REPORT OF ATTENDANCE AT
Tenth Congress - IAHR
England

BY ALVIN J. PETERKA

SEPTEMBER 1963

INCLUDING VISITS TO HYDRAULIC LABORATORIES IN ENGLAND, SCOTLAND, AND FRANCE
UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

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TENTH CONGRESS - IAHR

ENGLAND

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HYDRAULIC LABORATORIES
IN ENGLAND, SCOTLAND, AND FRANCE

BY
ALVIN J. PETERKA
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The 10th Congress of the International Association for Hydraulic Research was held in London, England, September 1-5, 1963, in the building of the Institution of Civil Engineers, Great George Street, Westminster, London, Figure 1. Meetings were held in two large halls adjacent to several other rooms used for registration, lounge, headquarters, food and drink bars, etc. The Great Hall was used for assemblies of the entire Congress, at times approaching 400-500 people, and for the formal presentation of papers. The Lecture Theatre had perhaps half the seating capacity of the Great Hall, and was used for the informal seminar meetings and also for the presentation of papers for two sessions when simultaneous paper presentations were being made. The adjacent rooms and the entrance hall were sufficiently large to accommodate the entire assembly between sessions. The list of participants in the Congress is given in Appendix I.

Papers or seminar discussions were delivered from a podium containing a microphone, in English or French, and immediate translations were available through earphones attached to individual multichannel radio. Lightweight portable radio receivers and earphones were given to each participant upon entering either of the lecture halls. Equipment was returned to a rack upon leaving the room. Only comments made into a microphone so that all could hear and the remarks could be translated were considered. The speaker’s voice was not amplified in the room and usually could not be heard except through the earphones.

General Sessions Procedure

In the general sessions, each 3-hour session was divided into halves; in each half a general reporter, appointed months before the convention, summarized in about 20 minutes the contents of a group of papers assigned to him. About 65 minutes were used for discussion of the paper by the members present. Participants were requested to signify their intention to speak by returning to the chairman, in advance, a rough outline of the intended remarks. Later they were to submit a summary, in 500 words or less, of their remarks to be included in the published proceedings. The time allowed each speaker was dependent on the number of discussers to be accommodated. In each session the number desiring to talk was greater than the time available and each general reporter was hard pressed to keep discussers within their allotted time.

Seminar Procedure

The procedure used during the seminars was entirely informal. No records were kept of the discussions and no report will be published in the Proceedings of the Congress. Participants signified their intention to talk by raising a hand, although some precautionary arrangements had been made between leaders and certain speakers to insure starting the discussion along the desired line. Seminar leaders tried to anticipate the most interesting areas of discussion and made appropriate remarks to indicate to the assembly the general direction the discussion should take. In these sessions, too, there were more speakers than time available and lively discussions covering new ideas and developments were the general rule. In the seminar, "Sediment Transport in Pipes," however, the seminar closed early because of a dearth of contributors. Apparently, the participants in the

*The IAHR was first established in Brussels in 1935. The first meeting was held in Berlin in 1937 and the second, to be held in Liège in 1939, was postponed on account of the war. This meeting was finally held in Stockholm in 1948. Subsequent meetings and dates were Bombay, India, 1951; Minneapolis, USA, 1953; Hague, Netherlands, 1955; Lisbon, Portugal, 1957; Montréal, Canada, 1959; Dubrovnik, Yugoslavia, 1961; and London, England, 1963. Previous participation in IAHR meetings by Bureau personnel are given in Appendix V. The organization has continued to grow in every respect since its inception. In 1961, at Dubrovnik, there were 259 delegates from 33 countries; in 1963 in London there were over 400 delegates from 40 countries. The organization has 1,158 individual members and 203 corporate memberships, as of July 1, 1963.
FIGURE 1. Entrance to Institution of Civil Engineers building, Great George Street, Westminster, London. The facilities here are ideal for a large convention, such as the IAHR, September 1-5, 1963 for an attendance of over 500.
well-attended seminar had come to listen rather than talk. A post-mortem discussion of the situation led to the conclusion that research on this subject has been limited to private engineering groups who have services to sell, and either these people were not present at the seminar, or were not about to give away their trade secrets. The British magazine, The Engineer, September 20, 1963, had this to say on the subject:

"There must have been, however, a number of people present at the seminar who were competent to make useful contributions to the discussion, but for reasons best known to themselves, did not wish to reveal information gained from their experience and researches.

"The seminar of 'Stable channels in alluvium' was well attended and, in the early stages, a good foundation for subsequent debate was laid, but later on it tended to subside into a series of lectures and reviews, which stifled discussion.

"'Laboratory techniques' was the most successful of the three seminars, although a lot of time was spent in dealing with the negative results obtained from using hot-wire anemometers in water. Increasing attention is being given to the thermodynamic method of measuring the efficiency of hydraulic machines and this topic provoked the most interest."

**Technical Displays**

Adjacent to the registration and lounge rooms was a large room filled with structural models, working hydraulic models, hydraulic devices, historical items, and other displays of general interest to hydraulic engineers. Working models were attended and could be seen in operation from 9:30 a.m. to 6:00 p.m. each day. A description of these displays is given in Appendix II. Figures 2 through 11 are photographs of some of the more meaningful displays.

**Technical Papers**

Papers reviewed and discussed in the general sessions had been submitted to IAHR headquarters prior to March 15, 1963, and had been preprinted and sent to members at the time of their preregistration. This allowed early registrants to read papers before arrival at the Congress and to prepare discussions or questions well in advance of the meeting. Since I registered on September 1, 1963, at the Congress, I received my papers at this time and could not read them sufficiently to participate in the discussions. I brought these papers back to Denver with me and they are available on loan through the Technical Library, Denver Federal Center.

I received a total of 119 papers*, covering the 4 general subjects of the Congress as follows:

1. Recent Research in Coastal Hydraulics -- 43 papers.
2. Correlation of Flood Prediction and Dam Design -- 22 papers.
3. Hydro-elastic Vibrations -- 26 papers.

Even though papers were restricted to eight (legal size) pages, the bulk of this material is so great it could not be reproduced for inclusion in this report. However, the first page of each paper, giving the title, author, paper number, and the "Summary" has been reproduced in Appendix III.

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*The IAHR is engaged in and is reporting the best hydraulic research being done in the world. The quantity is tremendous, and with only a few exceptions, the quality is high.
FIGURE 2. Architectural and working model of the powerplant at Kariba Dam, Africa. This is a remarkably well made model showing a tremendous amount of detail. (IAHR display by Boving and Company, Ltd., London.)
FIGURE 3. Working model to show how discharges are measured in pipes and conduits. Chemical, dye, and/or salt can be injected into the transparent 3/4-inch-diameter plastic tube flowing full of water, to demonstrate the chemical dilution method, salt injection method, and pulse and continuous sampling methods of measuring discharge. (IAHR display by National Engineering Laboratories, East Kilbride, Scotland.)
FIGURE 5. Working model of a 142,000-horsepower Francis reversible pump/turbine and generator for the Cruachan Power Station, Scotland. Even the butterfly valve and the human operators were done in marvelous detail. (IAHR display by English Electric Company, Ltd., London.)
FIGURE 6. Variable-pitch axial-flow pump model fitted with reinforced plastic blades. (IAHR display by Sigmund Pulsometers Pumps, Ltd., Gateshead, England.)
FIGURE 7. Working model of a siphon drawoff tower used to determine the suitability of the device for use at Tryweryn Reservoir, Wales. Five siphons placed vertically in a common tower allow water to be drawn from the reservoir at any elevation. (IAHR display by British Hydromechanics Research Association, Harlow, Essex, England.)
FIGURE 8. Models of rotary and straight-flow valves used in hydroelectric power stations as turbine inlet valves for high-head applications. (IAHR display by English Electric Company, Ltd., London.)
FIGURE 9. A working demonstration of various characteristics associated with the operation of pipelines, particularly those concerning pipe elasticity. Surges in the flow system caused the pipe to expand and shift the position of a beam of light reflected from the pipe surface to the screen behind and above the model. The relative positions of the three light beams indicated the degree of pipe expansion, the speed of travel of the surge, etc. (IAHR display by British Hydromechanics Research Association, Harlow, Essex, England.)
FIGURE 10. A working demonstration of the measurement of fluctuating velocities in a centrifugal pump using hot-wire anemometers. (IAHR display by British Hydromechanics Research Association, Harlow, Essex.)
FIGURE 11. Flow visualization test rig for valve components. Water entraining small air bubbles as tracers is pumped through a two-dimensional transparent model. Behavior in valve at partial openings, for example, is easily seen. (IAHR display by Glenfield and Kennedy, Ltd., Kilmarnock, Scotland.)
Special Events

The Congress was well organized and each technical session was conducted as smoothly as though it had been rehearsed. Extra events, both social and technical, were well chosen and contributed to the success of the entire Congress. Appendix IV contains reproductions of the Congress Time Table and the Ladies Programme, listing the events during the 5-day meeting.

Opening Address

The Congress was officially opened on Monday, September 2, 1963, at 9:30 a.m. by Mr. Denzil Freeth, Parliamentary Secretary for Science, who represented the British Government and was deputizing for Lord Hailsham, President of the Congress. In his address he welcomed the Congress to London and to England, and emphasized the need for world cooperation in the field of scientific endeavor.

Mr. Freeth said, "One of the perennial problems which must face the Government and people and scientists, is the extent to which a nation should divide the resources it puts by for research and development between basic research on the one hand and the application and development of the results of the research already done." He thought, however, that there was no single branch of science where basic and applied research marches so harmoniously together as they do in the field of hydraulics.

He spoke of the problems of water conservation and flood control, and of the enormous economic benefit which the study of hydraulics could bring to a nation. "Only recently a model study was carried out at the Hydraulics Research Station at Wallingford, England, of various designs for embankments and viaducts needed to carry a proposed road across a plain that was liable to flooding. I am sure that everybody can appreciate that arches in an embankment which will permit flood water to pass are expensive to construct, particularly for wide modern motor roads, and it is, therefore, necessary both to minimize their number and to place them where they may be most effective. The result of the model study was that there was a savings of about £800,000 ($2,200,000) in the cost of the proposed viaduct. Thus from basic research to the actual engineer we have in hydraulics an almost continuous process leading to immense economic and human advantages."

Reception

On Monday evening, September 2, a reception was given to Congress participants at Lancaster House by Her Majesty's Government, represented by Mr. Denzil Freeth. The reception which followed was in most respects similar to our cocktail parties and provided an opportunity for the Congress delegates, wives, and others to become acquainted.

Theatre

On Tuesday evening, September 3, the Congress attended the ballet, "Peer Gynt," at the Royal Festival Hall. Random seating of the delegates in groups of 4 to 10 provided another opportunity to meet more of the Congress delegates and to become better acquainted with the many representatives from other countries.

Noon Lectures

On Tuesday and Wednesday, September 3 and 4, following the morning sessions, technical talks were given to the entire assembly between noon and 1:00 p.m. (lunch was between 1:00 and 2:00 p.m.).

Tuesday Noon Lecture.--In the lecture on Tuesday, Dr. Charles Jaeger of the Imperial College of Science in London and also of the English Electric Company, gave a lecture, "Vibrations and Resonance in Large Hydro-Power Systems." Dr. Jaeger pointed out that vibrations may be either self-excited or forced. In some cases boundary flow conditions, unknown or unwanted, may be the cause of the vibration. Modern research in fluid mechanics and hydraulics has shown precisely where trouble will be encountered and generally where difficult areas are liable to occur. Causes of vibration may be reduced, or negative pressures, incipient cavitation, turbulent flow, pressure waves, or vorticity can be predicted. Sometimes a combination of these can lead to structural failure and resulting disaster.
Mr. Jaeger described one of the first investigations made of a failure known to be caused by vibration—a roller gate which failed and was investigated in 1912. He also showed slide photographs and diagrams of failures in several European clamps. One was occasioned by the collapse of a steel liner plate in a 20-foot-diameter tunnel, caused by open channel flow from a Y-branch entering the main tunnel and striking the far wall to produce spiral flow which passed over the crown of the tunnel. Resulting vibrations caused the liner plate failure. A hydraulic model was tested after the prototype failure and showed the same tendencies exhibited by the prototype. It was then proved that failure occurred because of excessive tensile stress in the steel liner. Failure began and was primarily located at the crown of the tunnel in an area just downstream from the Y.

This liner plate failure was of particular interest to me because we have, in the Bureau, been faced with the decision on several occasions as to whether flow should be allowed to spiral over the crown of a tunnel. In all cases it was decided, as a result of hydraulic model tests, to modify the design to prevent flow from spiraling in this manner. It appears that our caution and our decisions were proper, since our research might never have extended into the field of vibration.

Mr. Jaeger showed slides of other ruptures—these in penstocks—caused by vibration, water hammer, and by a pressure wave which passed through a surge tank. Mr. Jaeger pointed out that more data are needed to pinpoint the exact cause and effect of vibration phenomena. He felt that perhaps a better understanding could be reached if more cases of failure were thoroughly investigated to obtain the true facts, and were then reported, even though the investigators did not fully understand the reasons for the failure. He also felt that future failures could be eliminated by proper research, and that modern electronic devices could be used to obtain facts and data. He concluded his remarks by stating that research in this field could be accelerated and valuable results obtained if research efforts and vibration studies were to be made on a coordinated world-wide basis.

Wednesday Noon Lecture.—The noon lecture on Wednesday, September 4, was by Sir Geoffrey Taylor on, "Waves in Thin Sheets of Water." Sir Geoffrey, a world-renowned scientist, is on the staff at Trinity College and has written books on aeronautics, naval architecture, hydraulics, fluid mechanics, and many scientific phenomena. Sir Geoffrey opened his lecture by saying he had no idea as to the possible uses for his investigation. He said he was not prompted by need or uses but only by the fact that he was curious about a certain effect he had observed, and that he had decided to investigate the phenomenon as far as he could. He described how Joseph Boussinesq in 1869 had accomplished certain successful studies of capillary effects on nappes and had written about the breaking up of thin sheets of water into drops. He found that waves on a thin flowing sheet or nappe were standing waves and that they were controlled by surface tension and gravity.

Sir Geoffrey then explained how he deduced mathematically the wave forms for symmetric and antisymmetric waves in thin sheets of water. He then described how he produced a thin sheet of flowing water 0.005 inch thick having two free surfaces and with a very low Reynolds number. He described how he produced standing waves on the sheet by barely touching the flow with a point gage. He photographed the waves, using light reflected from point sources on the nappe produced by lens systems, and thereby studied the motion of the water within the nappe.

The logical methods he used to attack the problem and the clever adaption of ordinary tools and equipment to investigate a delicate phenomena were of particular interest to me. His talk was a reminder to me of a fact I have often emphasized to our own Bureau rotation engineers, to foreign trainees and others: Research primarily consists of people and ideas. Fancy buildings and elaborate equipment have their place in the overall program, and we do better work when we have them, but we cannot develop a research organization with these alone. We must have people who have imagination, curiosity, perseverance, and a knack for improvisation. Without a good staff little can be accomplished with even the best facilities.
Closing Banquet

On Thursday evening the closing banquet was held in the famous Savoy Hotel, in the Strand, adjacent to and overlooking St. James Park and the Thames River. The guest of honor was Mr. H. J. P. Harding, B.Sc. Engineer, M.I.C.E., President-elect of the Institution of Civil Engineers. The dinner was served in formal courses and was interspersed with many toasts, announced by an official toastmaster with a booming musical voice, to the heads of Government, the Civil Engineers, and to the continuing success of the IAHR.

Ladies Program

Since Mrs. Peterka accompanied me throughout my trip, I was particularly interested in and concerned with the activities of the ladies during the IAHR meeting. Worthwhile and entertaining programs had been planned for them and from 40 to 60 ladies made the organized sightseeing trips together each day. The complete ladies' program is shown in Appendix IV. I found that the associations between wives were of help to me in that my wife introduced me to many new couples and I made many new contacts that I might otherwise not have made. I was therefore able to make the Bureau of Reclamation name more familiar to a greater number of people throughout the world.

Post-Congress Special Tours

A group of special study tours were planned for delegates and their wives. Since much of each tour was concerned with inspection of facilities which were not of primary professional interest to me, I did not take a preplanned tour. Both before and after the Congress, my wife and I visited various hydraulic laboratories located in Scotland, England, and France. These were of great interest and value to me and the Bureau and my impressions are contained in another part of this report.

Business Meeting, Future Meeting and Program

Following the close of the General Session and Seminar on Thursday, September 5, 1963, a business meeting was held in the Great Hall, attended by several hundred of the delegates. Dr. A. T. Ippen, President, conducted this meeting and called on various council members to report on the progress and status of various items of business. These items will not be discussed here but certain items which may be of interest to readers of this report are given below.

1962-1963 IAHR Officers and Council. --The officers and council for the year of the London meeting:

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<tr>
<td>President</td>
<td>A. T. Ippen</td>
<td>U.S.A.</td>
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<tr>
<td>Vice-President</td>
<td>D. U. Jogilkar</td>
<td>India</td>
</tr>
<tr>
<td>Vice-President</td>
<td>F. H. Allen</td>
<td>U.K.</td>
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<tr>
<td>Vice-President</td>
<td>L. Escande</td>
<td>France</td>
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<td>Secretary</td>
<td>H. J. Schoemaker</td>
<td>Netherlands</td>
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<td>Council Member</td>
<td>R. Boucher</td>
<td>Canada</td>
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<td>P. Canisius</td>
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<td>O. J. Maggiolo-Campus</td>
<td>Uruguay</td>
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<td>P. Danel</td>
<td>France</td>
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<tr>
<td>Co-opted Member</td>
<td>J. Th. Thijsse</td>
<td>Netherlands</td>
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The officers and council elected for the 1964-1965 term are as follows:

- President: L. Escande, France
- Vice-President: F. H. Allen, U.K.
- Vice-President: B. U. Proskouriakov, USSR
- Vice-President: M. Homma, Japan
- Secretary: H. J. Schoemaker, Netherlands
- Council Member: A. Schlag, Belgium
- Council Member: A. Grzywinski, Austria
- Council Member: Leclere, Canada
- Council Member: C. Gole, India
- Council Member: M. Viparelli, Italy
- Council Member: J. Daily, U.S.A.

President Ippen announced that the next meeting of the IAHR, the 11th Congress, will be in 1965 in Leningrad, Russia, then called on Mr. Michail Skladnev, Master of Technical Sciences, Director, All-Union Scientific Research, Institute of Hydrotechnics, and leader of the Russian delegation, who came to the podium and, after complimenting the British for their successful IAHR meeting in London, invited the Congress to Leningrad. He promised that the success of the Leningrad meeting would be even greater than the London meeting and he acknowledged that the London meeting was one of the best to date.

Mr. Skladnev's talk was delivered in understandable English, a tremendous undertaking since Mr. Skladnev does not speak English. He read his speech from a script which appeared to be phonetic Russian arranged to sound like English when read with proper accents.

Dr. Ippen announced the technical topics for the next Congress but said they were subject to approval by the Russian hosts.

The four Topics or Questions:
1. High-velocity flow in open channels.
2. Outfall problems involving density differences.
3. Unsteady flow in open channels.
4. Hydro-elasticity.

The five Seminar topics:
1. Low temperature effects in rivers and reservoirs and ice problems in reservoirs.
2. Sediment transport with special reference to scale effects.
5. Hydraulic machinery.

Dr. Ippen then called on the newly elected President, L. Escande, of France. Mr. Escande said he was happy to be president of a growing organization and one that was in sound condition, both financial and otherwise. He said that as of July 1, 1963, the organization had 1,158 individual members and 203 corporate memberships, an overall increase of 8.6 percent since the last meeting, and predicted that the organization would continue to grow. He felt that the "over 500" people present for this IAHR meeting, the 120 papers reviewed or discussed during the technical sessions, and the tremendous response to the seminars forecast an even better outlook for the future.
Dr. Ippen then called attention to the new publication of the IAHR, *Journal of Hydraulic Research*, which will be sent free of charge to IAHR members. Volume 1, No. 1, 1963, the first issue, was presented to registered members at the London meeting. Dr. Ippen invited engineers to write papers for publication in the new magazine and for advertisers to buy space. Mr. Harold Schoemaker will handle all correspondence and the editorial work for the magazine.
GENERAL SESSIONS AND SEMINARS OF IAHR

General Session, Recent Research in Coastal Hydraulics, Monday, September 2, 1963, 10:00 to 11:30 a.m., M. J. Valembois (France) Reporter

During this period M. Valembois summarized the areas of importance in Papers 1.6, 1.10, 1.23, 1.25, 1.29, 1.36, 1.38, and 1.39. (See Appendix III for abstracts of papers.)

These papers had to do with similarity between models and prototypes and the fact that fluid friction and gravity forces cannot both be made to agree. In other words, the Froude and Reynolds numbers cannot both be reproduced in the model so that complete similarity exists. This is because water is used in both model and prototype, gravity forces are the same in model and prototype, and the other factors included in the tests cannot be modified sufficiently to compensate for gravity and fluid being the same. Considerable discussion ensued regarding the similarity of beaches found for models of prototypes. In was agreed that prototype beaches always have larger ripples than model beaches but that allowances can be made for this effect. Various types of sands used in models were discussed in terms of their characteristics for sorting and/or packing.

General Session, Recent Research in Coastal Hydraulics, Monday, September 2, 1963, 11:30 a.m. to 1:00 p.m., Mr. R.C.H. Russell, Reporter

Mr. Russell discussed Papers 1.3, 1.17, 1.18, 1.19, 1.20, 1.31, 1.32, 1.37, 1.43, making specific references to each paper. For example, in Paper 1.43 he asked whether the certain wave effects described could be reproduced in the laboratory.

In Paper 1.19 he asked how long it would take to achieve the stable profile described. He commented that the paper introduces ideas not previously known. He felt that this material would be particularly useful in canal wave analysis. He remarked that the threshold or incipient scour velocity given on page 142 of Paper 1.19 cannot be scaled up from a model and commented on the discussion of the energy required to break up a large rock into small pieces, page 144.

In Paper 1.17 he agreed with the concepts given by the author but indicated that the equation on page 2 has "P" missing.

In Paper 1.18 he felt that the author should interpret Figure 3 or give a better explanation of what he has presented. Figure 4, on the other hand, was very significant and will be very useful in predicting beach profiles.

In Paper 1.32 he invited the author to discuss how the bank lines in Figure 6 go from dashed line to solid in a period of time or why the intermediate stage is more severe than the original or fluid stage.

Since most of these questions went unanswered, I assumed that the authors will revise their papers before final printing in the Proceedings.

One of the most important facts which came out of the discussions is that there is a rise in water level on a beach caused by the fact that waves are there, not by the fact that there is pressure by the wind on the water with a resultant piling up of the water, but because there is a volume of water in the waves. There have been attempts made to calculate this effect but not enough data are available to be sure that the calculations are correct.
Another item of interest which came out in the discussion was the description of a material for use in sediment or beach erosion tests. This material is a type of pumice, called "Bims Material," found in Iceland, and used as insulation material in the U.S.A. The desirable characteristics of this material are that it can be obtained in any size particles and the density of the particle can be changed by heat treating. The heat seals the pores and by varying the heat treatment the density can be varied. Professor P. M. Brun, 912 NW, 36 Road, Gainesville, Florida, can be contacted if further details on this material are desired.

I drew the following conclusions from my attendance at this session. Although Coastal Hydraulics is not a part of Bureau of Reclamation work, the general procedures and problems yet to be solved are very similar to our work in Sediment Investigations and Wave Studies. In the Bureau, we can learn a great deal by following Coastal Hydraulics research, because problems of similarity between model and prototype, selection of material for model test, determination and use of parameters, and many other details are similar. Reading the papers discussed in this section will be of value to every hydraulic engineer engaged in research.

Seminar, Sediment Transport in Pipes, Monday, September 2, 1963, 2:00 p.m. to 5:00 p.m.

The need for knowledge pertaining to the transport of solids or semisolids in pipelines is changing as a result of changing economic conditions. For example, transport of solids alone is growing in certain areas of the world and slowing down in others. Coal transport in pipelines has already been abandoned in some cases because competitive freight rates, forced down by the pipeline competition, have caused a return to hauling coal in freight cars. In other areas where freight rates are still high, pipelines are being built or are being contemplated.

Dr. Kolar, Prague, reported that there is a growing use of pipelines in Czechoslovakia to transport coal, stone, aggregate material, dredging material, waste products, and many other materials. The interest in this method is brought about solely by the high cost of moving the material on wheels. He said that Czechoslovakia was doing research in this field and was particularly concerned with non-Newtonian fluids (toothpaste, for example). Many products are semifluid or semisolid and more needs to be known about the requirements of pipelines to move these products.

Discussion from the floor indicated that, in sediment movement in pipes, as the particle size (diameter) decreases from 0.88 to 0.41 to 0.30 millimeter, the head loss becomes less for various concentrations of water to sand. There was general agreement as to the validity of this concept. It was also the consensus that in future research the shear theory be used to analyze flow conditions and flow characteristics in the pipes. Professor Kolar described tests using plastic pipes 7 to 200 millimeters in diameter as models, with sediment concentrations of about 1 gram per cubic centimeter. He felt that if he could obtain velocity profile measurements (similar to those we have been measuring in our canal capacity research program using the air facility in the laboratory), he could provide better answers on sediment transport. He made a plea for better instrumentation, indicating that the known devices for measuring velocity, impact, or pressure were inadequate.

The use of computers in analyzing large masses of sediment transport data was discussed and it was universally felt that more data can now be handled in a short time and that better measuring equipment electronically tied to computers would provide better answers to the many pipe transport problems.

In conclusion, Professor Kolar indicated that he has obtained enough data to be encouraged to develop flow resistance equations for a variety of substances in a wide range of concentrations.
Dr. L. Straub, U.S.A., described how iron ore is moved through pipes in Minnesota. The ore, finer than No. 200 mesh, is a concentrate having a specific gravity of 3.5. Pipes 18 inches in diameter provide cheaper transportation than rail methods. The ore moves at 5 to 6 feet per second. Dr. Straub posed the question, "What would happen in a shutdown, would the material clog the pipe?"

A Mr. Berton—I believe from France, but he was not in list of participants—described tests where he had added sediment to flowing water to deliberately reduce the frictional resistance to flow in the pipe. He described how he added fine sand to the flow and then removed it later. Pumping costs were thereby reduced. This was done on an experimental basis only.

Mr. C. Izzard, U.S.A., referred to some work done at his request by the Iowa Institute of Research about 10 years ago, published as Bulletin No. 5, "The Design of Storm Drain Systems for Transporting Sediment." Mr. Izzard thought that there might be information of value in this bulletin which was being overlooked by present day investigators. He suggested that research people reread this bulletin before continuing their work.

Mr. R. K. Turton, England, described some tests he had made on coal slurries to determine friction losses. He said his data agreed with published data for 18 percent concentrations but disagreed at 30 percent. He said he was continuing his investigations.

Mr. A. J. Peterka, author of this report, discussed the movement of sediment in canals as it has been observed and reported in studies made during the Bureau of Reclamation's canal capacity research. Our research, which included measuring vertical velocity traverses both in a laboratory air-test facility using minute pitot tubes and in 20-foot-deep canals in the field using multiple current meters, was described. Our methods of gathering and recording data and the use of automatic data processing methods and computer calculations to speed up the conversion of data to usable facts were outlined. Although we are not engaged in doing research in sediment transport in pipes, some of our ideas and methods might be used in this research.

These remarks were well received and were discussed in terms of sediment transport problems. Following this discussion, however, the participation became less enthusiastic because, as indicated above, very little had been said that was directly applicable to the seminar subject. It seemed that many of the people in the audience had come to listen, rather than to talk. Either they had nothing to contribute or were associated with profit-making organizations such as dredging companies, or dust recovering and conveying companies, who were willing to learn about the subject but did not want to give away any of their trade secrets. The meeting was therefore adjourned some 30 minutes before the scheduled closure.

General Session, Modern Developments in Hydraulic Machinery and Equipment, Tuesday, September 3, 1963, 9:00 a.m. to 10:30 a.m., Professor S. P. Hutton, Great Britain, Reporting

Although most of the papers in this session, 4.6, 4.9, 4.14, 4.15, 4.16, 4.18, 4.19, and 4.23, had to do with large gates and valves. Papers 4.14, 4.18, and 4.19 covered sediment exclusion or removal devices. The reason for the grouping was never mentioned. The discussions centered around big gates, primarily, and followed a vein which would be of interest to our mechanical engineers in the Mechanical and Hydraulic Machinery Branches.

Flood control gates 100 feet long and 40 feet high were discussed and the difficulties in designing radial gates of this size were enumerated. These included the effect of water surface waves which strike only the top of the gate or a band near the water surface even though the band might be near the bottom of the gate. Differential forces at the top and bottom of the gate were also discussed in terms of thin shell structures. It was emphasized that thin shells handle shear forces very well.
The necessity for compromises in gate design was recognized. The requirements for hydraulic, structural, and mechanical needs were often conflicting and could not all be met. Compromise designs were therefore necessary.

It was brought out that gates also need to be designed for both dynamic and transient features. This is an innovation and is characteristic of modern design methods. It is felt that gate designs are becoming more realistic with respect to true forces and actual use conditions. This is true because instrumentation makes it possible to measure forces, twists, eccentricities, etc., to which gates are often subjected. Sometimes the dynamic and transient forces have more effect on the design details than do the static forces.

Human errors in gate designs were discussed and it was the consensus that these are as prevalent as mechanical errors. Efforts should be made to eliminate these and to work toward the simplest designs and operating procedures because they are always the cheapest.

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The second morning session, 10:30 a.m. to 12:00 noon, on this subject was quite different from the first session. In handling the session M. M. Hug, France, went into more detail. Papers 4.2, 4.3, 4.20, 4.24, 4.26, and 4.28 were included in the agenda, and all had reference to turbines, pumps, draft tubes, and associated equipment. Most of the material discussed in this session would be of concern to Bureau engineers but would not be their prime responsibility. The material would, however, be of primary interest to engineers employed by manufacturers of turbines, pumps, and other hydraulic machinery. The papers were well accepted and understood because the European methods of obtaining satisfactory pumps and turbines are more direct than ours and the papers were of primary interest to the European design engineers. For example, Paper 4.3 has to do with vibration in pumps. In the Bureau we would specify that the pump not vibrate and leave the pump design to the manufacturer. We would not furnish the design details unless we were asked. In Europe the buyer might even specify runner shape or draft tube design. In some cases a manufacturer's proposed design is model tested in a laboratory specified by a buyer, sometimes his own, and therefore a greater percentage of engineers would be interested in the most minute details of the design.

In Paper 4.2 which compares air and water tests on a centrifugal pump, M. Hug pointed out that the author did not correlate his findings with those of others. This should have been done since air tests are not new and have been used extensively in the past.

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The discussions seemed to lean toward the idea that air testing of turbines and pumps was the coming thing. Equipment for providing the airflow is inexpensive; no reservoir for fluid storage is needed, and the dynamometer can be greatly reduced in size, complexity, and cost. The latter item, dynamometer size and cost, it was agreed, had prevented many researchers from doing work with water. In air testing, dynamometer size is not important in terms of cost.

Several comments were made regarding Paper 4.28. The equations in this paper were found to be very difficult and the author made no suggestions as to how to solve them.

Mr. A. Nijiri, the author, tried to answer this criticism but did not speak English. He relayed his remarks in Hungarian to another man who translated them into English at the microphone. It was not clear to me, however, what answer he gave.

Seminar, Stable Channels in Alluvium, Tuesday, September 3, 1963, 2:00 p.m. to 5:00 p.m., Mr. Fergus Allen, Presiding

Mr. Allen asked Mr. Peter Ackers (on the staff headed by Mr. Allen at the Wallingford Hydraulic Laboratory, 45 miles from London) to orient the discussion by giving some initial material on which further discussion could be based. Mr. Ackers described some of the test facilities at Wallingford and stated that they were actively engaged in studying stable channels in alluvium. He described work done by Lindley in 1919 in which it was observed that in nature the width, depth, slope, and sediment load were in balance and that the balance was maintained throughout changes in discharge. Ackers indicated that at Wallingford they have found parameters to describe these variables and have plotted them, for three model channels at Wallingford, on a sheet containing data presented by Simons and Albertson (Fort Collins, Colorado). The data sheet was projected on the screen and it was apparent that the Wallingford data were in agreement with the Simons and Albertson data and provided an extension to the curve at the lower end.

Ackers then showed slides of some meander channels being tested at Wallingford. The channels had a 30-foot meander pitch. At the start of the test the channels were straight. After several days of testing the final curves and reversals became apparent, all at the same time, and each meander was identical with each other one. Meanders became more pronounced as the test progressed. Channel bed material was homogeneous, the flow was varied, not steady, and sediment was added to the inflow. Ackers indicated that they intended to continue their research to expand their knowledge regarding the meandering of channels.

One of the Russian engineers described sediment tests being made in Russia. Their approach to the problem is from the mathematics and physics angle. They are determining stresses and forces between individual particles and the adjacent turbulent flow in an attempt to rationalize the movement of the particles. They have written four equations to express the movement of a particle in three dimensions. They hope to conduct experiments, using sonic equipment, to learn how to write four more equations and then solve simultaneously for eight unknowns. In their experiments to date they have found that the pulsating element in turbulent flow contains 15 to 20 percent of the total energy in the flow. They have derived a "simple" equation to describe the conditions of a particle in turbulent flow. The Russian engineer started to present (by derivation) the equation by writing on a projection device supplied for the purpose. His writing was almost illegible (to me) and he took considerable time to present his material. Mr. Allen politely requested that he complete his presentation quickly, which he did without finishing his equation.

Two other Russian engineers spoke, Dr. Ananjan and Dr. Levy. Both spoke confidently, indicating that they could calculate the quantity of sediment carried in any given time. They indicated that their calculations had been checked using models to prove the ultimate values. Dr. Levy said he had done his checking on a 600-cubic-meter-per-second canal having a 20-meter bottom width and had been working on this problem since 1947.
At this point several questions were posed by Mr. Allen and an unidentified questioner:

1. Channel banks are not the same in model and prototype channels. How are compensating factors introduced?

2. Are meanders the same in model and prototype?

3. Should the ratio of suspended load to bedload be the same in model and prototype?

4. Do temperature differences in model and prototype affect the results of tests?

Comments from the floor indicated that the laboratory in Poona, India, working with channels of 1- to 3-cubic-feet-per-second capacity have been unable to reproduce meanders unless the model channel is steeper than the prototype. A small width-to-depth ratio gives a large number of meanders per unit of river length in fine material. Conversely, a large width-to-depth ratio gives few meanders per unit of river length in coarse material. Model investigations to determine the effect of a meandering channel downstream from a power dam showed that the use of coarse material, which did not produce ripple, in the model, simplified the process of getting data from the model.

Mr. A. J. Peterka stated that the Bureau is using jacks and jetties to prevent meanders where these are in the beginning stages and where the meander tends to cut into roads, railroad embankments, or valuable lands. He described how these jacks reduce the velocity of the sediment-carrying water so that sediment is deposited behind the jacks and the shoreline is thereby built up. He indicated how hydraulic models had been used to obtain data for the design of jetty fields and to predict the performance of the prototype jetty fields. He went on to contrast the efforts of the European engineers with those of the Bureau and indicate that at the same time the Bureau is trying to understand the action of meandering channels, it is doing something about them, too.*

Mr. C. D. Gole, India, a former Bureau trainee who spent 4 months in the Denver Hydraulic Laboratory in 1950, and who is now Director, Central Water and Power Research station at Poona, followed with a complimentary statement regarding Bureau research and design work. Mr. Gole went on to say that they have done extensive work in the stable channel field. He said they found that the slope and width of a canal changes with the sediment load in the canal. He briefly discussed some other factors but said he would not go into detail because of the time it would take to make his point. He said this would all be covered in a 500-page book about to be printed, giving their findings regarding the design of stable channels.

The meeting closed on this note and I contacted Mr. Gole to learn more about his book. He said he would send a copy to our laboratory as soon as it was available, he thought within about 6 months.

General Session, Correlation of Flood Prediction and Dam Design, Wednesday, September 4, 1963, 2:00 p.m. to 5:00 p.m., Professor L. J. Tison, Belgium, and Professor V. M. Yevjevich, U.S.A., Presiding

In this two-part session Papers 2.1, 2.3, 2.5, 2.8, 2.12, and 2.17 were discussed with Professor Tison presiding; and Papers 2.2, 2.4, 2.9, 2.16, 2.19, and 2.20 with Professor Yevjevich presiding, although both were at the podium at all times.

Professor Yevjevich's paper, 2.8, was well received and was the subject of a good bit of discussion. The idea that flood probability distributions with time, due to man-made changes in river basins, should be allowed for in estimating the probability of rare floods was thoroughly discussed, and most were in agreement with the ideas presented in the paper.

*Our approach in the Bureau to these problems is somewhat different than those reported by others during the meeting; I felt that I was being looked at askance by some of the delegates and with approving glances by others. Following the meeting, I was approached by several engineers who questioned me further regarding my remarks and commented that the Bureau always has a practical outlook, even when engaged in research. I felt rewarded for my efforts, since this was the impression I had tried to convey when I made my remarks.
In Paper 2.17 by Walenty Jarocki of Poland, the discussion centered around whether the graphic methods given in the paper were sufficient to determine the quantity of flow entering the reservoir. Some discussers thought the methods were good, others felt that they were not sufficient.

In Paper 2.5 by A. H. Blyskowski, Poland, "Spillway Design Flood Prediction," the discussion was favorable and the discussers seemed to accept the ideas presented, but the accent was on minor points of the paper rather than on the general aspects.

The succeeding discussions were along the same lines—emphasis was on details in the papers rather than on the overall concept. However, certain points were discussed which seemed to be of more overall importance.

One of these was, "Should spillways be designed to pass the maximum flood without mechanical devices or is it prudent to rely on mechanically operated gates?" Feelings were mixed and seemed to be determined by the size of the spillways each discusser had been associated with. If he had had experience with large gates he felt that gates were dependable and would be acceptable for use in any situation. Some of the other discussers felt that free crests or siphons should be used to insure passage of flash floods.

Another item of interest was the argument as to whether rain cycles repeat every so many years. One discusser showed how 13-year minimums and maximums were identical. He was loudly differed with and the opposition pointed out that he was selecting a few cycles out of thousands available and claiming that the selected ones were representative. Other discussers stated that records show a greater number of rainy and cloudy days in recent years, and that the weather in Europe and in general is wetter than it used to be. This was not acceptable to many and some lively arguments developed.

Seminar, Laboratory Techniques (New Instrumentation in Hydraulic Laboratories), Thursday, September 5, 1963, 9:00 a.m. to 12:00 noon, Dr. E. A. Spencer, Scotland, Presiding

This was one of the most interesting and informative sessions of the conference. More time could have been devoted to this subject since many delegates did not get a chance to speak and I know that some worthwhile subjects were not reported. On the other hand, some subjects were discussed which were not of prime importance to progressive laboratories. I took the floor and reviewed some of the Bureau laboratory equipment and methods and indicated to the assembly that the Bureau is a progressive organization that is aware of the latest developments in instrumentation.

Mr. H. R. A. Dedow, of the laboratory at Wallingford, England, opened the session and described a new type of water-wave-producing machine which is portable, adjustable, can be constructed in small units and assembled to produce an overall unit of any length, is dependable, and is cheap to construct, maintain, and operate. On my inspection trip to Wallingford the next day, I saw this machine in operation and agree that it is a great improvement over previous devices. A photograph of the mechanical portion of the device is shown in Figure 12.

The wave machine consists of a series of eccentric discs mounted on a horizontal shaft. In operation, the shaft is rotated and the eccentric discs cause the plungers to move forward then backward in chambers which have one end open to the area where waves are to be produced to force water out of or draw water into the chambers, thus creating a wave. About eight discs, each about 4 inches in diameter and mounted on a 1-inch-diameter shaft comprise a unit. Several units, each about 6 feet long, can be connected together to make a large wave generator. Lengths of over 50 feet have been used at Wallingford.

Each eccentric disc may be fixed on the shaft so that the maximum displacement along the line of discs varies gradually from one end of the generator to the other. Thus, waves may be created having wave fronts at an angle to the wave machine without moving the machine. Wave heights may be changed by changing the diameter of the plunger and wave periods may be changed by changing the speed of rotation of the shaft.
FIGURE 12. New piston-type wave generator is actuated by eccentric discs mounted on a shaft (shown here). Trouble-free, low-cost, portable, and adjustable, are characteristics of this development of the Wallingford Research Station.
These wave machines are used in harbor, coastline, and estuary models and can be clock- and/or cam-controlled to produce waves in patterns according to actual storm conditions. According to Mr. Dedow, the units have a low first cost and the power consumption is low, keeping operating costs low. They have not had any significant maintenance costs as yet, but do not expect any, either.

Mr. Francis Biesel, Director of Science, SOGREAH, Grenoble, France, discussed the wave machine’s design and indicated it was very satisfactory. Portability alone, he said, justifies its use.

Mr. A. J. Peterka inquired about the design of the discs, that is, what size disc or piston stroke is required to produce a wave of known size. Mr. Dedow said they did not have any method, as yet, to relate wave height to disc or plunger diameter; they were still using cut-and-try methods and experience from previous designs to guide them in their new designs.

This device was the subject of many comments and was of great interest to the IAHR delegates. Most laboratories throughout the world have more wave problems than we have in the Bureau and, consequently, any developments in this field are of primary interest and concern.

Mr. P. Canisius, Jr., Karlsruhe, Germany, described some new electronically controlled velocity meters used to record the movements of ebb tide and flood tide. This device uses micropropellers, manufactured and sold by Dr. Blau of East Berlin, and a recording device which operates as follows: The revolutions of the propellers are counted for 10 seconds, there is a 1-second pause, a camera photographs the counter dials, the counters are reset to zero, and the 10-second counting period is resumed. Facilities are provided to indicate date, run number, station, etc., on the film. The entire system is electronically integrated with the tide generators so that measurements are automatically taken at the most advantageous times. Data are taken day and night with a minimum of effort on the part of the engineers. This allows the time of the engineers to be used in efforts more profitable than routine data-taking and insures maximum accuracy and volume of data.

Mr. J. C. Orkney, Scotland, described experiments and thermal apparatus he has developed to measure, in effect, head losses produced by a valve in a pipeline. A successful application of the principles involved in these tests would be the determination of the efficiency of a turbine by measuring the change in water temperature upstream and downstream from the turbine runners. Conceivably the apparatus could be used as a discharge meter. The apparatus consists of a 6-inch gate valve installed in a 6-inch pipeline which was discharging water being circulated by a pump. Water sampling probes are inserted into the 6-inch line about a foot downstream from the valve. The valve operates partly open to produce turbulence with resulting head loss and an almost imperceptible rise in water temperature downstream from the valve. Water from the upstream sampling probe is conducted through an insulated line to a calorimeter containing an 18-inch-long brass rod. Similarly, the water from the downstream probe is conducted through another identical calorimeter. A comparator device is used to determine the difference in length of the two brass rods. This is done by fastening a horizontal bar to the top of one brass rod (with the long axis of the rod in the vertical position). The bar is adjusted to just touch the top of the other rod when the bar and rods were all at the same temperature. When one rod is warmed in the calorimeter receiving the warmer water, the rod expands and changes length, moving the bar away from the end of the cooler rod. A measurement of the gap between the bar and the cooler rod is a measurement of the expansion of the warmer rod.

In these experiments, a change in length of the 18-inch rod as small as $17.5 \times 10^{-6}$ millimeters can be measured. This corresponds to 1-millidegree change in temperature.

Dr. A. S. Thom, Glasgow, Scotland, described equipment, similar in nature, being used at the University of Glasgow to measure temperature rises produced by the head dissipated by flow passing through an orifice. The orifice was operated under differential heads of 25, 30, 60, 74, 92, 110, and 124 feet of water. Variations in the measured temperatures ranged from 0.0000° to 0.0010° C; the average variation was 0.0005° C. In terms of head, the temperature variations would predict the operating head to within 0.7 foot, on the average.
Professor C. Iamandi, Bucharest, Roumania, speaking on a subject he referred to as "Flow Visualization," described his efforts to show visually and in still photographs, flow patterns, flow problems, and solutions to flow and pattern problems. The purpose of this work is to familiarize students and engineers quickly with hydraulic flow phenomena and flow problems which are often routinely described and seldom illustrated in books. He projected photographs of some of his work; these were remarkably clear illustrations of various flow phenomena which are seldom seen with the clarity portrayed in his photographs. His success went far beyond photography alone; he had set up his equipment faultlessly, had chosen a particular type of metal flake to make visible the flow lines, and had caught the action at a favorable moment under ideal lighting conditions.

The photograph in Figure 13 is one of Professor Iamandi's. The eddy action downstream from a flat plate set on an angle to the approaching flow is clearly illustrated. The details evident in this photograph could conceivably supply information never before considered in the analysis of hydraulic losses.

Professor Iamandi also described equipment he has built to study and demonstrate the effect of the Reynolds number on flow patterns. He told of his successful search for transparent oils to use in his test equipment to extend the range of Reynolds number in his experiments, and of the optical and dynamic measuring devices he has developed to measure laminar flow. He said he had been successful in using the hot-wire anemometer in oil to measure low velocities. To a question of doubt raised by Mr. D. I. H. Barr of Glasgow, Scotland, Professor Iamandi again stated that he had had difficulty with the hot-wire anemometers in oil, but had overcome the problems and was using the anemometers in oil in a routine manner.

Professor Iamandi's talk was quite general and he never once mentioned "how" or "why" on any specific item. He emphasized that he was using the best equipment available to develop the best new equipment necessary to teach "Flow Visualization." He invited the delegates to visit him in his laboratory to see for themselves and then ask questions.

Mr. R. H. J. Sellin, Belfast, Ireland, continued the discussion on the subject of "Flow Visualization" by describing equipment he has developed to permit seeing and photographing surface flow phenomena without using aluminum powder or confetti. For low Reynolds number flows, where $R < 10^3$, he makes use of the Schleirin principle which assumes that the free surface of a fluid is a plane of constant pressure. He described an arrangement of a source light and a camera so that light reflected from the water surface entered the camera to show turbulence or other effects which cause the water surface to tilt or otherwise deviate from a plane surface. Any but a flat surface would show in the photograph as a dark area. At this point, the discussion returned to the use of the hot-wire anemometer in water. Several people had mentioned earlier that their attempts to use the hot wire in water had met with failure.

In an attempt to turn the discussion toward more rewarding items, Mr. A. J. Peterka described attempts made by him, and others, in about 1942 to convert the hot-wire anemometer to water use. At that time, it was generally conceded that the principle of the hot wire could not be adapted for use in water. The delicate wire, air bubbles, oxidation problems, grounding by water, and other problems proved insurmountable. Experience since that time has shown that it is not feasible to adapt the hot-wire-in-air idea to use in water.

Mr. D. M. McDowell, Calcutta, India, said he also had tried and failed. However, he presented an idea which he had worked on and thought could be developed into a water-velocity-measuring device. The device was shaped like a block letter C, 1-1/2 inches tall and 1 inch wide, cut from a flat sheet of metal 1/8 inch thick. The metal was a platinum alloy, "Platinax," and was magnetized after cutting to perform as a permanent magnet. The opening in the C was only 1/8 inch so that the device more closely resembled a letter "O" with a cutout, thus:

![Diagram of the water-velocity-measuring device](attachment:image.png)
FIGURE 13. Photograph is a superb piece of work in making visible the eddy action downstream from a flat plate set on an angle to the flow. (Photograph given to the author by Professor C. Iamandi, Bucharest, Roumania, following his talk on "Flow Visualization" at IAHR meeting in London.)
Three platinum wires, formed as in the sketch, were mounted, flatwise, between the poles forming the gap in the C. The wires and the magnet were wired into a bridge circuit so that the produced voltage would be canceled out, but water flowing through the gap would produce an electromotive force. The device could then be calibrated in a towing tank. In actual use, it could be used to measure two components of velocity at the same time. Velocities as low as 3 inches per second were measured in the low range and considerably higher velocities were measured, without physically changing the meter, in the high range.

One of the difficulties found by Mr. McDowell in working with this device was that the permanent magnet tended to become polarized. When an electromagnet was substituted, he found the instrument became too bulky. Another difficulty was the delicate nature of the platinum wire arrangement in the magnet gap. Mr. McDowell felt that the idea could be perfected, however, and encouraged other laboratories to continue the development of this device.

Mr. D. Rachman, Glasgow, Scotland, described a hot-film anemometer which he thought was composed of a glass bead coated with a platinum film, and was used instead of a hot wire. He wondered if this device had been used sufficiently to get a report on its reliability.

Mr. C. V. Gole, Poona, India, said they had used a hot-wire anemometer in water and found it to be useless. They could not adapt it to use although they were still trying. He said they had used the hot-film device for 3 years and had experienced a great deal of trouble. They were not satisfied with the device at all.

Mr. J. Caldwell, Washington, D.C., said that they had not been able to adapt the hot wire to water, but that he had seen a new type of hot-film velocity meter that looked to him as though it would work. This was a platinum film assembly mounted inside a glass bead. The bead was so small that the assembly of the internal components was done under a high-power magnifier. The device is a Japanese product. Mr. Caldwell said they had one on order and expected to begin to use it as soon as it was delivered.

Professor D. Harleman, Massachusetts, said that the device referred to by Mr. Caldwell was not a hot-film device, but was a "Thermistor" in a glass bead. He said they had been using this device at M.I.T. for some time. Professor Harleman said that Professor Eagleson had done the primary work with this device and knew more about it. Professor Eagleson was not present, however. It was thought that this device was similar to the one described by J. A. Veprek, J. Sci. Instrum., 1963, Vol. 40, No. 2, "Thermistor Flowmeter."

Discussion from the floor centered around the exact size of the glass bead. Reported sizes, it was agreed, ranged from 1.5 millimeters long for the Japanese version to one-fourth and one-half inch for two types manufactured by "Phillips" of the Netherlands. The Phillips device measures velocities as low as 8 inches per second.

Mr. P. Canisius, Jr., Karlsruhe, Germany, said he had used a Phillips device and had difficulty in sealing moisture out of the leads at the glass bead. This had been remedied by using a special grease supplied by Phillips. He felt that the device needed some more work on it to make it practical. The glass cover tends to delay the response of the instrument and acted as an inertia resistance. Also, minute bubbles collect on the bead surface and tend to change the calibration.

Mr. A. P. Larsen, Sweden, described a laboratory device developed to measure the quantity of air delivered to a hydraulic model of an outlet works. It was desired to know the air demand rather accurately, even though the rate of airflow in the model was very small. The device consisted of a plastic bag of 27-gallon capacity which could be connected by a 1-inch-diameter hose to the air demand pipe in the hydraulic model. Two other valved connections were made in the hose; one, an opening to the atmosphere and the other a tee to receive the air blown by a hand-held-type electric hair dryer. The blower was used to inflate the plastic bag while leaving the vent to the atmosphere open.
Then, simultaneously the connection to the blower and the vent to the atmosphere were closed, and timing was started as the plastic bag was exhausted of air as a result of the air demand of the model. Rates of airflow could then be calculated. The capacity of the plastic bag had been determined by filling the bag with water while it was under water.

Mr. J. Caldwell, Washington, D.C., described an in-place sediment density meter operating on the radioisotope principle which has been used by the Beach Erosion Board. The meter operates on the principle that gamma ray emissions will penetrate loosely packed material to a greater degree than they will tightly packed material. Mr. Caldwell described the meter (it is identical to the one in use in our Hydrology Branch) and probe, indicating how the Geiger tubes are contained in the probe along with a preamplifier to send the signal to the boat from which the equipment is operated. He stated that the device had operated satisfactorily on 10,000 to 18,000 counts per minute. He indicated that the instrument was entirely satisfactory.

Mr. A. J. Peterka, Denver, agreed with Mr. Caldwell in principle, but related some of his experiences in using this device. On Guernsey Dam Reservoir, while making the silt run in August to help seal the North Platte Canal system, the radioisotope density probe was used to determine sediment density in the Guernsey Dam Reservoir. In places, this sediment is more than 15 feet deep and at the time of the tests the top of the layer was some 3 to 4 feet below the reservoir water surface. The sediment density probe was an aluminum rod about 1-1/2 inches in diameter and about 12 to 15 feet long. In use, the rod was inserted vertically into the sediment, working from the boat, and held stationary for at least 1 minute while the Geiger counter was accumulating a total count. The probe was then pushed into the sediment another foot or so and the timing cycle repeated. After each 1-minute test, the counter in the boat is read to determine the number of gamma ray emissions passing through the sediment in the given time. To hear it related, the procedure sounds reasonable and easy, but when consideration is given to the facts listed below, it is easily seen that improvements in using the equipment could be made:

1. There was a current through the drawn-down reservoir of several feet per second.
2. There was a crosswind of some 10 miles an hour.
3. The boat anchor was useless against these forces.
4. The only means for holding the boat over a given point was the skill of the boat operator in running his engine and rudder at the proper settings, and the brute force of the probe holders in keeping the probe vertical while leaning over the side of the boat. The readings obtained were accurate as far as is known and the equipment functioned as it should. However, improved methods of inserting, holding, and withdrawing the probe (from 10 feet of sticky sediment) should be devised. Working from a small boat should be avoided unless a positive anchoring device can be devised which will hold the boat motionless over a given point for a period of several minutes.

Mr. H. R. A. Dedow, Wallingford, England, inquired as to where information on this probe could be obtained and asked several other questions. Before Mr. Peterka could reply to all questions time had run out and the meeting was adjourned. Mr. Dedow was told that the other answers, not available as of the moment, would be mailed to him from Denver. This has been done.

As I have said previously, this session was the most informative and rewarding of all the sessions I attended. The "off the record" type of discussion provided me with a true feeling for or against the equipment and methods discussed. If more time had been available, I am sure that more discussion would have taken place. Many raised hands at the close of the meeting indicated that many delegates did not get a chance to take the floor.
On August 27, 1963, I visited the Hydraulic Laboratory of the Imperial College, London, and spent most of the morning and part of the afternoon viewing the facilities in and adjacent to the Hydraulic Laboratory. (See Travel Itinerary in Appendix XII.)

The old laboratory, which was known as Hawksley, had been torn down and a new building constructed on the same site. This new building is the Civil Engineering Building and connected to it is the new Hydraulic Laboratory. The Hydraulic Laboratory is still under construction, Figure 14. The new laboratory will cost some $3,500,000 and will be equipped with $1,500,000 worth of new equipment. In addition, some of the equipment from the old laboratory was salvaged and is being installed in the new building to be used primarily for teaching purposes and for graduate study.

The operations in this laboratory are financed by the Government and by private contracts negotiated by the personnel engaged in the laboratory. The staff is composed of P. O. Wolf, T. O'Donnel, C. M. White, M. J. Kenn, D. Hardwich, N. M. Kahlill, P. Minton, A. Ashley, and J. Brannan, superintendent of the department.

The laboratory is known the world over for the important work done by Professors C. M. White and C. F. Colebrook on friction factors in closed conduits. The laboratory consists primarily of a single open area about 200 feet long and 40 feet wide, but there are other smaller rooms and alcoves which almost double this main area. The laboratory is about three stories high over the main testing area but is only one story high over some of the small isolated areas. The offices are above the single story areas. There are office arrangements for about 35 graduate students who are expected to use the laboratory and facilities for advanced studies.

I was welcomed to the laboratory by Professor Brannan who efficiently arranged for Professors Paul Minton and A. Ashley to take me on a tour of the laboratory, after an introductory discussion over a cup of coffee in their excellent faculty rooms. It was during this informal meeting that I learned about the history of the laboratory and the difficulties in operating a department while the entire building is being torn down and a new one is erected on the same spot. I was also asked numerous questions pertaining to Bureau work.

In the laboratory it was apparent that rehabilitation and completion of the equipment and building was still underway. Workmen and students were busy throughout the area. Of interest was a concrete pit about 20 feet in diameter and 5 feet deep over which was mounted a large wheel having spokes and a single bearing so that the wheel could rotate in a horizontal plane, Figure 15. The purpose of this wheel was to support a hydraulic model which might be 30 feet or more in diameter and rotate the model during testing to determine the Coriolis effect. Rotation of the model was to simulate the rotation of the earth so that all forces in the model would be in the exact ratios in which they occur in nature. It is believed that in hydraulic models, where mixing or tidal effects are critical, the rotation of the model is necessary to establish the true force characteristics. This is true only when the model is of a large area such as 1 mile long or more. In studying tidal problems in estuaries, harbors, and other places where sediment and water mix or where sea water and fresh water mix, the wheel is expected to improve the accuracy of the test results.

Another area of interest was a corner of the laboratory where a concrete tank 20 by 30 feet and 7 feet deep was being constructed with the bottom about 1 foot above the laboratory floor; concrete pillars support the tank. The tank bottom contains about 100 holes,
FIGURE 14. Interior of new and incomplete hydraulic laboratory (no name as yet) which replaces the old torn-down "Hawksley" at the Imperial College, London. Vertical and horizontal piping at right is for water supply to models. Three reservoirs are located on roof.
FIGURE 15. Spoked wheel about 20 feet in diameter on which hydraulic models will be constructed to determine the Coriolis effect. Rotation of the model will simulate the rotation of the earth and mixing (e.g., of salt water and fresh water) and tidal effects may be more closely predicted.
each 6 inches in diameter, and more or less uniformly spaced. There are also 6-inch-diameter holes in the sidewalls at various depths and locations. The tank will be filled with soil or gravel, or will be compartmented either horizontally or vertically, or both, with various types of soil mixtures. An overhead sprinkler system will operate in a variable pattern to represent the passage of storms of record. The storms will increase and decrease in intensity as they pass over the tank and every effort will be made to produce a model storm. Measurements will then be taken in the tank and at each drain hole to determine the runoff characteristics of the soils and gravels. Calculations of permeability, infiltration rates, runoff, and other hydrologic factors will be made. The tank may also be used later for ground-water studies. It appeared from the permanent type of construction, reinforced concrete, that the tank was expected to be used for quite sometime.

In another area of the laboratory is another reinforced-concrete tank which is also of permanent-type construction, and intended for general use in making hydraulic studies. This tank was, perhaps, 20 by 25 by 3 feet deep with the bottom set about 1 foot off the floor. No specific model was mentioned for this tank but in the past they had found great need for facilities of about this size.

Along one wall of the laboratory was being constructed a reinforced-concrete flume to be used for general studies of hydraulic problems, Figure 15. The flume is 200 feet long, 9 feet wide, and 6 feet deep. The top of the flume walls is equipped with heavy rails aligned to provide support for a towing carriage or for other equipment used in hydraulic model testing. At three locations along the length of the flume there are openings on the viewing side which are to be closed with plate glass or transparent plastic. Each opening is about 12 feet wide and almost as tall as the flume, containing three windows separated by posts. The flume is designed to discharge as much as 360 cubic feet per second at velocities as high as 8 feet per second. The reservoir to contain the flume water is beneath the floor; the flume and the reservoir are a complete unit having a pump used only for flume discharges.

The water supply for general use in the laboratory is contained in three tanks mounted on the roof of the laboratory. Longitudinal water supply piping is overhead and out of the way in the test area. Two 8-inch-diameter pipes run vertically from each takeoff point on the overhead piping to the laboratory floor. The permanently installed overhead piping, it is hoped, will provide better opportunity for spacing hydraulic test setups without interference.

One of the older pieces of equipment being rehabilitated for use in the new laboratory is a Hele-Shaw model, Figure 17, about 8 feet long and 5 feet high which has been used to study problems related to flow through porous media. The two transparent sides were plastic sheets and contained many inserts, either for maintaining the spacing of the plates or for piezometer or pressure taps. The model was last used with lubricating oil as the fluid. I was not able to learn the exact nature of the study since it had been interrupted by moving. I was asked to write to Mr. Peter Wolf (on sabbatical leave at Stanford University) to learn more about the previous use of this facility and to determine whether reports on this activity are available. The reason for my special interest in this particular equipment is that the Bureau is sponsoring tests at Colorado State University which utilize a Hele-Shaw model to find the answers to several ground-water and drainage problems. It is possible that the work being done at the Imperial College could be useful to us in helping to understand or supplement our work.

It was difficult to see the exact nature of the other types of work planned for this new laboratory because the floor was covered with old models and equipment salvaged from the old laboratory. There were straight channels, sinuous channels, and channels with various slopes or degrees of curvature stored in various places. These were to be rebuilt and reinstalled for undergraduate and graduate use in demonstration and thesis work. There was also a collection of demonstration devices, including head loss visualization, Reynolds number visualization, weirs, orifices, gates, valves, and other common laboratory devices. Professor Minton said he was anxious that the final work of putting the laboratory into order be accomplished so that work on some of the important projects could be resumed. He mentioned that Professor Wolf had taken a year's leave of absence during this moving period and was studying at Stanford University. He was expected to return, however, for the London Congress of IAHR.
FIGURE 16. Professor Paul Minton, Imperial College, and Mrs. Peterka in the new concrete test flume, 9 feet wide, 6 feet deep, and 200 feet long. Flume is equipped with glass inspection windows and towing facilities. Discharges up to 360 cubic feet per second are possible.
FIGURE 17. Hele-Shaw model used to simulate and study two-dimensional flow through porous media. Lubricating oil is used for the fluid between the two sheets of closely spaced glass. Model as shown is inoperative during laboratory construction, Imperial College, London.
I concluded my visit by extending an invitation to the laboratory staff to correspond with our laboratory in Denver, in the interests of solving our mutual problems. I am sure that the program planned for their new laboratory will be of interest to us in the future and that our experience in certain fields will be of help to them in their work.
VISIT TO NATIONAL ENGINEERING LABORATORIES

On August 29, 1963, I visited the National Engineering Laboratories, Department of Scientific and Industrial Research, 10 miles south of Glasgow in the community of East Kilbride. (See Itinerary, Appendix XII.) The laboratories are situated on a reservation similar to the Denver Federal Center, Figure 18, and the various departments encompass a wide variety of research. I was particularly interested in the fluid mechanics and hydraulics research but many other subjects were also investigated in the various buildings on the reservation. The laboratories are under a Civil Service system and employ about 600 people. In recent years the personnel have increased at the rate of about 40 per year. Many of the buildings on the reservation show signs of this growth in that they have new-appearing wings or annexes adjacent to the main structure. In many places the new part of the building is larger than the original.

The Division of Fluid Mechanics, (see Figures 19 and 20) is headed by Dr. E. A. Spencer and he was my host during my visit. I spent some time in his office, upon arrival, discussing the work of the National Engineering Laboratories and in pointing out to him the particular areas of their work that I was interested in. Dr. F. A. L. Winternitz, who had been head of the Fluid Mechanics Division of the Fluid Group and to whom I had written to ask about my visit had recently resigned to become Technical Director of a private corporation, Sigmund Pulsometer, Limited. (See Figure 6 and Items 36, 37, and 38 in Appendix II.)

Of the total staff employed at the NEL, there were 247 scientific and experimental personnel holding science or engineering degrees, 113 technical assistants or technicians, 72 office workers and 249 industrial workers. In addition, the laboratories use the services of employees of the staffs of British universities as consultants and a number of university students from the British Commonwealth had vacation employment as temporary members of the staff.

The NEL maintains contact with work in other countries by attending international conferences and by regularly scheduling visits to research laboratories and industrial organizations in countries throughout the world. Recently, personnel have participated in conferences such as the First European Symposium on "Fresh Water From the Sea," in Athens; "Surface Texture," ISO working group on Venturi tubes (ISO/TC30/ WG1) in Paris; "National Conference on Industrial Hydraulics," in Chicago; Second ASMI Symposium on "Thermophysical Properties," at Princeton University; "International Conference on Fatigue," New York; "North East Coast Institution of Engineers and Shipbuilders," Scotland.

The Fluid Mechanics Division is concerned primarily with closed conduit flow problems—both air and water, Figures 21 and 22. This includes pumps, turbines, and special types of blowers such as those used in "Hover Craft." Hover Craft are vehicles without wheels supported on jets of air emerging from the underside of the craft and moved forward by jets of air. Boats of this type are also being made. One was being used as a sightseeing boat on the River Thames in London.

Methods of testing the performance of centrifugal and axial flow fans are being investigated to see whether the current test codes are accurate. Particular attention is being given to accurate measurement of air and water flow. Other areas of interest include the design of turbine runner blades and the necessary testing to determine the efficiency of the runner and the possible areas of cavitation on and between the runner blades. Studies are also being conducted to determine the effect of model scale on cavitation in water turbines. Aerodynamic testing procedures for hydraulic machinery are being developed by comparing the air model results with measurements carried out on the water model. The
FIGURE 18. General view of laboratory complex comprising NEL (National Engineering Laboratories), at East Kilbride, Scotland.
FIGURE 19. Fluid Mechanics Division, Hydraulic Laboratory buildings, NEL Laboratory, Scotland.
FIGURE 20. Interior of NEL Hydraulic Laboratory as shown in a cutaway model. This model was displayed and this photo was taken at the IAHR Congress in London. The purpose of the model was to advertise the NEL to the Congress delegates.
FIGURE 21. General view of one testing area in the NEL Hydraulic Laboratory. Turbine draft tube model is in foreground.
FIGURE 22. Another testing area in the NEL Hydraulic Laboratory. These facilities are used for all kinds of closed-conduit problems.
effects of various types of installation on the performance of a particular water pump are being investigated and it has been found that cascade bends (directional vanes) attached to the pump internally can have a beneficial effect on the performance characteristics. Noise in centrifugal pumps has been measured over a range of operating conditions and flow rates, and various types of bearings and pump mountings are being investigated to improve the noise problem. Tests are being conducted to develop more efficient axial flow fans and better impeller designs for mixed flow fans. At the same time a study of fan test code methods is being made.

In the field of flow measurements a study is being made of the accuracy of differential and interferential flowmeters. Comparative measurements are being made at a power station in France in collaboration with "Electricité de France" to study the salt velocity method of flow measurement. Agreement between the NEL salt velocity results (see Figure 3) and the EDF salt dilution tests was within 1-1/2 percent. Laboratory tests on a new technique for measuring the time interval between electrode stations were satisfactory. Dilution methods of flow measurement are being studied and pilot tests with iodine and sodium dichromate as the trace chemicals have been carried out to develop techniques for measuring the flow of sea water in pipelines. Tests are being conducted on flowmeters of various kinds and the calibration of flow-measuring devices is a standard operation in the laboratory.

Mr. J. N. Mansfield of the laboratory staff took me on a tour around the laboratory and I saw a few tests actually underway. In the first test setup I saw tests in progress on a model turbine and runner. Two different runners were to be tested for efficiency and incipient cavitation. A stroboscope light was in operation and by looking through a glass window I was able to see cavitation occurring on and between the runner blades, Figure 23. These tests were on a Kaplan type of adjustable blade to determine the incipient cavitation point and the efficiency loss of the turbine at this point. The data were being taken automatically and electronically on a punched paper tape. The tape was then being fed through a computer and the results were being typed in final form on large sheets of paper with the results appearing in tabular form. All of the automatic data equipment had been designed and built by the laboratory staff. This equipment, which has been in operation for several years, was pioneered by their own electronics engineers.

The laboratory makes turbine tests at the request of the turbine manufacturers, the turbine buyer, or both. In effect the laboratory acts as a mutual third party to insure turbine evaluation which is fair to both buyer and seller. A good portion of the laboratory is devoted to turbine and pump tests of the type described.

Calibration of a flowmeter was in progress and I inspected the facilities. A single rotor propeller meter for measuring the flow in the water turbine test rig has been designed, manufactured, and installed in the laboratory. The tests were on a 30-inch-diameter propeller capable of measuring up to 300 cubic feet per second in a Venturi-type section. The propeller is installed in the restricted area. The calibration was by means of a weighing tank about 10 by 15 by 8 feet deep suspended on knife edges, Figure 24. The capacity of this tank is about 35 tons of water. Discharges from the current meter are diverted into the weighing tank by means of hydraulic and electronic devices. Electronic equipment is used to record the propeller revolutions and certain pressure-type data. The flow coefficients are automatically calculated as rapidly as the test data is recorded.

Between test runs I managed to test the weighing tank suspension system by hand and I could easily change the recorded weight of the 35-ton-capacity tank by placing my hand on the rim. It was explained to me that the calibration equipment was very elaborate and sensitive because it was used daily as part of their regular work and it was desired that calibration results be as accurate as possible.

In the same corner of the laboratory is an elaborate back-lighted manometer board containing perhaps 30 clear plastic tubes, Figure 25. To read the liquid level in any tube a cantilevered arm could be moved vertically to coincide with the meniscus in any tube. A scale with a vernier attachment could be read along one side. Fluorescent lighting behind a glareproof translucent plastic sheet provides the back-lighting. The overall effect was pleasing to the operator and provided a background for manometer reading which was easy on the eyes and which would promote maximum accuracy. I estimated that a board like this, made by hand as this one was, would cost thousands of dollars. The boards in use in our Denver laboratory are usually expendable and cost only a small fraction of a thousand dollars.
FIGURE 23. Turbine runner blade undergoing incipient-cavitation-determination test. Stroboscopic light is aimed through glass observation window where cavitation can be seen between the runner blades. Entire test is recorded on punched-paper tape which is fed directly into a computer.
FIGURE 24. Technicians operating electronic recording and computing equipment used in connection with flowmeter calibration tests. (NEL Laboratory, Scotland.)
FIGURE 25. Precision-made back-lighted manometer board used in conjunction with calibration tests described in Figure 24.
Cavitation studies of various kinds are a large part of the testing program in the NEL laboratory. I saw equipment which used the whirling-water-jet principle and also the magneto-striction principle to determine the comparative resistance to erosion of metal samples. The advantage of using these types of cavitation test rigs is that the testing times are relatively short, ranging from a matter of minutes to perhaps an hour, to duplicate erosion which might take months to produce in the field. Their investigations into ways of reducing cavitation damage have shown that the onset of erosion can be delayed by polishing the surface of the test sample. Tests on bronze showed that an improvement in surface finish alone resulted in a 25-percent increase in exposure time before damage could be detected on the sample.

In discussing the investigations done on conduits and large pipelines to measure discharges, I inquired particularly regarding the work done with radioisotopes. I learned that these tests had been conducted by an organization equivalent to our Atomic Energy Commission and that personnel from the commission had used the NEL facilities and equipment for tests. It was expected that these same people would return to NEL in October 1963 to conduct more tests. I was unable to find out exactly what would be done or where it would be done. The impression I gained was that the work was somewhat confidential in nature and the NEL personnel were not too eager to say much about it. They were willing, however, to discuss the tests made using chemical dilution methods. I found that they have used a flame photometer and a spectrograph to detect the quantity of chemical or dye in the diluted sample. With various methods of detection they have been able to detect 1 part in 10 million in both the chemical and dye tests. However, they emphasize this point (despite their ability to detect very minute quantities): They have been unable to measure these minute quantities within about 5 percent. Therefore, the discharge determination is accurate to only about 5 percent and they have not been able to improve on the overall accuracy. Thus, from an accuracy standpoint, the fact that chemicals can be detected to 1 part in 10 million has no real bearing on the overall accuracy of a discharge determination. Other factors hold the overall accuracy to the ordinary plus or minus 5 percent range.

The main problem in chemical, dye, and isotope tests, as they see it, is to obtain good mixing with the flowing water. To accomplish this there must be a certain amount of turbulence in the water. In some cases they have found it necessary to create turbulence at the injection point by various means. They even mentioned the use of "bomb" type injectors which blast the chemical or isotope into the interior of the flowing water.

In completing my tour around the laboratory I saw many tests and many pieces of test equipment which were of general interest. To name a few without discussing them in detail, there were tests being performed to determine the overall performance of a type of pump in terms of a particular method of installation of that particular pump; pressure losses were being determined for pneumatic control valves; tests were being made on ball bearings to determine their resistance to pitting failure (they have found that bearing failure is a form of surface fatigue failure which can be affected by the properties of the materials, the lubricant, and the environment); and studies are being made on conduction of heat by finned surfaces and on the amount of heat that can be transferred between a pipe and the fluid passing through it.

Studies are being made to determine the necessity for modifying Bernoulli's equation. Their concern is that the surrounding atmospheric pressure and the compressibility of the working fluid should be included in the equation when turbines are tested at 1,000 feet of head or more, or an oil pump is tested at 2,000 to 5,000 pounds per square inch.

Some of the tests which were in progress, but which I did not see, included a continuing study of the properties of hydraulic fluids, including thermodynamic properties, calculation of gas viscosities, thermoconductivity of gases, measurement of gas viscosities, studies of non-Newtonian fluids, and other detailed studies bordering on the physics and chemistry of materials. Tests have been made to develop apparatus for rapidly measuring the dissolved air content of any type of liquid. It has been used successfully with suspensions, emulsions, and volatile organic liquids.

A special group in the laboratory has been assigned the job of finding and analyzing problems for computer solution and teaching the use of computers in design and research. They have found that the electronic digital computer can make a considerable contribution
in the solution of design problems by doing the tremendous quantity of calculation usually required. Considerable time has been saved by using the computer to investigate the effect of various parameters. Some of the design problems concerned with axial flow fans which have been solved with computers could not have been solved in any other way.

I was impressed with the emphasis being placed on computers throughout my tour of the foreign laboratories and the emphasis by NEL was particularly strong. Computers were also being used to study feed water problems and heaters such as are found in steam powerplants, in the design of blade-type heat exchangers, for analysis of bearing data taken in every type of rotating machinery, and for analyzing the effect on beams where loading conditions in high-temperature situations produce elastic and creep strains. The computer is also being used to process data from various experimental rigs in the laboratory. It has been found that the major difficulty in all data processing on a digital computer is getting the data into a form intelligible to the computer. NEL therefore believes it is important that the transcription be done directly, using paper tape punched at the data source.

Before departing from the laboratory, I again visited with Dr. Spencer in his office and discussed the test setups I had just seen. I indicated to Dr. Spencer that the work in our Denver hydraulic laboratory is somewhat different from the work he is doing; that the emphasis is on a different group of subjects but that the overall purpose is the same. In response to his direct question, I told him I had come to visit his laboratory primarily to see his test facilities and to discuss water measurement problems in large conduits, and that I thought we could assist each other in our research by becoming better acquainted and by exchanging publications. Dr. Spencer said he was very agreeable to this idea and asked that I send him a list of our publications. Upon my return to Denver I immediately mailed him a list of some 100 publications that I thought he would be interested in to some degree or another. He gave me a list of publications available from his laboratory and said we could obtain selection from the list at no cost, on an exchange basis. Appendix VIII contains the list of publications available from NEL on an exchange basis.

Before leaving I told Dr. Spencer that I had enjoyed seeing the NEL laboratory and the tremendous amount of modern test equipment his staff is using. I told him I was impressed with the considerable amount of electronic equipment used to obtain, record, and analyze data and that I felt the NEL laboratory was very progressive and was doing a much-needed job in research in many important fields.
VISIT TO WALLINGFORD HYDRAULIC RESEARCH STATION

On Friday, September 6, I visited the Hydraulic Research Station at Wallingford, Berks, England, which is about 45 miles west of London. See Trip Itinerary in Appendix XII. I was in a party of about 60 people, IAHR delegates and wives, which had chartered 3 busses to take the group to Wallingford and return, Figure 26. The following account is based on my own observations. Appendix X contains additional material as reported by "The Engineer" of September 20, 1963.

The Wallingford Station is one of more than a dozen research laboratories administered by the Department of Scientific and Industrial Research. These laboratories cover a wide range of subject matter in science and engineering. The station is operated by a research board composed of eminent engineers, industrialists, and university professors. The Director of Hydraulic Research is responsible for the scientific work and its administration. The total staff at the station numbers about 210 and is increasing in size each year. Most of the staff are civil engineers, but others are qualified in physics, mathematics, mechanical and electrical engineering, and geography. The annual budget is about $750,000.

The Wallingford Station is engaged in the investigation of a wide variety of hydraulic problems in the field of civil engineering including the relationship between rainfall and subsequent runoff, the behavior of hydraulic structures, flood control, the training and control of rivers and estuaries, the development of ports and harbors, and a variety of coastal problems.

The function of the station is to study the behavior of water flowing in open channels and in particular the hydraulic problems encountered in civil engineering. It includes the problems concerned with the natural course of water after precipitation on the earth's surface and includes the study of flow through dams and of problems associated with hydroelectric schemes. It is concerned with the effects of the flow of tides in estuaries and of waves in harbors and on seacoasts, but does not cover pump or turbine research, flow in pipes under pressure, or closed conduit hydraulics, which are the concern of mechanical engineers. This latter work is conducted at the National Engineering Laboratories at East Kilbride, Glasgow.

Extensive specialized facilities have been provided for the investigation of specific problems and for the background research. Three types of facilities are available:

1. A Main Experimental Hall, which is used largely for model investigations and which has a floor area of 170,000 square feet. This continuous area is interrupted only by eight columns supporting the roof. It has radiant heat, ample supplies of electrical power and water, and provisions for water storage and return flows. It is provided with overhead cranes and there is access to the roof space to permit photographing models through apertures in the ceiling.

2. Wave basins. There are four large wave basins for studies of wave disturbance problems, tests of harbor designs, and research on bridges and breakwaters. These basins are equipped with means to reproduce tides, tidal currents, and waves. Their total area is about 42,000 square feet.

3. Flumes and channels. A number of flumes and channels are available, ranging in length up to 400 feet and in width up to 12 feet. Four channels are provided with wave-making devices, one of which is totally enclosed and fitted with a blower so
FIGURE 26. My companions on the bus from London to Wallingford Research Station were, among others, Dr. A. T. Ippe, M.I.T., President IAHR; Dr. D. R. F. Harleman, M.I.T.; Dr. J. W. Daily, M.I.T.; J. M. Caldwell, Beach Erosion Board; Professor S. Lennart Rahm, Sweden; Professor Ernst Vollmer, Germany; and Dr. Hunter Rouse, University of Iowa.
that wind can be simulated and its effect on secondary drifts, due to waves, studied. A tank for the calibration of current meters is maintained for continuous use.

The work accomplished may be classified under the following headings: surface water, hydrology, hydroelectric schemes, flood control, sediment transport, estuaries, wave disturbance problems along seacoasts, and an assortment of smaller hydraulic problems connected with these major divisions. The station maintains several "teams" which are organized to conduct certain special work such as a survey team which operates in the field to collect prototype data and photographs of field problems, and to supply the laboratory with information in the solution of model problems. An instrumentation team from the Instrument and Mechanization Section makes full use of modern techniques in the design of instruments and servocontrol systems. They thus provide models with a wide range of instruments and efficient automatic devices for the control of flows and the reproduction of tides.

Upon our arrival at the station, our group was welcomed by the Director, Mr. Fergus H. Allen (see Figure 27). We were given booklets, especially prepared for the occasion, which indicated the areas which could be inspected and the hydraulic models which could be seen in operation. Another touring group of IAHR delegates was expected in the afternoon, and we were told it would be necessary to limit our visit to about 3 hours. My inspection therefore was concentrated in the Main Hall exhibits and the outdoors models adjacent to the Main Hall, Figure 28. However, I quickly inspected one other building which contained several models devoted to sediment transport problems.

Outside the Main Hall was a test area used to study the transport of sediment in river channels. At the time of the inspection, 2 channels had been put in operation side-by-side to study the meandering of rivers, Figure 29. Injection devices had been constructed to discharge a mixture of water and sediment into the headwater and the mixture, 150 parts of sand per million, flowed through the river channel for a distance of about 350 feet. By changing the discharge in a periodic fashion, much as a normal stream would do during a period of rising and falling flood, the channel soon began to show signs of meandering, typical of prototype rivers. The one channel which was the main subject of the inspection was discharging 4.4 cubic feet per second and had been in operation for 3 days. The beginnings of the meanders were just becoming evident. It was expected that within several more days the meanders would be much more apparent. I was told that the meanders, which eventually become symmetrical s-curves, begin at once and become more pronounced as more testing time accumulates.

Of particular interest at this model was the instrumentation which had been installed to record the happenings in the channel. About every 50 feet there was a low bridge across the channel, Figure 29, and various sensing devices had been located on or under the bridge to record the depth, velocity pressures, and other hydraulic variables as the test progressed. The bridges were located where experience had shown that meanders would not interfere with the abutments. Data were recorded for determining the relationships of channel shape, slope, discharge, sediment load, mean particle size, and the formation of meanders. This research has direct connection with the "regime" theory of flow in alluvium.

Other sediment transport investigations were being made, including one in which the purpose was to find practical ways of measuring the rate at which sediment is transported in a river or in the sea. Fluorescent particles were being used in a flume to provide background data about the way in which radioactive particles become dispersed when they are injected into a stream at a single point. In another flume, ripples of sand, which make measurement of sediment transport difficult, disappeared under certain flow conditions. These conditions are being investigated and an attempt is being made to define the characteristics which produce ripples.

In the Main Hall a startling demonstration was the model of a large vortex in a glass container some 5 feet high and 3 feet in diameter. The tank is equipped with eight water-supply nozzles arranged so that they can produce either radial or tangential flows within the container. At the time of inspection the nozzles were producing tangential flow and a
FIGURE 27. Director of Research, Mr. Fergus H. Allen, welcoming and instructing the IAHR group, arriving from London, prior to their inspection of hydraulic facilities at Wallingford Research Station.
FIGURE 28. The Main Hall at Wallingford Research Station. This is a relatively new facility of 170,000 square feet of area devoted to hydraulic model testing. The entire floor area is interrupted by only eight columns.
FIGURE 29. Flow channels used at Wallingford Research Station to study the meandering of rivers. Recorders at each bridge across the channel record velocity, depth, etc., continuously.
very large vortex was formed which could be seen through the glass walls of the container. The vortex was very stable and extended down through the flow exit from the glass container. The vortex appeared to have a screw thread, Figure 30.

I was told that many tests had been run and that parameters had been developed to express the vortex formation in terms of Reynolds number and other characteristics of the fluid. It was found that the vortex is very sensitive to disturbances and that mechanical studies are very difficult to make because the insertion of a measuring probe causes the surface level of the vortex to drop and the air core to become unsteady. Measurements were therefore being made by observing through an eyepiece, seen in the lower photo of Figure 30, the behavior of particles suspended and moving in the water when they are illuminated by a strong light. Much of the value of this research is scientific in nature and results in better general understanding of vortex formation. However, it is expected that the results can also be of engineering value in that they can be applied to practical problems at flow intake systems.

An impressive model in the Main Hall was a large wave basin being used to investigate quantitatively the effect of seawalls on littoral drift. The aim in this model was to obtain an optimum design of seawall for particular conditions of service in the tidal range. The model was some 250 feet long by 150 feet wide and was equipped with several generators capable of producing storm-size waves, Figure 31. The material used in the model to represent the sand on the beach was a powdered plastic material which was designed to move according to criteria developed by the hydraulic research engineers.

The Hong Kong water-supply scheme model was also of interest. Fresh water is presently in short supply and various schemes have been explored to increase storage facilities. A tidal model of a cove was constructed to study the possibility of using the cove as a fresh-water storage reservoir. Typical spring tides were reproduced in the model to produce a maximum tidal range of about 8 feet. Provisions were also made for the model to represent critical conditions of flow when closure of the dam is made.

An investigation into the effects of improving the River Tees estuary was being made in a movable bed model. Great care had been taken in the selection of bed material for the model; a mean size of sand grains of 0.2 millimeter had been chosen. Representation of sediment was achieved by injecting fine wood flour into the water of the model. A study of tidal propagation, velocities, and salinity distribution was made for the existing configuration of the estuary. The improvement work, in progress, involved repeating in the model the various floods and surges of record, in order to determine proper modifications to the estuary.

In the Hamilton Bypass model, a new motorway near Glasgow, which crosses a flood plain, is being examined to determine height of embankments, and widths of bridges necessary to prevent flooding, Figure 32.

Another model of particular interest was a fairly large-scale reproduction of a 100,000-ton tanker (the model ship was about 10 feet long) which was modeled in almost exact detail. The ship was moored to a single fixed point with a single hawser attached to the bow of the ship as it would be during offshore unloading or loading of oil. Waves, winds, and currents were made to approach the tanker from different directions and the behavior of the tanker was observed and recorded along with the stresses in the hawser. This study was being done for a shipping company to investigate and improve the present practices in mooring large ships.

During the tour of the laboratory facilities, I was particularly impressed with the quality and quantity of instrumentation used on each model. A conservative estimate would indicate that several thousand dollars worth of equipment was in use on each study. In several instances the value of the instrumentation was perhaps as much as 10 times greater than the average.

It appeared that the personnel at the Wallingford Station are thoroughly sold on the idea of highly instrumented models. Much of the instrumentation was either built to fit a particular model or had been modified by their instrumentation and mechanization teams.
FIGURE 30. Vortex produced by tangential water jets in glass tank for study of characteristics. The base of the air core is about 3 inches in diameter. Viewing telescope is at right in lower photo. (Photos courtesy of Wallingford Research Station.)
FIGURE 31. Littoral drift study model showing waves breaking on model beach composed of powdered plastic, Wallingford Research Station.
FIGURE 32. London IAHR Congress visitors examining highly instrumented Hamilton Bypass model at Wallingford Research Station. Masonry construction is common. Wood is scarce. Display boards are well lighted and contain good explanations.
to fit a particular installation. In fact, several of their instruments were on exhibition and were offered for sale; for example, the water surface follower gage and recorder, Figure 33. The follower contains a two-phase servomotor which raises or lowers a finely pointed probe attached to a lead screw. When the probe penetrates the water surface, the electrical resistance between the probe and an immersed grounded wire decreases as the depth of immersion increases. The resistance through the water forms one arm of a bridge network supplied with a small alternating voltage, the bridge being adjusted to be in electrical balance when the probe is a few thousandths of an inch below the water surface. Any subsequent rise or fall of the surface varies the depth of immersion of the probe and so upsets the balance of the bridge. This causes a signal to be produced from the bridge network, which is amplified and applied to the servomotor. The motor then repositions the probe to restore the balance of the bridge. Thus, the probe follows the water surface and in so doing continuously measures the surface level. The equipment can be connected to a recorder to make a permanent record of the water level with respect to time.

Another instrument on display and for sale is a controlled-valve tide generator. This is a very complicated device which, by means of pumps and bypass valves, allows water to be drawn into a storage tank from the model or allows reverse flow through a distributor to produce a tidal effect. The device is shown and discussed in Appendix X. A piston-type wave generator described by Mr. H. R. A. Dedow in the seminar on September 5, 1963 (covered in this report), is shown in Figure 12.

Another piece of equipment offered for sale is the miniature current meter apparatus, used for measuring low velocities, which is extremely small and portable. The Denver laboratory purchased one of these meters from the Wallingford laboratory several years ago; finds that the performance is excellent and that this meter is very useful.

On display and for sale also was a direct-reading current meter. This meter is a well-constructed instrument which presents simultaneous readings of the direction and speed of water currents at any selected depth. It is considered more accurate than existing types of current meters, and it is very useful in that both direction and speed are presented directly to the observer on calibrated scales. No special plotting or interpretation techniques are involved. This means that all observations can be recorded on the site without the need for calculation time. The meter is in two parts, the underwater unit which is the meter, the weights, and a cable, and the indicator unit, which is the "black box" with the dials on the face. Batteries provide a continuous running life of about 150 hours. The meter is equipped with a damping control which can be adjusted to eliminate or emphasize the rapid velocity changes which occur in certain types of flow. In most cases the average velocity is desired and the amount of damping can be increased to provide the least amount of fluctuation. It is claimed that this damping does not affect the accuracy of the readings.

Another velocity meter of interest was an Ott propeller meter, Figure 34, which was some 5 or 6 feet long and was quite ruggedly built. Because of the size and weight, the meter should be handled with a crane to lower the device over a bridge railing. Inside the meter are devices which sense the direction and the velocity of the flow and continuously transmit the information to the observer on the bridge. This piece of equipment sells for about $1,000 and includes the handling winch.

In the studies being made at Wallingford it is often necessary to evaluate the specific gravity of different dilutions of seawater. One quick way to make this determination is to use small glass beads which have been blown in various colors and weights and have been calibrated to indicate certain specific gravity values when placed in the fluid. The position at which the bead remains suspended in the salt water indicates the specific gravity of the fluid. This method was invented in Holland (I was told) and is used extensively there as a rapid means for determining the salt content of various waters. Figure 35 shows a group of specific gravity beads submerged at various levels in a graduate containing salt water.

Following the inspection of the station, I spent some time talking to several of the personnel, Mr. Fergus Allen, Mr. Peter Ackers, and Mr. H. R. A. Dedow. I found these engineers to be particularly well qualified in the hydraulics research field and dedicated
FIGURE 33. Water surface follower gage and recorder. Motor-driven point gage follows changing water level. Beakers and siphon in photograph are used to change water levels only to demonstrate the instrument. (Display by Wallingford Research Station.)
FIGURE 34. Ott propeller meter, sensing devices and associated equipment used to indicate direction and velocity of flow continuously to observer. (Instrument for sale by Wallingford Research Station.)
FIGURE 35. Specially blown and weighted glass beads in various colors, used to measure specific gravity of fluids, are demonstrated in a graduate containing salt water. (Wallingford Research Station.)
to their work. They have had previous contacts with the Bureau of Reclamation in the past and expect to continue this relation in the future. They inquired about the progress of several of our hydraulic, sediment, and ground-water studies in which they have considerable interest, and asked about the status of the reports on these subjects.
On September 9, 1963, I visited the Laboratoire Central D'Hydraulique de France in a suburb of Paris, Maisons-Alford, about 15 kilometers south of the center of Paris. This laboratory was founded in 1939 by M. Jean Laurent, the present President and Managing Director. The first laboratory, in a house which used city water for a water supply, was started to study a problem concerning the national defense of France. Since this simple beginning, the laboratory has been devoted to research and investigation of all types of hydraulic undertakings. Soon after its creation, the initial installations became inadequate and it was necessary to provide larger water supplies and larger areas for testing. In 1943, the laboratory was transferred to its present location.

The expansion of the laboratory was possible because of the continuous support of the French Government, and, in 1953, to its transformation into a limited liability stock company having state backing. Thus, the laboratory is supported by a mixture of private and governmental monies. In 1958, the laboratory structure and organization was again enlarged to allow the participation by the following organizations: Ministry of Public Works, National Office for Navigation, Department for Hydraulic Development and Research, and others.

Since its creation, the laboratory has carried out numerous investigations in France, in countries of the Union Française, and in the Associated Territories. These include countries in Africa as well as others throughout various parts of the world. Studies have been made of important harbors, such as Dakar, Conakry, Sotuba, and others. Studies have been made of important projects in French ports; for example, Le Havre and Dieppe. Improvements have been made in waterways of the Seine, Rhône, and Loire Rivers, including the construction of locks and dams. The laboratories have contributed considerably to the French post-war reconstruction effort. The laboratories have also given technical assistance in creating, equipping and running hydraulic laboratories in Chile, Colombia, and Brazil. The Central Laboratory is said to be recognized throughout the world because of its wide experience in hydraulic problems of all kinds, and because it has developed original methods of solution for many difficult problems. The laboratory claims to be one of the first to build up a well-balanced team of site observation specialists (field engineers), research workers, and experienced model engineers.

The laboratory is recognized in five main branches of activity which are mutually complementary:

1. The Site Observation Department carries out field investigations of hydrography, oceanography, hydrology, sedimentology, and other similar studies. The personnel are specialists in these various fields.

2. The Hydrology and Agricultural Hydraulics Department makes hydrological observations and measurements to determine the characteristics of drainage basins, studies water requirements for the creation of irrigation systems, and investigates the measures required to protect against soil erosion.

3. The Reduced Scale Model Test Department operates for the most part in the Hydraulic Laboratory at Maisons-Alford but also maintains technical assistance missions in Chile and Colombia for running the national hydraulic laboratories in these countries.

4. The Sedimentology Laboratory has developed, by means of sedimentological studies, the requirements for the reproduction of material movements in reduced scale models, and also the requirements for the solution of a large number of varied field problems by means of models. The considerable progress made over the
years in improving model techniques makes it possible for them, it is claimed, to reproduce in any model the problems of field silting and to provide means for a solution.

5. The Planning Department analyzes, from on-the-site data, the studies to be made and suggests the most efficient, cheapest, and simplest solutions for the model studies or other type of study to be made. The long experience of the personnel involved makes it possible to broaden considerably the range of application of classical hydraulics to the solution of technical problems.

The laboratory at Maisons-Alfort is operated by 4 directors, 7 engineers, 4 field engineers, 20 technical assistants and a variable-sized group of industrial workers. The budget amounts to about $600,000 per year. The main building of the laboratory is about 360 by 250 feet, giving an overall area of about 90,000 square feet. There were offices adjacent to the laboratory, with one office overlooking the main laboratory floor. Other offices are situated adjacent to the main laboratory building. The entire area is fenced and includes some beautiful flower gardens near the entrance and around the parking area.

I was welcomed to the laboratory by M. Jean Laurent, Doctor of Sciences and President and Director General of the laboratory. Figure 36 is an overall photographic view of the laboratory through his office window. I was introduced to M. Michel Pechere, Technical Director, M. Pierre Gerlier, General Director, and M. Henry Castelnau, Director of External Services Department. After discussing the organization and purpose of the laboratory at some length, I was taken on a tour by M. Pechere. M. Pechere spoke English and we were able to communicate very satisfactorily regarding the work being done. M. Pechere told me that the work in the laboratory at the moment was concerned primarily with maritime problems, with emphasis on sedimentation, particularly the type of sediment called mud.

The first model I was shown was of the area near the mouth of the L'Adour River. At the point where the river empties into the sea, there is an existing jetty, but the littoral drift along the coast tends to bring mud into the river mouth. The model study was to determine the length, curvature, and shape of jetty necessary to prevent sedimentation in the river mouth. There is no sediment problem in the river itself.

A large dike had been constructed in the 1:60 scale model and tests were being made to determine the weights of the individual stones required to hold the jetty in place, considering the effect of waves and drift. The stones had been colored red, white, and blue to indicate their original zone of location and weight. At the end of the jetty the use of stones had been abandoned in favor of "Tetrapods," Figure 37. These are four-pronged artificial stones made of concrete which have been found to resist waves and currents and which are sufficiently porous when piled in a heap to allow rapid drainage of the surge water from waves. These tetrapods will weigh 30 tons each in the full size structure. Tetrapods are patented because they have good interlocking characteristics.

I noted that the model was being operated by two young women, perhaps 22 to 25 years old, and that their office was in a small enclosure on the model. The enclosure was equipped with glass windows, fans, and heating units so that they could work comfortably at their desks and observe the performance of the model through the windows. The building itself has no central heating system and this arrangement would be necessary during the winter months. Cables from several sensing devices on the model came through the enclosure wall to recording and indicating devices mounted on the inside wall.

I inquired as to whether the young ladies were engineers and I learned that they were classified as technicians. My questions directed to them indicated that they did know the answers to some of my questions that I thought an engineer might be expected to answer, but they often had to telephone to the engineering office to get the answers to more comprehensive questions. I was satisfied that they had enough overall knowledge to operate the model intelligently.

The model was well instrumented and, in addition to a wave-producing machine, there were several wave-measuring devices in place, Figure 38, and also a wave recorder. It was explained to me that the waves produced by the wave machine were nonmono-chromatic waves. I detached a sample of the paper wave record from the machine and
FIGURE 36. General view of the main testing area of the Central Hydraulic Laboratory Maisons-Alford, France, through the office window of Jean Laurent, Director General.
FIGURE 37. "Tetrapods" in foreground and colored stones in background form jetty to protect mouth of L'Adour River from clogging by littoral drift sediment. This large model is operated by the two girl technicians shown. (Central Hydraulic Laboratory, Maisons-Alford, France.)
FIGURE 38. Electronic wave-height measuring device in use on the L'Adour River model and others in the Central Hydraulic Laboratory, Maisons-Alford, France. Lower photograph shows a battery of wave-height measuring devices coupled together for multiple-simultaneous recording.
the record did indicate that the waves were of different heights and periods, Figure 39. I was told by M. Pechere that the recording equipment and the wave-height measuring equipment were manufactured in the Hydraulic Laboratory and were for sale.

Another model of interest was a salinity model, "Embouchure de la Vilaine." This was a model of a river including the mouth and a portion of the ocean along the southern coast of France, Figure 40. The horizontal scale was 1:750 and the vertical 1:100. The purpose of the model was to determine the effects caused by the construction of a dam some distance inland on the Vilaine River. After the dam is constructed, and the river flow is shut off, ocean water will flow upstream in the river to the base of the dam. The degree of salt-water intrusion was to be measured and the effect on fish and oysters in the river mouth was to be estimated. Also, upstream from the dam where the water will now always be fresh, certain effects will be created where sea water once flowed with the tide; it will be necessary to investigate the overall effect caused by the large body of fresh water. This model was well instrumented and had a considerable number of water surface and head measuring and recording devices as well as wave height and velocity measuring and recording equipment, Figure 41. Here, too, the model operators were technicians and had their office in an enclosure on the model. There seemed to be two men and two women working on this particular study; individual measurements were being made by hand in addition to the continuous automatic measurements being recorded. I watched one technician use a series of wood floats, consisting of wooden beads wrapped in aluminum foil, to make velocity measurements in the river mouth, Figure 42. He also had other heavier beads which rolled along the bottom to indicate the direction of bottom currents. These individual measurements were being checked with the data that were recorded automatically.

One of the more interesting harbor models was the extremely large layout of the Agadir Harbor in Morocco. The scale of the model was 1:250 horizontal and 1:150 vertical. Bakelite particles, having a specific gravity of 1.03, were used to represent the harbor bottom. The purpose of the study was to determine a method to reduce the amount of dredging necessary to keep the harbor open. Prototype data had been accumulated for the period 1939 to 1962, and had been used in the model for several months to prove the ability of the model to reproduce prototype conditions and events. Following this "proving" of the model, it was operated to represent conditions which were expected to occur in the future. It became apparent, as a result of this operation, that it would be necessary to dredge an average of 250,000 cubic meters of sediment from the harbor each year. After many trials, which included extending existing breakwaters and changing the arrangement of the harbor protective devices, a breakwater wall was devised which reduced the need for dredging practically nothing. The breakwater will be quite expensive, but if constructed it will eliminate the need for dredging until the year 1980. Tests are now being conducted to determine whether forecasts can be made for dates beyond this time. Other studies are being made to determine the economic feasibility of constructing the breakwater in terms of the expected costs of dredging. It appears that the breakwater will be the cheaper of the two.

Around the laboratory, there were many models contained in test flumes and in individual test boxes of various sizes and kinds. Most of the work had to do with the design of harbor works, breakwaters, or river problems. At one test flume where we stopped to observe a test in operation, I was introduced to the three young engineers conducting the tests. One was from Africa, one from France, and the third from Australia, Figure 43. This team seemed to work well together and they were eager to discuss the problem they were trying to solve. They were concerned about the effect of a breakwater on sediment transport. The sectional model they were operating had waves breaking on the face of the structure. The entire structure was founded on sand and it was possible to see the individual particles of sand move from the outside face on which the waves were breaking to the face inside the breakwater. There was, therefore, scour on the outside and aggradation on the inside of the breakwater. We spent some time discussing whether this same action could occur in a prototype structure. Since all three engineers spoke English to some degree, it was possible to learn a great deal regarding the attitude of the engineers toward their problem, and to compare their comments and outlook with those we might expect to receive from engineers in the same situation in the United States. I concluded that these engineers were very competent and were aware of the problems and pitfalls usually encountered in dealing with water waves and sediment.
FIGURE 39. Portion of recorder chart showing non-monochromatic waves which are considered to be more representative of ocean waves than the more regular types often produced in models. (Maisons-Alford, France.)
FIGURE 40. Outline of hydraulic model drawn on a map of the southern coast of France to show the portions of river and ocean which were used to study salinity and fresh water problems caused by construction of the dam, Embouchure de la Vilaine. (Maisons-Alford, France.)
FIGURE 41. Model, "Embouchure de la Vilaine," showing details of concrete construction, instrumentation, and woman technician model operator. (Maisons-Alford, France.)
FIGURE 42. Technician operating hand instruments to rough-check recording devices being tended in Figure 42. The aluminum-coated ball float is used to indicate surface velocity and direction. Embouchure de la Vilaine model. (Maisons-Alford, France.)
FIGURE 43. Sectional model of breakwater to be founded on sand. The three engineers operating the model are from three countries, Africa, France, and Australia. (Maisons-Alford, France.)
FIGURE 44. Left to right: M. Henry Castelnau, Director, M. Pierre Gerlier, Director, Professor Dooge's wife, M. Jean Laurent, Laboratory Director, the author, and Professor Dooge, University of Ireland, after tour of laboratory at Maisons-Alford, France.
Following our inspection of the laboratory, I was taken to lunch with Professor J. C. I. Dooge and his wife, Cork, Ireland. Professor Dooge was visiting the laboratory on business, and had spent the morning reviewing a reciprocal contract in which he was to do consulting work for the laboratory and the laboratory was to conduct certain model studies for him. Professor Dooge has no means for conducting model studies in his university; University College, which is part of the National University of Ireland.

Those present for the luncheon were, left to right in Figure 44, M. Henry Castelnau, M. Pierre Gerlier, Professor Dooge's wife, M. Jean Laurent, Mr. A. J. Peterka, and Professor Dooge; M. Michel Pechere snapped the picture. The luncheon was very formal, consisting of seven courses, including many French delicacies served with military precision. Following the luncheon, we returned to the laboratory to resume the tour. Most of the time, however, was spent discussing laboratory problems in general, and in talking about the organization of the laboratory and the future status of laboratories in general.

Before leaving the laboratory, I was given a catalog of instruments which are manufactured and sold by the Central Laboratory. This catalog contains photographs of 19 different items manufactured and sold for model testing or field testing use. These include 3 types of wave generators, tide generators of various types, water wave recorders and analyzers, various types of sediment and bedload samplers, current meters including pitot tubes, sediment distributors for use in models, and sieves and leveling devices used in model construction, enameled tide scales, levels for calibrating rectangular weirs, weighted rods for current trajectory measurements, boat winches for operating sounding lines, samplers and current meters, and an assortment of other equipment. The foregoing list includes only the most current items being manufactured. The laboratory can also develop or modify any equipment for any special use. No prices are stated since the selling is done on a contract basis negotiated with each individual buyer. During my tour of the laboratory I saw some of this equipment in operation, and I felt that it was of high quality.

Upon my departure I was given a standing invitation to return or to direct any Bureau of Reclamation people to their laboratory.
On Tuesday, September 10, I visited the Laboratoire National d’Hydraulique, Electricité de France, in Chatou, France. The laboratories at Chatou are on an island in the Seine River, 10 kilometers upstream from Paris.

In 1947, the organization Electricité de France decided to unite with the Ministere des Travaux Publics to provide more effective, more centralized, and more economical methods of conducting hydraulic and other engineering and research studies. The actual work was delegated to the newly formed Laboratoire National d’Hydraulique, but the administration was retained with Electricité de France. The direction committee is composed of two representatives from Electricité de France and two from the Ministry of Public Works. This committee studies and acts on the proposals for equipping the laboratory, determines the amount of money to be entrusted to each of the two founder institutions, and examines the balance and expense sheets. The committee, therefore, plays the same role as a board of directors in a private company.

The work of the laboratory has continued to expand ever since its foundation, and, at the present time, its various installations extend over an area of 25 acres belonging to the State and situated on the isle of Chatou in the Seine.

The laboratory itself consists mainly of large halls of a total floor area of 180,000 square feet where the tests are carried out. Also, there are a number of other buildings in which the models are built and where the apparatus necessary for recording test results is made.

The water supply for the models is provided by a closed-circuit system supplied by a number of pumps capable of a total flow of 150 cubic feet per second. The tanks and sumps have a total storage capacity of about 1 million gallons. There are about 250 people on the laboratory staff of which 30 are engineers; this number does not include the employees of the various services which are attached to the laboratory.

The research carried out at the laboratory can be divided into two groups; general and particular. General research is conducted either to augment the basic knowledge concerning the flow of fluids and the transport of solid materials, or to perfect methods of experimenting on scale models. Particular research, on the other hand, relates to a certain structure or site which is in the process of being investigated. These particular studies are carried out at the request of public agencies such as the Service des Ponts et Chausées (Bridges and Highways), by the departments of Electricité de France, or by various private or semipublic establishments (Compagnie Nationale du Rhône, Electricité et Gaz d’Algerie, Gaz de France, and other private enterprises, both French and foreign). The laboratory is allowed to accept any research which is within the scope of its activities, regardless of its origin.

The particular studies can be subdivided into the following sections:

1. Maritime work
2. River training for interior navigation and for flood control
3. Hydroelectric and tidal schemes
4. Thermal and nuclear power stations
5. Various studies concerning the circulations of fluids.
FIGURE 45. National Hydraulic Laboratory, Chatou, France, is located on an island in the Seine River. (Photo courtesy National Hydraulic Laboratory.)
Although the first costs of construction of buildings and purchase and installation of equipment were defrayed by the two founder organizations, the Ministere des Travaux Publics and Electricité de France, the costs of continuing development of the research facilities are defrayed by the "clients" who have ordered that work be undertaken. Expenses are divided in such a way that the annual expenditures account is balanced so that the laboratory shows no loss nor gain. In fact the laboratory is forbidden by statute to make any profit.

Another interesting characteristic of the laboratory is that it is completely free from any commercial interests. Research projects are in no way secret and any new discovery made at the laboratory is immediately made public unless, of course, the organization which has financed the particular scheme has expressed the wish that it be kept secret.

Occasionally the laboratory receives more financial aid than required to conduct a study. The extra money is then used to provide solutions to hydraulic problems not only in France but also in all countries of her Communauté, and sometimes for foreign institutions who may ask for aid. In addition to activity in the field of hydraulic research, the laboratory has taken upon itself the task of training both French and foreign engineers. To this end it accepts numerous students for post-university training and technical assistance to foreign countries.

In addition to the National Hydraulic Laboratory various other departments are housed on the isle of Chatou. These are connected with the study of hydraulics and are subject to supervision by the Direction des Etudes et Recherches de l'Electricité de France.

The following is a list of these departments:

1. The "Departement Essais" which is mainly concerned with measurements in the field to determine the efficiency of hydraulic turbines, and determining the head loss in diversion works; operating an experimental station for scale model tests of turbines.

2. The "Service des Etudes Hydrauliques" which includes the department "Etudes Générales." Here studies are made on heat transfer particularly inside atomic piles, structural studies, mechanical engineering, hydrology, and wind power.

On my visit to the laboratory, I was greeted by M. Georges Guillot (Capitaine de Frégate) the Director of the Hydraulic Laboratory. I was also introduced to M. J. Chabert, who was responsible for the technical studies. M. Jacques Danion, a hydraulic and electrical engineer, served as my guide for a tour of the laboratory. M. Danion spoke excellent English and proved to be a very capable guide.

Many of the studies in the laboratory consisted of harbor models; the purpose in each case was to improve the harbor facilities, increase the docking area, or to provide better protection from waves or sediment deposition. The first model I was shown was a model of the famous Dunkirk Harbor, Figure 46. The model was some 100 feet square and contained all of the existing harbor facilities. Because some new factories have been built which need dock area, the harbor was being enlarged, and it was desired to provide better wave protection to the ships moored in the harbor. Wave producing machines were used to produce storms of record, and the wave machines were rotated and moved through the model to produce the effect of a storm passing by. The new protective devices developed were ordinary breakwater walls but the unique arrangements produce the desired effect within the harbor. "Tetrapods" were being used for breakwater wall protection, and were being manufactured in model sizes in the shop adjacent to the model. The laboratory at Grenoble, France, SOGREAH, holds the patents on these Tetrapods, and I was told that the royalty charges are $1.40 each for the 2-inch size. Hundreds of tetrapods are often used in each model.

Another model of interest was the Nice River Model constructed to a scale of 1:200 horizontal and 1:150 vertical. The purpose of the model was to determine the rebuilding that would be necessary to construct a new highway along the river banks. Certain bridges and other structures were producing a backwater effect and flooding of the proposed highway area. The model contained a movable bed made from crushed apricot seeds having a density of 1.33. The model was well instrumented so that permanent records of the tests
FIGURE 46. Left to right at Dunkirk Harbor model; M. Jacques Danion, Engineer; M. Georges Gruillot, Director of the Laboratory, and Sr. Eduardo Basso, Chile, who accompanied the author on a tour of the hydraulic laboratory. (National Hydraulic Laboratory, Chatou, France.)
were put on paper tapes and charts, and the various effects could be integrated by engineers making calculations. Coefficients of flow for various critical areas had already been determined for various floods and backwater effects.

I saw many other models which contained movable beds, and which used various types of bed material, Figure 47. In one model, polystyrene, 1.04 density, was being used and was in the form of cylinders, 1/16 to 18 inches long, extruded through a 1/16-inch-diameter die. In another model, a much finer plastic material was being used because the critical velocity (the velocity necessary to start the movement of the bed material), is only 4 centimeters per second. This material was being used in a movable bed model which reproduced the area adjacent to an atomic powerplant on the Loire River. Some of the problems here had to do with the effects of warmer water in a narrow portion of the channel.

There were hydraulic models contained in some of the other buildings in the Chatou Laboratory complex. I saw models in concrete flumes, one of which was 5 by 5 feet in cross section and 165 feet long.

One entire side was constructed of glass to allow observation of tests on breakwaters and other structures. Beach profiles could be reproduced in sand, gravel, polystyrene, or bakelite. The glass panels were 3 by 5 feet, 3/4-inch-thick plate glass, and were set in "aquarium cement." I saw two flumes roughly 3 by 3 feet in cross section and 100 feet long containing glass panels 3 by 5 feet. One of these flumes was an automatic tilting flume.

In another area, I saw some studies being made to determine the force on a block submerged in a flowing stream, Figure 48. The purpose of the test was to determine the force on a pier which was to be set in a river and used for the construction of a bridge. The model block was made of brass, and was hollow so that it could be filled with water. The block had four points of bearing on the flume bottom, and provisions were made for measuring the tilting or sliding characteristics of the block. In making a test, the water was kept flowing past the block, and water was siphoned out of the block until the block either overturned or slid along the bottom.

In another facility tests were being made on a model siphon to determine priming characteristics and discharge coefficients, Figure 49.

I visited one of the buildings devoted primarily to mechanical engineering problems, and was shown a calibration flume which is also used by the hydraulic laboratory. This flume was very impressive because of its quality construction. It was 5 feet wide, 8 feet deep, and had a useful length of something over 100 feet. The top of the flume contained carriage rails which had been carefully adjusted for elevation and horizontal alignment. There was a motor-driven carriage which was in place on the rails and which could be driven at practically any speed along the flume. The device had been constructed particularly for the calibration of low velocity flowmeters. Also in this building, were many mechanical engineering projects along with nuclear projects associated with powerplants and power sources.

During one of our passages between buildings on the island, we had occasion to see and inspect the Chatou Dam, at the left in Figure 45. This dam is adjacent to the laboratory complex and is utilized for maintaining navigation depth on the Seine River. The dam was built in 1935, and has three spillway gates which were lowered sufficiently that water was discharging over the tops of all gates. This relatively new dam replaced an earlier structure on the river which was a very simple design and which did not always maintain the required navigation depths.

Before I left the United States, I was told that very little detergent was available in certain areas in France. After looking at the Seine River, I was convinced that this was not a detergent-shy area, because as far as the eye could see, there was an expanse of detergent foam much like we see on the rivers in the United States, Figure 50. My guides, M. Danion and M. Gruillot, told me that this was beginning to be a serious problem in France as it already is in the United States. Detergent foam is already contaminating some of the water supplies in the area. I told them that I had seen a new article stating that a break-through had been made by chemical engineers in the United States, and that
FIGURE 47. River model used to study movement of sediment, represented here by powdered plastic and plastic pellets. Plastic batts are used to form islands. (National Hydraulic Laboratory, Chatou, France.)
FIGURE 48. Force necessary to tilt or slide the rectangular block set in the flowing water is being measured. Block represents a bridge construction problem. (National Hydraulic Laboratory, Chatou, France.)
FIGURE 49. Transparent plastic siphon model used in irrigation studies. (National Hydraulic Laboratory, Chatou, France.)
FIGURE 50. Foam from "hard" detergents in Seine River downstream from Chatou Dam (see Figure 45) is a problem, as it is in the United States. Per capita use of detergents in certain areas of France is approaching the "billion pounds per year" use in U.S.A.
they had developed low-cost detergents which would break down under bacterial action, much as soap does in a natural stream. Use of this type of detergent, which should be available commercially in about 1 year, would eliminate the foam problem which is now beginning to become acute.

During my tour of the Chatou Laboratory, I was accompanied by Sr. Eduardo Basso, Head, Hydrology Division, ENDESA, Santiago, Chile, Figure 46. Sr. Basso had also attended the IAHR meeting in London and was making a tour of European laboratories. His concern was mostly with the hydrology group, but he did make a tour to see some of the models in the laboratory.

At noon, the laboratory staff drove us to a restaurant, some distance from the laboratory, for lunch. Those in attendance were M. Georges Gruillot, M. Pierre Gerlier, M. Jacques Danion, M. J. Chabert and his wife, Sr. Eduardo Basso and his wife, and myself and wife. This luncheon was the equivalent of a full course banquet and included many French delicacies ordered especially for the group by M. Gruillot, a true gourmet.

Late in the afternoon, we returned to the laboratory offices and sat around a long table to hold discussions on various hydraulic problems of mutual interest. This is where I learned much of the history of the laboratory, of their association with Electricité de France and of their overall policy. My hosts were very cordial, extending an invitation for me to return or to have Bureau personnel visit them at any time. They gave me several booklets containing information on previously made hydraulic model studies and a list of their publications; these are reproduced in Appendix VIII.
On Thursday, September 12, I traveled by rail from Paris to Grenoble by way of Lyons, a 7-hour ride. There is no commercial airport in or near Grenoble. Grenoble is located in the French Alps, and in making the trip, it is necessary to change trains in Lyons, from an ordinary railroad train to a special train equipped with locomotives capable of climbing the steep grades into Grenoble. On the return trip, no change is necessary because the regular locomotive can coast downhill.

On Friday, September 13, I spent the whole day in the SOGREAH laboratories, not only in making a tour of the facilities but in talking to their excellent personnel about subjects we are investigating in the Bureau of Reclamation laboratories in Denver. Upon my arrival at the SOGREAH Laboratory, I was met by M. Regis Delaborde, Chief of the Department on Model Studies. M. Delaborde was the engineer who took care of the needs of Mr. C. W. Thomas, of this office, when he studied in Grenoble several years ago. M. Delaborde was very business-like in his greetings, and asked first of all who in their organization I would like to talk to. Not being familiar with the specialized personnel in their organization, I told M. Delaborde of the subjects I would like to discuss, and he made arrangements for their specialists to come to the conference rooms singly or in small groups so that we could discuss the problems I had mentioned. Later in the day, after the discussions were completed, Mr. C. V. Gole, Director of the Central Water and Power Research Station, Poona, India, joined our party for a tour of the laboratory. Mr. Gole formerly was a foreign engineer trainee in Denver for 1 year, 1950 to 1951, and worked under my supervision in the hydraulic laboratory for about 3 months. Mr. Gole remembered his training in the Bureau, and without prompting, volunteered the information that he was the Director of the Poona Research Station because of his training with the Bureau. I felt somewhat complimented because I had been responsible for some of his hydraulic training.

I could not meet M. Pierre Danel, President of SOGREAH, or M. Francis Biesel, Director of Science, since they were out of town. Both Messrs. Danel and Biesel were present at the IAHR meeting in London, however, and I had ample opportunity to talk to them there. In fact, it was through these gentlemen that I arranged for my visit to Grenoble.

The name SOGREAH is an acronym formed from the longer name, Societe Grenobloise d’Etudes et d’Applications Hydrauliques. The company is a joint stock company engaged in engineering consulting and research, with a capital of $2,000,000. The head office is in Grenoble, but there is a suboffice in Paris. The laboratories employ over 1,100 people including 320 qualified engineers, 380 technicians, 165 industrial employees, and 280 people of various qualifications in the company’s agencies located in 70 different countries. The facilities in Grenoble include an extensive area of design offices, hydraulic laboratory, and hydraulic research facilities covering some 600,000 square feet. There are in addition facilities for soil mechanics and soil and water analysis laboratories, an electronics calculations center utilizing IBM 7070 and 1401 computers, test facilities for hydraulic machines and industrial plants, and a very large technical laboratory.

The SOGREAH Laboratories were formed in 1955, and took over the activities of several other organizations including the one probably best known and commonly referred to as Neyrpic. Neyrpic still exists as a part of SOGREAH but its work is devoted only to the design and sale of hydraulic turbines.

SOGREAH is still mainly concerned with hydraulics and the associated subjects of fluid mechanics and thermodynamics. The company acts both as a firm of engineering consultants and as a study and research center, and it is largely to this combination of two different activities that SOGREAH owes its vitality and progressive outlook.
SOGREAH assists public authorities or important private firms both in France and other countries in implementing economic development projects (e.g., hydroelectric, river, maritime, harbor, agricultural, and general industrial schemes). The company's participation in a project of this kind may cover all or any of its various stages (e.g., stating an initial opinion, collecting basic data, working out preliminary and final projects, and assistance in implementing the project), as well as considering any economic and financial factors required in assessing the profitability of a given development plan.

The fields of activity encompassed by SOGREAH include hydroelectric and river projects, agricultural development projects, water supplies and water purification including sewage problems and demineralization of drinking water, maritime development projects including theoretical and scale models of hydraulic problems associated with harbors, coastal protection, and navigation, sea energy including various ways and means of harnessing the energy of the sea, hydrology, hydrography, and climatology. Other interests are in the industrial fields and include applied industrial research of every type including nuclear engineering, research in the paper industry including the hydraulics and fluid mechanics problems in paper pulp making and transporting, hydromechanics research and hydraulic machinery testing including cavitation in machines on hydraulic structures. The work also extends into some unrelated fields such as scientific research in applied mathematics, nutronics, and other problems; economic studies having to do with financing, profitability, feasibility, and other complications resulting from finance difficulties or problems, wind power to determine the aspects of harnessing the wind to accomplish work, the design of laboratory test equipment, and finally, in the field of surgery. In this latter category, teams of hydraulic engineers are working with surgeons to determine the applications of hydraulics and thermodynamics necessary to study or possibly reproduce the circulatory blood system in human beings or animals.

The Hydraulic Laboratory has a staff of over 200 people of whom about one-third are engineers. The laboratory is divided into 6 departments which are classified as:

1. Scientific and power problems
2. Hydraulic Laboratory for river and maritime problems
3. Scale model machines (turbines, pumps)
4. Engineering project planning and design
5. Architectural land development, reclamation, irrigation
6. Industrial applications (materials laboratory, pipe transition).

Of these, the Architectural Department (5) is the largest.

The first technical interview I had with an employee of SOGREAH was with M. Francois M. P. Bazin, Head, Hydrology Services. My purpose in talking to M. Bazin was to obtain his reactions and get his comments on the Wellton-Mohawk Gila Valley salt-water problem. Hydraulic model studies are being made in our Denver laboratory to determine the various factors involved in flushing salt water from a two-layer aquifer. This problem is of primary concern in that the water being pumped from the Gila Valley drains into the Colorado River is too salty to re-use. The riverflow at certain times of the year is too low to dilute the drain water and farmers in Mexico cannot use the river water for irrigation. They have complained bitterly to the United States about this and have demanded better quality water. I explained this whole problem to M. Bazin, and drew sketches on a blackboard, to indicate the problem and the methods of solution we have chosen to investigate. I also gave him a resume of the model test results which are explained in detail in our hydraulic laboratory reports on the subject. I asked M. Bazin, who has had considerable experience with ground-water problems and flow in porous media, what other steps he would take, or suggest that we take, in trying to solve the many facets of this problem. He said he felt that we had done all we could in this model and that continuing the explorations along the lines I had explained to him would eventually lead us to usable answers.

He suggested, however, that we try to solve the problem using a Hele-Shaw model. This model consists of two sheets of glass or transparent plastic separated by a very narrow space which is filled with water or light oil. The movements of ground water
(or any type of laminar flow) can be represented to some degree in a model of this type.
I told M. Bazin that we had already made arrangements to have studies made at Colorado
State University using their Hele-Shaw model to investigate salt-laden aquifer problems
and that the personnel there were familiar with these techniques. However, we would
welcome any comments he might have regarding the operation of this model and the inter­
pretation of the results. M. Bazin said that the temperature of the water used in a Hele­
Shaw model was very critical and could greatly affect the results obtained. He suggested
that the model be tested in a constant temperature room and preferably in a constant hu­
midity room. He said he prefers to use a light lubrication-type oil in the model because
it is less sensitive to small temperature and humidity changes.

M. Bazin then volunteered the information that investigations might also be made using
an electronic analog. He said that he had solved many problems of this nature using
carbon-coated paper instead of a liquid electrolyte. I reminded him that in our problem
we had a two-layer aquifer, that each layer had a different permeability and that in the
analog the permeability would need to be represented by the conductivity or resistance of
the paper. M. Bazin said that he thought two kinds of paper, each having a different con­
ductivity, could be used and that a careful selection of the proper types of carbon paper
would result in a proper relation of permeabilities. I asked him if he knew where to ob­
tain papers of this type and he gave me the following addresses. He said that each of the
manufacturers had a selection of paper from which the exact relation of resistivity could
be selected:

1. Western Union Telegraph Company
   Development Research Department
   60 Hudson Street
   New York 13, New York
   USA

2. Renker-Belipa
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Another subject in which I had indicated interest had to do with discharge measure­
ments using dilution or isotope methods. M. Gilbert Mougin, Head, Hydrological Studies,
was brought into the conference room for discussions on this subject. I explained to
M. Mougin my interest in discharge measurements and indicated to him the work we were
doing. I told him about the canal capacity problem in the Bureau and about the radioiso­
tope discharge measurements we were making in Region 3, out of the Boulder City Office
in cooperation with Research Division personnel. I told him that we were interested in
eventually making measurements in closed-conduit systems, but at the moment our expe­
rience was in canals, and that we were trying to develop techniques in open channels that
could be applied to closed conduits. M. Mougin said that SOGREAH was not using radioi­
sotopes except in harbors to study flow currents and the directions and quantity of sedi­
ment transport. He said they were doing work in measuring stream discharges using
chemical dilution methods, however. In fact, he said that the SOGREAH Laboratories
manufactured equipment for making these tests and that they could supply equipment (for
sale) for this purpose, Figures 51, 52, and 53. He said that they had not been successful
in making discharge measurements for flows over about 3,000 cubic feet per second, but
that for smaller discharges they could practically guarantee their answers to within 5 per­
cent. One provision was that the equipment had to be used in streams rather than in canals.
He said that, in their experience, there was not sufficient turbulence in ordinary canals to
provide proper mixing of the tracer with the canal water. In natural streams, the rough
bottom and banks and the steeper slope provide turbulence to mix the chemicals vertically
and laterally with the stream water.

In most of the SOGREAH tests they used potassium dichromate as the tracer and the
centration was approximately 200 litres of solution for each 2,000 cubic feet per sec­
ond. The solution contained 100 grams of potassium dichromate per litre. I questioned
FIGURE 51. Making discharge measurement using chemical dilution method and SOGREAH equipment. Chemical solution is mixed in drums on bank, fed to hopper, and ejected through openings in long pipe extending over stream. (Photo courtesy of SOGREAH Laboratory, Grenoble, France.)
FIGURE 52. Hopper is designed to produce constant-head ejection of chemical solution into stream for discharge determination. (Photo courtesy of SOGREAH Laboratory, Grenoble, France.)
FIGURE 53. Sampling stream water containing diluted chemical tracer. Analysis of sample gives discharge of stream. (See Figures 52 and 53 also.) (Photo courtesy of SOGREAH Laboratory, Grenoble, France.)
M. Mougin regarding required mixing lengths, and I got the feeling that he was not particularly concerned about this, which we have found to be the most important variable in our Region 3 isotope tests. In our tests we have been unable to get mixing to the degree necessary for accurate discharge dimensions, regardless of the mixing length used. M. Mougin said that in a stream flowing about 1,500 cubic feet per second he selects a sampling point about 900 feet downstream from the injection point and always obtains a satisfactory discharge measurement. The SOGREAH equipment is arranged to distribute the chemical over approximately one-half of the stream width by dribbling it on the water surface, Figure 52. Under these conditions, he emphasized, the stream must be turbulent. He said this method and equipment would not work in a canal he investigated in Morocco. He said he had used wire fencing in the canal to create turbulence to help mix the chemical with the canal water, but that this was not entirely or always successful.

He said he tried, whenever possible, to obtain a concentration at the sampling point of about four parts of chemical per 1,000 parts of water. He felt, however, that he could detect one part of chemical in 1 million parts of water, but that he was not always sure. He stated, as did NEL Laboratory personnel in Scotland, that it was easier to detect a small quantity of tracer than to measure that same quantity accurately. (The accuracy of the discharge measurement is directly related to the accuracy of the measurement of chemical.)

During this discussion Messrs. L. Poutevegne, S. Ollier, and A. Michel, from the Instrumentation Section, SOGREAH, joined us. Their main purpose in entering the discussion was to ask questions regarding the progress of the Denver laboratories in instrumenting their studies on closed-conduit discharge measurements. After I told them the status of our equipment, the degree to which it had been used, and stated that we had not performed any closed-conduit tests, they left.

At this point Mr. Sultan Alam entered the conference room and introduced Mr. C. V. Gole from India, who had just arrived from Paris. Mr. Alam spoke excellent English and explained that he was to be my guide on a tour of the laboratory facilities. He explained that he was originally from Pakistan and had come to France to study hydraulics. He liked France and decided to go to work for SOGREAH. He has been on the staff for several years.

Our tour (I was accompanied by Mr. Gole and my wife), started in some of the older buildings of the laboratory complex and I recognized the test flume where studies had been made on a sectional model of a breakwater and the tests had been filmed and made into a sound movie containing electronic sound effects to characterize the waves striking the breakwater. This is probably the most famous motion picture made by the SOGREAH Laboratories and has been seen by many people around the world.

Mr. Alam explained that the main building of the laboratory was originally a turbine laboratory, but that since 1923 the main use of the building has been to house river models of various kinds. During the war years the building was used extensively to investigate preventive procedures which might have to be used if dams were blown up on the Rhône River as an offensive measure by the enemy. After the war the facilities were again modified to make it possible to use the laboratory for all types of problems.

One of the first operating models I saw was a module constructed with an automatic control for dispensing irrigation water from the ditch to a farm, Figure 54. The flow passed through an orifice with its top boundary so arranged that as the head became larger, the contraction of the orifice jet became greater. This increasing contraction reduced the vena contracts flow area and the discharge to compensate for the increase in flow which otherwise would have resulted from the larger head. Thus, the device tended to provide a constant discharge under a wide range of operating heads and there would be no need for a ditch rider to adjust the turnout discharge for a change in canal level.

Adjacent to this model was a display of devices manufactured by SOGREAH and sold throughout the world for use in irrigation systems. These included divider boxes of several kinds, and a variety of automatic gates which provided either upstream or downstream flow control. In one type the radial gate was equipped with a float which was mounted on the upstream skinplate. The float moved the gate up or down with the water level and tended to maintain a uniform upstream water level in the canal. In another type the float was mounted on the downstream side of the gate to maintain a uniform gate opening or a
FIGURE 54. Module for measuring and dispensing irrigation water at a farm turnout. Contraction of the issuing jet increases as the head increases, tending to provide a constant discharge. (SOGREAH Laboratory, Grenoble, France.)
constant discharge. Also in this display was a partialized siphon similar to one we developed in our Hydraulic Laboratory, some 10 years or more ago. The partializing device makes it possible to operate the siphon continuously at less than the maximum or priming discharge. In fact, the device used in the Bureau laboratory development seemed to me to be superior to the one used in the SOGREAH siphon. However, Mr. Alam explained that their purpose in partializing siphons was not only to change the discharge characteristics but, also, to relieve cavitation tendencies which are inherent in large siphons at near-maximum discharges. He said that the model I saw had been used to aid in the design of large siphons of up to 4,500-cubic-feet-per-second capacity. We do not use siphons which have cavitation tendencies.

Another model of interest, because the problem solved was similar to one we encounter in Bureau work, was the "Barrage de Daourat," in Morocco, constructed to a scale of 1:60. The head on the spillway gate, 66 feet, had produced severe cavitation damage in and around the gate slot and on the downstream crest. Extensive scour and erosion had undermined the stilling basin apron and a big piece of apron was missing. As a result of the model tests, the spillway crest had been reshaped to eliminate cavitation tendencies and the apron was to be repaired to eliminate future maintenance costs. The capacity of this spillway was about 900,000 cubic feet per second (for three gates).

A very interesting study, somewhat different from any I had ever seen, was a sectional or two-dimensional model of part of Sylt Island, Germany. This island is being eroded by waves to such a degree that in the near future the island may cease to exist. A study was being made to find ways to prevent the movement of beach material as a result of wave action. After trying to reproduce the observed prototype wave damage in the model without full success, the waves produced by a displacement type of wave generator were analyzed. It was believed that the characteristics of the model waves were quite different from natural waves, and it was, therefore, decided to produce waves in the model as they are produced in the prototype, by means of wind. Accordingly, a blower was set up to produce waves which could be directed, normal to the shoreline or at any angle. A study of these wave characteristics and wave effects showed the waves to be reliable model waves. After this modification the model results more closely reproduced the prototype actions of record, and it was decided to construct a large three-dimensional test facility to further refine the test procedures. In another building they had built a covered model with the roof or cover perhaps 1 foot above the water surface, so that air could be blown over the water surface (under the roof) to produce the waves which broke on a beach about 200 feet long. I was told that the airwave tests were producing very satisfactory results and that prototype conditions could be reproduced almost exactly. Preventive devices were also being investigated to reduce the possibility of losing the island.

A 1:50 scale sectional model was used to study the stability of a proposed breakwater in the Port de Gijon in Spain. Waves 30 feet high were expected to strike this breakwater wall, Figure 55. The stone blocks to be used to construct the breakwater are tremendous in size and vary in weight from 5 to 25 tons each. Different zones within the breakwater cross section use different sizes of stones. Literally thousands of these blocks will be required to produce even a short length of breakwater. In addition, the outside face of the breakwater will be covered with "tetrapods" of 40 tons weight and thousands of these will be required. The purpose of this breakwater, of course, is to protect the harbor from storm-produced waves.

Exhibited in connection with this sectional model was a small (6 by 8 feet) tabletop model which was cleverly conceived to show the overall value of a breakwater in a harbor. The model could be operated by the observer. When a button was pushed, a wave-producing device created waves which caused water surface disturbances throughout the harbor. After about a minute a breakwater slowly rose out of the water automatically and the extent of improvement in harbor conditions (smooth water surface) could be seen by the observer. The breakwater retracted and after several minutes the wave machine stopped and it was necessary to push the button to reactivate it.

I saw an assortment of models which had to do with navigation problems, including navigation locks and hydraulic filling systems, guide walls for navigation locks, perforated guard walls, and wave-reducing booms such as are used by the Tennessee Valley Authority on their river dam locks. Another model of interest was a spillway model which was part of a pumped storage system which had been built in southern France, Figure 56.
FIGURE 55. Port de Gijon, Spain, breakwater design, 1:50 scale. Waves 30 feet high are expected; stones and "Tetrapods" weighing up to 40 tons each will be used in the full size structure. (SOGREGH Hydraulic Laboratory, Grenoble, France.)
FIGURE 56. Spillway model with powerplant on left; part of pumped storage scheme developed from hydraulic model tests. Model is in mill-type building with one side removed, Figure 60. (SOGREAH Hydraulic Laboratory, Grenoble, France.)
Following these inspections I walked through building after building containing models and hydraulic test setups of all kinds. I gained the impression that the hydraulic models in the SOGREAH Laboratories are never torn down. They are built, modified, tested, and left in place in the hope that they may be used again in the future. Some of the buildings were very large, for example 300 feet square, and appeared to be of semipermanent construction. Other buildings were more permanent in nature and housed test equipment such as flumes and tanks which were being re-used over and over again.

In one of the outside buildings, which had a roof and two ends, was a spillway model with a tunnel flip bucket that resembled our Trinity Dam spillway bucket, Figure 57. This bucket, the subject of a technical paper, was developed in the Denver hydraulic laboratory under the supervision of the author. The SOGREAH bucket was similar in that it was self-draining and had a discharge pattern similar to the patterns believed to be best for Bureau structures. I had the distinct feeling when viewing this spillway bucket that the recommendations made in the Bureau Hydraulic laboratory writings on this subject had been closely followed. The model was built to a scale of 1:53 and the bucket was capable of discharging about 100,000 cubic feet per second.

Another model of interest was the Kariba Dam spillway in Africa, Figure 58. This dam has the world's largest reservoir. The spillway is about 300 feet high and discharges 500,000 cubic feet per second. The scale of the model was 1:110, a somewhat small model by our standards. The spillway model was only about 3 feet high. In comparison, our Morrow Point spillway model, which is currently in the laboratory and resembles the Kariba Dam spillway, is about 15 feet high. Kariba Dam and Morrow Point are similar in that in both designs spillway gates are located near the top of the dam which discharge jets of water through the air into the river below. At Kariba Dam very little effort was made to reduce scour where the jets impinge on the river bottom and the model tests had indicated that very large scour holes would occur as a result of flood discharges. At Morrow Point Dam, on the other hand, a large, secondary dam downstream from the main dam will be constructed to create a tailwater pool into which the spillway jets will discharge. The Morrow Point model has indicated that much less scour will occur under these latter conditions.

During a break in the tour of the laboratories I was taken to lunch in a nearby restaurant which served excellent food in a relaxing atmosphere. M. Edmond E. Chapus, President of Neyrpic, Incorporated, who has his home in New York City but spends about half his time in Grenoble, was my host. His main concern is the selling of turbines and other hydraulic equipment in the United States. Mr. C. V. Gole, Director of the Central Water and Power Research Station, Poona, India, Mr. Sultan Alam, M. Regis Delaborde, M. Pierre DeBony de la Vergne, M. Francois Bazin, M. Gilbert Mougins, my wife, and I lunched together in typical French fashion. The "lunch" consisted of multiple courses served by boys in training to be headwaiters, and lasted well into the afternoon.

Following the luncheon I returned to the SOGREAH Laboratories' Conference Room and had final discussions with several of the members of the Hydraulic Laboratory staff. At this time, I asked many questions and obtained the information which is contained in the first paragraphs of this writeup of my visit to Grenoble. Early in the evening I walked to the end of their laboratory complex to see some of the buildings I had not seen in the earlier tour. I was quite impressed with the extensive layout of the SOGREAH Laboratories, Figure 59.

The entire staff issued a cordial invitation to all Bureau people to visit their facilities and to consult with them at any time regarding mutual hydraulic problems. They were a most cordial group and indicated that they would, when possible, pay a visit to the laboratories in Denver.
FIGURE 57. Spillway bucket, scale 1:53, used on Serre Poncan Dam, discharging about 100,000 cubic feet per second. The bucket is very similar to the one developed in Denver for Trinity Dam spillway. This dam retains Europe's largest reservoir. (SOGREAH Hydraulic Laboratory, Grenoble, France.)
FIGURE 58. Kariba Dam (Africa) spillway model, scale 1:110, discharging a nominal flow. Spillway capacity is much larger, 500,000 cubic feet per second. (SOGREAH Hydraulic Laboratory, Grenoble, France.)
FIGURE 59. General view of some of the buildings, temporary and permanent types, used to house hydraulic models. (SOGREAH Hydraulic Laboratory, Grenoble, France.)
Appendix I

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Appendix II

CATALOG
OF EXHIBITS--IAHR
LONDON 1963


3. "Cooling Water Intakes for Sizewell Power Station," model testing has enabled the optimum design of the intakes to be determined. The British Hydromechanics Research Association, South Road, Temple Fields, Harlow, Essex.

4. "Multiple Syphon Draw-off Tower." The suitability of a multiple syphon draw-off tower for use at Tryweryn Reservoir has been assessed by testing various models. (Delegates will have an opportunity of seeing the actual draw-off under construction during the Welsh tour.) The British Hydromechanics Research Association, South Road, Temple Fields, Harlow, Essex.


6. "Dry Weather Flows of the Kaduna River." A model has been used to predict the calibration of a rough gauging weir formed by trimming natural rock rapids. The British Hydromechanics Research Association, South Road, Temple Fields, Harlow, Essex.

7. "Surge Effects in Pipes." A demonstration of various characteristics associated with the operation of pipelines and, in particular, those concerning pipe elasticity. The British Hydromechanics Research Association, South Road, Temple Fields, Harlow, Essex.

8. "Propeller Current Meter." Miniature current meter for laboratory use. There are three sizes of measuring head (4, 10, and 20 mm rotary) together with associated electronic equipment. Department of Scientific and Industrial Research, Hydraulics Research Station, Wallingford, Berkshire.

9. "Water Level Transmitters and Recorders." (1) An 8 in. water level transmitter plus digital recorder (2) a 2 in. water level transmitter (3) a 0.3 ft water level measuring instrument plus graphical recorder. Department of Scientific and Industrial Research, Hydraulics Research Station, Wallingford, Berkshire.

11. "Hydraulic Research Laboratory." The model illustrates the Hydraulic Research Laboratory, including facilities available for turbine and pump testing and for flow measurement. Department of Scientific and Industrial Research, National Engineering Laboratory, East Kilbride, Glasgow.


19. "Wellhead Oil Turbine." Manufactured by J. and S. Pumps Ltd. of Horley, Surrey, turbine supplied by Gilbert Gilkes & Gordon Ltd., of Kendal. The generator has an output of 300 watts and is powered by a mixture of oil and gas flowing from the oil well. Gilbert Gilkes & Gordon Ltd., Kendal, Westmorland.


22. "Siemen's Patent Balance Meter." Invented by Charles William Siemen and developed by Guest & Chrimes, Rotherham, around the year 1850. Guest & Chrimes Ltd., P.O. Box No. 9, Rotherham.

23. "Submersible Electric Pump," 475 h.p. submersible electric pump wound for 6,600 volts A.C. 3 phase 50 cycle supply. Capacity: 3.5 million gallons per day (16,000 cubic metres per day) against 430 feet (131 metres) head. Hayward Tyler & Co. Ltd., P.O. Box 2, Luton.

24. "Glandless Pump." Totally enclosed glandless electric pump for petroleum and chemical applications where no leakage can be tolerated. Hayward Tyler & Co. Ltd., P.O. Box 2, Luton.


29. "Unipulse Meter." Liquid metering and dispensing by the Unipulse meter. Suitable for remote control of liquid batch dispensing of gallon quantities to within 0.01 gallon. Parkinson Cowan Measurement, Terminal House, Grosvenor Gardens, London S.W.1.

30. "Industrial Stop Valves." Two original tracings, circa 1870, showing Rhodes Patent stop valves in the one inch size. B. Rhodes & Son Ltd., Danes Road, Romford, Essex.

31. "Ball Plug and Diaphragm Valves." The exhibit consists of two sectioned valves, a straight-through diaphragm valve and a ball plug valve. Saunders Valve Co. Ltd., Cwmbran, Mons.


33. "Original Impeller of the Appold Centrifugal Pump." Installed at Whittlesea Mere in 1851 for fen drainage. It is four feet six inches in diameter and delivers 15 thousand g.p.m. against four and a half feet head. Science Museum, Exhibition Road, Kensington, London S.W. 7.

34. "Centrifugal Pump Impeller--1887." Impeller from Professor Osborne Reynolds' first multi-stage turbine centrifugal pump with guide vanes in the discharge passages. The first turbine pump had four stages and was patented by Reynolds in 1875. (Property of Mather & Platt Ltd.) Science Museum, Exhibition Road, Kensington, London S.W.7.

35. "Model of Thomson Vortex Turbine." Thomson's Vortex turbine, British Patent No. 13,156, 1850, was a low head specific speed, double discharge, inward flow turbine with four fixed or adjustable guide vanes. Relatively high efficiencies were obtained even with small machines. Science Museum, Exhibition Road, Kensington, London S.W.7.


38. "Canvey Island Liquid Methane Terminal." This is an artist's impression including actual engineering drawings of plant layout and pumps at the Canvey Island Liquid Methane Terminal, the first of its kind in Europe. Sigmund Pulsometer Pumps Ltd., Team Valley, Gateshead, 11.


41. "Smeaton's Apparatus." The reconstruction of the apparatus used by John Smeaton (1724-1792) for his classic series of tests on model water wheels. University of Durham, King's College: Department of Mechanical and Marine Engineering.

42. "Contributions of Reynolds and Hele-Shaw to Hydraulic Research." Teaching apparatus to illustrate laminar and turbulent flows and the behavior of an inviscid fluid by analogy with laminar flow. University of Leicester: The Engineering Laboratory; Techquipment Limited, Clinton House, 2A Sherwood Rise, Nottingham.

43. "Hydraulic Brake Dynamometer." The modified Froude type as developed by Osborn Reynolds. University of Manchester: Engineering Laboratory.

44. "Reynolds Tank." The original tank as used by Osborn Reynolds to demonstrate laminar and turbulent flow in pipes--1883. University of Manchester: Engineering Laboratory.

45. "'Ferret' Detector." An electro-magnetic beacon and detector for monitoring the position of a cleaning "ferret" traveling in a buried water main. The Water Research Association, Ferry Lane, Medmenham, Marlow, Bucks.


Appendix III

ABSTRACTS OF PAPERS PRESENTED AT 10th IAHR CONGRESS
L'assainissement des "basses plaines" dont l'exutoire est soumis à l'action des marées nécessite des études assez complexes si l'on veut concevoir des ouvrages parfaitement adaptés et économiques. Ces études risquent alors d'entraîner des dépenses trop élevées en regard du coût des travaux et de l'accroissement du revenu brut agricole que l'on peut espérer.

Cette communication présente une manière de procéder pour évaluer l'efficacité de clapets ou de portes à flots déjà existants ou pour rechercher le dimensionnement optimal de ces ouvrages lorsqu'ils sont à projeter.

Les données du problème à résoudre sont les conditions de submersion admissibles pour les cultures, les débits entrant dans le marais liés aux pluies, les enregistrements limnigraphiques dans l'estuaire à l'aval immédiat de l'ouvrage et la topographie du marais.

Une méthode graphique permet de contrôler la variation du plan d'eau dans le marais une fois choisies les données du problème et fixées à priori les caractéristiques de l'ouvrage. Par tâtonnement il est possible ainsi de définir les caractéristiques de l'ouvrage pour les données les plus défavorables. Cette méthode suppose déjà certaines approximations.

On peut ainsi apprécier l'efficacité de clapets ou de portes à flots dans un certain nombre de cas simples. Pour des cas plus compliqués, on est obligé de faire des simplifications importantes et nous essayons seulement ici de proposer les hypothèses simplificatrices les plus justifiées.

THE EFFECTIVENESS OF TIDE AND FLOOD GATES CONNECTING WITH TIDAL ESTUARIES

The drainage of low-lying flat land with its outlet subjected to tidal action is a problem involving fairly complex studies if really suitable economical structures are to be designed. Such studies are liable to prove inordinately expensive compared to the cost of building the structures and the overall agricultural return to be expected from the project.

This paper describes a procedure whereby the effectiveness of existing tide or flood gates can be assessed or the optimum dimensions of gates in a new project determined.

The data required for the problem include the permissible submersion conditions for the crops, inflows into the marshland due to rainfall, stage recordings in the estuary at a point immediately downstream of the gate, and the topographical features of the marsh to be drained.

Once the design data have been chosen and preliminary structural characteristics have been decided upon, the water level variations in the marsh can be checked by a graphical method and the gate characteristics for the worst possible conditions determined by trial-and-error.

Despite the approximations in this method, it nevertheless provides a useful guide as to the effectiveness of tide or flood gates in a certain number of simple cases. Major simplifications are required for more complicated applications and this paper suggests some of the more justifiable simplifying assumptions that might be made in such cases.
LA PROPAGATION DE LA MARÉE DANS LES MÉTÉO ET LES CANAUX
par G. Supino, Université de Bologne (ITALIE)

I. 2

1.- Un canal avec un courant tranquille débouche dans la mer; il est par conséquent sujet à l'action de la marée, on demande comment l'onde de la marée se propage à l'intérieur.

Pour évaluer le phénomène il faut distinguer deux cas. Il peut en effet arriver que le canal se jette librement dans la mer ou que son embouchure soit fermée par des portes busquées. Dans ce dernier cas la marée ne peut pas se propager à l'intérieur du canal, mais celui-ci ayant un débit (constant) et l'embouchure étant fermée, le niveau de l'eau croît même à l'intérieur et, selon la pente et le débit il se peut qu'il croisse moins (ou plus) que la marée en mer. Dans le cas que le niveau interne tende à croître plus que le niveau externe, les portes busquées ne se ferment pas (et par conséquent elles son inutiles). Elles conservent au contraire une utilité (ce qu'on ne voit pas a priori premier abord) si elles sont de nouveau ouvertes au point culminant de la haute marée.

2.- Le problème sera considéré dans le champ du mouvement variable avec le temps et relativement à des petites oscillations en comparaison d'un mouvement uniforme.

Dans ce champ les deux équations de l'hydraulique réelles à un lit rectangulaire très large et au débit par unité de largeur (q) prennent la forme

L'équation du mouvement

\[ \frac{\partial q}{\partial x} + q \frac{\partial q}{\partial y} + \left( \frac{q}{g} \right) \frac{\partial h}{\partial y} + \left( \frac{q}{g} \right) \frac{\partial q}{\partial y} = 0 \]

On pose \( q = q_{0} + \eta \)

(\( \eta \) et \( q_{0} \) étant la profondeur et le débit du mouvement uniforme et \( \eta \) les oscillations (atténuation). On néglige les petites quantités du deuxième ordre \( (\eta^{2}, \upsilon \eta, \text{etc...}) \) et on observe que sur la base de l'équation de continuité\

\[ \frac{\partial q}{\partial x} - \frac{2q_{0} \eta_{x}}{q_{0}^{2} + \eta_{y}^{2}} - \frac{\partial \eta_{x}}{\eta_{y}^{2}} \frac{\partial q}{\partial y} - \frac{\partial \eta_{y}}{\eta_{y}^{2}} \frac{\partial q}{\partial x} = 0 \]

Avec déjà tenu compte du débit uniforme \( q_{0} \) l'on peut écrire

\[ \psi = A \ c_{0} \ c_{1} \ \omega \ \nu \left( r - \frac{\nu}{v_{0}} \right) \]

l'équation précédente donne une liaison entre \( \psi = 2\pi / \nu \) que l'on retient une donnée du problème, \( \lambda \) (atténuation) et \( \omega \) (célérité).

On trouve, en général:

\[ \lambda = X + \frac{3 \ i \ \nu}{2 (1 - F) v_{0}} , \quad \omega = -\frac{2(1 - F)}{1 + 2 F} \frac{\nu X}{v_{0}} \ U_{0} \]

etant

\[ R = \frac{2}{\nu \ \eta \ \eta_{y}^{2}} + \frac{\nu}{(1 - F) v_{0}} \]

\[ S = \frac{9 \ m + 2}{8 (1 - F) v_{0}} \]

Sur la base de ces résultats nous déduirons les particularités fondamentales des ondes ascendantes.

3.- Faisons d'abord quelques observations concernant l'atténuation et la vitesse de propagation.

Dans les formules précédentes \( R \) doit être choisi comme signe positif (sinon \( X < 0 \) serait imaginaire). On a donc un seul \( X < 0 \) et deux valeurs pour \( X < 0 \) et signe opposé. Si le courant en mouvement est lent les ondes peuvent remonter le lit et par conséquent elles s'atténuent si \( \lambda > 0 \) (parce qu'en procédant en l'amont on va vers les \( \mu \) négatifs). Au contraire les ondes descendantes demandent un \( \lambda < 0 \). Par conséquent dans ce cas il doit avoir \( X < 0 \) et comme \( 3 \ m / 2 (1 - F) \) est positif aussi l'on doit avoir \( X > 0 \).

Il s'ensuit que pour les ondes ascendantes \( \lambda > 2 \).

Where there exists a deficiency of alongshore material supply, increasing attention has been given to the concept of mechanically placing sand on a beach zone to create desired dimensions, and periodically placing more sand to maintain these dimensions. The practicability of this approach to shore stabilization is dependent on the existence of a nearby suitable sand deposit along with the economic factors in transferring the sand from the borrow area to the beach problem area. Coastal development of land often restrict the availability of inland borrow sources and in many cases inland borrow sources are non-existent or of inadequate quantity, to carry out this type of beach stabilization program. Coastal engineers have long recognized the added advantages to beach fill and periodic nourishment programs if sand composing the bottom in the offshore zone could be utilized. A number of projects have been completed along the coast of the United States where conventional type dredging plant was used to transfer offshore bottom materials to the beach zone. In an effort to learn about the behavior of the offshore hole where the sand was excavated, hydrographic surveys and procurement of samples of the materials composing the bottom were obtained in four cases. This paper describes the four projects, presents a summary of the collected data, and analysis and discussion of the data, and conclusions to the extent shown by the data.

"LE MAINTIEN DES BALLASTIÈRES COTIERES PENDANT LE COMBLEMENT LA PLAÎGE"

SOMMAIRE

Dans le cas où l'alimentation d'une plage avec des matériaux littorales est en défaut, l'attention est accordée de plus en plus, au procès de comblement le sable mécaniquement sur la plage pour produire les dimensions désirées et aussi pour maintenir ces dimensions, en ajoutant périodiquement le sable supplémentaire. L'usage des ballastières intérieures pour soutenir le programme de stabilisation côtière en question est souvent très limité à cause de développement des régions intérieures, aussi quand elles sont incapables de fournir la quantité des matériaux désirées ou quand les ballastières convenables sont inexistents. L'ingénieur maritime, depuis longtemps a reconnu les avantages de comblement le sable sur la plage et la maintenir avec les matériaux supplémentaires, qui tire l'origine dans le zone littoral. Aux États-Unis, plusieurs projets sont été accomplis par le déplacement des matériaux littorales du fond sous marine au moyen de machine à draguer ordinaire. L'hydrographie des côtes ont été faits en four cas pour examiner le maintien de la cavité d'ou le sand a été excave. Les échantillons de matériel composant le fond sous marine sont été pris. Le communication ci-joint décrit ces four projets en présentant le sommaire, analyse, discussion et conclusion des éléments assemblés.
RECHERCHES HYDRAULIQUES DE LABORATOIRE SUR L'EFFICACITE
DE QUELQUES TYPES D'OUVRAGES DE PROTECTION DES PETITS PORTS
MARITIMES CONTRE LA PENETRATION DES VAGUES ET DES ALLUVIONS CHARIEES

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RESUME
On présente les résultats comparatifs des essais sur modèle pour trois types de passe d'entrée portuaire : classique, à compartiments résonants et à double prisme de réfraction (devant l'entrée du port). Le type à ouvrages résonants est le plus efficace des deux point de vue (vagues, alluvions chariées). On donne les limites entre lesquelles se maintient l'efficacité de ce type.

SYNOPSIS
Comparative results of the model experiments are presented, concerning three types of harbour entrance : classical, provided with resonant basins and with refraction submerged prism type. The schema with resonant basins is the more efficient one, both for wave height and for bed load transport diminution. Then are given also the limits for maintaining the efficiency of this type.
EFFECT OF THE WAVE PRESSURES AND THE IMPULSES OF BREAKING WAVES ON THE STABILITY OF BREAKWATERS

By Taizo HAYASHI and Masataro HATTORI
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SYNOPSIS

The stability of breakwaters against sliding due to wave pressures has conventionally been examined by \( \mu W > P_{\text{max}} \), where \( \mu \) is the coefficient of static friction, \( W \) the submerged weight of the structures and \( P_{\text{max}} \) the maximum resultant horizontal pressure of the wave exerted upon the structures. Theoretically, however, the criterion of the stability of the wall should be \( F < \mu W \), \( F \) being the shearing resistance which is equal to \( P \) minus ( or plus ) the inertia resistance of the wall. Theoretical calculations have been made to obtain the time history of this shearing force by taking account of the slight sway or rocking of the wall caused by the initial shock of the breaking wave.

The calculations show that the behavior of the shearing force depends on two parameters, \( \lambda \) and \( \omega \tau \). Here, \( \lambda \) is a ratio characteristic of the wall dimensions, \( \omega \) represents the angular velocity of the rocking of the wall, and \( \tau \) represents a half of the duration of the shock pressure. The shearing force caused by the shock pressure exists even after the shock pressure is gone. Consequently, when the "bourrage" pressure follows the shock or the "gifle", the shearing force caused by the "gifle" is superposed on that caused by the "bourrage" pressure.

In many practical cases, the value of \( \lambda \) is as large as or larger than 0.8. In such cases, the maximum shearing force caused by the "gifle", occurs after the "bourrage" is gone, i.e., in the stage of the "bourrage". The magnitude of this maximum is given by \( 2\pi I_g / T \), where \( I_g \) represents the impulse of the breaking wave and \( T \) the period of rocking of the wall.

Whereas, when \( \lambda < 0.6 \), the maximum shearing force is caused, in most cases, at the peak of the "gifle", its magnitude being given by \( P_m \left[ 1 - \lambda \left\{ \sin \omega \tau / \omega \tau \right\} \right] \), where \( P_m \) is the peak pressure of the "gifle".

RESUME

Nous examinons la stabilité des jetées contre le glissement parvenu des pressions des lames, couramment par la formule : \( \mu W > P_{\text{max}} \), \( \mu \) étant le coefficient du frottement statique, \( W \) le poids submergé de la structure et \( P_{\text{max}} \) la pression totale horizontale maximum de la lame sur cette structure. Pourtant, théoriquement parlant, le critère de stabilité des jetées doit être \( F < \mu W \), \( F \) étant la force de cisaillement, qui est égale à \( P \) minus la résistance de l'inertie de la jetée. Les calculs théoriques ont été faits pour obtenir la connaissance de la variation de cette force de cisaillement en tenant compte des balancements faibles causés par le choc initial des lames déferlantes.

Ces calculs indiquent que la façon d'agir des forces de cisaillement dépendent de deux paramètres : \( \lambda \) et \( \omega \tau \). Ici, \( \lambda \) est un rapport caractéristique aux dimensions de la section de la jetée, \( \omega \) la vitesse angulaire du balancement de la jetée et \( \tau \) un demi de la durée du choc. La résistance dynamique causée par le choc de la lame existe même après ce choc soit sorti. Par conséquent, lorsque les pressions de "bourrage" suivent le choc initial, la résistance de cisaillement causée par "la gifle" est superposée sur celle causée par les pressions de "bourrage".

Dans beaucoup de cas en pratique, la grandeur de \( \lambda \) est : \( \lambda \geq 0.8 \). Dans ces cas, la force maximum de cisaillement causée par "la gifle" se produit après "la gifle" est sortie, c'est-à-dire, pendant "le bourrage". Cette grandeur maximum est théoriquement supposée comme \( 2 \pi I_g / T \), \( I_g \) étant l'impulsion de la lame déferlante, \( T \) la période des balancements de la structure.

Lorsque \( \lambda < 0.6 \), la force maximum de cisaillement, dans la plupart des cas, se produit en le moment de l'occurrence de la corne de "la gifle", au grandeur étant donnée par \( P_m \left[ 1 - \lambda \left\{ \sin \omega \tau / \omega \tau \right\} \right] \), ou \( P_m \) est la pression maximum de "la gifle".
THE DIRECTION OF NET SEDIMENT TRANSPORT CAUSED
BY WAVES PASSING OVER A HORIZONTAL BED

by


SYNOPSIS

Results are presented of experiments to determine when the net transport of sediment comprising the horizontal bed of a laboratory channel is towards, and when away from, the beach. The direction of the net transport and its discharge rate were determined by observations on the movement of fluorescent tracers.

It was found that when the bed was rippled, short waves produced transport towards the beach, and long waves transport away from the beach, the tendency to transport away from the beach being greater as the depth of water was reduced. Transport on a bed that was not rippled was invariably towards the beach.

It is shown theoretically that it is not possible to make a wave model, with water as the fluid, in which the net transport is correctly reproduced. Every combination of conditions needs to be studied separately.

On présente des résultats des expériences pour trouver quand un sédiment qui compose une assise horizontale d'un canal laboratoire, se fait mouvoir du large, et quand au large. La direction du transport net et son régime de décharge, se sont mesurés par des déplacements des traceurs fluorescents.

On a constaté que sur une assise ridée, des petites ondes ont produit du transport du large, et des grandes ondes au large: la tendance de transporter au large a dû plus marquée qu'on a réduit la profondeur de l'eau. Invariablement sur une assise qui n'était pas ridée, le transport était du large.

On démontre théoriquement qu'il n'est pas possible de faire un modèle aux ondes, avec de l'eau pour le fluide, sur lequel on reproduit correctement le transport net. Il faut étudier toutes les combinaisons des conditions à part.
WAVE FORCES ACTING ON A PIPE AT THE BOTTOM OF THE SEA

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SUMMARY

Model tests of wave forces acting on a large, horizontal sewage pipe placed at the bottom of the sea, and of the anchoring of the pipe have been carried out.

The horizontal and the vertical wave forces have both been measured at different wave amplitudes and at different angles between the wave direction and the pipe. When the wave direction was perpendicular to the pipe, the forces were determined by the equation \( P = C \cdot D \cdot \gamma \cdot u^2 / 2g \), where \( D \) is the diameter of the pipe, \( u \) the water velocity at the centre level of the pipe and \( \gamma \) the specific gravity of the water. The coefficient proportional to the horizontal forces is \( C_H = 3.7 \) and to the vertical forces \( C_V = 3.4 \).

Different methods for the anchoring of the pipe were studied. The final method is shown in Fig. 3.

FORCES ENGENDRÉES PAR LA HOULE SUR UNE CONDUITE REPOSANT SUR LE FOND DE LA MER

 SOMMAIRE

Les forces engendrées par la houle sur une grande conduite reposant sur le fond de la mer ainsi que les ancrages de la conduite ont fait l'objet d'études sur modèle. Pour différentes amplitudes de la houle et pour différentes incidences de la houle sur la conduite, on a mesuré aussi bien les efforts horizontaux que les efforts verticaux. Dans le cas d'une houle perpendiculaire à la conduite, on a trouvé que les efforts sont déterminés par l'équation \( P = C \cdot D \cdot \gamma \cdot u^2 / 2g \) avec \( D \) : diamètre de la conduite, \( u \) : vitesse de l'eau au niveau de l'axe de la conduite et \( \gamma \) : poids spécifique de l'eau. Le coefficient \( C \) a été trouvé égal à \( C_H = 3.7 \) pour les efforts horizontaux et \( C_V = 3.4 \) pour les efforts verticaux.

Différentes modes d'ancrage de la conduite ont été étudiés. Le type retenu est montré à la figure 3.
RECENT STUDIES OF WATER MOVEMENT IN THE RIVER TYNE ESTUARY (NORINTHERLAND)

By John H. Allen
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The overall pattern of water movement in the River Tyne estuary has been established through systematic observations carried out over a period of two and a half years by the Department of Civil Engineering, King's College, University of Durham. Fresh water inflow from the catchment area causes considerable density and salinity stratification within the estuary. The residual movement after one tidal cycle at any section under average run-off conditions was found to be seaward in the water above 40% of the depth and landward below this point. This results in a circulation occurring in the estuary providing additional flushing to that of the ebb and flow of the tide and the volume displaced by the inflowing fresh water. The volume of water involved in this circulation has been related to the fresh water inflow for two stations in the estuary and a comparison made with the circulation obtained from a consideration of salt balance. Scouring of bottom deposits out to sea during large fresh water floods is inhibited by the residual landward drift of the lower layers still persisting in the seaward half of the estuary and by the tendency for there to be little movement near the bed during the falling tide.

La disposition en générale des mouvements de l'eau dans l'estuaire de la rivière Tyne a été établi par des observations systématiques, faites pendant une période de deux années et demie, par le Département du Génie Civil à King's College, dans l'Université de Durham. Les eaux affluentes qui ont origine dans le bassin de réception établissent une stratification notable de densité et salinité dans l'estuaire. Le mouvement résiduel, à fin d'un cycle de marée étudié à n'importe quelle point, sous les conditions normales d'écoulement, exhibe une direction vers la mer dans la haute région de profondeur (40%) et vers la terre en-dessous de cette région. Il y résulte une circulation dans l'estuaire qui donne une chasse additionnelle à celle du reflux et du flux de la marée, et à celle du résultant volume déplacé par l'arrivées d'eau douce. Le volume d'eau en question dans cette circulation a été rapporté au volume arrivant de l'eau douce à deux stations de l'estuaire et une comparaison a été faite avec la circulation obtenue par une considération de la balance de sel. Nettoyage des dépots de fond est interdit par le mouvement résiduel vers la terre des couches inférieures qui persistent dans la partie vers la mer de l'estuaire, et par la tendance de peu de mouvement près du lit, pendant la marée baissante.
LITTORAL TRANSPORT IN THE BREAKER ZONE, CAUSED BY OBLIQUE WAVES

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SUMMARY
First the longshore transport in the breaker zone has been expressed in terms of the breaking wave. The relation between the data of the breaking wave and the data of the deep water wave has then been derived from the refraction theory supposing 1e. the breaking wave is a solitary wave, and 2e. the breaking wave is a trochoidal wave. The resulting transport formula in which the transport rate is expressed in terms of the deep water wave, is discussed with a view to the question, whether the breaking wave is a genuine solitary wave or not.

RÉSUMÉ
Une formule est dérivée, qui donne le débit du transport littoral dans le zonr de déferlement en fonction des caractéristiques de la lame déferlante. En plus, dans le cadre de la théorie de la réfraction, le rapport est établi entre les caractéristiques de la lame déferlante et celles de la houle profonde. L'auteur s'est placé dans deux hypothèses différentes, selon que la lame déferlante a le caractère d'une onde solitaire ou d'une onde trochoidale. Dans chaque cas une formule est établi, qui donne le débit du transport littoral en fonction des caractéristiques de la houle en eau profonde; célérité, cambrure et angle d'incidence. En conclusion, les résultats théoriques sont comparés avec des résultats de la laboratoire, pour voir laquelle des deux hypothèses faites se rapproche le plus de la réalité.
SEDIMENT DISCHARGES MEASURED BY CONTINUOUS INJECTION OF TRACERS FROM A POINT


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SYNOPSIS

A method is presented for obtaining the intensity of a sediment discharge by continuous injection of tracer sediment at a point near the bed, followed by sampling for surface concentration on a line across the flow. Experiments are described that were carried out in a wave-basin to determine the accuracy of the method and also to determine how close to the injection point the sampling could be done. A method is suggested for the way in which this minimum distance, 3 feet under the particular conditions used, should be scaled up to obtain the prototype figure.

On présente une méthode de déterminer l'intensité d'un débit solide par l'injection continue d'un traceur à un point près du lit suivie de l'échantillonnage pour constater la concentration à la surface à une ligne en travers de l'écoulement. On décrit des expériences effectuées dans un bassin à houle pour déterminer l'exactitude de la méthode et aussi à quelle proximité au point d'injection on pouvait échantillonner. On suggère comment cette distance minimum, qui a été dans les conditions de cette expérience de trois pieds, devrait être augmentée à l'échelle pour arriver au numéro prototype.
HYDRAULIC STUDIES OF A BARGE HARBOUR

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Synopsis

Studies were made of the effects of enlarging an existing barge harbor and of methods of reducing wave activity in the harbor. The methods considered included construction of a single arm breakwater and, alternatively, providing beaches around the perimeter of the basin. Hydraulic model studies were used to verify theoretical analyses and to study refinements in design.

Résumené

Des études furent accomplies sur les effets de l'agrandissement d'un port existant pour des barges, et les méthodes pour réduire l'activité de la houle dans le port. Les méthodes étudiées comprirent la construction d'un brise-lame simple à enrochement et, alternativement, des plages dans le périmètre du bassin. Des études sur modèle réduit furent utilisées pour la vérification des analyses théoriques aussi bien que pour étudier des améliorations dans le projet.
This paper describes the results of velocity measurements in the non-steady turbulent boundary layer, developing at a rough sea bed under a wave motion. The main purpose of the research project is to find the bed shear stresses and the energy loss, these being pertinent to problems like the damping of waves, determination of water surface gradients in a current subjected to a wave motion a.o.

Only rough turbulent boundary layers are of interest in coastal engineering. It can be shown from the formulae given in this paper, that the Reynolds' number for the boundary layer - defined as $U_{1,\text{max}}^2 / \nu$ - exceeds 1000 even for a 30 cm high wave on 3 m depth of water, if the wave period is 5 s and the Nikuradse roughness parameter is 1 cm. The simple case of a non-steady laminar boundary layer is therefore of no relevance. This applies also to smooth turbulent flow. Thus the kinematic viscosity disappears from all equations, the proper parameters being the maximum potential amplitude at the bottom and the roughness of the bed.

The local mean velocities were measured with a 5 mm diameter propeller in the so-called oscillating water tunnel. The bed consisted of rough concrete slabs. Only results from one test are available for the present (Table 1). Test No. 1 is characterized by a maximum potential amplitude of $285 \text{ cm}$ (and a Nikuradse sand roughness of $2.3 \text{ cm}$) corresponding to a theoretical wave height of $5.4 \text{ m}$ in $10 \text{ m}$ deep water, the wave period being $8.39 \text{ s}$.

Shear stresses, energy loss and wave boundary layer thickness were calculated on the basis of the measured velocities. No adequate theory for the phenomenon is given, but tentative, semi-empirical formulae for the above mentioned quantities are given as functions of the ratio between bottom amplitude and roughness.

To the author's knowledge measurements as described above have not been made previously.
SURF BEATS AT TARANAKI, NEW ZEALAND

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SYNOPSIS

Taranaki Harbour is the principal ocean port on the west coast of the north island of New Zealand. During severe storms overseas ships, moored at the wharves, tend to range and break their moorings. This paper describes the observations made at Taranaki which showed that the ranging was due to surf beats in the harbour - and discusses the results of a model investigation at the Hydraulics Research Station in which surf beats were reproduced and various schemes for improving the harbour were tested. It was found possible to reduce the surf beats by 40% by the construction of a new breakwater.

RESUME

Le port de Taranaki est le premier port de la côte occidentale de l'Isle du Nord de la Nouvelle Zélande. Pendant les orages sévères des vaisseaux venant d'outre-mer, amarrés le long des quais, ont tendance à rappeler et à rompre leurs amarres. Dans cet exposé on décrit les observations faites à Taranaki qui montrent que ce rappelage était causé par les "surf beats" dans le port. L'exposé discute également les résultats des recherches faites avec un modèle réduit au Hydraulics Research Station. Pendant ces recherches on a reproduit les "surf beats" et on a essayé des projets divers pour améliorer le port. On a trouvé que c'est possible de réduire les "surf beats" par 40% avec construction d'un nouveau brise-lame.
LABORATORY WAVE GENERATION

A COMPARISON OF THEORETICAL AND EXPERIMENTAL PERFORMANCE

by

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In certain problems of wave research it is desirable that the generator may be pre-set to produce a wave of specified characteristics without the necessity of trial and error adjustment. In this paper, following a brief outline of the methods and theory of wave generation, a relationship is derived between wave amplitude and paddle eccentricity for any relative depth (h/L). A description of a wave generator for two dimensional studies is then given, together with the derivation of the necessary calibration curves. Experiments carried out to test the validity of the theory are described and the results used to evaluate an efficiency factor for the wave generator.

Dans certains problèmes de houle, c'est désiré que le générateur soit réglé par avance pour produire une onde avec caractéristiques spécifiées, sans avoir besoin de procéder à l'ajustage par essais et erreurs. Dans ce papier, suivant une courte description des méthodes et théories de génération de houle, une équation est dérivée entre l'amplitude de houle et l' eccentricité de volet pour une profondeur relatif (h/L). Une description d'un générateur de houle pour les études de deux dimensions est donnée avec la derivation des courbes de calibration nécessaires. Des expériences faites pour tester la validité de la théorie et les résultats employés pour évaluer un facteur d'efficience pour le générateur de houle.
The prediction of salinity intrusion changes in partially mixed estuaries

by

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and

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SYNOPSIS

The longitudinal, time-average salinity distribution in an estuary is represented by the one-dimensional convective diffusion equation. In this equation the diffusion term \( \frac{E_n}{l} \) is an apparent diffusion coefficient incorporating both the turbulent mass transport induced by the tidal velocities and the mass transport caused by the density gradient along the estuary. This combined upstream salt transport is balanced by the downstream convective transport due to the fresh water velocity.

Experiments in an idealized laboratory estuary show that the apparent diffusion coefficient varies in the longitudinal direction and is dependent upon the product of the local salinity concentration, the fresh water velocity, and the rate of turbulent energy dissipation per unit mass of fluid. Using this correlation, a method is presented for the determination of the change in the longitudinal salinity distribution caused by a change in the fresh water flow rate.

The method is applied to the Delaware estuary and salinity distributions are calculated for fresh water discharges of one-third and two-thirds of the normal flow rate. The calculated salinity distributions are in good agreement with model test results for the Delaware. The procedures developed are particularly useful in obtaining rapid estimates of the effect of fresh water diversions on the extent of salinity intrusion in estuaries for which model results are not available.

SOMMAIRE

Dans un estuaire, la salinité moyenne par rapport au temps est fonction d'une seule variable, la distance longitudinale, et est déterminée par une équation de diffusion par convection. Dans cette équation, le terme de diffusion \( \frac{E_n}{l} \) représente un coefficient de diffusion apparent qui tient compte à la fois du mouvement de turbulence provoqué par les courants de marée et du mouvement du gradient de densité le long de l'estuaire. Ce double transport de sel vers l'amont est contrebalancé par le transport vers l'aval associé au courant d'eau douce.

Les expériences réalisées au laboratoire à l'aide d'un modèle d'estuaire idealisé, montrent que le coefficient de diffusion apparent varie longitudinalement et dépend du produit de la salinité locale, du courant d'eau douce et de la vitesse de dissipation de l'énergie de turbulence par unité de masse du fluide. Utilisant cette relation, une méthode est présentée qui permet de déterminer la variation du graphique longitudinal de salinité avec un changement du débit d'eau douce.

Cette méthode est appliquée à l'estuaire du Delaware. Le graphique de salinité est calculé pour des débits égaux à un tiers et deux tiers de la valeur normale. Les chiffres calculés sont en accord avec les résultats obtenus à l'aide d'un modèle même du Delaware. Pareille procédure est particulièrement utile lorsqu'on désire estimer rapidement l'effet d'une variation de débit sur la salinité dans un estuaire pour lequel aucun test sur modèle n'a été réalisé.

ACKNOWLEDGEMENTS

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ON THE THEORY OF MODELLING IN A STRATIFIED FLUID

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SUMMARY

Methods of partial inspectional analysis lead to the conditions that Froude Numbers should be modelled in a stratified fluid, with associated adjustments of distance-time scales. In the present note this condition is posed as a condition that the characteristic directions should correspond in model and prototype. Such a condition is shown to be sufficient as well as necessary for correct scaling.

Using a scaling through characteristic similitude, conditions for front simulation, surface spreading and density distortion are obtained. A measure of the errors involved in these scaling conditions may be obtained by comparing the scaled characteristic directions in the model with those in the prototype.

RESUME

Les méthodes d'analyse de Birkhoff nous amènent à tenir compte des nombres de Froude dans les modèles relatifs à un fluide stratifié, compte tenu des ajustements à faire pour les échelles de longueur et de temps. La présente note pose cette condition à savoir que les directions des caractéristiques doivent correspondre dans le modèle et le prototype. Il est montré qu'une telle condition est nécessaire et suffisante pour la détermination exacte des échelles.

En utilisant une échelle donnée par la similitude des caractéristiques on obtient les conditions de reproduction des propriétés des fronts, l'écoulement des fluides superposés et la distorsion de la densité. On peut obtenir une estimation des erreurs inhérentes à ces conditions d'échelles en comparant les directions des caractéristiques à l'échelle dans le modèle avec celle du prototype.
TIDAL INLETS AND LITTORAL DRIFT

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SYNOPSIS

Tidal inlets include a number of interesting phenomena and problems of hydraulic and sediment transportation nature. With respect to sediment transportation the following problems are involved (fig 1): (a) transport by unidirectional but periodic tidal flow in the inlet channel, (b) transport by unidirectional periodic flow superimposed by wave action which may propagate with or against the current in the inlet channel, (c) transport by longshore currents carrying material to the entrance area by combined wave and current action in inlet ocean entrance area and on both sides of the entrance, and (d) transport by various kinds of bay currents including wind currents, fresh water outflow and density currents.

Results of research on tidal inlets mentioned by Bruun and Gerritsen indicate that the "stability shear stress" $\tau_s$ is an important factor for gorge stability. Furthermore it was found that the $n/M$ ratio ($n =$ tidal prism in cu. yd., $M =$ net (predominant) littoral drift in cu. yd. per year) seems to be useful for description of the actual "degree of stability" of the inlet. The $M/Q_m$ ratio was found to be useful for the description of the inlet's ability to bypass sand.

As a result of their work, the authors suggested initiation of a research program comprising investigations of friction and the "shear stress parameters" under combined wave and current action. Furthermore, model studies were suggested to look into a number of pertinent tidal hydraulics and littoral drift factors and ratios between factors. Reliable and physically well reasoned model laws, therefore, are needed as discussed in detail in this paper.

The following paragraphs give an impression of a research program now in progress to fill out empty spaces in our knowledge about tidal inlets and littoral drift. The interest is concentrated on items (b) and (c) mentioned above.

A FIELD STUDY OF WAVE ACTION ON NATURAL BEACHES

By
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Model investigations of the behaviour of beaches under the action of waves and tides, have been carried out by numerous research workers in many countries. The number of field investigations has been far less, and of these very few have related to shingle beaches. The Paper presents observations and data collected during a field study embracing three locations at approximately 5 mile intervals on a practically straight beach. The diameter of the beach material at these stations was in the approximate ratio of 1:2:3. Observations were made simultaneously at all stations. The results seem to confirm that the breaker height is the dominant wave characteristic. The breaker distance (from break point to limit of uprush), the beach crest height above mean high water level, and the time of uprush appear to be directly related to breaker height for plunging breakers. The effect of permeability on beach slope is of decreasing importance as the wave height increases, and is finally restricted to the upper limits of the beach crest. The step at the plunge point is shown to be a feature mainly formed by deposition above the general beach slope.

ETUDE SUR PLACE DE L'ACTION DES LAMES SUR LES PLAGES NATURELLES

par
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Des recherches en laboratoire concernant le comportement des plages sous l'action des lames et des marées, ont été effectuées par nombre de chercheurs dans beaucoup de pays. Mais le nombre des recherches sur place est bien moindre, et, parmi celles qui ont été effectuées, peu ont eu pour objet les plages de galets. Cette communication présente des observations et données recueillies au cours d'une étude sur place ayant pour champ trois points situés à environ 5 miles anglais d'intervalle, et sur une plage pratiquement rectiligne. Le diamètre des éléments (galets, etc.), formant cette plage à ces stations d'observation, était du rapport approximatif de 1:2:3. Les observations ont été effectuées à toutes les stations simultanément. Les résultats semblent confirmer que la hauteur des lames déferlantes est la caractéristique dominante de la lame. La "breaker-distance" (du point de déferlement à la limite du frachissement de la lame); la hauteur de crête de plage au-dessus du niveau moyen de pleine-mer; et la durée du frachissement de la lame, semblent être en relation directe avec la hauteur de la lame déferlante pour les vagues déferlant en en volutes. L'effet de la perméabilité sur la pente de la plage va en importance décroissante avec l'augmentation de hauteur de la lame, et cet effet est finalement restreint aux limites supérieures de la crête de plage. L'observation montre que la banquette, au point de déferlement est une particularité formée principalement par le dépôt au-dessus de la pente générale de la plage.
FORECASTING SHORE TRANSFORMATIONS AT LARGE RESERVOIRS

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SUMMARY

Transformation of the shores of newly-created reservoirs should be regarded as a geomorphological process of protective bank shoal formation developing under the effect of wind waves and subjected to the influence of certain natural and water-management factors. The paper outlines the principles of shore transformation forecasting developed in the State Hydrological Institute (USSR) and gives initial designing formulas. Designing technique may vary substantially, depending on the specific forecasting tasks.

RÉSUMÉ

La transformation des côtes des réservoirs nouvellement construits doit être considérée comme un process géomorphologique de la formation du banc protecteur littoral qui se développe sous l'effet des vagues de vent et qui est soumis à l'influence des certains facteurs naturels et hydrotechniques. Dans ce rapport sont exposés des principes de prévision de la transformation des côtes qui ont été élaborés à l'Institut hydrologique d'Etat (URSS). Les formules de calcul de départ font également l'objet de ce rapport. La technique de calculs peut essentiellement varier suivant les problèmes spécifiques de prévision.
WAVE THRUST AND WAVE ENERGY LEVEL

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SYNOPSIS

In steady flow, the theorems of momentum and energy are of a fundamental nature. By applying these theorems to progressive waves, the concepts of wave thrust and wave energy level emerge.

By considering the mean values (over time) of the flux of momentum through and the pressures on a vertical section, the wave thrust is found to be:

\[ P = \frac{1}{16} \gamma H^2 \left( 1 + 2 \frac{2D'}{\sinh 2D'} \right) \]  

where \( D' = 2 \pi D/L \) is the dimensionless depth.

According to the Bernoulli equation for non-steady potential flow

\[ y_E = \frac{y + \frac{1}{2} \frac{U^2 + V^2}{2} - \frac{\gamma}{g} \frac{y_t}{t} = \text{constant}}{g} \]  

designates the energy level of the flow. For waves, the energy level above still water level \( y = D \) is found to be:

\[ y_E = \frac{H^2}{16 D \sinh 2D'} \]  

It follows from both concepts that the still water level varies when waves propagate over varying depths. If the water level is \( h = 0 \) at infinite depth, the water level at depth \( D \) will be \( h = -(y_E - D) \).

Refraction, diffraction, interaction with currents, breaking, and bottom friction are not considered in this paper; it is believed, however, that the concepts of wave thrust and wave energy level will play an important part in future theories for these phenomena.

SONMAIRE: POUSSÉE ET NIVEAU D'ÉNERGIE D'UNE LAME

Pour le courant stationnaire les théorèmes de l'impulsion et du niveau d'énergie ont pris une importance fondamentale. L'application de ces théorèmes aux ondes progressives fait surgir les notions de la poussée et du niveau d'énergie d'une lame.

À l'aide de considérations d'une part des moyennes (de temps) du flux d'impulsion à travers une section verticale, d'autre part des pressions contre la même section, la poussée de la vague s'exprime comme:

\[ P = \frac{1}{16} \gamma H^2 \left( 1 + 2 \frac{2D'}{\sinh 2D'} \right) \]  

où \( D' = 2 \pi D/L \) est la profondeur normalisée.

Selon l'équation de Bernoulli pour un courant potentiel et non stationnaire

\[ y_E = \frac{y + \frac{1}{2} \frac{U^2 + V^2}{2} - \frac{\gamma}{g} \frac{y_t}{t} = \text{constante}}{g} \]  

exprime le niveau d'énergie du courant. Pour les lames le niveau d'énergie au-dessus du niveau d'eau au repos \( y = D \) est:

\[ y_E = D = \frac{H^2}{16 D \sinh 2D'} \]  

C'est une conséquence des deux notions que le niveau au repos varie quand les lames se propagent sur profondeurs variables. Si ce niveau est \( h = 0 \) à profondeur infinie il sera \( h = -(y_E - D) \) à la profondeur \( D \).

L'article ne s'occupe pas de réfraction, diffraction, interférence avec des courants, déferlement, ou frottement au fond. Il est cependant cru que les notions de poussée et de niveau d'énergie d'une lame joueront un rôle important dans les théories à venir pour ces phénomènes.
SPREAD CHARACTERISTICS OF A BUOYANT MISCEBLE DISCHARGE

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In a previous I.A.H.R. paper (1) some observations of densimetric exchange flow in rectangular channels were described and a method was proposed whereby the results from such experiments can be used to determine the best choice of vertical scale exaggeration for heat dissipation model investigations. The density current studies have been continued and this paper largely concerns their relevance to a common problem in coastal waters - the prediction of the spread pattern of a buoyant effluent being discharged from an underwater outfall and being swept away by a coastwise current.

First the derivation of the densimetric Froude-Reynolds number, \( F_A R \), is given and its significance discussed. The generality of the densimetric exchange flow mechanisms is mentioned and a basic 'model' for the case under consideration is proposed. The applicability of this 'model' to field occurrences is then discussed. Disagreement is expressed with a previous approach made to the problem of prediction of downstream spread of a buoyant discharge. Finally the model simulation of such a type of flow pattern is considered.

Dans un papier A.I.R.H. précédent (1) quelques observations d'écoulement d'échange densimétrique dans des conduites rectangulaires ont été décrites et une méthode a été proposée par laquelle il est possible d'employer les résultats de telles expériences pour déterminer le meilleur choix d'exagération d'échelle verticale pour des investigations modèles de dissipation de chaleur. Le courant de densité a été étudié continuellement et ce papier concerne largement le rapport à un problème commun dans des eaux côtières - la prédiction de l'étendue d'un affluent flottant débitant d'un débouché submergé et étant emporté par un courant côtier.

Tout d'abord le numéro du densimétrique Froude-Reynolds, \( F_A R \), est donné et sa signification est discutée. La généralité d'écoulement d'échange densimétrique est mentionnée et un 'modèle' de base pour le cas en considération est proposé. L'applicabilité de ce 'modèle' aux événements sur place est alors discutée. Manque d'accord est indiqué pour une approche précédente faite à ce problème de prédiction d'étendue en aval d'un affluent flottant. En dernier, la simulation modèle de ce type d'écoulement est considérée.
EXPERIMENTAL CORRELATION OF GRAVITY WAVE HEIGHTS
MEASURED OVER A HORIZONTAL BOTTOM

By Daniel Vera-Cruz

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SUMMARY

An experimental variation law \( \frac{H}{H_0} = f \left( \frac{d}{L_0} \right) \), in which \( H \) is the wave height measured over a horizontal bottom at depth \( d \) is established in the present paper. This law is compared with the one of the small amplitude theory and they are proved to be qualitatively similar.

A new criterion for breaker height definition is adopted in this study in order to avoid the influence of personal judgement.

The experimental setup used reduced to a considerable extent the backwash current after breaking. Waves broke on a \( 10^\circ \) slope.

SOMMAIRE

Dans la présente étude on établit expérimentalement une loi de variation \( \frac{H}{H_0} = f \left( \frac{d}{L_0} \right) \), où \( H \) représente la hauteur de l'onde mesurée sur fond horizontal à profondeur \( d \). Cette loi est comparée avec celle de la théorie des petits mouvements et il en résulte que les deux lois sont qualitativement comparables.

Un nouveau critère est proposé pour définir la hauteur de déferlement, qui permettra d'éliminer l'influence personnelle de l'expérimentateur.

Le dispositif expérimental utilisé réduit considérablement le courant de retour après le déferlement de l'onde. Le déferlement avait lieu sur un talus ayant une pente de \( 10^\circ \).
A MODEL SHINGLE BEACH WITH PERMEABILITY
AND DRAG FORCES REPRODUCED

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SYNOPSIS

The paper presents a method for determining the scales of a model of a pebble beach. Since the particle-size is so large it is assumed that the direct influence of viscosity, even in the vicinity of the bed, can be neglected but there remains a need to ensure similarity of the percolation through the permeable beach which itself depends on viscosity. A model of the Seaford sea-wall, which was designed according to the suggested method, is used to illustrate a practical application.

SOMMAIRE

Cette communication soumet une méthode pour déterminer les échelles d'un modèle d'une plage de galets. Puisque le diamètre des grains est si grand, il est possible à négliger l'influence directe de la viscosité, même à proximité du lit; néanmoins il faut assurer la similitude de l'infiltration à travers la plage perméable, un processus qui dépend de la viscosité. Un modèle de la digue à Seaford, qui a été construit selon la méthode ci-suggérée, est employé pour démontrer une application pratique.
QUELQUES REMARQUES A PROPOS DES COURBES DE PROBABILITE DE
L'HAUTEUR DES ONDES DANS LA ZONE LITTORALE PEU PROFONDE

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RESUME
Tandis que les études sur les courbes de probabilité des hauteurs d'ondes en pleine mer sont assez nombreuses et ont déjà mené à des conclusions fermes, celle concernant les mêmes courbes dans la zone littorale peu profonde ont encore un caractère parfois controversé.

Le compte-rendu analyse les données de quelques séries d'observations sur les hauteurs d'ondes dans une zone de bas-fonds de la côte roumaine de la Mer Noire. Les résultats sont comparés aux courbes de probabilité recommandées par les recherches récentes de quelques spécialistes soviétiques.

L'analyse confirme la dépendance déterminée des coefficients de variation $C_v$ et d'asymétrie $C_s$, en fonction de la variable $H_m$.

SYNOPSIS
While the studies on the wave heights probability curves in the offing are numerous enough and led to firm conclusions, those concerning the same curves for the littoral shallow-water zone have still some times a controversial character.

The Paper analyses several series of field data on wave heights in a shallow-water zone on the Roumanian shore of the Black Sea. The results are then compared with the probability curves given by recent studies of some Soviet specialists.

The analysis confirmed the dependence of the variation and asymmetry coefficients $C_v$ and $C_s$ on the variable $H_m$. 
THE DETERMINATION OF QUANTITIES OF SEDIMENT TRANSPORT IN OSCILLATORY
MOTION BY CONSIDERATION OF THE DISPERSION OF TRACER-SEDIMENT

by P. J. Rance


SYNOPSIS

In this paper the dispersion of tracer material by diffusion combined with advection is considered. Particular solutions of the partial differential equation describing motion are given and in two cases illustrated with the resulting distribution curves. An example, the determination of the littoral drift along a shingle beach, shows how the distribution curves may be applied.

SOMMAIRE

Cette communication considère la dispersion de traces par diffusion autant qu'advection. Des solutions particulières de l'équation différentielle partielle de mouvement sont données et sont illustrées en deux cas par les courbes de distribution résultantes. Un exemple, la détermination de l'apport littoral le long d'une plage de galets démontre comment il est possible à appliquer les courbes de distribution.
THE USE OF INSTRUMENTED MARINE TOWERS IN OCEAN WAVE RESEARCH

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SUMMARY

This paper in the main describes the design, construction, and performance of a low-cost marine tower serving as a fixed platform from which to measure ocean wave heights in a wind-generated seaway. A discussion of some current methods of ocean wave height measurements is first presented with emphasis on their advantages and disadvantages. The paper concludes with a brief appraisal of wave research needs necessary to foster a better understanding of coastal hydraulic problems.

Sommaire

En grande part cette communication traite les calculs, la construction et l'action d'une fabrication métallique qui sert comme plate-forme stationnaire sur laquelle on fait les mesures de l'hauteur des ondes de mer qui sont produit par le vent. D'abord se présent une discussion des méthodes courantes de faire ces mesures et les avantages et désavantages correspondantes. Ensuite est une estimation brève des problèmes qui restent à résoudre avant d'obtenir une compréhension suffisante des phénomènes côtiers hydrauliques.
RADIATING SECOND-ORDER PHENOMENA IN GRAVITY WAVES

By Francis Biesel, Directeur Scientifique
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ABSTRACT

Second-order phenomena can be computed by the linear gravity wave theory as waves generated by surface pressure fluctuations which depend on the first-order phenomena. This gives both a physical insight into the nature and behaviour of second-order phenomena and a means of computing them. Among the new results thus obtained is the computation of second-order wave emission, which is an important factor in certain practical problems.

RESUME

LES PHÉNOMÈNES DU SECOND ORDRE RAYONNANTS DANS LES ONDES DE GRAVITÉ

Par Francis Biesel, Directeur Scientifique
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RÉSUMÉ

Les phénomènes du second ordre peuvent être calculés par la théorie linéaire des ondes de gravité comme des vagues engendrées par des fluctuations de pression superficielle fonction des mêmes phénomènes du premier ordre. Ceci facilite la compréhension et l'intuition physique des phénomènes du second ordre et donne un procédé de calcul pour ceux-ci. Un résultat particulièrement nouveau est la possibilité de calculer l'émission d'ondes du second ordre qui joue un rôle important dans certains cas pratiques.
RAPID SPECTRUM ANALYSIS OF OCEAN WAVE TRAINS
By
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SYNOPSIS

The Beach Erosion Board has developed an electronic analyzer for the purpose of making rapid spectrum analyses of ocean wave trains. The ocean wave record is stored on magnetic tape at the recording speed of one-half inch per minute. The analyzer scans a 20-minute sample of the record and plots a chart of the spectrum in 2.2 minutes. The tape record is not cut or destroyed in making the analysis. Five sets of band-pass filters are instantly available to the operator who selects the set giving the degree of detail needed in the analysis. Spectrum plots of selected wave records are given in the paper, including records made during the passage of a hurricane off Atlantic City, New Jersey. Also given are discrete spectrum plots showing the nature of the wave components passing the filters at a selected instant.

La Commission sur l'Erosion Littorale a développé un analyseur électronique qui fait possible une analyse spectrale accélérée des trains de houle océanique. Le registre de houle océanique est emmagasiné sur une bande magnétique qui mouve avec une vitesse d'une demi pouce à minute. L'analyseur scrute un témoin de registre de 20 minute et trace le graphique du spectre en 2.2 minutes. La bande avec le registre n'est pas coupée ou détruite pendant cet operation. Cinq filtres de bande sont instantament à la disposition de l'opérateur qui choisit l'ensemble, en indiquant le degré de détail nécessaire pour l'analyse. Les graphiques du spectre des registres de houle représentatives sont presentes dans le document cijoint, qui comprend aussi les registres faites pendant le passage de la tempête de l'Atlantic City, New Jersey. Les spectres graphiques choisis, représentant les caractéristiques des parties constitutantes de houle, qui passe les filtres en un moment choisi, sont aussi presentées.
A LABORATORY STUDY ON SUSPENDED SEDIMENT DUE TO WAVE ACTION

By Masashi Homma and Kiyoshi Horikawa
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SYNOPSIS

On the shallow sea bottom there is observed the formation of sand ripples under the action of periodic waves, and the sand particles of bed material are thought to be picked up from these ripples. The picked up grains may be suspended by turbulence in water and transported by wave current.

The purpose of this investigation are to observe the time-rate of change in the concentration of suspended sediment under translatory waves and to make clear the mechanism of sand transportation in suspension. A new apparatus was designed and prepared for the measurement of the instantaneous amount of sediment suspension in water. The description on the apparatus appears in this paper with the explanation of the measuring principle.

The observation made by using this instrument gave an interesting result; that is, the sediment concentration under a wave shows approximately a periodic change and it has four peaks during one cycle of wave period.

SYNOPSIS

Dans la mer peu profonde, on observe la formation des rides des sables sous l'action périodique, et on croit que les sables du fond sont pris haut de ces rides. Tels grains sont crus d'être suspendus par turbulence dans l'eau et transportés par le courant des ondes.

Les objets de l'investigation sont d'observer le taux, dans le temps, du change dans la concentration des sédiments en suspension sous la houle transitoire, et de mettre en évidence le mécanisme du transport des sédiments en suspension. Un nouvel appareil a été conçu pour mesurer la quantité instantanée de la condensation des sédiments en suspension dans l'eau. La description sur l'appareil est écrite, dans cette note, avec l'explication du principe à mesurer.

L'observation, effectuée en utilisant cet appareil, a donné un résultat intéressant; c'est-à-dire, la concentration des sédiments sous la houle expose approximativement un changement périodique, et elle a quatre maximum pendant un cycle de la période de la houle.
METHOD FOR SELECTING SCALES FOR MODELS WITH MOBILE BED INVOLVING WAVE MOTION AND TIDAL CURRENTS

by M. Selim Yalin
Dozent Dr.-Ing., Senior Scientific Officer

SYNOPSIS

The paper deals with the derivation of a system of equations for determining the scales of a model with a mobile bed for the case when the motion of bed material is due to the action of waves and tidal currents. The derivation proceeds mainly according to the theory of dimensions. Some special cases have been considered and some solutions applicable to different mobile materials shown by numerical examples. The presence of a current other than a tidal current was also considered.

SOMMAIRE

Cette communication traite de la dérivation d'un système d'équations pour déterminer les échelles d'un modèle ayant un fond mobile, dans le cas où le mouvement des matériaux solides dépende de l'action simultanée de la houle et des courants de marée. La dérivation procède pour la plupart selon la théorie des dimensions. Quelques cas spéciaux ont été considérés ici, et quelques solutions applicables à de divers matériaux mobiles, démontrées par des exemples numériques. La présence d'un courant autre qu'un courant de la marée a aussi été considérée dans cette communication.
THE SUPPLY AND CIRCULATION OF SILT IN THE WASH

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SYNOPSIS

After centuries of relative stability of the permanent salt marsh edge round the Wash, engineering works carried out since 1650 and particularly in the 19th century led to extensive and often extremely rapid build up of new mud flats and saltings. The paper examines the sources of the very large supplies of suspended silt necessary for this accretion. Suspended load was measured in various areas and tracked on the ebb and flood. Particle size distribution of undisturbed bed samples was compared. It is shown that the necessary material is a coarse marine silt, grain size below 128 microns, predominantly 64-128 microns. River supplies are negligible, the central Wash has a bed of coarser grain size and must also be excluded. There is however a considerable supply of the necessary material in a 3 miles wide belt of unstable mud flats and silt banks round the foreshore of the Wash where accretion and erosion continually alternate. It is shown that supplies in suspension and therefore rates of accretion round the margins depend on erosion in the marginal area itself and that permanent accretion occurs when engineering works interfere with local erosion and thus allow accretion to continue to permanent salt marsh level. Such accretion must involve permanent withdrawal of part of the circulating supply of available material. Since the supply of this <128 micron material round the Wash, although large, is not unlimited, it should be technically possible to consolidate the total supply into new saltings by a really comprehensive scheme of engineering works and in this way solve many of the problems of the area for a long time to come.

SOMMAIRE

Suivant plusieurs siecles de stabilité relative du ras des salines permanentes qui entourent le Wash, des travaux entrepris depuis que 1650, surtout au 19me siecle eurent pour resultat l'accumulation etendue et souvent rapide des plages de vase et des salines nouvelles. Il a fallu beaucoup d'envasement pour alimenter une telle accumulation et les sources de cette matière suspendue sont considérée dans cette communication. Le transport solide en suspension fut mesure aux plusieurs stations et fut suivi pendant le flot et jusant de la maree. La distribution des particules de diamètres spécifiques parmi des echantillons prise du lit fut compare. Les résultats indiquent qu'il faut de la boue assez grosse, d'origine marine, de diamètre moitié que 128 microns, 64-128 microns prédominent. La quantité de matière d'origine fluviale est négligeable: le Wash centrale est aussi peu important comme source en raison de diamètre trop gros des particules du fond. Cependant il y a une region autour du Wash de 3 miles de largeur entre les laisses de haute et basse mer ou se trouvent des plages de vase peu consolidé et ou les processus d'envasement et d'érosion reviennent tour a tour. Il est démontre que la quantité de matière suspendue, et par consequent la vitesse d'envasement autour des bords, depend de l'erosion dans cette region bordiere elle-même, et qu'une diminution de fond permanente se produit lorsque des travaux derangent le processus d'érosion locale et l'envasement peut continuer jusqu'au niveau des salines permanentes. Envasement de cette magnitude necessite qu'une partie de la matière circulante est retire d'une facon permanente. Quand'elle est grande la quantité de cette matière (de diametre<128 microns) au region du Wash n'est pas illimitée, et par consequent il doit être possible la consolidier pour faire des salines nouvelles par l'execution d'un programme de travaux detaille et complet et a resoudre de cette facon beaucoup des problemes du region, actuellement et a l'avenir.
SYNOPSIS

The paper presents the results obtained in the Institute of Hydrotechnical Research in Bucharest, Romania, on the sand filling capacity of different schema of shore protection structures.

Two series of tests were undertaken concerning normal and oblique approach of waves. In the first case, a graphical method is proposed for determining the sand filling capacity of insubmerged structures.

The efficiency of different groynes schema is discussed. The paper includes also some data on submerged longitudinal structures.

In the second case, concerning oblique waves, the model experiments allowed at present any observations on the sand filling capacity and on the necessity of artificial nourishment of the beach.

RESUME

L'article presente les resultats obtenus a l'Institut de Recherches Hydrotechniques de Bucharest, Roumanie, sur la capacite d'ensablement caracteristique pour differents epis maritimes.

Deux series d'expériences ont été effectuées envisageant le cas des ondes frontales et celui des ondes obliques par rapport à la côte. Au premier cas, une méthode graphique a été proposée pour déterminer la capacité d'ensablement des digues transversales ou longitudinales insubmersibles.

L'efficacité des différents schémas d'épis maritimes est discutée aussi. On présente des données sur les résultats obtenus dans l'ensablement produit par des brise-lames submersibles.

Dans le cas des ondes obliques, les expériences ont permis de mettre en évidence quelques formes spécifiques de l'ensablement des plages et la nécessité de l'apport artificiel de sable qui assure la continuité du transport solide.
ÉTUDE EXPERIMENTAL SUR LES VARIATIONS DE PRESSEATION DANS LE CLAPOTIS

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SOUS-MAIRE

Dans le présent exposé sont présentés les premiers résultats obtenus au laboratoire de l'Institut d'Hydraulique et de Constructions Hydrauliques de l'Université de Naples sur les variations de presseation dues au clapotis le long d'une paroi verticale.

Les courbes enregistrées, dont certaines ont été objet d'une analyse harmonique par la calculatrice électronique, ont mis en évidence l'influence prépondérante des termes d'ordre supérieur donnés par la théorie (Miehe, Chambert d'Hières), et surtout des termes ayant une fréquence multiple de celle de la houle incidente.

Cela se note par ailleurs en comparant la somme des valeurs expérimentales $|P_{2a}| + |P_{3a}|$, rapportée à l'amplitude du mouvement en surface, au coefficient de la sinusoidale fondamentale, ou bien au terme du premier ordre de la théorie, terme utilisé habituellement pour calculer l'amortissement de la presseation du clapotis.

SUMMARY

In the present work the first results obtained at the Institute of Hydraulic and Hydraulic Constructions of the University of Naples on the pressure variations along a vertical wall due to standing waves are reported.

The experimental curves, some of which have been harmonically analysed by electronic digital computer, have shown once again the main influence of terms of the order greater than one, as given by the theory (Miehe; Chambert d'Hières) and particularly the terms having a frequency which is a multiple of the incident wave frequency concerned.

This fact shows up when comparing the summation of experimental values $|P_{2a}| + |P_{3a}|$, related to the maximum oscillation amplitude, with the first order theoretical term usually used for calculating the pressure of damping due to the standing waves.

Correction & Formulas 5

$\gamma = 2a \frac{\sinh a - (h-y)}{\cosh a - h-y} \cos nt + \frac{\cos nt}{2} \sinh \frac{a}{h-y} \cosh \frac{a}{h-y} \left\{ \left[ 1 - \cosh \frac{2a}{h-y} \right] \left[ \cos \frac{2a}{h-y} + 2 \cosh \frac{a}{h-y} \right] \sin \frac{2a}{h-y} \right\}$

$\gamma = \frac{a}{2} \left( \frac{4 \cos^4 \frac{a}{h-y} - 11 \cosh^2 \frac{a}{h-y} + 6}{4 \cosh^4 \frac{a}{h-y}} \right) \cos nt + \frac{3}{2} \left( \frac{4 \cos^4 \frac{a}{h-y} - 11 \cosh^2 \frac{a}{h-y} + 6}{4 \cosh^4 \frac{a}{h-y}} \right) \sin \frac{3a}{h-y}$
MODEL TESTS ON THE BREAKING OF WAVES AT AN ANGLE WITH A SHORELINE

By Arthur Brebner and J. William Kamphuis
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SYNOPSIS

Given the deep-water characteristics of a wave, $H_0$, $L_0$ (or $T$) and $\alpha_0$, at a depth where shoaling and refraction commence (roughly at $d/L_0 = 0.3$) it is possible by a theoretical consideration using Snell's Law, assuming constancy of energy, (that is, no energy loss due to friction), and using some particular criterion of breaking, to compute mathematically the values of $H_B$, $\alpha_B$ and $d_B$ at the breaker line, for a beach of uniform slope on a straight coast-line. The authors compare this theoretical solution with model test results and find that friction apparently plays a part in reducing wave-heights during the shoaling and refraction process so that the breaking angle $\alpha_B$ is less than the theoretical value. Values of $\alpha_B$ and $d_B/H_0$ for various deep-water steepnesses, $H_0/L_0$, and wave-crest alignments, $\alpha_0$, are given.

SOMMAIRE

Etant données les caractéristiques d'une vague au large, $H_0$, $L_0$ (ou $T$) et $\alpha_0$, à la profondeur où commencent la diminution de fond et la réfraction (en gros à $d/L_0 = 0.3$), il est théoriquement possible, en utilisant la Loi de Snell, en supposant une énergie constante (c'est-à-dire aucune perte d'énergie provenant du frottement) et en utilisant un critérim particulier de déferlement, de calculer mathématiquement les valeurs de $H_B$, $\alpha_B$ et $d_B$ à la ligne de déferlement, pour une plage d'inclinaison uniforme le long d'une côte droite. En comparant cette solution théorique avec les résultats de tests-modèles, les auteurs découvrent que le frottement, apparemment, joue le rôle de réduire la hauteur des vagues au cours du processus de diminution de fond et de réfraction, de sorte que l'angle de déferlement $\alpha_B$ est inférieure à sa valeur théorique. On donne les valeurs $\alpha_B$ et $d_B/H_0$ aux différentes cambrures, au large, $H_0/L_0$, et $\alpha_0$. 

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UN TYPE PARTICULIER DE BRISÉ-LAMES POUR LA DÉFENSE CÔTIÈRE(*)
par Corrado Ruggiero
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RÉSUMÉ

On rappelle d'abord les méthodes employées pour la défense des côtes et pour obtenir assile coûtement du fond de la mer. Il s'agit surtout de brise-lames en blocs naturels de faible hauteur au dessus de la mer, parallèles au rivage, ou d'épis perpendiculaires au même.

Toutefois ces dispositifs ne réjoint pas toujours le but d'éviter l'érosion de la côte; c'est pourquoi on propose dans ce rapport un type particulier de brise-lame en béton armé, constitué par une poutre soutenue par des pales, opportunément disposées.

On refère sur des essais préliminaires effectués au laboratoire; le but des recherches c'était de fixer, dans un cas particulier et pour profondeur de 3 à 5 m environ, la surélévation du bord supérieur de la poutre et le plongement du bord inférieur de la même. Il resulte une pente de la poutre d'arrêt du choc des vagues compris entre 1/3 et 1/4.

Les essais doivent poursuivre, pour étudier aussi les possibilités de comblement.

SYNOPSIS

The present methods adopted for coastal defence and for assisting replenishment of the sea bed are first dealt with. These methods consist essentially of shallow breakwaters of natural blockwork parallel to the shore and of groynes at right angles to it.

However, these contrivances do not always prevent coast erosion and in this report a particular type of breakwater consisting of a reinforced concrete slab supported on piles is discussed.

Our report deals with preliminary laboratory tests. The object of the investigation was to determine the optimum level of the upper and lower edges of the slabs and in a depth of water of about 3 to 5 m. The resulting slope of the slabs was between 1:3 and 1:4.

Tests will be continued to establish the possibilities of sea bed replenishment.

* Mémoire effectué avec la contribution du C.N.R. (Conseil Nat. des Recherches- ROMA)
SYNOPSIS

A study of sediment movement along a coast is particularly important when location of a port is to be decided upon. Tracer techniques can now be conveniently used for such a study. The Netravati river joins the Arabian Sea in the close vicinity of the proposed Port at Mangalore. Sediment brought by it could form an immediate source of silting in the approach channel to the Port. Due to contradictory evidence regarding movement of sediment brought by the river shown by analysis of data in respect of hydrographic surveys, wave energy, float observations, coastal surveys, extent of travel of debris and muddy water, nature of material on the beach etc., it was considered desirable to carry out fluorescent tracer study at Mangalore where siting of the Port hinged upon the movement of bed material.

The fluorescent material was dumped at the mouth of the river. The study showed definite trend of travel of sediment to the south of the mouth of the river. It was, therefore, considered that lagoon harbour could be sited to the north of the mouth of the river as it was not likely to be affected by the material brought by it during the monsoon period.

RESUME

Une étude sur le mouvement des sédiments le long d'une côte est particulièrement important lorsqu'on doit décider de l'emplacement d'un port. Pour une telle étude on peut maintenant employer facilement des techniques de tracage. Le fleuve Netravati se jette dans la mer d'Oman à proximité du port en projet à Mangalore. Les sédiments qu'il apporte pourraient former une source immédiate de limon dans le chemin d'approche du port. À la suite d'evidence contradictoire sur les mouvements des sédiments apportés par le fleuve obtenue par l'analyse des renseignements sur les études hydrographiques, l'énergie des vagues, les observations sur radeaux, les études côtières, l'importance des déplacements des débris et de l'eau vaseuse, la nature du sol sur la plage etc., on a pensé qu'il était souhaitable de faire des études par tracage fluorescent à Mangalore où le choix de l'emplacement du port dépendait du mouvement du sédiment submergé.

Le produit fluorescent fut jeté à l'estuaire de fleuve, l'étude a montré une tendance bien déterminée du sédiment à se déplacer vers le sud de l'estuaire de fleuve. On a donc conclu que le port-lagune pourrait être situé au nord de l'estuaire du fleuve car il est peu probable qu'il soit affecté par les matériaux apportés par le fleuve à la saison des moussons.
PROTECTION AGAINST COASTAL EROSION AND FORMATION OF SAND BEACHES
TWO PROBLEMS IN THE MOZAMBIQUE COAST

By NELSON GOMES
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SYNOPSIS

The present paper deals with two cases of coast protection against sea erosion near the cities of Beira and Lourenço Marques, in Mozambique - the former with more salient features of shore-line protection, and the second bearing also on the problem of the formation and protection of beaches of special touristic interest.

1. In chapter I, brief reference is made to types of coast protection.

2. In chapter II, special reference is made to the great amplitude of the tide in Beira (exceeding +7.00 m.); to the predominance of undulation from E-SE and to the intense alluvial drift from east to west. The author then studies the transverse profiles of the beach from 1954 to 1959, the behaviour of the groins built by local authorities over several years, and the drawbacks arising from deficient structuration of the protection. He explains briefly the phenomena that occur close to the groins and along the estran; he notes a sudden drop in the beach slope at mid-estran coinciding with the end of the groins, and the ensuing disadvantages in Spring tide high water (of great amplitude). He points out the serious drawbacks of high vertical face groins, especially on the west side, opposite to that whence sea alluvium comes. He defines in general terms the purposes of groins and stresses the economic aspect of the problem, which should comprise not only the structure of the work but also the value of the areas to be taken advantage of in the protection or for any other important purposes.

3. In chapter III, reference is made to the project of transverse-type protection to arrest the sand erring along the estran of the Lourenço Marques beaches and to make possible the formation of beaches of real touristic interest and which were disappearing as a result of the old shore works. The author presents the type-profiles of protection adopted and describes the success obtained.

4. Chapter IV sums up the information or recommendations derived from the experience with the works described and groups them under two headings: general and special appreciation. In the former, the advisability is stressed of interconnecting eventually other problems too with coastal protection works - like town-planning, harbour planning and channels of access to harbours, etc. - and of trying to profit to the utmost from the investments to be made. In the second heading, he condemns in general the type of high groin with vertical sides; he recommends that groins be given a slope corresponding approximately to the one intended for the estran, and that their length attain or exceed hydrographic zero, depending on individual cases; he stresses the importance of the amplitude of the tide for the design of the protection, and dwells on the combining of protection of the transverse type with that of the attached longitudinal type, it being advisable to lighten the latter as much as possible if efficient use has been made of the former.

Ce rapport s'occupe de deux cas de protection côtière contre l'érosion maritime dans les environs des villes de Beira et Lourenço Marques, à Mozambique.

1. Dans le premier chapitre l'on fait une brève référence aux types de protection côtière.
L'EMPLOI DES TETRAPODES POUR LA PROTECTION DU LITTORAL

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Il est apparu que les qualités hydrauliques des blocs Tétrapodes utilisés avec succès pour la protection de brise-lames importants pouvaient également avoir un intérêt tout spécial dans le domaine de la protection des côtes.

Trois exemples d'utilisations récentes des Tétrapodes aux Indes à Bombay, en Allemagne dans l'Ile de Sylt, en France sur le littoral méridional en Camargue, donneront une idée des diverses possibilités offertes par ces blocs pour la protection du littoral.

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The hydraulic properties of Tetrapods, which have been used with considerable succes for the protection of big breakwaters, have also been found to be of great value in coastal protection work. The possibilities of Tetrapods in this field are illustrated by examples of recent coastal protection projects at Bombay, on the German island of Sylt, and in the Camargue region of the French Mediterranean coast.
This study was carried out to obtain a general idea of the development of a constricted tidal inlet connecting a lagoon to the sea. Two series of movable-bed model tests were made; the first was concerned with the development of self-formed channels due to tidal action alone, while in the second series the additional effects of waves were examined.

Without wave action two similar underwater deltas formed such that the jet flow initially present at efflux gradually diverged with successive tides until the current patterns at influx and efflux became almost identical. Waves approaching normally from sea ward created a much more complex situation due to strong interaction between waves and currents. Characteristic bar and channel deformations were observed. Synchronized time-lapse cinematography provided a visual method for distinguishing between the motions of waves and currents. Tidal propagation through the inlet has been compared with theory and, finally, the application of test results to real inlets is discussed in general terms.
WAVE ACTION ON ISOLATED VERTICAL CYLINDERS OF LARGE DIMENSIONS

par René Bonnefille et Pierre Germain
Laboratoire National d'Hydraulique de Chatou, France.

ABSTRACT

Many studies have been made concerning the action of waves on obstacles whose dimensions are small compared with the wavelength. The extent to which the conclusions can be applied decreases, however, as the comparative size of the obstacles increases. The Authors have attempted to extend the range of previous investigations and in the Paper they present a method of calculating wave-pressures on cylindrical obstacles having dimensions comparable with the wavelength. Their method is derived from theoretical analysis and scale-model tests.
SYNOPSIS

During the last decades research has been made in order to find out the coefficient of reflection of gravity waves for rubble-bound breakwaters. The results of the tests have shown that the factor of reflection depends on the steepness of the incident wave, the depth in front of the breakwater, the inclination of the breakwater slope and the material composing the breakwater. Theoretical formulas for calculation of the reflection have still not been derived.

At the Institution of Hydraulics at Chalmers University of Technology, Sweden, about 1300 different test-runs have been performed to investigate the coefficient of reflection for different slopes and wave characteristics. In this article these tests are described and a brief summary of a theoretical calculation of the coefficient of reflection obtained at different kinds of slopes is also shown. The theory is founded on the energy loss of the compound wave due to friction against the slope and the walls and bottom of the wave flume. Owing to the fact that the friction factor for waves is not known and that the equation of second order of approximation for waves on a slope is not derived, a complete agreement between the test results and the theoretical calculations has not been obtained. The discrepancy is at most about 20%.

Pendant les dernières dizaines d’années des recherches ont été faites pour trouver le coefficient de réflexion de la houle du côté des brise-lames en enrochements. Les essais ont montré que le facteur de réflexion dépend de la cambrure de la houle incidente, de la profondeur d’eau devant le brise-lames, de l’inclinaison du talus et des matériaux du brise-lames. Des formules théoriques du coefficient de réflexion ne sont pas encore dérivées.

A l’Institution Hydraulique de l’Université Polytechnique de Chalmers, Suède, environ 1300 essais différents sont effectués pour trouver le coefficient de réflexion pour talus différents et caractéristiques différentes de la houle. Dans cet article les essais sont exposés et un bref résumé du calcul théorique du coefficient de réflexion est aussi montré. La théorie est basée sur la perte de l’énergie de la houle à cause du fricition au long du talus et des murs et du fond du canal à houle. A cause du raison que le coefficient de résistance des houles n’est pas connu et que la théorie de houle au second ordre d’approximation au long d’un talus n’est pas dérivée, une concordance parfaite n’a pas été atteinte. La divergence entre les valeurs calculées et mesurées est au maximum d’environ 20%.
ANTICIPATED HURRICANE EFFECTS ON A SUBMARINE PIPELINE

EFFETS DES OURAGANS SUR UN PIPE-LINE SOUS-MARIN

By Basil W. Wilson

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SYNOPSIS

The susceptibility to exposure and damage of a 7-mile long hot sulphur pipeline entrenched in the sediments between Grand Isle, Louisiana, and the offshore sulphur mine in the Gulf of Mexico, from natural forces, is the subject of enquiry. It is shown that the pipeline is sited on the only portion of Grand Isle's coastline that is currently stable in the face of general erosional advances along most of the Louisiana coast. The area has escaped any optimum hurricane onslaught in its recorded history but the effects of such an event are specifically investigated to determine how the pipeline might suffer. It is concluded that the pipeline should suffer no ill effects provided it is deeply entrenched as planned, even though very great erosional damage may be sustained by the shoreline and the nearshore region.

Cette communication est consacrée à l'étude des dommages possibles causés par les forces naturelles à un pipe-line de sulfure à haute température, d'une longueur de 11 km, posé dans une tranchée creusée dans un sol sédimentaire entre Grand Isle (Louisiane) et le dépôt de sulfure dans le golfe du Mexique. Le pipe-line repose sur le seul endroit de la côte de Grand Isle qui soit actuellement stable, la majeure partie de la côte de Louisiane étant continuellement en érosion. Toutefois, nous avons supposé dans notre étude que cette région était aussi soumise aux effets maxima d'un ouragan, ce qui, de mémoire d'homme, ne s'est jamais produit à cet endroit. La conclusion est que le pipe-line ne peut être endommagé, à condition toutefois d'être enterré profondément, comme prévu, malgré la possibilité d'une forte érosion littorale.
VARIATIONS DE LA PERIODE DES LAMES AU COURS DE LEUR DEFERLEMENT

par Jean LARRAS, Inspecteur General des Ponts et Chaussées
Conseiller scientifique du Laboratoire National d'Hydraulique (France)

La période de l'ultime rouleau de déferlement à la plage ne représente qu'une fraction de la période du premier rouleau côté mer lorsque la houle forme un grand nombre de lignes de rouleaux successives à la côte (voir tableau n° 1).

La période de la houle naturelle n'est donc pas toujours invariable au cours de la progression des lames vers la côte.

Mais la période de l'ultime rouleau de déferlement à la plage diffère d'autant moins de la période des brisants sur les obstacles au large que la houle reprend une forme plus simple et plus régulière en fin de tempête (voir tableau n° 2).

On ne retrouve rien de tel pour les huules pures de laboratoire.

Les variations de période précédentes semblent donc liées à l'existence d'harmoniques complexes des huules naturelles, qui correspondent eux-mêmes à l'existence d'une vitesse de groupe (1).

(1) La vitesse de groupe est voisine de 50 % de la célérité de la houle fondamentale pour les huules complexes dotées d'une infinité d'harmoniques, en profondeur infinie, et voisine de 100 % de cette célérité à faible profondeur.
OPTIMAL DESIGN OF A FLOOD CONTROL RESERVOIR.

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SYNOPSIS

An optimal design is one which fulfils a specified function in the most efficient manner. In a flood control reservoir the operating policy governs the peak discharge rate and the required storage capacity. Determination of the most efficient policy in terms of the chosen design criteria is therefore essential to the preparation of an optimal reservoir design.

To minimise downstream flood damage an optimal policy will be determined by the available storage capacity and the time over which releases can be effected. A reasonable basis for decision is the probability of further flood inflows before the reservoir is emptied. A dynamic programming model is employed to determine the optimal releases for different reservoir levels at successive stages in the routing of a forecast flood hydrograph, when the probabilities of additional flood inflows are known.

On the basis of this optimal policy an optimal reservoir design can be selected for given design criteria. The basic model may be adapted to suit a variety of such criteria. The model may also be used to optimise reservoir operation under real operating conditions.

... .

LA CONCEPTION OPTIMALE DES RÉSERVOIRS POUR LE CONTRÔLE DES CRUES.

La conception optimale est celle qui remplit une fonction spécifique de la façon la plus efficace. Dans un réservoir pour le contrôle des crues, la politique opérante régit le débit maximum d'évacuation et le pouvoir de contenance requis. La détermination de la politique la plus efficace dans les termes des critères de la conception choisis est donc essentielle pour la préparation de la conception d'un réservoir optimal.

Pour minimiser les dégâts d'une crue en aval, la politique optimale sera déterminée par le pouvoir de contenance disponible et le temps de débit. Une base raisonnables de décision est la probabilité des crues additionnelles avant que le réservoir soit déchargé. Un modèle de programme dynamique est employé pour déterminer les débits optimales pour les différents niveaux du réservoir aux étapes successives du 'routing' pour une hydrogramme de crue quand les probabilités des crues additionnelles sont connus.

Sur la base de cette politique optimale on peut choisir la conception d'un réservoir optimal pour satisfaire aux critères d'une conception donnée. Le modèle de base peut être adapté pour satisfaire à une variété de tels autres critères. Le modèle peut être aussi employé pour optimiser l'opération du réservoir sous les conditions d'opération réelle.
FLOOD DISCHARGE OF THE MOUNTAIN RIVERS IN NORTHERN SWEDEN DURING NATURAL WATER REGIME AND AFTER REGULATION OF THE WATER IN LAKE STORAGE RESERVOIRS AND ITS CONNECTION WITH DAM DESIGN

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SUMMARY

Through long series of water-stage observations, the oldest one beginning at the end of the eighteenth century, it has been proved that the extreme high floods rise up to about the same height. For that reason the water-power dams are designed in order to discharge the highest flood during the observed period 50 to 60 years as a rule increased with 10 to 20%. The water utilized in a power-plant is not taken into account as the plant might be out of function because of damages at the time of high floods. In rivers with lake-storages, high floods theoretically can be larger than the natural ones. It has been found from about 20 years' regulation work that it is possible to reduce the flood-peaks if the regulations are handled with care according to precipitation, temperature and snowmelting within the river basins. As the experiences are not too great and one must consider the possibility of heavy rain-fall, impossible to anticipate, at a time when the storages are filled up, the Water-Courts prescribe dam designs in order to discharge the maximum as if the rivers had natural flows. Concerning lake-magazines where it is possible to store almost the whole normal yearly flow, a design for a smaller amount than the max-flow is being discussed.

RÉSUMÉ

On a prouvé, à la suite d'une longue série d'observations des niveaux d'eau que commença à la fin du XVIII-e siècle, que les crues maximales atteignaient toutes environ le même niveau. C'est pour cette raison que les barrages hydro-électriques sont construits afin d'évacuer, pendant la période examinée, 50-60 ans, le débit maximum, en général augmenté par 10 à 20%. L'eau utilisée dans une centrale n'est pas prise en considération car celle-ci pourrait ne pas fonctionner par suite de dégâts en période de crue. Les crues des rivières équipées de lacs de retenue peuvent théoriquement être plus importantes que le débit naturel. Après 20 ans de travaux de régulation, on a trouvé qu'il était possible de faire baisser les niveaux maximum de crue, si la régulation est faite avec soin et en tenant compte de précipitations, de la température et de la fonte des neiges dans le bassin de la rivière. Comme les expériences faites jurent peu nombreuses, et étant donné que l'on doit envisager la possibilité de grosses pluies imprévisibles alors que les réservoirs sont pleins il est décidé qu'il y aura une construction de barrages afin naturel. Quant aux lacs où l'on peut retenir une grande partie du débit normal d'une année, des discussions sont en cours au sujet de la construction de barrage pour une quantité d'eau inférieure au niveau maximum de crue.
The pumped storage scheme at Ffestiniog in North Wales incorporates a precise automatic system for the detection and discharge of flood water at any stage in the operating cycle.

Pumped storage schemes such as this consist essentially of two reservoirs, with a constant volume of water which is pumped up during off-peak hours and which is used for generation during peak hours. This is normally a daily cycle, but power must also be available for emergency use. Therefore, flood water entering either reservoir must be detected at once and passed out from the lower reservoir at a rate no worse than the natural flow.

The total volume of water in the system must be kept constant, so that there is always space in the lower reservoir for the water in the top reservoir.

The automatic system described in this paper detects any variation in level of the lower reservoir from what it should be in relation to the upper reservoir, and controls the discharge from the lower dam accordingly, with an overall accuracy of about 1/2%.
The role played by the flood plains in the correlation between flood prediction and the determination of the optimal dam size in a flood control project is examined.

An optimal dam design is one that leads to an overall optimal benefit to cost ratio for the entire project. This aim can be achieved only through an effective utilisation of the flood plains as an integral part of the flood control scheme.

For such a utilisation, both short range and long range predictions are needed, not only of peak and average flood flows, but also of several other features of the flood hydrograph. An important element of prediction for the utilisation of the flood plain is also the warning time.

With a combination of "static" and "dynamic" floodproofing in the flood plain, the overall operation of a flood protection scheme acquires a degree of elasticity, characterised by a "cost elasticity coefficient", which reduces the effect of errors in flood predictions.

The steps involved in the optimization of the reservoir - flood plain system are examined. The need both for more effective operations research techniques and for long range predictions of the economic pattern in the flood plain to match the precision of long range flood predictions is emphasized.

**Résumé**

L'on examine le role des terrains de crue dans la correlation des predictions de crue avec la determination des dimensions optimums du barrage d'un project de protection contre les crues.

A project optimum d'un barrage est un project conduisant a un rapport maximum entre les benefices et les couts pour l'entier schema. Ce but peut etre etabli seulement avec une utilisation efficace des terrains de crue comme partie integrale du schema de protection contre les crues. A ce but, pronostics a breve et a longue eschance sont necessaires, pas seulement des debit maximum et des debit moyens de crue, mais aussi de plusieurs autres caracteristiques de l'hydrogramme de crue. Un autre element d'importance pour l'utilisation des terrains de crue est le temps de preavis.

Avec une combination de protection "statique" et "dynamique" des terrains de crue, le fonctionnement d'un project de protection contre les inondations acheve un degre d'elasticite, caracterise par un "coefficient d'elasticite de cout," qui reduit l'effect qu'erreurs dans pronostics peuvent avoir dans le procede d'optimization.

Les etapes necessaires pour optimiser le systeme barrage - terrains de crue sont examinees. Le besoin de techniques d'analyse operationelle plus puissantes que les actuelles et de predictions a longue eschance du developpement economique dans les terrains de crue avec la meme precision des predictions des crues est accentue.
SPILLWAY DESIGN FLOOD PREDICTION

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The flood prediction does not concern dam design in respect of the storage capacity, since for a given characteristic of flow oscillations corresponds always a determined size of the reservoir. Reservoir design, as well as reservoir control based on the phenomena of waves propagation, as flood protection concerns, has become to some extent independent of the inflow to the reservoir, and by the same of flood prediction.

But for the design of the spillway it is necessary to know the characteristics of floods to be expected, in order to insure the safety of the dam. The determination of the proper flood to provide for involves the question of probabilities. However statistical method of reasoning could have real sense only when relying on a great number of events thus, the probability calculations should be based on an extended record of homogeneous source material for a long period of years. But as in a long period of years, there are often important modifications in physical characteristics of the watershed, affecting the peak producing ability of the stream, the records may not be homogeneous. To avoid deceiving results, a more physical way of reasoning was adopted.

An extended stream flow record period was divided so, as to show the hydrological characteristics of each period, and by the same demonstrate the tendency of future peak flood flows. Some numerical examples were examined.

La conception des barrages, en ce qui concerne le volume du reservoir, ne depend pas de la prediction des innondations, puisque pour la caracteristique donnee des oscillations des debits, correspond un volume du reservoir determine. Les conceptions des barrages ainsi que leur exploitation vue de l'aspect de propagation des ondes sont devenue independant du regime du cours d'eau amont et par consequence de la prediction des innondations.

Mais pour les projets des deversoires il est indispensable de savoir la caracteristique des intumescences expectees, pour pouvoir assurer la securite du barrage. La determination du debit maximum de crue exige l'application de la theorie de probabilite. Cependant les methodes statistiques de raisonnement pourraient avoir un sens reel, seulement pour le cas quand ils sont basés sur un materiel nombreux et homogene pour une long duree d'annees. Mais pendant un temps prolonge les changements survenant dans le bassin versant peuvent modifier les facteurs d'ecoulement et de meme les debits maximum des crues faisant que ces donnees ne sont plus homogenes. Pour eviter les resultats casuels, un raisonnement rapproche plus a la physique fut adopte. Les donnees d'ecoulement d'une long duree furent divisee de facon a montrer les caracteristiques hydrologiques de chaque periode et par le meme la tendance future des debits maximum des crues etait releve. Quelques exemples numeriques ont ete examine.
PREDICTION OF FLOOD WAVES IN CONNECTION WITH DESIGN OF RESERVOIRS

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When projecting and using reservoirs it is necessary to predict the alterations of water regime occurring in lower and upper reaches when flood waves spread.

The Institute of Hydrodynamics, Siberian Branch of the Academy of Sciences of the USSR to solve hydraulic equations of unset flows in open channels has developed, making use of method of nets, differential implicit scheme which makes it possible to solve the equations with bigger time interval.

The paper gives some information concerning accomplished calculations of flood-wave motion in a large river system under natural conditions and when controlling reservoir drain.

En projetant et en exploitant des retenues d'eau on a besoin de prévoir les variations du régime hydraulique qui se produisent lors la propagation des vagues de grande crue par les biefs en amont et en aval.

Pour résoudre les équations hydrauliques du mouvement instable dans les lits ouverts l'Institut hydrodynamique de la Filiale sibérienne de l'Académie des Sciences de l'URSS a établi un schéma différentiel implicite fondé à la méthode des réseaux qui permette de faire les calculs à grand pas d'après le temps.

On donne quelques renseignements sur les calculs accomplis pour le mouvement des vagues de grande crue dans un grand système gluvial dans les conditions naturelles ainsi qu'avec un écoulement régularisé par une retenue d'eau.
CONTROLES DES CRUES AU BARRAGE DE MANICOUAGAN 5
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SOMMAIRE

Les études de contrôle des crues à Manicouagan 5 ont permis de prévoir un évacuateur très économique. Cet avantage découle de consignes d'exploitation prévues dont la souplesse sera rendue possible par la grande superficie de la retenue.

Le souci d'éviter d'exagérer les dimensions de l'évacuateur au Site 5 se justifie du fait qu'il évitera la construction d'évacuateurs de dimensions excessives aux deux autres aménagements prévus en aval.

L'important barrage de Manicouagan 5, dont la retenue sera l'une des plus volumineuses au monde, exige une retenue de 10 pieds en tout temps, même dans l'éventualité d'une crue dix-milliénaire (fréquence de l'1/10 000 ans).

Malgré une telle sujétion, il a été possible de réduire le débit de l'évacuateur au tiers de la crue dix-milliénaire en considération des consignes suivantes:

A) cote maximale de retenue au printemps
B) déversement d’après une courbe limite garantissant contre tout risque d’entamer la revanche prescrite.

Ces consignes ne sont présentées à la fois comme les plus économiques et les plus sûres pour l'étude des ouvrages; elles ont ainsi permis une économie substantielle sur les frais d'implantation.

Cette exposition n'a pas la prétention d'élaborer une nouvelle méthode pour l'étude des ouvrages mais bien de préciser quelles ont été les bases d'étude de l'évacuateur de Manicouagan 5.

SUMMARY

Flood control studies at Manicouagan 5 have allowed the design of a most economical spillway. This is a result of planned operating procedures whose flexibility will be made possible by the size of the storage area.

Avoidance of a very large spillway at Site 5 means smaller spillways at the 2 downstream developments. The important dam at Manicouagan 5, with one of the largest storage capacities in the world, requires a freeboard of 10 feet at all times, even in the eventuality of a flood happening once in 10 000 years.

Despite such a limitation it has been possible to reduce the capacity of the spillway to one third of the 10 000 year flood, in consideration of the following factors:

A) Maximum control level in spring
B) Discharge following a limiting curve which prevents any risk of encroaching on the required freeboard.

These factors have proved to be both the most economical and the safest for the study of such works; they have allowed substantial savings on construction costs.

The purpose of this paper is not to elaborate a new method of study, but to state precisely the basis of study for the Manicouagan 5 spillway.
FLOOD CHARACTERISTICS AND SPILLWAY DESIGN

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SYNOPSIS.
Floods are of probabilistic character, while hydraulic structures for flood evacuation have deterministic properties. As floods are the primary factor for consideration, the design of spillways and other flood discharge structures should be adapted to the probabilistic phenomenon.

The concept of maximum probable flood of a river basin is defined in the Borel’s sense. The difficulties in determining reliable flood probability distributions from small samples of flow records do not justify a change from the probabilistic to the deterministic principle in spillway design.

Changes in flood probability distributions with time due to man-made changes in river basins should be allowed for in estimating the probability of rare floods. These probability estimates should also take account of the probability distribution of reservoir level at commencement of the flood.

The characteristics of flood phenomena suggest the spillway should be designed in such a way that the rate of change \( \frac{dQ}{dH} \) of the spillway capacity rating curve should increase with an increase of discharge. Spillways with the flow under pressure for the largest floods should be provided with safeguards of the free surface flow type.

RESUME
Les crues sont des événements régis par les lois des probabilités. Les evacuateurs de crue, au contraire, ont des dimensions bien déterminées. Le calcul des evacuateurs étant surtout fait en fonction des crues, il doit tenir compte de leur caractère probabiliste.

La notion de crue maximum probable d’un bassin versant est définie au sens de Borel. Les difficultés d’obtenir la loi des probabilités des crues à partir d’observations de débits sur des périodes relativement courtes, ne peuvent pas justifier l’abandon des principes probabilistes pour des considérations purement déterministes dans l’étude des evacuateurs de crue.

L’évolution dans le temps de la répartition des probabilités des crues, due aux changements apportés par l’homme au bassin versant, doit être prise en considération. Cette répartition doit aussi tenir compte de la probabilité du niveau des réservoirs au commencement des crues.

Les caractéristiques des crues suggèrent que la dérivée de la courbe des débits \( \frac{dQ}{dH} \) croit avec le débit maximum d’une crue. Les evacuateurs fonctionnant en charge lors de crues exceptionnelles devraient être amenagés par des evacuateurs complémentaires de secours où l’écoulement serait à surface libre.
ECONOMICS OF CALCULATED RISKS IN DAM DESIGN

SYNOPSIS

Hydrologic techniques and design criteria developed during the last half century permit the conversion of storm rainfall into flood runoff and the design of dams in a rational and logical manner which insures essentially no risk of dam failure. The details concerning the engineering techniques involved have been amply presented in published documents available to engineers in most countries. On the other hand, the economies which might result from deliberately accepting some risks have received proportionately little consideration. Design criteria based on the acceptance of limited structural damage during a major flood which would have little or no effect on the safety of the dam have not been extensively documented in the literature.

This paper presents the idea of accepting calculated risks in the design of dams to reduce project costs. Design criteria and economic considerations are presented for diversion works, outlet works, spillways and stilling basins which will serve as guides in selecting the degree of security that should be provided against structural damage and possible dam failure during extraordinary floods. Special emphasis is given to the correlation of flood prediction with design capacities, structural dimensions, foundation or streambed characteristics and savings in cost. It is concluded that the deliberate acceptance of calculated risks in the design of dams may be justifiable when the damage will be limited to structural components of the dam, or when a dam failure would not imperil the lives nor excessively damage properties of the populace in the downstream flood plain.

LES ECONOMIES DES RISQUES CALCULES
DANS LA CONSTRUCTION DES BARRAGES

SOMMAIRE

Les techniques hydrologiques et les critères de calcul développées depuis cinquante ans permettent la conversion des précipitations des tempêtes en écoulement de crue et le calcul des barrages d'une manière logique et rationnelle qui, essentiellement, prévient le risque d'une rupture de barrage. Les détails sur les techniques employées ont été largement présentés dans des ouvrages publiés et accessibles aux ingénieurs de presque tous les pays. D'autre part, les économies qui peuvent résulter lorsqu'on prend des risques délibérés, ont reçu relativement peu de considération. Les critères de calcul basés sur l'acceptation de dommages limitées pendant une crue majeure qui aurait peu ou pas d'effet sur la sécurité du barrage n'ont pas été très documentés.

Le papier ci-après présente l'idée d'accepter un risque délibéré dans le calcul des barrages pour en diminuer le prix de revient. Des critères de calcul et considérations d'économie sont présentés pour des ouvrages de déviation, et déversement, des déversoirs et des bassins de repos qui serviront de guide dans la sélection du degré de sécurité qui doit être prévu contre les dommages à l'ossature et l'éventualité de la rupture du barrage durant une crue extraordinaire. La corrélation de la prédiction des crues avec les calculs de capacités, les dimensions, les fondations ou nature du lit du fleuve et le prix de revient est particulièrement étudiée. Ou en conclue que l'acceptation délibérée d'un risque prévu dans le calcul des barrages peut être justifiée quand les dommages seront limités aux éléments de l'ossature du barrage ou quand la rupture du barrage ne causera pas de pertes de vie ou des dommages matériels excessifs dans la zone aval inondée.
A brief description is made of the eastern slope of the Andes mountain chain. The basin of the Atuel river is described in particular. The method of prediction by correlation adopted is commented, and it is shown how it is possible, by means of only one "snow course", located out of the basin but close enough, to obtain sufficiently approximate data. The application given to the predictions is indicated, and some examples are given showing the use of prediction in the construction of dams in other rivers.

Il est fait une description sommaire des caractères physiques du versant oriental de la cordillère des Andes. On décrit en particulier le bassin de la rivière Atuel. On commente la méthode de prédiction par corrélation adoptée, et on montre comment il est possible, au moyen d'une seule "snow course" située en dehors du bassin mais pas très éloignée, d'obtenir les données avec suffisante approximation. On indique l'application donnée à ces prédictions, et on donne quelques exemples de l'utilisation des prédictions pour la construction de barrages sur d'autres rivières.

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APPLICABILITY OF UNIT-HYDROGRAPH METHOD TO FLOOD PREDICTION

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Synopsis: In this paper, the applicability of the unit-hydrograph method to flood prediction is discussed theoretically, after disclosing the hydraulic mechanism of rain-water flow on a mountainous slope in a river basin and the behaviour of the occurrence area of overland flow in details.

The runoff phenomenon is characterized mainly by the soil condition covering the surface of a river basin and the rainfall condition. If the porous stratum with high permeability covers the surface of a basin as in Japan, the flow behaviour of rain-water becomes very complicated. By means of the method of characteristics, the physical significance of the lag is clarified from a dynamic point of view that the runoff phenomenon in a mountainous area is a transformation system from rainfall to discharge. Furthermore, after evaluating the character of the system, it is shown that there are three types of runoff patterns: non-linear time-invariant of overland flow, non-linear time-invariant of interflow, and non-linear time-variant of overland flow. After disclosing the characteristics of each runoff pattern, the generalized relation between the peak flow and the lag is presented. Under these considerations, the applicability of the unit-hydrograph method is discussed and the new modified method in runoff analysis involving the effect of non-linearity is proposed.

L'APPLICABILITÉ DE LA MÉTHODE DE L'UNITÉ-HYDROGRAPHE CONTRE LA PRÉDICATION DES CRUES

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Sommaire: Dans cet étude, l'applicabilité de la méthode de l'unité-hydrographe contre la prédiction des crues est discutée théoriquement après avoir trouvé en détail le mécanisme hydraulique de l'eau de pluie sur une pente montagneuse dans un bassin et la conduite de la surface de l'occurrence de l'écoulement audessus le terrain.

Le phénomène d'écoulement est caractérisé surtout par la condition du terrain qui couvre la surface du bassin et la condition de l'eau de pluie. Si la couche poreuse avec une haute perméabilité couvre la surface du bassin comme au Japon, la condition d'écoulement de l'eau de pluie devient très compliquée. Selon la méthode des traits caractéristiques, la signification physique du retard est clarifiée par un point de vue dynamique que le phénomène d'écoulement dans une surface montagneuse est un système de transformation de la pluie à l'écoulement. D'ailleurs, après avoir évalué le caractère du système il a été démontré qu'il y a trois types de modèle: le temps invariant non-linéaire de l'écoulement audessus le terrain, le temps invariant non-linéaire de l'écoulement sous le terrain, et le temps invariant de l'écoulement sous le terrain. Après avoir trouvé les traits caractéristiques de chaque modèle d'écoulement, la relation générale entre le pic d'écoulement et le retard est présentée. Selon ces considérations, l'applicabilité de la méthode de l'unité-hydrographe est discutée, et la nouvelle méthode modifiée dans l'analyse d'écoulement d'eau contenant l'effet non-linéaire est proposé.

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DESIGN FLOOD CRITERIA FOR SPILLWAYS IN UTTAR PRADESH

By


SYNOPSIS

The criteria adopted in the construction of storage reservoirs in the past in U.P. have been described. These were invariably based upon the use of Dicken’s formula \((Q=CM^2)\) wherein the value of \(C\) was generally adopted by Engineers, based on their experience and judgment of the basin characteristics. Some unexpectedly heavy floods recorded in the U.S.A. and India have been described which led the designer to take a realistic stock of the considerations mentioned in the paper.

The important catchments, namely, Sarda at Banbasa, Ganga at Hardwar, Ramanga at Kalagarh, Rihand at Pipri and Betwa at Paricha, have been considered for which the design of the storage reservoirs is discussed. For smaller storage works, low recurrence intervals, of the order of once in fifty years, were adopted for the design flood, while for barrages and weirs, like the Sarda at Banbasa and the Ganga at Hardwar, the recurrence intervals of the design flood was 144 and 334 years respectively. For the dams built recently and those which are under construction in U.P., such as the Rihand at Pipri and the Ramanga at Kalagarh, the design flood was derived from detailed hydrological investigations including the application of empirical formulae, unit hydrograph method and flood frequency approach, wherein the recurrence interval was kept at 1000 years or more.

It has been recommended that in the absence of detailed hydro-meteorological data, it will not be advisable to modify the existing design criteria radically.

INTRODUCTION

Rivers in Uttar Pradesh can be broadly classified into two categories:

1. Himalayan rivers - These take off from Himalayas in the North, flow towards the East and being snowfed, are perennial.

2. Vindhyan rivers - These take off from Vindhyas in the South, flow towards the East and being monsoon fed, are non-perennial.

In the North, therefore, rivers like Yamuna, Ganga and Sarda have been harnessed by building across them weirs and barrages for irrigation systems while in the South, low dams have been built on rivers like Betwa, Ken and Dhasan. While the storage works were constructed during the last 100 years or so, very little was known about the hydrology of the catchments feeding these rivers. There were hardly any rain gauge and stream gauging stations in the catchments and, therefore, recourse had to be made to estimate flood flow mainly with the help of empirical formulae. The most popularly accepted formula is that of Dicken’s \((Q = CM^2)\). The author gave the value of \(C\) as 825 and contemplated the use of this formula for Northern India for regions having an annual rainfall of 24 to 50 inches. Subsequently, different values of \(C\) were adopted depending upon the topography of the catchment.

After independence in 1947, India undertook Bhakra, Koyna, Tungabhadra, Lower Shavani and D.V.C. and in U.P., Rihand Dam, Yamuna Hydro-electric Scheme Phase I and II, Ranganga Dam and others came up for execution. A good number of rain gauge and stream gauging stations were established in the catchments of these projects and it was possible to estimate flood flow by ‘Unit Hydrograph’ method, Flood Frequency method, Regional Envelope curve (Kanwar Sain and Karpov), and World Enveloping Formula in addition to other empirical relations like that of Inglis, etc.

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FLOODS IN RIVER INDUS — THEIR FREQUENCY AND MAGNITUDE

By

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SYNOPSIS

Observed annual maxima of discharges for Kalabagh, Ghazigah, Sukkur and Kotri have been studied. Expected frequency and magnitude of future floods at these sites have been computed both by "Hazen-Foster" and "Gumbel" theories. Least square equations have also been fitted to the observed data of floods which show the ratio of the annual flood to the mean annual flood as dependent variable and the corresponding percentage frequency as independent variable. Frequencies computed from least square line are found to correspond nearly with those computed from Gumbel Equation.
L'OPTIMUM ECONOMIQUE DU DIMENSIONNEMENT DES OUVRAGES DE PROTECTION CONTRE LES CRUES

par Jacques BERNIER

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RESUME :
Le calcul économique du dimensionnement des barrages pose le problème de la prévision statistique des crues. Dans ce rapport la recherche de l'optimum économique est formulée dans sa plus grande généralité de façon à montrer la portée des approximations et simplifications nécessaires pour conduire les calculs jusqu'à leur terme pratique et souligner la difficulté de l'estimation des divers paramètres hydrologiques et économiques qui entrent en jeu.

SUMMARY :
The economic determination of size of dams sets the problem of the statistical prediction of floods. In this paper the research of the economic optimum is formulated with the greatest generality so as to show the bearing of the approximations and simplifications required for conducting the calculations until their practical terminal, and to emphasize the difficulties of the estimation of the diverse hydrologic and economic parameters which occur.
LA PROBABILITÉ DU DÉBIT MAXIMUM ANNUEL ET SES RELATIONS
AVEC LA LOI DE DISTRIBUTION DES DÉBITS JOURNALIERS

M. Pierre GUILLOT, Ingénieur à ELECTRICITE DE FRANCE

I - LA LOI DE LA PLUS GRANDE VALEUR

Nous rappelons tout d'abord que si on effectue n tirages indépendants d'une variable
aléatoire, inférieure à x avec la probabilité \( F(x) \), la probabilité que la plus grande
des n valeurs tirées soit inférieure à x est celle que les n valeurs tirées soient toutes
inférieures à x. \( [F(x)]^n \), que nous noterons pour simplifier : \( F^0 \), constitue donc la loi
de probabilité de la plus grande de n valeurs. Dans le système de coordonnées habituel
la disposition relative de \( F \) et \( F^0 \) est la suivante :

Il est très avantageux, pour tracer et examiner \( F^0 \), d'adopter un autre système de coor-
donnees, un peu baroque à première vue, mais dont les nombreuses vertus vont apparaître.
Portons la grandeur \( x \) en ordonnée (c'est la coutume dans l'étude des valeurs extrêmes),
en abscisse \( F \) après lui avoir fait subir une dilation d'échelle doublement logarithmique : les
longueurs portées pour représenter \( F \) seront proportionnelles à : \( u(F) = -L(-LF) \).

La fonction \( u \) convient bien pour une transformation d'échelle puisque \( u \) croît de façon
monotone de \(-\infty \) à \(+\infty \) quand \( F \) croit de 0 à 1 ; en outre, elle dilate considérablement
l'échelle des probabilités au voisinage de 1, où nous voulons travailler. (2)

(1) Division Technique Générale - 37, rue Diderot - GRENOBLE - (France)
(2) Fonction \( u(F) \)

\[
\frac{du}{dF} = -\frac{1}{PLF} \\
\frac{d^2u}{dF^2} = \frac{LF + 1}{(PLF)^2}
\]

\( u \) et \( d^2u \) s'annulent pour \( LF = -1 \),
soit \( F = \frac{1}{L} \). Pour cette valeur \( u' = \left. \right|_{F=\frac{1}{L}} \)
la tangente au point d'inflexion passe par \((0,-1)\)

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EVALUATION OF THE MAXIMUM FLOOD DISCHARGE WITH REFERENCE TO THE TYPE OF STRUCTURE WHICH IS SUBJECTED TO IT

By Egidio Indri,
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SYNOPSIS
An analysis is made of the damage that can be caused by the inability of a dam or a weir to dispose of an oncoming flood which is in excess of the calculated figure.

The degree of risk that could be introduced in the evaluation of the maximum flood discharge by means of empirical or probability expressions, is to be established by reference to the type of structure which is subjected to it.

A short examination of the data pertaining to Italian dams and weirs is given in order to control the actual application of the criteria.

RESUMÉ
On fait une analyse des dégâts qui peuvent être causés au cas où les organes de décharge d'un barrage ne sont pas à même de débiter la crue qui arrive au-dessus de la valeur prévue.

Le pourcentage de risque qui peut être adopté dans le dimensionnement des œuvres de décharge, d'après les données déduites des formules empiriques ou expérimentales, dépend du type du barrage.

On fait un bref examen des données relatives aux barrages et aux prises d'eau italiennes, pour déterminer l'application pratique de cette hypothèse.
A GRAPHIC COMPUTATION METHOD
OF THE INFLUENCE OF RESERVOIR STORAGE ON THE
TRANSFORMATION OF MAXIMUM DISCHARGE

By Walenty Jarocki
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SUMMARY
This paper deals with the problem of the influence of a reservoir on the transformation of maximum discharge. This influence can be represented by various shapes of hydrographs determined for the entrance to the reservoir and modified by the cross-section of the catchment. The author describes hydrographs which are recommended for various local conditions in cases when there is hydrological data or if they are not sufficient. To calculate the influence of a reservoir on the transformation of maximum discharges diagrams are provided for the following cases: spillways without gates, spillways with gates and outlet sluices under pressure.

RESUME
L'ouvrage presente l'influence du reservoir sur le transformation d'ecoulement maximum. Cette influence est exprimee par hydrographes de differentes formes, au premiere partie de reservoir et a la section de l'installation elevante. L'auteur presente les schemas d'hydrographes, qui sont recommandes pour des differentes conditions locales de la formation d'inondation dans le cas ou on ne dispose pas de donnees hydrologiques ou quand elles ne sont pas suffisantes. Pour calculer l'influence du reservoir pour la transformation des ecoulements maximum - on a elabore des diagrammes pour barrages pleines sans clapet deversant, barrages pleines avec clapet deversant, et les conduites forcees de fond sous pression.
Flood Forecast for Rapel Dam Construction in Chile

By Eduardo Basso S.
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Summary

The basin of the Rapel river is located at about latitude 34° S, with an annual rainfall averaging 500 mm. The Rapel river comprises two main tributaries: the Cachapoal and Tinguiririca.

Flood due to snowmelt in the mountain zone is limited due to irrigation in the central zone. Where the dam will be built the maximum volume is almost entirely due to rainfall.

For the operation of the power plant it will be necessary to count on an adequate system for flood prediction. In this paper this aspect is not analysed but it covers the forecast of floods during the construction period which will provide experience for future use when the power plant will be operation.

Therefore it may be interesting to present the methods used in this case, which may be applied in countries where the scarcity of data makes the accurate treatment of the problem difficult.

The results are shown in Table I, and have a mean error of 15.6%.

It can be concluded that the methods indicated may satisfactorily be substituted for more elaborate systems for flood forecasting when there is not sufficient basic information or when it is not possible to invest in equipment.

Pronostic des crues pour la construction de la central Rapel au Chili

Pour Eduardo Basso S.
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Résumé

Le bassin versant du fleuve Rapel est placé autour de la latitude 34° S, la précipitation moyenne annuelle étant de 500 mm. Le fleuve Rapel est formé par deux affluents principaux: le Cachapoal et le Tinguiririca.

Les débits provenant de la fonte de la neige du massif des Andes sont annulés par l’effet de l’irrigation à la zone centrale. À l’endroit où on placera le mur les débits maximum sont d’origine presque exclusivement fluviale.

Pour le manœuvrement de la centrale il faudra compter avec un système convenant de pronostic des crues.

Dans cet article on ne traite pas cet aspect, mais on analyse le pronostic des crues pendant la construction, ce que permettra de profiter cette expérience pour l’exploitation de la centrale.

Étant donné que le bassin versant est relativement petit, les méthodes traditionnelles pour ces pronostics ne sont totalement appropriées, si l’on considère que la documentation basique pour leur emploi n’existait pas ou était incomplète.

C’est pour ceci qu’on a estimé qu’il serait intéressant de présenter les méthodes utilisées dans ce cas, qui peuvent être employées dans des pays où la manque de données empêche un traitement rigoureux du problème.

Les résultats tirés des pronostics effectués s’indiquent dans le tableau I, et ils ont une erreur moyenne de 15.6%.

On infère que les méthodes exposées peuvent substituer d’un manière satisfaisante des systèmes plus élaborés pour le pronostic des crues quand on n’a pas d’information suffisante ou quand il n’est pas possible de faire un grand renversement en équipement.
MODERN CONCEPTIONS ON FLOOD PREDICTION AND THEIR CORRELATION TO SPILLWAY DAM DESIGN

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SYNOPSIS

In this paper problems relating to flood prediction and their correlation to spillway dam design are presented. The advantages and limitations of forecasting techniques and their development are briefly outlined, and new methods are proposed. General considerations and conceptions based upon flood experience and forecasting procedure necessary to obtain reliable predictions are also described.

INTRODUCTION

Floods and their Prediction

Floods or excessive overflows of water coming from rivers are the result of a favourable combination of the numerous natural causes or phenomena among which can be noted storms, rapid snow melt and principal characteristics of the water shed. The more rare disastrous flood may be due to other reasons such as the sudden release of a large volume of water owing to failure or overtopping of a dam. Also floods are greatly increased when a rapid snow melt occurs at the same time as excessive rainfall. However, this combination of events can be rarely expected to occur at the same time and season of the year because the characteristics of these two phenomena are different so that they should be studied and analysed as separate events.

The greatest amount of precipitation does not necessarily produce the greatest flood unless the period of precipitation over the entire water shed of a big river is of very long duration. In temperate zones, especially, the occurrence of the maximum possible storm in a relatively large catchment does not necessarily mean that the maximum possible flood will occur. The largest flood that can reasonably be expected in such cases should be based on existing knowledge of the past history of the discharges. However, as the size of the catchment decreases the historical evidence becomes a less important criteria and the maximum possible storm becomes of greater importance in determining the maximum possible flood.

Floods can be classified into various types. They are usually grouped as rare, frequent, occasional, maximum and so on. From the point of view of forecasting, floods are separated into "prediction of maximum flood", "prediction of probable flood" and "prediction of individual flood". In the case of the maximum flood the forecast is expressed in terms of duration and magnitude. For the probable flood the frequency of occurrence should be added. The individual flood is expressed in terms of duration, magnitude and the expected time of occurrence.

Different floods have quite different longitudinal profiles and crests. Some are long and some are short. Also the slope in front of the crest of a flood is usually quite different from the slope behind. For some floods the front slope is sharp and for others gradual.

Data recording the basic characteristics of floods are valuable to engineers responsible for planning and designing spillways, dams and flood control structures. To ensure the safety of a dam a good knowledge of the principal characteristics of the flood is necessary and it is of vital importance to make a correct estimation of the probable maximum magnitude of future floods. Such estimations form one of the most important and fundamental factors determining the economic and technical success of the design. For this reason all available hydrological information and basic physical characteristics of the water shed should be thoroughly examined before settling the design. Careful and detailed study of all existing rainfall records and the frequency of occurrence of floods must be considered an indispensable part of the preliminary investigations, and
C. I. AHR. Congress
LONDON, 1963

SYNOPSIS

The Ishikari River is the second largest river in Japan with a length of 323.6 kilometers and a drainage area of 14,400 square kilometers. Whereas its downstream area along the river extending ninety-two kilometers in length is inhabited densely and enjoying economic prosperity, this area is subject to flood warning, and the Ishikari River Control Office is held responsible for offering flood forecasting service.

With the aim of preventing and reducing flood damage a multiple-purpose dam is under construction in the upstream reach of the Sorachi River, the largest tributary; a long-term project of embankment and river improvement is also being undertaken, taking part in flood control.

This paper describes in detail an estimation method for flood prediction, centering about the effect of flood control at the site of a dam in an upstream reach upon the reduction of a flood peak in downstream reaches; in the process of estimation the storage-routing method is used. Calculations are illustrated to show how this method is applied to recent floods.

In addition, this paper touches upon the speeding up of calculation by means of the low-speed analog computer and a fundamental field measurement designed to find out the change of a hydrostage in downstream reaches in case dam gates are opened abruptly.

RéSUMÉ

La rivière ISHIKARI est la deuxième grande rivière du Japon avec sa longueur de 323.6 km et sa surface de réception de 14,400 km². La région aval de cette rivière de la longueur de 92 km a été désignée comme la région de la prédiction et l'annonce des crues à cause de sa population dense et son développement économique, et ces travaux de la prédiction et l'annonce sont à la charge du Bureau de l'aménagement de ISHIKARI.

En ajoutant aux travaux de la construction des digues et de la régularisation de la rivière tenus depuis longtemps, un barrage aux fins multiples est en construction à l'amont de la rivière SORACHI, le plus grand affluent de ISHIKARI, pour la protection de la région aval contre les crues.

Dans ce rapport, l'auteur présente, en utilisant la méthode de routier des crues basé réserves-variation, une méthode pour l'estimation de l'effet de la régularisation des crues par le barrage, construit à l'amont de la rivière, sur l'abaissement de débits de pointe aux stations de jaugeage de la région aval, et montre un exemple numérique avec les relevés du cru récent pour l'explication de la procédé.

Puis, l'auteur décrit l'emploi du calculateur à analoge de vitesse pour faciliter le calcul, et le mesure in situ fondamental sur le changement des hauteurs de hydrogramme de la région aval par suite de l'enlèvement brusque des vannes du barrage.
COMPUTATION OF CHARACTERISTICS OF FLOOD WAVES FROM STORM RAINFALLS

By Jaroslav Balek and Alexander Puzanov, Institute of Hydrodynamics of the Czechoslovak Academy of Sciences, Czechoslovak Socialist Republic.

SYNOPSIS

An attempt was made at complex computation of fundamental characteristics of flood waves from storm rainfalls. There are various methods of computation of these characteristics, i.e. the runoff volume, the shape and peak discharge of the flood wave. However, these methods are not justified under all natural conditions. On the basis of a generally derived equation of unsteady motion of water from atmospheric precipitation in a basin which is considered as a natural storage reservoir, parameters are chosen that characterize all flood waves in the best way. The set of nature models is obtained from multiple linear regression. The combination of computations on a digital computer with statistical testing and logical considerations makes it possible to estimate the importance of different parameters determining the optimum equations. The correctness of assumptions is confirmed by high values of adjusted correlation coefficients and favourable results of statistical tests. The method yields equations determining the volume of flood wave, recharge, peak discharge and nine time characteristics defining the shape of the flood wave. A further application is mentioned for the case when a system of reservoirs must be taken into account in studies of transformation of flood waves. The advantages of a.d.c. analog differential analyzer are presented as well as a scheme for a system of reservoirs and various operation of hydraulic structures. A complex appraisal of all achieved results is made and the possibility of performing the computations even in combined cases is indicated as well as the way to suppress the imperfections due to results of practical experiments.

LE CALCUL DES CARACTÉRISTIQUES DES CRUES OCCASIONÉES PAR DES AVERSES


RÉSUMÉ

Un essai est présenté des calculs complets des caractéristiques fondamentales des crues occasionnées par des averse. On connaît différentes modes de calculer ces caractéristiques, c'est à dire, d'évaluer le volume de l'écoulement, la forme des ondes et leur dimensions maxima, mais ces méthodes ne se justifient pas dans tous les conditions naturelles. Alors une équation générale du mouvement nonstationnaire des eaux provenant des précipitations atmosphériques est déduite dans un bassin considéré comme un réservoir naturel. Après cela on a calculé des paramètres naturels qui caractérisent le mieux les différents éléments de l'équation et qui sont faciles à déterminer dans la nature. En partant de l'ensemble des modèles naturels on a acquis des données les plus favorables pour les calculs au moyen d'un traitement statistique à l'aide des équations linéaires de la régression multiple. Les combinaisons des calculs sur une machine électronique avec les tests statistiques et considérations logiques ont fait possible de vérifier l'importance des divers paramètres. Ainsi on a obtenues équations utilisées ensuite pour les calculs pratiques des caractéristiques suivantes: le volume de l'onde de crue, le débit maximum, la différence entre le volume de précipitation et le volume de l'onde, ainsi que nœuf coordonnées de temps, qui déterminent la forme de l'onde de crue. On a mentionné aussi une autre application des résultats obtenus dans le cas d'un système de réservoirs, quand on doit étudier la transformation des ondes de crue dans diverses conditions de l'opération des ouvrages hydrauliques. Les avantages d'emploi d'un analyseur différentiel électronique et le schéma pour un système des réservoirs sont présentées. On a fait une appréciation complexe de tous les résultats obtenus et on a démontré les possibilités des calculs dans le cas plus compliqué, ainsi que les façons de supprimer les imperfections résultantes des essais pratiques.
THE EFFECT OF THE AVERAGE HEIGHT OF A CATCHMENT ON THE ESTIMATION OF THE INTENSITY OF FLOOD DISCHARGE

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and

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SYNOPSIS

The Report of the Flood Committee of the Institution of Civil Engineers includes a curve for the estimation of "Normal Maximum Floods" on upland catchments. If this is used to estimate the flood from a lowland catchment, the estimate is unreasonably high. The authors consider that their approach of taking into account the area and average height of the catchment for the estimation of the 150 yr. flood will lead to more realistic results. The paper sets out the results of an investigation into the correlation between the 150 yr. flood, the area and the average height of the catchment for some 26 catchment areas.

RESUME

Le rapport de la Commission des Crues de la Société des Ingénieurs Civils d'Angleterre donne une courbe pour l'évaluation des "Crues Normales Maximales" des bassins versants collinaires. Si l'on emploie cette courbe pour la prévision des crues des bassins versants de petite altitude on obtient des valeurs qui sont déraisonnablement hautes. Les auteurs sont d'opinion que leur méthode d'évaluation de la crue d'une fréquence de 150 ans, en tenant compte de la superficie et de l'altitude moyenne du bassin versant, mène à des résultats plus réalistes.

Cet rapport démontre les résultats d'une étude de la corrélation qui existe entre l'importance de la crue d'une fréquence de 150 ans, la superficie et l'altitude moyenne de vingt-six bassins versants.
L'ÉVACUATION DES CRUES DANS LES BARRAGES DU DOURO
Par Antonio Lencastre
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Résumé

Pour le dimensionnement des déversoirs des barrages portugais sur le Douro, ont été évalués les débits de crue, par l'application des méthodes statistiques. Les valeurs considérées ont été 11 000 m³/s et 22 000 m³/s, respectivement pour les barrages situés en amont et sur la partie aval du Douro portugais. Les débits maximaux constatés depuis 400 années ont pu être estimés, respectivement, 7 500 m³/s et 17 000 m³/s.

Les débits de deux des plus grandes crues connues ont été causés par des précipitations qui, considérées séparément, ne peuvent pas être classifiées comme peu fréquentes. Une fois que ces débits ne se justifient que par la forme dont s'est faite la superposition des hydrogrammes des différents affluents avec l'hydrogramme du cours d'eau principal, on a considéré la possibilité théorique d'une situation exceptionnelle, à laquelle le correspondrait un débit de crue supérieur à celui qui a été déduit avec base sur les registres connus.

On a donc prévu qu'on donnerait passage à des débits de crue supérieurs à ceux du calcul. Étant donné les types de déversoirs construits et prévus pour le Douro - sur la crête des barrages - ces débits seraient évacués avec un accroissement de la charge sur le déversoir. Une marge plus grande pour l'emplacement du couronnement et du viaduc sur le déversoir a donc été considérée, la protection des centrales respectives, localisées auprès des barrages, ayant été prévue avec une spéciale attention.

Lors du dimensionnement des seuils déversoirs, on a cherché à assurer que les dépressions engendrées par une crue d'occurrence presque improbable n'atteignissent pas des valeurs inadmissibles, ayant cependant admis des valeurs supérieures à celles qui sont normalement acceptables. L'effet de cette crue sur les bassins de dissipation doit être également considéré.

RESUME

For designing the spillways of the Portuguese dams on the Douro, the flood flows were estimated by using statistical methods. The values considered were 11,000 cu.m. per sec. and 22,000 cu.m. per sec., respectively for the dams located upstream and on the downstream part of the Portuguese Douro. The maximum floods occurring in the last 400 years are assessed respectively at 7,500 cu.m. per sec. and 17,000 cu.m. per sec.

The flows of the two greatest floods known were due to precipitations, which considered separately should not be classified as unfrequent. Because these flows were caused only by the way the hydrographs of several tributaries and that of the main stream were superposed, the theoretical possibility of an exceptional situation has been considered which would result in a greater flood than the biggest one deduced from the basis of the known records.

Provision has been made therefore for passing a flood greater than the estimated one. Considering the types of spillways constructed and anticipated for the Douro - crest spillways these flows would be coped with by an increase in head over the crest. A greater freeboard was therefore provided over the crest and special attention was also paid to the protection of the respective power stations placed near the dams.

When designing the spillway aprons, we attempted to secure that negative pressures caused by almost improbable floods should not reach unacceptable values; notwithstanding, values higher than those normally accepted have been admitted. The effect of the flood over the stilling basins had also to be considered.
MODEL AND PROTOTYPE OBSERVATIONS OF GATE OSCILLATIONS

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For Presentation at
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SYNOPSIS

Tainter or radial gates capable of passing flow either over or under the same gate are being installed on the spillways of many of the navigation dams in the United States of America. Also, the majority of the culvert valves for the navigation locks are radial gates with the concave side of the gate toward the reservoir. Discussed in this paper are recent model and prototype observations of oscillations of radial gates when used in these two types of installations.

Oscillations of the submergible spillway gates have been found to be caused by flow over the top of the gate, surges in the stilling action on the downstream side of the gate, and flow in the gap between the face of the gate and gate sill.

Fluctuating pressures on the structural members of the culvert valve, particularly those near the bottom of the gate, have been found to be the principal contributıng factors to the oscillations caused by these valves.

SYNOPSIS

Les vannes Tainter ou à segment capables de passer l'écoulement par dessus ou par dessous la même vanne sont installées à présent sur les déversoirs d'un grand nombre de barrages de navigation dans les États-Unis d'Amérique. De même, la plupart des vannes d'aqueduc pour les écluses de navigation sont des vannes à segment avec le côté concave vers le réservoir. Dans cet exposé l'auteur présente des observations sur les oscillations qui se produisent dans les modèles des vannes à segment et dans les prototypes de ces vannes quand elles sont installées dans ces deux types d'ouvrages.

On a constaté que les oscillations se produisant dans les vannes de déversoir submersibles sont causées par l'écoulement au dessus de la vanne, par des accroissements et décroissements dans l'action d'amortissement en aval de la vanne, et par l'écoulement dans l'ouverture entre le parement de la vanne et le seuil de cette dernière.

De plus, on a constaté que les pressions fluctuantes sur les éléments de construction des vannes d'aqueduc, en particulier les éléments près de la lèvre inférieure, constituent le contributıng principal aux variations de charge et par conséquent aux oscillations des vannes causées par elles.
MODEL INVESTIGATIONS OF THE VIBRATION OF A VERTICAL-LIFT SLUICE GATE.

by James Allen Perkins,
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Synopsis:
In the course of a model study of the drawdown forces on a sluice gate it was observed that under certain conditions the gate was subject to substantial vibrations.

A model study of these vibrations was therefore made.

The gate was hung in such a way that the effect of suspension stiffness and of gate opening on the vibrations could be studied. The observations of the gate were recorded on a chart.

The amplitudes of vibrations were treated statistically so that an estimate of the maximum forces on the gate could be made and the behaviour of the gate examined over a range of operating conditions.

Au cours des études, à l'aide de maquettes, des forces de rabattement d'une vanne, il a été observé que sous certaines conditions la vanne était sujettes à des substantielles vibrations.

Une étude-maquette de ces vibrations fut alors faite.

La vanne fut suspendue de telle manière que l'effet de la rigidité de suspension et l'effet de l'ouverture de la vanne sur les vibrations puissent être étudiés. Les observations de la conduite de la vanne furent enregistrées sur un diagramme.

Les amplitudes des vibrations furent traitées statistiquement de façon que l'estimation des forces maximum dérivées sur la vanne puisse être faite et la conduite de la vanne examinée sur une étendue des conditions d'opération.
SOME MEASUREMENTS OF AUTO-OSCILLATION
INITIATED BY VALVE CHARACTERISTICS

By Ian W. McCaig and William L. Gibson
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SYNOPSIS

Sustained vibration of the water column in a pipe line can have many possible characteristics and causes. This paper describes and compares two examples of self-generated and self-sustained vibration of virtually closed valves in initially quiescent water columns.

The first example occurred when a twelve-foot diameter bore penstock valve leaked because the pressure on the inflated seal accidentally diminished below normal. Tests showed that even with initially quiescent conditions in the penstock and power tunnel system, a very slight leak, caused by reducing the seal pressure, generated violent self-sustained vibration of the valve. The valve movement and pressure oscillations were sinusoidal. Opening a bypass subdued the vibration to zero.

The second example occurred when a ten-inch diameter spring-cushioned check valve in a pump discharge line leaked under static head. The vibration was complicated by air valves in the pipe lines and by the long suction pipe. Measurements showed that the resultant pressure oscillations were approximately sinusoidal with sharp impulses of large magnitude imposed every third cycle. The vibration was prevented by installing a weaker cushioning spring in the check valve and removing the air valves from the pipeline.

RESUME

QUELQUES DONNEES SUR L'AUTO-OSCILLATION ENGENDREE PAR LES CARACTERISTIQUES DE LA SOUPAPE

La vibration soutenue de la colonne d'eau dans une conduite peut avoir maintes causes et caracteristiques. Ce texte souligne et compare deux exemples de vibration auto-engendree et continue de soupapes virtuellement fermees dans des colonnes d'eau calme.

Le premier exemple se presenta lorsqu'une fuite se produisit dans une soupape de douze pieds de diametre de la conduite forcee. Cette fuite fuit occasionnee par une baisse accidentelle de pression, en dehors de la normale, sur l'obturateur de pression. Des essais ont demontré que même sous les conditions calmes au debut, dans la conduite forcee et le canal de derivation, une tres legere fuite, causee par une baisse de pression de l'obturateur, engendra une vibration violente et continue de la soupape. Le mouvement de la soupape et les oscilations de pression etaient sinusoidaux. L'ouverture d'un canal de derivation reduisit la vibration a zero.

Le deuxieme exemple se presentait dans une soupape de retenus, de dix pouces de diametre, et munie d'amortisseur a ressort, situee dans la conduite de decharge d'une pompe. Sous une pression, une fuite se developpa. La vibration etait compliquee par des ventouses dans la conduite, et par le long tuyau d'aspiration. Des donnees demontrèrent que les oscilations de pression qui en resultèrent furent a peu pres sinusoidales, se reproduisant a tous les trois cycles. La vibration fut alors controlee par l'installation d'un ressort amortisseur plus doux dans la soupape de retenus, et la suppression des ventouses dans la conduite.
ELASTIC SIMILARITY OF MODELS OF STRUCTURES

COMPARISON OF MEASUREMENTS ON THE Prototype
AND THE ELASTICALLY SIMILAR MODEL OF THE HAGESTEIN WEIR

By M. Geleedst and P.A. Kolkman, engineers
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SUMMARY

To check the reliability of the technique of models with elastic similarity on Froude scale for vibration tests of gates, identical measurements are carried out on an actual gate and the model (scale 1 : 20) of the weir at Hagestein.

The program of investigation comprises:
1. Comparison of the dynamical properties of the gate under conditions where the gate is not surrounded by water.
2. Comparison of the dynamical properties of the gate under conditions where the gate is surrounded by dead water.
3. Comparison of the vibrations of the gate caused by water flowing underneath the partially lifted gate, viz. operational conditions.

SOMMAIRE

Pour contrôler la sûreté de la technique de modèles avec similitude élastique à l'échelle de Froude, afin d'examiner des vibrations de vannes, des mesures identiques sont en cours à une vanne du prototype et du modèle (échelle 1 : 20) du barrage "Hagestein".

Le programme des recherches comprend:
1. La comparaison des propriétés dynamiques de la vanne quand celle-ci n'est pas entourée d'eau.
2. La comparaison des propriétés dynamiques quand la vanne est entourée d'eau stagnante.
3. La comparaison des vibrations de la vanne causées par l'eau passant en-dessous de la vanne partiellement levée, c'est-à-dire la situation du barrage en action.
OSCILLATIONS IN A SURGE-TANK
-- Calculation and Measurement --

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Summary. Some results of calculated mass oscillations in a surge-tank are presented in comparison with the measurements. They are in a good accordance.

Sommaire. Les résultats d'un calcul théorique des oscillations dans une chambre d'équilibre sont présentés en comparaison des observations. La concordance est très satisfaisante.
Les vibrations d'un élément tubulaire, dans un plan perpendiculaire à l'écoulement, sont liées à la formation de tourbillons alternés. Ceux-ci se détachent de part et d'autre de l'élément à une fréquence qui dépend de sa forme, de ses dimensions et de la vitesse de l'écoulement.

Cette étude expérimentale a pour but de mesurer avec précision la fréquence et l'amplitude de la vibration d'un barreau cylindrique en fonction de la vitesse de l'écoulement. Des précautions spéciales ont été prises pour éliminer les sources de vibration autres que la formation des tourbillons alternés. Les vibrations du barreau ont été mesurées au moyen de jauges d'extensométrie collées sur le barreau dans le plan de l'écoulement et dans le plan perpendiculaire. La fréquence de vibration du barreau est comparée d'une part à sa fréquence propre et d'autre part à la fréquence théorique des tourbillons alternés. En fonction de la vitesse de l'écoulement elle est égale, inférieure ou supérieure à la fréquence propre, l'écart entre ces deux fréquences restant toutefois inférieur à 15 %, sauf à faible vitesse. L'amplitude de la vibration croît d'abord avec la vitesse, atteint sa valeur maximum quand la fréquence de vibration est égale à la fréquence propre, puis elle décroît. Enfin, dans certaines zones de vitesse l'amplitude et la fréquence deviennent très instables, pour une vitesse constante de l'écoulement. Une vibration de plus faible amplitude, et dont la fréquence est égale à la moitié de la fréquence propre, est également observée pour une vitesse de l'écoulement plus faible.

VIBRATIONS OF ROD IN PERPENDICULAR FLOW
By Paul LEON, Research Engineer at SOGREAH - France

SUMMARY

Vibrations of a tube or rod in a plane perpendicular to the flow are related to the formation of vortices which break away from alternate sides of the element at a frequency depending on the shape of the element, its dimensions, and the velocity of the flow.

The purpose of the experimental work described in this paper was to obtain a precise measurement of the vibration frequency and amplitude of a cylindrical bar in terms of flow velocity. Special precautions were taken to eliminate any sources of vibration other than the formation of the alternating vortices. The bar vibrations were measured by means of strain gauges fitted to the bar both in the flow plane and in the one perpendicular to it.

When compared with the natural and theoretical frequencies of the alternating vortices, it was found that, depending on the flow velocity, the bar vibration frequency was either equal to, below, or above the natural frequency, and that, except at low flow velocities, the difference between the two was always less than 15 %. The vibration amplitude increased with the flow velocity to start with, then reached a maximum value at the natural frequency of the rod, and finally decreased. In certain velocity ranges, the vibration amplitude and frequency at constant flow velocity both became very unstable.

At low flow velocities, a low-amplitude vibration occurred; in this rather special case, the frequency of vibration perpendicular to the flow corresponded to half the fundamental frequency of the bar and the frequency parallel to the flow (the amplitude being about twice that measured perpendicularly) was equal to the fundamental frequency.
A LABORATORY INVESTIGATION OF TRANSIENT PRESSURE WAVES IN PRE-STRESSED CONCRETE PIPES

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SYNOPSIS

The aim of investigation was to discover the elastic properties of thickwalled, pre-stressed concrete pipes and their breakage strength when subjected to transient pressure waves of very short duration.

The impact was produced by means of a pendulum hammer and the duration of the impact was about $1.2 \times 10^{-3}$ sec. The water pressure was measured with piezoelectric crystals and the strain in the pipe walls with wire strain gauges.

The value obtained showed that the time curves for the water pressure in the middle of the pipe-section coincided extremely well with the corresponding time curves for the tangential strain in the pipe-wall despite the high loading frequency. The strain due to the dynamic loading was considerably less than that due to the corresponding static loading. This agrees with the fact that the elastic modulus of the concrete increases with increased rate of loading which is also emphasized by the fact that the dynamic breakage pressure was considerably higher than the static.

Le but des recherches était de déterminer les propriétés d'élasticité et de résistance à la rupture de tuyaux en béton précontraint à parois épaisses soumis à des ondes de choc de très courtes durées.

Les impulsions de charge étaient engendrées à l'aide d'un mouton à pendule et la durée de l'onde de choc était de l'ordre de $1.2 \times 10^{-3}$ sec. La pression de l'eau et la dilatation de la paroi du tuyau furent mesurées à l'aide de cristaux piezoelectriques et d'indicateurs de tension à fils, respectivement.

Les mesures indiquèrent une excellente coincidence des courbes de temps relatives à la pression de l'eau au centre de la section du tuyau et à la dilatation tangentielle correspondante de la paroi du tuyau malgré la vitesse de charge élevée. La dilatation due à la charge dynamique était cependant considérablement inférieure à celle due à la charge statique correspondante. Ceci correspond à la propriété selon laquelle le module d'élasticité du béton s'accroît avec la vitesse de charge, ce qui fut également souligné par le fait que la pression de rupture dynamique était bien plus élevée que la statique.
THE DELIBERATE GENERATION OF SONIC VIBRATIONS BY MEANS OF HYDRAULIC DEVICES

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and
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SYNOPSIS

Recent years have brought increased interest in experimental and commercial uses of sonic vibrations. The most serious deterrents to broader use of such vibrations appear to be the cost of special equipment and the difficulties in vibrating sizable masses at relatively high frequencies.

It is the purpose of this paper to discuss the possibility of using hydraulic means for the generation of sonic vibrations. Various devices by which this might be accomplished are considered.

RÉSUMÉ

Ces dernières années, l'intérêt s'est porté de plus en plus vers l'usage expérimental et commercial des vibrations soniques. Les obstacles les plus sérieux à la généralisation de l'emploi de ces vibrations semblent être, d'une part, le prix de revient excessif de l'équipement spécial et de l'autre, les difficultés rencontrées pour créer les vibrations à hautes fréquences, dans des masses de taille considérable.

Le but de cet exposé est de traiter de la possibilité d'engendrer les vibrations soniques par des moyens hydrauliques. Les différents procédés par lesquels cela pourrait être accompli sont tour à tour considérés.
ON THE ROLE OF EDDIES IN FLOW-INDUCED VIBRATIONS

By Eduard Naudascher

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The instability of vortex or shear layers and their tendency to break down in discrete eddies play an important role in many flow-induced vibrations. Possible mechanisms that change the random nature of this process of eddy formation into a periodic one are discussed, and their significance with respect to structural vibrations is illustrated by examples of wake flows and flows involving separation at boundary angularities. Emphasis is placed on the distinction between forced, self-controlled, and self-excited vibrations, and upon the respective dimensional aspects.

L'instabilité des couches fluides internes avec fort gradient de la vitesse donne lieu à des tourbillons discrets jouant un rôle important dans beaucoup de phénomènes de vibrations dues à un écoulement fluide. Les mécanismes possibles qui changent la nature aléatoire de ce procédé de formation de tourbillons en une formation périodique sont discutés et leur signification, quant aux vibrations structurales, est illustrée par des exemples relatifs aux sillages et aux écoulements avec séparation le long des parois anguleuses. Une importance toute particulière est donnée aux différences entre vibrations forcées, auto-controllées, auto-excitées, ainsi qu'à leurs aspects respectifs du point de vue de l'analyse dimensionnelle.
THE EFFECT OF BOUNDARY LAYER THICKNESS AND VIBRATIONAL AMPLITUDE
ON THE STROUHAL NUMBERS FOR FLAT PLATES

by

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and

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SYNOPSIS

The reduced frequency or Strouhal number, \( \frac{f t}{V} \), written in terms of the vortex shedding frequency, free-stream velocity and a transverse body dimension, has long been recognized as the fundamental parameter defining the forcing force in problems of flow-induced vibration of structural elements. Experiments are reported here which describe the effect of trailing edge boundary layer thickness on these conventional Strouhal numbers for stationary flat plates. Analysis shows that flow-induced vibration decreases the Strouhal number and increases the forcing force through dependence of the wake under-pressure coefficient upon a self-excitation parameter, the ratio of the transverse velocity of the trailing edge to the free-stream velocity of the fluid. Experiments evaluate this dependence and permit the prediction of conditions producing large amplitude, self-excited vibration.

RÉSUMÉ

La fréquence réduite, ou nombre de Strouhal, \( \frac{f t}{V} \), où figurent:
- la fréquence \( f \) avec laquelle apparaissent les vortex
- la vitesse \( v \) du fluide
- une longueur \( t \) caractéristique des dimensions transversales de l'objet immergé,
a été reconnu depuis longtemps comme le paramètre fondamental déterminant la force d'excitation qui engendre la vibration d'un élément de structure placé dans un fluide en mouvement.

Les expériences rapportées ici montrent l'influence qu'a, sur le nombre de Strouhal, l'épaisseur de la couche limite sur le bord de fuite, pour des plaques planes immobiles. L'analyse montre que la vibration induite par le courant a pour effet de diminuer le nombre de Strouhal et d'augmenter la force d'excitation, ceci étant dû au fait que la depression du sillage dépend d'un paramètre d'autoexcitation, rapport de la vitesse transversale au bord de fuite à la vitesse du courant fluide. Les expériences faites permettent d'apprécier cette dépendance et de prédir les conditions donnant naissance à des vibrations induites de grande amplitude.
By using graphical integration and statistical analysis the author has tried in this paper to obtain an equation which would ensure a quick determination of the absolute values of the resultant of the hydrodynamic pressure on a flap gate in any of its positions.

As is generally known from actual measurements on prototypes or models for the value $R_d/R_s < 0.4$ (see Fig. 1), flap gates show a tendency to vibrate. By calculating function (1) by means of Eq. (12) the critical position of the gate $\Theta_{cr}$ can also be determined. This method can be of use in designing preliminary flap gate projects, for it makes it possible to obtain the size and the form of a gate.
THE VIBRATION OF A SUBMERGED WALL EXPOSED TO A JET

by

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SYNOPSIS

The response of a structure to fluctuating hydraulic forces is discussed in general terms and results are presented of instantaneous pressure measurements in a model of a baffle wall exposed to a high velocity jet from a tunnel.

The magnitude of the pressure fluctuations varied over the face of the wall and analysis into frequency components showed that the spectra of the intensity (amplitude)$^2$ of the components of different frequencies were continuous with an absence of dominant frequencies but displayed a strong increase of intensity at low frequencies.

The frequency components at neighbouring points on the front of the wall showed little correlation over distances which were greater than $D/6$, $D$ being the diameter of the jet at exit. This enabled the components of the pressures over the wall at a particular frequency to be compounded as a set of vibrations of random phase and also enabled the mean amplitude of the force on the wall and the probability that this force will be exceeded to be estimated.

The most dangerous frequencies of the fluctuations in relation to the vibration of the wall were those near resonance with the natural frequency of the wall. The amplitude of vibration of the wall was limited both by soil and water damping. In the present case calculation showed that the amplitude was negligible.

SOMMAIRE

On traite en des termes generaux de la reaction d'un ouvrage a des forces hydrauliques variables et presente les resultats des mesures des pressions instantanees sur un modele d'une chicane en face d'un jet de grande vitesse d'un tunnel.

La grandeur des fluctuations de pression a varie sur la face de la chicane, et un analyse en des composantes des frequences a montre que les spectres (l'amplitude)$^2$ ont ete continus sans des frequences dominantes mais ont montre une forte augmentation d'intensite a des basses frequences.

Les composantes des frequences a des points voisins sur le devant de la chicane ont montre peu de correlation sur des distances plus grandes que $D/6$, $D$ est le diametre du jet a l'eljte. On a pu donc allier les composantes des pressions sur la chicane a une frequente determinee comme une ensemble de vibrations dephasees et calculer l'amplitude moyenne de l'effort sur la chicane et la probabilite que cet effort sera depasse.

Les frequences les plus dangereuses des fluctuations, quant a la vibration de la chicane, ont ete celles dont la resonance s'est approchee de la frequente naturelle de la chicane. L'amplitude de la vibration de la chicane a ete limitee par l'amortissement du sol aussi bien que de l'eau. Dans le cas qui nous occupe, le calcul a montre que l'amplitude a ete negligeable.
PHÉNOMÈNES D'OCCILATION OBSERVÉS AUX VANTAUX OUVERTS
D'UNE PORTE BUSQUÉE

Par Hans-Werner Partenscky,
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RESUME

Lors de la dérivation partielle des crues par des écluses-rivières, les phénomènes de pulsation causés par les séparations à la porte amont de l'écluse peuvent apparaître dans le ressaut en aval de la porte. Les effets de ces pulsations dans le ressaut se superposent à l'écoulement sous forme d'ondes de surface. Si l'on suppose que ces pulsations sont périodiques, les forces dynamiques, causées par les ondes de surface, qui agissent sur les vantaux ouverts de la porte aval de l'écluse, seront aussi périodiques et variables en intensité et direction. Leur grandeur peut augmenter considérablement, si la masse d'eau se trouvant entre les vantaux ouverts et les murs de la chambre de porte entre aussi en oscillation. En cas de résonance des deux oscillations de la nappe d'eau devant et derrière chaque vantail, les forces agissant sur les ancrages des vantaux peuvent atteindre des valeurs qui éventuellement causent l'arrachement des vantaux.

La détermination théorique de ces forces qui agissent sur les parties submergées des vantaux pendant le passage partiel de la crue constitue le sujet de la communication. A l'aide d'un exemple pratique, l'application de la théorie développée pour le dimensionnement des ancrages des vantaux est démontrée.

SYNOPSIS

When river locks are used to discharge part of the flood of the river, pulsation phenomena caused by the separation of the flow from the upper gate of the lock are sometimes observed in the hydraulic jump downstream of the gate. The effects of these fluctuations in the jump are superposed upon the flow in the lock as surface waves.

If the pulsations are assumed to be periodic, dynamic periodic forces which vary in intensity and direction will be exerted on the wings of an open miter gate at the downstream end of the lock. Their intensity can be amplified, if the water mass between the gate wing and the gate slot is excited to oscillate also. In the case of resonance, the forces which have to be resisted by the anchorage of the gate can reach values high enough to cause failure of the anchorage.

The theoretical prediction of the forces acting on the submerged parts of the gate wings during the discharge of part of the flood through a lock is the subject of the paper. The application of the theory developed to the dimensioning of the necessary anchorages of the gate wings is shown in an example.
CAVITATION OBSERVATIONS AND NOISE MEASUREMENTS AS A MEANS OF INVESTIGATING
THE TRAILING-EDGE VIBRATIONS OF TURBINE BLADES

By Walter A. Lecher
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SYNOPSIS

In turbo-machines periodic separation of eddies can occur along the trailing edges of the runner and happen to be in resonance with a natural frequency of the blades. As similarity laws exist both for the natural frequencies and for the hydraulically excited vibrations, these problems were studied in the laboratories of Escher Wyss.

The natural frequencies of two model Francis runners and a model Kaplan blade were tested. A comparison of the results of the measurements of the natural frequencies with the two Francis runners showed the effect of deviations from geometric similarity of rim and hub.

The frequency of the periodic eddy separations at the trailing edges happening in the cavitation test-rig for water turbines was registered in two different ways: by frequency analysis of the whistling noise and by measuring from stroboscopic photographs the distances between the cavitating vortices leaving the trailing edges.

Tests with variable heads and different operating points showed several frequencies where resonance occurred.

The test results are discussed and compared with theoretical calculations of the exciting frequencies. The possibilities to prevent periodic eddy-separation at the trailing edges of hydraulic turbo-machines are stated and proved by tests.

Dans certaines circonstances, des décollements tourbillonnaires périodiques peuvent se produire le long des arêtes de sortie des turbo-machines et entrer en résonance avec la fréquence propre des aubes. Comme il existe des lois de modèles, pour les fréquences propres de même que pour les oscillations provoquées hydrauliquement, ce problème fut étudié de plus près dans le laboratoire d’Escher Wyss.

Les nombres de vibrations propres de deux modèles de roues Francis et d’un modèle de pale Kaplan furent mesurés. La comparaison des résultats des mesures de la vibration propre montre l’influence d’un écart de similitude du modèle près de la couronne et du moyeu.

Les vibrations dues aux décollements tourbillonnaires périodiques aux arêtes de sortie furent obtenues de deux façons différentes sur le stand d’essais de cavitation : par une analyse de fréquence du sifflement et par la mesure directe des photos stroboscopiques des tourbillons de cavitation issus des arêtes de sortie des aubes.

Quelques fréquences de résonance furent déterminées lors des recherches sous différentes chutes et à divers points de fonctionnement.

Les résultats des mesures seront discutés et comparés à ceux obtenus par un calcul théorique de la fréquence induitrice. Les moyens d’éviter la formation de décollements tourbillonnaires périodiques aux arêtes de sortie des machines hydrauliques furent établis par des essais et seront cités.
ON THE PROPAGATION OF HYDROELASTIC WAVES IN A COUPLED SYSTEM

By Michael B. Abbott
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SUMMARY

In some cases, coupled systems may be satisfactorily treated as homogeneous systems, while in other cases this approach fails. In the present note, an elementary model of a coupled system is used to derive criteria for the success, or otherwise, of this approach. The model consists of parallel layers of fluids 0 and 1, with the layers orientated in the direction of wave propagation. The pressure waves are supposed so long compared with the thickness of the layers that all motion is mainly horizontal while, at the same time, the pressure is constant in any plane normal to the direction of wave propagation.

The characteristic equations of this system are derived and a graphical method developed for finding the characteristic directions, or wave celerities. Certain examples are treated using this method. In particular, it is shown that with elements of air and water, the elementary coupled system cannot be approximated by a homogeneous system.

It is concluded that the properties of the elementary system indicate that the assumption of homogeneity can only be maintained when the densities of the coupled elements are of the same order of magnitude.

DE LA PROPAGATION DES ONDES HYDROELASTIQUES DANS UN SYSTEME À ELEMENTS COUPLES

RESUME

Dans certains cas, les systèmes à éléments couplés peuvent être considérés à bon escient comme des systèmes homogènes, tandis que dans d'autres cas cette supposition est prise en défaut. La présente note utilise le modèle élémentaire d'un système à éléments juxtaposés pour trouver les critères du succès ou non de cette méthode d'approche. Le modèle consiste en couches parallèles de fluides 0 et 1, orientées suivant la direction de propagation de l'onde. Les ondes de pression sont supposées suffisamment longues comparées à l'épaisseur des couches pour que tout mouvement puisse être considéré comme horizontal, tandis qu'en même temps la pression est constante dans un plan quelconque normal à la direction de propagation de l'onde.

Les équations caractéristiques de ce système sont déduites et une méthode graphique s'est développée pour trouver les directions caractéristiques ou célérités de l'onde. On utilise cette méthode dans certains exemples. En particulier, il est démontré qu'avec l'air et l'eau comme éléments composants on ne peut guère aborder le système élémentaire juxtaposé en le supposant homogène.

On peut conclure que les propriétés du système élémentaire indiquent que la supposition faite quant à l'homogénéité ne peut être soutenue que dans le cas où les densités des éléments couplés sont du même ordre de grandeur.
ON THE ATTENUATION OF HYDROELASTIC WAVES USING A SCREEN OF AIR BUBBLES

By Michael B. Abbott and Ian Larsen

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SUMMARY

If an air-water mixture is treated as a homogeneous fluid, a very low sound velocity is predicted for the mixture. This low sound velocity should lead to a considerable reflection of elastic waves. According to an alternative approach however, which treats the mixture as a coupled system, this low sound velocity and consequent high reflection cannot, in fact, obtain.

As a check on the validity of the objections raised by the alternative approach, an experimental procedure has been devised. Elastic waves generated by small explosive charges impinged on glass plates, the frequency and nature of failure of the plates being recorded against charge to plate distance. It was found that the frequency of failure was not significantly reduced by the intervention of a screen of air bubbles, even though the assumption of homogeneity predicted a high reduction for the screen employed.

It is concluded that, in accordance with approximate theoretical conclusions, the assumption of homogeneity cannot be justified when, as in this case, there is a considerable difference between the densities of the component fluids.

DE L'INFLUENCE D'UN ÉCRAN DE BULLES D'AIR SUR LES ONDES HYDROÉLASTIQUES

Par Michael B. Abbott et Ian Larsen

RESUME

Si un mélange d'air et d'eau est considéré comme un fluide homogène, on peut prévoir une très faible vitesse de propagation du son dans ce mélange. Cette faible vitesse de propagation doit conduire à une réflexion considérable des ondes élastiques. Cependant, d'après une méthode alternative d'approche qui considère le mélange comme un système à éléments juxtaposés, cette faible vitesse de propagation du son - et conséquemment la forte réflexion - ne peuvent être obtenues en fait.

Dans le but de vérifier la validité des objections soulevées par la méthode alternative, on a procédé expérimentalement. Les ondes élastiques prenant naissance à partir de faibles charges explosives viennent en contact avec des plaques de verre, la fréquence et le mode de rupture des plaques étant reportées par rapport à la distance de la charge aux plaques. Ce procédé a montré que la fréquence de rupture n'est pas réduite d'une façon appréciable par la présence de l'écran de bulles d'air, même lorsqu'il est de supposer l'homogénéité du mélange laissait prédire une forte réduction due à l'écran utilisé.

On peut conclure que, d'accord avec les approximations théoriques, on ne peut pas justifier la supposition qu'on a faite quant à l'homogénéité lorsque, tel ce cas, il y a une différence considérable entre les densités des fluides composants.
WATER LEVEL OSCILLATIONS IN A SURGE TANK WHEN STARTING A PUMP IN A PUMPED STORAGE POWER STATION

By Hiroshi Miyashiro(1), Takeshi Kobori(2) and Shigeyoshi Yokoyama(3)

Synopsis

In pumped storage power stations, where the pump and the turbine are placed on one axis, the pump is usually started by the turbine. Unless the starting sequence is properly determined in this type of power stations, change in water quantity in penstock and in pressure tunnel due to each action of the starting sequence will cause a considerable water level change in surge tank. This paper presents a method of analysis of water level change in surge tank at pump starting in pumped storage power stations. Several examples are calculated and the results are compared with the measurements. The results coincide fairly well with the measurements.

VARIATION DU NIVEAU DE L’EAU DANS LA CHAMBRE D’EQUILIBRE AU DEMARRAGE DE LA POMPE DANS UNE CENTRALE HYDRO-ELECTRIQUE INSTALLÉE POUR LE POMPAGE

Résumé

Dans les centrales hydro-électriques installées pour le pompage, où la pompe et la turbine sont placées sur une axe, le démarrage de la pompe est généralement effectué au moyen de la turbine. Quand les mouvements du démarrage ne sont pas correctement enchaînés, la variation du débit dans la conduite forcée et la galerie causée par chacun des mouvements de démarrage donne lieu à de considérables variations du niveau de l’eau dans la chambre d’équilibre. Une méthode de calcul est donnée pour la variation du niveau de l’eau dans la chambre d’équilibre au démarrage de la pompe. Plusieurs exemples ont été calculés et les résultats de calcul comparés avec des mesures. Les résultats de calcul coïncident bien avec des mesures.

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THE STABILITY OF A RELIEF VALVE CONNECTED TO A LONG PIPE.

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SYNOPSIS

Linearised equations of motion are used to analyse the stability of a relief valve connected to a reservoir by a long pipe and the effect of distributed resistance in the pipe is considered. Simple relations are found which determine the damping of the valve required for stability whatever the length of the pipe and the maximum length of the pipe for which no damping is required. The stability of a system using a flat disc relief valve has been examined experimentally and the measured stability parameters are compared with those predicted by the theory.

Les équations linéaires de mouvement sont utilisées afin d'analyser la stabilité d'une soupape de sûreté, ou de réglage, qui est reliée par un long tuyau au réservoir, et l'auteur a pesé l'effet des pertes de charge distribuées dans le tuyau. On trouve les formules simples qui fixent l'amortissement nécessaire à la soupape quelque soit la longueur du tuyau, et la longueur la plus grande d'un tuyau quand la gouppe n'a pas besoin d'amortissement. La stabilité d'un système utilisant une soupape à siège plat a été examinée expérimentalement et les valeurs obtenues des paramètres ont été comparées aux prédictions théoriques.
TRANSMISSIONS SONIQUES AVEC DISCONTINUITES

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RESUME

Les transmissions soniques utilisent les ondes produites dans une colonne liquide pour le transport de l'énergie vers un dispositif récepteur. On connaît que l'étude de telles transmissions s'effectue par des méthodes semblables à celles qui sont utilisées en électricité pour les courants alternatifs dans l'hypothèse que la déformation des courants dans les lignes de transmission est négligeable. Le rapport traite des transmission soniques avec des discontinuités importantes comme est le cas des installations soniques de pompage qu'on a étudié à l'Institut de Recherches Hydrotechniques de Bucarest.

Au début on expose l'idée fondamentale de la méthode de calcul qui consiste à représenter la réaction du dispositif récepteur par une pression de réaction exprimée par une série de Fourier. Les coefficients de cette série restent à être déterminés par les conditions de fonctionnement du récepteur, en utilisant les équations générales qui sont présentées dans le rapport.

Ensuite, on montre une méthode pour introduire les conditions de fonctionnement du récepteur, afin de déterminer la série qui exprime la pression de réaction. La méthode est appliquée pour le cas des systèmes soniques de pompage. On donne aussi des résultats expérimentaux qui confirment les conclusions théoriques.

SYNOPSIS

The sonic transmissions use the waves which are produced in a liquid column for transporting the energy to a receiver. It is known that the studies on sonic transmissions are made by methods analogous to those used in the electricity for alternative currents supposing negligible the deformation of currents in the transmission lines. This paper presents the sonic transmissions with great discontinuities, which occur in the sonic pump installations, investigated in the Institute of Hydrotechnical Research, Bucharest.

The author exposes first the fundamental idea of the computing method which consists in the representation of the receiver reaction to pressure expressed in Fourier series. The coefficients of this series may be determined by the functional conditions of the receiver using the general equations which are presented in the paper.

After, there is described a method for introducing the functional conditions of the receiver in order to determine easily the series which expresses the reaction pressure. The method is applied in the case of the sonic pump systems. There are shown also the experimental results which confirm the theoretical conclusions.
Résumé
Le rapport signale la possibilité d'absorption dans un tuyau d'un débit de liquide dans les conditions de la présence dans ce tuyau d'oscillations hydroélastiques (soniques) entretenues. Le phénomène a été nommé "éjection sonique".

Le rapport contient un bref exposé du phénomène, la méthode de calcul utilisée, la démonstration théorique et les conditions nécessaires pour réaliser l'éjection sonique, les indications nécessaires pour évaluer le débit d'éjection et pour éviter l'apparition de la cavitation.

Le phénomène est à la base de certains dispositifs très simples de pompage des liquides.

Synopsis
The paper shows the possibility of a pipe discharge absorption in the presence of hydroelastic (sonic) oscillations. This phenomenon was called "sonic ejection". The paper contains a succinct exposition of the phenomenon, the computing method, the theoretical demonstration and the conditions necessary to the sonic ejection realising. It presents also some indications relating the ejection discharge estimation and the avoidance of cavitations.

This phenomenon is utilised for any very simple installations for fluid pumping.
PULSATIONS OF HYDRODYNAMIC LOADS ACTING ON BOTTOM GATES OF HYDRAULIC STRUCTURES AND THEIR CALCULATION METHODS

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SUMMARY

The paper contains the results of extensive systematic investigations, carried out by author's methods, of pulsations of hydrodynamic loads (exciting loads) acting on bottom gates of hydraulic structures. Pulsating loads being taken into consideration it is possible to determine properly the value and the character of actual forces acting on gates and possible gate vibration, to choose reliable safety coefficients and in the design stage to make provision for some measures ensuring structure safety and durability. On the base of systematic review and theoretical analysis of experimental data the universal relationships are developed. These relationships enable one to determine pulsation characteristics of hydrodynamic loads acting on flat, segment and butterfly bottom gates, as well as pressure pulsation in different points of flat gates under different hydraulic conditions of operating structures. The theory of modelling of the complicated phenomenon under study is checked and the question of automodel region boundaries is investigated on the models constructed to the series of scales. The equations obtained enable the model test results to be applied to a prototype, and the knowledge of automodel region boundaries to be used for the choice of the best model scale. The study of the mechanism of oscillations and the analysis of test results allow to take adequate measures for reducing load pulsation and gate vibration.

SOMMAIRE

Ce rapport donne les résultats de vastes essais systématiques effectués par les méthodes mises au point par l'auteur afin d'étudier les pulsations des charges hydrodynamiques (charges excitatrices) agissant sur des vannes de fond des ouvrages hydrauliques. En tenant compte des charges de pulsation, on peut déterminer correctement la valeur et le caractère des charges actuelles agissant sur les vannes et la vibration possible des vannes; choisir des coefficients de sécurité convenables et prévoir, au cours de calcul des vannes, certaines dispositions assurant la sécurité et la longévité des ouvrages. Sur la base de l'analyse théorique des résultats obtenus, on a établi les équations universelles. Ces équations permettent de déterminer les caractéristiques de pulsation des charges hydrodynamiques agissant sur des vannes de fond (vannes plates, vannes papillon, vannes segment), ainsi que les pulsations en divers points des vannes plates pour différentes conditions hydrauliques de fonctionnement des ouvrages. On a vérifié la théorie de reproduction sur modèle réduit du phénomène complexe et étudié des limites de la région d'automodèle par les essais sur les modèles construits à une série d'échelles. Les équations obtenues permettent d'appliquer les résultats des essais sur modèle à un prototype et les données concernant les limites de la région d'automodèle peuvent être utilisées à choisir la meilleure échelle pour les modèles. L'étude du mécanisme des oscillations et l'analyse des résultats des essais ont permis d'élaborer un certain nombre de dispositions à prendre pour diminuer la pulsation des charges et la vibration des vannes.
REVIEW OF MICROSHOCKWAVES IN INDUSTRIAL
FLUID TRANSPORT.

Some causes and simple remedies
by
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SYNOPSIS.
A review is given of the origin of variations in flowrates, where a constant flow is desired. An important cause are the microshocks generated by pumps, valves, and their fittings. Observations on some experience with these parts and the correct way to construct them is given. Special attention is given to a valve of unusual construction and to a closed buffertank based on the principle of rotation - where it is found that this construction can decrease shock pressures to about 10% of the original.

SYNTHÈSE.
Un aperçu est donné des causes des variations du débit, là où un courant constant est nécessaire. Des causes importantes sont les micro-chocs causés par des pompes, des soupapes et des conduits. Des observations de ces pièces sont décrites et des manières de les perfectionner sont données. De l'attention spéciale est dédiée à une soupape d'une construction inusité et un réservoir - d'équilibre qui est basé sur le principe de rotation et avec lequel souvent une diminution des chocs jusqu'à dix pour cent peut-être réalisée.
ANALYSIS OF VIBRATION MEASUREMENTS ON AN UNDERFLOW TYPE OF GATE

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SUMMARY

A method of analysis of vibration recordings is shown, which enabled an evaluation of the forces exerted on a weir gate for underflow. To study relations between amplitudes and resonance frequencies, damping, head etc. characteristic amplitudes had to be developed for both the low frequency and the resonance frequency movements. Briefly the results are given of comparative model tests with different types of the edge of the gate.

SOMMAIRE

L'article expose une méthode d'analyse des enregistrements des vibrations, qui donnait la possibilité de déterminer les efforts provoqués par l'écoulement de l'eau au dessous une vanne. Pour l'étude des relations entre les amplitudes et la fréquence de résonance, l'amortissement, la chute de l'eau etc. on a développé une méthode d'obtention des amplitudes caractéristiques pour les mouvements de la vanne aux fréquences basses, et aux fréquences de résonance. Des résultats d'essais sur modèle réduit pour différentes formes de la poutre inférieure sont enfin exposés brièvement.
VIBRATION CHARACTERISTICS OF SLUICE GATES

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SYNOPSIS

The sluice gates of dams generally designed for structural safety give rise to violent vibrations and fluttering under certain conditions of operation. The design of sluice gates is perhaps inadequate without the proper investigation of their vibration characteristics especially under high heads and partial openings. The causes for and the elimination of these dangerous vibrations were studied in a hydraulic model at Irrigation Research Station, Poondi, South India. This paper brings out the experimental results of the vibratory motions of the gate and few remedial measures attempted to mitigate the same. Theoretical explanation of the vibration phenomenon and the details of the exciting forces are given. The mechanism of the formation of the vortices causing vibrations and the annihilation of the same as observed in the model are explained.

SYNOPSIS

Les vannes des barrages, dessinées, en général, pour la préservation structurale, donnent lieu à des vibrations violentes et à des frémissements sous certaines conditions d'opération. Le dessin des vannes est peut-être insuffisant, sans une bonne recherche de leurs caractéristiques vibratoires, surtout, sans des "pressions hautes" et des ouvertures partielles. Les causes de ces vibrations dangereuses et l'extirmination en étaient étudiées dans un modèle hydraulique, à la station de recherche de l'irrigation à Poondi, aux Indes du sud. Ce traité démontre les résultats expérimentaux des mouvements vibratoires de la vanne et donne quelques mesures pour y remédier, essayées dans le but de les atténuer. L'explication théorique du phénomène de la vibration et les détails des forces excitantes y sont donnés. La mécanique de la formation des tourbillons, causant les vibrations, et leur annihilation comme on a pu observer dans le modèle, y sont expliquées.
HYDRO-ELASTIC VIBRATIONS OF DAMS

BY

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SYNOPSIS

Studies on hydraulic performance of prototype structures including hydro-elastic vibrations were done for last one decade. In this connection experiments were performed on dams at Khadakwasla, Hirebhasgar, Krishnarajsagar, Vaitarna, Sarlasagar and Mettur. The results of these studies have shown that when the magnitude of the superimposed forces are small, the spectra of the induced oscillations are closer to the natural vibrations of the dam in one or the other possible mode; and hence the results can be used for evaluation of elastic constants of the material of the structure in-situ. However, when the magnitude of these forces are large, such as, during the primed stage of siphon including cavitation conditions, the spectra of these induced oscillations generally exhibit the characteristics of the superimposed hydro-elastic forces. In addition, dynamic pressure observations inside volute siphon have given important information regarding high frequency hydrodynamics of the water mass.

RESUME

Durant les dix dernières années on a fait des études sur les performances hydrauliques de structures prototypes comprenant les vibrations hydro-élastiques. A ce sujet on a fait des expériences sur les barrages de Khadakwasla, Hirebhasgar, Krishnarajsagar, Vaitarna, Sarlasagar et Mettur. Le résultat de ces études montre que lorsque l'amplitude des forces superposées est petite, le spectre des oscillations causées est plus proche des vibrations naturelles du barrage dans l'un ou l'autre des cas possibles; par conséquent on peut employer les résultats pour évaluer les constantes d'élasticité des matériaux de structure sur place. Pourtant, lorsque l'amplitude de ces forces est grande, comme par exemple pendant la période d'amorcage du siphon, y compris les conditions de cavitation, le spectre de ces oscillations fait généralement apparaître les caractéristiques des forces hydro-élastiques superposées. De plus, des observations de pression dynamique à l'intérieur de la chambre de siphonage ont données des renseignements importants concernant l'hydrodynamique de haute fréquence de la masse d'eau.
MODEL EXPERIMENT ON DYNAMIC BEHAVIOR OF RING FOLLOWER GATE

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SYNOPSIS

Model experiments, which are divided into two parts, have been made to study the dynamic behavior of ring follower gate. One part concerns fundamental study to find the following characteristics as, gate friction, static down pull, negative pressure and air entrainment. The other part is related to gate vibration to obtain such characteristics as, frequency distribution of gate vibration and amplitude, standard deviation of amplitude, and dynamic down pull. In these experiments, the above quantities have been measured as the function of both gate ratio and orifice opening of air inlet. The authors have also theoretically treated the dynamic behavior of gate as a vibration of one freedom, and have obtained certain relationships to estimate the amount of dynamic down pull from measurable values, such as frequency, amplitude, gate friction, static down pull, and elastic constant. Finally it has been estimated that dynamic down pull force is nearly proportional to static one and the former amounts to about 10% of the latter in this experiment.

SYNOPSIS

Un essai sur modèles réduits, qui se divisé en deux partis, a été fait pour étudier la fonction dynamique de robinet vanne à lunette. Une première parti traite une étude fondamentale pour décider caractéristiques suivantes comme friction de vanne, poussé hydrostatique verticale, préssion négative et entrainement d'air. Une derniere parti s'agit de vibration de vanne pour deviner quelques caracteres comme les fréquence-distributions de vibration de vanne et l'amplitude les déviation de standard d'amplitude et la poussé hydro-dynamique verticale. Dans ces essais, des quantites susdites ont été mesurées en fonction du rapport de vanne et orifice d'air-entrée.

En traitant de fonction dynamique de vanne théoriquement comme une vibration qui a un degré de liberté, les auteurs ont obtenus quelques relations entre la quantité de la poussé hydrodynamique verticale et les valeurs mesurables comme fréquence, amplitude, friction de vanne, poussé hydrostatique, et constantes elástiques.

En dernier lieu, il a été estimé que la force de la poussé hydrodynamique verticale était presque proportionnel à la poussé hydrostatique et le premier se monte à environ 15% du dernier dans ces essais.

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SOME CONSIDERATIONS ON THE ANALYSIS AND DESIGN OF HYDRAULIC MACHINERY FOR NON-NEWTONIAN FLUIDS

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SYNOPSIS

Some of the aspects to be considered in the design and operation of hydraulic machines for non-Newtonian fluids are presented. After a brief discussion of the problems encountered in determining the proper rheological characteristics of the fluid and the characteristics of the flow in the piping system to which the machine is connected, the treatment is focused on the losses in turbomachines. The major emphasis is on the determination of disk friction characteristics for a simple power-law fluid, both under laminar and turbulent conditions, and on the way in which these characteristics differ from corresponding Newtonian cases. The problem of the internal losses, and the significance of the non-Newtonian characteristics of the fluid with regard to cavitation phenomena are also briefly discussed.

RESUME

Le but de cette communication est de traiter quelques des aspects qui doivent être pris en considération dans le calcul et l'exercice des machines hydrauliques pour fluides non-newtoniens. Après une brève discussion des problèmes que l'on rencontre dans la détermination des caractéristiques rheologiques du fluide et des caractéristiques de l'écoulement dans les systèmes de conduites où la machine est insérée, l'on passe à traiter plus en détail le problème des pertes d'énergie dans les turbomachines. L'on s'entretient particulièrement sur le calcul des caractéristiques du frottement de disque dans conditions de régime laminaire et turbulent pour fluides obéissant la simple loi de puissance, est sur le paragraphe entre ces caractéristiques et les mêmes caractéristiques pour fluides newtoniens. Le problème des pertes d'énergie internes, et la signification des caractéristiques non-newtoniennes du fluide au regard des phénomènes de cavitation sont aussi discutés en bref.
COMPARISON BETWEEN AIR AND WATER TESTS ON A CENTRIFUGAL PUMP

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SYNOPSIS

Testing hydraulic machines with air rather than with water often has practical advantages but air test techniques have not been widely used because of the uncertainties about scaling the results to water test conditions.

In order to clarify this situation a six inch centrifugal pump has been carefully tested over a wide range of speeds using both air and water. The air tests were done at the British Hydromechanics Research Association, Harlow, and the water tests were done at the National Engineering Laboratory, East Kilbride and the results of the two series are compared.

It is shown that the results of air tests are the same as those of water tests at equal Reynolds numbers if the definitions of head and delivery are suitably chosen and the pressure ratio in the air test is small. The effect of the greater fluid viscosity in an air test is to increase the input power rather than to decrease the delivery head; in fact, it appears that the delivery head will usually be slightly greater in an air test than in the corresponding water test, due to the pumping effect of impeller friction.

RESUME

Eprouver les machines hydrauliques avec de l'air plutot qu'avec de l'eau a souvent des avantages pratiques, mais ces techniques n'ont pas ete largement utilisees parce qu'il n'est pas certain comment appliquer ces resultats au pompage de l'eau.

Afin d'eclairer cette situation une pompe centrifuge a ete eprouvee a plusieurs vitesses differentes, utilisant a la fois l'air et l'eau. Les essais pneumatiques ont ete fait au laboratoire du British Hydromechanics Research Association, Harlow, et les essais hydrauliques au National Engineering Laboratory, East Kilbridge, et les resultats ont ete compare.

Il a ete conclu qu'en depit de la compressibilite de l'air, les resultats des essais pneumatiques sont egales a ceux des essais hydrauliques aux memes nombres de Reynolds quand on applique les definitions de chute et de debit ordinairement utilisees avec les compresseurs, pourvu que la difference des presions n'est pas grande. L'effet de la plus grande viscosite de l'air est d'augmenter la force demande plutot que de diminuer la chute. En fait, il semble que dans les essais pneumatiques la chute soit d'habitude legerelement plus forte que dans les essais hydrauliques parce que la meme frottement sur la roue motrice a l'effet de pompe.
A THEORETICAL INVESTIGATION OF THE FORCES LIABLE TO
CAUSE VIBRATION IN CENTRIFUGAL PUMPS AND TURBINES

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SYNOPSIS

The pattern of flow in radial pumps and turbines is studied with a simple mathematical model in order to clarify the nature of the fluctuating hydrodynamic forces which may cause vibration or noise. The model replaces individual blades of the rotor and stator by single vortices so that the interaction between the two sets of blades can be studied. Expressions are found from which the magnitude of velocity and pressure fluctuations at any point can be estimated, but these are not valid very close to a blade. The fluctuating forces on individual blades of the rotor and stator are found and from these the nett torque and radial thrust (which are also fluctuating quantities) are obtained, when the principal dimensions and approximate operating conditions of a particular pump or turbine are known the magnitude of the fluctuating forces can be estimated.

It is found that the magnitude of the fluctuating force on an individual blade of rotor or stator depends on the number of blades in the other member, as well as on the radial clearance between the two; this magnitude decreases rapidly as the number of blades is increased. The nett torque fluctuations are determined by the least common multiple of the numbers of blades in the rotor and stator and may be considerable when these numbers are equal, or share a common factor.

RESUME

L’écoulement dans les pompes et les turbines est étudié à l’aide d’un simple modèle mathématique afin d’éclairer la nature de la fluctuation des forces hydrodynamiques qui pourraient causer des vibrations et du bruit. Dans ce modèle les pales individuelles du rotor et du stator sont remplacées par de simples tourbillons ainsi que les effets mutuels des deux rangs de pales peuvent être étudiés. Des formules mathématiques sont trouvées d’où la grandeur des fluctuations de vitesse et de pression peut être estimée partout, mais elles ne sont pas valides très proche d’une pale. Les fluctuations des forces sur les pales individuelles du rotor et du stator sont trouvées, et de celles-ci la couple moteur et la force radiale (qui sont aussi des quantités variables) sont obtenues. Quand on connaît les dimensions principales et les conditions approximatives d’opération d’une pompe ou d’une turbine la magnitude des forces fluctuatives peut être calculée.

On apprend que la force variable sur une pale individuelle du rotor ou du stator depend du nombre de pales de l’autre partie, aussi bien que de la distance radiale entre les deux. Cette variation diminue rapidement quand le nombre des pales augmente. Les fluctuations de la couple moteur sont déterminées par le petit commun multiple des deux nombres de pales et peuvent être considérables quand ces nombres sont égaux ou partagent un facteur commun,
For Rotodynamic machines whether turbines, pumps or compressors, energy exchange is carried out through changes in the angular momentum of the working fluid medium. The basic component parts for such machines are almost similar except for some secondary differences that by no means alter the main lines. Moreover, it can be stated that the mechanism involved in the energy exchanges between the through flow and the rotating element is identically the same. This is quite true irrespective of whether the machine is intended for developing or doing work and whatever the fluid medium may be. This did reflect clearly upon the design and performance of all types of machines of that class.

In spite of this fact, each field of applications remained, for no justifiable reason, to be treated as being isolated and independent of the other domains. Furthermore, it is noted that designers of each class of machines are to some extent reluctant to make full use of a nondimensional approach and to extend and correlate their findings and experience in one particular field of application to other fields. It is in the authors opinion that a globural survey of the whole field backed with a unified non-dimensional analysis will help a good deal in the preliminary estimates, design and moreover will facilitate the rational study of the influence of the various parameters and coefficients upon the different component losses and finally the efficiency and size of a particular machine for a given duty.
AUTOMATIC WATERLEVEL REGULATORS

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SYNOPSIS

Hydraulically controlled automatic water level regulators are still of interest and of significance mainly in the field of irrigation. Their features are the discharging capacity, head-loss, accuracy of regulation, sensitivity of response and regulation. The three lastmentioned concepts offer an opportunity for qualifying automation.

Experiments conducted in Hungary with reduced scale prototypes of a headwater regulator with additional tailwater control, a tilting-leaf and a butterfly-valve type tailwater regulator showed favourable results. The first type may be suggested for installation in main and lateral canals, while the latter two for intake control.

The operation of the installations may be influenced by canal waves, for which reason the expected magnitude of canal waves should be taken into consideration in the design.
SYNOPSIS

When the length of a dam is too small to permit the discharge of floods by a free spillway, gates have to be provided. The control system of these gates must be such that the gates are opened in time to keep the reservoir level from exceeding the maximum permissible level. The Paper is mainly concerned with automatic control systems.

With motor operated gates the principal feature of an automatic control system is the control programme which lays down the action to be taken by the motor when the reservoir level is at various marks. A control programme must satisfy the requirements of "competence" and "stability". A control programme of the "multi-aperture" type gives good control of reservoir level but less satisfactory control of rate of outflow. The "continuous-movement-with-floating-stops" type gives good control of rate of outflow but less positive control of reservoir level.

With water operation the main feature of the mechanism is a control chamber in which a water level is created having a definite relationship to the level in the reservoir; the relationship is achieved by balance between inflow from the reservoir over a calibrated weir and outflow through a calibrated orifice or by several other systems.

The reliability of automatic control systems diminishes as the intricacy of the systems increases. In the United Kingdom the Reservoirs (Safety Provisions) Act 1950 seems to preclude an engineer from relying on gates to protect a dam against rupture.

The following order of preference of gate systems emerges: (a) non-automatic gates; (b) automatic water operated gates; (c) motor operated gates.

CONCLUSIONS

Quand des vannes s'imposent pour évacuer les crues sur un barrage, leur système de contrôle doit être tel que les vannes seront ouvertes à temps pour empêcher le niveau de monter au-dessus de la côte maximum permise. Ce Rapport se concentre principalement des systèmes de contrôle automatiques.

Avec vannes actionnées par moteur l'aspect important du système est le "programme de contrôle" qui définit l'action que doit prendre le moteur quand le niveau du réservoir est à certaines côtes. Il doit satisfaire les conditions de "compétence" et de "stabilité". Un programme du type "multi-ouverture" donne un bon contrôle de niveau mais un moins bon contrôle de débit. Le type "mouvement-continu-avec-arrêts-flotants" donne un bon contrôle de débit mais un contrôle de niveau moins positif.

Avec vannes actionnées par l'eau la partie principale du système est la chambre de contrôle dans laquelle un niveau d'eau est maintenu qui est en rapport exact avec la côte du réservoir; ce rapport est effectué par un équilibre entre un apport d'eau du réservoir passant sur un déversoir calibré et une perte d'eau passant un orifice calibré ou par d'autres systèmes.

La sûreté des systèmes de contrôle automatiques diminue pour autant que leur complication augmente. Dans le Royaume-Uni la loi sur la sûreté des barrages empêcherait un ingénieur de se fier à des vannes quand il s'agit de la sécurité du barrage à la rupture.

L'ordre de préférence suivant semble émerger pour les systèmes de contrôle: (a) vannes non-automatiques; (b) vannes actionnées automatiquement par l'eau; (c) vannes actionnées par moteur.
Approximate expressions are derived for the frequency response of some types of hydraulic laboratory plant suitable for regulating the level or flow of water in, or to, large hydraulic models. These expressions may be used in the design of automatic feedback control apparatus such as tide generators and flow control systems.
QUELQUES PERFECTIONNEMENTS APPORTES AUX
APPAREILS DE MESURE DES VITESSES ET DES NIVEAUX

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Sommaire
Dans cette communication, les auteurs présentent des compteurs électromécaniques associés à des moulinets hydrométriques et un dispositif destiné à l’enregistrement des variations rapides de plan d'eau.

Les compteurs électromécaniques utilisés pour enregistrer les "tops" délivrés par les moulinets présentent deux inconvénients principaux : ils nécessitent une puissance de commande pour laquelle les contacts des moulinets présentent des risques de détérioration et ils sont sensibles aux impulsions de caractère erratique provenant de contacts imparfaits. Un montage, utilisant des transistors, permet de pallier ces inconvénients.

La deuxième partie de cette communication a trait à la description d'un dispositif électronique de mesure des niveaux d'eau rapidement variables. On enregistre les variations de résistance entre deux fils conducteurs parallèles plongeant dans l'eau lorsque la profondeur d'immersion varie. Le dispositif, ainsi mis au point, est d'une exploitation très souple, parfaitement linéaire et de sensibilité réglable.

SOME PERFECTIONS TO APPARATUS FOR MEASURING SPEEDS
AND LEVELS

Synopsis
In this communication, the writers are presenting the electromechanical counters joined at hydrometer moulinets, and still an apparatus which it is possible to read in the register the rapid variation of the water level.

The electromechanical counters, vised to register the "tops" which moulinets are giving, have two main disadvantages: they need a commanding power, for which the contacts of moulinets present risks of deterioration, and are sensitive in impulses of erratique form, caused to defective contacts. A mounting using transistors is able to correct the disadvantages.

In the second part of this communication, they described an electrometical apparatus measuring water levels, with rapid variations. They register the resistance variations between two parallel wires submerged in the water, when the depth of submerged wire changes. So, the realised apparatus can be very early used, and has an adjustable sensibility.
EMERGENCY CLOSURE GATES FOR NAVIGATION LOCKS

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SYNOPSIS

Two types of vertical lift gates which differ from previous designs are being used as emergency closures at navigation locks. Double-leaf vertical lift gates are used at four new projects on the Ohio River, while a single-leaf gate will be used at the Barkley project on the Cumberland River, a major tributary of the Ohio River. Although these gates are primarily for making an emergency closure, they also have other functions. The double-leaf Ohio River gates will be used for permitting flow through the lock chamber to flush ice and debris accumulating in the upper approach or for permitting the locks to be used as floodways when the water level in the river rises above the top of the lock walls. The single-leaf Barkley gate has a roadway on top of the gate to provide access to the river wall for maintenance and repair equipment. At each installation, the gates are located in the upper approach and stored in a submerged position below a concrete sill. They are electrically operated by push-button control to be available for prompt closure in an emergency, such as accidental damage to, or failure of, the lock gates.

The hydraulic loads on these gates as they are raised and lowered through flowing water, together with the shape of the overflow crest, were determined from model tests. At two of the Ohio River projects, the gates have been completed and tested under simulated emergency conditions. The gates operated satisfactorily in all respects, including the absence of observable vibrations.

SYNOPSIS

Deux types de portes levantes, d'une construction nouvelle, ont été installées récemment comme vannes batardeaux dans quelques écluses de navigation. Sur l’Ohio, on utilise des portes levantes à vantail double dans quatre projets nouveaux, tandis qu'une porte levante à vantail simple sera utilisée dans le projet Barkley sur le Cumberland, affluent important de l'Ohio. Quoique ces vannes soient conçues essentiellement pour servir comme des vannes batardeaux, elles ont aussi des fonctions différentes. Les portes levantes à vantail double de l'Ohio seront utilisées pour permettre l'écoulement à travers le sez afin d'éliminer la glace et l'éboulis s'accumulant en amont, ou pour servir comme des évacuateurs des crues quand le niveau de l'eau dépasse le sommet des parois de l'écluse. Au dessus de la porte levante Barkley à vantail simple il y a une chaussée pour faciliter l'accès du matériel d'entretien et de réparation au parement de la rivière. En chaque installation, les vannes sont placées dans le large amont, et quand elles ne sont pas en opération elles sont submergées et retirées dans une fosse se trouvant sous un seuil de béton. Elles sont commandées électriquement par des poussoirs, de sorte qu’elles peuvent être formées immédiatement dans une situation critique comme dommage accidentel ou non-fonctionnement des vannes de l'écluse.

Les charges hydrauliques actionnant sur ces portes quand elles sont soulevées et abaissées à travers l’écoulement, ainsi que la forme de la crête déversoir, furent déterminées à partir d’essais sur modèle. Pour deux projets de l’Ohio, les portes furent complétées et essayées sous des conditions critiques simulées. Elles fonctionnaient de façon satisfaisante à tous les points de vue, sans aucune vibration observable.
THE QUANTITATIVE STUDY OF THREE DIMENSIONAL FLOW PATTERNS IN CENTRIFUGAL PUMPS

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SYNOPSIS.
A technique is described for quantitatively measuring the three dimensional flow pattern in a rotating centrifugal impeller. The flow is made visible by small solid particles and photographed on colour film by a camera rotating at pump speed to give the velocity relative to the impeller directly.

Velocity profiles at various radii in an impeller are drawn and the volumetric flow through the impeller, and the inlet and outlet velocity triangles are evaluated. The method is shown to be quantitatively reliable and some qualitative studies of flow separation in the impeller are reported. The true slip coefficient of the impeller is also calculated.

SOMMAIRE.
Une technique est décrite pour mesurer quantitativement le diagramme tridimensionnel, d'écoulement dans un rouet rotatif centrifuge. L'écoulement est visible au moyen de petites particules solides et photographié en couleur par un appareil photographique qui tourne à la vitesse de la pompe, donnant comme ça directement la vitesse relative au rouet.

Les profils de vitesse pour divers rayons de rouet sont dessinés et le débit à travers le rouet et les triangles de vitesse d'entrée et de sortie sont évalués. On démontre que le méthode est quantitativement digne de confiance et on donne compte de quelques études qualitatifs sur la séparation de l'écoulement dans le rouet. Le vrai coefficient de glissement du rouet est aussi calculé.
DIFFUSERS WITH BOUNDARY LAYER SUCTION.

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In the flow of water through hydraulic installations diverging passages referred to as diffusers are frequently employed for the conversion of kinetic energy of flow into potential energy. Unless small angles of divergence are used, separation of the flow from the diverging walls results in large energy losses. Small angles however necessitate lengthening the diffuser thus increasing both friction losses and material costs.

This report gives an account of experiments in which boundary layer suction was applied to comparatively large angle conical diffusers in order to delay separation and so increase the efficiency of energy conversion. The study was confined to straight taper diffusers with conical angles of 15° and 20° and area ratio 4 : 1. It is shown that substantial improvements in efficiency of the order of 15% to 20% can be achieved using low suction rates of about 3% of the main flow. For both diffuser angles similar gains in efficiency were achieved with the same percentage draw-off and within the range of Reynolds number employed - 32,000 to 35,000 - the improvement in efficiency was independent of scale.

The effect of varying the suction draw-off position was investigated and consideration given to the determination of the optimum distribution. The concentration of draw-off tends towards the inlet with increasing Reynolds number and the angle of divergence and spreads further from the inlet with increasing percentage draw-off.

Le processus d'écoulement de l'eau dans les installations hydrauliques comporte fréquemment un parcours à travers des passages divergents, destinés à convertir l'énergie cinétique d'écoulement en énergie potentielle. A moins que l'on n'emploie de petits angles de divergence, le flux se sépare des murs divergants, d'où de grandes pertes d'énergie. Pour avoir de petits angles, cependant, il faut allonger le diffuseur, et par là on augmente les pertes dues au frottement, ainsi que le prix de revient.

Le présent rapport est un compte-rendu d'expériences où, dans des diffuseurs coniques d'angle relativement grand, l'on a pratiqué la succion de la couche limite afin de retarder le séparation et d'accroître ainsi l'efficacité de la conversion en énergie. L'étude se limitait à des diffuseurs à parois droites dont l'angle conique était de 15° dans un cas, et de 20° dans l'autre, avec un rapport de superficie de 4 : 1. Il est démontré que l'efficacité peut être augmentée très substantiellement - amélioration de l'ordre de 15 à 20% - si la quantité d'eau aspirée reste petite; de l'ordre de 5% environ du flux principal. Dans les deux cas (diffuseur d'angle 15° et d'angle 20°) on obtint la même amélioration d'efficacité avec le même pourcentage d'aspiration d'eau, et, dans une gamme de "nombre de Reynolds" allant de 32,000 à 35,000, l'amélioration de l'efficacité était indépendante de l'échelle.

On s'est livré à des investigations en ce qui concerne les variantes possibles dans l'implantation des aspirations d'eau, et l'on a cherché à déterminer la meilleure distribution possible. Plus le "nombre de Reynolds" est grand et plus l'angle de divergence est grand, plus le coefficient d'aspiration d'eau l'ira en augmentant vers l'entrée du courant; plus le pourcentage d'aspiration d'eau est élevé, plus, en revanche, le préféreront aux orifices de sortie éloignés de l'entrée du courant tendra à rester relativement élevé.
USE OF HIGH SPEED PHOTOGRAPHY TO ANALYZE PARTICLE MOTION
IN A MODEL DREDGE PUMP

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SYNOPSIS

High speed photography was employed to observe and analyze particle motion through the impeller and in the volute casing of a model dredge pump in an attempt to determine the effect of behavior of silt-clay-water mixtures in centrifugal dredge pumps.

Particle movements were photographed at a camera speed of between 6000 and 8000 frames per second through a transparent plexiglas volute casing, suction side head and impeller shroud.

Particle motion was traced on paper from the films and the characteristics of the motion were analyzed. A comparison was made between the observed motion and theoretical pump flow and reasons for any discrepancies were discussed.

RESUME

La photographie à haute fréquence permet d’observer et d’analyser le déplacement des particules à travers la roue et dans la volute d’une pompe centrifuge; cet essai a pour but de déterminer l’effet des mélanges d’argile de sable et d’eau sur le fonctionnement de cette pompe.

Grâce à des éléments en plexiglas transparent, tels que la volute, le tuyau d’aspiration et une flasque de la roue, le déplacement des particules put être filmé, la fréquence étant comprise entre 6000 et 8000 images par seconde.

A partir des films, le mouvement des particules fut tracé sur papier, et analysé. Une comparaison entre le mouvement observé et l’écoulement théorique fut établie, et les causes des différences furent discutées.
Hydraulic friction and losses experienced by fluid in its passage through a machine effectively raise the fluid temperature. Measurement of the temperature rise enables the hydraulic losses to be obtained and so the hydraulic efficiency can be evaluated. Theory of the thermodynamic method of measuring hydraulic efficiency is introduced, with division into null and thermometric methods. Apparatus is described and details given of field tests using the null method with resistance thermometers in a D.C. circuit on turbines having heads between 83 and 1,300 ft. Details are given of a new adiabatic expander and a water mixer for obtaining representative samples from tail races. Measurements taken simultaneously with conventional efficiency tests on turbines of 1,300 and 185 feet are discussed. Repeatability of test results is claimed.

Flow measurement is possible in turbines and pumps if shaft powers are known. Laboratory tests have been carried out on a pump of 100 ft. head using the direct thermometric method.

A report is given of experiments involving accurate measurement of temperature rise through a throttle in a 5-inch pipe where the rise measured by two thermometers in an A.C. bridge network incorporating transformer ratio arms was compared with that calculated from the drop in pressure head.

As conventional methods of measuring efficiency are expensive, it is suggested that the thermodynamic method provides a quick and cheap method for routine testing of turbine and pump efficiencies and for measuring pump delivery rates.

Le friction et les pertes hydrauliques subies par un fluide pendant son passage dans une machine augmentent effectivement sa temperature. En mesurant la hausse de temperature on est a meme d'obtenir les pertes hydrauliques du fluide et d'estimer le rendement hydraulique de la machine. Les principes de la methode thermodynamique de mesure du rendement hydraulique sont exposes (methodes nulles et thermometriques). Il suit une description des appareils qu'on a utilise en appliquant la methode nulle et en employant des thermometres a resistance dans un circuit de courant continu. Les details des essais effectues sur des turbines a chutes de 83 a 1300 pieds (27 a 400 metres) sont exposes. Un nouveau detendeur adiabatique est decrit, aussi qu'un appareil pour brasser l'eau (water-mixer) et permettre de prelever des echantillons typiques dans les canaux de fuite.

Des mesures effectuees en meme temps que des essais de rendement classiques pratiques sur des turbines a chutes de 1300 et de 185 pieds (400 et 60 metres) sont analysees. La repetition des essais effectues en utilisant la methode thermometrique a montre un bon accord dans les resultats obtenus.

Si la puissance sur l'arbre est connue, il est possible d'estimer la force du debit dans les turbines et les pompes. On a effectue des essais en laboratoire avec une pompe a chute de 100 pieds (30 mètres) en utilisant la methode thermometrique directe.

On presente un compte-rendu du debit du fluide pendant son passage par une tuyere d'elargissement dans un tuyau a diametre de 5 pouces (13 cm.) ce qui a necessite la mesure exacte de la hausse de temperature. Pour mesurer cette hausse on a employe deux thermometres dans un pont a courant alternant ayant des branches qui comprennent des transformateurs. Cette hausse de temperature a ete comparee avec celle qu'on a calculee d'apres la chute de pression.

Puisque les methodes classiques de mesure du rendement sont onereuses, on préconise l'utilisation de la methode thermodynamique. Elle représente un moyen rapide et peu cher d'effectuer des essais routiniers pour constater le rendement de turbines et de pompes; elle permet aussi le mesurer la vitesse de debit des pompes.
After a consideration of the general principles for the selection of an economic and technically fit type of movable weir, the possible increase in structure height of the concrete ground beam before the weir floor (weir-hump) is explained. This saves steel-structure of the movable parts of the weir without decreasing the capacity of the weir for high water discharge. With sector weirs this also means considerable savings for the underwater structures. Consequently this type of weir becomes a strong competitor to all other weir-types. Sector-weirs, however, until now still had two great disadvantages concerning their technical fitness. As a weir type with fully-automatic hydraulic pressure drive it showed an instability in a critical range of the downstream water levels. Also in rivers with heavy fine sand transport during the movement of the sector body, sand was pressed through the face sealing, thus fell into the chamber and obstructed the lowering of the weir body. The elimination of the first mentioned disadvantage, the instability in a critical range was outlined in a previous publication of the author. The second technical disadvantage, the ineffectiveness of the face sealing against fine sand and its elimination is outlined in this paper. Model tests with a scale 1:1 allowed the development of a new form of rubber-sealing, which overcomes the mentioned difficulties. Prototype tests confirmed the model results completely so that both disadvantages of sector weirs can be considered as overcome.

RESUME

Sortant d'une consideration générale des principes de l'économie et de l'épreuve technique, en choisissant un type particulier des barrages mobiles, l'exhaussement possible du seuil fixe de barrage ("bosse de barrage") est cité comme moyen d'économiser de l'acier des vannes sans influence sur la capacité de rendement du barrage à grandes crues. Ceci donne de plus une épargne fondamentale à l'ouvrage en béton sous sol, de sorte que ce type représente une vraie concurrence aux autres types de vanne. Cependant la vanne à secteur avait à son épreuve technique jusqu'à présent deux grands désavantages. Elle montrait comme vanne à commande entièrement automatique - hydraulique une position labile relative à certaines hauteurs critiques du nappe d'eau en aval de barrage. En outre, pendant le mouvement des vannes aux rivières à fort charriage de sable fin, une certaine quantité de sable pénéttrait par l'étanchement de front dans la chambre de vanne à secteur, de sorte que l'abaissement des vannes fût empêché. Pour remédier au premier désavantage de l'instabilité sous certaines conditions critiques, on est renvoyé à une publication précédente de l'auteur. Le deuxième désavantage technique - la pénétration de sable par l'étanchement de front - est traité dans le texte suivant. Par l'étude sur modèle à l'échelle 1:1, on pouvait développer une nouvelle forme d'étanchement n'ayant pas ce désavantage. Des expériences aux barrages existants confirment entièrement le résultat. On peut donc considérer les deux désavantages, adhèrent aux vannes à secteur, comme écartés.
SYNOPSIS

Two formulae are derived for the prediction of head-loss coefficients of butterfly valves in the full-open position.

The first formula is for use with valve plates of lenticular shape customarily used in large hydro-electric schemes. Up to thickness ratios of 0.25 the formula agrees well with the scanty published experimental data.

The second formula is for use with the newer and smaller type of butterfly valve with higher thickness ratios which are increasingly used in plant work in place of the traditional forms of shut-off and control valve. The formula as given tends to underestimate the head-loss coefficient by comparison with results from a number of commercial valves tested at NEL but predicted values can be obtained by suitable design.

SOMMAIRE

Deux formules ont été dérivée pour la prédiction des coefficients de perte pour les vannes-papillons dans la position complètement ouverte.

La première formule est pour usage avec les vannes ayant la forme lenticulaire qui sont employé d'habitude dans les projets hydro-électrique. Jusqu'à une raison d'épaisseur de 0.25 la formule s'accorder bien avec les résultats d'essais qui sont d'ailleurs insuffisants.

La deuxième formule est pour usage avec les plus petites et plus récentes vannes papillons avec des grades raisons d'épaisseur qui sont de plus en plus utilisés dans les installations remplaçant les vannes traditionelles de contrôle et d'interception.

La formule donne sous-estime les coefficients de perte par comparison aux résultats obtenus des nombreux vannes d'une fabrication commerciale qui ont été essayé au NEL mais des valeurs prédites pouvant être obtenus par des desseins convenables.
SYNOPSIS

This paper deals with the design and equipment of outlet works of large dams and their mechanical equipment.

The main effort is directed towards avoiding cavitation in the whole area of the outlet, including the mechanical equipment. For the investigation of possible cavitation occurrences in various plants, several comparative hydraulic model tests were carried out. Particulars of one of these tests are given in this report. It was found necessary to take into consideration the brief pressure fluctuations as an important criterion of cavitation-free design. The suitable shape of the high-head gates as well as of the slot recesses is discussed basically. In the conclusions, the most suitable arrangements of outlets of large dams are indicated.

RESUME

Cette communication a pour but l'exposition des principes de la disposition des pertuis de fond des grands barrages et de leurs organes.

L'effort principal est tourné vers le problème d'éviter une cavitation dans le domaine entier des pertuis de fond, l'équipement mécanique inclus. Plusieurs essais sur modèles réduits ont été effectués afin de poursuivre des investigations sur les possibilités de cavitation pouvant se produire dans les différents aménagements. Les essais pour un aménagement sont décrits dans ce rapport. L'auteur a trouvé nécessaire de considérer les fluctuations de pression brèves afin de pouvoir établir une critère d'un projet sans cavitation. La forme convenable des vannes ainsi que les rainures sont discutées.
MODERN DEVELOPMENTS IN HYDRAULIC EQUIPMENT

THE ELECTROMAGNETIC WATER-FLOW AND VELOCITY METER

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SYNOPSIS

Presented herein is a new, prototype and specially designed hydraulic device, the Electromagnetic Water-Flow and Velocity Meter for measuring the rate of flow and the velocity of currents under a large variety of conditions.

A combination between the electromagnetic induction and the propeller current meter is realized and, so, a modern as well as essential development in hydraulic equipment and measuring apparatus is obtained.

RESUME

Dans cette communication est présenté un nouveau, prototype et spécialement désigné instrument hydraulique, l'appareil électromagnétique pour la mesure du débit et de la vitesse de courants, dans une large variété des conditions.

Une combinaison entre le moulins d'hélice et l'induction du courant électromagnétique est réalisée en obtenant dans cette manière un développement moderne et essentiel dans le domaine de l'équipement et des appareils de mesure hydraulique.
L'HYDRO-ASPIRATEUR GRAVITATIONAL

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RÉSUMÉ
L'hydro-aspirateur gravitational est un transformateur hydraulique (brevet R.P.R.) utilisé à entraîner les masses alluvionnaires sédimentées au fond des lacs d'accumulation. Il est formé d'un système d'ajoutages qui permet d'obtenir - grâce à la différence de charge - des vitesses d'entraînement très élevées, qu'il serait impossible d'atteindre à l'aide des pompes de boue (hydromasse) ou des dragues aspirantes.

Le compte-rendu présente le principe de calcul hydraulique de l'hydro-aspirateur, de même que quelques résultats expérimentaux.

SYNOPSIS
The gravity hydro-suction device is a hydraulic transformer (patented by R.P.R.), for carrying away the sedimentary alluvia masses from the storage lakes bottom. He consists from a series of nozzles and permit to obtain - by means of the high head - increased bottom flow velocities, which were impossible to realize when mud pumps or suction dredges are used.

The proceeding presents the principle of the hydraulic design of the gravity hydro-suction device and some experimental results.
L’ÉVACUATION PAR ABSORPTION GRAVITATIONALE DES ALLUVIONS DES LACS D’ACCUMULATION

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RESUME
On présente un nouveau procédé d’évacuation des alluvions des lacs d’accumulation, qui permet de réaliser un régime constant du courant dans le lit de la rivière. Le procédé consiste dans l’utilisation de l’action gravitationnelle distribuée sur toute la largeur de la zone de sédimentation du fond du lac d’accumulation. Cette action amorce l’érosion par aspiration gravitationnelle, à l’aide d’un hydro-aspirateur. La méthode constitue un brevet R.P.R.

SYNOPSIS
A new method of alluvia sediments evacuation from storage lakes are presented, which allows a constant flow in the river bed. The proceeding consists from the utilisation of the distributed gravity effect on all the width of the sediments zone, on the storage lake’s bottom. This effect primes the erosion phenomenon by gravitational suction, by means of a hydro-suction device. The method is patented by the R.P.R.
INFLUENCE DE LA CHUTE D'ESSAI SUR LE DEBIT ET LE RENDEMENT
D'UN MODELE DE TURBINE PELTON

Mr. VERCASSON.
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RESUME.
Les résultats présentés ici constituent le point de départ d'une étude plus générale sur l'effet d'échelle dans les turbines Pelton. Les essais réalisés sous des chutes comprises entre 60 et 600 m pour les débits et entre 200 et 600 m pour les rendements ne mettent en évidence aucun effet d'échelle notable.

SUMMARY.
The results presented in this paper must be considered as the beginning of a more general study on scale effect in Pelton turbines. The tests performed under heads of 60 up to 600 m for discharge scale effect, and of 200 up to 600 m for efficiency, have brought no evidence of noticeable scale effect.
LIMITEUR DE DÉBIT À CAVITATION

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Sommaire
Après avoir exposé le principe d'un limiteur de débit basé sur le phénomène de cavitation, les auteurs exposent les résultats d'une étude expérimentale effectuée sur quatre ajutages différents. Des photographies réalisées au 1/1.000.000 de seconde illustrent la formation des poches de cavitation qui se produisent au col de l'ajutage. Les résultats expérimentaux permettent de conclure à la bonne efficacité du dispositif préconisé l'accroissement du débit ne dépassant pas 25% lorsque la charge varie dans le rapport de 1 à 5.

LIMITING DEVICE OF DISCHARGE IN CAVITATION

Synopsis
After explaining the principle of a flow limiting device based on the cavitation phenomenon, the writers describe the results of an experimental study using four different nozzles. Photographs were taken with an exposure time 1/1.000.000 second, illustrating the formation of cavitation pockets, which are produced in the neck of the nozzle. The experimental results confirm the high efficiency of the recommended devices, because the increase in discharge does not exceed 25% for a head variation of 1 to 5.
PROBLEMS OF PUMP HEAD MEASUREMENT

(Fluids Group: Fluid Mechanics Division, NEL)

SYNOPSIS

There is no universally accepted method of measuring pump head, and even standard codes of practice differ. The common practice of assuming uniform energy distribution across inlet and outlet head measuring stations ignores the fact that asymmetric three-dimensional flow patterns are usually found to exist. The total energy associated with such flow regimes is difficult to measure, and does not necessarily represent useful output from a pump.

The differences obtained by adopting various methods of defining and measuring total head are examined in the case of axial asymmetric flow and in two-dimensional swirling flow.

It is recommended that both asymmetry and swirl be limited if pump-head readings are to be meaningful, since the pump duty in terms of head and flow is based on system characteristics which have been measured or calculated for symmetrical axial flow only. Where the flow pattern is unduly complicated another convention for defining pump head is proposed. For this separate tests are carried out first on the circuit by itself and then with the complete installation. Such limitations and departures from common practice are increasingly important as the ratio between velocity head and pump head increases.

LES PROBLEMES DE MESURER LA HAUTEUR TOTALE D’ELEVATION D’UNE POMPE

SOMMAIRE

Il n’existe aucune méthode universellement acceptée qui mesure la hauteur totale d’élévation d’une pompe, et même les codes étalons de pratiques ne sont pas d’accord. La pratique commune, de supposer que la distribution d’énergie est uniforme entre les points où l’on mesure la hauteur totale d’aspiration et la hauteur totale de refoulement, ignore le fait qu’un régime d’écoulement asymétrique en trois dimensions existe normalement. L’énergie totale associée à de tels régimes est difficile à mesurer, et ne représente pas nécessairement le rendement utile d’une pompe.

Les différences obtenus par l’adoption des méthodes diverses de définir et de mesurer la charge énergétique totale sont examinées pour les cas d’écoulement axiale asymétrique et ainsi les tourbillons en deux dimensions.

Il est recommandé que l’asymétrie et le tourbillonnement soient limités afin d’attacher une signification aux valeurs de hauteur totales d’élévation, car le service nominal de la pompe (en termes de hauteur totale d’élévation et débit) a comme base les caractéristiques du système, que l’on mesure ou calcule pour une condition d’écoulement simplement axiale symétrique. Dans la circonstance où le régime d’écoulement est indument compliqué, on propose une autre convention de définir la hauteur totale d’élévation. Pour ce qui, des essais individuels sont exécutés d’abord sur le circuit-même, et ensuite sur l’installation complète. De tels limitations et éloignements de la pratique commune deviennent de plus importants à mesure que la proportion entre la hauteur dynamique et la hauteur totale d’élévation augmente.
EVOLUTION OF THE DESIGN FOR THE RED RIVER FLOODWAY GATES

by J.L. Haydock and J.F. Fulton

H.G. Acres & Company Limited, Niagara Falls

SUMMARY

The Red River Floodway will divert flood flows in the Red River around the city of Winnipeg. In order to effect and regulate the diversion, a control structure will be built immediately downstream from the floodway inlet. This structure will incorporate two submerged gates of a new type, each 112.5 feet wide which are designed for very severe hydraulic conditions. When the gates are in the fully raised position, the head on the sill of the structure will be about 50 feet and the depth of flow over the gate crest will exceed 15 feet. Submerged sector type gates hinged at the upstream edge were selected after a thorough examination of existing alternative types. Under all conditions, the hydraulic torques on the gates about the hinge line are virtually balanced so that each gate can be operated by two comparatively small, double-acting hydraulic servomotors. The hydraulic pressures on the major areas of the gate are also virtually balanced and hence the structural components are comparatively light.

The gate, in its final form, was developed after extensive model testing. The first series was performed in a 12 in. wide flume on a section of the gate. Several variations in shape were investigated to develop the most satisfactory profile. These tests also served to establish the optimum configuration of the energy-dissipating bucket. A second series of tests was subsequently executed on a model of the gate, structure and the adjacent dykes. The complete hydraulic characteristics of the proposed inlet control structure were investigated in this model. Tests simulating the passage of large ice flows over the gate were also conducted. The design studies and model tests have confirmed that the proposed gate arrangement will provide a reliable and economic means of satisfying the complex operating requirements of the inlet control structure.

SOUS-TITRE

Le projet de contrôle des crues sur la Rivière Rouge concerne la dérivation des eaux de crues dans cette rivière autour de la ville de Winnipeg. Pour réaliser et régler la dérivation, un ouvrage de protection sera construit directement en aval de la prise. Cet ouvrage comprendra deux vannes submersibles d'un nouveau type, chacune 112.5 pieds de large, et à l'épreuve de conditions hydrauliques sévères. Lorsque les vannes seront complètement ouvertes, la crête au-dessus du seuil sera d'environ 50 pieds, et la profondeur d'eau au-dessus de la crête de vanne dépassera 15 pieds. Après une étude sérieuse de solutions alternatives déjà existantes, le choix se portera sur des vannes secteur submersibles, avec pivots montés sur leur bord amont. Sous toutes conditions, les moments de torsions hydrauliques s'appliquant sur les vannes autour de la ligne de pivot sont virtuellement balancés de façon que chaque vanne puisse être manœuvrée par deux servomoteurs hydrauliques à double effet, de format relativement réduit. Également, les pressions hydrauliques s'exerçant sur les surfaces principales de vannes étant virtuellement balancées, il s'ensuit que les composants de construction sont relativement légers.

La vanne, dans sa forme définitive, fut développée après des essais approfondis sur modèle. La première série d'essais fut conduite dans une canalisation de 12 pouces de large, sur une section de la vanne. Plusieurs variantes de formes furent étudiées afin d'obtenir le profil le plus satisfaisant. Ces essais auraient également pour but d'établir le profil optimum de la doucine dissipatrice d'énergie. Par la suite, une deuxième série fut conduite sur un modèle réduit de la vanne, de l'ouvrage et des digues adjacentes. Toutes les caractéristiques hydrauliques de l'ouvrage de contrôle de prise proposé furent étudiées sur ce modèle. Des essais simulant le passage de grosses masses de glace flottante par-dessus les vannes furent ainsi effectués. Les études du projet et les essais sur modèles réduits ont confirmé que l'agencement proposé des vannes satisfait d'une manière sûre et économique aux besoins complexes de fonctionnement de l'ouvrage de contrôle de prise.
L'INTRODUCTION DE L'AIR DANS LE DIFFUSEUR

par Prof. Ing. Albert Struna, professeur d'université, Conseiller technique des Ets. Litostroj, Ljubljana, Yougoslavie

et

par Ing. Léopold Solc, Constructeur en Chef des Ets. Litostroj, Ljubljana, Yougoslavie.

RESUME

Tout au début, la communication donne une démonstration du passage de l'eau de la roue motrice vers la section d'entrée du diffuseur et de la formation du noyau de rotation aux petites charges ainsi que de l'apparition de la cavitation aux grandes charges. Dans le premier cas est également mentionnée l'interdépendance avec la hauteur statique d'aspiration. Cependant le chapitre se termine en citant la directive bien connue d'introduire de l'air dans le diffuseur. Certaines expériences pratiques confirment les indications susmentionnées. Elles sont complétées de données concernant les pressions dans la partie supérieure du diffuseur du point de vue du lieu, du temps, de la grandeur et du passage d'un symbole au symbole contraire.

Les données de la littérature technique indiquent la manière d'introduire l'air tout en constatant que cette question n'a pas encore trouvé sa solution définitive. Sont indiquées également mesures à prendre pour prévenir les suites de la marche agitée aux petites charges et les mesures devant empêcher les causes de ces phénomènes.

La Litostroj propose en cinq points la manière d'introduire l'air, parmi lesquels le plus important est la condition qui exige que les deux systèmes d'introduction de l'air tant au centre que sur la périphérie soient complètement séparés. À la place des données parcimonieuses de la littérature technique en ce qui concerne la quantité d'air nécessaire, la communication donne une équation empirique qui a été confirmée par la pratique. La justification des propositions s'appuie également sur les expériences obtenues dans certaines usines hydrauliques.

Etant donné le fait que le problème n'a pas encore été résolu, la communication se termine en indiquant, à part la proposition concernant l'exécution, les différentes étapes des recherches au laboratoire hydraulique.

SYNOPSIS

As an introduction, the authors describe the flow conditions from the runner exit to the draft tube entry and the formation of a vortex core at part loads and of cavitation effects at high loads. The relation of the former to static suction head is discussed, and the chapter concludes with the well known rules concerning admission of air to the draft tube. Some practical experience is presented which confirms these views and supplementary data is given on pressure conditions in the upper part of the draft tube showing the variation from positive to negative pressures with varying quantity at different locations.

Published data deals with the method of air admission, but emphasises that no definite solution to the problem has been found. Methods, both of minimising the effects of part load pulsations and of eliminating this phenomena, are given.

In a summary of five points, the authors suggest a method of air admission which clearly separates the systems for admitting air to the draft tube centre and to the periphery. To supplement the inadequate data available from technical literature, an empirical formula is given which has been proved by experience. Further suggestions are given based on operating experience at hydro electric power stations.

As the problem is far from being completely solved, the conclusion sets out the different phases of research which should be performed at hydraulic laboratories, quite apart from the suggested practical design solution.
LA MÉTHODE D’INTÉGRATION DE MESURE DU DÉBIT DES TURBINES

Ing. Karol TAUS, Institut des recherches hydrauliques Bratislava,
Ing. Ladislav KUTIS, Institut des recherches hydrauliques Praha,
Ing. Ivo BÁCHTL, Institut des recherches hydrauliques Bratislava, Tchécoslovaquie

RÉSUMÉ
Les auteurs décrivent l’application de la méthode d’intégration de mesure du débit pour mesurer celui-ci dans les turbines à basse et à moyenne pression, avec les canaux d’aménée rectilignes, dans les essais de rendement. Ils relatent la vérification de cette méthode de mesure par les essais dans un laboratoire hydraulique et dans la nature et démontrent la vitesse, la précision et d’autres avantages de la méthode d’intégration de mesure du débit sur la méthode classique de mesure ponctuelle. Ils décrivent ensuite les appareils nécessaires, le mode de calcul du débit et les expériences avec l’application de cette méthode en Tchécoslovaquie.

SUMMARY
An application of current meter integration method measurement of discharge for discharge measurement through low- and mean head turbines with open rectangular intake canals during guarantee tests is described. The verification of this method of measurement by means of experiment in the hydraulic laboratory and in the field is presented an the expeditiousness, accuracy and further advantages of current meter integration method compared with the classic point measurement are proved. Further the devices necessary for the measurement, the method of discharge computation and experiences with the application of this method in Czechoslovakia are described.

On the basis of several year good experiences the current meter integration method of discharge measurement was comprised into the Czechoslovak Standard rules for field acceptance tests of hydraulic turbines in 1962.
ACHIEVEMENTS IN SOME STUDIES AND DESIGNS
OF HYDRAULIC TURBINES

By Semen A. Granovsky, M.Sc., Deputy Chief Designer of Leningrad Metal Works.
Aleksey A. Melovtsov, Engineer, Deputy Chief Designer of Kharkov Turbine Works.

USSR

SUMMARY

Leningrad Metal Works (LMZ) and Kharkov Turbine Works (KTZ) have made outstanding achievements in design research of large-size Francis and Kaplan type turbines. A new type runner for a head 100 m was developed at the LMZ works which made it possible to build a 500,000 kW turbine of 7.5 m in diameter. New designs of largest adjustable-blade turbines have permitted the diameter of the runner hub to be reduced thus permitting more power to be obtained from the same size of wheel.

Creation of a new type of adjustable blade turbine at the LMZ works by incorporating a twin-blade runner in its design meant a great progress.

RÉSUMÉ

L'usine métallique de Leningrad (LMZ) et l'usine des turbines de Kharkov (KTZ) réalisent les plus grands progrès dans le domaine des recherches des constructions des grosses turbines Francis et Kaplan.

En LMZ, on a obtenu une nouvelle roue motrice type Francis pour des chutes de 100 m, ce qui a permis de réaliser une turbine de 500,000 kW de puissance pour un diamètre de 7.5 m. De nouvelles constructions des grandes turbines Kaplan ont permis de réduire le diamètre du moyeu de la roue motrice et d'améliorer, par cela même, les données énergétiques des turbines. Un grand pas en avant a été marqué par la création d'une turbine Kaplan de nouveau type, dotée d'une roue motrice à pales geminées.
SALT-VELOCITY AND DILUTION TESTS AT CHEVRIL POWER STATION

By J. M. Hobbs, Ph.D., B.Sc., Fluids Group: Fluid Mechanics Division, NEL, and R. Wolf, Electricité de France

SUMMARY

In collaboration with the Electricité de France (EDF) the National Engineering Laboratory (NEL) salt-velocity team took part in a series of comparative flow measurements at Chevril Power Station in south-east France. Simultaneous measurements by salt-velocity and salt-dilution techniques were made on eight discharges up to 6 m³/s through a 1.3 m diameter penstock. Turbine efficiency measurements by the Poirson thermodynamic method were made at five of the discharges, readings of electrical power output being taken throughout.

The patent cartridge-operated injection valve, 'star' electrodes and battery-powered electrical equipment were used for the NEL salt-velocity tests. Additional 'point' electrodes and recording equipment were installed by the EDF. The salt-dilution tests were made by the EDF using a sensitive colorimeter specially adapted for comparing sodium dichromate concentrations.

Analysis of the results showed that the discharge rates obtained by the salt-velocity method were higher than those obtained by the salt-dilution method. The deviations were within about 1 per cent at the higher flow rates but over the whole range varied from +0.5 to +3.8 per cent. The standard deviation of all the results analysed by the centre-of-area method was ±1.6 per cent. There was some evidence of poor dispersion of the injected salt at the first electrode, but in spite of this reasonably good records were obtained at all but the lowest discharges.

The thermodynamic method also gave results that were higher than those obtained by the salt-dilution measurements, the differences varying randomly from +0.6 to +3.2 per cent.

SOMMAIRE

En collaboration avec l'Electricité de France (EDF) le National Engineering Laboratory (NEL) équipe de sel-vélocité a prit part à des essais comparatifs de mesure de débit à l'usine du Chevril au sud-est de la France. Des mesures simultanées par les techniques de sel-vélocité et sel-dilution étaient effectuées pour huit débits jusqu'à 6 m³/s dans un conduit forcé à 1.3 m de diamètre. Mesures du rendement de la turbine par la méthode thermométrique Poirson étaient fait pour cinq de ces débits, indications de la puissance électrique étant prises partout.

Pour les essais de sel-vélocité de NEL la valve opérer par des cartouches, et les électrodes d'une forme d'étoile, et l'appareil électrique dont la puissance était obtenue d'une batterie, étaient employés. Des électrodes pointues supplémentaires et l'appareil d'enregistrement étaient installés par l'EDF. Les essais de sel-dilution étaient effectuées par l'EDF avec un colorimètre de haute sensibilité, spécialement adapté pour comparer les concentrations du dichromate de sodium.

L'analyse des résultats indique que les valeurs des débits obtenues par la méthode de sel-vélocité étaient plus hautes que celles obtenues par la méthode de dilution. Les déviations étaient au-dessous de 1 pour cent avec les plus grands débits, mais surtout l'étendue des débits les déviations a varié de 0,5 pour cent à 3,8 pour cent. Les déviations standards de toutes les résultats analysées par la méthode du centre de superficie étaient ±1,6 pour cent. Il y'a d'évidence de mal dispersion du sel injecté au premier électrode, mais malgré ça des traces raisonnables étaient obtenues pour toutes les débits sauf les plus bas.

La méthode thermodynamique a aussi donné des résultats qui étaient plus haut que ceux qui ont été obtenus par la méthode de dilution, les différences n'étaient pas systématiques et varié de 0,6 pour cent à 3,2 pour cent.
CALCULATING CASCADES OF BLADES OF MIXED-FLOW HYDRAULIC MACHINES.

by Andras Nyíri

Central Office for Designing Hydraulic Machines,
Ganz-Mávag,
Budapest, Hungary.

In developing hydraulic machines, during the recent years considerable advances have been made by the firm Ganz-Mávag, Budapest. For designing water turbines and pumps up-to-date, mathematically well-founded dimensioning methods have been put forward, the usefulness of which have in practice been demonstrated by machines with outstanding overall efficiencies.

In this paper a brief summary of these calculation methods will be given.

When developing hydraulic machines, the main part for power conversion, i.e., the impeller or runner must first of all be appropriately designed. In the general case of an impeller with mixed-flow a three-dimensional flow is to be dealt with. Now, as a recent development, this three-dimensional flow can be reduced to the task of solving two two-dimensional problems. Firstly, the meridian flow, and secondly, the flow around the lattice of airfoils on one meridian stream surface need be determined.

The two two-dimensional flow tasks introduce obviously certain neglections as against the three-dimensional one, at this cost, however, a method for dimensioning impellers can be reached, which can be handled with a relative ease even in the engineering practice.

When designing impellers or runners a vane crown has to be developed which effects a change of predetermined value in the given moment of momentum and given velocity distribution of the liquid stream entering the impeller. The inlet velocity pattern is determined by the pre-impeller geometry, the discharge velocity pattern by the post-impeller geometry, and the change in momentum by the operating characteristics of the machine.

In the following a frictionless and incompressible liquid will be considered.

Let us examine the flow within the impeller. The vanes are acting in the flow as discontinuous surfaces cleaving and displacing the rotation-symmetrical stream surfaces of the flow space without blading. As a consequence, the actual stream surfaces consist of congruent, periodically arising sections, the determination of which makes the direct solution of the three-dimensional task inevitable.

Apparently enough, the actual stream surfaces lend themselves to be compensated by surfaces of rotation. A hydrodynamic model must thus be found the stream surfaces of which are composed of such surfaces of rotation. Since the boundary conditions specified for the impeller must be satisfied by our model, a homogenous rotation-symmetrical vortex flow will be attained which in effect gives rise to a change in the circulation of the flow entering the impeller—with the points of the meridian plane considered—from point in the same manner as do the impeller blades constituting discrete vortex surfaces in relation to the circulation of the actual, non-rotation-symmetrical flow.

It can be said, therefore, that the vortex distribution is a function of the meridian plane points, but it does not undergo peripherally any change owing to the symmetry of rotation.

As a result of this homogenous vortex distribution a velocity field will come about which delivers average values for velocities of the field induced by the velocity leaps on the blades regarding the space between two adjacent blades. The rotation-symmetrical stream surfaces of the said mean velocity field will be determined and used to divide the blade space into part-channels.

On the middle stream surface of a part-channel of variable width the flow is likewise
# TIME TABLE

**ALL MEETINGS WILL BE HELD AT THE INSTITUTION OF CIVIL ENGINEERS.**

<table>
<thead>
<tr>
<th>DAY</th>
<th>Time</th>
<th>Place</th>
<th>Subject/Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUNDAY</td>
<td>1030</td>
<td>Lectures Hall</td>
<td>Registration of participants in the Annual Report of the Institution.</td>
</tr>
<tr>
<td></td>
<td>1130</td>
<td></td>
<td><strong>MONDAY</strong></td>
</tr>
<tr>
<td></td>
<td>1030</td>
<td></td>
<td><strong>SUBJECT I. Recent research in coastal hydrodynamics</strong></td>
</tr>
<tr>
<td></td>
<td>1100</td>
<td></td>
<td><strong>SUBJECT II. Motion due to lots, equipment &amp; receptions</strong></td>
</tr>
<tr>
<td></td>
<td>1200</td>
<td></td>
<td><strong>MEETING OF ABSTRACTS</strong></td>
</tr>
<tr>
<td></td>
<td>1400</td>
<td></td>
<td><strong>SUBJECT III. Predictions of flood phenomena</strong></td>
</tr>
<tr>
<td></td>
<td>1500</td>
<td></td>
<td><strong>SUBJECT IV. Correlation of flood prediction and data design</strong></td>
</tr>
<tr>
<td></td>
<td>1600</td>
<td></td>
<td><strong>SUBJECT V. Conservation of flood protection and data design</strong></td>
</tr>
<tr>
<td></td>
<td>1700</td>
<td></td>
<td><strong>CLOSING MEETING AT THE SAVOY HOTEL, LONDON, W.C.</strong></td>
</tr>
</tbody>
</table>

*The timetable includes lectures, meetings, and events related to coastal hydrodynamics, flood phenomena, and conservation of flood protection.*
LADIES PROGRAMME


10.30 a.m. Assemble at the Institution of Civil Engineers
11.30 a.m. Embark at Westminster Pier and sail down river to Greenwich by private hire launch with commentary on board.
12.30 p.m. Arrive Greenwich.
1.00 p.m. Lunch in a marquee in the grounds of the National Maritime Museum Restaurant.
2.00 p.m. Guided visit to the National Maritime Museum.
3.00 p.m. Guided visit to the Painted Hall and Royal Chapel at the Royal Naval College.
4.00 p.m. Embark at Greenwich Pier for return journey to Westminster Pier. (Tea and biscuits provided on board.)
5.00 p.m. Arrive Westminster Pier.

Tuesday, 3rd September, 1963.

Free for sightseeing and shopping.

Wednesday, 4th September, 1963.

9.00 a.m. Assemble at the Institution of Civil Engineers.
10.00 a.m. Depart by motor coach for morning conducted sightseeing drive of London visiting the Tower of London and Crown Jewels (if time permits) and St. Paul's Cathedral.
1.00 p.m. Lunch at the "Guinea and Piggy".
2.00 p.m. Continue by motor coach to Hampton Court via Putney and Kingston-on-Thames.
3.00 p.m. Arrive at Hampton Court. Visit Gardens and Hampton Court Palace.
4.15 p.m. Afternoon tea at the "Mitre" Hotel.
5.00 p.m. Return to London via Bushy Park, Richmond and the Hammersmith Flyover.
6.00 p.m. Arrive at the Institution of Civil Engineers.
### APPENDIX V

**BUREAU OF RECLAMATION PARTICIPATION IN PROCEEDINGS OF VARIOUS MEETINGS OF INTERNATIONAL ASSOCIATION OF HYDRAULIC RESEARCH**

<table>
<thead>
<tr>
<th>Paper</th>
<th>Meeting</th>
<th>Authors</th>
<th>Place</th>
<th>Date</th>
<th>Presented by:</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Development of High Head Outlet Valves</td>
<td>2nd</td>
<td>J. W. Ball and D. J. Hebert</td>
<td>Stockholm, Sweden</td>
<td>June 7-9, 1948</td>
<td>Walker R. Young</td>
</tr>
<tr>
<td>Some Principles of Design of Stable Channels in Erodible Materials</td>
<td>4th</td>
<td>E. W. Lane</td>
<td>Bombay, India</td>
<td>Jan 2-5, 1951</td>
<td>L. N. McClellan</td>
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<tr>
<td>Model Studies of Sediment Control Structures on Diversion Dams</td>
<td>5th</td>
<td>H. M. Martin and E. J. Carlson</td>
<td>Minneapolis, Minnesota</td>
<td>Sept 1-4, 1953</td>
<td>H. M. Martin</td>
</tr>
<tr>
<td>The Effect of Entrained Air on Cavitation</td>
<td>5th</td>
<td>A. J. Peterka</td>
<td>Minneapolis, Minnesota</td>
<td>Sept 1-4, 1953</td>
<td>A. J. Peterka</td>
</tr>
<tr>
<td>Laboratory and Prototype Tests for the Investigation and Correction of Excessive Downpull Forces of Cylinder Gates under High Heads</td>
<td>6th</td>
<td>H. M. Martin and J. W. Ball</td>
<td>The Hague, Netherlands</td>
<td>Aug 30-Sept 6, 1955</td>
<td>H. M. Martin</td>
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</table>
## APPENDIX V--Continued

**BUREAU OF RECLAMATION PARTICIPATION IN PROCEEDINGS OF VARIOUS MEETINGS OF INTERNATIONAL ASSOCIATION OF HYDRAULIC RESEARCH**

<table>
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<th>Paper</th>
<th>Meeting</th>
<th>Authors</th>
<th>Place</th>
<th>Date</th>
<th>Presented by</th>
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<tbody>
<tr>
<td>Velocity, Scour and Pressure Measurements from Three Models of the Same Structure</td>
<td>7th</td>
<td>C. W. Thomas</td>
<td>Lisbon, Portugal</td>
<td>July 25-31, 1957</td>
<td>C. W. Thomas</td>
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<tr>
<td>Cavitation and Vibration in a Cylinder Gate Designed for High Heads</td>
<td>8th</td>
<td>J. W. Ball</td>
<td>Montreal, Canada</td>
<td>Aug 24-29, 1959</td>
<td>Dan Linsen (Australian trainee)</td>
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<tr>
<td>Hydraulic Performance of 96-inch Regulating Gates in Closed Conduits</td>
<td>8th</td>
<td>C. W. Thomas</td>
<td>Montreal, Canada</td>
<td>Aug 24-29, 1959</td>
<td>C. W. Thomas</td>
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<tr>
<td>Hydraulic Studies to Develop Design Criteria for Use of Steel Jack and Jetty Fields for Channelization in Rivers</td>
<td>8th</td>
<td>E. J. Carlson</td>
<td>Montreal, Canada</td>
<td>Aug 24-29, 1959</td>
<td>C. W. Thomas</td>
</tr>
<tr>
<td>Use of an Electric Computer to Analyze Data from Studies of Critical Tractive Forces for Cohesive Soils</td>
<td>9th</td>
<td>C. W. Thomas and P. F. Enger</td>
<td>Dubrovnik, Yugoslavia</td>
<td>Sept 3-7, 1961</td>
<td>H. M. Martin</td>
</tr>
</tbody>
</table>
DISCUSSIONS WITH RUSSIAN DELEGATION

Conspicuous during the entire IAHR Congress was the large delegation of Russians who took an active part in the General Sessions and in the Seminars. They were in attendance at the reception given by Her Majesty's Government, at the banquet and all other scheduled events. (I understood they also took the Post Congress Tours.)

The delegation consisted of 23 registered members—the number in evidence seemed to vary from day to day as did the components of the delegation. It seemed that new faces appeared each day while some of the familiar faces of the previous day were not in evidence.

Of particular interest to me, however, were three members; Mr. Michael Skladnev, Dr. Dzhimielskishevili, and Mr. Kuliguin, who were part of a group of eight Russian engineers who spent 2 days in the Denver laboratories in the spring of 1962. In fact, I was cordially greeted by the group leader Mr. Skladnev, who is Chief of Hydraulic Research in Russia, when I entered the convention headquarters for the first time and was immediately invited to attend the next Congress to be held in Leningrad. (It was not until 4 days later that it was officially decided by the Congress Committee that the next meeting, 1965, would be held in Leningrad.)

Mr. Skladnev was surprised and disappointed to learn that I was the only representative from Denver and, also, the only delegate from the Bureau of Reclamation. He inquired about the well being of many engineers in the Chief Engineer's Office and said he hoped he would meet some of them in Leningrad.

The Russians took an active part in the Congress and managed to have one or more of their delegates stand to be recognized or to speak in almost every session I attended. (Their participation is covered in detail in the technical portions of this report.) In every possible way they made their presence felt and tried very hard to enter into the spirit of the Congress. They were hampered to some degree because of their inability to communicate quickly and fluently in English or French. However, they were well received by the Congress and by their contributions helped to make the meetings successful.

Mr. Skladnev told me he was greatly impressed during the visit to Denver of the Russian engineers in 1962 with the quality of the hydraulic research conducted in the Denver Federal Center Reclamation laboratory. He contrasted the practical nature of the work being done with some of the theoretical approaches being used in many laboratories and commented favorably on our down-to-earth policies. He felt that this research, which is aimed directly toward producing a better operating structure at less first cost and less overall cost, was similar to the research being conducted in the USSR. He had no literature he could cite, however, to show me that much of their work was of a practical nature.

In London, Mr. Skladnev repeated parts of the above discussion and then presented me with a very recent book (1963) of 215 pages, printed for the most part in Russian, but with a summary in English at the start of each of the 13 chapters. This book appears to be very practical in nature and is well illustrated with factual matter. It should be of interest to Bureau engineers and should be translated in part, at least. The papers deal with hydraulic and aerodynamic models, concrete research, powerplants, surge tanks, and many other items and should be of interest to hydraulic research and design engineers, concrete research engineers, and structural designers, and civil engineers in general. Subjects covered include hydraulic vibration studies, hydraulic energy dissipators and flip buckets, model and prototype comparisons, river closure by end dumping, surge tanks at powerplants, hydraulic model and prototype comparisons, creep tests on concrete specimens loaded in increments, and other concrete research.
ИЗВЕСТИЯ
ВСЕСОЮЗНОГО Н.-М. ИНСТИТУТА
ГИДРОТЕХНИКИ
ИМЕНИ Б.Е. ВЕДЕНЕЕВА

ГОСЭНЕРГОИЗДАТ

Government Manufacturing Committee
for Power and Electricity USSR

REPORT

(Allunion N. -E. Institute)

HYDRAULICS

by B. E. Vedeneeva

Govt. Energy Publishing House
The English summaries to the 13 papers are as follows:

1. The paper examines the results of an independent section of systematic investigation of the hydraulic jump on the apron with increased roughness in the form of transverse sills or individual baffle piers. General concept of the investigation and detailed analysis of the regimes of the hydraulic jump on such apron are presented. It is revealed that these regimes are influenced by the roughness type, the length of the roughened section, the roughness height and spacing, the Froude number, the degree of the hydraulic jump submergence and some other factors.

2. The paper contains the results of experimental investigations of instantaneous hydrodynamic loads acting on separate blocks of rock foundation in the zone of jet falling, which is thrown off by the ski-jump bucket of a high overflow dam. The results obtained enabled to establish the conditions of scouring of rock foundation in the zone considered and to give the computation scheme of the highest possible depth of the scoured pit.

3. Review, analysis and some general conclusions of the literature published on the problem of the stable operation of power stations with surge tanks are given in the paper. The aim of the paper is to establish the conditions under which unstable processes induced by the power plant operation damp. The articles published on this problem dealt only with some aspects of it.

The present paper studies the stability conditions of power plant operation when the power system is influenced by the factors causing oscillations of small (theoretically infinitely small) or any finite value. Some power stations connected as well as individual power stations were considered. For each case the necessary design formula is recommended.

4. The classification of the methods, used in engineering practice for energy dissipation below overflow dams, is presented. The applicability of different methods of energy dissipation for high overflow dams is shown.

Recommendations for high overflow dams concerning rational methods of energy dissipation, principal dimensions of the ski-jump bucket and methods of determination of the main hydraulic characteristics of the jet, leaving the ski-jump bucket are given.

5. The paper deals with the analysis of the differential equations of movement in water of two elastic systems, considered to be the "model" system and the "prototype" one. The basic rules of reproducing the vibration phenomenon on models are given and also a number of recommendations to keep them.

6. The paper details unsteady flow calculation by the method of characteristics. The author proposes the equations for definition of position and parameters of the auxiliary point on characteristics net without successive approximations.

The proposed equations enable one to avoid manual methods and to save machine-computation time when the electronic digital computer is used.

7. The paper deals with the design of river closure by end dumped method. Much attention is paid to the experimental determination of the relationship between the volume of the material, required for river closure, its grain size and hydraulic parameters of the flow to be closed. Besides, the effect of dumping intensity by end dumped method is shown.

8. The paper gives the results of creep tests conducted to study the deformations of concrete in specimens under compressive loads increased by steps. Some of the specimens were subjected to the load periodically changed at maximum stresses $0, 8--0, 9Rpr$ and many loading-unloading cycles. The tests indicated that in the specimens under this load an intensive accumulation of irrecoverable creep deformations occurred, the values of which were many times more than those of recoverable creep deformations.
9. Principal results of the studies of strength, stiffness and crack resistance of precast reinforced concrete trusses of a new type are reported. The methods of test performance are described, design data are compared with test results. On the basis of the analysis of test results the qualities of the above trusses are estimated.

The paper contains economic comparison data for the parabolic Vierendeel truss and other trusses used nowadays.

10. A method for the analysis of beams of variable stiffness, resting on elastic foundation with the variable foundation modulus, is presented herein.

The shear strain in the beam is considered and the foundation of general nature is examined. The method described is universal over a wide range of variations of parameters of elastic system and may be used for the solution of axial symmetrical problems of the shell theory.

11. The results of experimental investigations of new methods of energy dissipation in the spillway chutes are presented. By means of these methods energy dissipation downstream the outlet works is considerably improved.

12. The paper reviews the results of laboratory studies of the hydraulic structures of the Cherepetskaya State Regional Thermal Station, conducted on hydraulic and aerodynamic models. The results of field investigations of the cooling pond and distribution channel of the station, carried out by Teploelektroproekt, are also presented.

The data obtained in laboratory and in field are compared.

13. The new laboratory for testing hydraulic turbine blocks is described in the paper. The main aims of the laboratory are stated. The parameters of models and the essential features of the energetic, partial three-dimensional, high-head, cavitation and aerodynamic test stands are given.
Appendix VII

DISCUSSION OF SALMON SPAWNING PROBLEMS
WITH
PROFESSOR W. FRAZER, SCOTLAND
AND
ERNST VOLLMER, GERMANY
DISCUSSION OF SALMON SPAWNING PROBLEMS
with Professor W. Frazer,
Head, Dept. Civil Engineering, Royal
College of Science and Technology, Scotland
and Ernst Vollmer, Stuttgart, Germany

During the course of the IAHR Congress I had occasion to talk to Professor Frazer
and learned, inadvertently, that he had quite a knowledge of salmon habits including those
pertaining to spawning. This subject was of particular interest to me because of the
current work in the Bureau on the Tehama-Colusa Project in which an artificial salmon
spawning grounds will be constructed in a 12-mile reach of canal below Red Bluff Dam
in California. Not too much information is available to aid our designers in Denver in
the design of a spawning grounds; consequently, I tried to learn as much as possible
from Professor Frazer.

The first item of interest I learned was that the salmon in Scotland do not die after
traveling upstream into a fresh-water stream and laying their eggs; our West Coast
salmon do. In practically all other known respects the Atlantic and Pacific salmon have
the same habits.

Professor Frazer stated that salmon are an important part of the fishing industry and
that fishing is a big part of the economy in Scotland. Consequently, various interests have
done experimental work, mostly in the field, to improve salmon fishing. Some of this
work had to do with the improvement or creation of spawning grounds in the inland
waterways.

I inquired as to the features or items that would constitute or define a good spawning
grounds. Professor Frazer felt that the most important single item was a continual flow
of clean clear water having a normal supply of dissolved oxygen. This would insure that
the salmon eggs would be properly kept in an ideal environment. To induce the salmon
to lay eggs, a clean-gravel channel bottom is desirable. This clean gravel may be of
any size from coarse sand up to 6-inch cobbles but the gradation should be such that
water can circulate through the gravel to some extent and it should be relatively easy
for a salmon to move the gravel. This moving is accomplished by the fish "groveling"
in the gravel and making worm-like movements to push the gravel into a hump called a
redd. Redds may be 6 feet or more in length, crosswise of the stream, and may have a
depression of 9 inches below and a hump of 9 inches above the original gravel level. The
available gravel should, therefore, be at least a foot deep in the spawning channel. Mov­
ing of the gravel by the fish produces two benefits, apparently; the gravel is cleaned as
it is moved--the current carries away oxygen-consuming organic matter--and a hump
of gravel downstream from the depression is produced which projects into the bottom
flow currents. When the eggs are laid in or on the hump and covered with gravel by
further movements of the fish, the eggs are in a protected location but have a current
of fresh water circulating around them, to maintain them in prime condition for hatching.

Professor Frazer thought that fish choose areas for egg laying where there is a
velocity of about 1 foot per second near the bottom of the channel--this agrees well with
our information that a velocity of 1.5 feet per second at a distance 0.3 foot above the
bottom is ideal.

Fishing interests in Scotland have been successful in improving natural spawning
grounds which have been adversely affected by man-made interferences, and have also
improved some natural spawning grounds by making them more like the ideal areas.
They have not attempted to construct an artificial channel for use as a spawning area
because they have not had a real need for one. There is no reason that this could not
be done, however. It is the consensus that any reasonable approximation of the ideal
conditions described here and elsewhere would produce a satisfactory spawning area.
Nature provides many safety factors in insuring the continuation of a species and condi­
tions in nature are often far from ideal. To be more certain of success, however,
Professor Frazer felt that every effort should be made to provide as near ideal spawning
conditions as possible at the start of the project and that the project be operated and main­
tained so that deterioration does not become a factor after a few years of operation.
Professor Frazer suggested that perhaps the "fish literature" in Norway or Sweden could throw some light on our problem. He said that the Norwegians, in particular, raise salmon on "farms" in commercial quantities—not leaving the catch of salmon to chance—and that perhaps an examination of their methods would reveal recommended practices in regard to spawning. He did not recall any particular publications but indicated that several were in existence.

Mr. Ernst Vollmer was also familiar with some of the habits of salmon, the Pacific Coast variety, since he had lived in British Columbia for a period of time while doing hydraulic research work. His knowledge of fish habits agreed with the knowledge given in this discussion. He indicated that some work had been done by the Canadian government on artificial spawning grounds. Upon my return to Denver, Mr. Vollmer, in Germany, sent me the following news article from the "Sunday Sun," Vancouver, British Columbia, September 21, 1963.
PINKS IN MAN-MADE BED

Fish Spawning Fails Twice, But This Year It Pays Off

ALBERNI (CP) — The world's largest man-made salmon spawning bed, which two years ago seemed to be a complete flop, has suddenly become an unqualified success.

By the end of next week the spawning bed should be filled to capacity with nearly 7,000 pinks, one pair of salmon for every square yard of gravel.

The bed, on Robertson Creek near this port, went into operation in 1959, when federal fisheries scientists planted some 1.6 million eggs.

Importance of the development can be gauged by the fact it is the first time scientists anywhere have succeeded in establishing a completely new run of pink salmon in a river.

OFF-YEAR RUNS

The scientists hope the salmon now entering the spawning grounds will produce some 4.5 million eggs.

Under the ideal conditions at the Robertson Creek bed 90 per cent of the eggs should survive to become fry.

Another 10 million eggs will be taken from mainland rivers this fall, but if all goes well this will be the last year man will come to nature's aid — the salmon next year will be left to their own devices.

ON THEIR OWN

This year's return to the Robertson Creek beds comes from a plant of 4.5 million eggs taken from the Indian River on the mainland.

Normally, pink salmon runs in the Fraser River and Juan de Fuca Strait are generally in odd years. This year, however, the increase in the return has been little short of astronomical — 5,000 pink salmon are already in the Stamp River, homing in on Robertson Creek.

By Sept. 10, 1961, only five of an anticipated 10,000 had shown up, and most observers considered the experiment a total failure.

Ninety per cent of the eggs reached maturity and made it to sea in April and May of 1960.

They were due back the fall of 1961. But by Sept. 10, 1961, only five of an anticipated 10,000 had shown up, and most observers considered the experiment a total failure.

One of the few who still had faith was Bob MacLaren, federal biologist in charge of the experiment. More eggs were planted, and the scientists awaited the results.

The turnout last fall was a lot better — 250 fish reached the beds — but it was far from the number needed to justify the $256,000 expenditure involved.

This year, however, the increase in the return has been little short of astronomical.

Normally, pink salmon return to their spawning grounds every two years — on the east coast mainly in even years and in the Juan de Fuca Strait area generally in odd years.

The scientists hope the salmon now entering the spawning grounds will produce some 4.5 million eggs.

Under the ideal conditions at the Robertson Creek bed 90 per cent of the eggs should survive to become fry.

Another 10 million eggs will be taken from mainland rivers this fall, but if all goes well this will be the last year man will come to nature's aid — the salmon next year will be left to their own devices.
INTERNATIONAL ASSOCIATION FOR HYDRAULIC RESEARCH
10th CONGRESS, LONDON--1963

Appendix VIII

PUBLICATIONS AVAILABLE FROM
NATIONAL HYDRAULIC LABORATORY
CHATOU, FRANCE
AND
NATIONAL ENGINEERING LABORATORY
EAST KILBRIDE, SCOTLAND
# Publications
## du Centre de Recherches et d'Essais de Chatou

Publications by the Research and Experimental Centre at Chatou

Les listes que nous donnons aujourd'hui comportent la presque totalité des articles et livres publiés jusqu'à cette date par le Centre de Recherches et d'Essais de Chatou ou les Services d'E.D.F. qui en font partie à l'heure actuelle.

La liste complémentaire de tirés à part concerne des publications que nous signalons, mais que nous ne pouvons plus fournir, le tirage en étant pratiquement épuisé.

Les ouvrages mentionnés dans la première liste sont disponibles en librairie.

Today's lists include nearly all the articles and books published to date by the Research and Experimental Centre at Chatou, or by the Departments of Electricité de France belonging to it at the present time.

Our supplementary list of reprints refers to articles to which we wish to draw attention, but which we are no longer able to supply as our stocks are practically exhausted.

The publications mentioned in our first list are available from booksellers.

## I. Ouvrages parus en librairie

**I. Publications available from booksellers**

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La Mécanique des fluides et la magnétohydrodynamique. 1961

**OUVRAGES PARUS CHEZ DIVERS ÉDITEURS**

| VALEMBOIS (J.) | - La mesure des pressions variables - Paris, Hermann, 1946 |
| REMENIERAS (G.) | - Eléments d'hydrologie appliquée - Paris, A. Colin, 1960 |
| STEPANOFF (A.J.) | - Pompes centrifuges et pompes hélicièes - Traduit par M. HUG - Paris, Dunod, 1961 |
| LEVTASKY (S.) | - Précis d'hydraulique fluviale - Traduit par J. CHABERT - Paris, Dunod, 1961 |
| LARRAS (J.) | - Cours d'hydraulique maritime et de travaux maritimes - Paris, Dunod, 1961 |
## II. Tirés à part

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<td>Remenieras (G.)</td>
<td>Application de l'électro-osmose à l'exécution de certains travaux en terrains aquifères. La Houille Blanche, A, 1949 (épuisé).</td>
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<td>9</td>
<td>Valebois (J.)</td>
<td>Un manomètre enregistreur des pressions sous-marines pour la détermination des caractéristiques de la houle par la mesure des variations de pression en profondeurs. La Houille Blanche, B, 1949.</td>
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<td>Remenieras (G.)</td>
<td>Prédétermination de la perte de charge dans une canalisation d'eau sous pression à partir de celle mesurée sur la même canalisation parcourue par de l'air. A. Exposé de la méthode. - Communication présentée au 3e Congrès de l'Association Internationale de Recherches Hydrauliques, Grenoble 5-7 septembre 1949.</td>
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<td>Bourguignon (P.)</td>
<td>Prédétermination de la perte de charge dans une canalisation d'eau sous pression à partir de celle mesurée sur la même canalisation parcourue par de l'air. B. Contrôle de la validité de la méthode sur la galerie d'aménée r.g. de l'usine hydroélectrique de Pont-Scosfier. - Communication présentée au 3e Congrès de l'Association Internationale de Recherches Hydrauliques, Grenoble, 5-7 septembre 1949.</td>
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19 - REMENIERAS (G.) et BOYER (J.) - Monographie hydrologique de la Vienne. La Houille Blanche, n° 2, 4, 6, 1950.


24 - NIZERY (A.) - Electrothermic rig for the boring of glaciers. Transactions of American Geophysical Union, février 1951.


26 - BONNET (P.) - Sur les surpressions qui peuvent résulter du remplissage d'une bâche de turbine par ouverture de sa vanne de garde. La Houille Blanche, B, 1951.

27 - MORLAT (G.) - Note sur l'estimation des débits de crues. La Houille Blanche, B, 1951.

28 - LASAYE (G.) et FAUCONNIER (B.) - Étude sur modèle des mesures à prendre pour améliorer le dégravement d'une prise d'eau existante. La Houille Blanche, B, 1951.

29 - CHABERT (J.) - De l'utilisation du phénomène d'injection dans un évacuateur de crues. (Mémoire présenté au comité technique de la Société Hydrotechnique de France le 22 novembre 1951.) La Houille Blanche, A, 1952.

30 - JUPILLAT (R.) et TRIVIDIC (A.) - Sur l'évolution du coup de bélier dans une galerie d'aménée à l'amont de la cheminée d'équilibrage. La Houille Blanche, B, 1951.


32 - MORLAT (G.) - Sur la consigne d'exploitation optimum des réservoirs saisonniers. La Houille Blanche, n°4, juillet-août 1951.


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48 - REMENIERS (G.) et NOUGUETON (P.) - Prédétermination des pertes de charge d'une canalisation d'eau par circulation d'air. Le Génie Civil, 15 mars-1er mai 1953.


50 - NIZERY (A.) et BRAUDEAU (G.) - Variation de la granulométrie de charriage dans une section de rivière : Proceedings Minnesota International Hydraulics Convention, 1-4 septembre 1953, Minneapolis.

51 - NIZERY (A.) et BONNIN (J.) - Observations systématiques de courants de densité dans une retenue hydroélectrique. Proceedings Minnesota International Hydraulics Convention, 1-4 septembre 1953, Minneapolis.

52 - VALEMBOIS (J.) - Étude de l'action d'ouvrages résonnants sur la propagation de la houle. Proceedings Minnesota International Hydraulics Convention, 1-4 septembre 1953, Minneapolis.

53 - MARQUENET (G.) - Entraînement d'air par un écoulement en conduite verticale : application aux puits d'adductions secondaires. Proceedings Minnesota International Hydraulics Convention, 1-4 septembre 1953, Minneapolis.


56 - SCHNEEWEBLI (G.) et HUARD DE LA MARRE (P.) - Nouvelles méthodes de calcul rapide des écoulements de filtration non permanents à surface libre. (Comité technique S.H.F., 19 mars 1953.) La Houille Blanche, B, 1953.

57 - FAURE (J.) - Calcul des pertes d'énergie dans un systèmes à marée (Gironde). Principe et exécution du calcul à l'aide d'une machine mathématique. (Comité technique S.H.F., 19 mars 1953.) La Houille Blanche, B, 1953, 10 fig., discussion.


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61 - SERRA (L.) - Le vent en France et ses possibilités d'utilisation. La Météorologie, octobre-décembre 1953, p. 273-292, 14 fig.


63 - BRAUDEAU (G.) - Dispositif d'arrosage de la veine pour les déchargeurs de Fessenheim. (Comité technique S.H.F., 10 juin 1954.) La Houille Blanche, B, 1954.


82 - CHABERT (J.) - Résultats principaux de l'étude sur modèle réduit des ouvrages de prise et de retenue de la chute de Montelimar. La Houille Blanche, n°3, juillet 1955.
83 - SCHNEEBELI (G.) - Expériences sur la limite de validité de la loi de Darcy et l'apparition de la turbulence dans un écoulement de filtration. La Houille Blanche, n°2, mars-avril 1955.
88 - LABORATOIRE NATIONAL D'HYDRAULIQUE - Essai d'application des résultats de la physique ondulatoire à l'étude des phénomènes de propagation de la houle. Annales des Ponts et Chaussées, janvier-février 1946 et mai-juin 1946.

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104 - LARRIEU (J.) - Méthodes d'analyse de la structure fine des débits. Revue de Statistique Appliquée n° 2, 1956.


109 - MORLAT (G.), BILLIET (A.) et BERNIER (J.) - Les crues de la Haute Durance et la théorie statistique des valeurs extrêmes. Publication n° 42 de l'Association Internationale d'Hydrologie (Symposia Darcy, Dijon, 1956).

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112 - SERRA (L.) - L'étude météorologique des possibilités de crue. Application à la Durance. Publication n° 42 de l'Association Internationale d'Hydrologie (Symposia Darcy, Dijon, 1956).

113 - MILLIAT (J.P.) - Étude expérimentale de l'écoulement turbulent dans un conduit divergent parcouru par l'air. (Mémoire présenté au comité technique de la S.H.F. le 16 mars 1956.) La Houille Blanche, B, 1956.


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129 - BONNIN (J.) - Quelques applications de la conductivité à l'hydrologie. *Assemblée générale de l'A.I.R.H., Lisbonne, juillet 1957.*


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SUMMARY

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VISIT TO SCIENCE MUSEUM
LONDON, ENGLAND
AND
GENERAL OBSERVATIONS
AND
COMMENTS
In returning from the Imperial College to my hotel, I walked across the Imperial College campus to observe the extent of the campus and the types of buildings. Near the end of the campus I came upon a group of buildings which I at first thought were part of the college but turned out to be a Science Museum, one of several on the campus itself. I was greatly impressed by the number of children who were going in and out of these museums. They all seemed to have more than a superficial interest and were busily engaged in discussing the various displays. One room of the building was devoted to power development and contained working models of many early power sources which are unheard of today but which also included water wheels, primitive turbines, gasoline engines, and steam engines. In connection with these devices there was also a display of electrical generators, turbines, pumps, locomotives, automobiles, and motorcycles, and these were being carefully observed and operated by children ranging in age from about 8 to 16 years. Apparently the children were making a day of it because they had brought their lunches and some were in the process of eating while they were observing. There were relatively few adults in charge of the children. I was particularly impressed with the entire situation because of the extremely sincere nature of the children with respect to the equipment being displayed. I tried to visualize the same thing occurring in the United States, and I could not stretch my imagination enough to picture the same degree of interest here. It seemed to me that the European children were considerably more interested in the mechanical aspects of the devices and natural laws of gravity and motion than a random group of children in the United States. This feeling was confirmed later as a result of some of the observations I made at other times and in other places during my European tour.

I felt that European children were considered by their parents to be a vital part of the family; often they are not in the United States. I had always thought that we put our children first but in observing the methods of the European parents I do not believe that this is as true as I had originally thought. European parents have a primary concern for their children which extends far beyond the monetary or material aspect. They have a primary concern which extends to teaching of manners, respect, true values, interest in local and world doings, straightforwardness, and other virtues which make their children likeable. The children seem to reflect this attitude and return to their parents and teachers a fulfillment of the objectives expected of them. They seem to have proper respect for authority, are better mannered, and are easier to talk to than children of the same age in the United States.

In discussing this with European parents familiar with American children, I found that some agreed with me; others thought that the more self-reliant attitudes of our children was a very desirable attribute.

Other Observations

Although forewarned, I was surprised to find a very low salary scale in Europe. In London a foreman of an "Underground" (subway) station earns $42 per week. This is an above-average job which would pay over $100 here. In keeping with the lower salaries, I noted that, generally, people in Europe do not have as many possessions as we do. Many own no real estate or many chattels—no homes, autos, furniture, or refrigerators. They live in apartments, shop for one meal at a time, ride in common carriers, and have little concern or worry about upkeep or maintenance of a variety of things we believe to be necessities. They, therefore, spend more time and money, relatively, than we do on clothing, in working and eating and relaxing, and less time in maintenance or worrying about their possessions.

The monumental traffic problems in Europe make ours look simple. I don't know how they will ever solve those in London and Paris when more people have cars. (Only a very small percentage of the people own cars.) Some of the problems, I believe, are due to the fact that the majority of drivers in Europe are people who learned to drive after
they were mature—first generation drivers. Drivers who learn to drive as children—who have been driving and riding all their lives—second generation drivers—are better drivers and are not so prone to produce the kinds of traffic tieups I saw in Paris. I saw drivers whose routes were blocked and were therefore angry, and who then blocked cross traffic and refused to move; drivers who shook their fists at pedestrians; drivers who charged into red lights only to slide to a stop; drivers who recklessly changed lanes or sped through blind intersections; and drivers who continuously gunned their engines even when gasoline costs $0.80 to $1.25 per gallon. Education and experience will help to solve the traffic problems; in addition eliminating bottlenecks such as these where traffic from eight avenues is funneled into one street will also be necessary. Of the many taxi rides I took, I enjoyed only one—this where the driver was a young widow who was trying to conserve gasoline and the wear and tear on her secondhand cab (on which she had a large mortgage at 35 percent interest).

Throughout my travels, I saw little unemployment. In most areas there are more jobs than people. I also saw some of the reasons why. Business in Europe is on a small scale; there are many small shops—no supermarkets as we know them. Even department stores are relatively small and unimpressive with a limited number of items and little variety in the choice of items. "Little business" has a chance, and is the backbone of the European economy. More people are required to run little shops. Restaurants are small; grocery stores sell only groceries; meat is sold in separate small butcher shops where merchandise is kept moving because there is no refrigeration. There is no self-service, and discount houses manned by only a cashier do not exist. Meat is displayed on open marble slabs or counters and is often at the mercy of the public and flying insects. No screen doors are in evidence.

Many job categories are retained which we have done away with by automation or by custom. Many attendants, porters, service personnel, street cleaners, etc., are in evidence which we could not afford to maintain in our economy. In Europe these people make a living for a family in a job we would consider too unimportant to mention.

One reason for the small physical size of many businesses is the lack of capital to make them larger. Money is scarce and interest on loans is very high. I noticed that personal savings accounts in banks can earn 8 to 12 percent interest. Conversely, loans must command a much higher rate.

London and Paris are both very cosmopolitan cities—even more so than New York. I saw and photographed many people in native dress, Scots, Arabs, Indians, etc., who were mingling with people in western dress with not an eyebrow being lifted. Even in blasé New York the costumes would have attracted some attention. Likewise, in Europe I saw people of various races and colors living in the same hotels, eating in the same dining rooms, and riding in the same train compartments without even an awareness that was visible to me.

In the rural areas near Glasgow, which seem to be entirely of older construction, I was surprised to see new areas known as Industrial Estates. Industry (several units of several corporations) has been moved to new offices in rural areas and homes and shopping facilities for the workers have been built adjacent to the places of employment. Employees can walk to work, to shopping and entertainment facilities, and lead semi-rural lives without moving too far from their birthplaces. These "Estates" are quite successful, I was told.

In contrast, in the Glasgow airport, we met a family who were emmigrating to New Zealand. They had run a successful fish business north of Glasgow for years, but the future looked bleak for their children and they were moving to a land of more opportunity. They had gotten a fair price for their business and were flying to their new home. They were prosperous-looking people, well bred, well dressed, well mannered. The husband was being accompanied by his young-looking 82-year-old father. When I asked the grandfather why he was going to New Zealand he seriously said he was "about to seek a new life."

In rural England I was impressed by the relatively great amount of open country—land devoted to farming and other typical rural uses. It seemed to me that over the past thousand years there would have been more housing developments with a succession of suburbs and adjacent towns extending for miles outside of London. Upon inquiry, I
learned that strict urban development laws prohibit the construction of new dwellings on land devoted to farming or other uses (there is no idle land). Additional housing in many cases, therefore, cannot be built at all. Later, I learned that a friend, who had lived in a rented apartment in London for years while searching for a suburban home, finally made a purchase some 100 miles from town. He bought one-seventh of an old castle hundreds of years old and had to redo it, including putting in a heating system. He was in the process of learning that commuting to London even once or twice a week, was too strenuous and time-consuming and was about to return to an apartment. In London, apartments are not easy to obtain unless money is no object.

I was impressed by the abundance of flowers throughout Europe. They seemed to be almost a necessity of life in England and France. Shoppers buy cut flowers to take home even when they do not have money for other things. Apartment houses (and even tenements) have flower boxes in each window, hotel rooms come equipped with flowers in vases, streets and corners have flower vendors in abundance, markets offer a selection for sale, street intersections, parks, and walkways are lined with flowers, railroad trains have bud vases with a single blossom in each compartment, and the railroad stations in even the smallest towns have flower gardens adjacent to the waiting room benches. Some of the most beautiful flower gardens I have ever seen are adjacent to the Louvre in Paris. These are formal-type gardens, well kept, and in good taste.

Although I do not consider myself an art lover, I was greatly impressed by the quality and beauty of the art and sculpture in the National Galleries in London and in the Louvre in Paris. Some of the paintings are unbelievably lifelike, and the detail in some of the sculptured work is amazing. The Eiffel Tower is also a work of art, in a different way, and is a very popular structure. Thousands make the trip to the top each day and they, as I, marvel at the concept, design, and accomplishment of such a structure.
Hydraulics Research

Following the recent congress in London of the International Association for Hydraulics Research, a number of visits to various engineering and research centres throughout the country have been made by delegates to the congress. The opportunity was therefore taken to hold open days last week at the British Hydromechanics Research Association and at the Hydraulics Research Station. The work of the former organisation is referred to in a note on page 466 of this issue; this article gives some examples of recent work at the latter.

The Hydraulics Research Station of the D.S.I.R., which is at Wallingford in Berkshire held an open day on Wednesday, September 11. An impressive array of hydraulic models was to be seen, for the Station's work has increased in recent years, and quite a number of model studies—each applied to some specific problem, and most frequently to investigation of a hydraulic structure of some kind which it is planned to construct—are now in progress. This class of work comprises the bulk of the Station's activities, and frequently is carried out for a fee; about half the Station's annual cost of something like £250 000 is recovered by fees. In addition, there is of course, research of a more fundamental nature in progress. Part of this relates to hydraulic model techniques and instrumentation, and is likely, therefore, to be of direct benefit to future model studies. But a clearer understanding of the nature of flow in open channels is also sought. Two examples of work of a fundamental nature to be seen at the open day may be cited.

The first concerns sediment transport. A new theoretical approach to the transport of cohesionless sediment by currents has been evolved at the Station over the past few years, and three papers on aspects of this work were presented at the I.A.H.R. congress by authors from the Station. Two experimental studies are now in progress. One uses the Station's long flume (which is 350ft long and 5ft wide) to find practical ways of directly measuring the rate at which sediment is transported. Continuous injection of tracers from a single point is one technique of interest here. In a second flume, an attempt is being made to find out under what conditions the surface of a sand bed does not take up a rippled shape, but becomes flat. Clearly the measurement of sediment is much easier if its surface is flat, and it would be an advantage if experiments could be arranged so that flat beds were present. Reproduction of exact conditions of dynamical similarity for these problems is considered quite feasible.

The second example is an investigation of the entrainment of air at vortices. A vortex with a core of air is maintained in a large "Perspex" tank. Radial and tangential inflows can be varied and controlled separately. The first step is to measure the velocity distribution in the vortex. To do this a strong pencil of light is shone through at the required radius, and the movement of particles in the water can be seen by observing the pencil of illumination; a rotating cube of glass is interposed in the optical system and its speed of revolution adjusted until the particles appear to be stationary; thence the velocity can be deduced. This study has been undertaken because conditions of similarity between model and prototype have not been satisfactorily established for this class of phenomena.

The model studies at the Station are somewhat numerous, and here we have only attempted to give one or two examples of what is being done. The illustration shows less than half of the floor area available for model studies in the main hall. In addition there are wave basins in another building, and there is a flume building and also a meander area where experiments are carried on out-of-doors.

The "Ciel Étoile"
The harbour models at the Station are generally much concerned with waves— their penetration and occurrence at and inside the harbour entrance. One experimental set-up is of interest not for the actual harbour itself but as a demonstration of a method of measurement with the unexpected name of the "starry sky" which has been applied to a study of the long waves which cause "ranging". A grid of "point source" lights is suspended 16ft above the model, and their reflections in the water of the model are photographed. The photographic plate of the camera is exposed for one complete wave cycle (i.e. one to four seconds in these experiments).
The lengths of the light traces are a direct representation of the gradient or slope of the long waves and are thus also representative of the forces acting upon a ship in such waves. These forces can give rise to a "to and fro" horizontal motion of a ship, known as ranging if it is fore and aft. To obtain the true scale length over which a particle of water in a wave oscillates, requires the application of a factor to the measured length of the light trace; this factor varies with the wave period. For these photographs it is about 0.6.

A ship unrestrained by moorings will move horizontally with the particles of water in her vicinity; therefore the length and direction of the light traces give an indication of the possibility of ranging. Points of light are to be seen at anti-nodes (also wave-free areas) where there is little or no horizontal movement, and streaks of light indicate nodes (also progressive waves) where there is greater movement. The method is of French origin and has been used in France to record wave heights. This is not considered to be a good application of the method, the virtue of which is to give a direct indication of the surface gradient.

Tyneside Sea Outfalls

An investigation is being made into the effect that winds will have on the disposal of effluent discharged from sewage outfalls to be sited 3 miles off the Tyneside coast. The purpose is to determine the best places for sewage to be discharged (there is to be one outfall corresponding to the main drainage along each bank of the river) so that it will not be washed ashore by wind-generated surface currents.

The model, which is tidal, is covered over and is equipped with a wind-generating system that enables winds to be blown across it from any direction. Axial flow pumps also produce longshore currents. Field observations, made by the clients and analysed at the station, have made it possible to relate the strength and direction of the wind to the strength and direction of surface currents. It is thus possible to use a purely empirical relationship between wind and current on the model, and there is, of course, no question of the model laws of similarity applying to wind speeds. The model has a horizontal scale of 1:3000 and a vertical scale of 1:150 and the Station's clients are the consulting engineers, Messrs. J. D. and D. M. Watson. This particular type of investigation with a covered model may well be unique.

Sea Walls and Littoral Drift

A vertical sea wall that is built too close to the shore line will usually cause erosion. This is partly due to an increase in the rate at which sand or other bed material drifts along the local coastline and is, itself, a secondary effect of increased wave-height just in front of the wall. Different designs of sea wall are being compared quantitatively by measuring the increase that occurs in littoral drift. Optimum designs are being sought for particular combinations of waves and tidal ranges. The bed material is granular coal.

An example of how a sea wall might be of benefit in reducing rather than increasing littoral drift, so long as it is placed in the right position, can be seen by following a particular experiment. In this experiment, carried out in one of the station's large wave basins which measures 190ft by 60ft excluding the channels around it, a stable beach was first obtained and a sea wall built along the mean water line. Both before and after the wall was in position, waves were produced at an angle normal to the beach. Tides were also produced, together with longshore currents. The experiment was conducted under these conditions until there was no change in the profile of the beach. The amount of littoral drift—the amount of bed material moving along the beach in front of the wall, and its rate of movement—was measured after each tide.

Although, once equilibrium had been established, the beach profile was observed to be always the same after each tide, with or without the wall in position, the quantity of littoral drift was seen to vary over a range of 20% for the same hydraulic conditions. It was, however, always highest in front of the wall, although the net amount of littoral drift was less with the wall in position. Other experiments similar to this, with differently designed sea walls (different contour and slope, for example) in different positions and using oblique waves, are being conducted in the wave basin. The relative effect of a longshore current experienced at high or low water will also be assessed.

The wavemaking apparatus consists of 240 oscillating plates, each 9in wide and 24in deep, and hinged at the bottom of the basin. The phase and amplitude of oscillation of each of these plates can be varied independently. The upper end of each plate is connected through links and a bell crank to an eccentric drive. A series of discs, one to each wave plate, are driven from a common shaft. Each disc carries a slideway, and the eccentricity with which the wave plate linkage is set in this slideway determines the amplitude of oscillation of the plate. When waves skew to the basin are required, each slideway can be set a few degrees in advance of its neighbour.
The maximum amplitude of the plates is \( \pm 4\text{in} \) and frequencies from zero to approaching 100 crests per minute are obtainable. The wavemaking machine was made by Macdonald and Co. Ltd., of Haydock, Lancs. In the test described here the wave height was 2-6in, its period one second and the tidal period was seventy-five minutes.

Tides are fed into the basin along its long side—the same side that accommodates the wave machine. Littoral currents, which are of much higher velocity than the tidal currents, are superimposed from end to end of the basin. Up to 25 cusecs may be needed for the littoral currents, control being by controlling the speed of the pump.

The sketch shows the principle of the tide-generating apparatus. A constant speed centrifugal pump draws water from one side of a four-way valve and delivers it to the opposite side. One of the two remaining limbs of the valve is connected to a sump, the other to a distributor in the model. Trim valves and the pipework connected to these two limbs are designed to present similar head loss characteristics so that water is removed from or delivered to the model in varying flows depending on the position of the valve vane. An automatic control system regulates the position of the vane to produce the required tides in the model.

The tidal sequence to be reproduced is supplied by either a tide cam mechanism, or an automatic curve reader, in the form of a d.c. voltage analogue. This voltage is compared with a second voltage produced by a float-operated potentiometer which continuously measures the water level in a stilling chamber connected to the model. A difference between the two voltages represents the instantaneous error in the level of the model. This error signal is advanced in phase over the critical frequencies of the system to ensure a stable performance, and is then converted to an a.e. voltage before being amplified and applied to a two-phase servo-motor. The motor positions the wiper of a small potentiometer, so producing a feedback signal which nulls the error voltage at the output of the phase-advancing circuits. Thus, the servo-motor drive is displaced by an amount proportional to the error. This displacement is applied to the four-way valve which causes water to be supplied to or removed from the model at a rate proportional to the error.

**Single Point Mooring**

Another model study which is of rather a different character than most of the studies at Wallingford is an investigation of the loading and unloading of oil from an offshore installation. Tests are being carried out to study the behaviour of a 100 000-ton tanker, 900ft long, while it is moored to a single, fixed tower. Several different types of moorings are being tested, and waves and winds and currents are made to approach the tanker from all directions, at model scales of 1:80.

In the present tests the mooring consists of either flexible or rigid struts or of a flexible nylon rope. The forces exerted on these and on the tower, as the tanker is moved by the waves and winds, are being measured by strain gauges attached to the tower. Polaroid cameras record the movement of the tanker. The model tanker itself has a correct load displacement and moment of inertia in all planes. Winds equivalent to 27 m.p.h. are generated by a fan and directed on to the tank from one end of a looped wind tunnel which can be manually rotated. Water currents are produced by axial flow pumps on two adjacent sides of the model. Short storm waves, having periods equivalent to about twenty seconds in nature and longer ones having periods equivalent to two minutes, are also produced.
Appendix XI

LIST OF PUBLICATIONS ACQUIRED
APPENDIX XI

Publications Acquired, IAHR and Tour of Hydraulic Laboratories
England, Scotland, and France

1. Report--All Union NE Institute Hydraulics by B. E. Vederreeva. Covers the 13 papers or chapters abstracted in Appendix VI. Published in Russia by the Government Energy Publishing House, 213 pages, hard cover.

2. Booklet--Wallingford Hydraulic Research Station, 20 pages, illustrated, giving facilities, scope, abstract of activities, etc. Published by Department of Scientific and Industrial Research.

3. Booklet--Hydraulics Research Station, Wallingford, 20 pages, maps of station and area, resumes of hydraulic research problems, responsibility, duties, etc.

4. Booklet--National Engineering Laboratory Annual Report 1962, East Kilbride, Scotland, 77 pages of abstracts of research projects, organization, work program, results achieved, personnel activities, and accomplishments, etc.

5. Booklet--Papers Issued by Fluid Mechanics Division, NEL Laboratory, East Kilbride, Scotland, July 1962, 8 pages. Contents reproduced in Appendix VIII.


7. Portfolio--12 sheets containing photos and descriptions of Hydraulic Model Experiments successfully completed at National Hydraulic Laboratory, Chatou, France.

8. Publications by the Research and Experimental Center at Chatou, France, 15 pages. Reproduced in Appendix VIII.


11. Booklet--Problemes Portuaires en Amerique Latine, Maisons-Alford, France, 24 pages of accomplishments in hydraulic investigations in Brazil, Chile, Colombia, etc., illustrated, printed in French.


13. Seven booklets from SOGREAH, Grenoble, France as follows:
   A. SOGREAH (yellow cover)--12 illustrated pages giving organization, information, scope of operations, and fields of activity. Printed in English.
   B. Laboratoire De Calcul Electronique, about 20 colored and illustrated pages giving hydrology and hydraulic problems solved by computer methods. Printed in French.
   C. SOGREAH in the Hydro-Agricultural Field--70 pages, colored, illustrated. Printed in English. Scope and accomplishments in this field.
D. References SOGREAH--Hydrology and Hydrography, 14 pages of summaries of work accomplished in this field. Printed in English.

E. References SOGREAH--Maritime Hydraulics, 30 pages of accomplishments in this field. Printed in English.

F. References SOGREAH--Agricultural Development and Urban Hydraulics, 40 pages of accomplishments in this field. Printed in English.

G. References SOGREAH--Hydroelectric Development and River Training, 40 pages of accomplishments on over 100 dams, powerplants, or projects in over 50 countries of the world.

14. 120 preprinted papers up to 8 pages each, IAHR Congress, London 1963, (see Appendix III for Abstracts).
Appendix XII

TRIP ITINERARY FOR
ALVIN J. PETERKA
## Itinerary for Alvin J. Peterka

<table>
<thead>
<tr>
<th>Day</th>
<th>Month</th>
<th>City</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunday</td>
<td>August</td>
<td>Denver</td>
<td>Leave on Continental Airlines Flight R22 at 10:55 a.m.</td>
</tr>
<tr>
<td>Monday</td>
<td>August</td>
<td>Chicago</td>
<td>Arrive O'Hare Field 3:00 p.m. Change planes. Leave O'Hare on Pan American Flight Y58 at 5:00 p.m.</td>
</tr>
<tr>
<td>Tuesday</td>
<td>August</td>
<td>London</td>
<td>Arrive Heathrow Airport 6:45 a.m.</td>
</tr>
<tr>
<td>Wednesday</td>
<td>August</td>
<td>London</td>
<td>Visit Imperial College</td>
</tr>
<tr>
<td>Thursday</td>
<td>August</td>
<td>London</td>
<td>Leave Heathrow Airport 11:30 a.m. on BEA Flight 840</td>
</tr>
<tr>
<td>Friday</td>
<td>August</td>
<td>Glasgow</td>
<td>Arrive Renfrew Airport 12:30 p.m. Visit NEL Laboratories, East Kilbride</td>
</tr>
<tr>
<td>Saturday</td>
<td>August</td>
<td>London</td>
<td>Leave Renfrew Airport on BEA Flight 5033 at 12:40 p.m.</td>
</tr>
<tr>
<td>Sunday</td>
<td>September</td>
<td>London</td>
<td>Arrive Heathrow Airport at 2:00 p.m.</td>
</tr>
<tr>
<td>Monday</td>
<td>September</td>
<td>London</td>
<td>Visit Science Museum, etc.</td>
</tr>
<tr>
<td>Tuesday</td>
<td>September</td>
<td>London</td>
<td>Register for IAHR Congress at Institution of Civil Engineers Building</td>
</tr>
<tr>
<td>Wednesday</td>
<td>September</td>
<td>London</td>
<td>Attend and participate in IAHR Congress meetings</td>
</tr>
<tr>
<td>Thursday</td>
<td>September</td>
<td>London</td>
<td>Attend and participate in IAHR Congress meetings</td>
</tr>
<tr>
<td>Friday</td>
<td>September</td>
<td>London</td>
<td>Attend and participate in IAHR Congress meetings</td>
</tr>
<tr>
<td>Saturday</td>
<td>September</td>
<td>London</td>
<td>Attend and participate in IAHR Congress meetings</td>
</tr>
<tr>
<td>Sunday</td>
<td>September</td>
<td>London</td>
<td>Leave from Institution of Civil Engineers Building on chartered bus at 9:00 a.m.</td>
</tr>
<tr>
<td>Monday</td>
<td>September</td>
<td>Berkshire</td>
<td>Arrive Wallingford Research Station, Berkshire at 11:00 a.m. Inspect Station. Leave 3:00 p.m. for London</td>
</tr>
<tr>
<td>Tuesday</td>
<td>September</td>
<td>Paris</td>
<td>Arrive from Wallingford at 5:00 p.m.</td>
</tr>
<tr>
<td>Wednesday</td>
<td>September</td>
<td>Paris</td>
<td>Leave from Heathrow Airport BEA Flight 344 12:15 p.m.</td>
</tr>
<tr>
<td>Thursday</td>
<td>September</td>
<td>Paris</td>
<td>Tour of city, parks, etc.</td>
</tr>
<tr>
<td>Friday</td>
<td>September</td>
<td>Paris</td>
<td>Tour of Central Hydraulic Laboratory, Maisons-Alford (suburb of Paris)</td>
</tr>
<tr>
<td>Saturday</td>
<td>September</td>
<td>Paris</td>
<td>Tour of National Hydraulic Laboratory, Chatou (suburb of Paris)</td>
</tr>
<tr>
<td>Sunday</td>
<td>September</td>
<td>Paris</td>
<td>Leave railroad station (Gare de Lyon) 9:15 a.m. on Train 51</td>
</tr>
<tr>
<td>Monday</td>
<td>September</td>
<td>Grenoble</td>
<td>Arrive at railroad station (Place Louee) at 4:00 p.m.</td>
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<tr>
<td>Day</td>
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<td>Location</td>
<td>Event</td>
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<tr>
<td>Thursday</td>
<td>September 12</td>
<td>Grenoble</td>
<td>Tour of SOGREAH Laboratories in Grenoble</td>
</tr>
<tr>
<td>Friday</td>
<td>September 13</td>
<td>Grenoble</td>
<td>Leave railroad station (Place Louee) 11:20 a.m. on Train 1822</td>
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<tr>
<td></td>
<td></td>
<td>Paris</td>
<td>Arrive railroad station (Gare de Lyon) 7:10 p.m.</td>
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<tr>
<td>Saturday</td>
<td>September 14</td>
<td>Paris</td>
<td>Tour of Eiffel Tower, Louvre, etc.</td>
</tr>
<tr>
<td>Sunday</td>
<td>September 15</td>
<td>Paris</td>
<td>Leave Le Bourget Field at 1:30 p.m. on Pan American Flight Y115</td>
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<tr>
<td></td>
<td></td>
<td>New York</td>
<td>Arrive Idlewild Airport 5:00 p.m. (11:00 p.m. Paris time). Change planes. Leave Idlewild Airport on United Airlines Flight R821 at 8:15 p.m.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Denver</td>
<td>Arrive 10:20 p.m. at Stapleton Airport. (Paris time 4:20 a.m. September 16.)</td>
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