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NOTES ON 1952-53 VISITS TO EUROPEAN LABORATORIES

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General

As Fulbright Research Scholar, the writer was privileged to spend the academic year 1952-53 at Grenoble, France; in addition, through arrangements with the Office of Naval Research, he had the opportunity of attending the Eighth International Congress for Applied Mechanics at Istanbul and of visiting laboratories in neighboring countries during the remainder of the thirteen-month period that he resided abroad. These visits duplicated in part those that he had made on four previous occasions, the last of which was reported upon to the Bureau of Ships in November 1946. They also supplemented those made by his colleague, Dr. John S. McNown, following a similar Fulbright year and reported upon to the Office of Naval Research in January 1952. The present notes will largely avoid repetition of material contained in these reports (and in the annual summaries of the International Association for Hydraulic Research), directing attention to complementary aspects of the present European laboratory situation.

Leaving Iowa City the latter part of July 1952, the writer proceeded directly to Grenoble, thence to Istanbul for the Applied Mechanics Congress early in August, and back to Grenoble in September. His time there was divided between the university, where he held a nominal exchange professorship and supervised several advanced research projects, and the Etablissements Neyrpic, where he was engaged in the completion of a history of hydraulics. Visits to Belgium and England in the spring of 1953 resulted from invitations to deliver lectures on the work of the Iowa Institute at Liège, Ghent, Louvain, Brussels, London, and Cambridge. These lectures were also given in full or in part at Paris, Toulouse, Milan, Hamburg; and Karlsruhe, in the course of separate trips to representative institutions in France, Italy, and Germany during the summer. Laboratories in Switzerland, to which Grenoble is very close, were visited on several occasions.

### Applied Mechanics Congress

By now well in the past, the Eighth International Congress for Applied Mechanics will probably remain in the memories of participants for its social rather than its technical excellence. Istanbul was an unequalled attraction, and full advantage was taken of its entertainment possibilities by the organizing committee. The less satisfactory nature of the technical sessions themselves was as much the fault of the participants as of the organizers. The setting in the new university buildings was a mixture of extremes - beautiful rooms with poor summertime ventilation, an elaborate assembly hall that was so large as to eliminate the personal element from the general lectures, and so on. But whereas the congresses were once truly international, that at Istanbul seemed to be divided into a series of national cliques: the sessions in French were attended almost exclusively by the French, those in German by the Germans, and those in English by the English and Americans. Language abilities surely played a leading role in the mass turnover preceding each paper, but one wonders as to the usefulness of attending such a meeting to those who arrange to hear only what they could hear at home. Unfortunately, moreover, a considerable portion of the numerous papers were either second rate or had already been given elsewhere, so that their presentation on the Istanbul program seemed largely a means of justifying the trip. The congress proceedings, usually a noteworthy addition to mechanics literature, did not appear to warrant publication except in abstract and general-lecture form.

### France

Though once the primary source of hydraulics principles, France lost this position of leadership early in the present century, and by and large the general situation has since remained unchanged. The country's engineering and scientific interests have tended primarily in the theoretical direction, and the widespread application of these theories seems to lie beyond either the interest or the ability of its scientists and engineers. It is for this reason that the Laboratoire Dauphinois d'Hydraulique of the Etablissements Neyrpic at Grenoble, probably the greatest organization of its kind, is a wholly atypical French phenomenon. Largely the creation of one man, Pierre Danel, this laboratory embodies a healthy combination of theory and practice, of specific model tests and fundamental investigations, and of people of many interests from many different countries. As a commercial rather than a government- or university-sponsored organization, the Neyrpic laboratory stresses the development of trained personnel and the provision of space and source material rather than of permanent equipment. In fact, except where refinement is definitely needed, the experimental facilities themselves are the least impressive

part of the establishment. Facilities and personnel are steadily increasing, however, and the laboratory now dwarfs, in space if not in staff, the turbine factory to which it is attached. The general nature of its work has changed little from that described in the McNow report; but the size of the organization is approaching - if it has not already passed - the point of optimum efficiency and effectiveness, the latter still depending as it originally did upon close contact between the director and those engaged on the actual projects.

One phase of the Neyrpic establishment which cannot grow too large is that with which the writer was most closely associated: the reference library on hydraulics and related fields. This is without question the most active and extensive in the world. Danel had initially collected several hundred volumes of early source material, which, as professor, he presented to the university library. Upon his association with the Neyrpic firm, he began the collection of additional material, both old and current, and the process has continued with ever greater zeal. Not only does the library now contain many thousands of books, countless reprints and microfilms of individual articles, and current subscriptions to all pertinent journals, but each is thoroughly cross-indexed, and an average of nearly a dozen people give their full attention to the maintenance and expansion of the collection. Above all, the reference facilities are in constant use by all sections of the laboratory. Whether for the historical work carried on by the writer or the contemporary resistance and wave studies conducted by Dr. McNow, to cite extreme examples, in no other library could the pertinent material have been found so conveniently and completely.

The fluid mechanics laboratory of the University of Grenoble is more nearly typical of those found elsewhere in France. It is equipped primarily for student instruction but provides limited research facilities for three or four post-graduate assistants. Its new director is Professor Julien Kravtchenko, a mathematician who nonetheless possesses the initiative and national contacts that may well bring its experimental activities into greater prominence. The writer was asked to supervise one phase of a doctoral project of some five years' standing on a rather narrow two-dimensional model of an ejector pump. He suggested that another doctoral candidate utilize the relaxation method for the analysis of free-surface flow toward partially penetrating wells. And assistance was provided him for an original study of turbulent diffusion across a density interface, with equipment provided by Neyrpic. A new project for which equipment was installed during the year involved the efficiency of Pelton-wheel jets. Professor Antoine Craya, previously a visiting professor at Iowa and Columbia, returned to Grenoble the middle of the year, a move which strengthened considerably the laboratory staff.

The two other French laboratories visited by the writer, one old and one new, were that at the University of Toulouse and that of the Electricité de France at Chatou, near Paris, both of which were described in the McNow report. Suffice it to say that the Chatou organization, under A. Nizery, already possesses many of the characteristics that have made Neyrpic famous, and that Professor L. Escande, at Toulouse, is simultaneously continuing the type of work begun early in the century by Camichel, engaging in a large consulting practice, and writing prolifically.

### Belgium

Of the four Belgian universities, only those at Liège and Ghent have hydraulics laboratories, and the writer was able to inspect only the former. Under the leadership of Professor Alb. Schlag, this modern laboratory is devoted primarily to student instruction, for which it is well adapted. Only two research projects appeared to be in progress. One dealt with the phenomenon of proportionate overflow at the end of a channel carrying a fluid with density stratification. The other was a continued calibration of the pneumatic device developed by Jorissen for the prediction of hydraulic roughness in terms of the rate of lateral leakage of air under pressure through the controlled longitudinal gap between the device and the pipe surface. Good correlation is claimed for the many tests that have been run, but it would seem to the writer that the results would be biased in favor of the lateral direction.

Judging from the considerable literature published by Professor L. J. Tison, who is in charge of the Ghent laboratory, primary interests lie in the usual civil-engineering directions of hydraulic structures and sediment. The same is true of the federal laboratory at Antwerp, which the writer was also unable to visit. Both Schlag and Tison complained repeatedly of the difficulty in obtaining graduate assistants in the face of current employment salaries offered by federal and private organizations, their staffs being limited to two or three young engineers.

### Italy

The writer's laboratory visits in Italy were limited to the four universities in the northern part of the country, and that at Turin was unfortunately closed for the summer at the time he passed through. The remaining three - Bologna, Padua, and Milan - displayed both similarities and dissimilarities. Student instruction in each appeared to be limited to demonstration, so that their major activity was research and testing. Otherwise one was impressive for its newness, one for its age, and one for its breadth of endeavor.

The Bologna facilities were completely destroyed in the war, and hence buildings and equipment, recently completed in modern style, were not yet in full use. Professor G. Evangelisti's hydraulic-structures laboratory already had in operation a project on high-velocity bends; Professor Supino's hydraulics laboratory seemed to be concentrating on a high-speed diverter for flow measurement.

Following Professor Scimemi's death a year ago, leadership of the laboratory at Padua had passed to Professor F. Marzolo. Projects of which the equipment was still in operation or existence were largely specific model studies of hydraulic works. There was evident an interesting lack of parallel between the antiquated appearance of the facilities and the vast amount of literature that continues to come from this establishment.

Professor G. De Marchi's laboratory at Milan is large, active, and well staffed. Experiments were in progress on air entrainment, siphon similitude, and wave amelioration in forebays, and vestiges were left of many model tests recently run. In view of the fact that ultimate attention is given there to applied investigations, the obvious familiarity of the staff with basic principles and the healthy caution against generalization were heartening. This laboratory is undoubtedly the major one in Italy from all points of view.

### Switzerland

Aside from such private laboratories as that of the Escher-Wyss plant visited by the writer in 1946, Swiss research in fluid motion is conducted at the French- and German-language universities at Lausanne and Zurich, respectively, each of which possesses active civil- and mechanical-engineering divisions. For the size of the country, the Swiss engineers are very active and rather self-centered, their attention being focused largely on their own past and present accomplishments - which, to be sure, are usually excellent.

The hydraulic-machinery laboratory at Lausanne, under Professor P. Oguey, is primarily for research, two special units being devoted to the study of jet dispersion and turbine cavitation. Professor D. Bonnard's laboratory for hydraulic structures, only loosely connected with the university, was engaged in so many specific model tests for the government that the small quarters seemed a beehive of activity. The two laboratories are located in a center of rather stimulating scientific research in related fields, noteworthy among which was the study at reduced scale of dam deflections under load.

With the retirement of Professor Meyer-Peter, direction of

the hydraulic-structures laboratory at Zurich has been taken over by Professor G. Schnitter, formerly a practicing hydraulic engineer. The originally large experimental hall had been doubled in size since the writer's last visit, yet both sections were well filled with model tests for Swiss power developments. The laboratory of Professor J. Ackeret, now the unofficial dean of fluid mechanics in Teutonic Europe, is still devoted primarily to research in aerodynamics and supersonic flow - his latest demonstration involving the ignition of wood by a supersonic jet of air directed into a small cavity.

### Germany

For the first time the writer had the opportunity of visiting the plant of A. Ott at Kempten, the source for many decades of such precision instruments as planimeters and current meters. The founder and his son are no longer living, but the plant is still managed by a member of the family. His greatest pride was the perfection of a current meter indicating the cosine function of the velocity up to angles as high as  $45^{\circ}$ . The writer was intrigued by the fact that the propeller has thereby been restored to the screw form from which it was derived, the helical blades often extending for a complete turn along the shaft; it appears, moreover, that their design is now geometric rather than hydrodynamic.

At the Walchensee in Upper Bavaria the writer revisited the open-air experiment station where he spent several summers twenty-odd years ago. This is no longer a part of the Kaiser Wilhelm research organization but seems to be managed locally with limited state support. The leadership has changed, and - although several small models were in operation - it has hardly fulfilled the promise that it once held.

Three laboratories were inspected at the technical university of Munich, the staff of each seeming to have little knowledge of or contact with the others. One was that of Professor W. Kaufmann, for aerodynamics (although the professor was away, the writer's visit coincided with that of J. Nikuradse's brother, the two Nikuradeses apparently having a private research organization in the vicinity of Munich); a moderately large wind tunnel is in process of installation. The late Professor Thoma's laboratory, badly deteriorated, was undergoing extensive repairs; attention will be given almost exclusively to hydraulic machinery, and some rather large pumps and turbines of various sorts were being installed. The small hydraulic-structures laboratory, of long standing but not before discovered by the writer, had several models of the routine type.

With Professor G. Weinblum's return to Germany, the restora-

tion of this country's prewar activity in ship research shows good promise; he now holds a professorship at Hannover, is associated with the University of Hamburg, and is stationed in a Hamburg engineering trade school. Dr. K. Wieghardt has been a major addition to the staff (the writer was impressed by the latter's experiments on the flow of sand during the period in which tests with "real" fluids were outlawed by the occupation authorities). The small towing tank in the school is being used by the Kempf tank staff pending completion of their new building.

Except for the retirement and death of Professor Prandtl and the appointment of Professor W. Tollmien in his place, the situation at Göttingen is about the same as on the writer's previous visit. Tollmien and Professor A. Betz divide responsibility between theory and practice on the one hand and fluid mechanics and fluid machinery on the other. Under Tollmien Dr. H. Reichardt is conducting open-channel studies with an oil having five or more times the viscosity of water to accentuate the boundary-layer thickness on the side walls, and under Betz a graduate student is investigating flow with induced circulation at a conduit inlet. The writer's general impression was that instruction and analysis were again at their normal high level but that experimentation was only slowly recovering from its abrupt disruption at the end of the war.

The laboratory of Professor H. Schlichting at Braunschweig was in a relatively great state of activity, although space was quite limited and only two wind tunnels of small and moderate size were in operation. Recent studies had been made for the reduction (27%) of aerodynamic drag of a "Volkstruck" and the stability of an over-streamlined motorcycle which had set speed records. Tests were in progress to complement theoretical analysis of cascade resistance and extend it to the axisymmetric case. Schlichting was somewhat astonished by the fact that his boundary-layer book had greater sales abroad than at home. There was also a laboratory for hydraulic structures on the campus, but from casual inspection this appeared to offer little beyond the routine type of work.

The Franzius laboratory at Hannover, under Professor W. F. Hansen, which was rather inactive on the occasion of the writer's previous visits, had been rejuvenated to the extent of being the busiest institution of its type in Germany. The large hall was filled to overflowing with specific model tests, and new outdoor installations were in the process of completion for further studies. Wave and harbor tests, river regulation, and shore protection received primary attention, and extensive models for Wilhelmshaven and one foreign port were involved.

The Rehbock laboratory at Karlsruhe, the direction of which

is now divided between Professors P. Böss and H. Wittmann, is doing much the same type of work as in the past. The annex building, destroyed during the war, has been only partially reconstructed, and the scale of models is hence again limited by the facilities in the original building. Considerable contract work was in progress, but it bore the same earmarks as during the writer's studies twenty-five years ago. The Spannhake laboratory, completely destroyed during the war, has been entirely replaced under Professor H. E. Dickmann by a very modern hall devoted to all phases of mechanical-engineering fluid mechanics. Pump and turbine theory continues to play a leading role, but interest in problems of supersonic flow, heat transfer, jet atomization, and instrumentation was evidenced by the projects under way. The director and his staff, the plant, and the tenor of the investigations made a very favorable impression.

### England

Since his visit in 1946 the writer has considered the laboratory of Professor C. M. White at City and Guilds College, London, one of the most interesting and fruitful in Europe. The experimental hall is large, the permanent staff small, and the activity astonishingly great. Of particular interest on this visit were an investigation (by Bagnold) of the movement of sediment having an essentially zero buoyancy, the study of boundary roughness in non-uniform as well as uniform flow, propeller design, and various aspects of wave motion. A plastic pipe below a tank outlet had been set up for Professor Squire of the aeronautics department, who was studying the decay of a vortex along the axis of a pipe in air flow, thereby disclosing the longitudinal secondary motion (upstream along the axis) also noted at Göttingen and Cambridge. It is the writer's belief that this laboratory is well worth inspecting by Americans abroad. He was also impressed by the size of the graduate class in hydraulic engineering (to which Dr. Ch. Jaeger is part-time lecturer), some thirty of whom visited Grenoble during a holiday inspection trip.

At Cambridge visits were made to a number of laboratories dealing with fluid motion from quite different points of view. That of Mr. A. M. Binnie is for the training of civil and mechanical engineers but provides facilities for research in a number of directions; work was being done on the design of a recirculating flume for ship models, on secondary flow in conical outlets, on induced cavitation within a vibrating reservoir, and on circulatory motion in an idealized hydraulic machine. In the aerodynamics laboratory of Professor Mair, Mr. J. H. Preston had devised a means of determining the intensity of wall shear through a single reading of a stagnation tube in contact with the wall. Professor G. K. Batchelor was supervising in another laboratory the characteristics of convective cells formed

between hot and cold plates. And Sir Geoffrey Taylor - in a small laboratory impressive for the elegance of its output rather than of its equipment - was engaged in studies of limiting wave crests and the diffusion of salt-water slugs in horizontal and vertical tubes.

#### Concluding Remarks

Each of the countries that the writer visited differed technically from the others in various ways, due in part to its national traits, in part to its role in the recent war, and in part to factors which the writer found it difficult to assess. England appeared to be continuing in the same pattern followed for the past century or more, not striving for a position of leadership but contributing solidly to both analysis and experimentation at an unhurried pace. The situation in France ranged from one extreme to the other, depending upon the laboratory in question: there was evident at Neyrpic a concerted effort to lead the hydraulics world, but few others showed any tendency to follow. Belgium evidenced a good rate of output, but Switzerland - a country of comparable size - displayed the quantity and quality of production of a much larger nation. Italy's post-war recovery was reflected to a considerable degree in its laboratory activity. Germany, recovering at a surprising pace, was reverting largely to its pre-war trends: rapid advancement in the mechanical and aeronautical phases of fluid motion, yet repetition of the same hydraulic practices that brought it fame many years ago. The language barriers are still either surmounted or accepted, depending upon long-established custom: the Italians, with a tongue that is not widely used, seem fully aware of all works published in English, French, and German; the French follow the English literature but not the German; the Germans and Swiss, though capable of reading both French and English, continue to expect the works worth noting to be found in their own literature; the English are in much the same situation as the Americans - poor linguists, and hence perforce restricted to what is available in English. The situation becomes the less excusable as one realizes that neither a single country nor a single language has a monopoly on scientific knowledge in any field.

The various factors producing the foregoing situation are national rather than personal, and hence there are many individual exceptions - particularly among the leaders responsible for the international organizations in hydraulics and applied mechanics. The writer as an individual was received very cordially, and often with extreme hospitality, in each of the laboratories which he visited, although in many cases he had not before met his hosts and sometimes his name was not known to them. His own point of view was considerably enlarged, not only by contact with other people and other methods of research but also by the opportunity to observe his own countrymen and methods from a distance and through others' eyes. He is firmly

convinced that bilateral visits of this nature throughout the scientific and engineering world are essential to the breadth - if not the depth - of continued accomplishment. From purely the American point of view, he further believes that the nationalism stemming from (and simultaneously strengthening) the language barrier must be surmounted here as well as abroad if this country is to maintain the advanced position it is now tacitly assumed to hold.