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THE CARL BOSCH LABORATORY OF BERLIN

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COMBINED INTELLIGENCE OBJECTIVES

SUB-COMMITTEE

LONDON - H.M. STATIONERY OFFICE

[redacted]

Report on

THE CARL BOSCH LABORATORY OF BERLIN

Reported by:

R. H. RANGER, LIEUT. COL. SIG. C., U.S.A.

B. R. GELBAUM, 2ND. LIEUT. SIG. C., U.S.A.

on behalf of the

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TABLE OF CONTENTS

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Infra-Red Telescopes

1. In order to provide as complete a picture of the essential elements of infra-red telescopes, a joint report on their research and manufacturing is here made.

2. Dr. Carl Bosch, who was very active in A.E.G. research, has perhaps the keenest insight into the theoretical side of the matter. He has come from Berlin, with a brief stage at Lehesten, to Heidelberg where he now may be found on the large family estate at 33a Schlosswolfsbrunnensweg.

3. In his laboratory work, he has increased the resolving power greatly, down to the order of 5 mm.

4. Increased sensitivities were being accomplished by the use of a spongy colloid to support the Caesium photo-sensitive surface.

5. Sensitivities of fifty time normal have been accomplished by this process in givne spots on the surface. This might be particularly useful in photocell development.

6. By the use of dicyaninea, sensitivity much further towards the long infra-red, was accomplished; as far as 2.4 mm. This cell was good for one week before it gradually failed; but to date it has not been duplicated.

7. Dr. Bosch insists on extreme care in eliminating contamination. In this direction, a very fine water filter was a by-product of the development. It was very efficient, and at the same time provided water that was quite free of metals.

8. Another by-product was the construction of a very neat high voltage source, a light compact Wimshurst machine.

9. To provide a reticle in the Bildwandler, Dr. Bosch projected an image of a micro-film of a sight by a small lense system directly on the front of the infra-red sensitive surface of the tube.

10. The relative position of the reticle and the image as picked up by the tube at a given time could not be then changed by any later inaccuracy of the electron focussing.

11. As many as 22 different types of reticle were tried by different services, and this micro-film method accomodated all variations readily.

12. This showed the remarkable accuracy to which the Germans were anxious to go in the use of this equipment in conjunction with flack firing.

13. Quantity production of these tubes was being accomplished by the CHF Mueller Co. in Greiz. Their process is here described.

14. The key personnel and test equipment are now available at Erlangen.

15. Dr. Franz Lohmann heads the group, and he may be located through the local Phillips representative, Adolf Biegel at Nurnberger Str. 82-88 (Behelfheim) or Mr. Hans Ziegler at the large Siemens-Halske plant.

16. It is believed that the best method of getting the full value out of all this work, would be to have a pilot set-up made by these people in Germany under our careful supervision.

17. While there may not be much direct use for Bildwandler tubes, nevertheless the technique is directly applicable to photocells.

18. Likewise, there may well be further direct use for infra-red equipment, especially for scientific and astronomic purposes, so it is felt that this technique should be thoroughly established, before it is dissipated.

19. Lieut. Gelbaum of Technical Liaison, Signal Corps, cooperated in this investigation very completely.

Regarding Developmental Work in the Laboratory of Dr. Bosch of A.G.E., Berlin

The following report embodies a summary of the work carried out in our laboratory during the course of the war. Part of the report - the smaller section thereof - deals with the further development of the 'Image-transformer' apparatus (Bildwandlergerat) (Sections 1 - 11) - Here, we deal with the subject in a brief manner, sufficient to enable the technician to understand what is being dealt with. More detailed descriptions would far transcend the scope of this report, yet we are in a position to furnish such for every single point touched on, if necessary.

Points dealt with in sections 13 to 17 sketch the progress of our development in various single instances, and in this regard it may be said that the matters dealt with in sections 13 and 14 have already led to practical results. Nevertheless, even here further research was envisaged. Sections 15 and 16 tell of two further tasks we were engaged on, which, however, in spite of prolonged research, did not lead to any reproducible results. Mainly for this reason, but also owing to the fact that the greater part of the writings on the subject were destroyed in an air-raid, we have abstained from furnishing more exact data. Nevertheless, it is our opinion that here we are faced with two extraordinarily interesting possibilities.

The final point - (Section 17) - deals with research regarding Albumen (egg-white) - In this case, too, we have ample descriptions, these, however, cannot be fully made use of at present. We regard as concrete results the development of the Casein process for light-screens and - should further research yield positive results -- the influence of certain types of ions on the organic state of body tissues, as well as research concerning the size of the albumen molecule.

We should like to mention here that the research work carried out resulted in our being confronted with a whole range of new problems, solution of which had to be deferred until the end of the war.

With the report, - we likewise furnish a record of the applications for patents; this, however, is not complete, as a later record has been lost.

Developmental Work

Several processes for the production of light-screens for electron-optical 'image transformers' were developed. In the first instance, the screens were created simply from soluble glass by means of sedimentation. We found, here, that dispersion with silicic acid (colloidal) - which could be achieved through the addition of acetic acid, - resulted in a notable improvement in the granular quality of the screen. The analysis of the screens with ultra-violet light

65638 2

resulted in a figure of approximately 40 to 50 microns. As, however, a finer granular arrangement soon became necessary and it was obvious that the soluble glass process would not fulfil our requirements, we started to work the screens with aluminum salt (Aluminiumsol). The grain by this method was noticeably finer (about 5 microns), but at first we failed to bring the screens up to the desired degree of brightness. Further research revealed that treatment of the light-substance in weak acid solution, as is necessary in the case of argillaceous earth in order to stabilise the salt, was the cause of this phenomenon. Of the two chief light-substances used - (Zinc-sulphide-selenide, zinc-cadmium-sulphide) - the latter showed itself specifically somewhat brighter and finer-grained, but at the same time, more sensitive to outside influences in working. After the influence of hydrogen ion concentration on brightness had been discovered, the Casein process was developed, because in this the dispersing albumen body is only effective in a weak alkali solution. Analysis showed that we had achieved a figure of about 5 microns, but brightness was notably greater.

We attempted at first to attain greater degrees of resolution by means of making the grain still finer with consequent greater dispersion, but in the meantime, other research had shown that we had just about reached the limit of resolution, so long as the same electronic energies were to be dealt with. It is true that diminishing the thickness of the fluorescising layer at first increases resolution, but it brings in its train a striking decrease in brightness, as electronic absorption is too slight. On the other hand, an increase in the thickness of the layer results in an increase in brightness up to an optimal value, but unfortunately this decreases resolution owing to the presence in the light-layer of diffused light. Thus, achievement of the optimal effect involves the question of effecting a compromise between two different thicknesses for the layer, so that the tube in the hands of an observer will give the best results. Such phenomena, which also involve physiology, can only be determined as a result of more prolonged research. In general, it may be said that with a customary voltage of approximately 15 kilovolts, a thickness for the layer of 20 microns will be about right.

Experiments have shown that covering the light layer with a very thin aluminum layer enhances the brightness of the optical image and further, this prevents random high potentials from being set up on the surface of the screen and prevents an optical back coupling because of its light screening effect.

The evaporation of an aluminum layer on to such a light-substance is not so easily performed. Aluminum sulphide and Aluminum oxide are possibly formed and the immediate result of this may be that the fluorescent substance is completely destroyed and further, that no coherent metallic surface is realized. For this reason, the surface of the light-layer should only be protected by a very thin layer indeed.

This is an exceedingly tricky job...in the first place, when the aluminum layer is condensed, the fine coating of the screen must not be damaged, - the layer must be able to stand up to the operation and must be capable of removal on heating in a high vacuum. Furthermore, the layer must not display any structure, as this may affect the image considerably. The usual type of 'zapon' foil cannot as a rule be made use of. Closer study of the problem showed that type, method of production, - and pre-treatment of the nitro-cellulose used are of paramount influence. This applies also to the choice of solution, and the blending and softening mediums. It is also necessary to filter the saponaceous solutions beforehand, in order to get rid of the not quite thoroughly nitrated cellulose residue which is always present. It was only after the most careful experiments that a standard solution was fixed on which could be made use of in practice.

Evaporating on the aluminum layer created great difficulties at the beginning as when melted it reacted very easily with other metals and also rendered these fragile or ate its way through them. Then too, it can very easily happen that drops of aluminum get scattered on to the screen and render this unusable. It was only after a suitable type of wolfram furnace had been designed that such phenomena were almost wholly suppressed. Pertinent to the procedure, too, is the preservation of a good vacuum, in order to avoid too great heating of the layer and consequent burning of same.

For the final testing of the fluorescent screens for the 'image transformer' a testing chamber was finally set up, in which ten screens at a time could be tested and compared. This consisted as a rule of an electron-optical compartment creating an evenly intensive stream of electrons; the screens were held in a revolving disc, which could be viewed from below through a glass pane. Every screen ready for use was once again tested for errors, brightness, etc.

The Caesium cathode for the 'image transformer' had to be provided with a metallic discharge plate. This was contrived by plating the glass with a fine layer of silver by chemical means. It was found in practice, however, that the silver solution sometimes fell on the spot where the cathode was to rest and had to be carefully wiped off. The result, however, was that the place where the caesium cathode was to be placed became somewhat spotted and it could further be noted that the silver sometimes still held traces of electrolytes, which made their presence unpleasantly perceptible later. For this reason, it was decided to evaporate on the silver layer. In order to secure an even and unbroken layer a magnet mask was developed which consisted simply of a round piece of nickel-plate - held in position from outside by means of a magnet and this screened the cathode surface so effectively that a silver ring without any breaks in it could be evaporated on.

Cleansing the cathode was a difficult job. The customary method, i.e. with the use of chrome-sulphuric acid and washing with distilled water, or any similar procedure, did not prevent unsightly dry spots from appearing which lowered the quality of the electron image. Even the apparently-purest of distilled waters dissolves so many alkalies from glass that when condensation of the vapor took place spots appeared in many places. For this reason, we perfected a new process, free from such defects. At this point, we should remark that the glass bulb, which is kept with the opening pointing downward, should be blown out with a powerful jet of steam and it should be seen that it penetrates every corner of the interior. This warms up the globe and by withdrawing it some distance from the source of the jet the formation of droplets will be avoided and in the heated state of the glass an extraordinarily speedy and unspotted drying takes place.

The procuring of adequate supplies of distilled water was not an easy matter; only after repeated setbacks could it be ascertained that in most cases technically distilled water was not suitable, since in most cases it contained slight percentages of heavy metal salts, which had a 'killing' effect on the fluorescent substances. This influence is especially noticeable at high temperatures, such as are used to warm up the tubes. We therefore went over to using distilled water which was distilled into and out of glass carboys. It was not possible to set up the plant for the supply of so much distilled water without a great deal of constructional material and many breakages, the reason for the latter being that the heat conductivity of glass is less than that of metal. For this reason, as we say, we had to develop a new form of apparatus. In this, the water was not heated from the outside inwards, as is generally done, heating was carried out through the medium of an electric current which was passed through the fluid. The degree of effect was notably enhanced, small and inexpensive apparatus was fashioned, and an ultra-pure form of distilled water - free from heavy metal salts - was produced. An apparatus measuring, for instance, - 20 x 20 x 50 cm gave a delivery of about 150 litres per day, required practically no attention, and proved in every respect of excellent service.

The positioning of the image transformer in the tubes was another problem. Good electrical insulation, as well as mechanical strength, had to be ensured. Welding insulators to glass, owing to the different expansion coefficients of these, causes many breakages, quite apart from the problems inherent in making the joints. Care had therefore to be taken to see that the 'putty'ing displayed not merely the requisite firmness, but also a certain degree of elasticity:- we were able to solve this problem by using cottonwool, and then impregnating the cottonwool with a lacquer solution. This gave both a firm and an elastic fixture. Our experience with this was so satisfactory that we have decided to make use of the method also for radio tubes and photo cells. Polyvinyl-chloride was used as an insulator. The stuffing was of triacetate wool and the lacquer a solution of polyvinyl-chloride in methyl-chloride with a small quantity of Cyclohexanon. It should be remarked that this joint was also perfect from an electrical point of view. Composition of the lacquer was:- 90 parts methyl-chloride, 30 parts cyclohexanon, and 10 parts polyvinyl-chloride.

For the tube of the image transformer a vizier (sight) - was also developed. At first it was bedded into the light-screen, but we found that owing to the deflection of the electronic beam in the magnetic field of the earth errors occurred, so that we had to give up this method. For this reason, the sight was projected on to the cathode at the same time as the objective image. This projection sight is really a small projecting apparatus located in front of the eye piece. An adjusting device enabled the sight to be brought exactly in line with the optical axis. The target was first drawn in Indian ink and then photographed with the use of a hard, fine-grained film. For the sighting optic we used a very weak microphotographic lens made by Leitz (focal length approx. 25 mm.) This device proved quite usable and, of course, - was free from the errors mentioned above.

For viewing the image on the screen a magnifying glass of about five magnitudes power with a very wide field of vision was developed. Corresponding products of Carl Zeiss and Leitz proved too heavy and too expensive. We followed the path taken for a microscope - oil immersion with - in the first instance, a hemispherical lens, with the object of taking in as large a field of vision on the surface of the screen as possible. By placing in the rear of this two weak double convex lenses of about twice the diameter of the screen, it was possible to cover almost the entire field of the screen to the desired magnification. This mode of construction was also used for all the tubes of the image transformer.

For simultaneous reflection of the entire horizon a certain order of arrangement for the lenses was devized. It consisted mainly of a number of well-lighted single systems, arranged in such a way that the field of vision of each lens touched on the other. In itself, such as arrangement would be capable of covering the entire horizon in small sectional parts but it has this disadvantage that sometimes the coverage of one part of the image would spring to the other, because the reflected pictures are turned sidewards. However, this error can be cured if a mirror is placed either before or behind the eye piece. In this manner, it is possible to build a continuous reflected image in small parts. Nevertheless, this device has never been put into practice.

Developmental Work in General.

The research work described above constituted but a small fragment of our program of operation. They were all more or less concerned with the construction of the electronoptical image transformer. After we had worked out the formulae they were for the most part taken over by the production units, who followed the prescribed directions and put them into effect. The services of our laboratory were subsequently only called upon in cases of interruptions in the producing plants and in most cases were devoted to the speedy correction of any errors which had supervened. With the production side of the image transformer - properly speaking - we really had nothing at all to do.

About five years ago developmental work was initiated on electrostatic high voltage generators. We took the well-known Wimshurst 'Influence Machine' for our model and sought to build a copy of this with artificial plastics such as Polystyrol-Polyvin-chloride. These experiments were started in the first place purely out of scientific curiosity because we have been able to note that the known types of influence machine are not very efficient and display certain not very desirable qualities, as for instance, - irregular output, sensitivity to moisture, - susceptibility to polaric reversal,- and very short life. We believed, first of all, that we should be able to remedy such defects through the use of better insulating materials but as a matter of fact we achieved the very opposite effect. I might remark at this point that in spite of the apparent simplicity of the influence machine from the point of view of theory, in actual practice it is not in the least simple, and moreover, no satisfactory explanation for this fact has hitherto been advanced.

Not that plenty of would-be explanations have not been put forward; but physical clarity has not been an outstanding feature of such. The failure of our experiments with the artificial materials mentioned above was what induced us to make a thorough-going investigation of the whole problem. Since the appearance of high voltages in the atmosphere leads to the formation of ozone the problem was first attacked from the point of view of Chemistry. From this standpoint, the use of hard rubber in the presence of ozone was to be deprecated, seeing that ozone happens to be the very strongest oxydizing medium which we know. An attack by this substance on chemical compositions with double combinations leads to the formation of ozonides and - if water is present - to splitting up of the molecules and the formation of carbonic acids which conduct electricity. Experiments along the lines indicated, demonstrated that artificial substances such as Polystyrol, Polyvin-chloride and combined polymerisates of the metacryl-acid series are not attacked by ozone, at any rate to a far lesser extent than hard rubber. The next item was to produce a high tension resisting fastening material such as - for éxample - is used for the making of rotors.

Usually, a fastening material - such as Polystyrol - is dissolved in Benzol and brought into contant with the two parts to be cemented. But the defect of this is that such a joint has not the strength of pure Polystyrol or similar substance. It is not possible to clear away the solvent quickly enough from the joint and sunce it is ionized - even if only to a slight extent - the joint is not firm enough for requirements.

In spite of the fact that the best artificial insulation was employed we were unable to solve this problem and we had therefore to strike out along a fresh path.

Polystyrol is an excellent insulating substance, its monomeric form - Styrol - a highly mobile, benzol-like fluid, easily polymerized. These qualities could, then be utilized for the production of high-tension-proff joints, that is to say - the joint is made in the first instance with Styrol, which is then polymerized with ultra-violet light.

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By this means, it was possible to turn out a homogeneous union with Polystyrol. Experiments of this sort demonstrated that such weldings correspond to what would be expected from Polystyrol, so far as high tension conductance is concerned. Such a process has since been put into operation for the making of our high tension generators and has since been developed further. It has now been adopted in many other branches of commerce, notably in the electrical industry. (To reduce the blisters in the material very thin coats of styrol wereapplied to the laminations forming the discs - Ed.)

Since Polystyrol, in spite of its hardness, is not proof against mechanical wear and tear great difficulty was experienced when using sliding contact springs. Aluminum contact springs enjoyed a very short life, however, Molybdemum springs was much better, although these had to be very carefully adjusted.

The choice of the metal for the contact springs now seemed solved. But it was not so at all, as further research showed. The first thing we discovered was that electrical loading of a contact spring was similar to that of loading the cathode in the lighted discharge tube, that is - many of the substances involved in their composition are subject to dispersal. So far as we have been able to ascertain up till the present, the process is similar in both cases, - silver and copper disintegrate decisively, whereas molybdenum and aluminum sustain hardly any abrasion. For that reason bronze springs or brushes should not be made use of, since the pulverized copper, particularly, it is deposited on the insulators as copper-oxyde, a semi-conducting substance, and leads to fractures. In one case, it was possible to verify the presence of such copper deposit chemically. The next logical step was to try out the possibilities of aluminum, since its resistance to dispersal is great and also, aluminum oxyde is not a semi-conducting material. But it has one great disadvantage, - namely, that the oxyde layer formed by contact with ozone has such a grinding effect that this metal is of no use for contact springs.

So the next step was to try molybdenum, and we found that this was excellent for the purpose desired. It was now possible to run the machines for periods of 5,000 hours instead of for 24 as had been the case at the beginning, without too much wear and tear taking place.

Then we had another problem to solve the choice of the proper type of lubrication. Oil, - even the best quality oil - was out of the question, as it soon forms oxydes with ozone, - even after the briefest period of working. This was true even of the finest parafin oil, as well as of all the other oleaginous mediums whose resistant powers one hears so often vaunted. Nor was Graphite any use, as the powder whirling off the machinery settled on the insulators and lead to the current jumping across the gaps. This problem, in fact, severely taxed our ingenuity, since the running time of the machines was at the most 200 hours. Recognising that ozone would always oxydize an oily substance we started our search for a lubricating medium that would not be attacked by ozone. It seems clear that ozone will be capable of attacking any carbohydrate of low viscosity which contains no double combination - (with a few notable exceptions!).

But it does not attack high-polymeric substances like Polystyrol. We finally reached a solution of the problem by the use of chlorinated carbohydrates. Speaking in general, a substance which has been chlorinated can no longer be oxydized by ozone. Among the chlorinated carbohydrates there are several which do not split up chloride in a watery solution in ions. An example is tetrachlorohydrogen. It is a characteristic of the higher members of the parafin series that the higher the chloride content, the more pronounced is the tendency to split off free hydrochloric acids. There are to be found, however, some which with the proper degree of viscosity do not attack metallic surfaces and are no longer effected by ozone. Similar considerations are naturally valid for aromatic carbohydrates.

So we started to use chlorinated Diphenyl, which is sold under the name of Chlophen. Using this as a lubricant, it was possible to increase running time to 3,000 hours.

The axle of the machine ran in a cintered steel bearing previously impregnated with this lubricant. We believe that the solution of the above problem will be of general interest. It is a universally known fact that lubricating mediums after long exposure to the open air are prone to be resinated, i.e. - to be oxydized. It was therefore only to be expected that chlorinated carbohydrates would also be more resistant to the influence of the atmosphere than the normal types of lubricant. This has, in fact, proved to be the case, and it is now used in many cases as a lubricant.

After such preliminary research work, we started to consider the question of the electrical construction of the Influence Machine. It can easily be proved that a machine of the Wimshurst type only operates satisfactorily when the insulating covering of the excitor plate is really not insulation in the strictest sense of the work, but only a semi-conductor. Exploitation of this fact led to the construction of the circuit given, in which only conductor, defined resistance, and high quality insulation were used as the elements. It is our considered opinion that in this way we have solved the problem of the Influence Machine; the mechanical characteristic now accords with the theoretical predictions and is independent of chance. The running time achieved of 3,000 hours should suffice perfectly for practical requirements. In this respect, it should be remarked that the machine ought to operate in an absolutely dry atmosphere - most suitably - in CO_2, as the slightest degree of dampness leads to interior discharges. It is a further characteristic of the machine that it is not self-exciting, but only springs into life after receiving a small electrical charge which can be applied by means of any contact substance.

It was in our minds to utilize the influence machine as a high tension generator for the Bildwandler; even the largest tubes only call for a comparatively small type of machine. This led to the evolution of a smaller type (diameter of Rotor 8 cm, weight 300 grams with driving motor). However, we were not able to make use of such a type directly, owing to the fact that its interior resistance was too high.

So we were impelled to consider the creation of a suitable tension-stabilizor. This involved the adoption of a Corona discharge tube, so contrived that it broke down at a specific voltage - and with as flat a characteristic as possible with no dips or rises. We were able to achieve our desire more or less satisfactorily by copper electrodes in a glass tube, operating in pure hydrogen at approximately 2 atmospheres. The inner electrode is in the form of a short, perfectly rounded off rod with a diameter of approximately 5 - 6 mm, enclosed in a copper case whose interior diameter is approximately 25 mm. These sections can be adjusted to a very fine degree by means of the proper choice of pressure and when coupled to the above type of influence machine the tension variation with a tension of approximately 12,000 volts there is only a variation of 200 volts from no current to full current. By means of coupling the high tension generator to the load in parallel with the Corona tube effective low internal resistance corresponding to excellent regulation is attained, such as is usually achieved only with a powerful rectification apparatus. It is our opinion that the use of the influence machine in conjunction with the tension stabilizor is the ideal form of voltage source for the Bildwandler. It was intended by us to carry out developments on a much greater scale, but the fortunes of war prevented this.

In recent times we began research on the subject of <u>exterior photoelectrical effect</u>. It was less our intention to add to the plethora of writings on the subject of the creation of cells sensitive to infra-red rays than it was to attempt to come to an adequate explanation of the many baffling phenomena occurring so frequently with photo-cathodes. Since this was an entirely new project and the work had to be started from the ground up we are not in a position - owing to want of the requisite time for experiment - to give a full report on this matter. However, one thing seems fairly certain:- a satisfactory explanation of the problems inherent in the sensitisation of photo cathodes is further off then ever. This is our conclusion after experiments, which we shall proceed to give a report on.

The influence of the glass sub-layer in the case of alkali cathodes, - its composition, - and its pre-treatment, are of paramount importance. Within the range of properties of one and the same glass there exist variations in sensibility which have never been properly explained - in a simple way. We approached the problem from the point of view of the silico-chemical side, without, however, reaching any concrete results. We established the fact that with variations in pre-treatment of the same type of glass notable differences appeared. Within the framework of our colloido-chemical research we began to a study of the photoelectrical effect in highly activated surfaces. One experiment showed that at a certain place on the prepared layer, the photoelectrical value achieved was extraordinarily high. But we did not succeed in producing a layer with the same sensibility evenly spread, nor did we manage to reproduce the effect again. The substances utilized for these layers were:- Silicium-dyoxide, Aliminum-oxyde, - and Titanium-dioxyde: we modified their activity by means of tinting them with organic coloring materials. Their porousness lay far below the point of visibility.

In further experiment on sensitivity to infra-red rays of Caesium cathodes it was found on one occasion that sensitization with Dicyanin lengthened the curve for sensibility to about 2.3 u. Unfortunately, this effect also was not capable of being stabilized nor were we able to reproduce it. Many other experiments with other organic substances had, in some cases surprising results, but at the present time we are not able to say anything of a concrete nature on the subject.

Summarizing, it must be said that just this very line of research is in our opinion of paramount significance for the Bildwandler. And, had we only been in a position to verify the above results, we are confident that our apparatus would have been far superior to any other of this type.

Further research was carried out on the subject of the so-called 'suppression layers'. In this case, too, it is a question of phenomena of fundamental importance for the build-up of photo-elements and dry-rectifiers. As is the case with the photo-cathodes, we are aware that there are other influences, the nature of which is not understood. However, all the data collected on the subject was lost as the result of an air-raid.

The developments described heretofore on the production of light-screens, especially the dispersion occasioned by albumen, raised a whole series of questions of great interest. We may mention, for the sake of completeness, that we carried out research work in our laboratory on the subject of these as well. Novel phenomena, for instance made their appearance in the process of coagulation by means of albumen solutions, the proper nature of which has not yet been established.

It may be that here we have effects which will provide us with a solution to the question of the size of the molecule of albumen. In experiments conducted regarding the source and coagulation of albumen by means of certain defined electrolytes and the application of same to the human organism we observed effects which might possibly be of great medicinal significance. We are concerned here with the question of abnormal states of the bodily tissues, which are obviously responsible for rheumatism. A comparatively small number of experiments were carried out which yielded positive results and it was intended to conduct similar experiments on a much greater scale in collaboration with the Robert Koch Hospital in Berlin.

We have already furnished fuller data on the subject to the interested American investigators.

Heidelberg, 10 July 1945.

Dr. Carl Bosch.

THE PRODUCTION OF FLUORESCENT SCREENS BY THE ECRANOL PROCESS

AlOH stabilized with Al Cl_3)

1. Cleansing Every screen is to be thoroughly washed with a 10% soda solution, this can best be done with a rubber sponge or a soft brush. They are then rinsed, first with ordinary tap water, and then with distilled water.

2. Pouring of the sub-layer When the screens have been thoroughly cleansed, they receive a sub-layer of gelatine. This consists of:

1,000 ccm distilled water
3 grams of gelatine
0.1 grams of glycerine
A small piece of Thymol

The gelatine is first of all put into cold distilled water and left for about an hour to swell, after which it is heated to 50 - 60°; if there is a sand or water bath handy, this should be used. If a burner is made use of it should be seen that the flame is not kept too high or too hot andthe mixture must be frequently stirred until the gelatine is completely dissolved. The 0.1 g. of clycerine is then added and the whole passed through a glass filtering bottle No.3. Finally, a small piece of Thymol is added as a disinfectant. This prepared solution is used to pour the screens, that is to say, a quantity of the solution is poured on to a screen and tilted this way and that.

It is a property of gelatine that it froths very easily when shaken, for this reason it should be poured in a very carefully and swung gently around in the screen and lastly poured off. The layer of gelatine on the screen must be completely free from impurities. If any dots show up or there is the slightest trace of air bubbles, then the whole screen must be washed again and the process carried out anew. The screens can then be set out for drying in the air. No screen, however, should stand for longer than three days with the gelatine layer exposed as the latter will undergo alteration in its constitution and the screen will be unusable. If a fast gelatine is made use of, the screens can be dried in a thermostat at about 50o but in any case not higher than 60o.

The Process of Sedimentation. When the gelatine is dry, it is now ready for pouring with the light substance, a specimen of which in solution consists of: 1,000 ccm distilled water, 2 g. Ecranol, 4 g. acetic acid, and 25 - 40 g. Fluorescent substance. 2 g. of Ecranal are added with 4 g. of acetic acid to 1,000 ccm distilled water and the whole thoroughly shaken and passed through a hard paper filter and freed from air bubbles. The quantity varies, it depends on the composition of the light substance to be used. If it is very fine-grained then a lesser weight is used, if not, then more. In general the weight required lies between 25 and 30 grams of substance. The measure for judging the right weight, however, is that the suspension should be in condition after about 25 to 30 minutes sedimentation.

The right density is that suitable for a pouring height of 10-15 mm. When a new bottle is opened it is best to make a trial pouring first. For laying the deposit of light substance itself a 2 litre clearing bottle is taken., so that height of sedimentation will be about 9.5 cm. If different bottles are used then an adjustment must be made. The filtered solution is shaken well with the light substance and then a period of 25-30 minutes is allowed for sedimentation. Removal is made with a siphon, hung about 15 to 20 mm from the bottom of the flask. If the gelatine is ready, the screens are then poured. The screens are placed after pouring in a perfectly horizontal position and must be left for at least two hours for sedimentation to take place. Thereafter they are each slightly tilted, and traces of substance is syringed off the surface, and they are then emptied with a not too fast dripping capillary. It might be added that after the light substance has been added the screens should not be left for longer than four days. Before adding the metal layer the screens are to be washed out with a 6% soda solution.

Report On The Development of a Process of Producing Fine-grained Fluorescent Screens

The efficiency of a Bildwandler apparatus depends to an overwhelming extent on the quality of the fluorescent screen built in it - i.e. - on the granular texture of the light layer. Our experiments and research, therefore, were first of all directed towards improving the texture and increasing sensitivity in the light screens we were turning out.

We have used the sedimentation process, as this seems the most adapted to the production of a sufficiently large number of screens of even quality. This is a very important point, since the sensitivity of a screen depends to a very great extent on the thickness of the layer of fluorescence.

Sedimentation Process. The light substance is stirred into an alkali-silicate solution and then left standing for a certain length of time: this allows the larger grains to settle at the bottom of the vessel, the finer suspension above this is siphoned off and used for pouring the screens: after the fine particles have sunk to the bottom forming the screen, the clear solution on top is siphoned off and the screen is dried.

The chance of error in this process is rather high and it is higher still when it is a question of producing screens with a very fine grain. It must be pointed out first of all that an alkali-silica solution is not a chemically defined entity. Sodium soluble glass, for instance can display the most diverse qualities and even equal thickness of different layers does not prevent two layers from displaying two quite different degrees of Na_2O: SiO2 content. And further, the state of coagulation can be uncontrollably different, owing to the absorption of carbonic acid from the air. And again, heavy metal salts, which exert a devastating influence on the light substance in even the smallest of quantities are no longer subject to attack by chemicals, since such alki-silicates are colloidal solutions.

Drying the screens caused another difficulty to arise:- so long as it is possible for chemical reaction to occur, so long will this lead to irregular formation of the light layer and to spotting. However, as a result of many and difficult experiments in the realm of the still almost unknown field of Silicate Chemistry, we succeeded in mastering the difficulties.

The need for using alkali-silicate solutions in the production of light screens is explained by two outstanding qualities possessed by these. The first is the striking adhesive properties on glass - the second - their stability with temperature. The need for this last quality unfortunately excludes the possibility of using organic binders, which otherwise are bett r and simpler to use. Over and above these immediate problems there were other difficulties: the unequal wetting of the glass and its cleansing, the problem of keeping away dust particles, and the germ problem,- the necessity for continuous control over the other reagents used and the sensitivity to light of the substance, to mention some of them.

Then there were other snags with regard to the light substance itself: impurities of a chemical or physical nature, a poor degree of sensitivity, too coarse grain or too great complications of working procedure,- these were the chief troubles. However, after we had talked the questions over with the makers, Telefunken, and with Professor Schleede and we had offered criticisms or given new hints we were able to reach the present standard of efficiency.

However, the increasingly exacting requirements with regard to fineness of grain led us to a realization of the fact that we were approaching the ultimate. So we struck out along a new path of research, a path which led to new and striking discoveries, which we were the first to recognize and use. The finer the suspension, the more it must necessarily approach to a colloidal solution in its properties.. In other words,- new factors come into play, factors which play a decisive role. Questions of spotting, surface tensions, electrostatic powers, and so on decide the fineness of similar suspensions.

The experiments carried out proved that the observed texture of a screen depends hardly at all on the fineness of its grain, always provided this is not too coarse,- but is almost exclusively a matter of coagulation. Reactions between solution and light substance, as well as electrical powers used, lead to the substance becoming clotted and the "grain" coarser. At the same time we found that alkali-silicate solutions and the sort of light substance we made use of - regarded as a colloidal system, were really a bad thing for high dispersal systems.

At first, however, we had no other choice but to go on using the same kind of solution, owing to the heat properties mentioned above. Colloidal chemistry teaches us that such systems can be protected against flaking by the addition of suitable protective colloids. Albumen is the most effective, Saponine, etc., - but most of all- colloidal silicic acids themselves. As soon as the protective influence of such substances became clear to us and the problem was recognized as one of colloidal chemistry, it became relatively simple to slow down coagulation. We thought of trying colloidal silicic acids, since in any case alkali-silicate solutions were to be used.

Now- alkali-acid salts form colloidal solicic acids. The definitely colloidal silicic acid must have a protective influence. which in fact proved to be the case. Screens produced by this method proved to be noticeably finer and more regular in grain; we have been turning them out in this way for some time now. Before the screens are ready to be built into their permanent positions they must - of course - be submitted to the coating process and to aluminum treatment.

In the case of a foil of "Zapon" the problems of a sufficiently constant factor of the nitrocellulose solution, as well as problems of splashing, were hard to solve at first but were finally overcome. In this regard we have made plans for new developmental work to be done. The aluminum steaming plant broke down first of all over the question of suitable material for the furnace (oven) - but that problem was solved, too, by establishing the proper standards of dimensions and form.

It should finally be mentioned that further research has resulted in a new process which enables much finer grains, - right from the point of view of colloidal chemistry - to be sedimentated. However, tests on this are not yet complete.

Dr. Bosch.

THE FLUORESCENT SCREENS AND PHOTO-SENSITIVE SHEETS OF BILDWANDLER TUBES.

1. In the following report, the processes employed by both AEG and the Deutsches Reichspost, Hassenberg, will be described. There are three important phases in the construction of the tube. These are the preparation of the fluorescent screen, the preparation of the photo-sensitive sheet and the glass-welding of the two sections of the tube. These will be taken up in order, and the sources of information, Dr. Carl Bosch for AEG and Dr. Schade for the Deutsches Reichspost, will be indicated wherever necessary by "(AEG)" and "(DR)" respectively.

2. The preparation of the fluorescent screen: Reference to the accompanying photograph and diagram of a typical Bildwandler tube (made by C H F Muller, Greiz, now in Erlangen) reveals that the envelope is made in two pieces, later welded together at the point indicated. It is with the smaller, non-bulbous piece that we are now concerned.

a. (DR) The glass is washed in a 2 to 2½ percent solution of hydrofluoric acid. This is followed by a washing in standard chromic acid cleaner, then in hot, distilled water and finally in double-distilled water at room temperature.

b. (DR) The cylinder is then filled to a height of 8 to 10 mm with a mixture of the fluorescent material (powder form), known as H3, green, developed by Telefunken under Dr. Kamm), the purest water glass and acetic acid all dissolved in double di tilled water. (A typical set of proportions (AEG) is the following: 1900 cc of 5 to 7% purified water glass , 90–100 cc of a 2 normal solution of acetic acid and 40 to 60 grams of the fluorescent material). After five hours the powder settles and the liquid remaining is siphoned off. The sediment is allowed to dry for 10 to 12 hours in air and is then baked for 1 hour at 40 to 50 degrees C.

c. The coating thus obtained is tested for bare spots by holding it before a strong light. It is then illuminated with ultra-violet light and examined for failures in fluorescence. (DR)

d. (DR) A rim of clear glass is created around the coating by "erasing" a strip about 3 mm wide, using a blunt wooden stick. The cylinder is then filled to a height of 10 mm with pure water. A small drop of triacetate solution is placed on the water, and as soon as the triacetate spreads itself over the surface, the water is drawn off and the triacetate film is gradually lowered to the bottom to form a protective sheet over the fluorescent screen. The screen is again tested as described in 2c, and then dried for 2 hours in an oven at 50 to 60 degrees C.

e. (DR) Using a tungsten heating element and a small piece of aluminum (see Fig 3) a conducting sheet is now evaporated on to the triacetate film. To control this process the tungsten is brought to white heat by passing a current through it. As the aluminum begins to coat the film and the neighboring regions of glass, the glowing wire is watched. When the white glow begins to appear blue (because of the light coating of aluminum on the glass) when viewed through the glass sides of the cylinder, the evaporation is stopped. ((AEG) The evaporation is continued until the glowing tungsten is invisible.)

3. In 2 above, the (DR) method for producing fluorescent screens was described. Dr. Bosch of AEG claims that many objectionable properties result in the (DR) screens unless the most extreme precautions are observed. Furthermore, a high degree of resolution is not obtained. To get resolution of the order of 5 microns, Bosch developed several different refinements for making the screens. These will be described in the following paragraphs.

4. The Amicid (Casein) process (AEG): The casein, (Amicid P) employed here is designed to create a smoother surface (less graininess) which increases the resolution potentialities of the screen. (Note: Properly focussed electron beams have resolving powers much less than micron. This was determined by viewing thin surfaces edge on).

a. 1.5 grams of Amicid P are dissolved in 500 cc of NaOH and the mixture is shaken thoroughly. The solution is passed through a glass filter (Glasfilternutsche) which is constructed by taking glass chips of a definite grade of coarseness, heating them just to the fusing temperature and then allowing them to fuse, causing a filter structure to be formed. The filter is size 2. When a pure solution has been obtained, 30 grams of the fluorescent substance are added and the mixture is shaken thoroughly. It is then left in a settling beaker for 24 hours. The liquid is drawn off and the sediment is shaken in 1000 cc of a 5% water glass solution. This new mixture is allowed to stand in a 2 liter flask for 110 minutes, and the sediment resulting is about 9.5 cm high. A siphon is placed in the flask with the mouth of the tube 15 to 25 mm from the bottom. What remains is filtered through a Glasfilternutsche, size 2, and the screen is poured to a height of 6 to 10 mm. After drying, the screen is cleaned with a 10% solution of soda.

b. Precautions (AEG): All operations must be carried out in dust-free air.
All settlings involving the fluorescent substance must be carried out inside light-proof boxes. Fluorescent material, when wet, is sensitive to light.
Settling tables and boxes should be shock-mounted to make them immune to vibrations.
During siphonings, containers should be tilted to prevent water residues from forming at the circumferences of the containers. Settling flasks should be closed with rubber stoppers. Stoppers should be kept in distilled water when not in use. Flasks should be washed with distilled water only. A 1% solution of hydrofluoric acid may be used for cleaning, but not oftener than once every 2 weeks.
Water glass must be purified before use. The material used by AEG was DAB6, specific gravity 1.35. The purchased product must be allowed to stand in 5 liter containers for 4 weeks to allow impurities to settle out. The water glass is then dissolved to a 5 to 7% solution in distilled water. The pans used for this process should be about 150 cm in diameter. A carbon dioxide absorber should be placed around these pans to prevent the introduction of CO2 in the solution.

5. In the ordinary screens similar to those produced by DR. AEG takes special precautions with the acetic acid used. The acid is derived from a solution of 99 to 100% Iron acetate, diluted down to a 2 normal solution in distilled water. (The distilled water is tested for purity by mixing 100 cc of the water with 1 cc of sulphuric acid and 1 drop of pottasium permanganate and heating. The resulting mixture should becom pink, if the water is at a proper stage of purity When the distilled water is stored, thymol is mixed with the water to keep it free of organisms. In the actual process, similar to that used by DR the following steps are taken.

a. We shall consider a screen made from the substances given in 2b, and used in the proportions given there. The water glass and acetic acid are mixed and then the fluorescent substance is added, and the whole mixture is shaken thoroughly. Settling is then allowed to take place. If, after 1 hour, too many fine particles of the fluorescent material appear, the liquid is drawn off and 2 liters of the mixture of water glass and acetic acid are added.

b. The settling flask is shock mounted and a siphon is installed with the mouth of the tube 15 mm from the bottom of the flask. The siphoning rate is adjusted so that the sedimentation is allowed to proceed for at least 10 minutes, and very often longer. There must be enough sediment to provide a final pouring at least 10 mm high.

c. The resulting sediment is siphoned into an Erlenmeyer flask and then poured.

d. Precautions: Some sediment should always be left in the mixing glass.
Mechanical mixers should never be used because the crystals of fluorescent material are very delicate.
Just before the final pouring, the glass should be washed with distilled water, emptied and the pouring made.
The pouring height for the screen should be such as to leave the bottom still visible and to provide 72 to 80% absorption of white light.

e. Sedimentation of the screens should last 3 hours and then the liquid should be siphoned off. The cylinders should be covered and mounted in shock-proof, light proof boxes.

f. Resolution of the screens so produced should be at least down to 7 microns. If there are holes in the coating, the acetic acid content should be varied and the temperature of the room placed at a new value.

g. Foliation: (Application of the organic protective coating.) Distilled water should be filtered through hard paper, and 0.6% (by weight) of glycerin should be added. This mixture should be sloshed around over the fluorescent coating and then allowed to come to rest at a height of 6 mm. AEG used butyl - instead of triacetate. The mechanics of the coating are the same as those described in 2d. The water should be siphoned off while the container is tilted slightly, to prevent residual water deposits under the acetatefilm.
The glass is inverted for drying.

h. The thickness of the acetate coating can be judged by the following tests: If it is too thick, the coating looks shiny and yellowish. If it is too thin there is no reflection from its surface. If the thickness is correct, the appearance is frosty and the surface reflects considerably.

i. The aluminum is evaporated in a vacuum (5x10-3 mm Hg). 6 mg of aluminum are used on an evaporating coil BW 1199. Aluminum must be 99.9% pure. Coil should be 6 mm from screen.

6. The Ecranal process: This process is akin to that described in 4. An attempt is made to prevent crystallization by using a colloid such as Tonerdegel (Aluminagel) Silicagel, albumin or a fatty acid glycerine ester. The details are:

a. The glass is washed with a 10% solution of soda. It is then pre-coated with a film of gelatine. This is accomplished by dissolving 3 grams of gelatine, 0.1 grams of glycerine and a small piece of thymol in 1000 cc of distilled water. The gelatine is first dissolved for 1 hour, heated to 50 to 60 degrees C, and then shaken. The glycerine is added and the mixture is filtered through a Glasfilternutsche, size 3. The thymol is then mixed into the solution. All this is then poured into the cylinder, and after thorough contact has been established between solution and glass, the mixture is poured out, leaving a slight residue to coat the glass. It is then allowed to dry for more than 3 days in air.

b. Two grams of ecranal (a smoothing colloid) and 4 grams of iron acetate (pure) are mixed with 1000 cc of water, shaken together, filtered through paper and aired. 25 to 40 grams of fluorescent material are then added and after mixing, sedimentation is allowed to take place for 30 minutes. The operation is carried out in a 2 liter flask, 9.5 cm high. A siphon is introduced with its mouth 15 to 20 mm from the bottom of the flask. The residue is poured into the gelatine-coated cylinder, and after then normal sedimentation and drying, the screen is washed with a 6% soda solution, before foliation.

7. The remainder of this report will deal with DR processes employed in the fabrication of the photo-sensitive sheet and in the welding of the two sections of the Bildwandler envelope.

8. Although the envelope is closed when the photo-sensitive sheet is applied, there are several tubular projections which allow the operations described to be performed. (SeeFig 1.)

9. The "photo-sensitive end" (the one with the greater diameter is first coated with a sheet of s lver by evaporation. The tube is evacuated with a mercury diffusion pump and heated to a temperature of 360 to 380 degrees C to remove gases from the metal electron gun and the glass walls. Then the silvering process is carried out in the following steps:

a. To remove impurities from the surface of the silver to be evaporated, a pre-evaporation is carried out before the heating element B (Fig 1, and enlarged detail of B, Fig 1A), is introduced inside the envelope D, Fig 1. Then by means of the magnet M, Fig 1 and the slug A, Fig 1, the heating element is brought into the evelope and centered behind the glass area to be coated. Current is passed through the platinum wire and the silver is evaporated onto the glass. During the silvering, the transparency of the area being

being coated is measured relative to its transparency when clear. (This is done by means of a simple source of light of constant intensity and a photo-cell.) When the transparency falls to 35% of the clear glass value, the evaporation is halted.

b. At this point the silver coating is oxidized. This is accomplished by placing 800 volts between the first two electrodes of the electron gun and introducing oxygen until the gas pressure within the tube becomes 0.001 to 0.0001 mm of Hg. The gas thus introduced ionizes and in the g low discharge that results the silver sheet is oxidized. In so doing we have made the silver sheet translucent and 68 to 70% of clear glass transparency results. The oxygen is pumped out and the screen is resilvered until 50% of clear glass transparency is obtained.

c. The photo-sensitive sheet is now applied. The ampule at the base of the tube in Fig 2 contains Cesium bichromate and Zirconium. By means of a magnet, the iron slug F, Fig 2 is lifted and then allowed to drop, breaking the ampule. The envelope is heated at a center of a cubical electric oven to a temperature of 130 degrees C for half an hour. The tube containing the ampule is heated separately and the cesium vapor is directed into the envelope and through a nozzle onto the appropriate area of the face of the glass. Using the first two electrodes for an accelerating field, one measures the electron emission of the cesium sheet being formed. The emission rate continues to rise until a saturation level is reached. If the coating of the cesium is continued beyond this point, and this is done in manufacture, the emission falls off, and in the process being described, is made to fall off to 80% of peak value. The fall in the emission rate is the result of an excessively thick coat of cesium. The envelope which has been at a temperature of 130 degrees C is now brought to 160 degrees C, at which temperature the excess cesium boils off and the coating is brought back to maximum sensitivity. If, during the cooling, the sensitivity falls, the procedure to maximize sensitivity is repeated. The excess cesium is pumped out. The emission rate must be watched very carefully during the cooling, and steps to keep sensitivity maximum must be taken whenever necessary. Cesium can be added at a temperature of 125 to 130 degrees C (the boiling point of cesium) and any excess quantities can be pumped off later.

10. At this point the Bildwandler should have a sensitivity of 10 to 13 microamperes per lumen of visible light at a temperature of 30 to 40 degrees C. Using a Schott and Genosse infra-red filter UG6 or UG8 (either of which allows only infra-red light of a wave-length greater than some critical, invisible wave-length to pass), the sensitivity is measured again and should be at least 10% of the sensitivity for visible light.

11. The area is now resilvered and the sensitivity rises to a new peak approximately 1.8 to 2 times the old peak value. This results from the better conductivity induced by the new silver coating. Again there is a saturation value beyond which the peak falls. The resilvering is brought past saturation so that the final sensitivity is 1.5 times the original peak. The tube containing the cesium ampule is then removed from its connection to the envelope. By heating the tube to 130 to 170 degrees C, in a period of 35 minutes, and then allowing cooling to take place naturally, the final sensitivity is brought to 22 to 25 microamperes per lumen of visible light and the infra-red percentage using the UG6 or UG8 filter is then 12%.

12. The welding of the two glass sections: The smaller section of the envelope is suspended by leaf springs in a rotatable cup immersed in water (see Fig 4). The other section of the envelope is brought into contact with the first section along the appropriate line, a high temperature flame is directed at the seam and the whole device is spun rapidly. The water is at room temperature.

13. At this point several miscellaneous and concluding remarks are in order.

a. If the Bildwandler tube is to be used as a direction finding instrument for airborne gun-laying or Flak, a precaution should be observed. In the conventional design of such an instrument cross-hairs or some suitable sighting device are etched on the viewing glass (on the other side of which is the fluorescent screen), and by means of optical directional discrimination, the target's image is brought onto the intersection of the cross-hairs. Dr. Bosch claims, however, that the currents existing in the Bildwandler and the length of the tube allow the earth's magnetic field to influence the position of the striking point of the electron beam. To correct for this, instead of etching the cross-hairs on the glass of the viewing screen, a small microfilm of the cross-hairs (about 4 mm in diameter) is centered on the axis of the tube. A small extra lens combines with the regular objective of the unit, to throw an image of the cross-hairs on the photo-sensitive plate, right along with the image of the target area being viewed. Thus any distortion introduced between the photo-sensitive end and the fluorescent screen by the earth's magnetic field applies equally to the image and the cross hairs and the calibration of the device is unaffected.

b. Bosch developed a pocket-sized, motor-driven Wimshurst machine to provide the high voltages necessary for the electro-static lens. By the use of a hydrogen filled voltage over-flow tube and some modifications in the design of the Wimshurst machine, a very stable voltage source is obtained. These machines will be treated in a separate report.

c. The best production figures given by any of the sources of information indicate that under normal large-scale manufacturing conditions, not more than 35% of the Bildwandlers begun ever come off the production lines as satisfactorily operating instruments.

Bernard R. Gelbaum
ad Lt., Sig C

The Production of Fluorescent Screens by the Soluble Glass Process

In the making of fluorescent screens, absolute cleanliness plays a decisive role. It should only be possible to approach the Sedimentation Room through the medium of an ante-room, and all ventilation should be by means of dust-proof filters. It is a good idea to have the walls of the sedimentation room tiled, or at any rate - covered with washable oil paint.

Apparatus required.

It is to be recommended, that settling should take place in cabinets (tubs), since many of the substances used, such as Zinc-cadmium photo sensitive materials, are sensitive to light when in a moist condition. This has the added advantage of keeping the substances free from dust, which would not be the case in larger rooms. The cabinets should be shock-proof and the screens themselves when stacked in rows should be slightly inclined, so that in the removal of fluid no water-edges are formed. A slight tilt, even, during the sedimentation process will not do any harm if the proper pouring height is observed.

Suspension should be done, so far as is feasible, in wide flasks. As a rule, sedimentation height of the solution should be between 10 and 12 centimeters. The bottles should always be corked with rubber stoppers and these in turn should be kept in a bath of distilled water when not in use. The containers should be washed out with distilled water and - not more than once every two weeks, - a solution of 1% hydrogen fluoride should be used with the distilled water, so as to remove all possible traces of soluble glass.

Materials required.

For the soluble glass, Sodium Silicate, is possible, DAB 6 with a specific weight of approximately 1.35 - should be used. It is desirable that the waterglass purchased, when received, should be poured into flasks holding about 5 litres and left to stand for about a month, to allow the impurities to settle. The final purification takes place in diluting the solution for use, a solution of 5-7% - in the clearing apparatus........soda lime (natronkalk) flasks should be used in order to prevent silication of the solution through the absorption of carbonate of soda from the atmosphere. The tube in which clearing takes place should be 1 m long and 50 m in diameter and the solution should pass through it at the rate of 1 drop per second. Traces of iron are almost always to be found - - (Ammonia-Rodanide) - but experience shows that they have almost no effect on fluorescent substances, which is perhaps due to the presence of the silicic acid; heavy metal salts in the distilled water on the other hand are sometimes very injurious to fluorescent substances (copper-iron).

A small quantity of acetic acid should be added to the suspension.

It is best to use best quality acid (Ice Vinegar) - and for the sake of simplicity of handling a larger quantity should be prepared than will be used at once - generally two normal lots - (in this case 12%).

The distilled water, as we said already, - must be free from impurities and should contain no traces of heavy metal salts. On testing with potassium permanganate for organic substances a droplet should not change colour.

100 ccm distilled water.
1 ccm dilute sulphuric acid
1 drop 1% potassium permanganate.

When the solution is heated, a faint red tinge should appear. When distilled water is kept for any time in containers a small amount of Thymol should always be added as a disinfectant.

Preparation of the Deposit.

A normal deposit consists of:

1,900 ccm 5-7% of cleared soluble glass solution.
90-100 ccm of 2 normal acetic acid.
40-60 grams of fluorescent substance.

The acetic acid is added to the glass solution and thoroughly shaken up. Only after this has been done is the light active substance added. Only the exact quantities should be taken, as has been found out beforehand by testing. The prepared solution should once more be thoroughly agitated and then submitted to a sedimentation separation. If the light active substance used contains many small floating parts, these must be first removed. The solution is left to settle for about an hour, syringe away the fine particles - and the settling vessel is then again filled with a soluble glass-acetic acid solution, about 2 litres being poured in. The actual separation can now begin........

After thorough mixing, the solution is made up,- it should be stood where it will not be subject to vibration, and a siphon is then inserted whose opening is situated 15 mm from the base of the flask. Experience teaches that the sedimentation should take about ten minutes; it should however, go on until the 'pouring height' for the screen is abot 12 mm. The exact time is only found by test. Mechanical mixers for the solution should be used with the greatest of caution, since the single crystals are exceptionally fragile. The prepared extract should be siphoned off, if possible into a Erlenmeyer flask, from which it is then poured on the screen. The last few millimeters should always be left in the vessel as the surface is never quite free from impurities.

Since full use is never made of the substance in one abstraction, the sedimentation vessel should once again be villed with 2 litres of acetic acid-soluble-glass solution and separation should again be done as above. With certain light active substances this can be done three times without harm.

The screens arriv ng clean from the washing process should be half-filled with distilled water and only be emptied again just before pouring begins. After the moisture content of the room has been brought to has high a pitch as possible by artificial means,- in order to keep down the dust as much as possible, each screen before actual pouring takes place should be shaken vigorously, the distilled water poured out,- and immediately thereafter they should be filled with the suspension. Height of the pouring depends on the thickness desired in the light layer. As a standard it can be said that just enough should be poured in as will allow the rim of the 'bullseye (Planscheibe) to shine through. Tests have shown that the most favorable thickness for a fluorescent screen gives an absorption of a white light source of from 72 to 80%. Analysis of the layer with ultra-violet light gives a moderately uniform figure of 7.5 lu.

A poured screen is immediately covered over and at its highest point to give it the appropriate tilt is placed in the sedimentation chest appropriately supported; after pouring is finished the cabinets are shut and the room aired. Siphoning should last about three hours at least, longer standing is even more advantageous. During this period, the other vessels can be thoroughly washed out and the necessary capillaries for removal of the liquid can be got ready.

The capillaries should be about 180 mm in length and curved in such a manner that one of the shanks - that which is later to be hung over the screen - will be at least 20 mm shorter than the other. It must be very evenly cut, otherwise the fluid will not leave it in a continuous drip. The height of the water should be taken as a measure for the length; it should be between 25 and 45 mm.

Since sometimes very fine impurities are to be noted on the surface of the sedimented screen, these should first be very carefully syringed off. Only then should the bent capillary be hung in place and in such a way that the shorter of the two shanks is in the liquid at its lowest point. When all the capillaries have been hung in position the sedimentation chest should be half closed and - by increasing the temperature of the chamber, the moisture content of the latter is decreased gradually and evenly. The screens should be dry in about 12 hours.

Checking the Screens.

The best and quickest way of testing the screens is to test again with the light of an opalescent, bright type of lamp. The magnifying glass used should always be at least as strong as the type which later on is to be with the screen in the equipment.

The main fault to watch out for is the formation of tiny holes. If they occur very frequently the acetic acid content should be varied. Should the situation not improve, then the general temperature of the room and of the suspension should be changed. The acetic content of the solution can be increased, so long as it does not cause the layer to curl off. The appearance in great measure of any impurities is to be attributed to an insufficient degree of cleanliness. Brown spots frequently appear as a result of the use of impure distilled water. The existence of a structure in the layer is seldom visible in the electronic beam, provided it does not have any sharp edges. If small grains of coagulated light substance are visible, this is due to an unprofessional siphoning off of the liquid from the sedimentation.

The nozzle of the siphon might have been too low in the solution and took up the thicker element from the bottom. Fine lines, - usually bright yellow or yellow ochre in color, are the result of soiled cleaning gear. The soluble glass is always subject to slight silication and separates from the edge of the settling flask in the form of floating membrances which get carried over into the prepared solution. As a rule, thorough cleansing of the apparatus causes these defects to vanish. If the surface is not carefully enough siphoned off streaks will be formed. They cannot be very easily detected by the naked eye, since they are not very easily separated from the fluorescent screen. But they show up black in the electronic beam and completely ruin the screen, which has to be discarded. If areas of irregular thickness appear when the screen is held up to the light - generally in the form of waves originating from the edges, this means that the suspension contained too many fine particles. They are very hard to see with the naked eye as granular formations, they merely appear to be in the form of a finely spread slime. They are due to the faults described above and will be cured in the manner described. Badly hung capillaries - they sometimes are slightly askew at the end of the operation - will hinder the complete siphoning away of the solution. Dry edges are formed, which showup in the electron ray as black marks.

It is a good plan to analyse every deposit with ultra-violet light. If the solution is of the right quality it should show not less than 7,5 lu and not more than 10. As already mentioned, the correct thickness of layer can be ascertained by measuring the deposit solution.

Depositing the Film

This is best carried out in a dark room kept as far as possible at an even temperature. It goes without saying that perfect cleanliness should always be observed. The room should be illuminated by a diffused white light arranged in such a way that it is reflected from the surface of the screen which is being treated.

The air-dried screens should be lifted from the light layer with a wooden stick and any grains adhering to them should be wiped off with a clean cloth. A quantity of 'film-water' - (dust free distilled water passed through a hard filter paper, - with the addition of 6 parts per thousand of Glycerine) - should be poured in and moved about over the surface; this should serve to clear away small particles on the edges. Washing is best carried out several times, but this of course depends on the firmness of the layer. The receptacle containing the distilled water and glycerine must be protected from the air by a thick filter. The screens are filled up to about 6 millimeters from the edge with the water and placed on a slightly tilted rest. A suction tube is then inserted at the lowest point, through which, after the lacquer film has been put on, the water is allowed to drain off slowly. With the aid of a metal rod a drop of the film solution is lifted from a small flask, which should always be kept carefully stoppered, and placed on the surface of the water; the exact size of droplet will be ascertained with practice. If the film solution is right, the droplet will spread out quickly over the surface about 20 mm from the edge. Hardening of the film can be observed where the 'interference tints' meet and mingle. In about 20 seconds they should be transformed into a white color. If the drop is too thick then the change occurs more slowly; if they are too thin then the white appears first.
Holes appear as black points, but they are sometimes very small indeed, so that the use of a binocular glass is to be recommended. After the water has been drained off, during which the film should not display any folds, a drop of Butylacetate is allowed to run slowly down the glass tube to bring about local dissolution of the film; this will enable the suction tube to be lifted clear. The screens are then placed in a tilted position, with the opening lowest, in such a way that the air can circulate freely round them. Drying should occupy about 14 hours.

Testing is carried out by holding the screens in a slanting light. If the film is right it should show up a dull white and reflect the light slightly. If it is too thick, it gleams and is often yellow. Too thin, - it does not reflect the light and so appears dark. Holes show up dark in a slanting light but appear bright spots when the light is direct. Grains of light substance lying below the film show up as small bumps when regarded in a slanting ray. The electronic beam will not penetrate these, so that they show up as black spots. Defective films can be removed with Butyl-acetate if it is done carefully enough and - after thorough washing, be used again. If the light layer shows sings of becoming detached, then washing should be cut down a bit. If this does not help, then pure alcohol should be poured in and left for about one minute, after which the screen is reinserted into the process.

Experiments have shown that the fluorescent screens, when coated with aluminum, gain at least 1,5 in brightness. For that reason it should be ensured that when forming takes place, as well as when they are stored, they are protected. A vacuum of at least 5.10-3 is required (5x10-3 mm Hg) otherwise the mirror will not be free from defects. (the layer will display a brownish tinge and the reflection will be unequal at the edges). A spiral BW 1199 should be employed. For Screen Type 115 about 6 mg is required and for Type 130 about 8 mg aluminum (99.9%). The distance between the spiral and the screen should be about 60 mm. The metal, first of all, should be melted and run into the spiral. The gases thus created have a disturbing effect, so that they should be pumped off before the reflecting surface is produced. Deposition of the metal is to be carried out quickly and without pause. All unnecessary overheating of the spiral is to be avoided, as this is injurious. It leads to injury of the film..... If the spiral has become gray or if much aluminum oxyde has been deposited, then it should be renewed. Nor should it be used for so long that danger of burning out is imminent.

Final Test.

Each tested and finished screen should be tried in the electron gun with 15 kilovolts power. It has been demonstrated that not every fault is detected optically. If the screen is of good quality - then the ground edges are to be freed from adhering impurities, - the walls rubbed clean and then polished. The screens should not be stored a long time in the dark, in the air, but in our work they were put in store for six months without sustaining any damage, which should be quite enough for production requirements.

The Production of Fluorescent Screens by the Sedimentation Process

Normally, the method of producing light screens by the sedimentation process is to suspend the light substance in a suitable solution and then transfer it to the screen by means of sedimentation. However, to turn out light screens with a superfine grain there are two conditions which must be fulfilled:-

(1) The solution must act as a dispersor - that is to say - it must hold the light substance in the finest grade of dispersal possible.

(2) It must be able to fix the light substance transferred firmly on its foundation.

It is hardly ever that these two conditions are equally fulfilled. When we are dealing with superfine light substances we must make use of colloidal chemistry and these two conditions are in such case almost impossible to fulfil. Our manner of dealing with the problem was to meet both conditions separately, so as to achieve the maximum degree of fineness of the light layer. For the dispersor, we used a properly made up solution, and for the binding medium, - a layer of substance previously spread on the foundation, which later acted as the welder for the light substance; the latter became bedded into this and when dry, held fast.

In general, the suspension of small particles in a solution is a matter of the proper hydrogen ion concentration, prepared with the use of protective colloids, or a mixture of both ideas. The method of usage, naturally, depends on the nature of the light substance used and can only be determined by experiment. The preparation of a suspending medium with the use of hydrogen ion concentration is in general an extraordinarily delicate operation. On the other hand, suspensions transferred with the assistance of protective colloids as a rule display markedly greater stability. For this reason, which has a great deal of bearing in the technical adoption of the process, we concerned ourselves mainly with the colloidal process. The most favorable for the purpose are Albumen - (gelatine, casein, etc.) - or salines of inorganic substances (Silicic acid, Argillaceous Earth, etc.)

For the binding medium, it is a question of substances which, as a result of their chemical nature, form strong absorption bindings and which do not themselves dissolve in the solution. These are mostly albumens such as Gelatine, fatty acid glycerine esters, the higher aliphatic carbohydrates, - jellies, as for instance Silicic Jelly or Argillaceous Earth Jelly. The addition of the suspension solution to the binder must take place in such wise, that the binder is allowed to swell as much as possible without being dispersed in the solution. For this reason, binders like Silicic Jelly or Gelatine were unusable as they were peptonized in the solution. It was a question of a jelly of argillaceous earth. In general it may be said that when dispersor colloids are joined to binder colloids the effect is that they each cause the other to flake, - in a watery solution.

Our experiments have proved that for the light active substance we use the best dispersor is a brine of argillaceous earth (Protective colloid). This brine has the peculiarity that it flakes up in an alkali solution and must for this reason be worked in weak acid solution.
For acidization, the comparatively weak acetic acid is used, so as not to injure the light substance itself. Gelatine is used as a binder. Gelatine has the property of merely swelling in a weak acid solution, so that no chemical alteration takes place in its composition. Our experience has taught us that with argillaceous earth and acetic acid on the one side, and gelatine as a binder and sublayer on the other - acting respectively as dispersor and binder, excellent results can be obtained. As mentioned above, gelatine can be replaced by silicic salt (equally balanced) - and as a matter of fact a silicic acid binder displays the same properties as gelatine so far as fine grain is concerned, but the layers do not hold together very firmly when this type of binder is used. The explanation of this is probably that silicic acid forms only unreversible jellies and does not swell to the same degree as gelatine. We also attempted to use alkaline suspensions using argillaceous earth as a binder. Gelatine salt can be used with this as a dispersor. The results are similar to those with a silicic binder, the layer is very fine in texture, - but not nearly so firmly adherent as is the case with gelatine. Another, - apparently paradoxical phenomenon is the use of gelatine as dispersor <u>and</u> as <u>binder</u>.

The explanation of this is, that gelatine, being an amino acid., - is capable of functioning both as a base and as an acid. True, the experiments were not entirely satisfactory because flaking occurred when weakly acid suspension solutions were used with gelatine as a stabilizer, although we must remark that this depends to a very great extent on the derivation of the gelatine. There seem to be certain gelatines which are very prone to this fault. Unfortunately, too little is known of the nature of the various gelatines for an exact explanation to be forthcoming.

Further variants of this sedimentation process are the use of weakly refined (tanned) gelatines (formaldehyde, Chromalon, aluminum salts, etc) and that of saponaceous bodies or soaking mediums as dispersors. However, such mediums do not seem to us so universally adapted for use as those we have described, since their influence is to such a great extent dependent on the nature of the light active substance used.

It is sometimes a good plan to wash the light active substance to be used beforehand in weak acetic acid,- giving it a thorough wash, in order to rid it completely of alkaline content. Finer distribution can be achieved with the use of mixing apparatus.

Dr. Carl Bosch,

19.7.43

The production of Fine-grained Fluorescent Screens

1. Cleansing of the Screens.

The screens, - both new and those to be repaired - are to be filled up to half their height with a 20% soda alkaline solution, which should be left in for about a couple of hours. They should thereafter be washed out with tap water first of all, and next with a 30% acetic acid solution. Finally, they should be rinsed with distilled water and after that with water vapor. The vapor is blown into the screen with a powerful jet and the screen is then held in a cooler part of the jet to dry. Care is to be taken that the screens are absolutely free from dust, they should not be wiped with a cloth, as this generates electricity and causes dust to be sucked into the interior of the screens. The screens are checked for cleanliness and the presence of faults in the glass under a strong light falling slantwise on them, against a dark background.

2. Producing the Suspension.

The fluorescent substance is contained in a 5% soda-silicate solution (specific weight 1,365). It usually is the case that the light active-substance coagulates in this and falls to the bottom. If the light active-substance forms in globules the screens produced from it are entirely unserviceable. To avoid this defect, therefore, we add a small amount of protective colloids. In general, albumens, gelatines, saponaceous or alkalies, or inorganic protective colloids such as silicic acid or stannic acid may be used. We used colloidal silicic acid which was produced from alkali-silicate solution by the addition of acid. 100 ccm 2n acetic acid is added to 2,000 ccm alkali-silicate. From 20 to 50 grams of light active substance are added to the suspension solution, according to the type of screen desired.

The distilled water made use of should be as free from dust as possible, should not have come in contact with the air, and should be of pure quality. When certain very sensitive light active substances are being used it is a good plan to add a little of the substance to the distilled water, shake it very thoroughly, and thus rid it of the heavy metal salts which may be present; it should then, of course, be filtered. When the suspension is being deposited, a strong light should be avoided, as many fluorescent substances are injuriously affected by such. Likewise, no paper filters should be used when depositing occurs, only glass filters should be used.

3. For Sedimentation

Flasks should be made use of, and a pouring height of 7.5 cm

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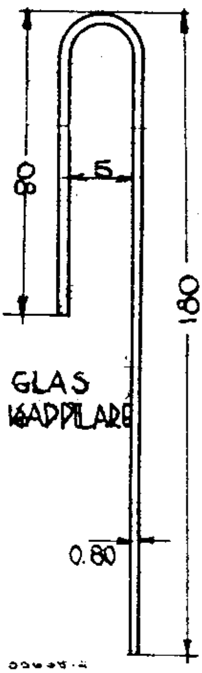
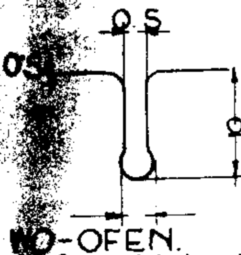
should be maintained; the temperature should be even and vibration should be carefully avoided. The time taken for the process - of course- depends on what particular light substance is being used. The type of siphon used should not have too sharp a point, and should be suspended about 1 cm from the floor of the tub; the solution should be drawn into a polished Erlenmeyer flask, when it is then ready for pouring. When new alkali-silicate solutions are used they should be checked. If gelatine is used as a protective colloid a disinfecting medium should be added to obviate bacterial attacks (formaldehyde, Cresol, etc.) - it should be noted, too, that when making up the solution it is not a matter of indifference which order is followed, - we begin with the water, to which is added the alkali-silicate,- and only then are the acids added. After a thorough mixing has ensued the light active substance is added. It goes without saying that before sedimentation takes place the solution should be once more thoroughly shaken. It should also be noted that tr ces of nickel, iron, or cobalt are injurious in their effect on the light active substance and should not be allowed to come near it; it is for this reason that glass vessels only should be used.

4. Pouring and after-treatment of the Screens.

Pouring of the screens is carried out simply by hand, and the height to observe depends of course on the thickness desired. Each time pouring is carried out the suspension should be reshaken and as soon as it has taken place each screen should be covered with a conical cellulose cover, the screens are thereafter placed in a clean aluminum box which can be darkened at will and which stands in a spot free from vibration. They should remain there for about 20 hours under an even temperature, to obviate streaking. 'U'-shaped capillaries are used for siphoning off, (See sketch). These must be long enough to ensure that the contents of the screen will drain off continuously, - in the case of screens of average dimensions, the liquid should run away at the rateof a drop per second. The capillary must be hung accurately inside the screen, after it has been tested to see that the edges do not prevent the liquid for draining away and it has been filled with distilled water. The capillary end should be cut with a fine oilstone, to make sure that the edges are level and smooth. If the tube gets stopped up, it can be cleaned with a soda solution. As soon as the capillary has been hung in position inside the screen and it is seen that the liquid is dripping away at the proper rate, the screen should be covered over again. In the normal way, it should take about 24 hours for the screens to empty and dry, but if too thin capillaries are used and they are not properly hung, dry spots will show on the surface





of the dried screen. They should be tested for average quality as soon as they are dry. Any flecks of light substance adhering should be cleaned off with a very light touch, a soft tapering wooden rod is used to clean the edges, thereafter, they should be heated for two hours at a temperature of 200°C.
Placing of the 'Zapon' foil occurs as follows:- the edges of the screen are first of all cleansed with a 20% solution of potash after which the screen is rinsed with distilled water. The screen is then filled about 6 mm high with ice-cold distilled water and a drop of the Zapon solution is taken on a smoothly rounded glass rod and placed neatly in the center of the surface. The Zapon solution to be used should consist of 4 parts of ordinary commercial collodium and 1 part Iso-amyl-acetate. The film should spread out evenly towards the edge and display a regular 'interference' color when dry. If spots or dust grains show up the film must be renewed.

The water below the film is now very carefully drained off and the screen is placed at a slanting angle,- with the opening downward, to dry; this should last at least 20 hours, if possible - all night. No dust at all should be present in the air when the film is added- (glycerine can be used as a protectant)- and after drying is complete the screens are once more tested and then vaporized with aluminum.

<u>The Aluminum Vaporizing.</u>

Vaporizing takes place under a glass bell, on which a narrow edge is milled and sealed with a Mipolam ring. During the process a good vacuum must be maintained, since otherwise overheating may cause burning of the film and the glass may be attacked by the aluminum. The aluminum should show a faintly bluish tinge and be slightly transparent. The heater - (see sketch on page)- consists of an incandescence-proof wolfram wire bent into the rough shape of a 'T'. The aluminum,- in the shape of a small piece of wire - is placed between the two shanks of the wolfram and fused into the shape of a small pellet, which then runs between the two shanks and vaporizes. The wolfram should then shine with a brighter glow. The current is then switched off, so as to avoid overheating. If the job is done smartly, the wolfram can be used about fifty times. Vaporization with the aluminum causes the wolfram to become brittle and fragile, so that it cannot be bent again.

To get rid of the aluminum in the glass bell, tetra-chloro-carbon should be used, only in obstinate cases should a alkali-hydroxyde solution be made use of. Only alcohol should be used for the cleaning of the ring. Between mercury pump and glass globe a cooling device (Ausfrierfalle) should be placed.

After completion of the above process the screens are once more tested. They are then ready for use.

The Production of Fluorescent Screens by the Casein Process.

1.5 grams of Casein P is dissolved in 500 cm^3 of a 5% Sodium Hydrate. The vessel must be shaken without pause until the casein is completely dissolved. The solution is then drawn through a glass-filter suction flask 2 (without a vacuum). If the solution is pure, 30 grams of light active substance are added. The suspension is shaken thoroughly and poured afterwards into a reaction glass and left for 24 hours. The substance is by that time completely sedimented and should be decanted, care is to be taken that the whole of the casein lotion is sucked out. The light active substance thus treated is agitated together with 1,000 cm^3 of a 5% soluble glass solution and placed in a 2 litre clearing flask for sedimentation, which should last about 1 hour 50 minutes. The water-glass solution must likewise be filtered, and this is best done with a hard paper filter in a vacuum. Sedimentation height should be about 9.5. A siphon is used for drawing off the solution; this should be hung about 1.5 to 2.5 cm from the bottom of the flask. The prepared solution is then once more passed thro gh a glass filter suction flask 2. The screens, after being thoroughly cleansed,- are then poured. Pouring height is as nearly as possible to 6 - 10 mm.

Cleansing of the screens can be done with acids or alkalies. The best medium is a 10% soda solution, since soda has no ill effects on the screens and also, a brush or sponge may be used. Proper cleansing of the screens is an extraordinarily important matter, since the efficiency factor depends entirely upon this.

Special distilling apparatus for producing pure water, free of heavy metals

1. The device pictured in the accompanying diagram was used by Dr. Bosch (see Bildwandler report by the undersigned) to produce water free of heavy metals. This last requirement is quite important in the manufacture of the fluorescent and photo-sensitive coatings of Bildwandlers.

2. Tap water enters at the point marked "input", travels on the inside of the upper set of s irals, through the leveling section and finally to the distilling chamber whose bottom constitutes the Calcite catch. 220 volt power is fed to the carbon rods (the power used must be AC and single phase or three phase: in the case of three phase power, three carbon rods, instead of two are used.) The heat generated by the passage of the current through the impure water causes rapid evaporation (or slow boiling) of the water. The steam passes out the side through the "trap" and is fed into the space around the outside of the upper set of spirals. There the steam is condensed, (giving up its latent heat of vaporization to the tap water flowing through the inside of the spirals), and the condensate flows down through the inside of the lower set of spirals (giving up more heat to the incoming water) and finally comes to rest in the collecting jar.

3. Details and refinements:

a. The upper set of spirals consists of three spirals "in parallel". (Some idea of this cnstruction can be gained from the photograph). In this way the cndensing area of the spirals is multiplied by a factor of 2½ approximately.

b. If, after extended operation, the residue of distillation becomes appreciable, the conductivity of the liquid in which the rods are immersed rises. The current passed is therefore greater, more heat is generated and rapid instead of slow boiling takes place. The rapid boiling causes water to spill over the sides of the inner container and much of the impurities are thus removed. This overflow-water drains away through the steam trap. As a consequence, the Calcite catch needs to be cleaned only once every 3 months.

c. The height at which the hole in the leveler is placed determines the water levels in the operating portions of the device.

d. The efficiency of the apparatus is said to be 90%.

e. The tightly packed cotton above the collection jar allows air to escape as the distilled water fills the jar, and yet prevents dust from entering the pure water.

f. Three or four liters of distilled water can be produced hourly by this method. (The overall size of the equipment can be judged by comparing it with the hand in the photograph).

g. When the current is first turned on, about 1 ampere is drawn. The current drawn after the machine is well in operation can be computed from the known efficiency of the machine and the hourly production rate of d istilled water.

4. The remainder of this report consists of the diagram and photograph referred to in the text.

Refinements and modifications of the Wimshurst machine

1. The accompanying report by Dr. Bosch, Wolfsbrunnenweg 33a, Heidelberg, gives an outline of the work done to make an improved Wimshurst machine. The results of his developments led to the manufacture of a small "pocket-sized" motor driven Wimshurst machine for use as a power supply with a portable Bild-wandler infra-red detector. Some details and explanations missing from Bosch's report will be found in the following paragraphs. Photographs of some of the experimental models of the machine, and of the regulator tube are attached.

2. In the standard Wimshurst machine, the storing plates L and L' (see diagrams of Bosch's report) are separated from the rotating wheel by insulators. The combination of the plate L, the insulator and the grounded portion of the wheel near L forms a condenser, although there is no ground connection of the insulator. After L and L' have been charged and are used as a source of voltage, a heavy drain by the load may discharge them severely, lowering their voltages with respect to ground. (L will become less positive, say, and L' less negative). The side of the insulator nearest ground will fall an equal amount and the resultant potential distribution between L (or L') and ground will be that indicated in Graph 2. (Graph 1 shows the potential distribution before loading). The fall in potential on the "ground" side of the insulator can thus result in a reversed polarity and the voltages being developed on L and L' will grow, but in directions opposite from those in which they were originally being charged.

3. To eliminate this danger, Bosch split the plates with resistances of 10^{10} ohms each, R and R' to the added plates E and E'. As soon as the voltage on E or E' rises above a given potential which depends on the dimensions of the machine and the pressure and character of the gas in which it operates, there is an arc-over to ground. This arc-over draws current through R or R' and the protective voltage drop between L and E (or L' and E') allows L (L') to keep its polarity without danger of reversal. Under no circumstances can the potential in the vicinity of the grounded portion of the wheel fall into a polarity different from that in which the neighboring plate was originally charged. Also the actual load is taken from the laminations at b and b'.

4. The lubricant for the bearings of the machine suffered from the effects of oxidation caused by the ozone in the air surrounding the machine. By the use of chlorinated parrafin oil, hexa-chlorbutadien, this difficulty was eliminated and the machines can be run for 3000 hours without the lubricant's being destroyed by ozone oxidation.

5. To provide a steady voltage source for the Bildwandler

electrostatic lens a small regulator tube was installed as described in Bosch's report. The tube appears in the foreground of the photograph of the Wimshurst machines. A schematic diagram is attached. The copper anode B' is fastened to the copper cap B. B is soldered directly onto the glass envelope C. (This last is accomplished by: 1. sputtering aluminum onto the glass with a flame jet; 2. following this with a sputtering of copper using a flame jet again: 3. soldering the copper plate to the coated surface using the ordinary tinning and soldering techniques.)

The glass envelope is filled with pure hydrogen at $2\frac{1}{2}$ atmospheres creating a glow discharge in the tube by the application of a suitable voltage between A and B, then re-evacuating the envelope and refilling it with pure hydrogen again at $2\frac{1}{2}$ atmospheres. This reworking is to remove any ocluded gases and completes the fabrication of the tube.

6. As the final important change, Molybdenum brushes are used at b and b'.

7. The motor employed to drive the Wimshurst machine when used as a voltage source for a field Gildwandler is a 4 volt DC affair with a permanent magnet in it. The entire device, excluding theBildwandler tube can be placed in a case 6" x 6" x 4".

Improving the Reticle for the Bildwandler

For the Bildwandler, a Reticle Projector has been made. It consists of a photo-lens, film sighting device, - (contained in a sighting ring)- and electric lamp,- all housed on one frame (see illustration). The Provi is located in front of the lens of the Bildwandler and projects the sight or cross-hair reticle on to the fluorescent screen of the latter, where an illuminated sight appears. It is important that the projector be adjustable in all directions, so that it can be trained on the optical center and exactly on to the spot desired. For this reason each projector must have an adjusting device, enabling it to be displaced in all directions. This device will consist of two rings, adjustable one within the other (See illustration)- it is fitted on to the sight. The casing of the sighting ring has two small holes, which enable it to be fixed in place. The two screws on the inner ring are used to fix the sighting ring in position andthose on the outer ring screw the whole in position when the proper direction has been attained. In the improved model, the following alterations were made:-

The adjusting device is done away with. The frame of the sighting ring is cut away to such an extent that only two narrow rings remain. One of these has been drilled through and serves as a guide for the lamp cord. The sighting ring now has two projecting parts, so that it can now be taken hold of with the fingers and placed in position.

The improvement has the following advantages:-

1. The adjusting device being abolished, both time and material are saved.

2. Even unskilled operators can now adjust the sighting ring with two fingers without a tool.

3. The sighting ring can now be extracted sideways through the interstices in the frame for changing of the microfilm sight without having to unscrew the lamp fixture.

4. Greater angle of movement of the sighting ring, since the cord is led through the ring itself.

Dr. Carl Bosch.

Argillaceous Earth Lyes as Binders for Light Substances - The 'Ecranol Process

Sodium Silicate (water glass)- is in general use as a binder for fluorescent substances. And yet, to date it is far from being the ideal form of binder. Its sensitivity to the presence of carbonic acid in the atmosphere, which renders it difficult to have the preparation of the basic solution uniform, leads in practice to uncontrollable changes. Moreover there is the contamination caused by the presence of heavy metal salts, quite important and in practice hard to obviate.

A further - purely colloidal - chemistry question which had its due influence on the results of this experiment is that the photo sensitive material mostly used by us (generally zinc-sulphide and selenide) - is rather inclined to floculate in alkaline solution. Since the soluble glass itself is alkaline in its nature, floculation appears which can only be cured with great difficulty. With us, therefore, it is customary to prevent floculation by the use of protective colloids (formation of colloidal silicic acid through acidization) - which, however, owing to the low definition of the soluble glass, as well as the conditions laid down by drying - constantly lead to further setbacks, since,- after a certain point has been reached, the inclination towards gelatinization rises sharply. Further, when drying is in process the jelly tends to shrink noticeably, which in turn leads to cracks in the screen. My attention had been drawn in earlier work to the peculiar qualities of bases of argillaceous earth, which,- used only in slight concentration - are capable of pronounced absorption effects. In this, they differ from soluble glass, since the latter functions mainly as an inorganic adhesive, that is to say, in comparatively great concentration and volume. No doubt, however, as a silicic acid salt it represents an almost unequalled binder for glass.

The results of the experiment were twofold: in the first place, argillaceous earth and soluble glass have a mutually floculent effect on each other and in the second place a base of argillaceous earth has a dispersing influence on the photo active substance. It may be supposed that they are both equally loaded. It was also established that the photo active substance takes a perfect grip on the glass after it has dried. Since practically no adhesion of the photo sensitive substance to the glass is observed in the suspension, we must suppose that in drying, a weak, irreversible splitting of the water particles takes place, apparently brought about through modification of the photo substance by the stabilizing acids.

As mentioned earlier, it was difficult to avoid removing the deposit on the bottom of the tube along with the solution when we were siphoning off the liquid. It is also to be noted that the photo substance of itself does not adhere sufficiently to the glass. To get around this we undertook an examination of the useful characteristics of the photo substance.

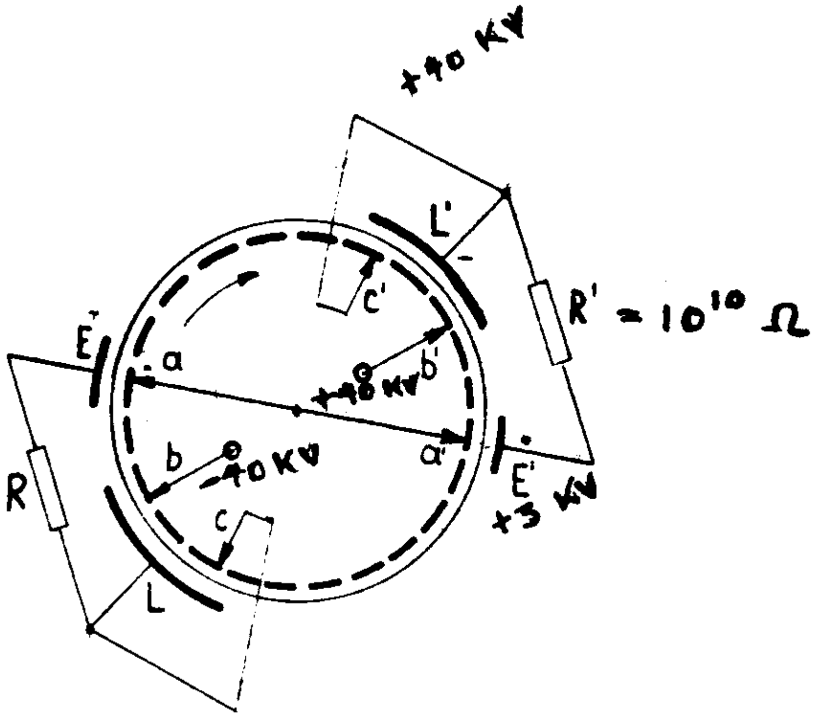
Is the affinity of carbohydrates to the paraffin series greater than it is to water? If a flask is filled with water and a photo substance suspended in it the latter is taken up in the liquid. If, now, the suspension has a layer of benzine poured over it and the whole is thoroughly shaken, the result is that the photo substance collects almot quantitatively between the water and benzin surfaces: consequently the affinity must be greater to benzine than it is to water: (this procedure allows of a quantitative separation of the photo material and the hygrophilic impurities, such as cellulose fluff, etc., (for the purpose of purifying and checking). The next logical step was to utilize a carbohydrate of the paraffin series to fix the photo material on the glass (fatty acid-glycerine esters like butter have the same effect). Putting paraffin-oil, paraffin, or butter on the glass presents certain difficulties, since the water, on account of its great affinity to glass, presses lightly on such layers, especially when, as in this case, they are derived from water solutions. Then too, they hardly ever spread themselves over the glass in an even, coherent film but rather in the form of droplets, which easily become dissolved in the water. But if the fat or butter is smeared lightly over the glass with the finger, then the photo material adheres firmly to it and the solution can be siphoned away.

The results of the entire experiment were watched under a microscope on hollow-ground supports and it was very easy to recognize where the photo material took hold, when the table was slightly tilted. Trial pourings with this sublayer of fat gave from the very first good and what is more important very fine-grained screens, which of course was more or less to be expected. The buttering of the fat on the glass was a messy job. It can, it is true be evenly put on by evaporation but as this merely signifies a further complication in the process and as it could not then be used as a solvent for the photo material we struck out along a different path.

Among the substances which group themselves in a hygrophile-hygroscopic form is gelatine, other than the saponaceous or other similar bodies which are unsuitable because they dissolve in water. Gelatine as a result if its chemical composition, is in a manner of speaking - predestined for such a task. Quite thin layers of

96630-2

gelatine furnished a perfectly satisfactory adhesive for the photo material, they are easy to spread, smooth in consistency and there need be no concern that there will be any trouble as a result of the tendency of this substance to swell; anyway this only occurs to a very slight extent. The gelatine is poured on in a very thin solution (approximately 1/1000) and the layer settles out in a slightly tilted position. The thin film of gelatine then dries evenly and very smoothly and the dry layer should only be several molocules in depth. This dried yet firm layer then swells up sightly when pouring takes place, without, however, distributing the firmness of the layer. As was observed under microscopic examination, the photo material then adheres evenly and tightly. Screens produced in this manner were noticeably better in quality than those made using water glass.



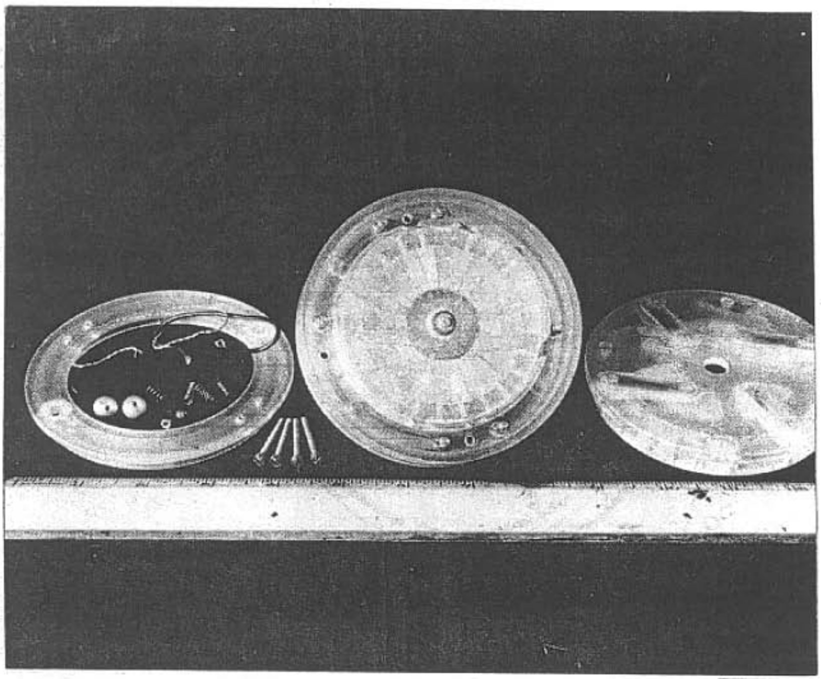
Figur 1

BOSCH WIMSHURST MACHINE

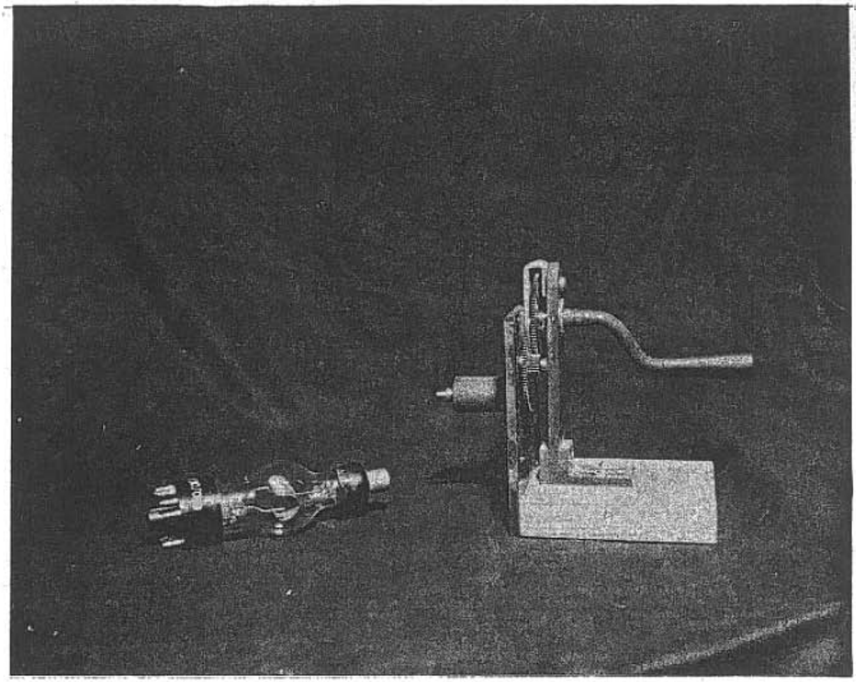
Inductor plates L and L'. Secondary inductors E and E' with a breakdown voltage point of about 3 KV. Current drawn thru Resistances R and R' tends to stabalize the entire reaction.

Load is taken off rotating segments at b and b'. Impossible to discharge inductors and thus possible reverse the polarity.

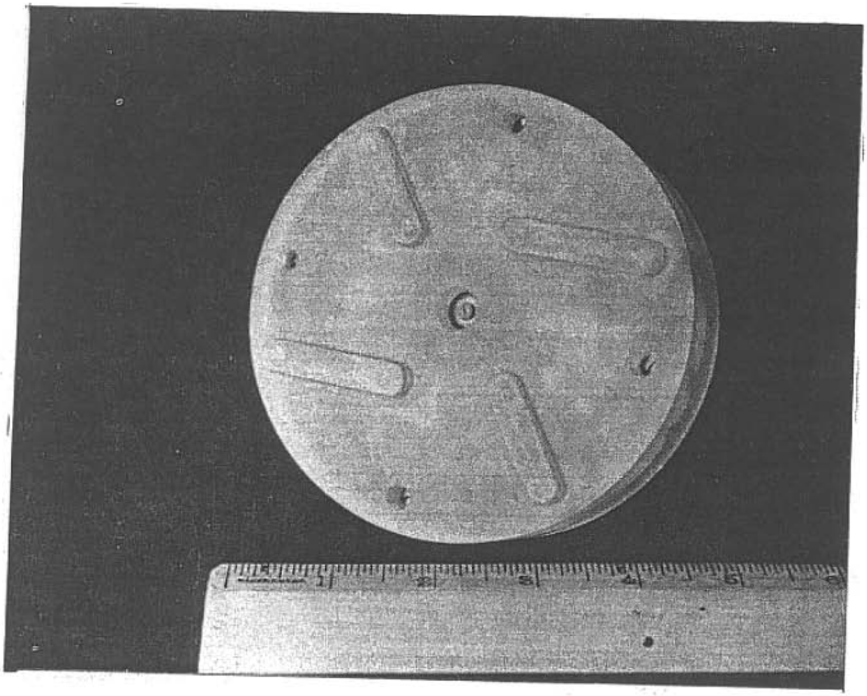
Molybdenum brushes sued throughout gave greatly increased life. Very thin spark pulsed at segment rate.



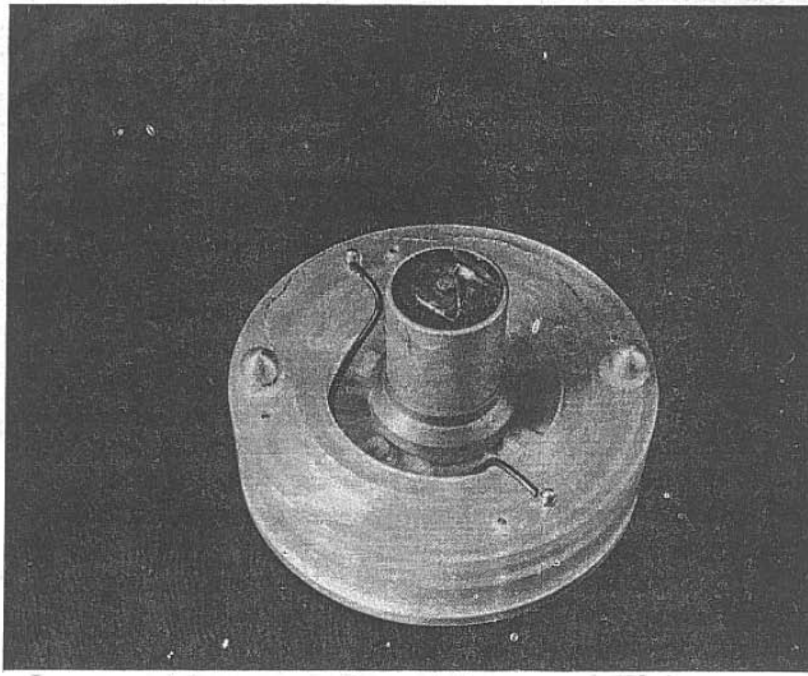
SMALL WIMSHURST OPENED



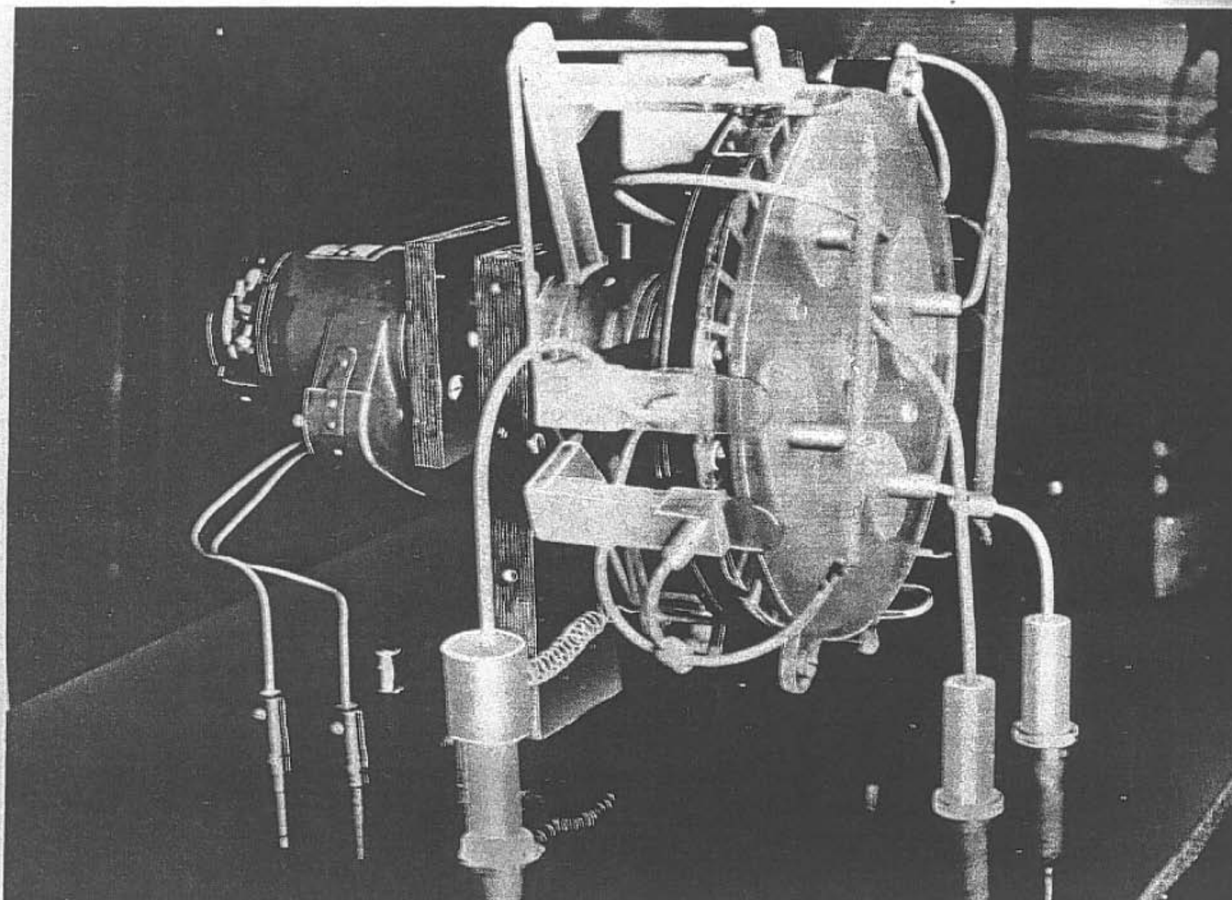
Crank at right is rubber covered, flexible, so tubing slips around crank as it turns. Makes it possible to rotate equipment in a vacuum. Vessel closes around upright.



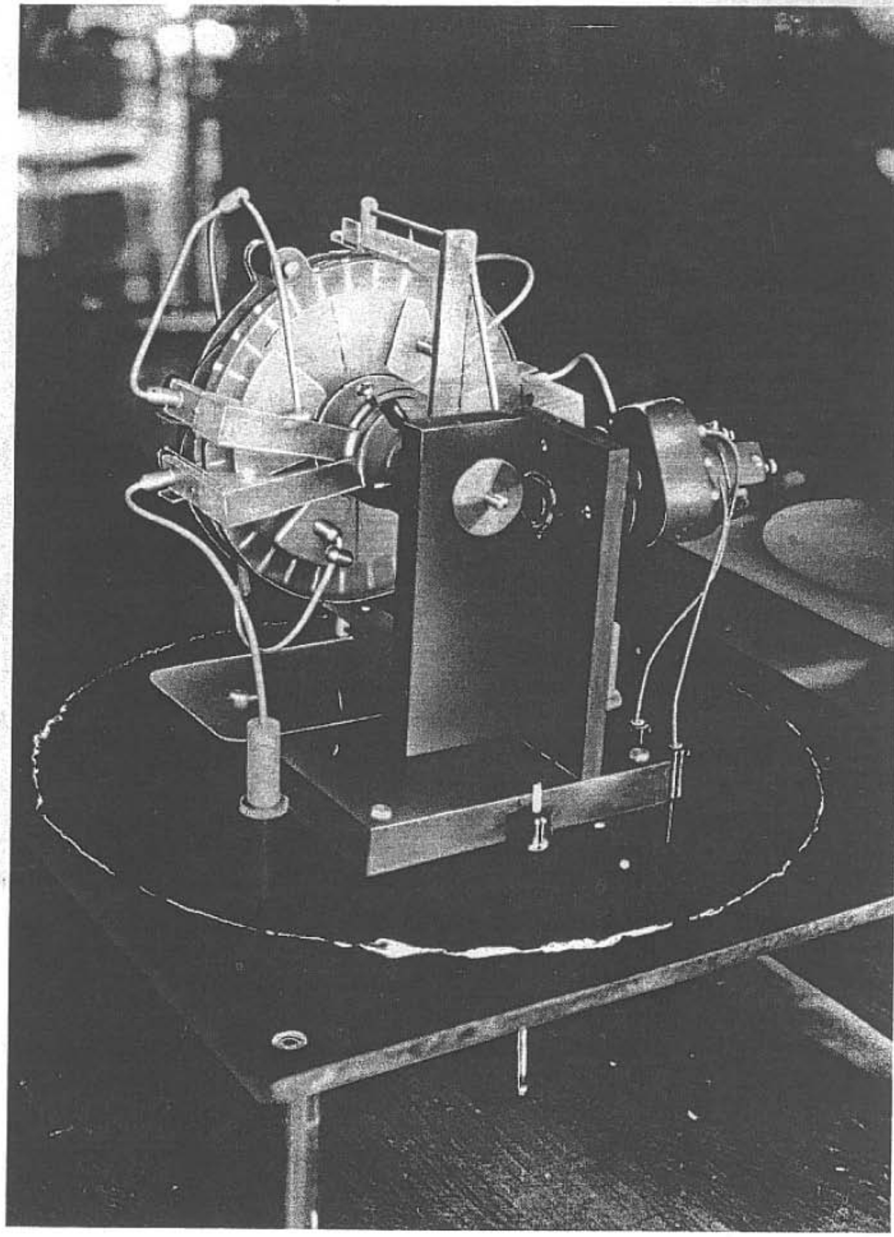
SMALL WIMSHURST MACHINE 350 GRAMS
Resistance insets.



- Motorside -

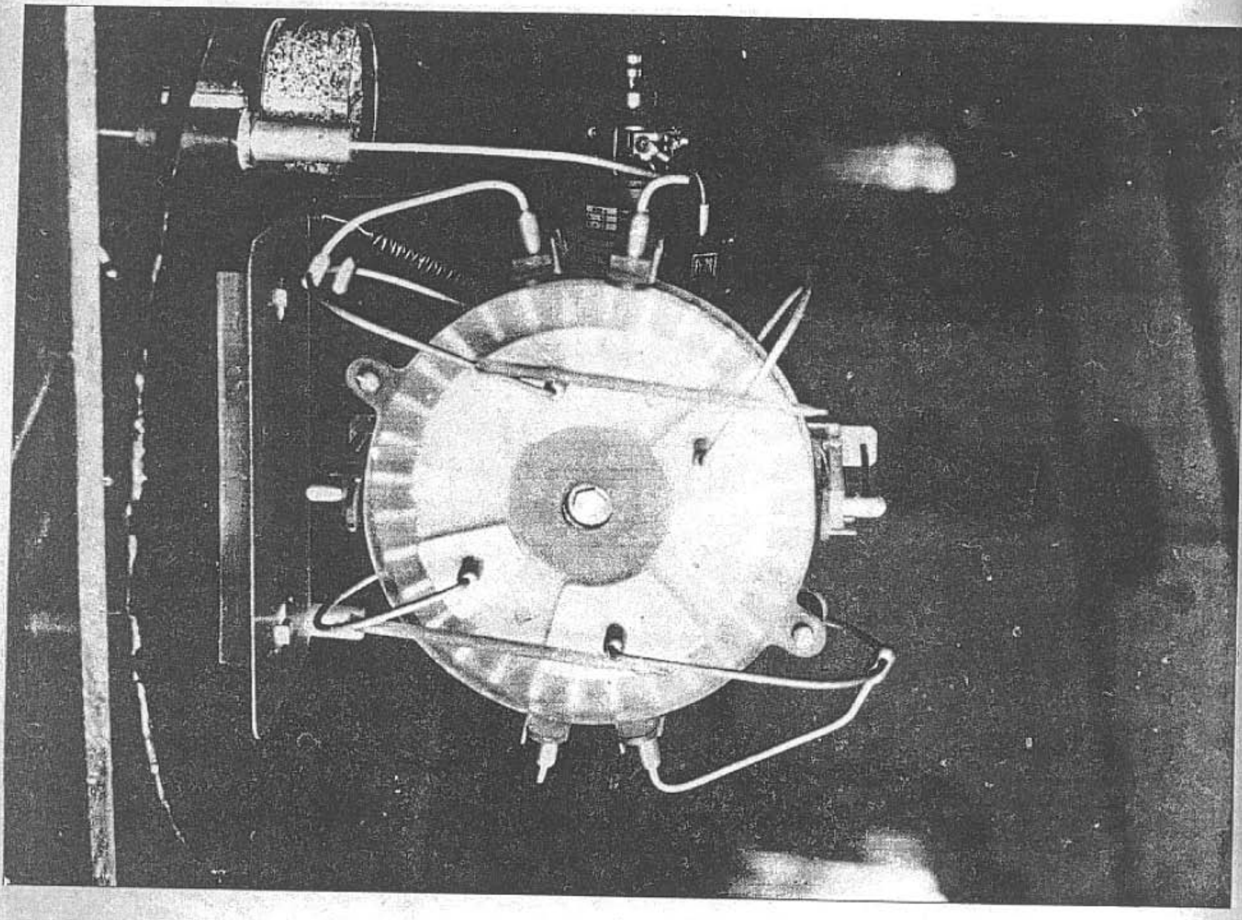


- DIRECT DRIVE MACHINE -



BOSCH WIMSHURST MACHINE

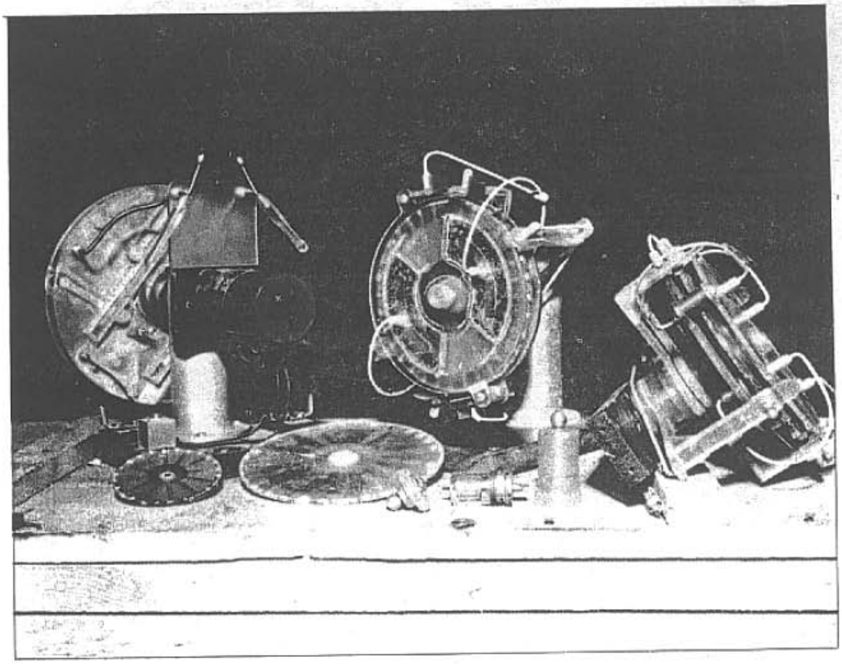
Right angle drive to
gear up speed.



VARIOUS TYPES OF WIMSHURST
MACHINES

Rotating discs in front for small and large machines.

Hydrogen filled voltage regulator in right center front.



Good view of large and small inductor plates. (Large)

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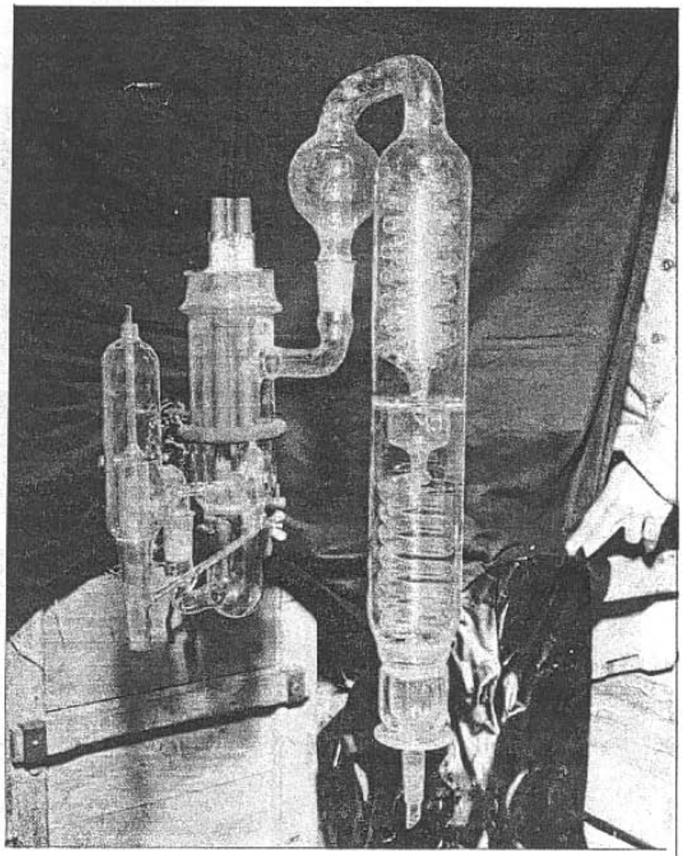
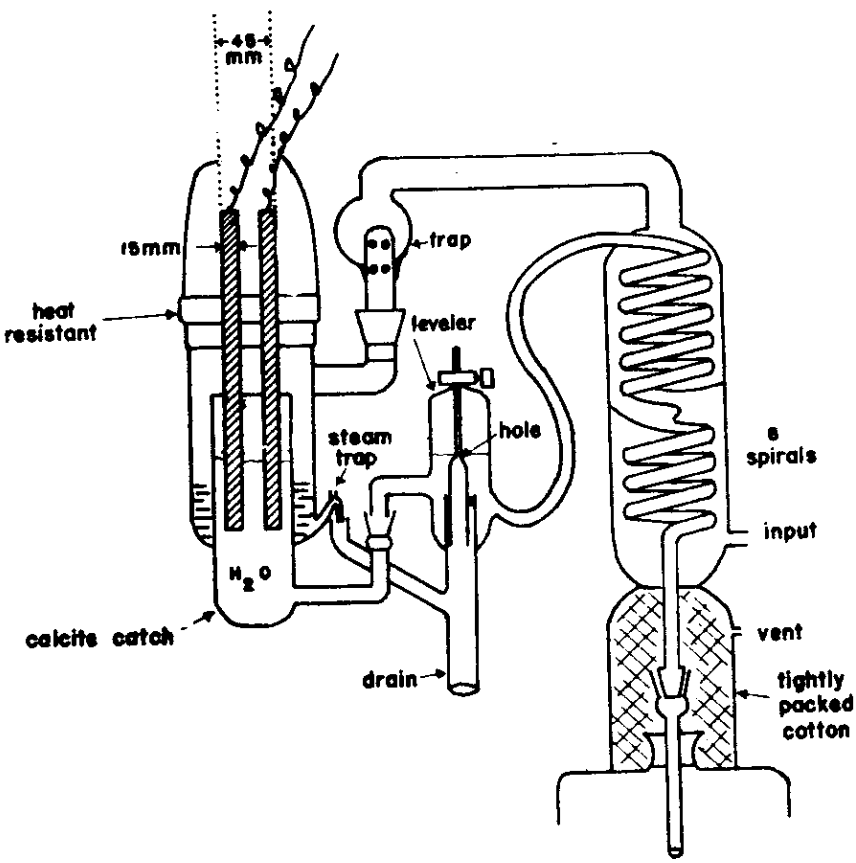


Beautiful glass blowing job. Note three spirals inside each other in uppèr right.

BOSCH METAL-FREE STILL

66638-2

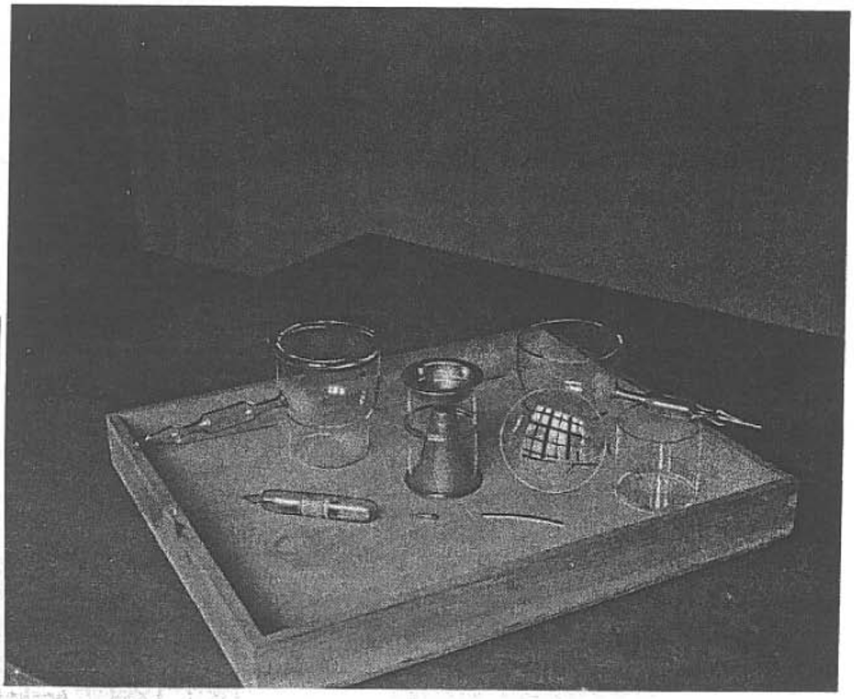
Electric Water Distiller



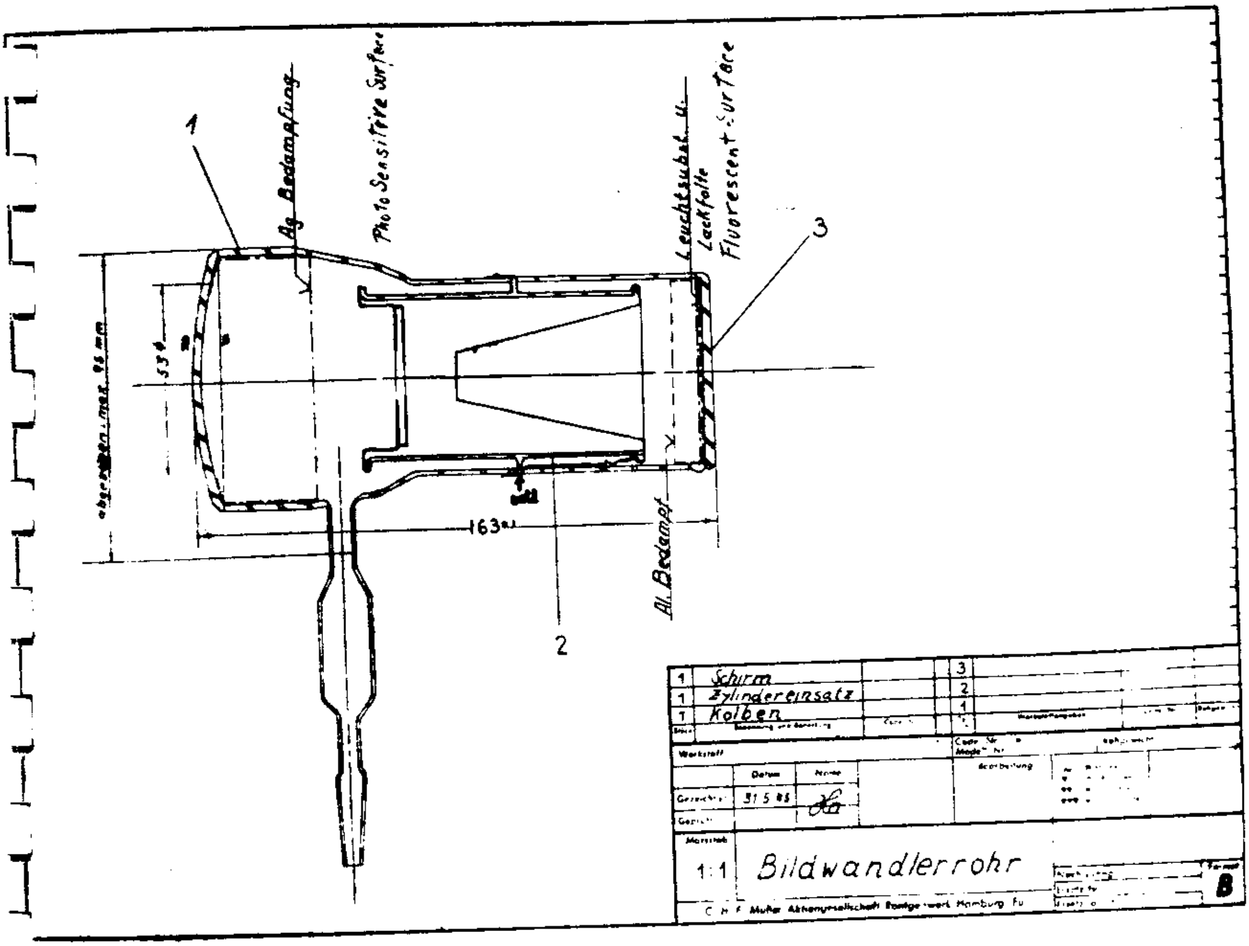
Beautiful glass blosing job. Note three spirals inside each other in upper right.

BOSCH METAL-FREE STILL

65838-2



Parts sufficient for one BW tube.
From C.H.F. Muller Factory at Greiz



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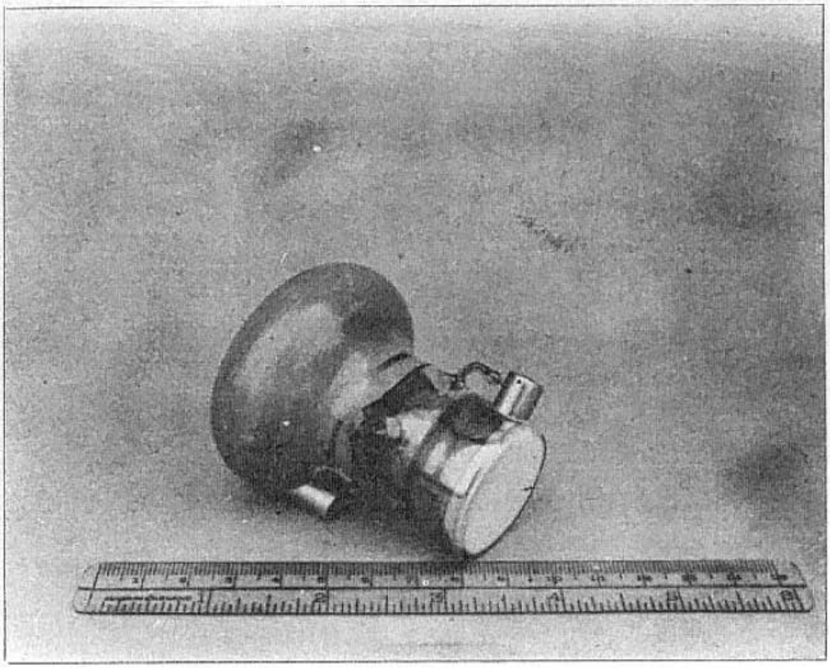
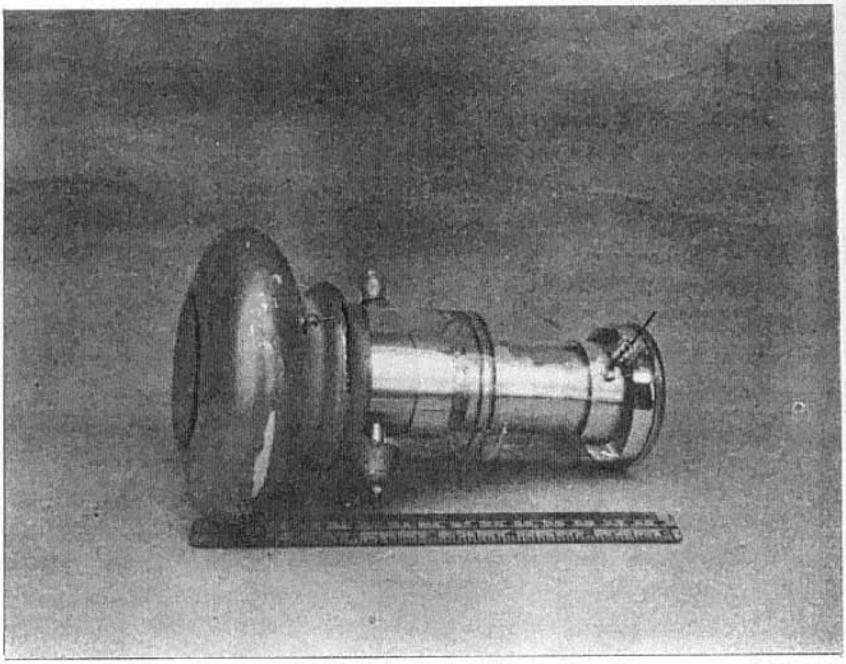
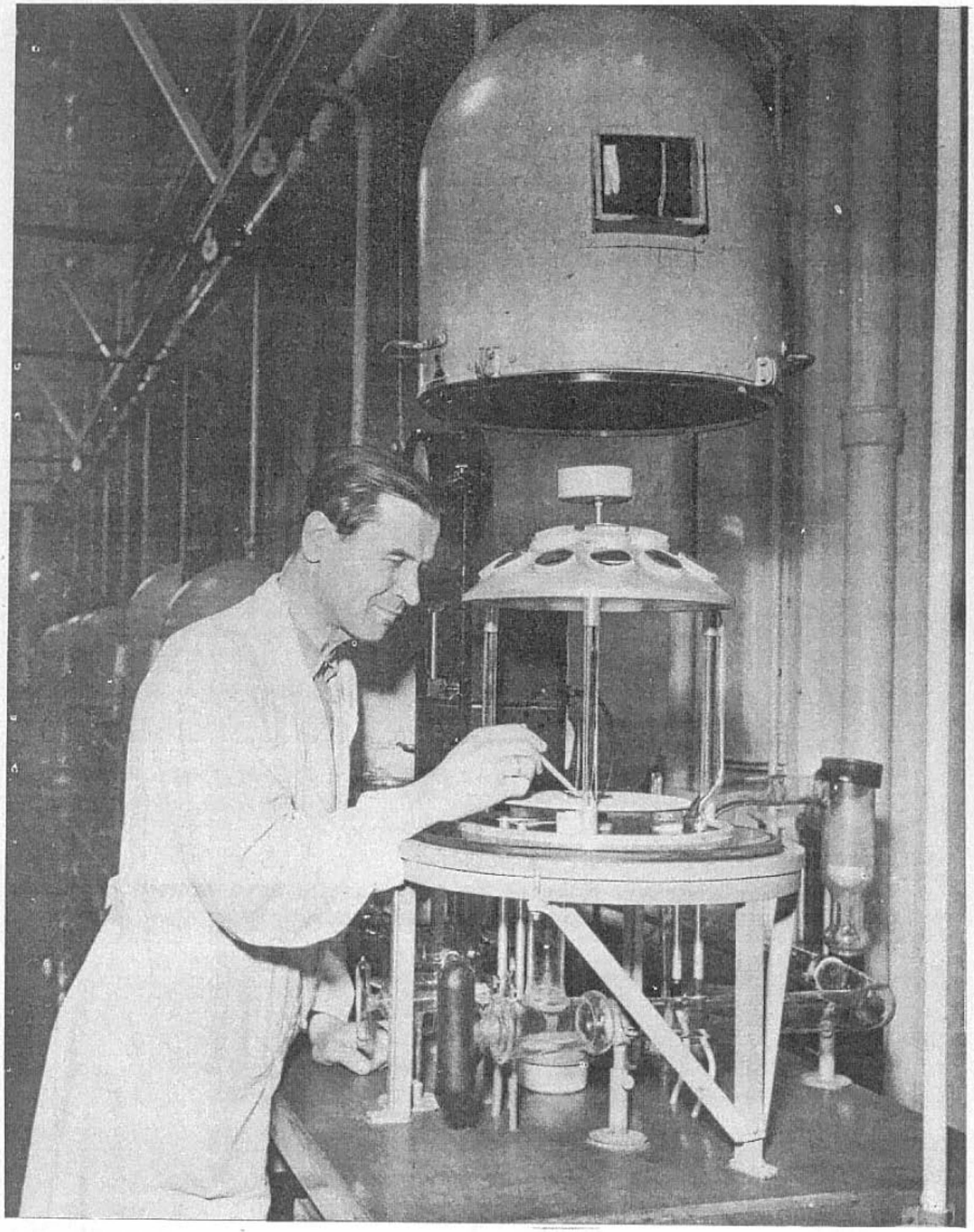


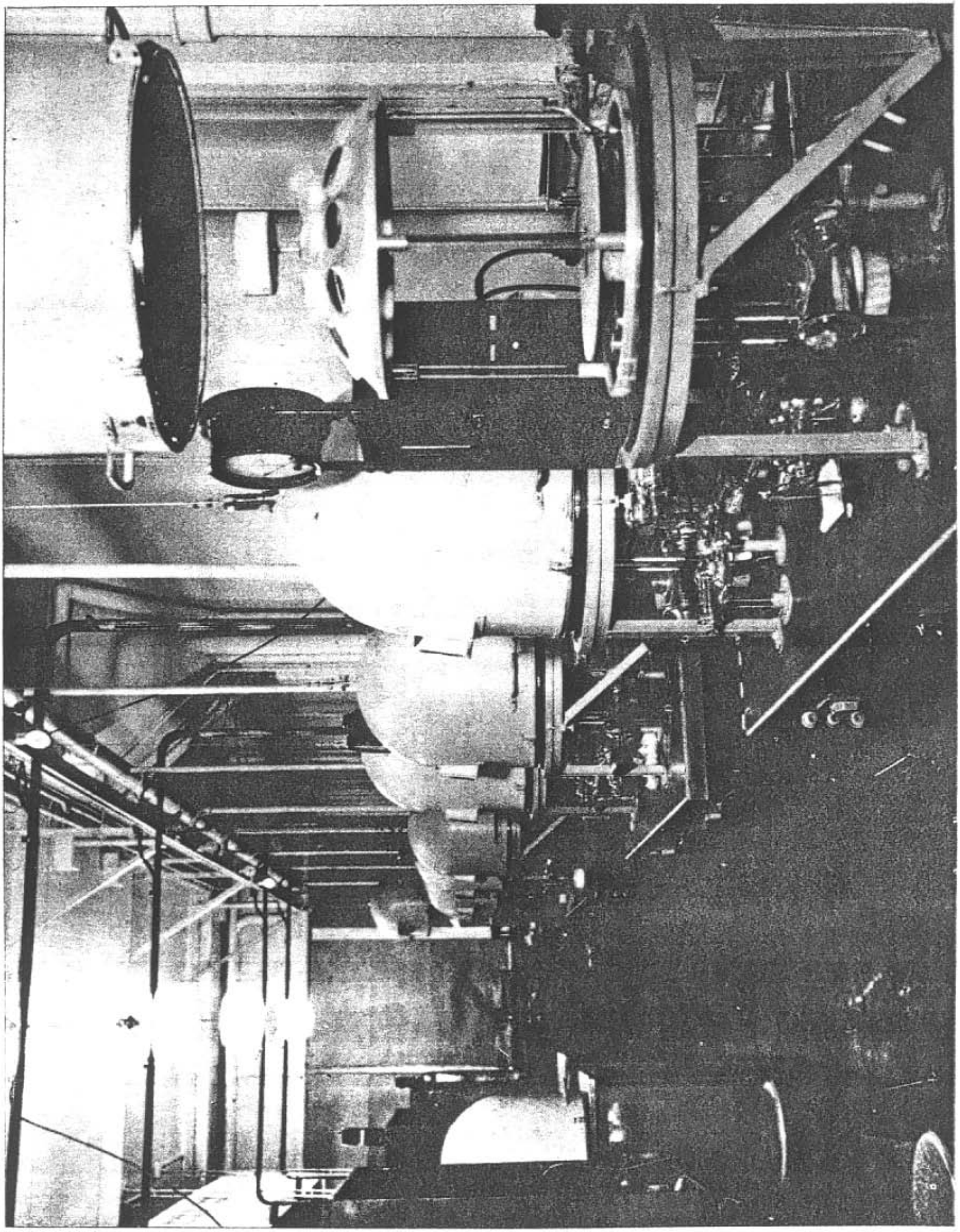
SMALL BILDWANDER TUBE

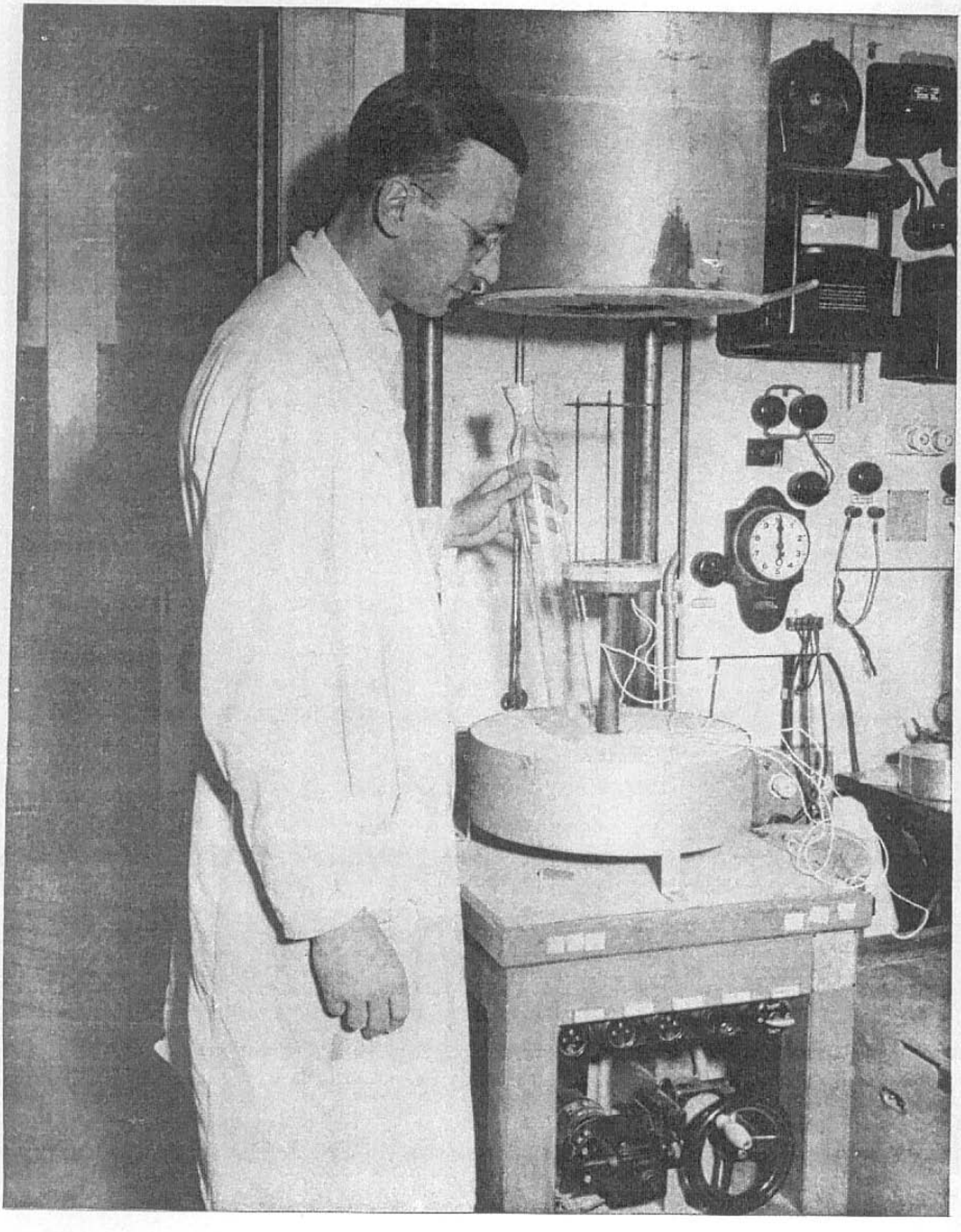


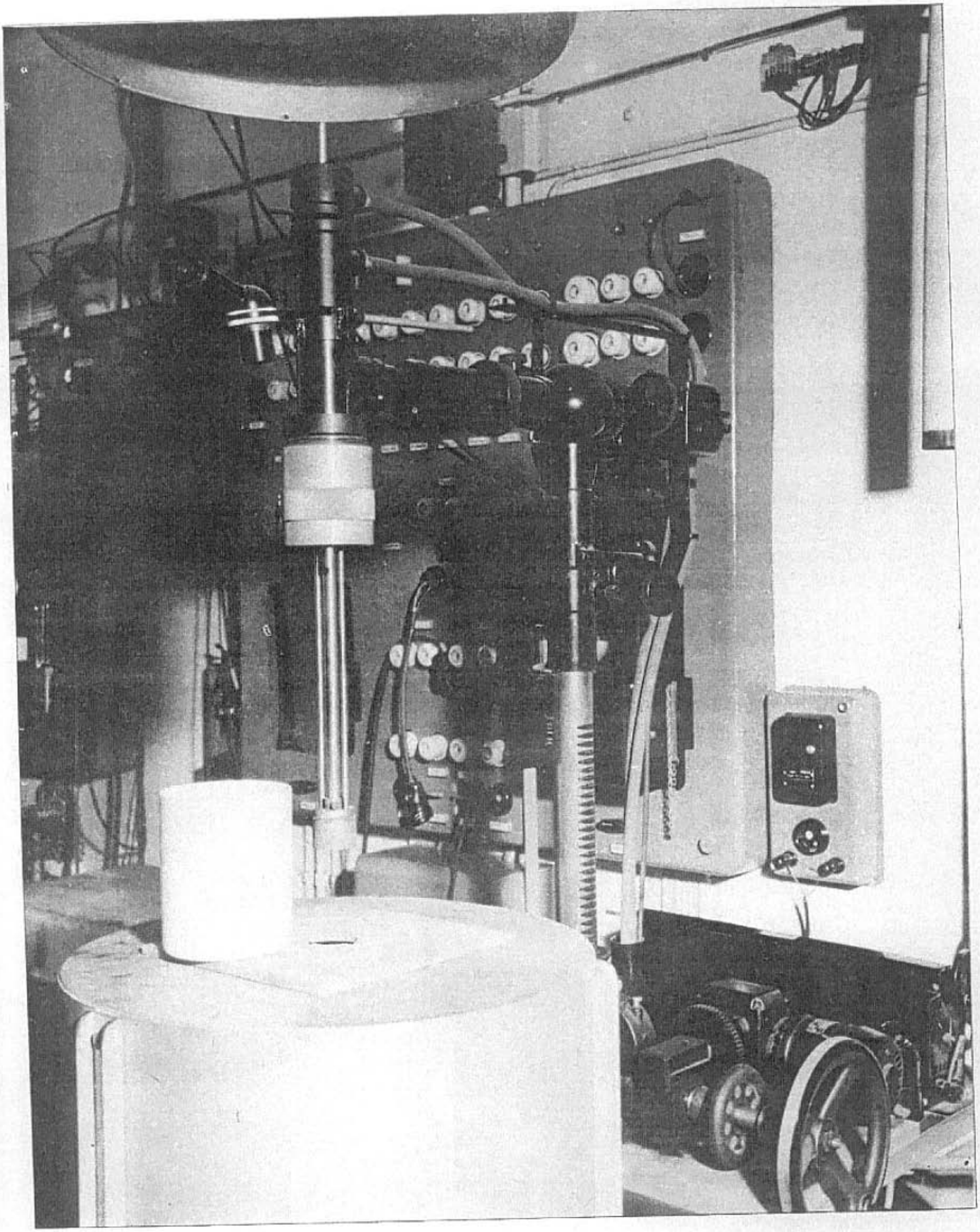
LARGE BILDWANDER TUBE

Potentiometers mounted in polystirene were around this tube in the seehund.









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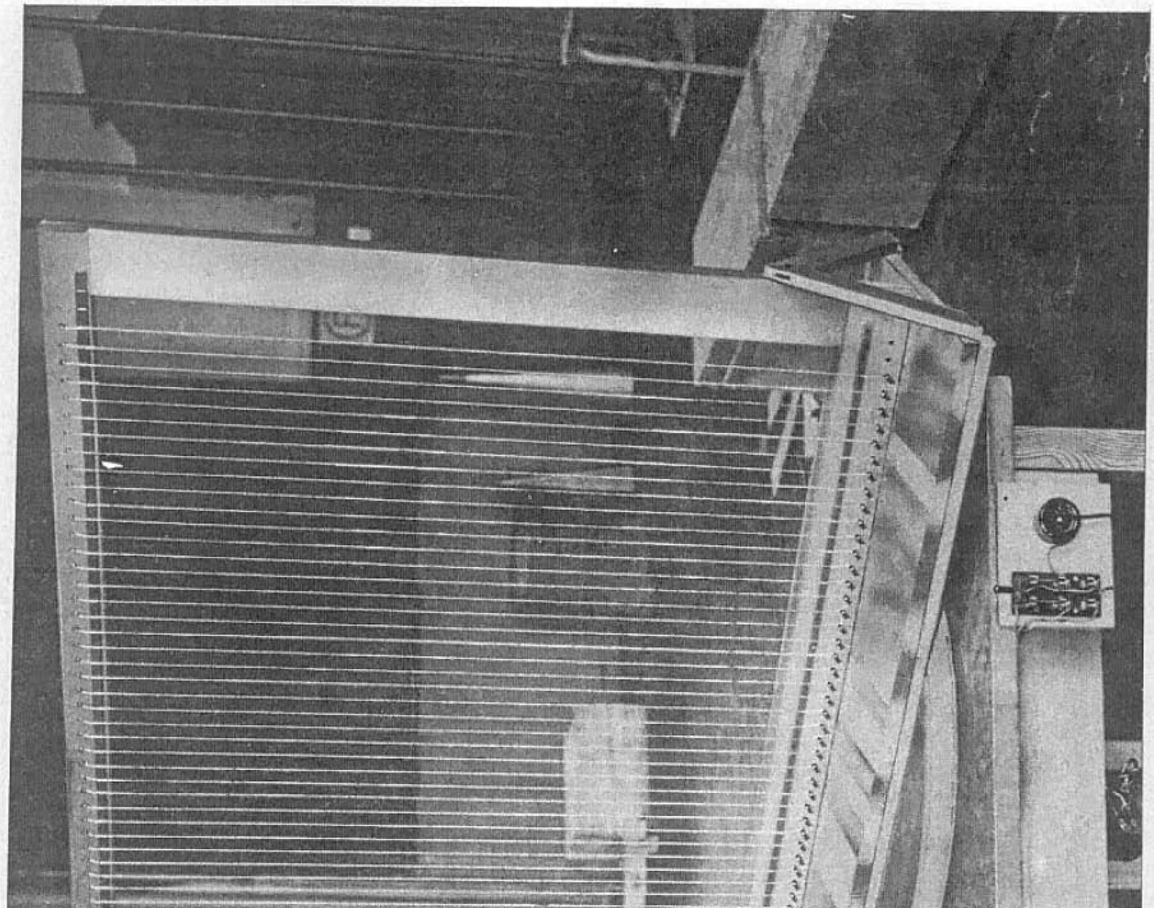

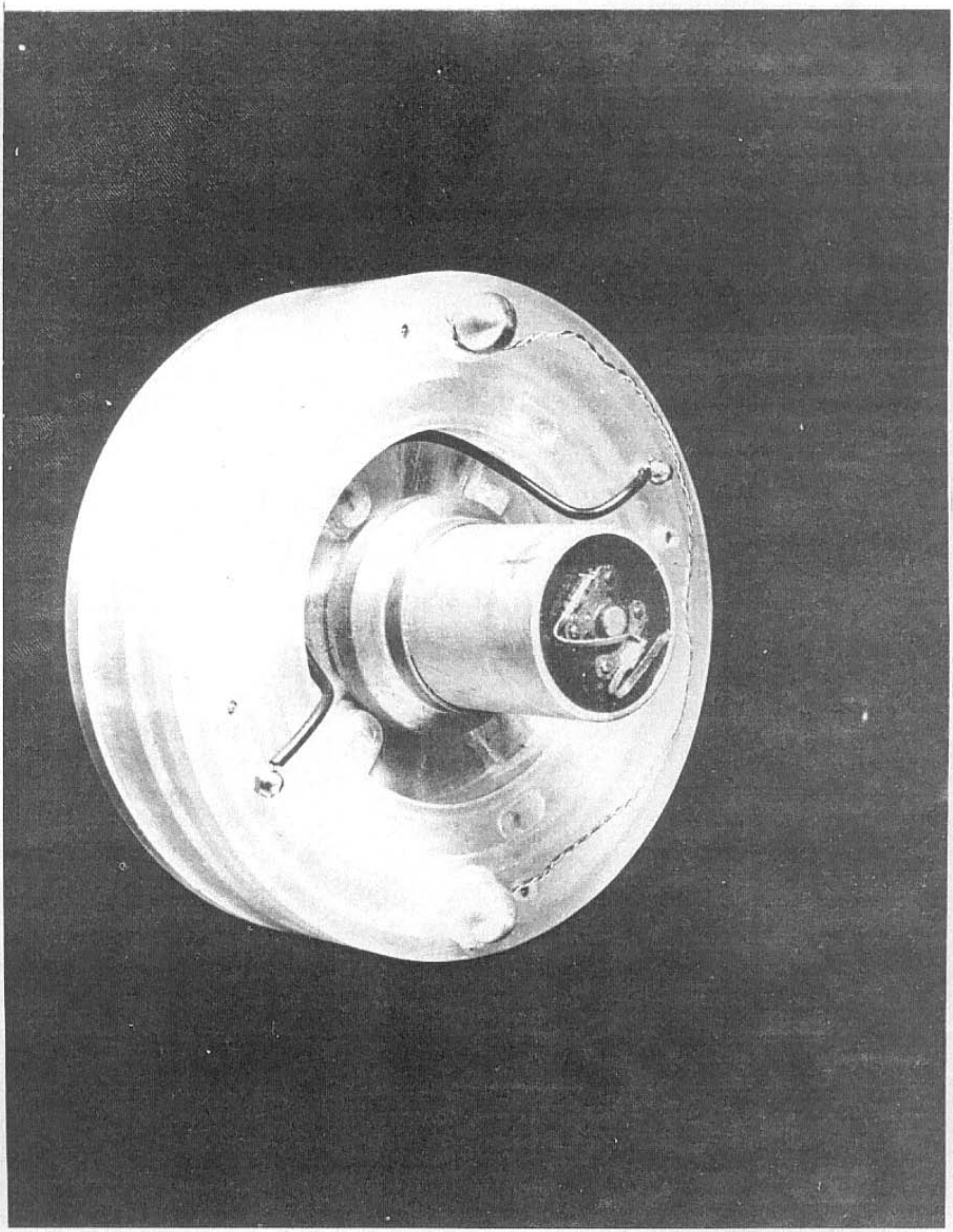

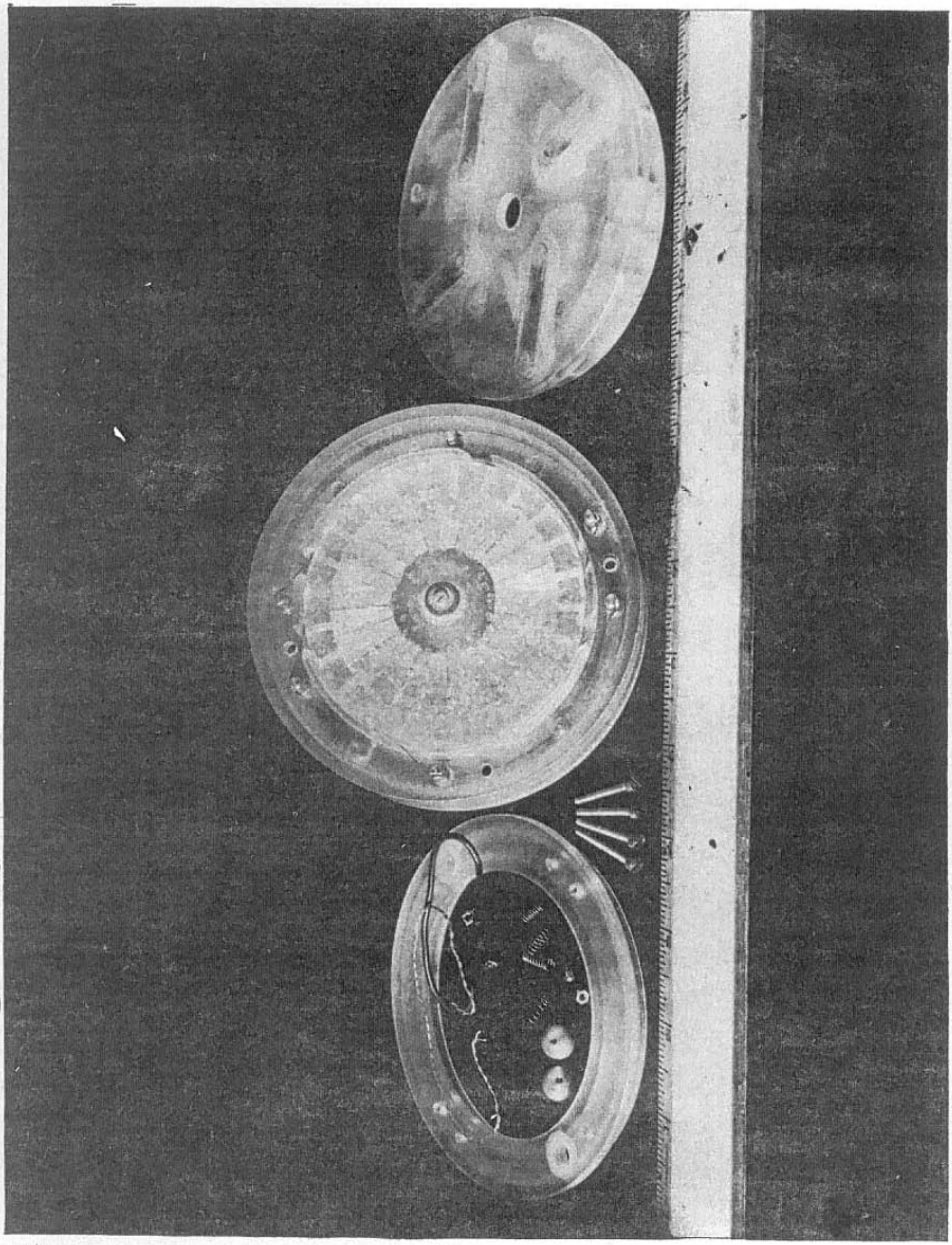

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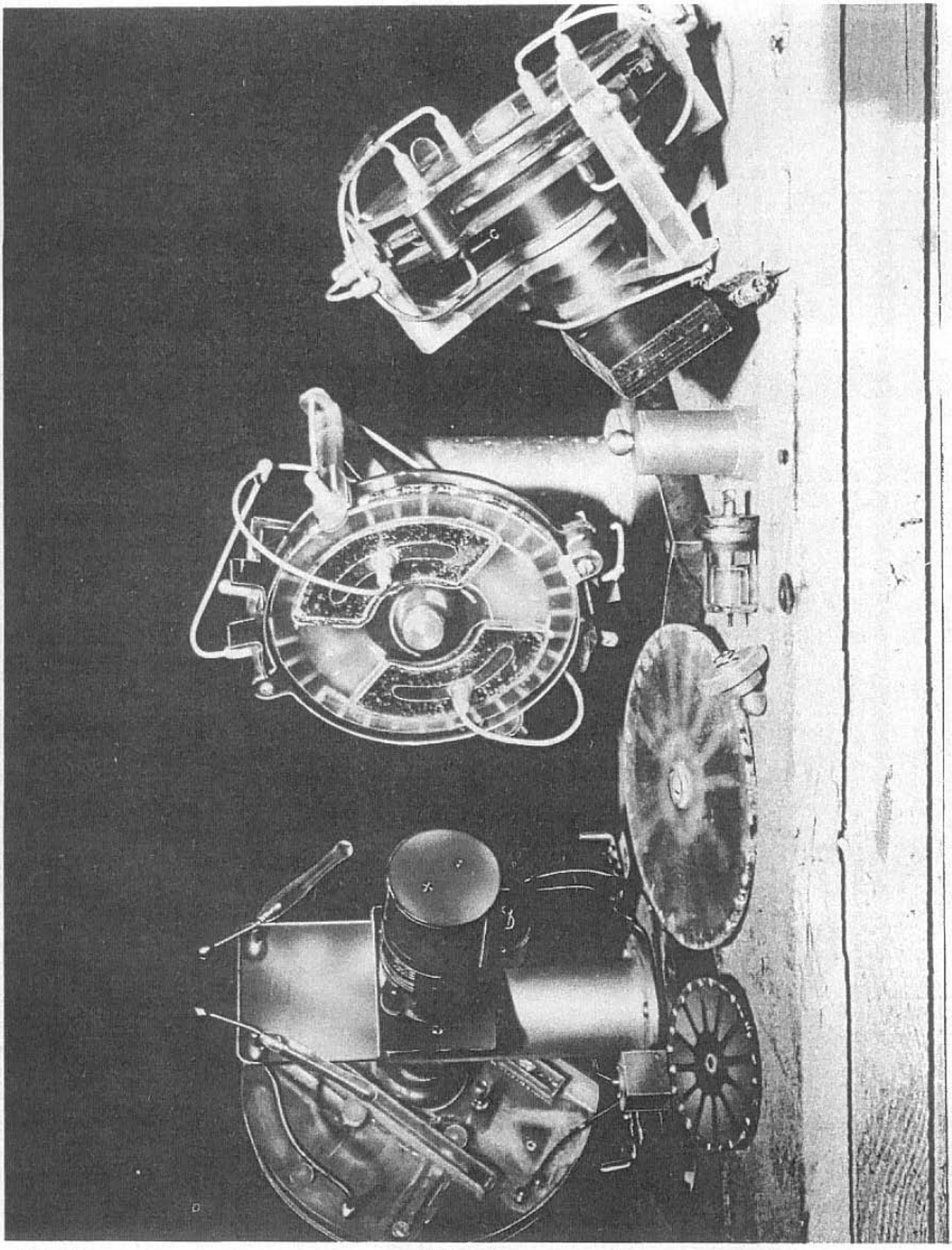
S 25 Boch Wimshurst



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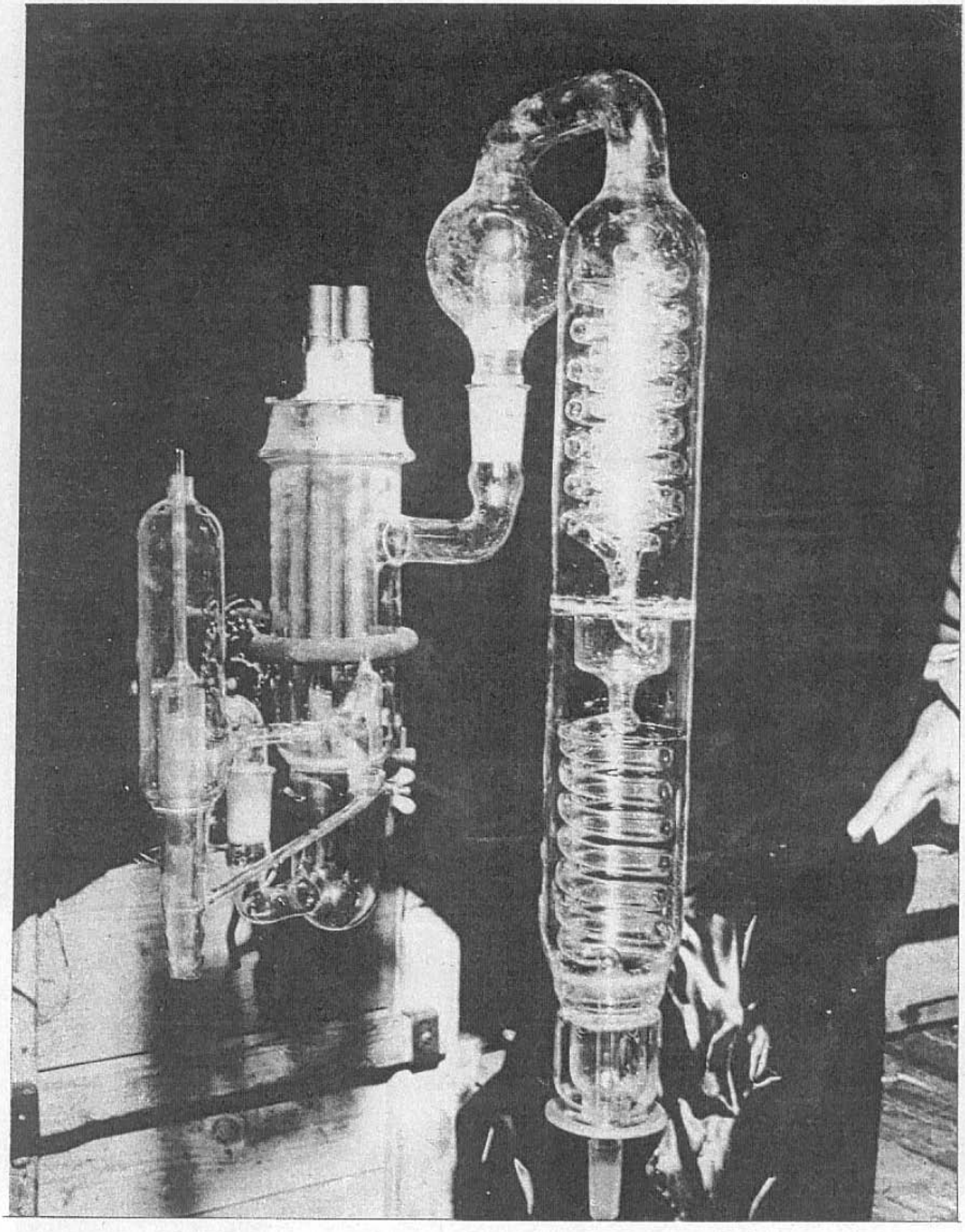

S 36 Greiz, Bildwandler parts