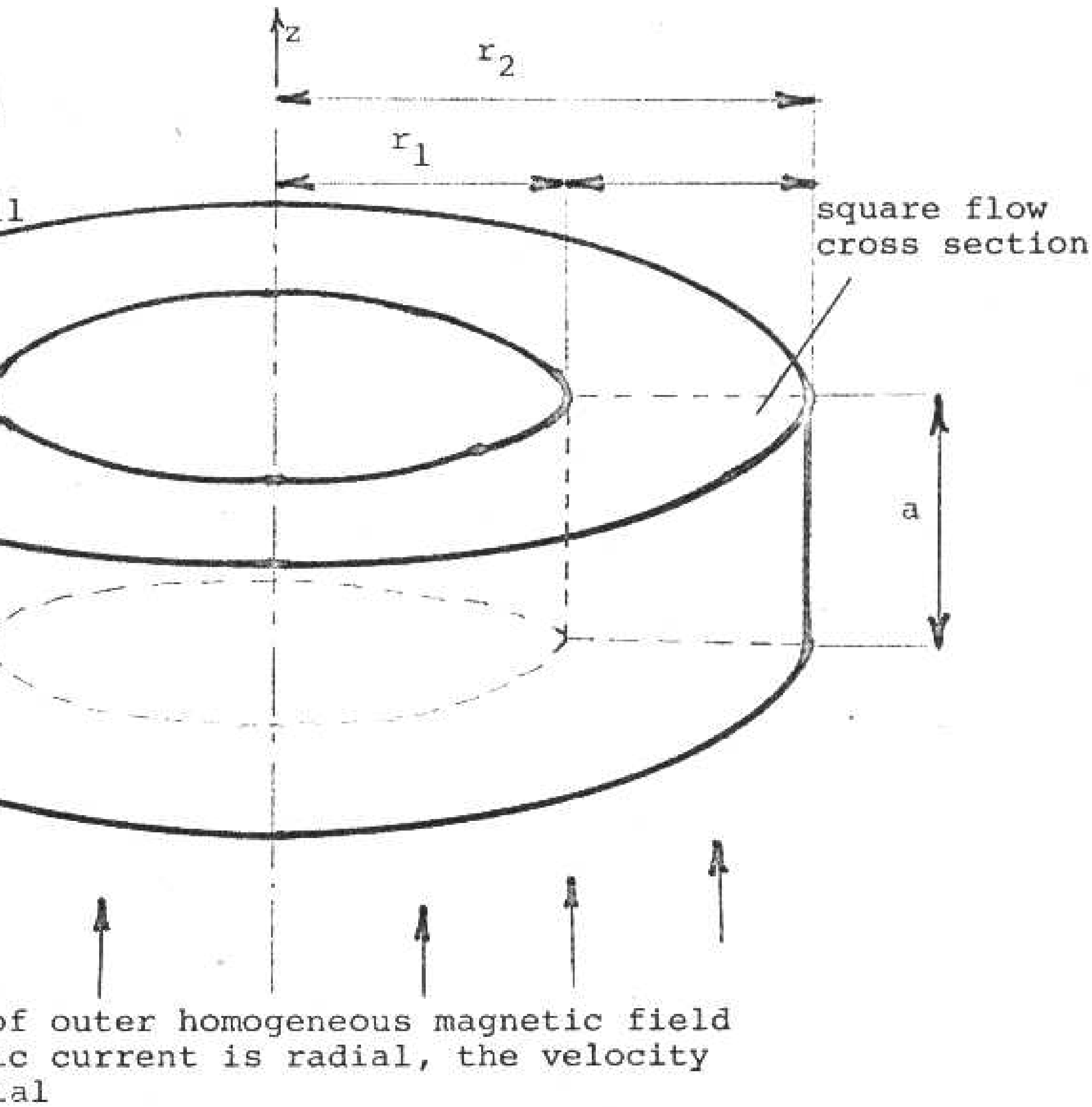


Figure 6.

a/ 3 dimensional open-surface singular velocity field at a given radial cross section

b/ markers made of thin metal foil

c/ coaxial flow without velocity singularity
The local velocity maximum is at the $z=a/2$ plane.

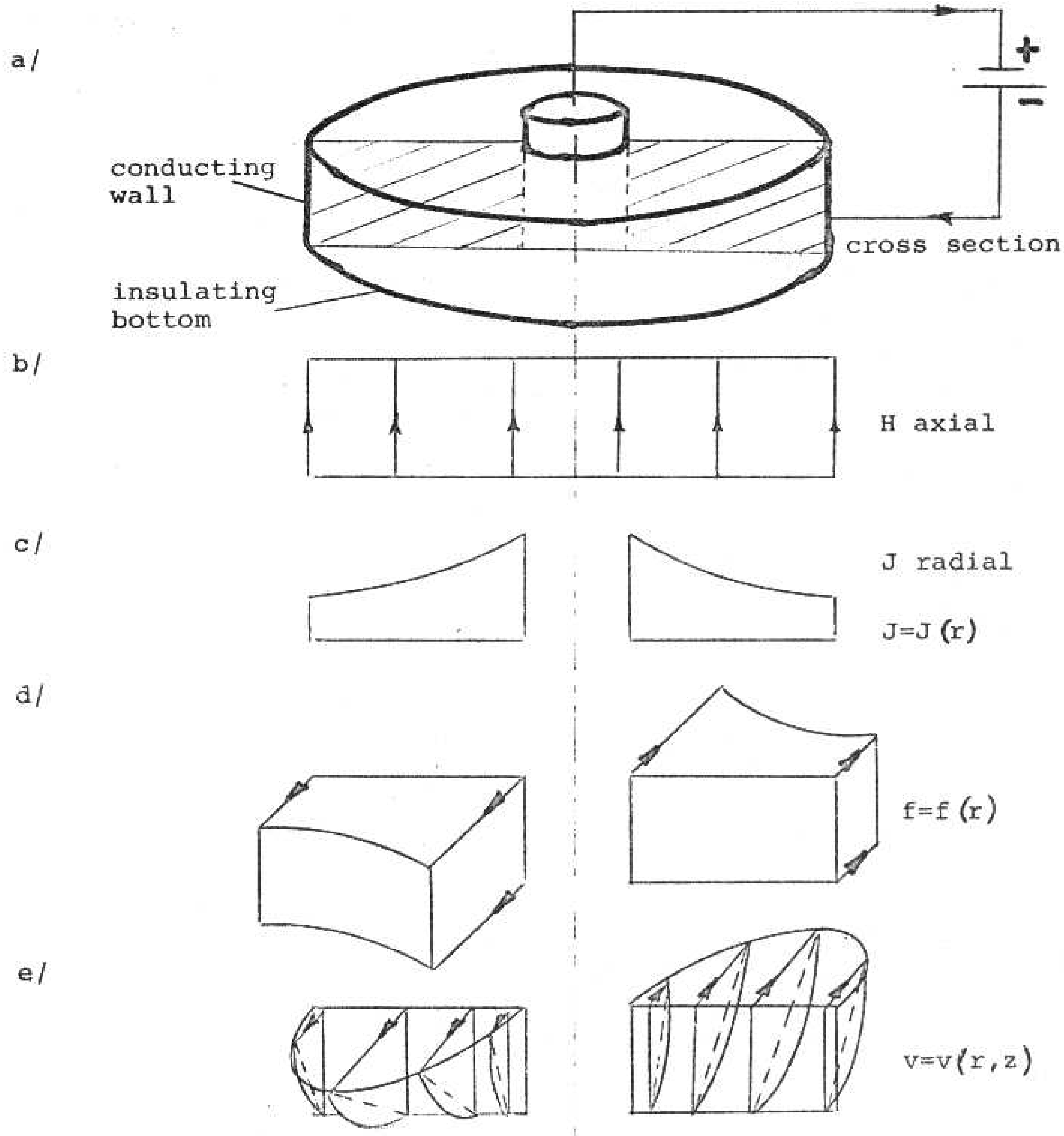


Figure 7. Fields of open-surface MHD flow at a given cross section

a/ General layout of the coaxial flow and electrodes

b/ Homogeneous ambient magnetic field. The electric current induces an additional field not plotted here.

c/ Electric current field, its direction is radial, the absolute value is plotted vertically here.

d/ Mechanical force field distribution

e/ Velocity field distribution, Hartmann boundary layer. In the case of a flow induced by air current the velocity distribution is linear, Couette flow, dotted lines.

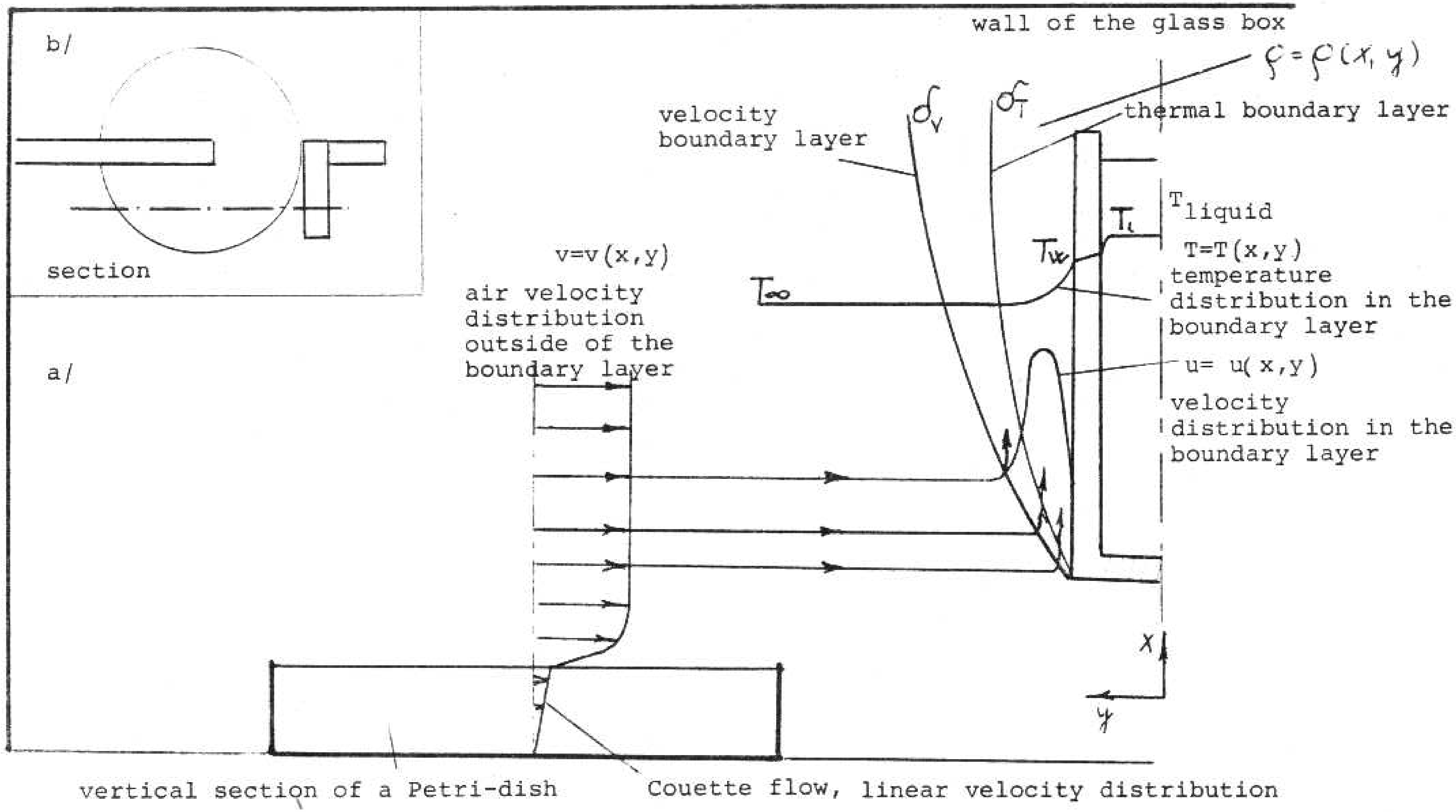


Figure 8. a/ Simplified liquid flow mechanism induced by thermal effect. Only a two dimensional section is shown. The mass transfer mechanism is not shown, it has a boundary layer as well. Only assymetric three dimensional wall hand arrangement will induce liquid movement. The temperature distribution is distorted on the plot.

b/ The location of the selected section from above.

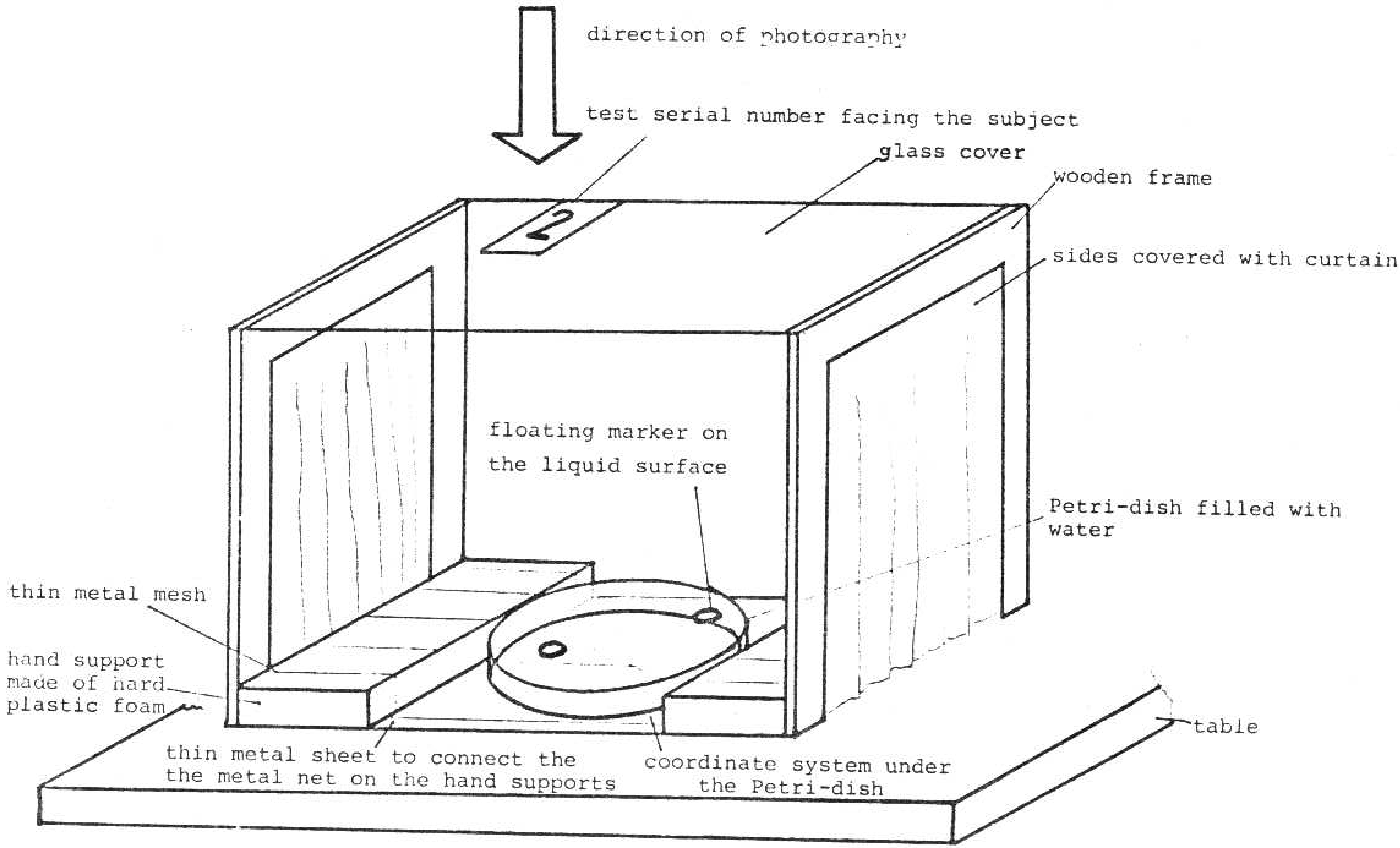
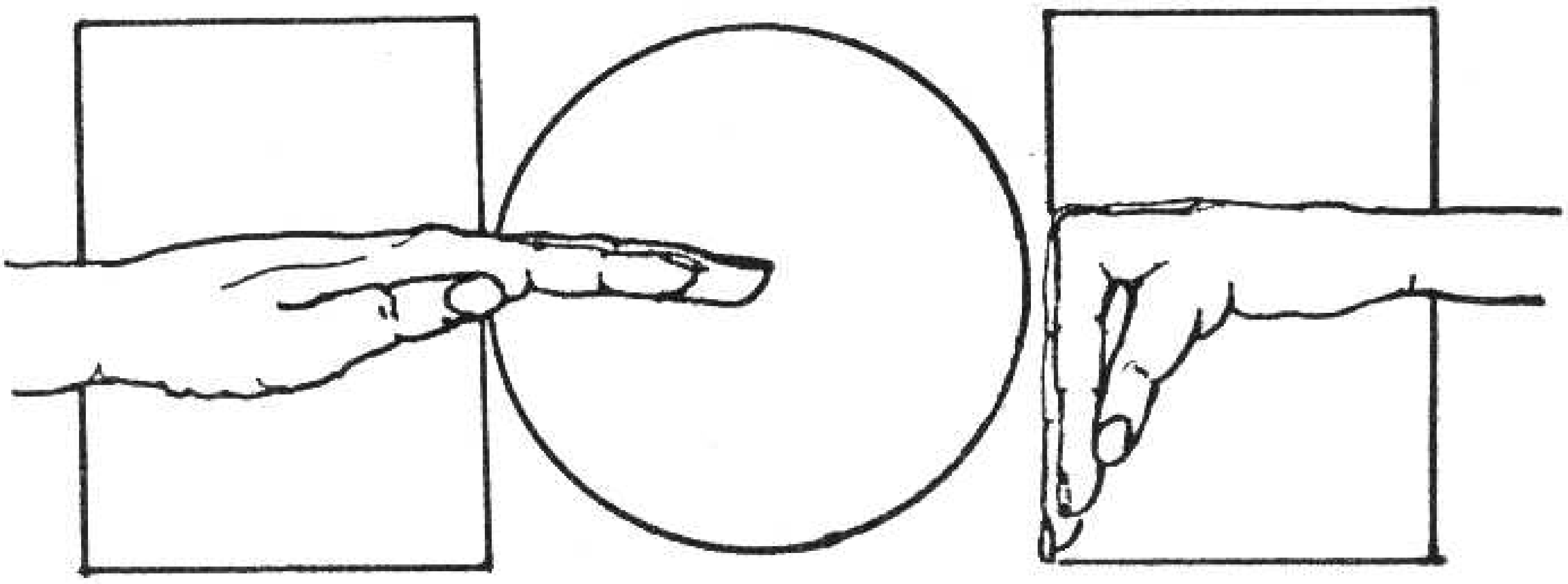
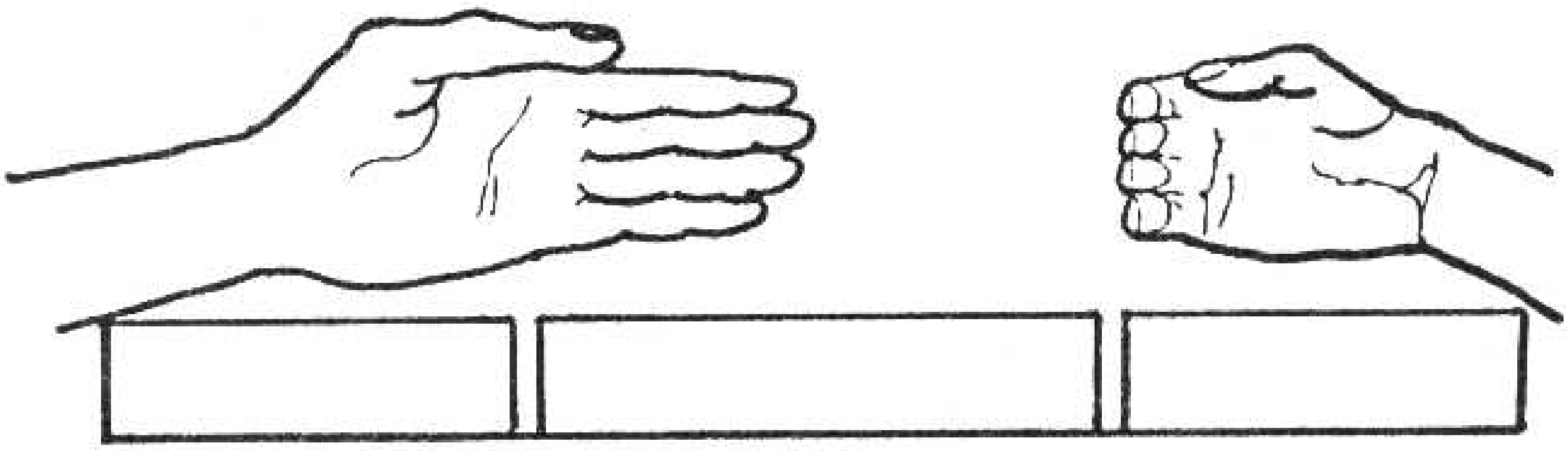


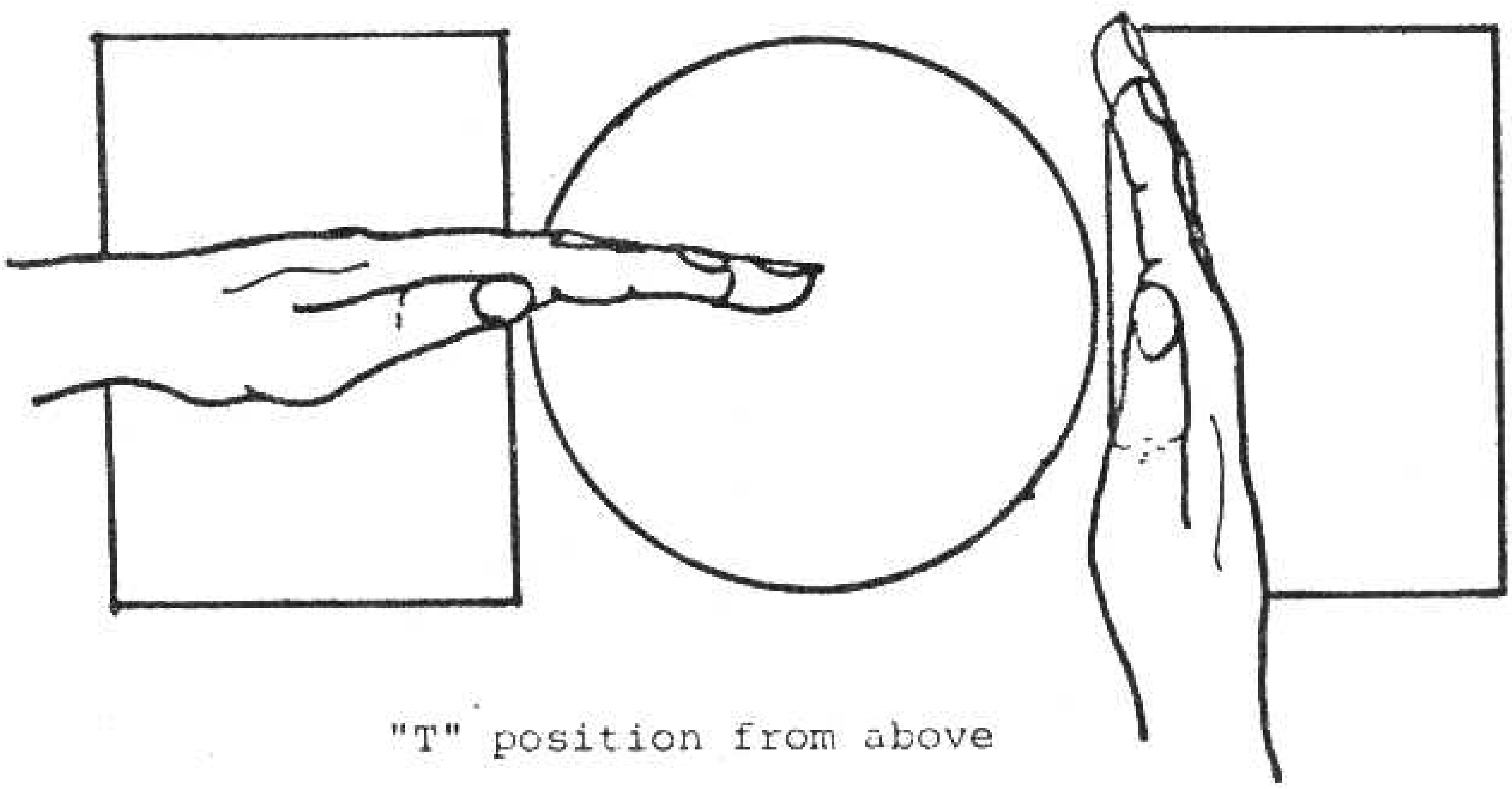
Figure 9.: The layout of the experimental device
Characteristic dimensions: glass box 40x25x25 cm, Petri-dish 14 cm diameter, 2 cm height
marker diameter 1.2 cm



"L" position from above



"L" position, side view



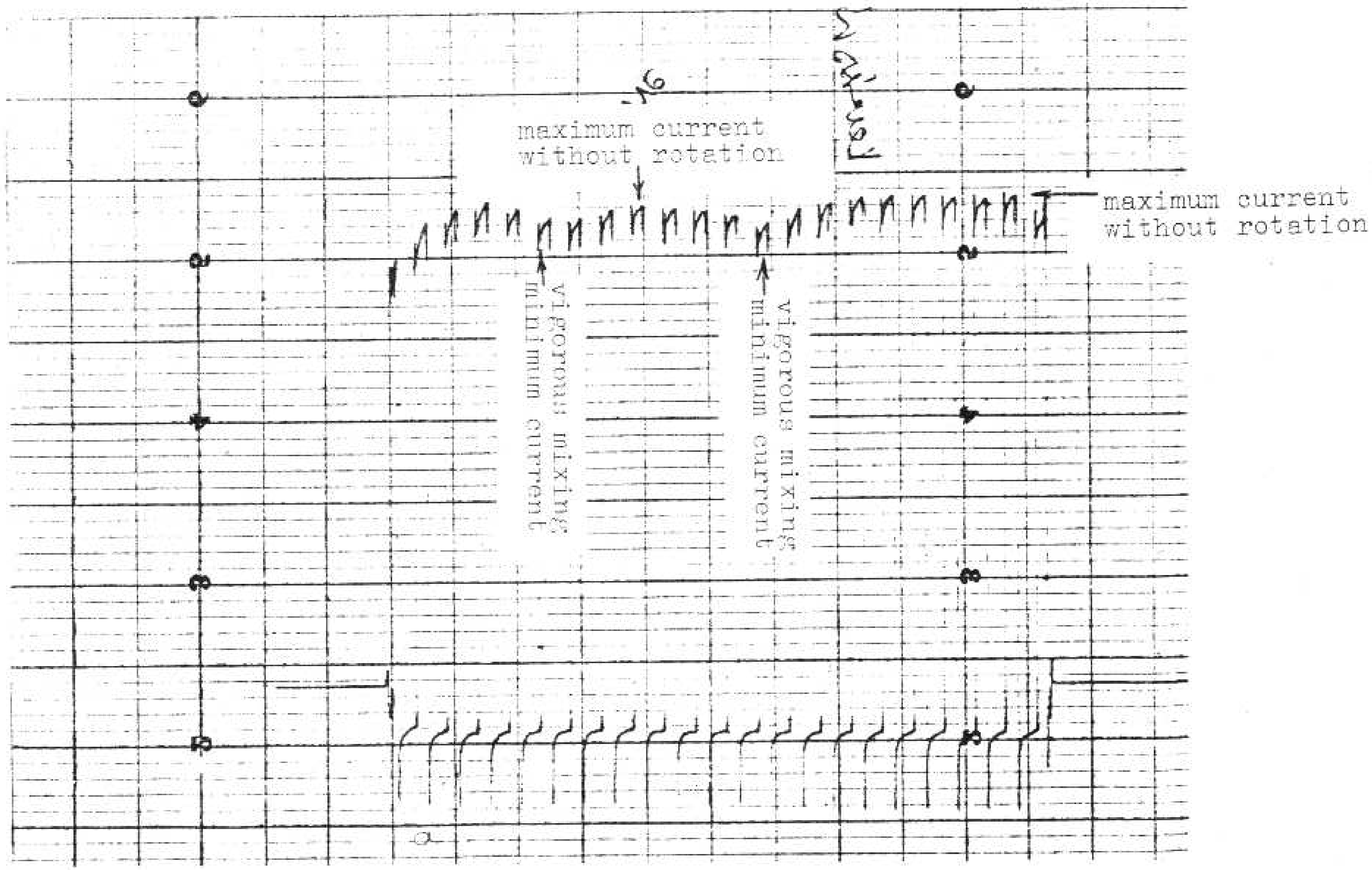
"T" position from above

Figure 10.: Different hand positions

Text to the plates 1-8

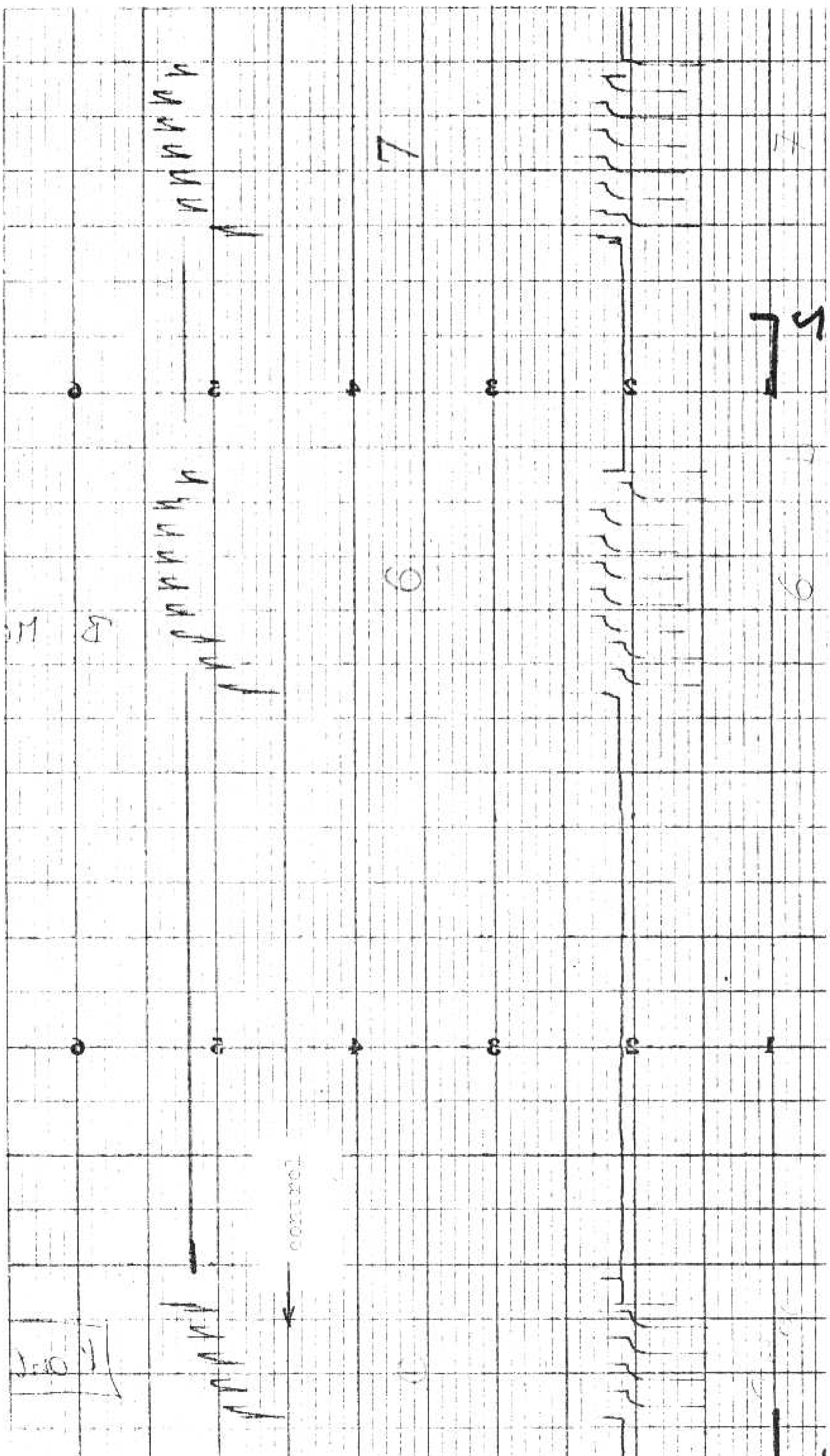
1. General setup of the experiment. One leg of the camera tripod is visible.
2. The setup of the thermal control tests, the aluminium box without a cover in the "L" arrangement.
3. Unsuccessful test, steady hands, 120 sec exposure time after a 180 sec "warmup" period.
4. Unsuccessful test, shaky hands, 120 sec exposure time after a 180 sec "warmup" period.
5. First part of a very successful test, 120 sec exposure time after a 120 sec "warmup" period. The rotation started slowly (strong white marker trace) then rapidly accelerated (thin marker trace).
6. Second part of the test. There was a 50-80 sec technical break between the two photographs, the camera had to be rewound and redirected. The movement is strong at the start of the 120 sec exposure time, but by the end it becomes weaker and weaker (the marker trace becomes whiter). The centre of the rotation is steady on the first photograph, but changing on the second one. The subject left her hands inside the box during rewinding.
7. The centre of the rotation is not the centre of the Petri dish. The marker near the wall has an unusually high speed. The other marker, the one near the centre, rotates slowly. Exposure time is 120 sec after a 180 sec "warmup" period. It is very probable that the maximum of the liquid velocity was somewhere between the two markers, but only a third marker (which cannot be used for technical reasons) could have detected it. This example was selected to show the difficulty in measuring the velocity distribution with the marker method.
8. A weak mechanical force field around the fingertips, the outer marker is steady, there is no velocity there. Exposure time is 120 sec after a 180 sec "warmup" period.

On some photographs thin wires are visible, these were used to eliminate any static potential difference between the hands. Where the picture is overexposed, they are not visible.

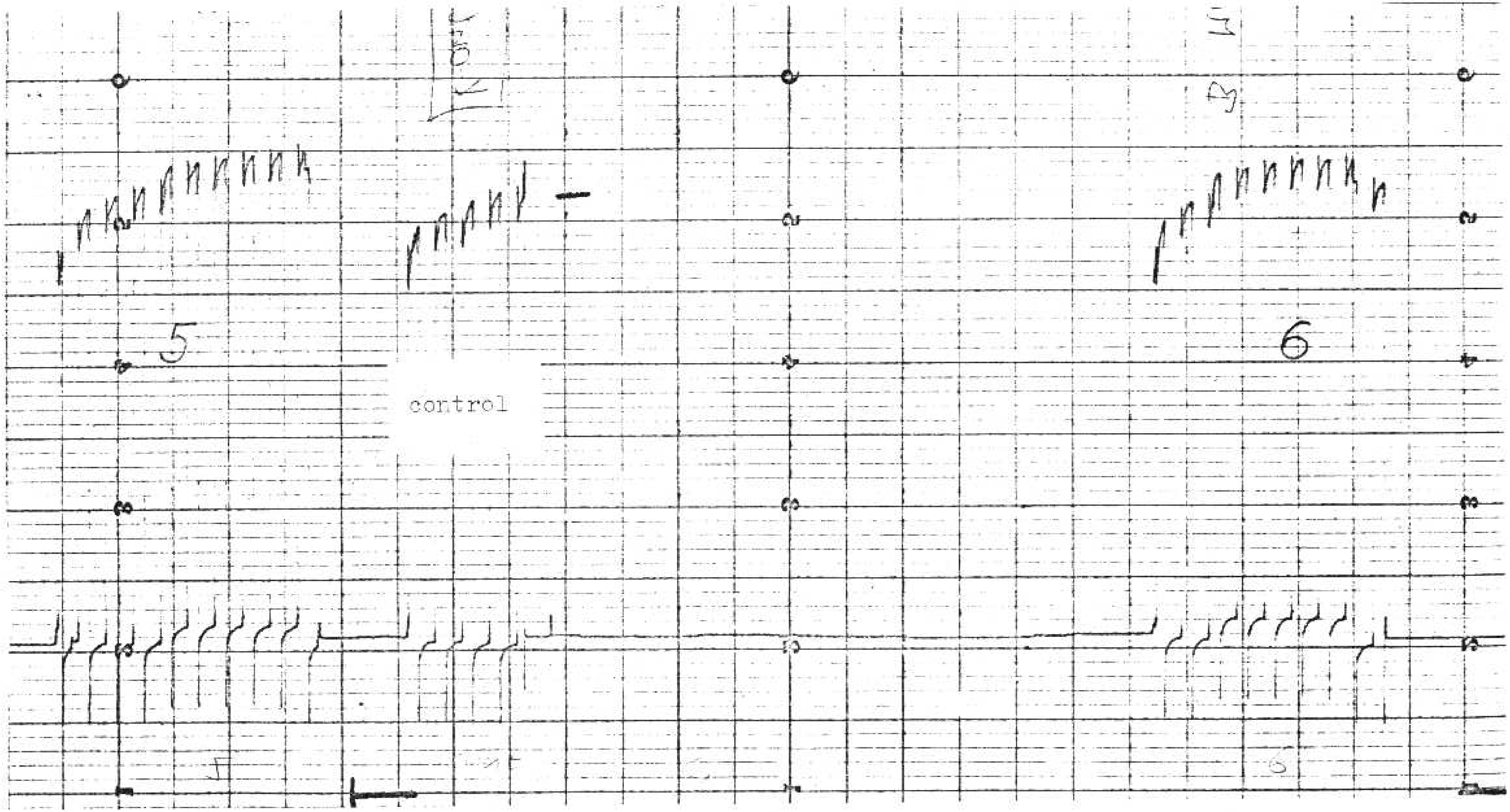


a) A long control run. The liquid has been stirred, rotated by a stick.
Paper speed: 1cm/min for all figures

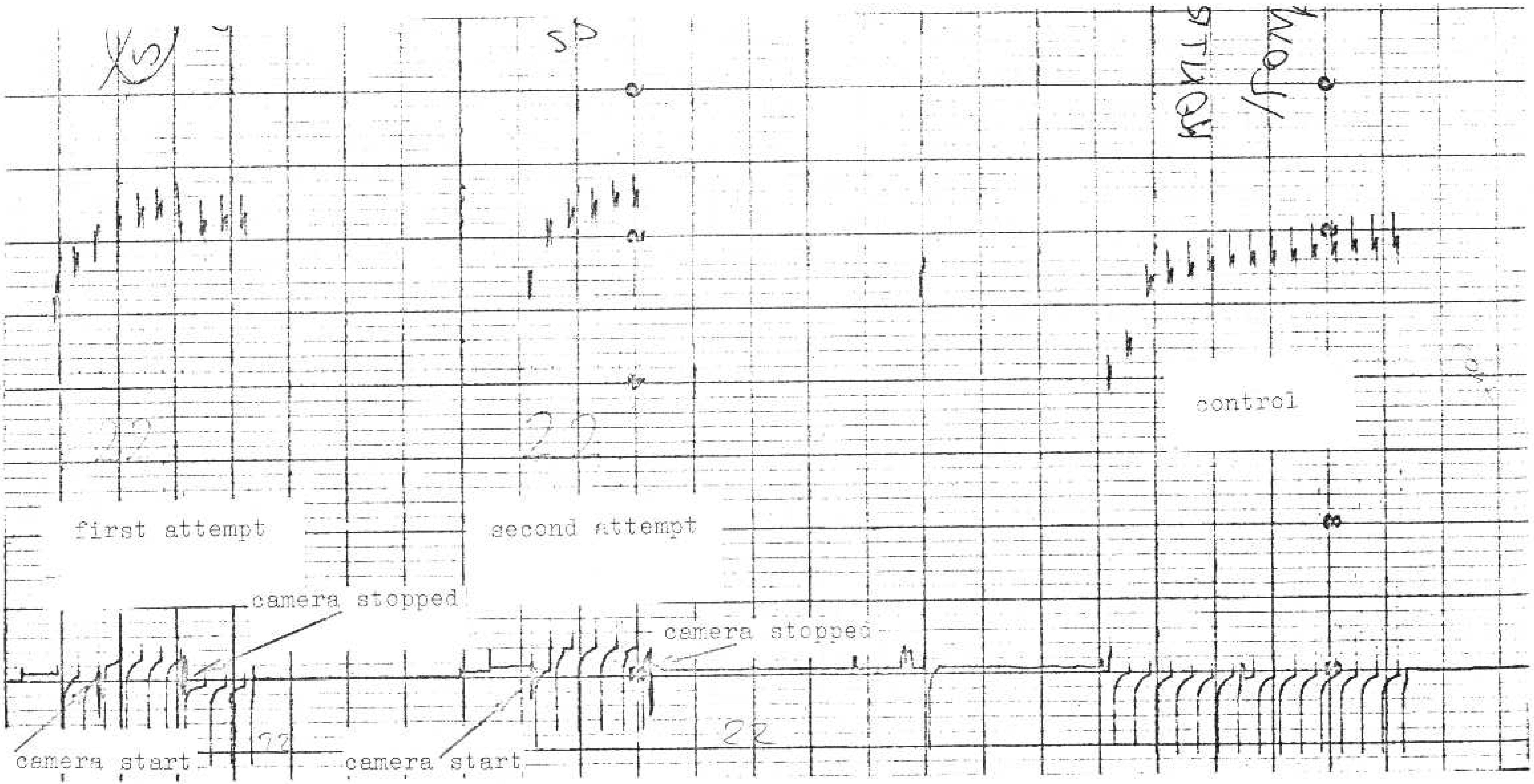
The effect of rotation results in a current change of about 5%



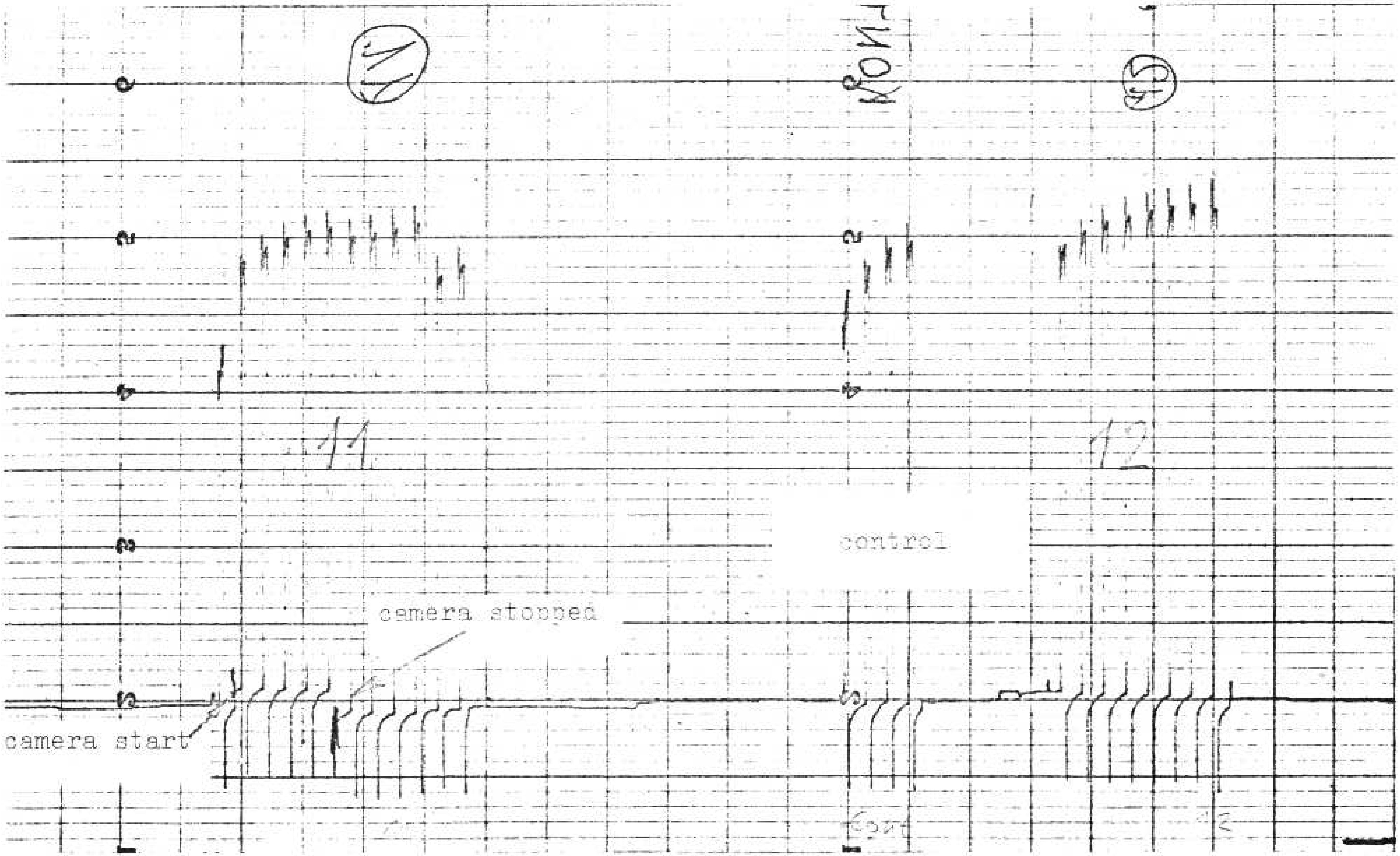
b) Three consecutive very successful runs compared with a control run
Paper speed: 1 cm/min



c) Three consecutive very successful runs compared with a control run
Paper speed: 1 cm/min

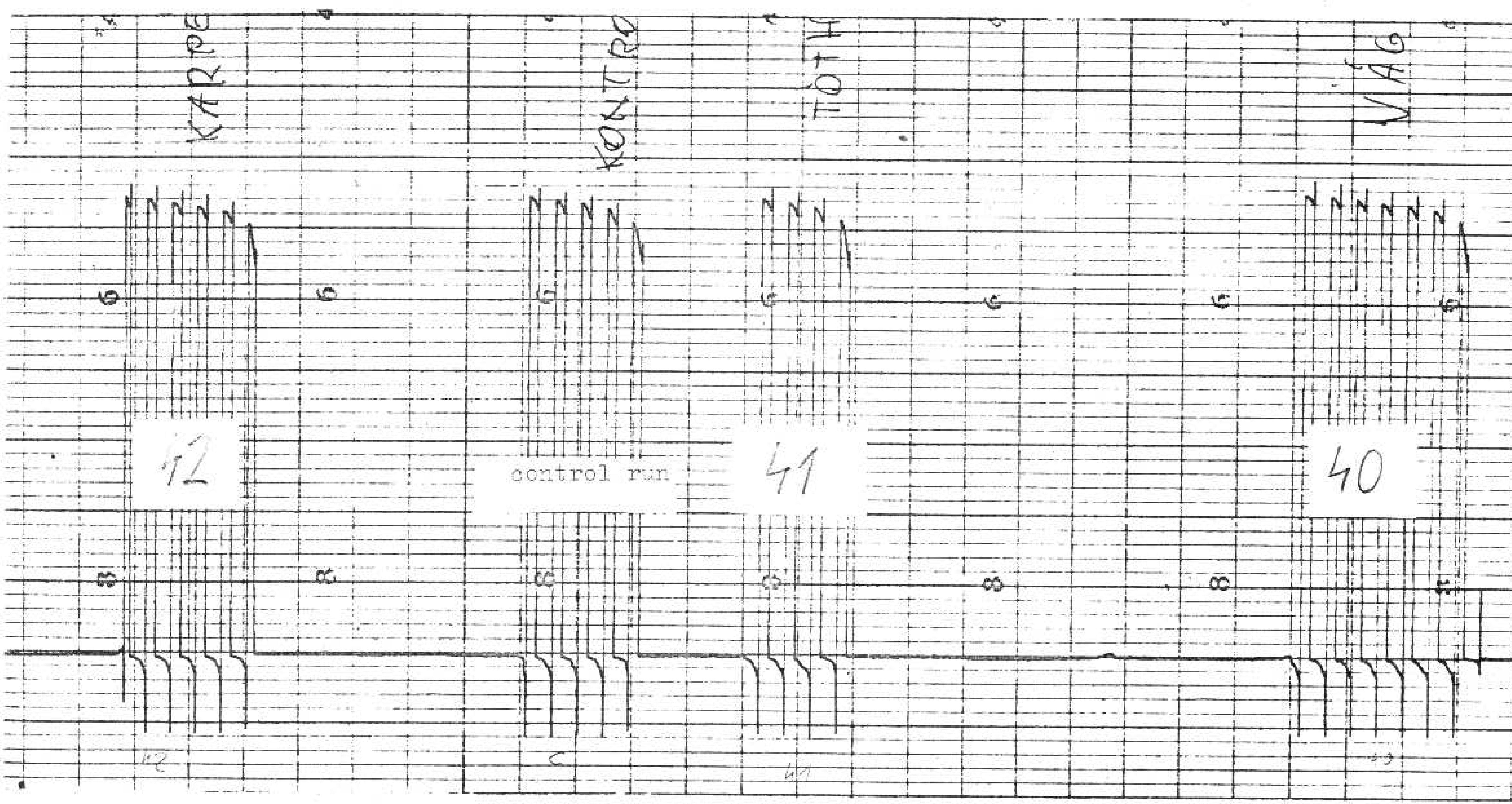


d) Two consecutive successful trials by the same subject
Both runs were filmed. The filming periods are inducated by thick black marks at the base line. The upward shift of the base line during the filming is noticeable. Despite this shift the current increment is noticeable in both attempts. In the first attempt, the camera was stopped earlier so for about one minute there is a noticeable current increment without a shift in the base line.

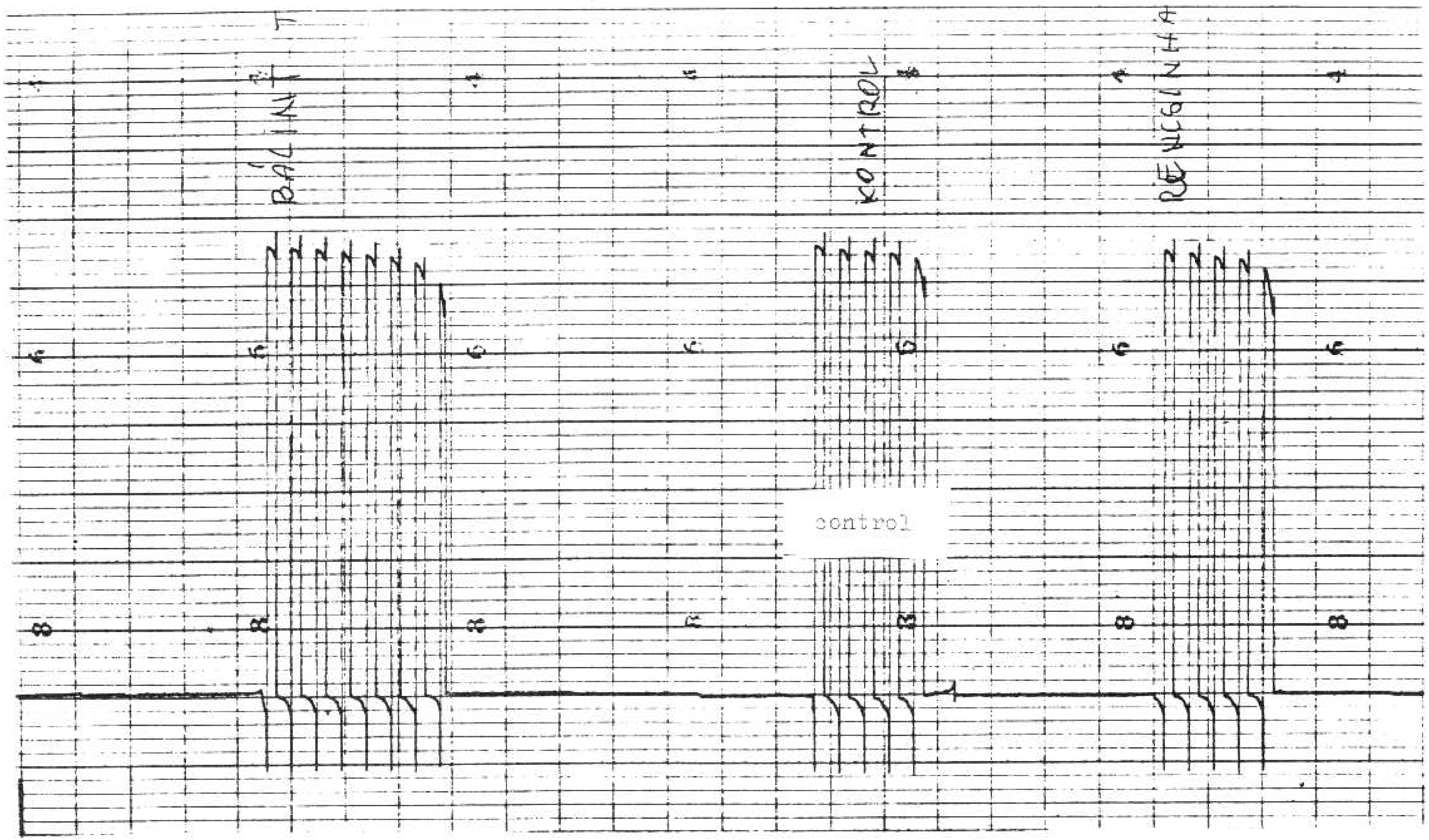


e) A marginally successful run No. 11 and a highly successful one No. 12 compared with a control test

Run 12 was not filmed so there is no base-line shift due to the effect of the camera.



f) Unsuccessful runs
Movement was marginal or zero. The test was conducted during late afternoon when the participants were tired.



g) Unsuccessful runs

Movement was marginal or zero. The test was conducted during late afternoon when the participants were tired.

Text to plates 9-25.

(Two cross-shaped thin platinum wires were used for liquid dyeing, at about 7 and 14 mm from the glass bottom.)

9 control test. The human hand is simulated by rubber gloves filled with water at 40 ^{o}C. Note the lack of rotations.

10 one minute after the start. The dye diffusion is marked.

11 two minutes after the start.

12 three minutes after the start.

13 (Run 7) Unsuccessful test. The dyed liquid filaments are along the electrodes, or just marginally moved. The arrow points to the non-dyeing electrodes at the bottom.

14 (Run 9) Unsuccessful test. The velocity of the filaments is just under the threshold value. The arrow points to the wires, conducting the dyeing current to the liquid

15 (Run 23) Unsuccessful test. Movement of the dyed liquid filaments is marginal. The arrow points to the metal grid covering the hand supports.

16 (Run 18) Unsuccessful test. Marginal movement of the liquid filaments. The arrow points to the line of a polar coordinate system, placed under the Petri-dish.

17 (Run 19) Marginally successful test. Note the local rotation at the upper right quarter: see arrows indicating the direction of velocities.

18 (Run 15) Marginally successful test. Local rotation. Note the distance between the dyed liquid filaments, indicating Hartmann-type flow.

19 (Run 24) Successful test. The rotation of the liquid is more pronounced, though quite irregular. The electric conductance anomaly is shown beside the photo, note the current increment.

20 (Run 8) Marginally successful test. Note the local rotations.

21 (Run 5) Marginally successful test. Note the bow-like velocity distribution in the upper left corner. The BETA effect existed for a brief period only, the click of the dyeing current switch disturbed the concentration of the subject. The liquid became stirred a little by the rotation, so the current increased to the upper threshold only slowly. (See plot below the photo)

22 (Run 11) Marginally successful test. Note the local rotations.

23 (Run 16) Marginally successful test. Note the local rotations.

24 Petri-dish with electrodes. The thick electrodes are visible on the bottom, but the thin dyeing electrodes are barely visible, only where the light is reflected by them (See arrow)

25 Rubber glove for thermal simulation.

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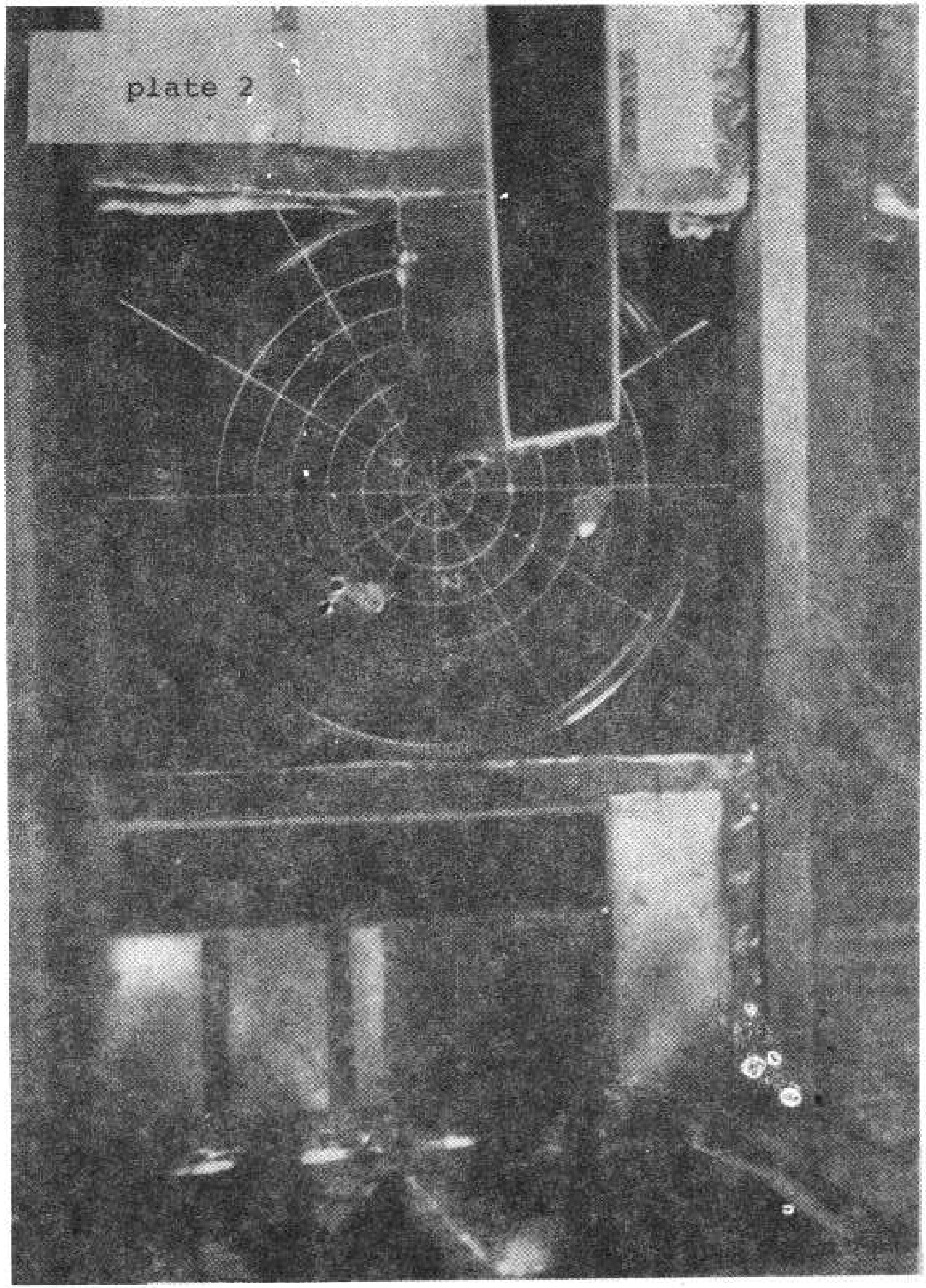

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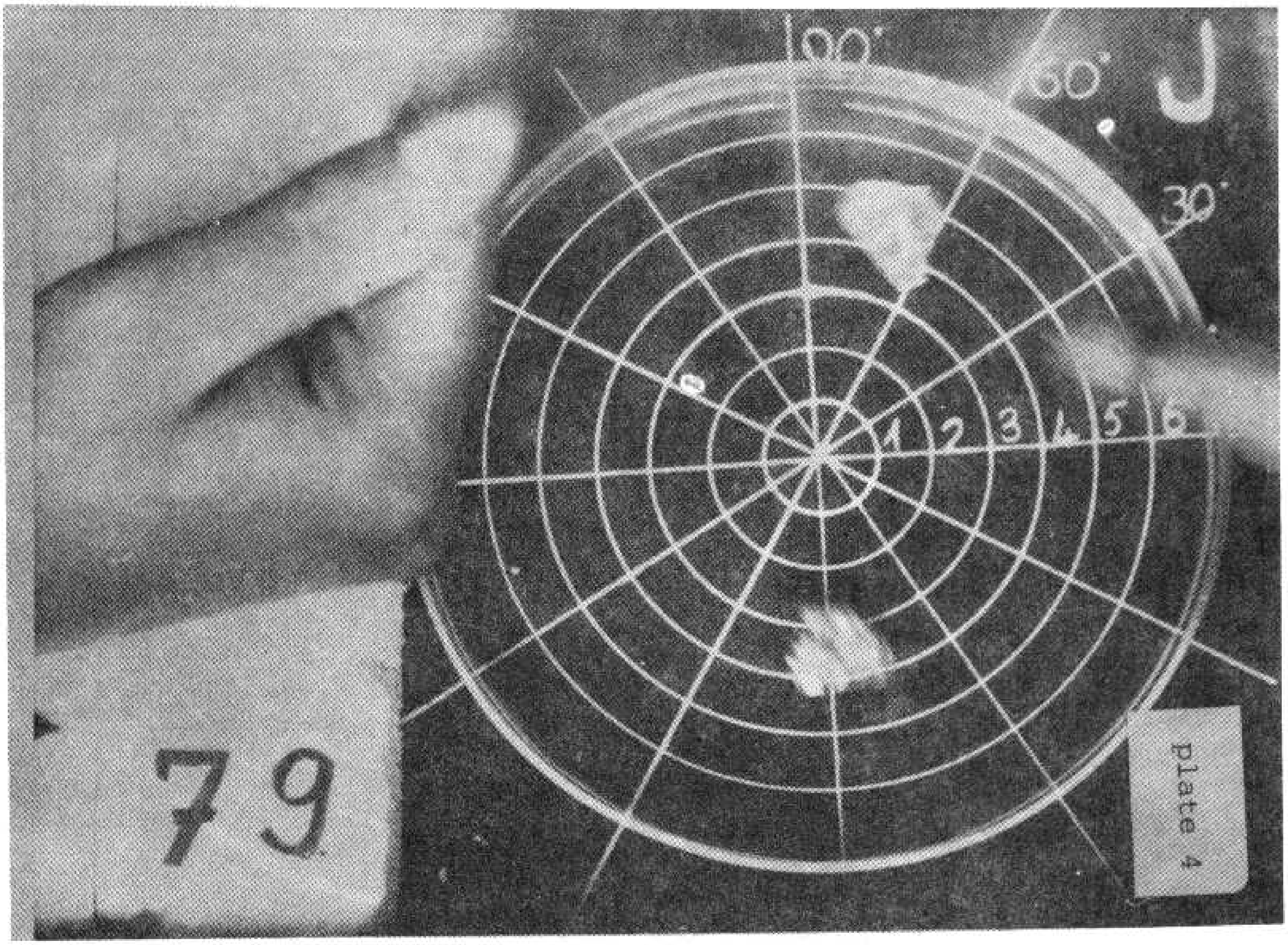
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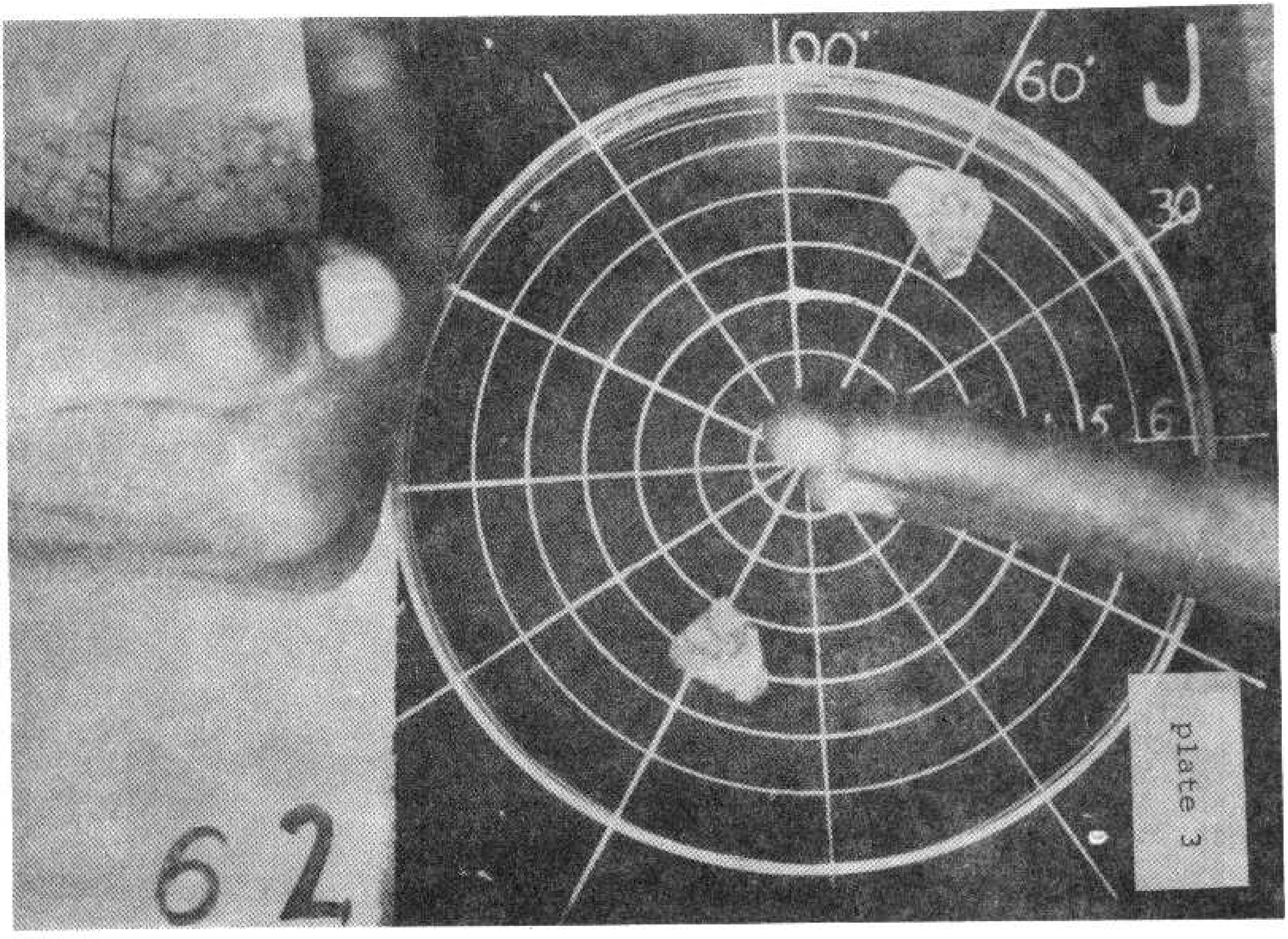
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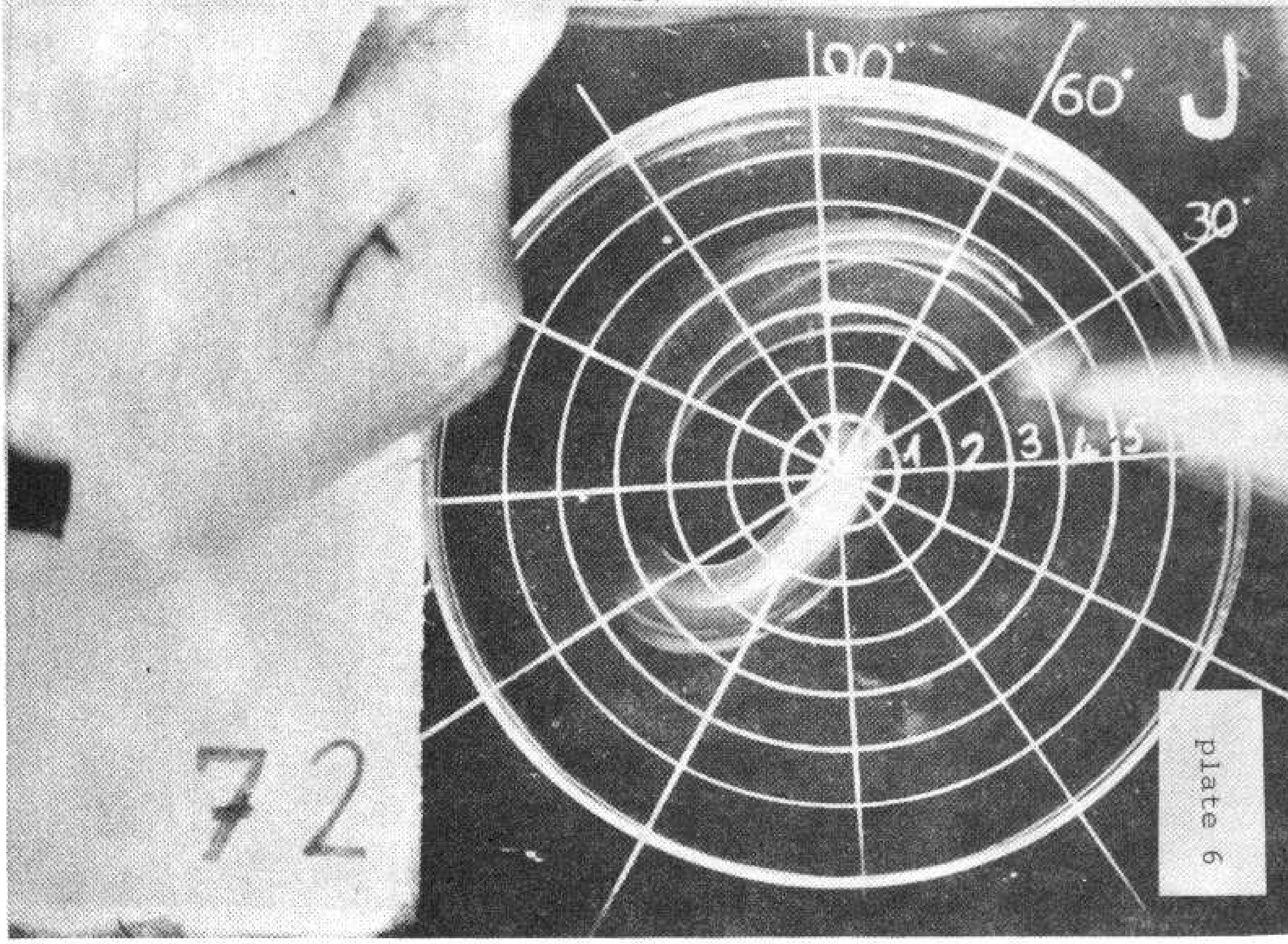

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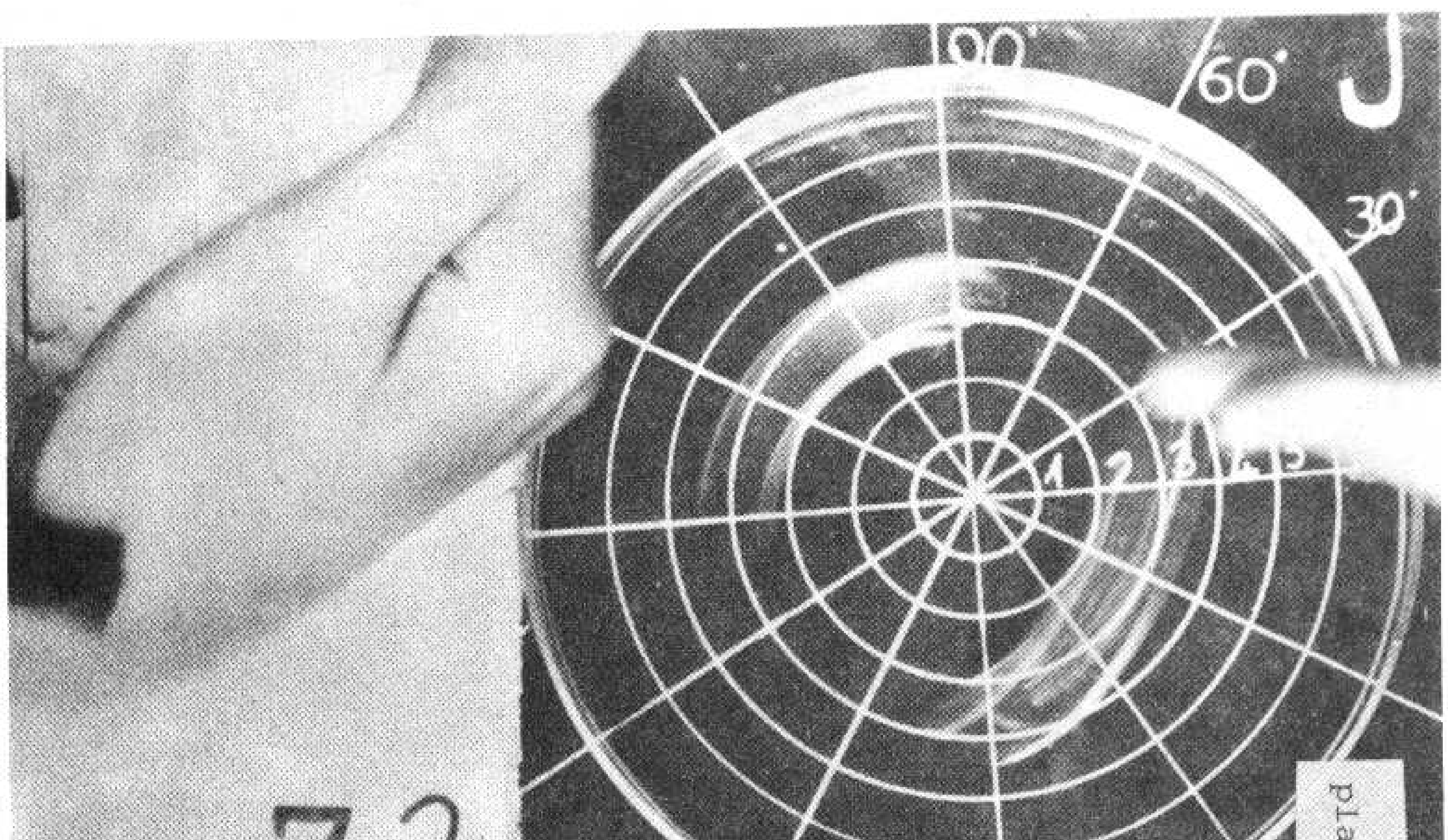

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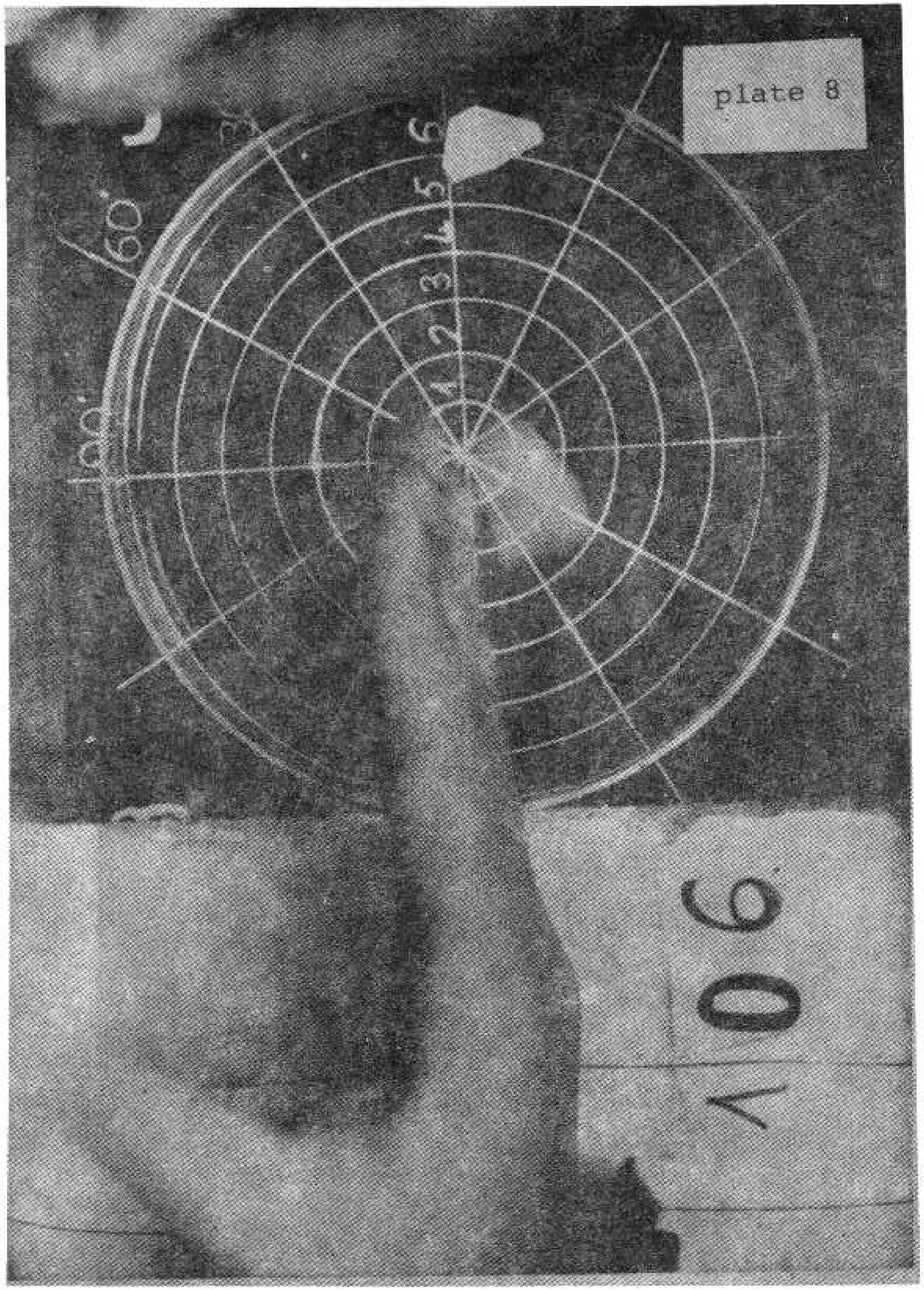

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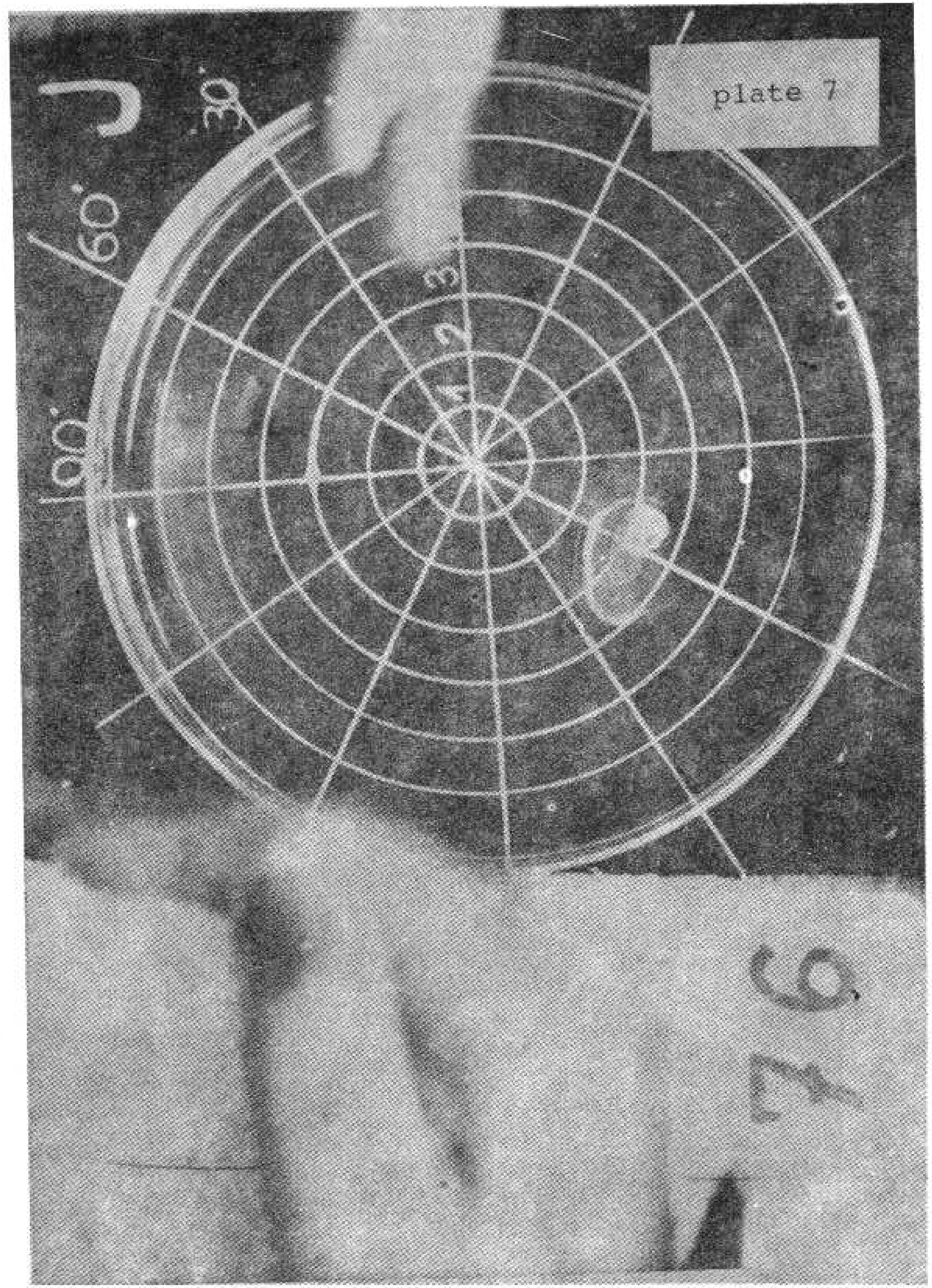

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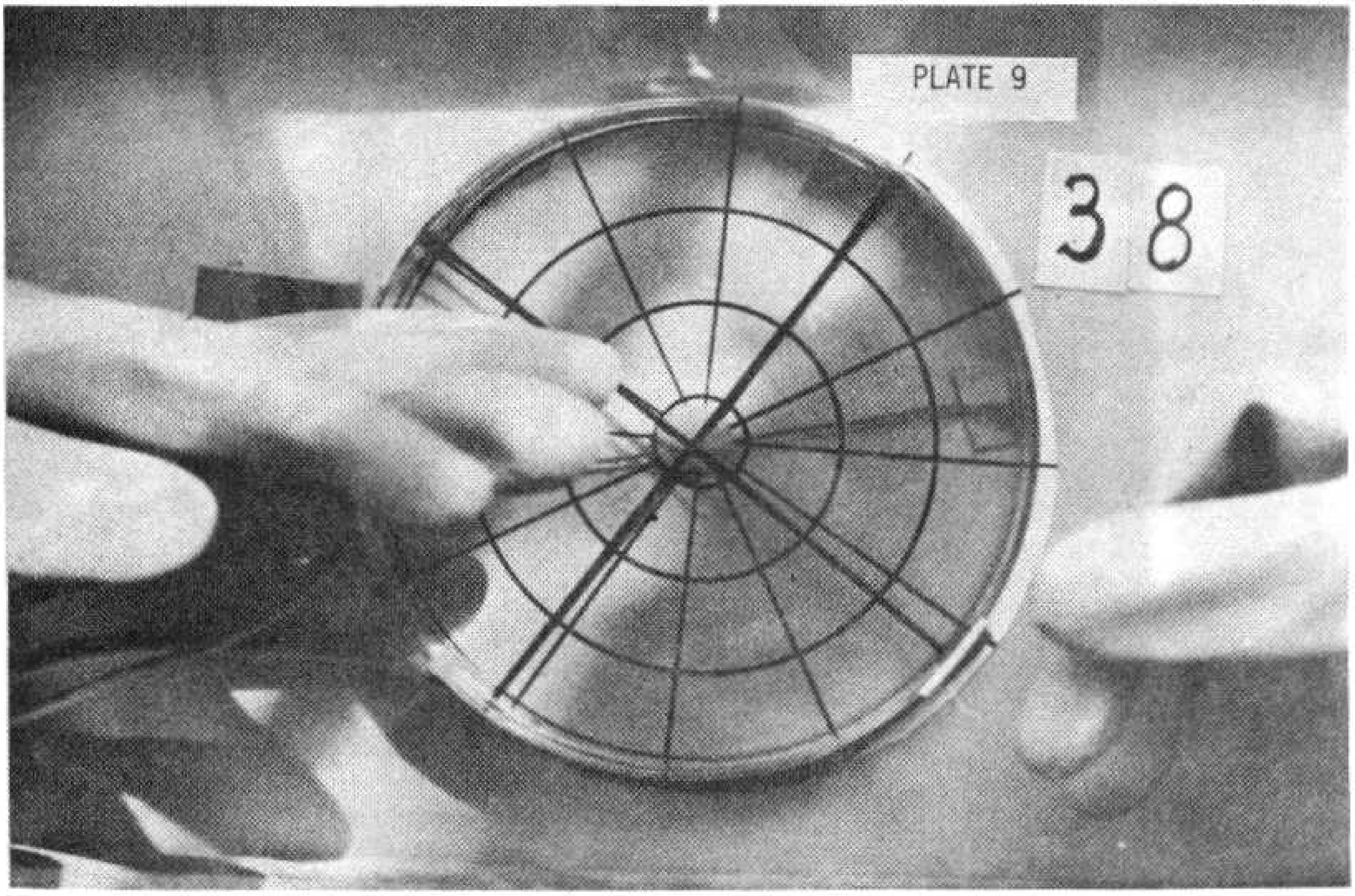

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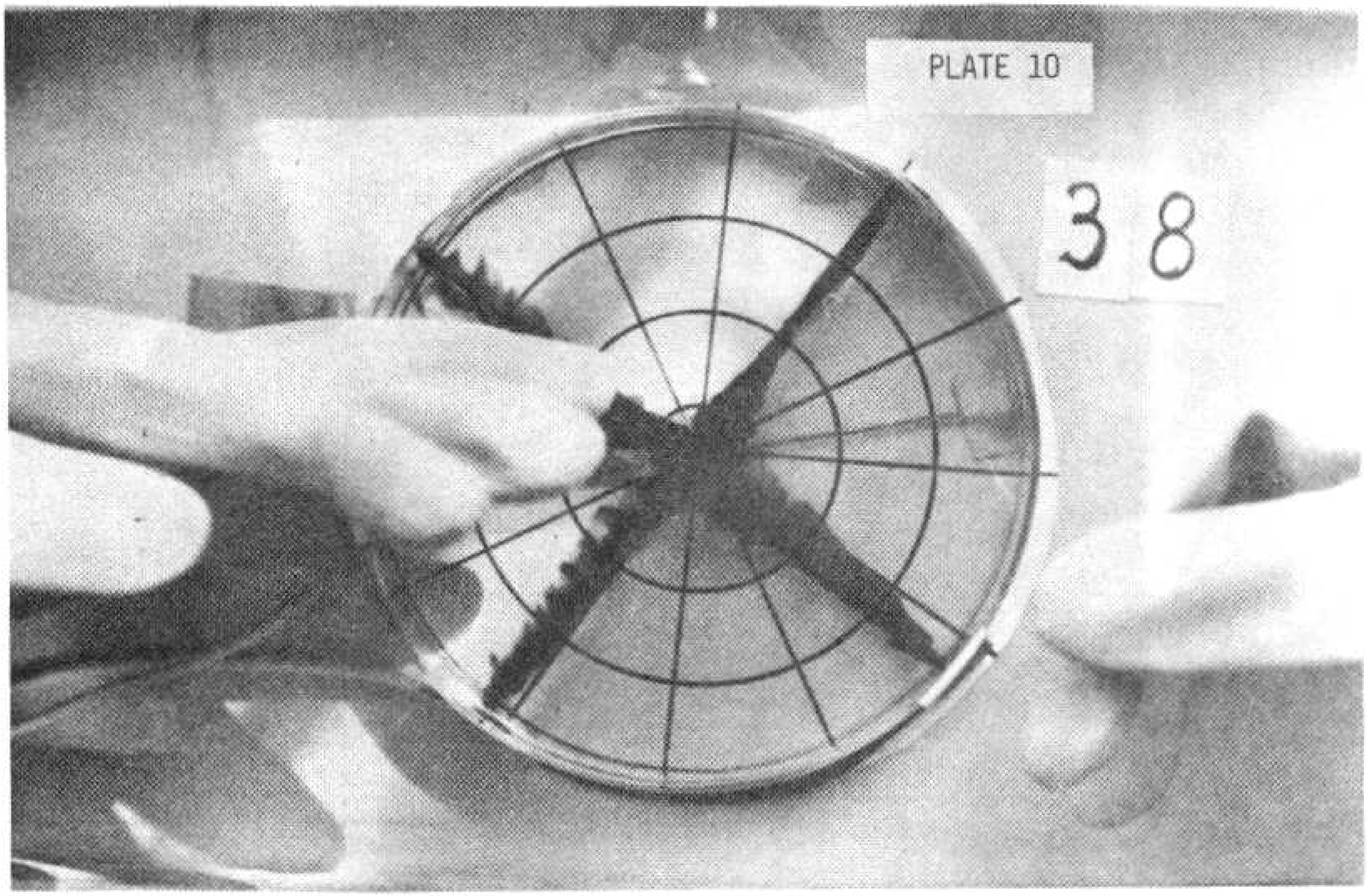

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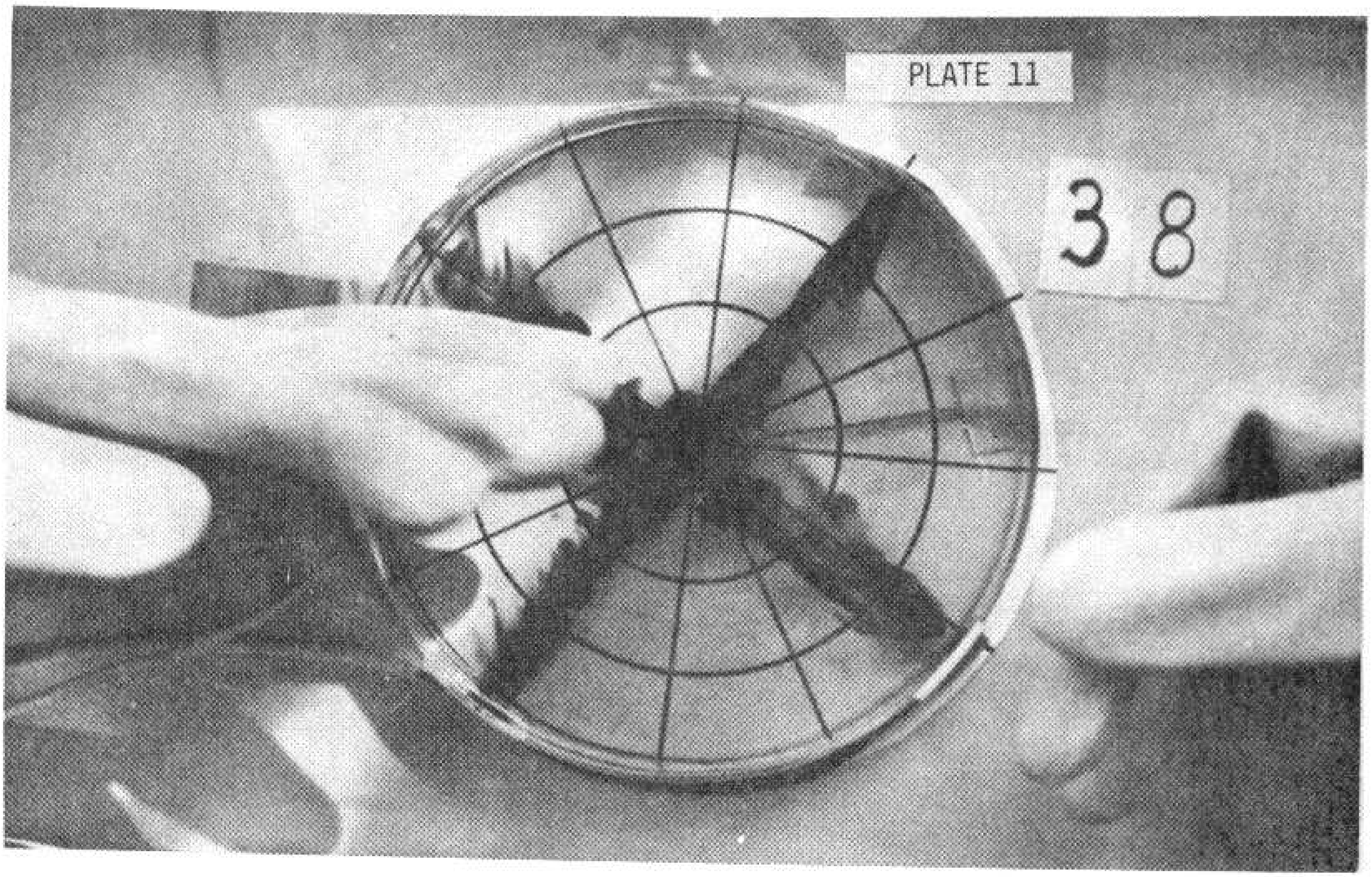

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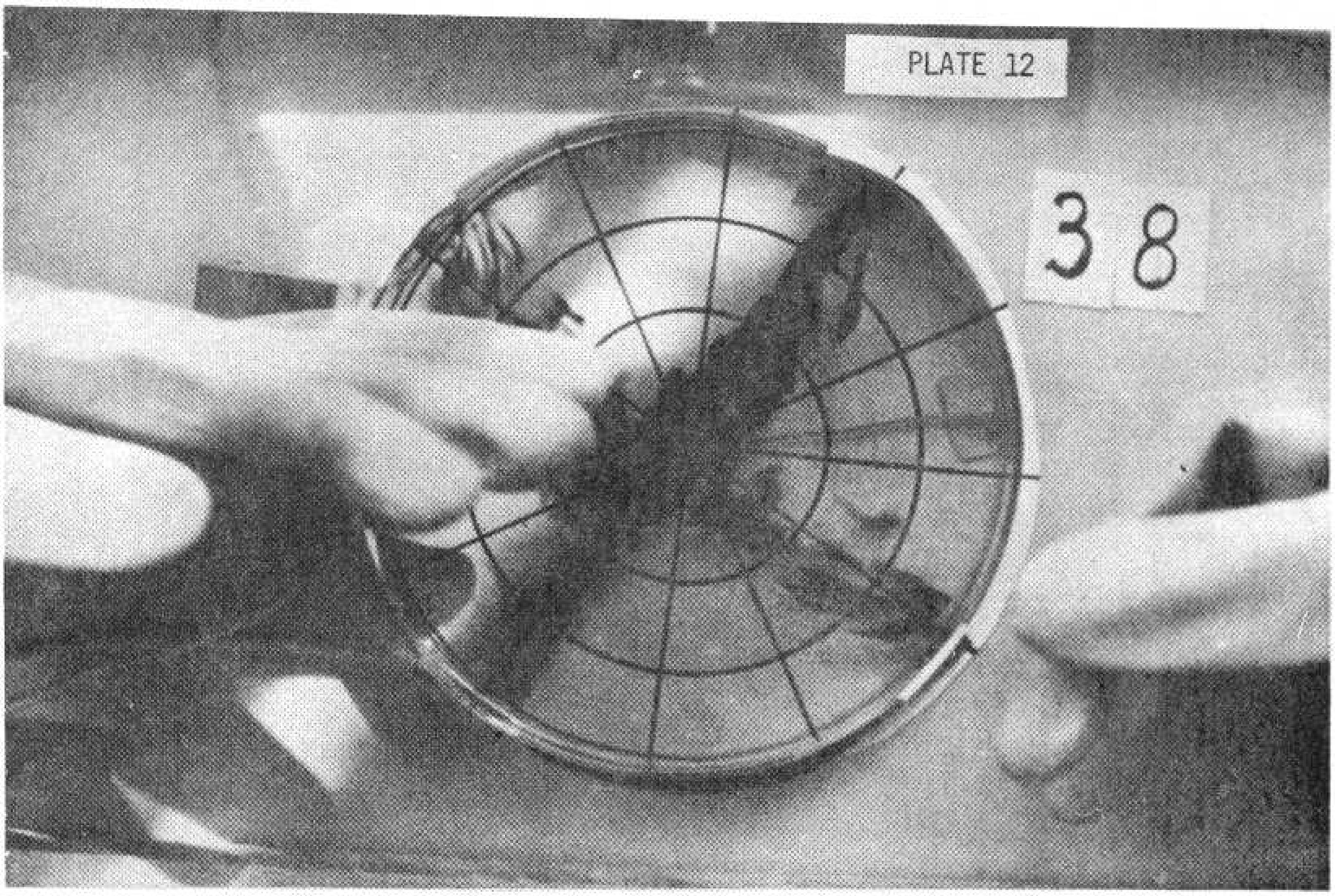

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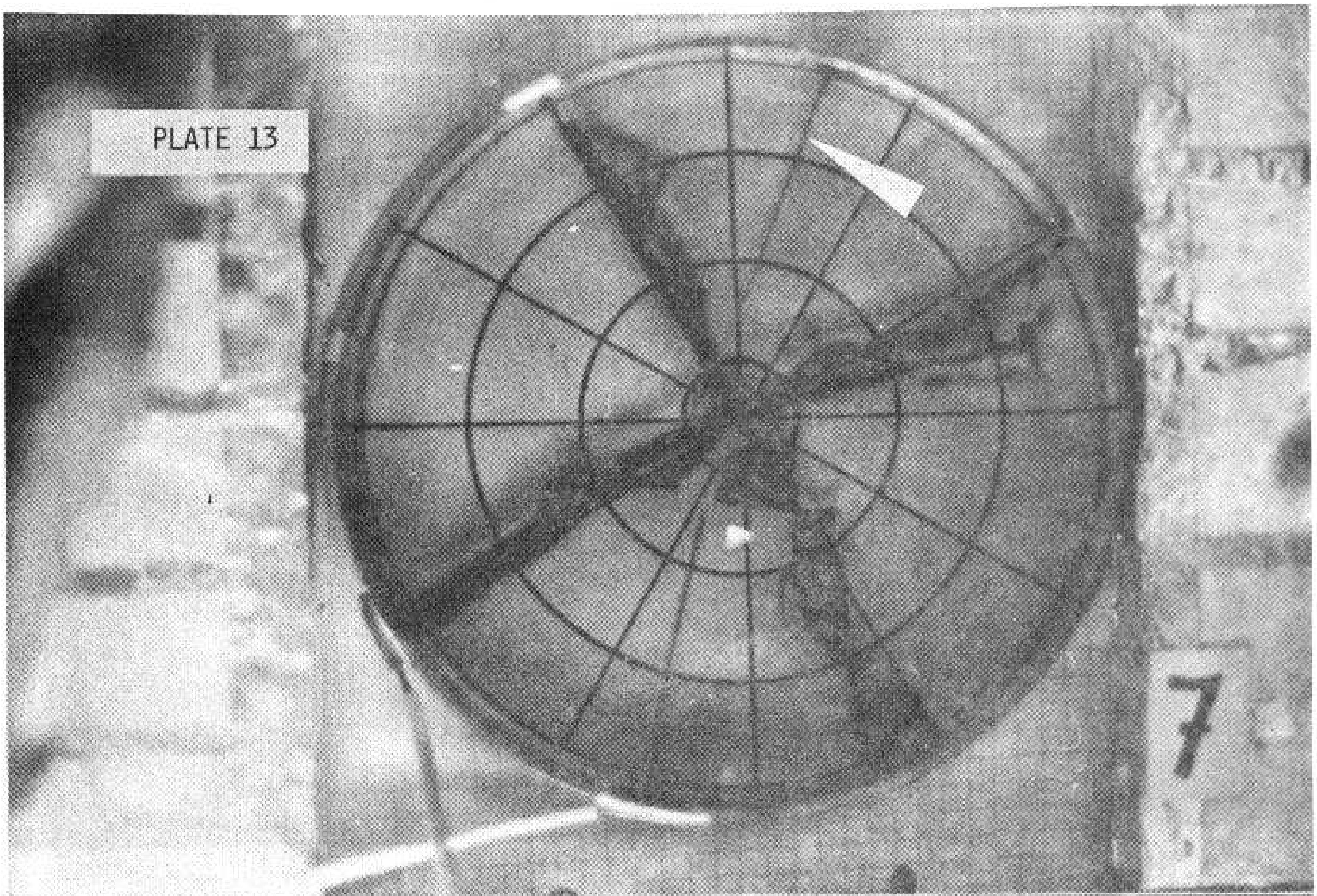

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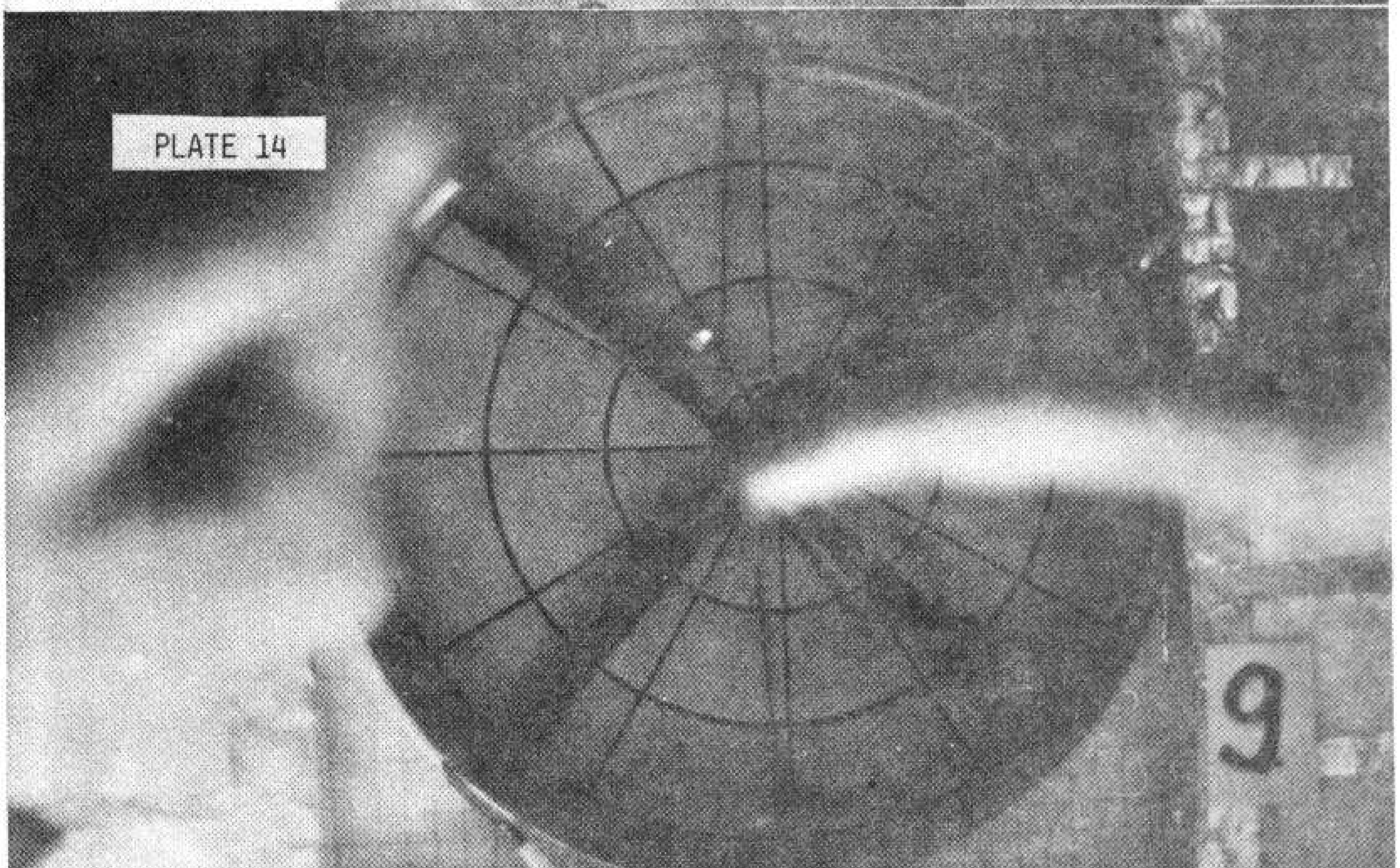

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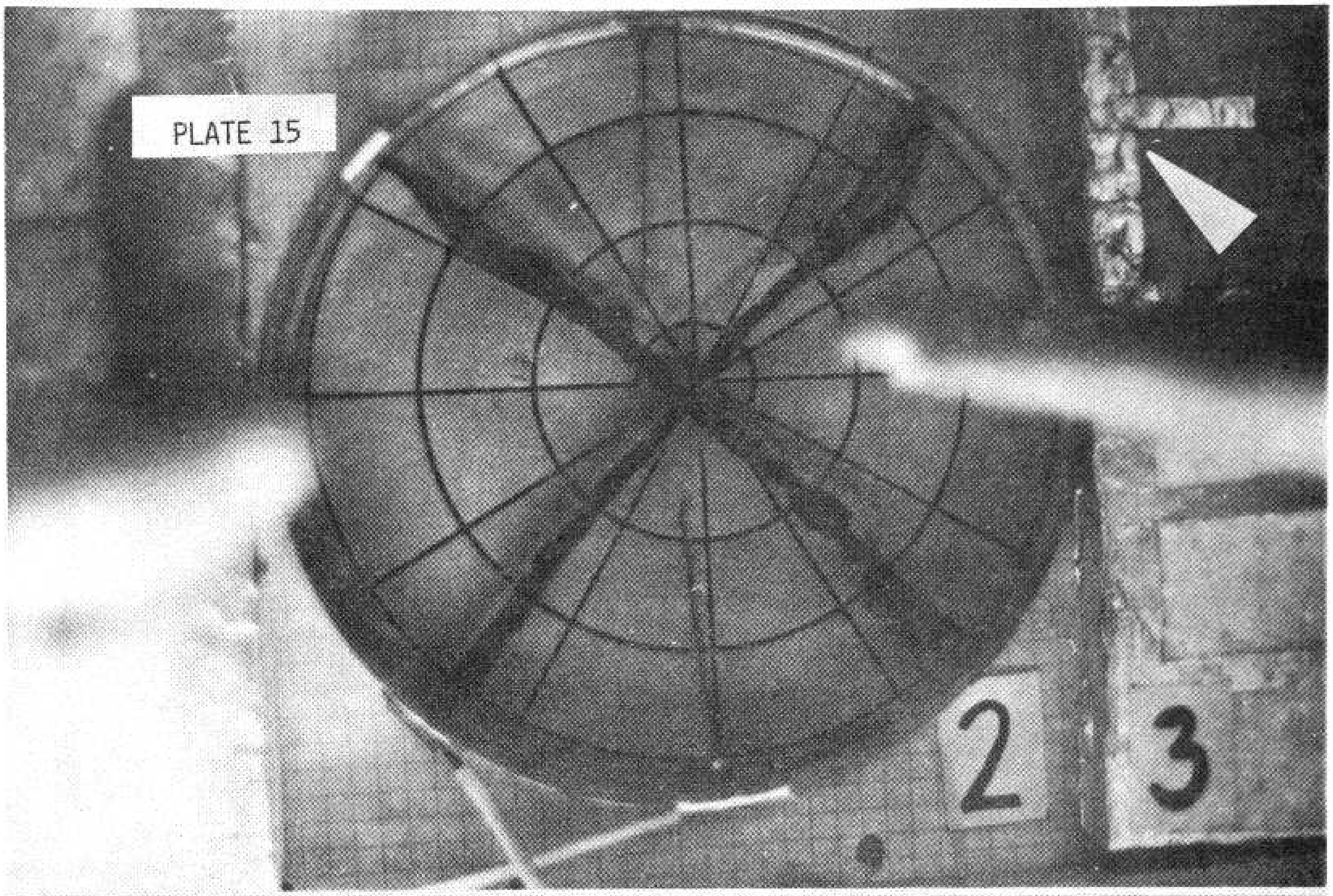

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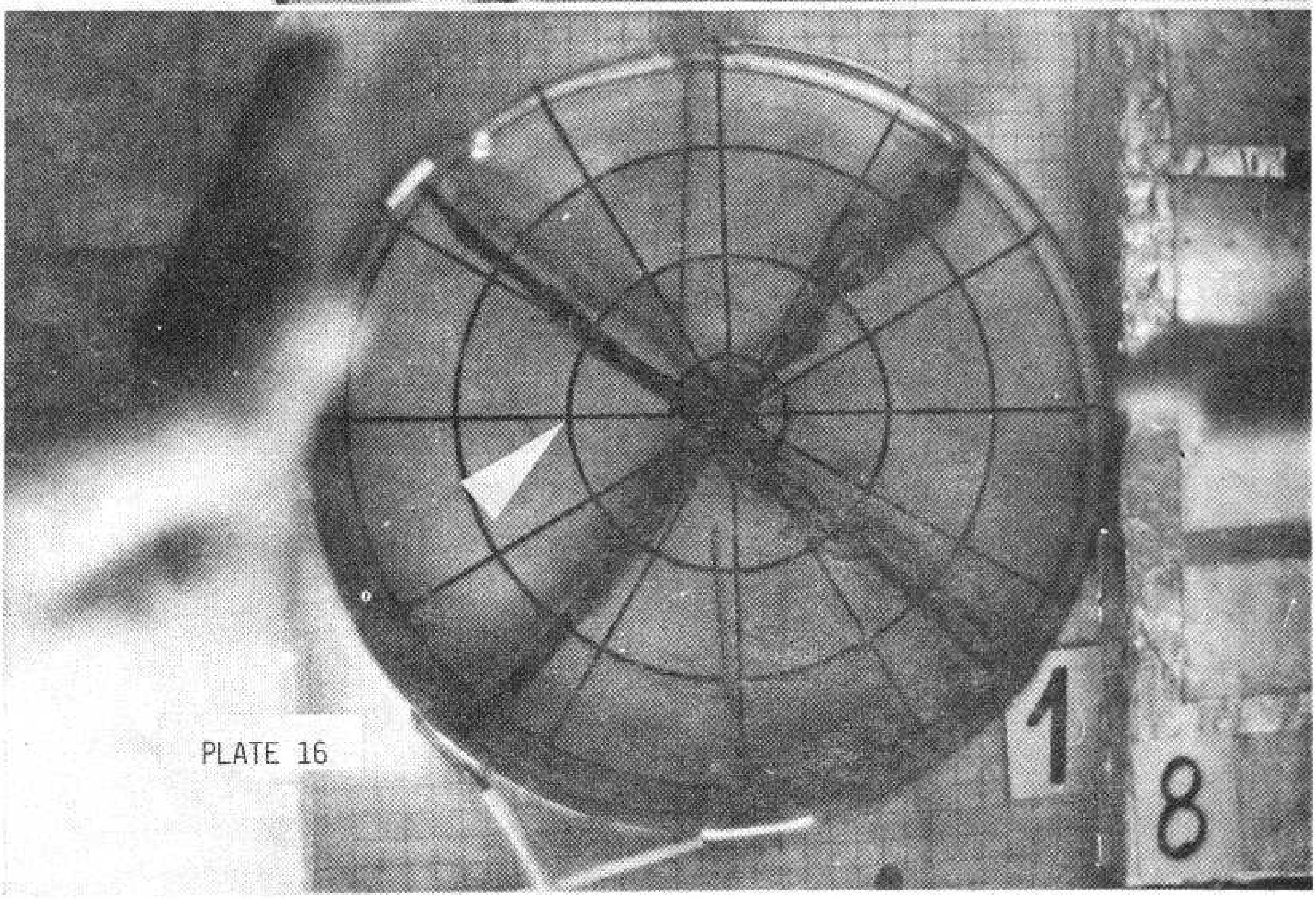

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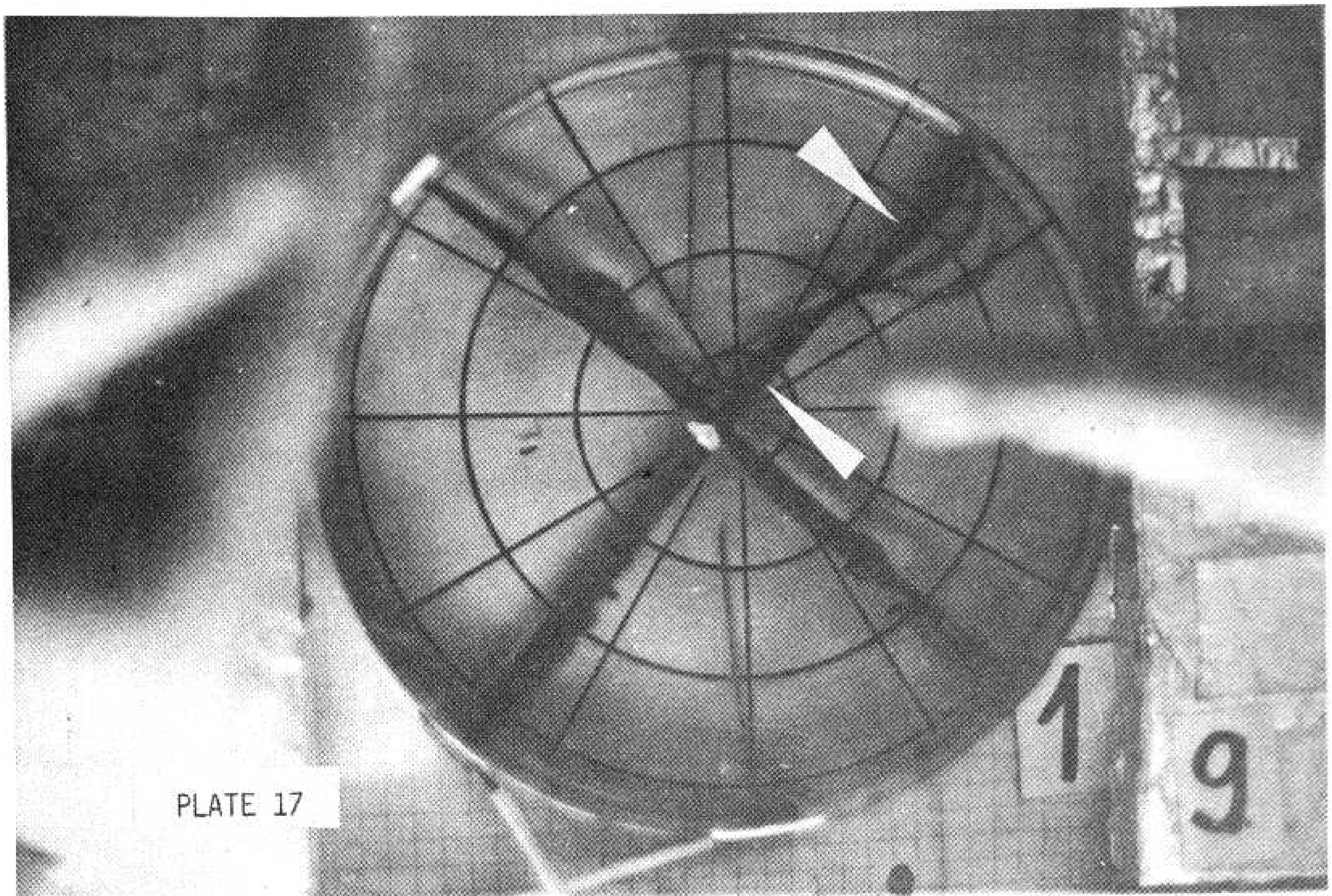

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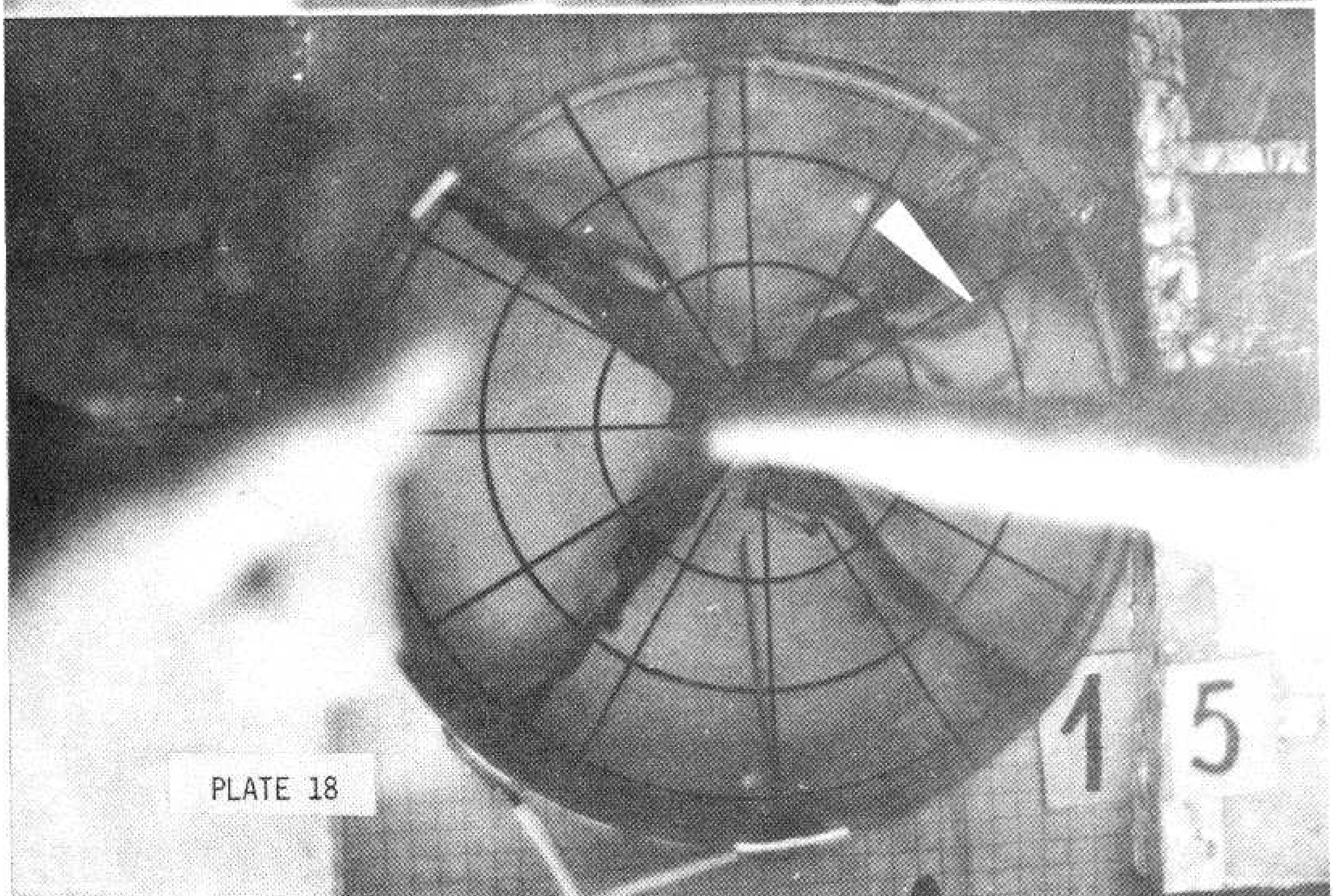

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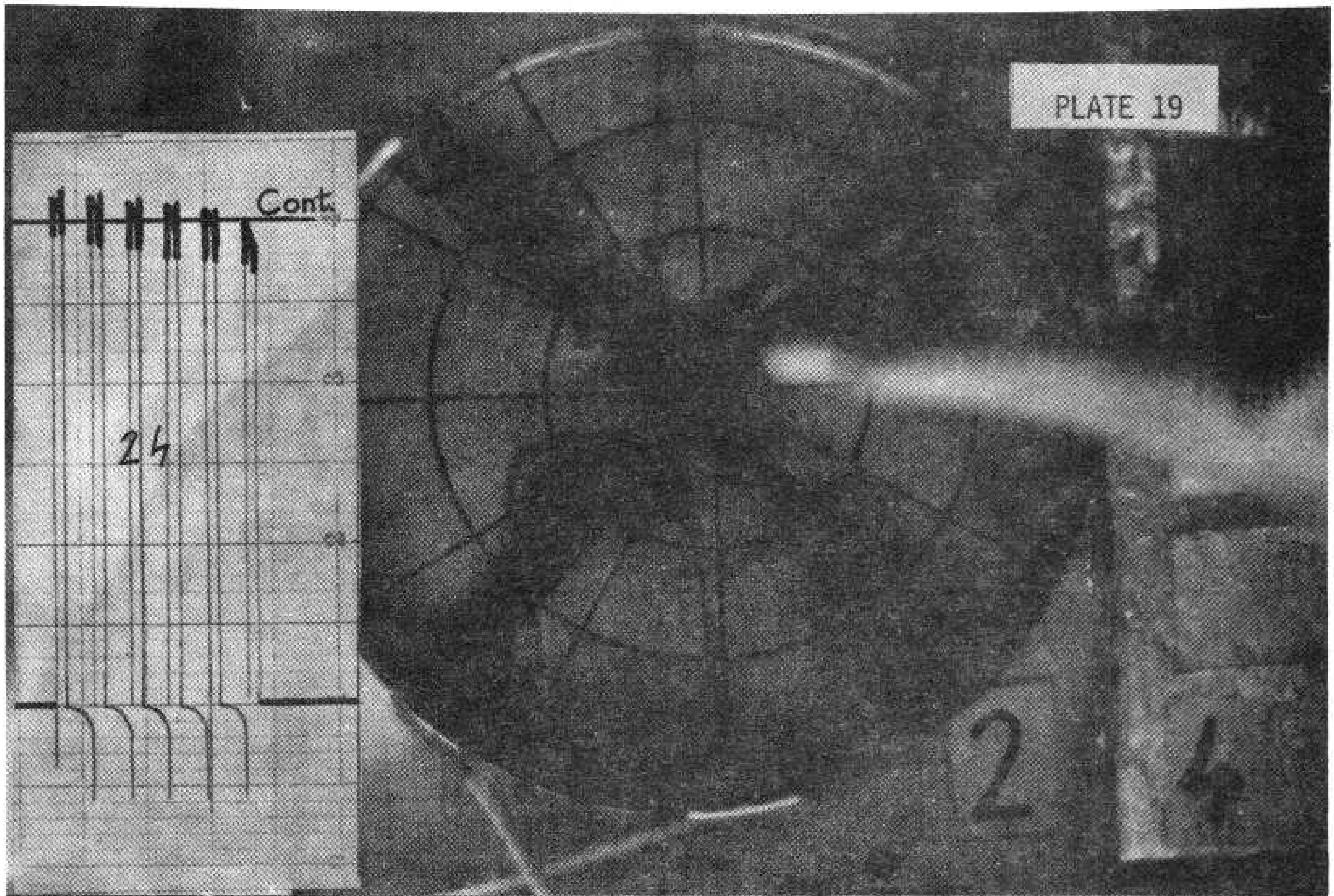

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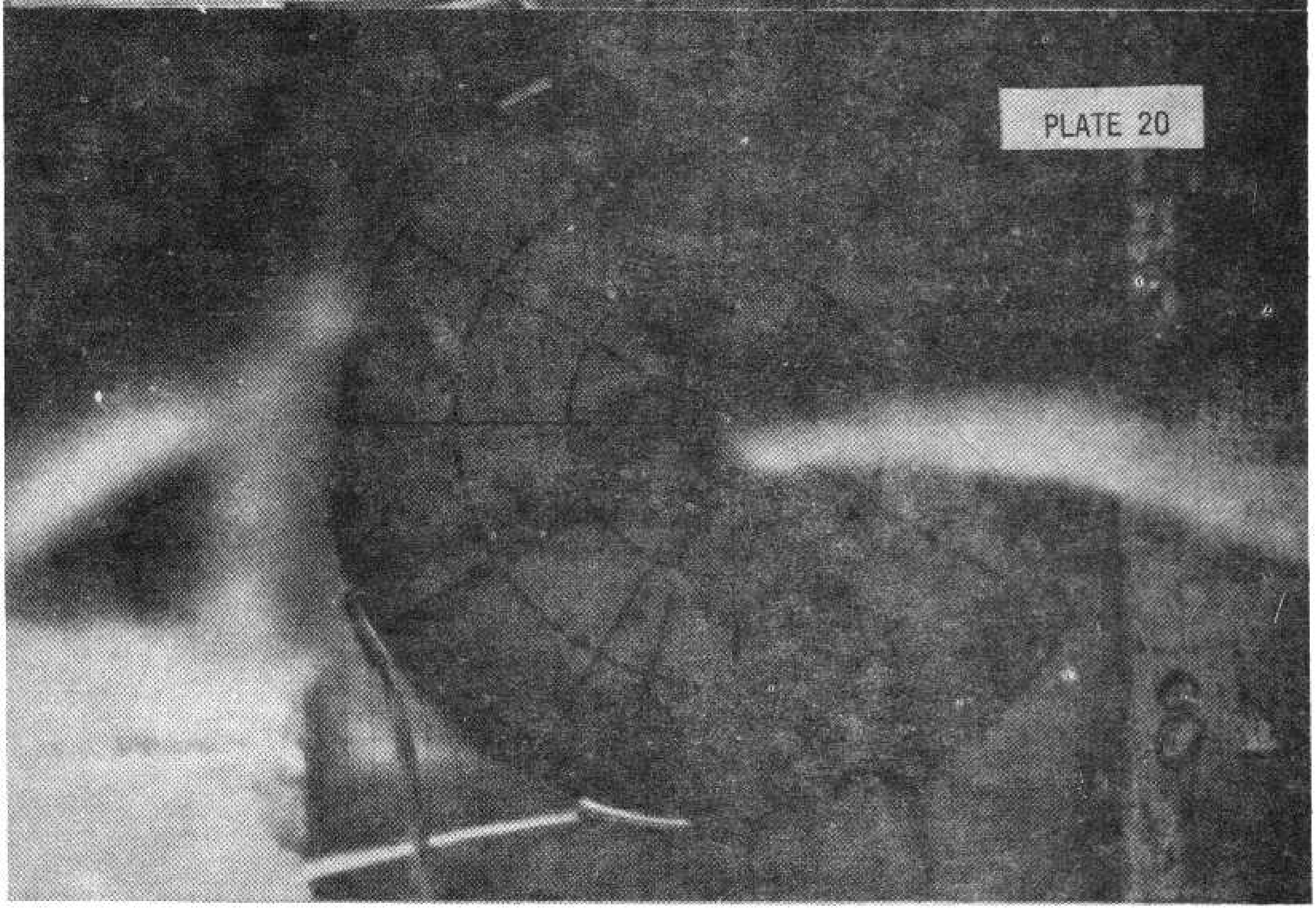

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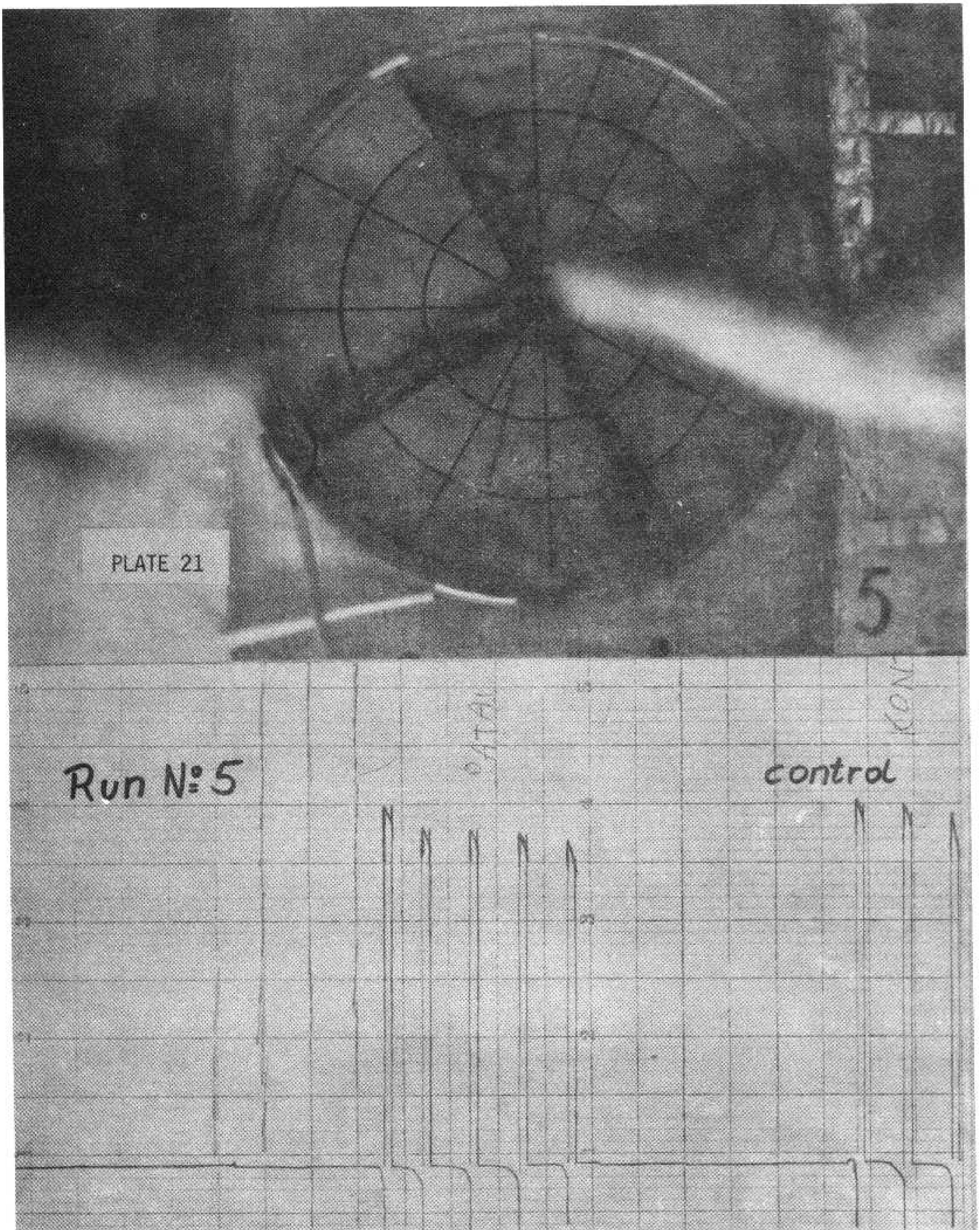

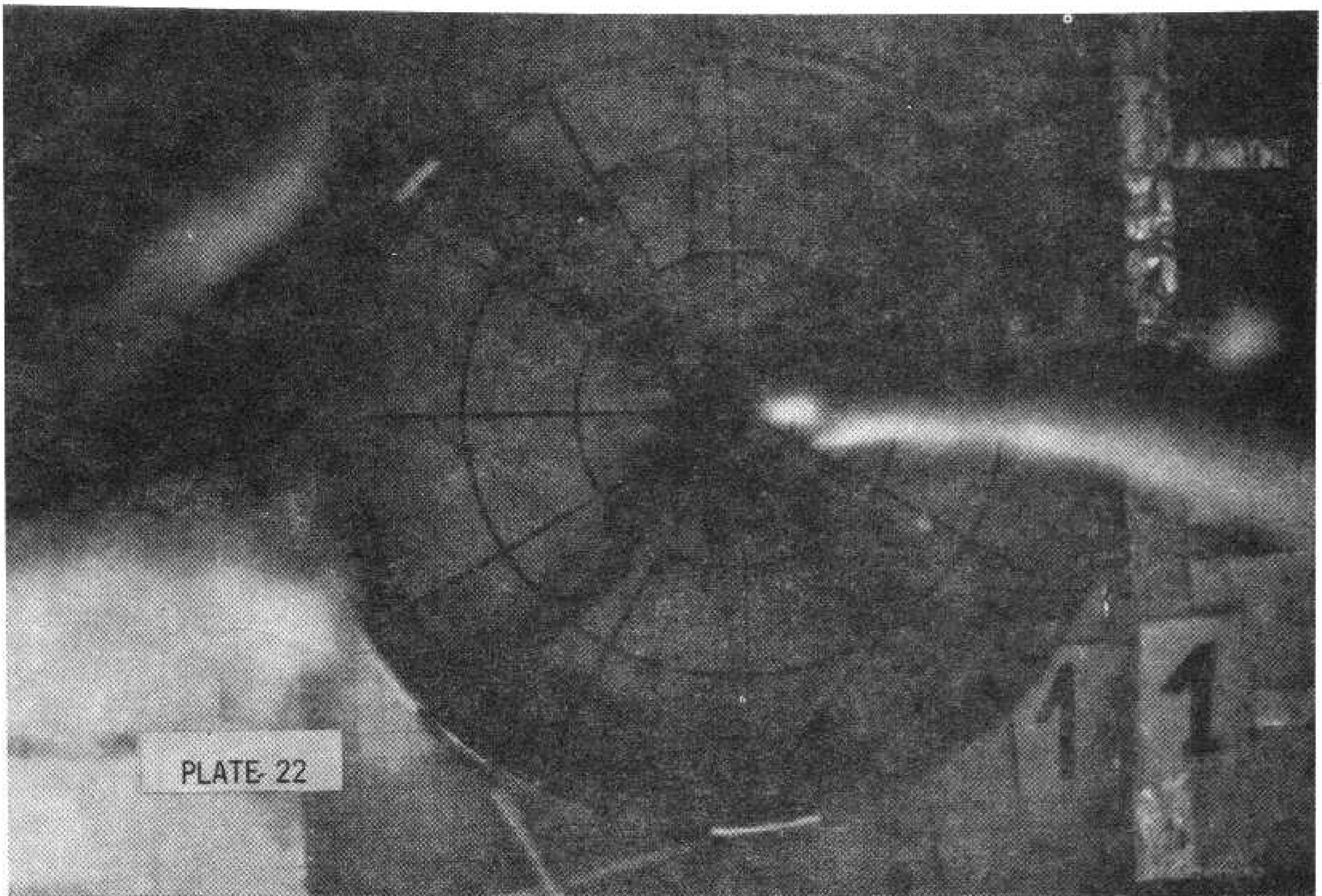

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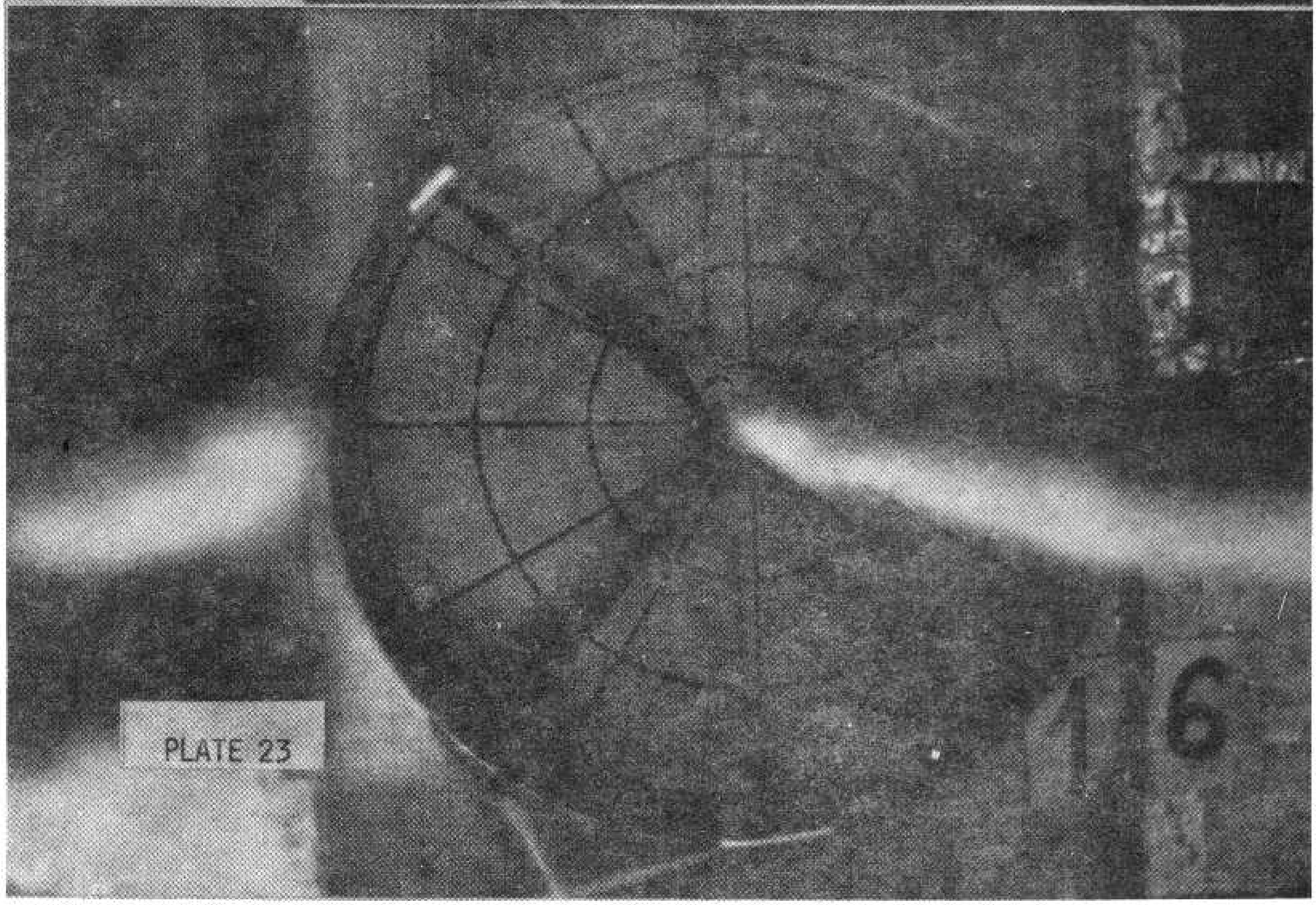

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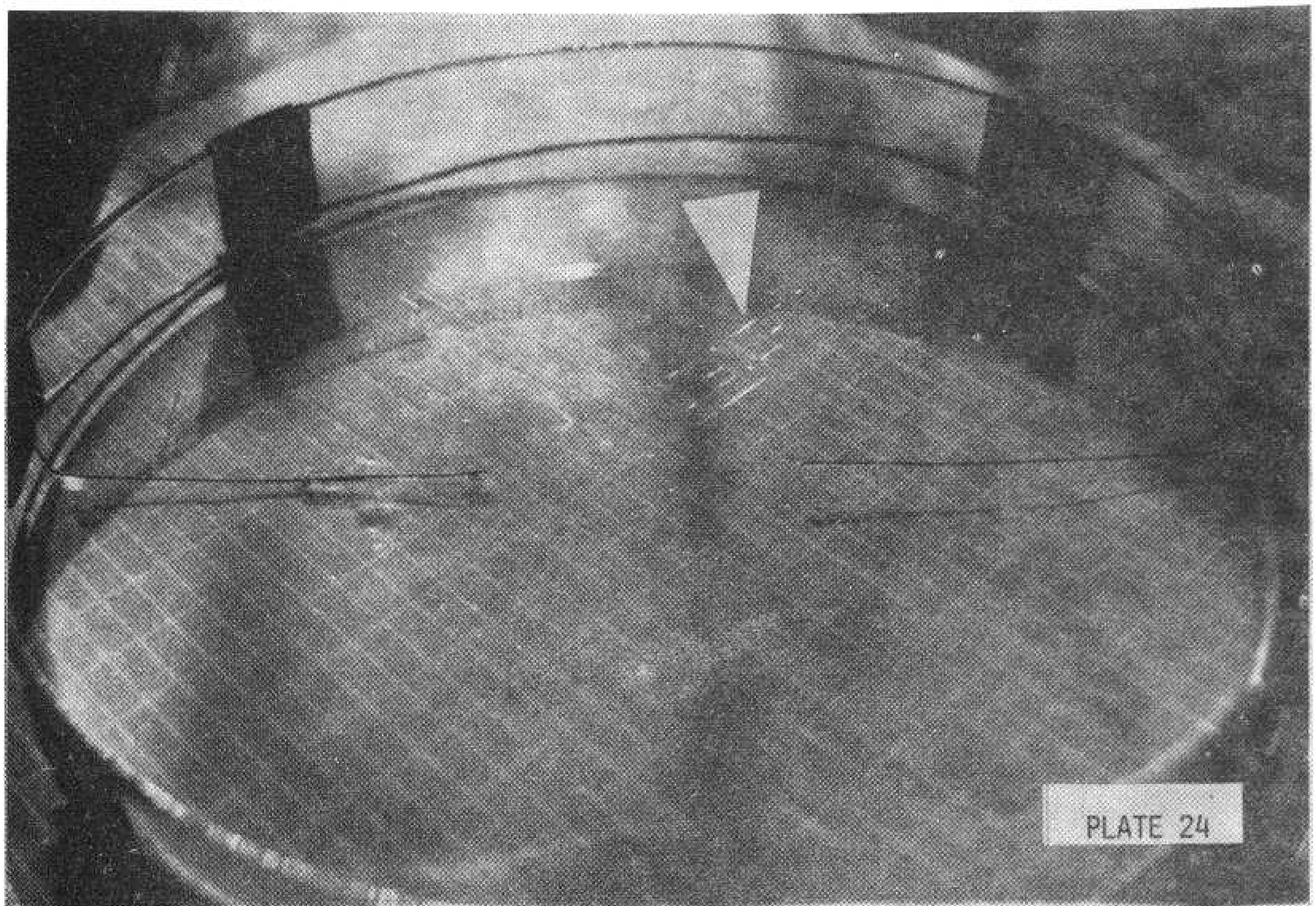

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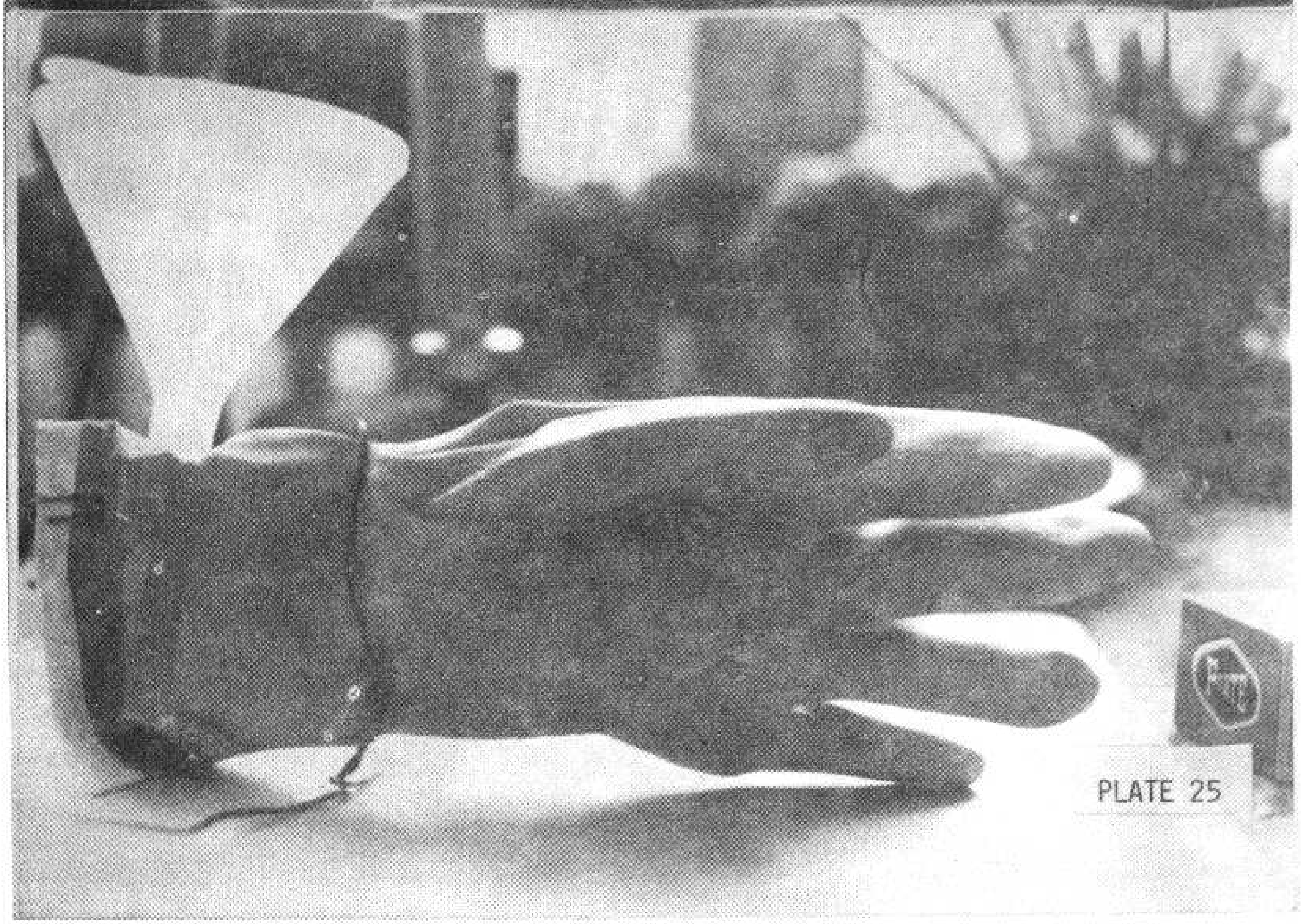

PLATE 25

Kiadja a Központi Fizikai Kutató Intézet
Felelős kiadó: Gyimesi Zoltán
Szakmai lektor: Apai Pál
Nyelvi lektor: Harvey Shenker
Példányszám: 365 Törzsszám: 86-654
Készült a KFKI sokszorosító üzemében
Felelős vezető: Töreki Béláné
Budapest, 1986. december hó