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The "Palace of Discovery" at the Paris Exposition of 1937

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DURING the summer of 1937 it was my pleasure and privilege to visit on many occasions the "Palace of Discovery" of the Paris Exposition. This vast, splendid and instructive exhibit of scientific principles and progress was essentially the idea of that "grand old man" of French science, Jean Perrin. The details were admirably worked out with the wholehearted cooperation of many of the most important French scientific workers who gave freely of their time and energy.

The purposes of M. Perrin in organizing this scientific exhibition are so well expressed in his own words that I merely quote him here in my own translation.

"It should be made evident to all that the recent and prodigious progress of our civilization has had its source in *pure* and *disinterested* research directed toward the discovery of the unknown. Thus, no one should leave this exhibit without realizing that no part, I repeat absolutely no part, of the vast electrical industry of today would exist were it not for the discoveries of the electrical currents and their properties by the Italian, Volta; the Frenchman, Ampere; and the Englishman, Faraday.

"We wish at the same time to disseminate the idea that this country, that any country, has a primordial *and very practical* interest, however great its financial difficulties may seem, in giving to its first class research workers the sums of money, relatively insignificant as they are compared to a national budget, which they need for their research instead of economizing absurdly on the seed with which future harvests are sown.

"Finally pinning our hopes on the plain people, who in every country have shown in the most touching and moving manner their faith in the value of Science, we wish to stress among the adolescents who come with eager curiousity to see our experiments, the opportunities of vocational choice which may lead to the repetition of such miracles as the rise of Faraday from the position of book-

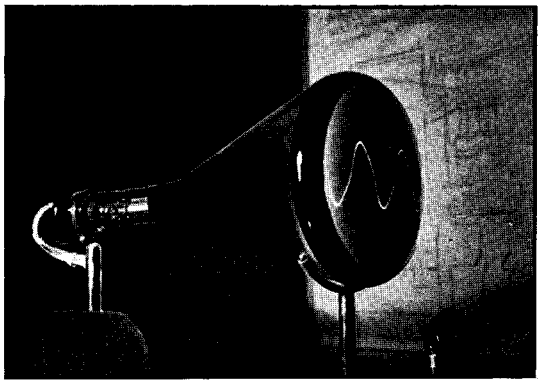

FIG. 1. Mounting of cathode ray to show sound waves.

binder-workman to that of the most eminent physicist of his country.

"The 'Palace of Discovery' built for this triple purpose was organized by *French* scientists. Those who visit it will see, however, that it is as *international* as is the science which it summarizes. Save for any forgetfulness or omissions which it shall be our constant effort to correct, we have tried to display the work of the great research men of all nations."

M. Perrin goes on from here to point out the solidarity of effort in world research which becomes even more apparent when we consider present living workers. For example, a discovery in nuclear chemistry may frequently be the result of the conscious collaboration of researchers in far distant lands all attracted at the same time toward the same enigma. He concludes by expressing the hope that a crusade in favor of scientific research such as the recent one in Belgium may spread to all countries in order that they may reap both the ideal intellectual and natural benefits that are sure to follow and he closes with the sentence, "Do you not see that then Peace will follow of necessity?"

The Science Exhibit was located in the "Grand Palais," the huge building which has in the past always been used for the annual exhibitions of French painting and sculpture. It was divided into sections of mathematics, physics, chemistry, astronomy and the biological sciences. It is impossible in a short article to do justice to all of these different sections. The excellent French journal *La Nature* in its issues of the first and fifteenth of September, 1937, has given fairly complete and accurate descriptions accompanied with many photographs and diagrams of the exhibits and experiments in the sections of physics and chemistry, respectively. I wish here to speak especially of the exhibits classified under physics. Taking for example the sections of mechanics and structure of matter, these were divided into sub-sections with the following names: Mechanics or Hall of Galileo (M. A. Marcellin), Crystallography (Mauguin and Wyart), States of Matter (J. Basset), Molecular Magnitudes (N. Choucroun), Fluorescence and Phosphorescence (F. Perrin, Rouault and Coustal), Negative Electrons and X-Rays (H. Hulubei, G. Y. Cauchois), Cosmic Rays (P. Auger and P. Ehrenfest), Radioactivity (M. Debierne), Atomic Synthesis (F. Joliot). I have purposely given after the title of each section the name of the French physicist who devoted time and energy to make it a success although these names were nowhere in evidence in the exhibit. It seems to me that it was this wholehearted and self-sacrificing devotion and cooperation of the French representatives of pure science and research which is the most instructive object lesson of the exhibit. Their work would of course have been sadly handicapped had they not been generously supported with funds and technical assistance.

One could, of course, go on to mention all the other divisions of physics, such as geometrical optics (Fabry, Bayle, Arnulf, Guerian, Penciolelli), physical optics and the velocity of light (Cotton, Andant), the Hall of Ampere and Faraday (Cotton, Tsai, Leprince-Ringuet, Poirson); oscillatory phenomena (Langevin, Lucas),

THE photographs in this paper and the one used on the cover were supplied by the editors of the French periodical "La Nature," and we take this opportunity to express our appreciation for their kindness and cooperation.—THE EDITOR

physics of the globe (Maurin, Salles) with their various subdivisions but space does not permit. The place was a veritable physicists' paradise—a show appealing at once to the most highly sophisticated savant and to the general public—there was a wealth for everybody. I shall mention therefore just a few exhibits and experiments taken at random.

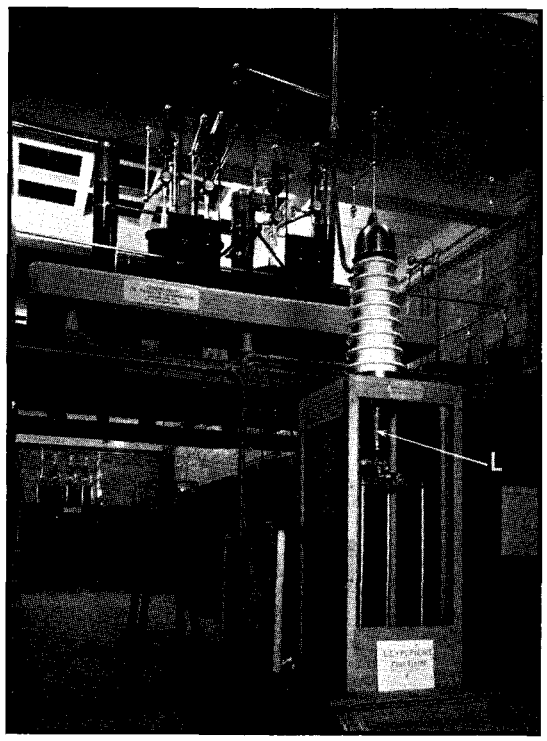

FIG. 2. General view of the "Hall of Negative Electrons" with the Lenard ray tube in the immediate foreground operated by the 250 kv 30 milliampere constant tension generator seen above. Fast electrons issue from the thin window in the bottom end of the tube L where they provoke luminescence in the air and in minerals which are placed below and which exhibit superb colors. Booths containing automatically operated exhibits can be seen lining either wall of this large room.

In the Hall of Galileo not far from the Foucault pendulum is a large rotating circular table turning night and day. Small plumb bobs and vessels of fluid placed at different radial distances from its axis of rotation showed that a citizen of this little rotating world would at each position form a quite different impression of the vertical and horizontal from that formed by the stationary observers in the room. The lesson was driven home with curious vitality by the fact

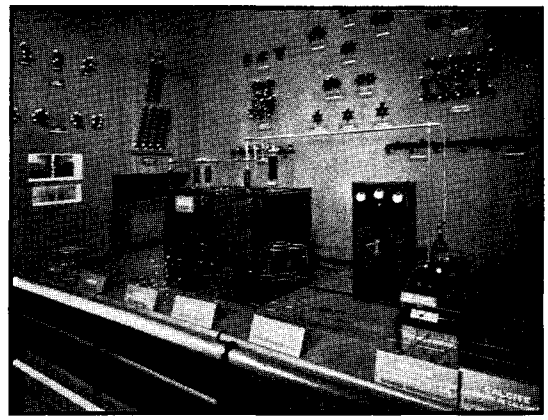

FIG. 3. Section of the large display of crystal models.

that *grass* and other plants planted in earth distributed all over the surface of the rotating disk had grown in the direction of the plumb bobs and normal to the water surfaces but inclined relative to the earth's vertical by greater angles the farther the plants and grass were from the center. The effort of growth of the plant was always exerted against what for it was the prevailing gravitational field. Thus was both centrifugal force and Einstein's principle of equivalence driven home.

I cannot forget the demonstrations of change of state, the critical point, the continuous passage from gaseous to liquid states, etc. so ably explained to the spectators. Nor can I pass over the elegant microprojections permitting anyone to see the Brownian movement, discontinuous thickness of thin films, etc., and to understand through clear explanations the evidence for the reality of the molecular structure of matter. The entrancing new fields of monomolecular layers or two dimensional fluids furnished some delightful experiments. Such layers apparently can behave as two-dimensional solids (as Devaux has shown) or as two-dimensional liquids or gases (Marcellin, Langmuir, Blodgett).

Under crystallography a bewildering multitude of models made to a uniform scale of 400 million times magnification showed how x-rays reveal the structure of materials and teach us most valuable practical information as to why, for example, diamond is hard and graphite is soft though they are made of exactly the same atoms. The value of this discovery *in pure science* for

the understanding of nature, even in biology or in the practical field of the invention of new materials with desired physical properties is a

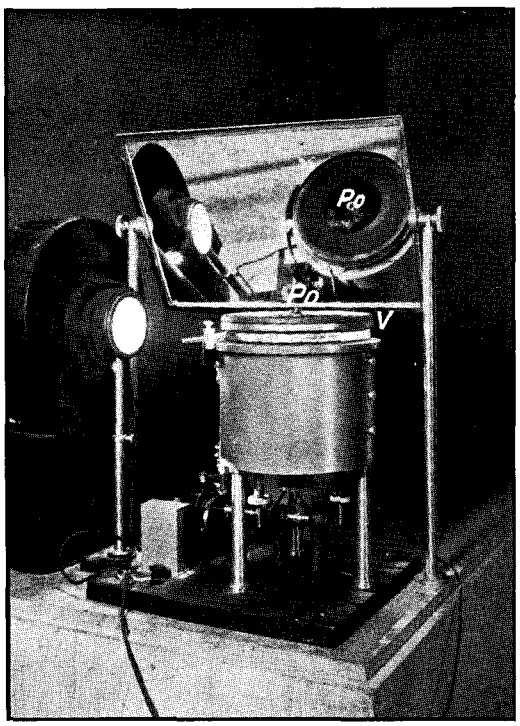

FIG. 4. Wilson cloud expansion chamber to demonstrate ranges of alpha-rays. Built by Surrugue.

lesson whose value we think should sink deeply into the minds of those who hold the purse strings of potential funds for research.

The highly practical sections on electrolysis and electrophoresis as well as the section on photoluminescence can only be mentioned with warm praise for lack of space. However, the Hall of Negative Electrons was of such exciting interest to me, I must tell about it in some detail. Mlle. Cauchois and M. Hulubei are to be congratulated for the splendid results of their really very ambitious efforts. Nearly all the exhibits which lined the walls in booths on either side of a large room were *automatic* so that the visitor, by pushing appropriate buttons and levers and reading the accompanying printed explanations, could instruct himself as to the nature and laws of thermionic emission, the deflection of electron beams by electric and magnetic fields, the ways of determining the specific charge e/m, photoelectric emission, electric discharges in different gases at different pressures, x-ray generation, x-ray absorption, photographic effects of x-rays, ionization of gases by x-rays, and many other experiments in generous profusion. Especial mention should be made also of the contributions to this exhibit from the work of Manne Siegbahn and of the electron diffraction tube operating automatically which J. J. Trillat of Besançon set up. The latter was arranged so that by pushing a button anyone could see as often as he liked a beam of electrons diffracted by a crystal forming beautiful clear and regular "Laue" spots on a fluorescent screen. The important results which Cauchois and Hulubei have achieved in the development of the curved crystal focusing x-ray spectrograph which has recently permitted the discovery of element 87 by these workers were exhibited along with many examples and forms of this powerful new tool. As a climax there was in the center a large high voltage cathode-ray tube fitted with a Lenard window from which could be made to issue into the air fast electrons which falling on an assortment of minerals made the latter emit a gorgeous display of colors.

For those who read without running printed explanations and spectra displayed about the "Hall of Negative Electrons" made evident such highlights of the history of atomic physics during

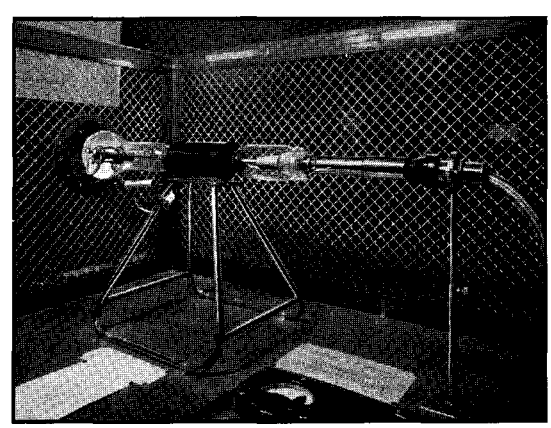

FIG. 5. Trillat's permanently evacuated and automatically operated electron diffraction tube. The fluorescent screen at the left end of the tube showed the von Laue patterns of the electron waves diffracted by a crystalline lattice very clearly to all spectators who pressed the button.

the twentieth century as the Bohr atom model, the concept of atomic number of Moseley, the wave particle duality of electrons and of radiation based on the immortal experimental findings of Gray, Compton, Davisson and Germer, and G. P. Thomson together with its enunciation in Heisenberg's principle of indetermination.

One is torn between the limitations of space and the aversion for omitting to speak of even one of so many well conceived displays; the section on radioactivity and atomic synthesis, for example, with its Wilson cloud chambers in operation and with the original apparatus of the Curies; the section on cosmic rays with the automatically started cloud chamber set off by counters so skillfully realized by Auger and Ehrenfest; the projection views accompanied with automatic phonograph transcriptions explaining the epoch making discoveries and photographs taken with the Wilson chamber by

FIG. 6. High luminosity spectrographs and some models of organic chemicals from the chemistry section.

workers in this field from America, England, France and many other countries with a fine, generous impartiality. There was the huge electrostatic belt generator of *Van de Graaff* type which formed the "pièce de resistance," as one entered the great central rotunda of the exhibit which so impressed the French public that it was very amusingly used in political cartoons in the newspapers in which the debates in the Luxembourg over financial policy were represented as the crashing disruptive discharges of this machine.

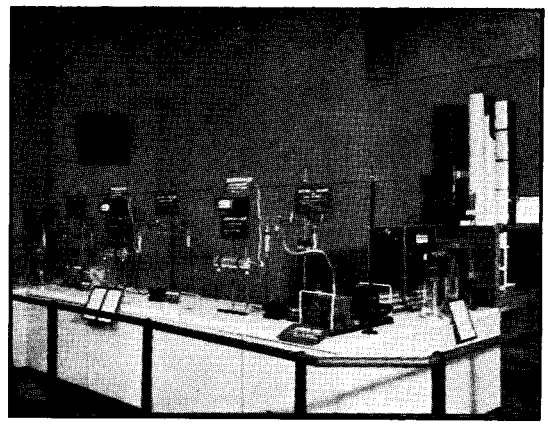

FIG. 7. The constituents of air including the rare gases were separated and exhibited by means of electric discharge tubes continually for every spectator to see in this apparatus. Section on chemistry.

By the time one had reached the section on optics one was prepared for anything and again one was not disappointed. There were beautiful and lucidly clear explanations of geometrical optics showing the rays going through lenses or reflected by mirrors or showing the formation of the mirage or of the rainbow; the experiment of the measuring of the velocity of light with mirrors turning on a jet of air and a beam only thirty meters long; every type of interference and diffraction experiment of which it seemed to me I had ever heard and many others all in perfect adjustment and clearly explained so as to make the wave properties of light self-evident, and a host of other beautiful experiments making clear the scattering of light, the colors of the sunset, the polarization and rotatory polarization of light, double refraction and its multitudinous applications, and so on almost it seemed without end.

The Ampere-Faraday hall contained a huge so-called "homopolar" generator which I believe was said to furnish 50,000 amperes in some experiments. These tremendous currents flowing through huge conductors were made to perform weird tricks at various places in the room and visitors were warned to leave their watches at a distance. Measurement of the magnetic fields with the "Cotton balance," a clear demonstration of the Zeeman effect, experiments on the magnetic birefringence of liquids, on falling bodies in a magnetic field and a very large

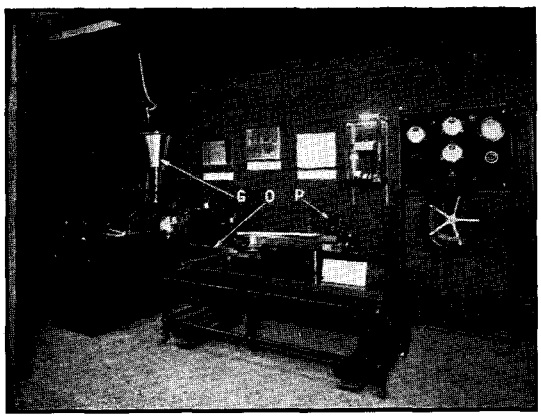

FIG. 8. Cauchois curved crystal spectrograph for demonstrating absorption and emission x-ray spectra. *G*, x-ray tube; *O*, optical bench; *P*, photographic plate holder. From the "Hall of Negative Electrons."

magnetic Wilson cloud chamber of de Broglie and Leprince-Ringuet were a few of the other exhibits which used the source of the immense electrical current just mentioned.

Of the sections on sound and ultrasonics and other vibratory phenomena we have not room to speak nor can we say but a word about the fine section on meteorology where there were striking experimental demonstrations of the cellular formation of thermoconvective vortices.

And we must not forget that my description says nothing of the subdivisions other than physics; the great display for instance of the progress in biology, medicine, surgery, heredity, microbiology, etc., etc., nor can I speak of the subdivisions of astronomy nor of mathematics with its museum of precise mathematical instruments or its little round treasure room whose frieze was decorated with the value of π computed to heaven only knows how many decimals spiralling again and again around. And last but not least the subdivisions on chemistry and industrial chemistry so vital to our modern civilization must be passed undescribed.

But I have said enough perhaps to point out the moral to this tale which many a reader may already have guessed. In this work-a-day world I think recently one can detect a misunderstanding which may have grown out of the too speedy and careless popularization of science—a misunderstanding of the nature, value, and role, as Perrin put it, "*of pure and disinterested research directed toward the discovery of the unknown.*" There is no doubting the meaning of his well chosen words. As our own Jewett has said "You can't have applied research until you have built up by pure research a body of knowledge to apply." Experience has shown (and an exhibit such as the French "Palace of Discovery" is a marvelous way of teaching this) that these frontiers of the known which must be ceaselessly pushed forward in order that all our technique of civilization may flourish and grow in its wake *can only be pushed forward by disinterested research. The immediate practical so-called utilitarian goal* must therefore not be our exclusive aim or we risk nipping in the bud the Newtons and the Faradays and the Maxwells and the Diracs and the Heisenbergs. It is the lesson of their part in the world picture that such a science exhibition should aim to teach. Whether we believe that government (as in France) or private initiative (as in America) is the best agency to encourage pure research is certainly a question which I believe is still open for debate but it is certain to me in either case that the value of "pure and disinterested research directed toward the discovery of the unknown" must be driven home to the public unless civilization is to die a slow death from malnutrition in these United States. The physicists of America have two opportunities to do their part in this cause in the near future—one is the exhibition in San Francisco, the other the exhibition in New York. Let us hope they will see the need and rise to the occasion.

FIG. 9. Reflection, refraction, and grating diffractions of short radio waves.