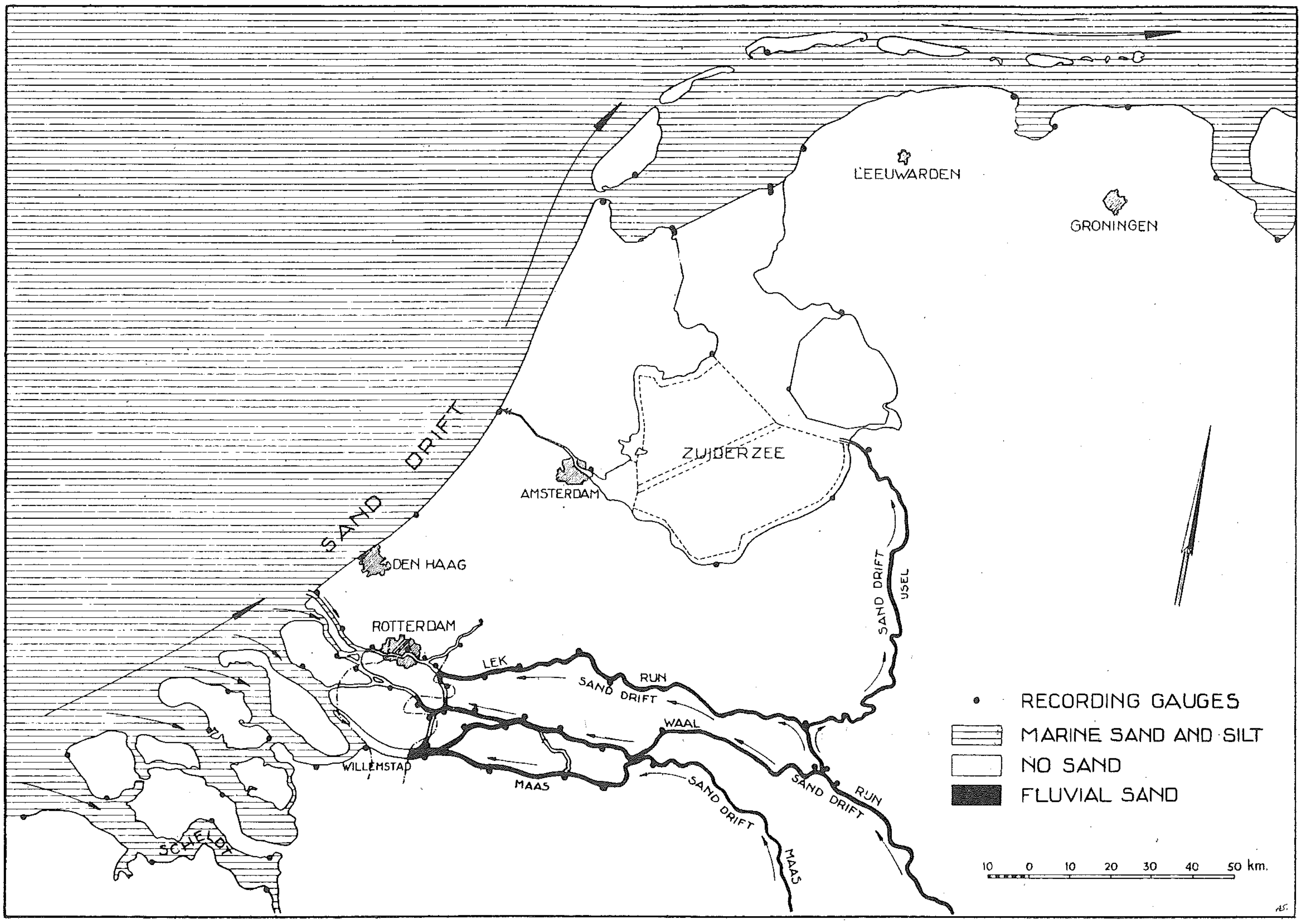

Fig. 1. Coast of the Netherlands showing position of Recording Gauges and the two main Sandstreams.

Research of Tidal Rivers in the Netherlands*

A Successful Combination of Theory and Practice

By DR. J. VAN VEEN
Chief of the Tidal Research Department of the Rijkswaterstaat, Holland.

RESEARCH into water, sand and silt movements in tidal channels is necessary in order to deal with many engineering problems in an intelligent way. Ignorance is expensive and unsatisfactory. Laboratory tests are advisable, too, but even then the study of natural phenomena cannot be neglected. Not everything can be imitated in a laboratory, while in order to be able to imitate we first must know the conditions of nature exactly. The danger of waning trade due to the silting of harbours hardly exists to-day, because of the power of modern dredges, yet enormous amounts of capital are often required for dredging purposes. In Holland alone, about 30 million tons of silt must be removed annually, while many millions of guilders are wanted for the defence of a relatively short coast.

With those interests in view, research into problems of harbours, river mouths, tidal inlets and coasts seemed quite justified, and in 1930 a research bureau was established in order to make a thorough investigation of the tidal streams and coasts of the Netherlands. Dr. J. A. Ringers, then Director General of the Rijkswaterstaat, now Minister of Public Works, saw the necessity of possessing full information and a thorough knowledge of the natural forces and phenomena relating to our inlets, rivers and shores, in order to be able to make economical plans and provisions. His command was: "investigate everything"—a broad-minded attitude indeed.

Great value was attached to the investigation of the transport of solids by water. About this matter hardly anything was known. C. Lely, later famous for the plans to reclaim the Zuiderzee-bottom, had published a report on the transport of solids by the rivers Rhine and Maas as early as 1883-1887, but since then this good example had not been followed. Not before 1920 did the question come again into the foreground, when J. J. Canter Cremers took up the research of the Rotterdam Waterway with an instrument of his own design which, with modifications, is still in use. This clever investigator died soon afterwards in Egypt, while giving advice about the Nile.

Experience since 1930 has shown that theory and practice should not be separated. Practice needs theory (or research), and theory without practice is nothing but lame, academic knowledge. The activities of the research bureau—in which 50 to 60 persons are engaged—are along the following lines.

*Written in 1940, since then the survey-ships were destroyed by the Germans.

Research of Tidal Rivers in the Netherlands—continued

Natural Research.

This means the investigation of existing conditions. How are the currents in some estuary during a normal tide? How during springtides or storms? What is the influence of wave action? What are the natural laws governing the mechanics of that estuary? What is the strength of the currents near the bottom and what direction have they? What is the location of the so-called sand streams and what is their magnitude? Can those sand streams be influenced in such a way that sand transportations diminish or cease to exist? Very often sand does not come from a river but with coastal drift. This marine or coastal sand penetrates into river-mouths because of undercurrents due to salinity. Therefore salinity differences must be studied with great care.

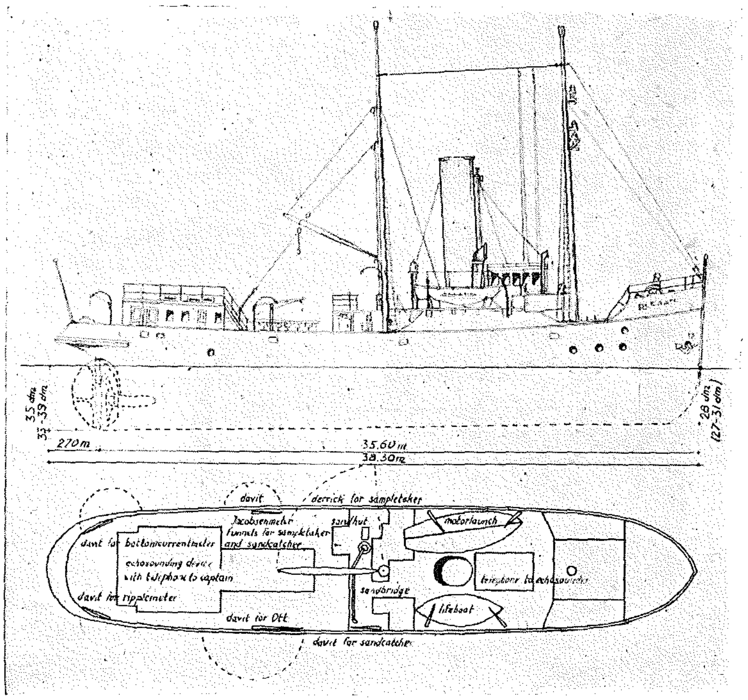

Fig. 2. Survey Ship *Ocean*.

From these and other factors, it follows that the research of natural conditions asks for a well-equipped ship and much work and study. In the research bureau there are four parties working separately. One in the south (Scheldt); one along the coast; one in the Rhine-delta; and a fourth in the North (Waddenzee). The Dutch practice leads to research seasons of six months during the summer. For inlets of a medium size, say, 10 by 10 kilometres area, about 50 spots are chosen, in which measurements during 13 successive hours are taken at normal, neap and springtides. This means, at least, 150 measuring days per inlet of that size. In addition, measurement for a period of 16 successive days and nights is taken once or twice in every inlet in order to learn the fortnightly changes due to lunar influences.

Of course, the vertical tide has to be measured as accurately as the horizontal tide (another name for streams). The readings of the tide gauges at shore (see Fig. 1), which have given continuous records since about 1850 or 1870, are supplemented during the measurements with those of recording instruments for the vertical tide, placed in the sea and giving tidal curves of 16 days' length. Thus the tides and their propagation in front of the coast can be learned in an exact way. **An exact knowledge of the co-tidal lines is necessary, because they govern the tidal currents near the coasts and the inlets.**

Another branch of activity is to investigate the configuration and character of the bottom. Series of soundings have to be taken periodically, while bottom samples are thought to be necessary. With the aid of recording instruments, the phenomena which occur during storms are studied.

Historical Study.

The natural research described in 1, can only be temporary. Its' time dimension is generally not longer than 13 hours, or, in the case of the longer measurements, 16 days. Even this, comparatively, is very short. Because prediction of the future is wanted, a certain knowledge of the past is required. The inlets where the channels migrate periodically often show a cycle of 10, 20 or perhaps a 100 years. If works are to be carried out in such inlets, these migrations must be known thoroughly, and it is not possible to gain a complete knowledge of them in one or two years by natural research alone. Old charts, therefore, must be looked up in archives, and from these a so-called " film " must be composed. The scale of all charts making up this film and the level to which the depths relate should be the same. This question of level often causes some trouble when, in different periods, different levels have been used. Often the " films " do not reach very far back in history. In Holland the year 1800 is a fair limit. There exist remarkably fine charts of the 16th and 17th centuries, but these are not accurate in the modern sense. Between 1800 and 1900 the charts are infrequent. Recent ones are better. It is important to say that the old hydrographers were mainly after the shoalest spots, therefore they put too many figures of the extreme shoal sort on their charts. We need the exact natural shapes. Some of the inlets require sounding yearly, others even more frequently; while there are also some which change little.

Cubature.

From the old charts, profiles are taken and these are compared so that regions of silting and scouring can be spotted for the intervening periods. This is very important to know; the accuracy of the charts must be such that the cubatures may be trusted. The amount of sand coming into our channels or going out of them, and the periodicity or irregularity of its migration, can be learnt only in this way.

Geology.

This may seem to have only a faint relation with river improvement, but it has to be considered that our engineering works affect the geological or natural forces and are destined to function even in the remote future. The Netherlands are, from a geological point of view, a nascent country. Owing to sand coming from the southern shores, and due to the situation at the mouths of rivers—also bringing some silt and sand—stable conditions cannot be expected. Research into the prevailing geological factors is therefore necessary. The amount of solids brought hither annually is only a few millions of tons by river and about the same amount by the coastal drift from the southwest. This may not be so very much, yet it accounts for the many " Villes mortes."

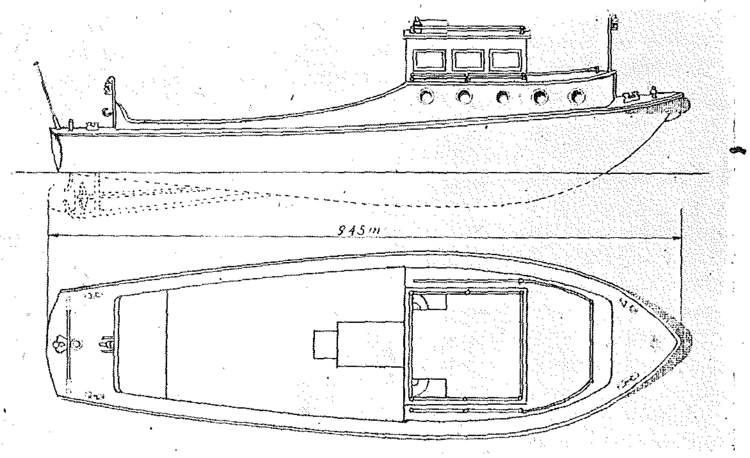

Fig. 3. Launch *Vlet*.

Research of Tidal Rivers in the Netherlands—continued

Observations at the Dutch tidal gauges show that the bottom subsides about ½-inch per 10 years, rather too much for a low country. We do not know as yet whether this is due to geological subsidence, to the melting of more ice in the world, or to ordinary mechanical settling of loose soil. The geological research of seas is still insufficiently developed. In order to know the spots near coasts and inlets which might be resistant to erosion, borings beneath the sea are being made.

Holland badly needs sand for improving the soil for building town enlargements and roads. The Rhine and Maas do not bring enough to satisfy these needs. Therefore the sand will have to be taken out of the sea, or from those spots which might be made deeper without damage to any other interests. Navigation gains by this costless dredging, but salinity becomes worse.

Mathematics.

Calculation cannot be dispensed with; it is quite necessary. Every new design carried out in some part of a system of tidal channels affects the tides in all of them. About 15 persons, under the direction of a doctor of mathematics, are constantly at work calculating with the aid of modern calculating machines how the tides are going to be in the future, when some plan of river improvement is to be executed. Each new open harbour, each deepening of some channel, each widening or narrowing of it, causes changes in the tides. The currents will increase or decrease, the amplitude of the vertical tide is likely to be affected, and the flow of the fresh water through the different channels will be altered. The magnitude of these changes must be known exactly beforehand.

Measurements taught us that the sand content in the water is proportional to the 3rd or 4th degree of the water velocity. The sand movement, therefore, is proportional to the 4th or 5th degree of the water velocity. If the original water velocity—taken as unity—is increased by 100%, the sand movement will then be proportional to 2^4x original water velocity. That is to say the original sand movement multiplied by 16. As mentioned, the sand movement may increase $2,^5$ equals 32 times. An increase in velocity, therefore, may cause severe scouring; a decrease may cause silting. Both silting and scouring are to be avoided if possible; scouring may cause land slides and it means silting elsewhere. The best thing one can wish, is a channel with no sand stream at all.

Of great importance are the calculations covering the expected storm floods. When, owing to the execution of new plans, a rise of the storm flood of only a few centimetres can be calculated, the result in most cases is a heightening of the embankments (dikes), and this entails vast expenses. The theory of the tides had to be developed in such a way that these accurate calculations became possible. For this reason, a very extensive series of total flow measurements in a great many channels has been performed in the years 1931-1936, the result being that the theoretical calculations now are about as accurate as the measurement of tidal currents and vertical tides. The formulae are complex and the solving of a problem for a net of 20 channels means the handling of 40 of those complex formulae.

Statistics.

Because of the long series of observation data, a statistical research is necessary. Statistical series are those of the lightships, where the velocity of the currents are taken every half-hour, day and night continuously. Results are to be compared with similar observations of neighbouring countries and with those of the past. In Amsterdam a long continuous series of data exists about the level of the sea from 1700 onwards. There are still other series which ask for statistical analysis. Often these studies lead to contact with meteorologists. With the statistics of storm surges must go the theory of probability.

Chemistry, Petrography, Botany.

In many harbours, not sand but silt must be dredged. We call silt the fraction of solids smaller than 20 micron. Silt content can be best estimated by comparing the sample in glass tubes with the "solutions" of known percentages of silt. The difficulty with silt is that it is so voluminous. Sometimes silt with as much as 80 per cent. of water content must be dredged away; therefore means are sought to condense it. The question: whence does the sand and silt come from? points in the direction of petrographical science, by which the heavy minerals (grains sinking in bromide) are determined. The different kinds of sand and silt should be known, in order to be able to draw correct conclusions as regards the places of origin.

The land reclaiming schemes, which go hand in hand with river improvements and coastal defence, demand chemistry, biology and bacteriology. For fertility the right combination of sand and silt must be brought to settlement—therefore the mechanical and biological processes which influence this fertility must be studied with care. Botany comes into the picture with the cultivation of *spartina-townsendii* and other marine plants fit to retain the silt on salt or brackish sand flats. Land gaining is one of the most fascinating jobs for a river engineer, but it asks for much research and many tests. Here a research bureau may accomplish its best results "making work with work"—normalising channels by making fertile land—using natural means.

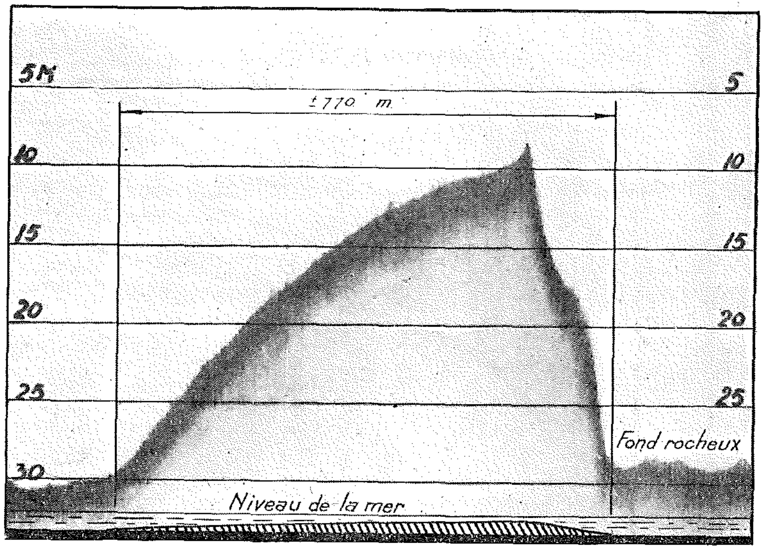

Fig. 4. Typical cross-section of Sandbank on Rock Bottom.

One of the most important questions where we touch the domain of agriculture again is the gradual salting of the low areas of Holland. With the water and the soil of those low areas only very slightly brackish, the agricultural and horticultural harvest shows a decrease. A normal horticultural harvest may be reduced by 50%, horses may fall ill, and cows may produce only a small quantity of milk. A salt percentage of no more than 200 milligram Cl per litre or less is not dangerous. 300 mg is the ultimate limit. The salinity must therefore not exceed that of ordinary drinking water.

It has been learned that open tidal harbours in the so-called brackish region silt up very quickly. They also have a great influence on the salting of the whole lower part of the river. This occurs because the heavy salt water gets into the harbour along the bottom and always carries much silt. It enters the harbour towards the end of the floodtide and leaves this basin near the end of the ebb. After that, the flood, coming again, takes this salt further up river. In a regularised river mouth with smooth borders, the salt does not come so far as in rivers with irregular borders or with many open harbours. Therefore no open harbours should be made in the brackish sections, and we should remember well that everywhere where a particle of salt water may come, a particle of sea silt may come also. Plans to provide all low areas of Holland with a constant stream of fresh Rhine water require many millions of pounds. The drainage of the Zuiderzee must be partly considered in that light, one of its main purposes being to create a fresh water basin in the heart of Holland.

Research of Tidal Rivers in the Netherlands—continued

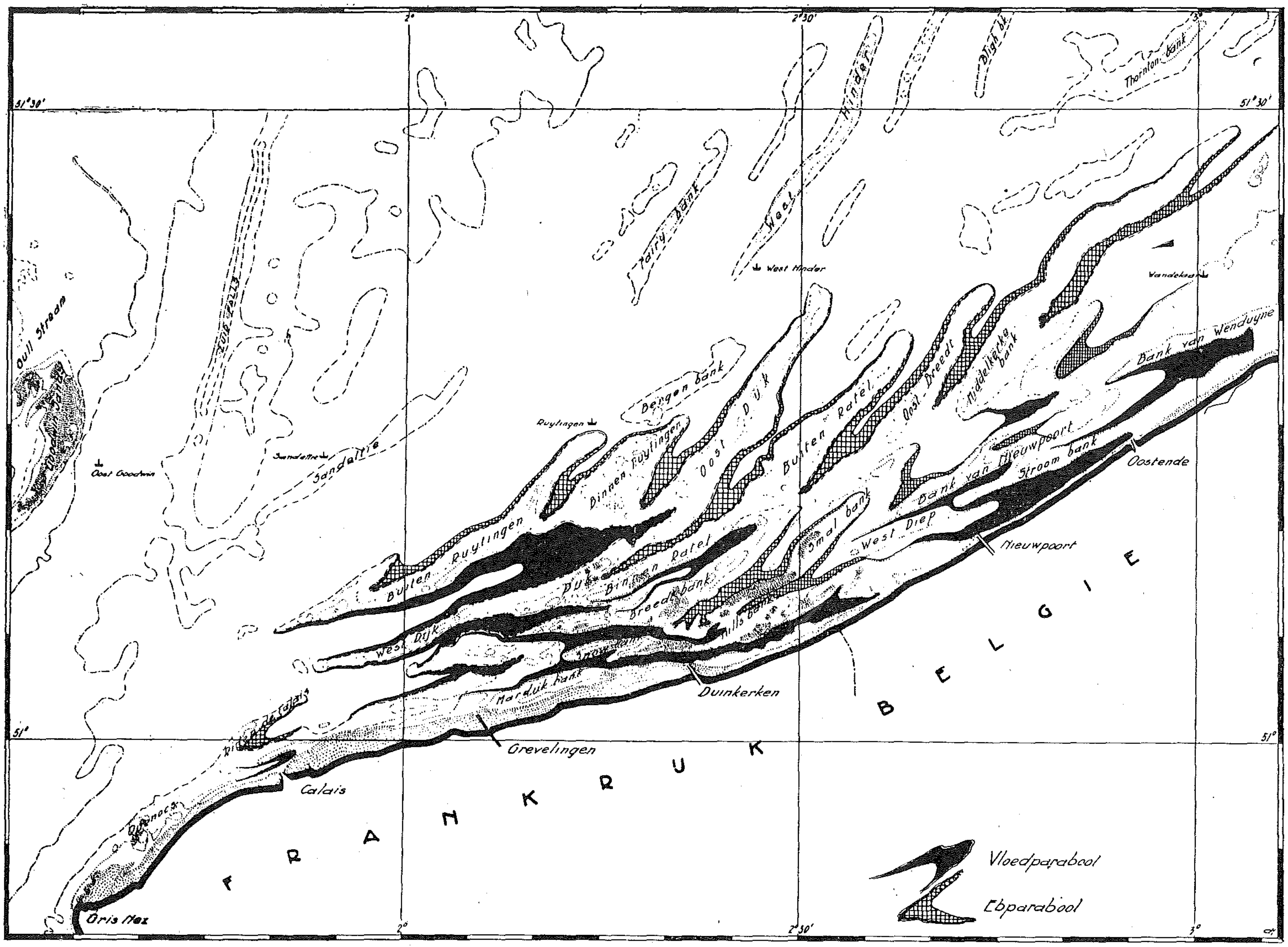

Fig. 5. Flood and Ebb Parabolas of the Flemish Banks.

Instruments.

These must be simple and they must give trustworthy data. Several instruments had to be evolved and had to go through their period of infantile diseases. Without the invention of new instruments, further discoveries are impossible, so new ones must be constantly tried, tested and simplified. For this purpose a small workshop, where new devices are being made or repaired, has been established. Those of the instruments which have stood the tests of practice for several years will be described hereafter.

Exploring Ships.

The largest vessel in use is a sea-going boat of 400 tons and 4 metre draught (Fig. 2). With this boat observations are being made during six months of the year. For the inlets, vessels of 20 to 60 tons are used. All ships possess a launch, shaped as indicated in Fig. 3. These launches are very seaworthy and are meant to assist the investigations. Mostly the bigger ship lies at anchor during a whole tide or during 16 successive days and then the launch (called " vlet ") can in the meantime explore the surroundings and keep contact with the shore. The launch should have an echo-sounder on board.

The ships should not sway while lying at anchor, or else they must have two or more anchors, which is a great nuisance.

Echo-Sounding.

Six instruments, system Hughes, are in use in order to investigate the bottom configuration and to provide regular sounding charts of the rivers and inlets. A description of this fine and accurate instrument is not necessary; sounding lead and rod are fairly well out of use nowadays. For the investigation of an inlet or a river, the echo-sounder is essential. By its use the regularity or irregularity of the bottom can be learned distinctly and quickly. In a preliminary way it shows where the bottom consists of sand, silt or rock. It is the " eye on the bottom " which we hydraulical engineers have been after since time immemorial, and which enables us to get an insight into the condition of the bed.

Remarkable light was thrown on the bottom conditions when going out of the harbour for the first time with the echo-sounder in 1933. We were quite surprised to find an endless series of beautiful *rhythmic waves* on the recording paper. These wave forms of the bottom were not then known. In the North Sea, in front of the Dutch coast, most of the crests reached a height of 10 metres above the troughs between them. They were gigantic ridges caused by the pendular movement of ebb and flood, standing perpendicular in the direction of the alternating water currents. These ridges may cause inconvenience to ships because they can shift easily. In ordinary rivers similar sand waves are found, but they are smaller there. At a mean depth of 5 metres, the height of the sand tops is often 80 to 100 centimetres, i.e., about 20%. A typical echo-record of a sand ridge is shown in Fig. 4.

The shape of the sand waves shows the direction in which the sand travels. When, for instance, the northern slope of the ridge is steepest the general direction of the sand stream is towards the north. If the shape of the sand wave is purely trochoidal and symmetrical, it can be deduced that there is a sand movement which is in equilibrium. In that case, there is a sand movement, but it has no forward resultant.

Research of Tidal Rivers in the Netherlands

(continued)

Another phenomenon which may be studied easily with the aid of the echo-sounder is the situation of ebb and flood channels. If there is a bar at the northern end of some channel, then the resulting sand stream is likely to go to the north. An example of the analysis of an area of ebb and flood channels is shown in Fig. 5 (the Flemish banks). The flood current from the Straits of Dover pushes into the channels near the coast and has scoured "flood channels" or "flood parabolas" there; the ebb current from the North Sea is prevailing in the northern domain of the banks and causes "ebb channels" or "ebb parabolas." In analysing sand bank complexes in this way, they begin to have a clear meaning to us. We must know the bottom of our waters as if it were the soil of our own garden. All forms of its sand-banks and bars must be familiar to us, so that we can detect even small changes immediately. Investigation with vlet (launch) equipped with an echo-sounder and with a bottom grab, and, in brackish water, an hydrometer, gives a good preliminary knowledge of the main points of any inlet.

For the determination of distances, range-finders of about one metre base, or sextants, are used. Range-finders are to be preferred to sextants when distances of less than 1,000 metres are concerned and alignment-sounding is carried out.

(To be continued)

Wellington Harbour Board, New Zealand

Excerpts from the Chairman's Address at the Sixty-fourth Annual Meeting held on 26th June, 1946

In moving the adoption of the Annual Report and Balance Sheet for the year ended 30th September, 1945, I would like briefly to comment on some of the salient features of the year's operations.

The trade of the Port showed a considerable decrease last year both in regard to tonnage passing over the wharves and in shipping arrivals. This is attributed to largely by the heavy falling-off in our imports from overseas, particularly from the United Kingdom. During the first four years of the war (1940-44) there was a steady increase in overseas import tonnages handled at the Port, but with the war moving to its end, particularly in the Pacific, the diminution of the flow of war materials and equipment last year revealed the extent to which overseas imports for industrial and commercial uses had been reduced.

The total cargo handled through the Port showed a decrease of 23.7 per cent., the actual tonnage of 1,916,335 tons being the lowest since 1935.

British and Foreign imports decreased by 36.8 per cent. and Australian imports by 28.2 per cent., while coastal imports, which have been well maintained over the war years, increased by 0.4 per cent. The total decrease in all classes of imports was 19.1 per cent.

Taking the trade of the Port on a Customs value basis, it is interesting to note that for the last year over 41 per cent. of the total imports and 30 per cent. of the total exports of New Zealand passed through the Port of Wellington. These percentages of total trade, when compared with pre-war figures, show a small increase which is due mainly to the centralisation of shipping, but the figures are an indication of the importance of the Port of Wellington in the trade of this Dominion.

The financial figures reflect the comparatively low level of port trade, and the income of the Board was reduced by £156,099 whilst the expenditure, including the customary transfers to Special Funds, dropped by only £51,190. The loss on working was £143,541 which, added to the deficit of £38,632 in the previous year, makes a loss of over £182,000 for the past two years.

The rapid deterioration in the finances of the Board during the past year, gave justifiable concern to members of the Board, and the position was constantly under careful consideration. Having in mind the fact that the Board's work is not profit-making undertaking, and that the Board has an obligation under statute to provide services and facilities for the efficient operation of the Port, it was indeed disappointing to learn that, as a result of an application made to it in July, 1945, for authority to increase the Board's charges, the Price Tribunal had decided to defer the request until 1st October, 1946, when the position was to be again considered, leave being reserved for an earlier hearing in the event of a further adverse change in the Board's position warranting such a course. Subsequent to the hearing of the Board's application, further increases in wages (retrospective to 1st April, 1945) were granted by the Court of Arbitration and the Waterfront Control Commission to the Board's staff and waterside workers respectively, and involved a further heavy increase in the Board's expenditure.

At the end of the financial year withdrawals from the Special Reserve Fund to meet expenditure amounted to £50,000, and as the Board could see no prospect of a reduction in the heavy daily loss on working then being incurred—particularly as its charges, based on 1937 levels, were entirely inadequate to meet the operating costs of 1945—the application was renewed in November last and resulted in authority being granted for the Board to increase its dues and charges by a surcharge of 30 per centum.

This increase, which became effective as from 1st January, 1946, is considered to be insufficient for the Board's requirements, without taking into account the fact that within the next two or three years the expenditure that will be necessary for deferred repairs and maintenance is estimated to cost £152,700, against which the special fund established for this purpose amounts to only £60,362, leaving an additional £92,338 a portion of which will have to be found from revenue. While it is extremely difficult to forecast the volume of trade that might be expected to pass through the Port in the next year or two, it seems certain that with the Government's policy of import selection some considerable time must elapse before the levels of pre-war overseas import tonnages are again reached.

The conditions appertaining to the employment of labour on the wharves are by no means constant, and it must be borne in mind that requests for new Awards for employees of the Board, and systems of contract work, appear to have the objective of increased proposals designed to alter the methods of cargo-handling under remuneration for service. With the Board's charges subject to Governmental approval, it is more than ever important to emphasise that proposals that would increase expenditure, must be given serious consideration as to their effect on the economic working of the Board's wharfinger system.

War-Time Services of the Port

The past year was marked by success to the Allied arms in the victorious end of the war against the Axis Powers, and the dark clouds that threatened the progress of humanity have disappeared in the effulgence of the dawn of world peace. In New Zealand's contribution to the prosecution of the war we are justly proud of the achievements of the members of our armed forces. A glorious page has also been written in the annals of the mercantile marine, and the fortitude and courage displayed by those who were associated with the steady flow of vital goods to and from our shores is, I am sure, acknowledged with gratitude and admiration by the people of this Dominion.

I think it is appropriate at this time to refer to the significant position of the Port of Wellington, more particularly in the war now ended. The far-seeing policy of past administrators of the Port in providing adequate and up-to-date facilities for shipping and the handling of goods, proved to be of immeasurable value in meeting the heavily increased demand for services to shipping, and in the handling of the large volume of war materials landed and shipped, particularly by the United States Government. The Aotea Quay Breastwork, which had been completed to meet the future requirements of the Port, proved to be of exceptional importance as a berth for American shipping, and also provided an extensive concrete-surfaced area for the storage of military equipment. The Board was pleased to be able to make this area available free of rent, and a rebate of 25 per cent. was also allowed on all dues on transports and their cargoes.

The Floating Dock, which was installed in 1931 as an added facility for shipping, was also found to be of inestimable value to

*Research of Tidal Rivers in the Netherlands**

A Successful Combination of Theory and Practice

By DR. J. VAN VEEN
Chief of the Tidal Research Department of the Rijkswaterstaat, Holland.

(Continued from page 171)

Self-Recording Gauges.

There are 74 recording gauges along the Dutch coast, many of which have worked without interruption for decades. Owing to this, the vertical tide along and inside the coast is known thoroughly, but out in the open sea little or nothing is known. In order to learn more about the tides further from shore, the tide-meter shown in Fig 6 is used. It is based on the manometer principle, and records the vertical tide during a 16 days period. The greatest depths where it can be used is about 15 metres at high water. They are placed, therefore, on the sand banks in the North Sea.

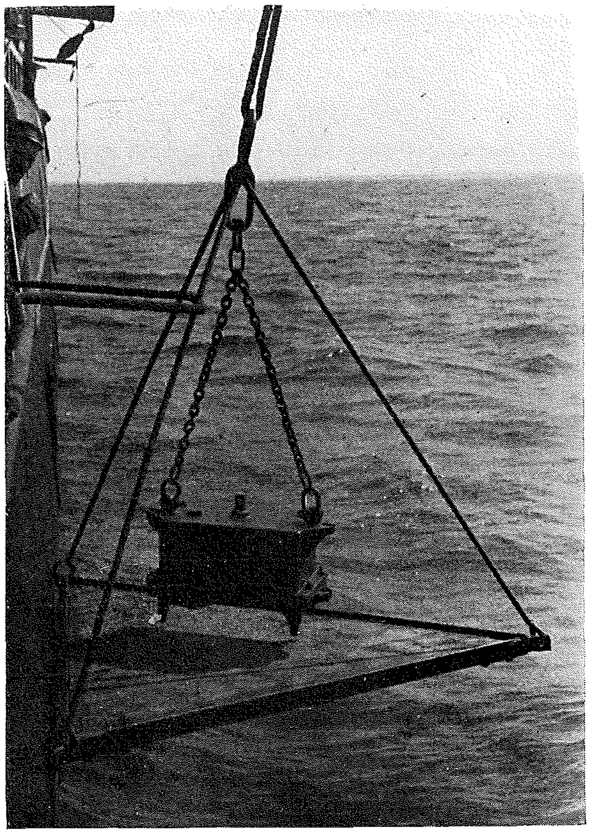

Fig. 6.—Registering Tide Meter for Open Sea.

It is the velocity of propagation of the tidal wave along the coast which determines the inclination of the river to flow out towards the left or towards the right. As along the Netherlands coasts, the propagation takes place from the Straits of Dover northward, the river mouths of these coasts tend to flow out in a south-western direction. If the said velocity of propagation is small, as is the case in the shallow waters which prevail along the Dutch coast, the inclination to flow out in the direction of the point where the tide wave comes from is very strong. This law of the *preferent outflow* of rivers and estuaries must be taken into account when improvements of mouths and inlets are being planned.

*Written in 1940, since then the survey-ships were destroyed by the Germans.

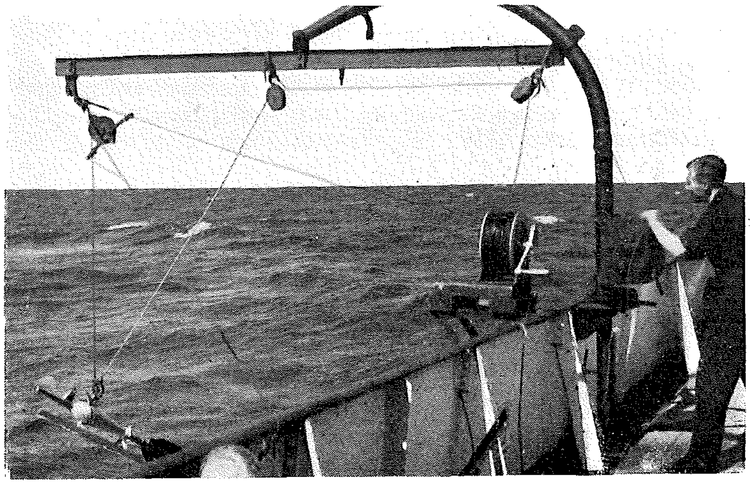

Fig. 7.—Ott Meter of 100 k.g. weight.

Current Meters.

The discharge of the tidal rivers is measured by means of floating sticks in alignments lying at distances of 30 metres from one another. The sticks are used as long as possible, but they must not touch the bottom. They are let loose from anchored boats lying in alignment at 6 to 15 points of the breadth of the river. The measurements are taken during a whole tide between two slack-waters, the floats giving the velocity every 5 or 6 minutes. Once in about 15 years the capacities of the tidal rivers south of Rotterdam-Dordrecht are determined in this way, because many changes are taking place there. Comparison with former flow measurements show the changes brought about in the water movements by dredging, etc. These observations are taken with the greatest care and accuracy, while many gauges are being read every five minutes at exactly the same moment. With these accurate measurements, the theoretical tidal formulæ are compared and the constants of de Chezy fixed for every channel.

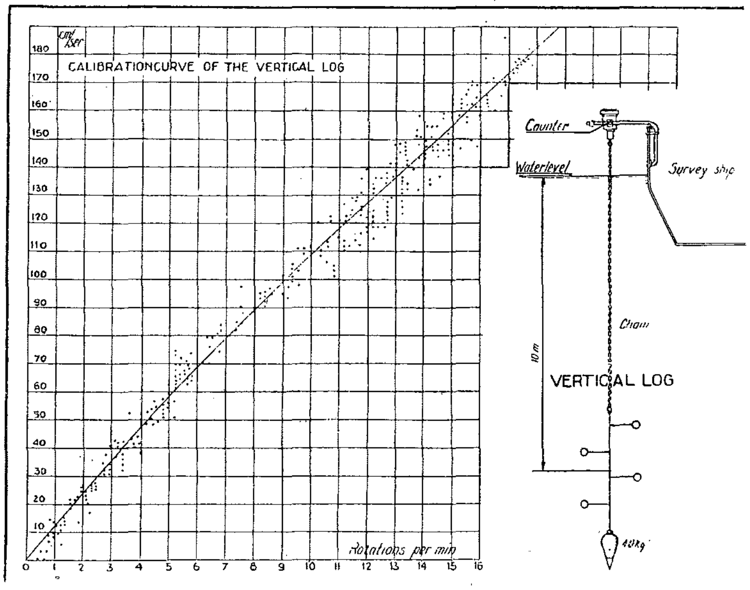

Fig. 8.—Vertical Log of Dr. Carruthers.

Research of Tidal Rivers in the Netherlands—continued

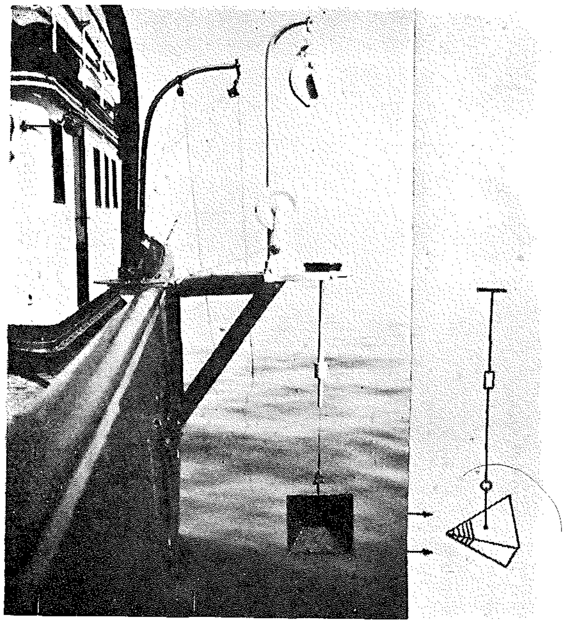

Fig. 9.—Current Direction Meter.

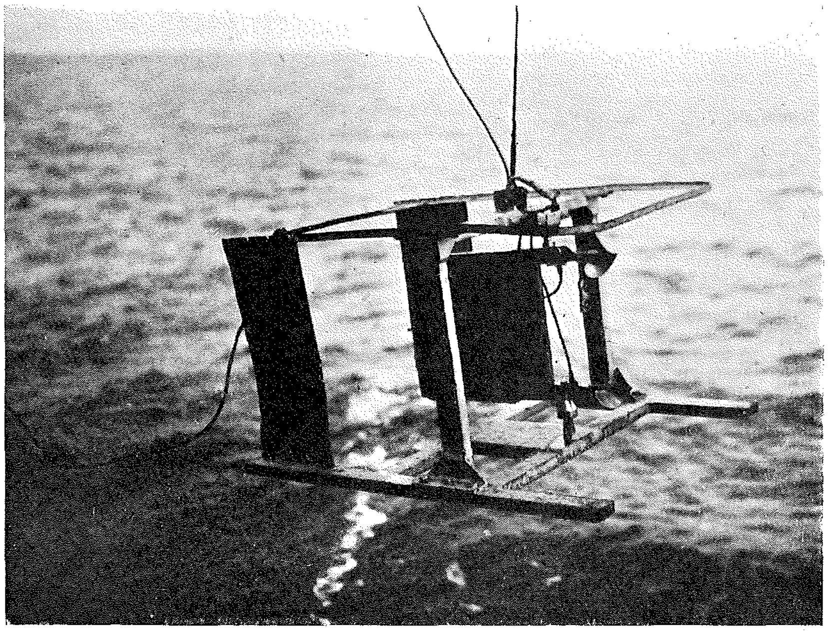

Fig. 10.—Bottom Current Meter (Double).

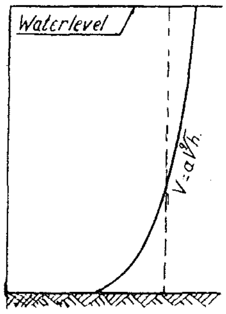

Fig. 11.—Stream Vertical (Parabola)

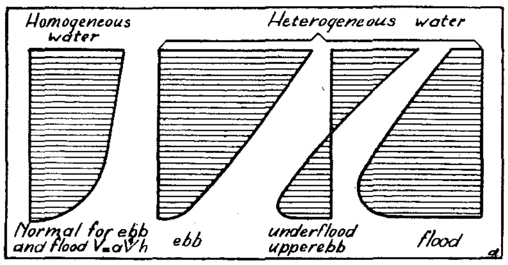

Fig. 12.—Stream Vertical (Heterogeneous Water)

For ordinary current measurements taken from exploring ships, Ott meters are in use (Fig. 7), weighing from 50 to 100 kg. With the Ott of 100 kg. it is possible to work at a depth of 70m and a mean velocity of 2 m/sec., but this is the limit because the electric cable cannot bear too strong a tension. The current meters must be very heavy to resist the pressure of the streams.

Carruthers' Vertical Log.

A good instrument which stands all weather conditions and which is easy to manipulate was designed by Dr. J. N. Carruthers, now of the British Hydrographic Department (Fig. 8). As it lends itself admirably for continuous measurements, the Dutch light-ships are provided with it. It is suspended on a chain outboard the ship and turns slower or quicker owing to a weaker or stronger current. A counting device near the point of suspension is read off every half-hour. It has the advantage that the turning device is above the water and that observations can also be made during a gale.

Current Direction Meter.

The Ott does not give direction. For finding direction at different depths, the Jacobsen principle is used (Fig. 9). Pyramids of different sizes, hung with the point towards the currents, give

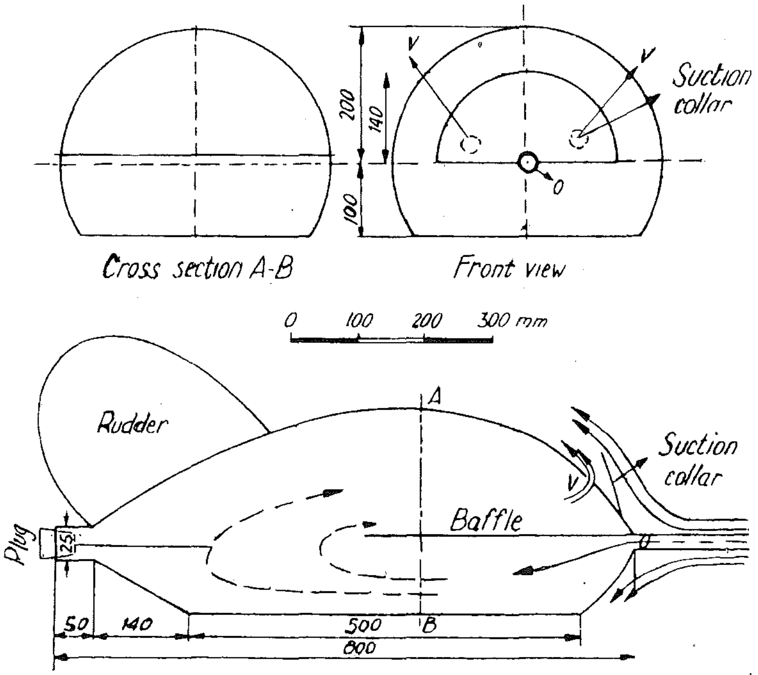

Fig. 13.—Sand Catcher.

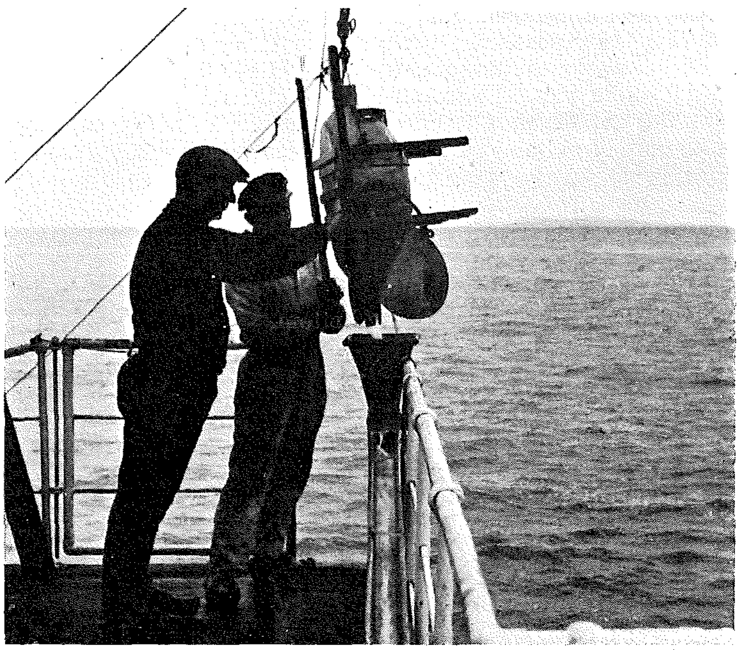

Fig. 13a.—Sand Catcher Direction Meter.

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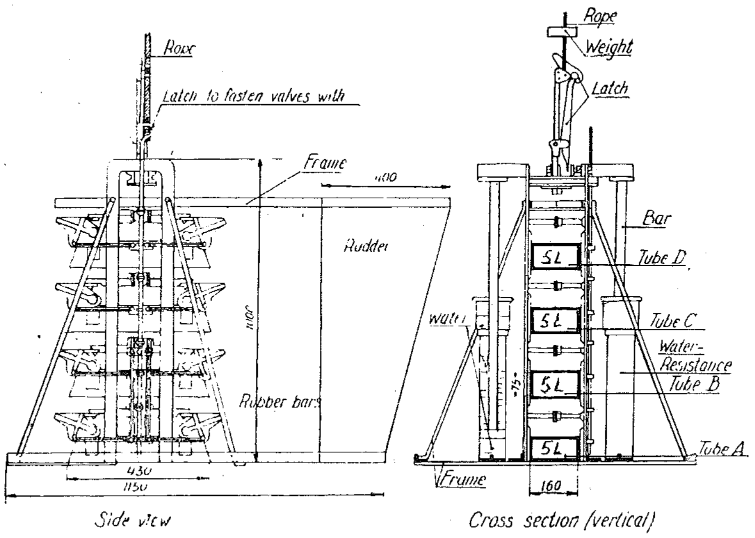
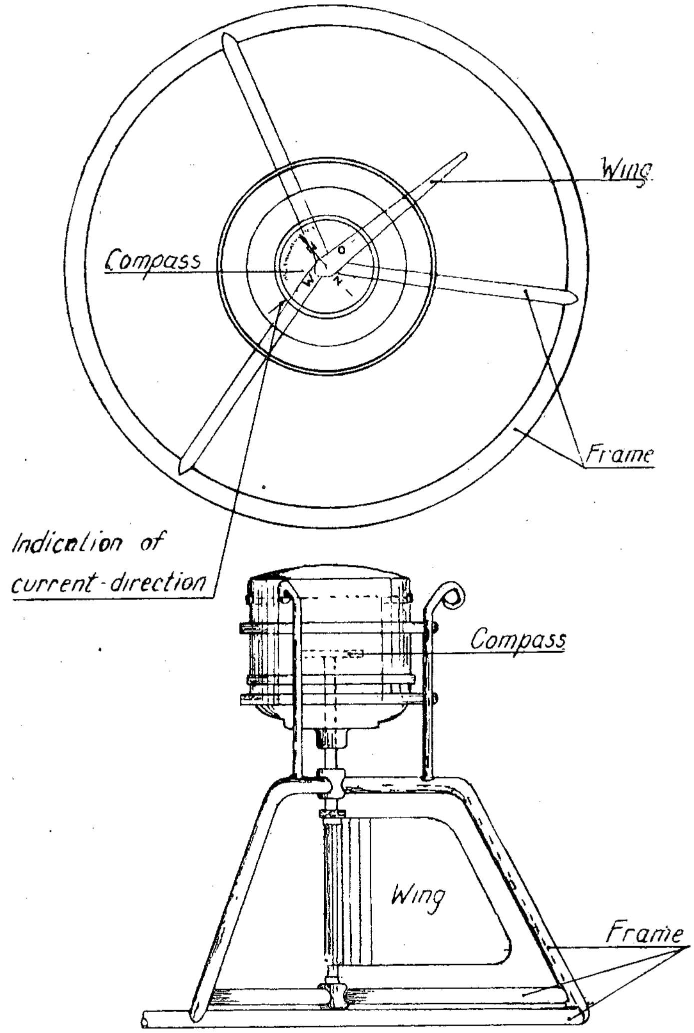


Fig. 14.—Sample-Taker.



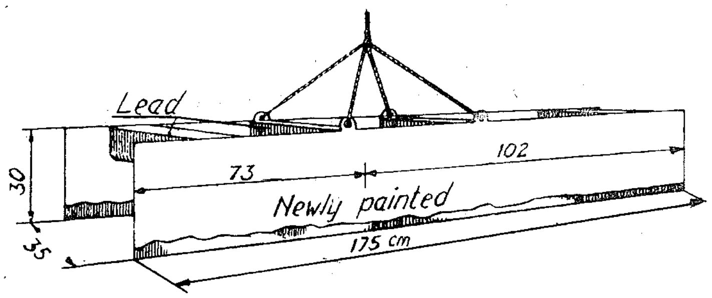


Fig. 16.—Ripple-Meter.

Fig. 15.—Bottom Current Direction Meter.

a slant which is measured by a bubble. We use pyramids because they do not wobble in the stream. Carruthers' vertical log may be used in the same way, so that this instrument gives the direction as well as the velocity of the current.

Bottom Current Meter.

Also an instrument for measuring bottom currents, system Ott (Fig. 10), possessing two propellers, one at 15 and the other at 50 cm above the bottom, is used. It is placed on the bottom during whole tides. Each half-hour current verticals are measured with the aid of an Ott current meter. We have found from thousands of old and new accurate observations that these stream verticals can be very well approximated by the formula $V = a \sqrt[q]{h}$ in which V is the velocity of the current, a is the velocity at 1 m above the bottom, and h the height above the bottom. For the sea, q varies between 4.8 and 4.9 (Figs. 11, 12). In rivers and inlets, q = 5 to 7. It is not right to suppose that the velocity graph intersects the bottom.

Sand Catcher (Canter Cremers).

The mixture of water and sand flows through the narrow opening of this apparatus into the hollow interior and comes to rest there (Figs. 13 & 13a). The water flows out of the instrument behind a suction collar through holes which are gauged in a laboratory in such a way that the current enters " O " in a straight line. Silt is retained in the apparatus, as " O " is narrow in proportion to the hollow room inside. The accumulating action prevents the fluctuations of the sand transport being studied with this instrument. Only the sand in suspension can be measured, not the rolling sand. The smallest height above the bottom where measuring is possible with this instrument is 10 cm. The apparatus is used on light-ships continuously, being emptied at every slack water—that is, once in about 6 hours.

Sample Taker.

The water flows freely through one or more short, wide, square tubes, which can be closed suddenly by means of two valves with rubber springs. In this way, four samples of 5 litres are taken at 0, 20, 40 and 60 cm. above the bottom and these can be examined carefully with regard to the contents of silt and sand. Instead of four, two or one tube can be used. The short tube, or set of tubes, are lowered very slowly by means of water buffers to the bottom, till the undermost tube rests immediately on the bottom. The rolling sand and little sand waves can therefore enter. Usually some small distance above the bottom is taken as the lowest position because general comparison is mainly what is wanted. The amount of sand and silt in the samples of 5 litres is always sufficient for accurate measurements. In the tidal area the sand usually whirls up to a great height. Besides the percentage of sand and silt, the salinity of the bottom sample can also be measured, as well as the temperature. The sand catcher (Canter Cremers) and the sample taker (Fig. 14) are used alternately for mutual checking.

One of the most important results of the investigation with sand catchers is the discovery of sandless areas. These exist in the rivers between Rotterdam and Willemstad—covering a breadth of about 10 km. (see Fig. 1)—in the Straits of Dover and in some places in river bends. These sandless areas point to a discontinuity of the sand currents and are very suitable for harbour works.

Direction of Bottom Currents.

As mentioned, the current direction is measured by means of the Jacobsen (see Fig. 9). This apparatus is not thought suit-

Research of Tidal Rivers in the Netherlands—*continued*

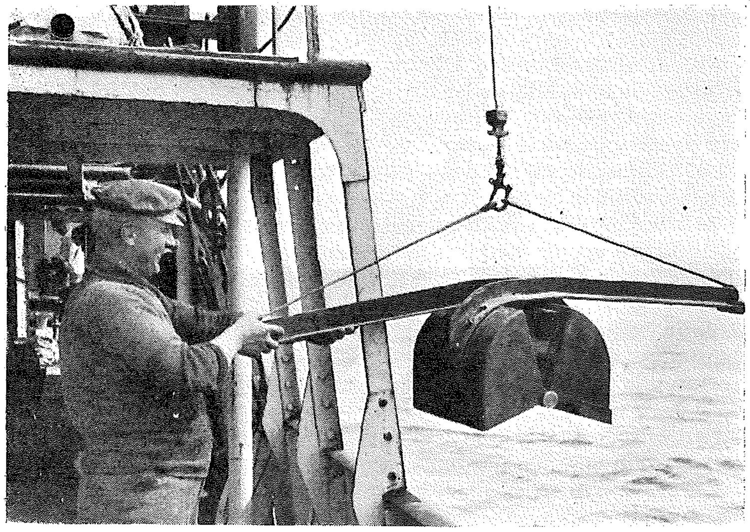


Fig. 17.—Grab.

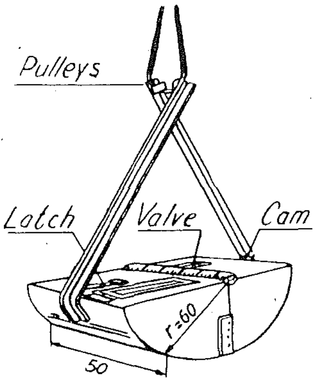


Fig. 17a.—Grab.

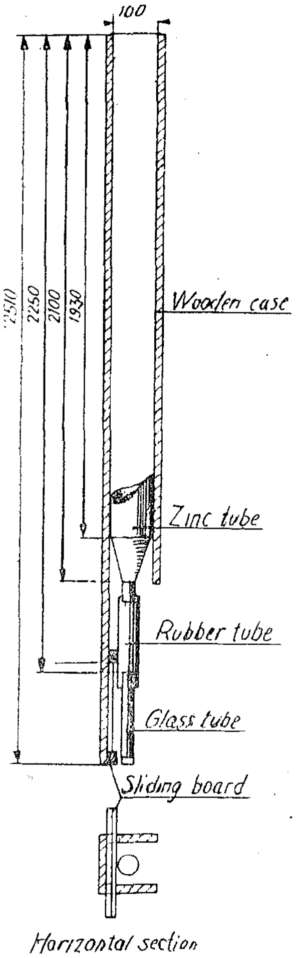


Fig. 20.—Sink Meter.

able for measuring the direction of bottom currents. For this a more accurate instrument is shown in Fig. 15, based on the following principle. A watertight box contains a magnetic needle which is fixed by a clock after 3 minutes. Because the box as well as the clock are made of brass, and the box is not kept closer to the ship than 30 m., the readings are trustworthy.

Ripple Meter.

A simple but good device used to determine the ripple-shapes on the bottom is shown in Fig. 16. The two plates are painted with fresh paint beforehand and the bottom sand sticks to this moist surface, so that the shape of the bottom can be clearly seen. By a slightly eccentric suspension, the plates turn into the direction of the current, which always is perpendicular to the ripples. The form of the ripple profile gives the direction of the prevailing sand movement.

Grab.

The existing grabs were too small for our purpose or did not shut properly, so that a new model was made (Figs. 17 and 17a). It is scissor shaped and has pulleys over which runs an endless steel cable, on which the grab hangs. When opened, a latch prevents it closing. As soon as the grab touches the bottom, the latch falls out by its own weight and the grab closes before being pulled up. This grab rarely fails and is to be recommended.

Ramming Drill.

In order to penetrate deeper into the bottom, a ramming drill was made (Fig. 18). A tube is placed on the bottom and rammed into it to about 1 metre depth. Often we find some clay quite close under a thin layer of sand, or sand and silt in alternating layers.

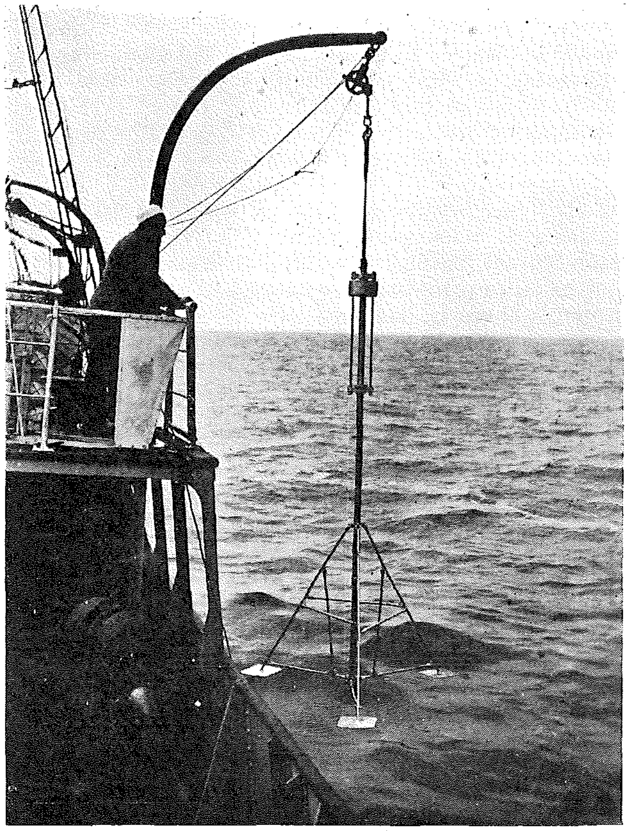


Fig. 18.—Ramming Drill.

Borings.

A still deeper penetration into the bottom is possible in good weather by executing pulse drilling with tubes of 10 cm. diameter. When the currents are too strong and the depth is too great, the tubes snap. Usually we do not reach a greater depth than 8-12 metres below the bottom surface (Fig. 19).

Sink Meter.

The size of the sand grains is determined with the aid of a pipe of 2.50 m. length, in which water is kept (Fig. 20). When throwing some sand into it, the coarsest sand grains fall quickest through the water. A chronometer gives the exact time of settlement of the different layers which gather in the glass tube at the lower end. The accuracy reached with this very quick method is thought to be greater than with sieves. The temperature of the water

Fig. 19.—Boring in the Sea.

Research of Tidal Rivers in the Netherlands

(continued)

through which the sand settles must be known, because it has a great influence upon the rate of fall (Stokes law). Salinity has only a small influence. Determination of silt percentage is more difficult than that of sand, because silt settles so slowly. A filtering apparatus with a suction device is used, but we prefer a simpler way by comparing the samples with those of suspensions of a known percentage.

Recording Salinity Meters.

Because of the serious effect salinity has on horticulture and agriculture, several registrating and non-registrating instruments are in use, measuring the salinity through the electrical resistance of the water. These instruments give good results for the low salinities in which we are interested. The salinity lines of 300 mg. Cl per litre are fixed daily at high water slack tide by means of portable " dionic " instruments.

Research and Planning.

The research bureau gradually and quite naturally became a planning bureau. The engineers in charge of the research were also in charge of a certain district, where they did the daily work such as the making of new contracts, etc. Therefore the connection between theory and practice was good. It was found that research leads to planning, and that planning without research and study cannot have the best results.

Tyne Improvement Commission

Chairman's Address at Annual Meeting

At the Annual Meeting of the Tyne Improvement Commission held on the 19th November last, **Mr. W. A. Souter,** who was first appointed Chairman of the Board in November, 1945, was unanimously re-appointed to that position, and the re-appointment of **Mr. Alfred Raynes** as Deputy Chairman was also confirmed.

Acknowledging his appointment, Mr. Souter said:—

I regard it as a very great honour to have been re-elected as Chairman of the Tyne Improvement Commission for another year. It gives me the opportunity of continuing the great work which has already been carried on by my predecessors on the River Tyne which is of such great importance to the welfare of Tyneside as a whole. Considering that our annual expenditure exceeds a million pounds and that we will handle this year nearly seven million tons of exports and imports it is also a great responsibility.

In view of the big programmes of development announced by our near neighbours there has recently been some criticism that the Commission is not putting forward anything of a similar nature. The fact is, however, that we do not need to embark upon a costly addition to our facilities. Owing to the continuous development of the Tyne which has been going on for a great many years, we now possess a waterway suitable for deep sea vessels at high or low water for 15 miles of its length, and with dock and quay accommodation fully equipped for the present volume of trade or for any probable increase for many years to come.

The capital cost of our undertaking stands at $8\frac{3}{4}$ millions stirling; its value can be put far higher than that figure because in addition to the capital cost we have spent in the past about £10,000,000 out of revenue at a time when costs of construction were much less than they are to-day. To-day our outstanding debt is only £3,332,975.

We have to thank our predecessors for making wise provision for the annual redemption of debt. This redemption of debt is continuing each year, and we can look forward to the time when the annual charge for redemption and interest will be so reduced that we can eventually make a substantial reduction in dues.

I think, therefore, you will agree that it would be wrong and wasteful at the present time to go in for any large scheme of port development which is unnecessary. We are, however, continuing to improve our properties and increase our facilities for the quick turn-round of vessels and the handling of cargo. In the past year we have repaired and strengthened " A " and " D " Staiths in Tyne Dock so that they will give good service for many years to come. We have spent over £10,000 in providing 307 more wagons for use at our docks; we have bought two locomotives for use at Albert Edward Dock at a cost of £11,200, and we are providing three additional electric cranes at Albert Edward Dock at a cost of £26,000. I am glad to report that our Norwegian trade is reviving, and I hope before long it will attain its pre-war volume. Our import trade of timber and iron ore is also showing a considerable increase.

The chief problem is to increase our export trade, and particularly our export of coal. That is of great importance in itself, and also because it would mean a further increase in our import trade. The Scandinavian countries in particular cannot send us an adequate quantity of the imports we require because we cannot send them coal. We are shipping more coal than last year, and it seems probable that this year we will ship more than 6 million tons, which is 1 million tons more than last year. Unfortunately very little little of this coal is going abroad; so far this year 92 per cent. of our shipments are coastwise, and we are shipping less abroad even than we did last year. No concessions in dues would help even if we could afford them, and we are prevented from reducing dues because of the small quantity of coal shipped, which, as you know, is considerably less than half what we shipped before the war.

I am not a pessimist regarding the coal position; I believe that the supply of coal which we need will eventually be forthcoming because the coal is there. At present the demand is there also, and I can only express the hope that when the coal is forthcoming the demand will still be there, because it is quite certain that our customers abroad, whose need now is so great, will develop their own coal mines and hydro-electric power to the maximum possible extent.

Regarding coal, I venture to make this observation:—

Among the ample coal resources of this locality, we have at our doorstep perhaps the finest quality of coking coal in the world; its supply, however, is not unlimited—I understand it is likely to last about 60 or 70 years. That should be sufficient for us and for our grand-children. Between the two wars we have exported to the Continent—much went to Germany—large quantities of this coking coal at prices and at rates of freight which left no profit to the collieries or to the British ships which carried the coal. On the Continent this coal was converted into coke with its valuable attendant by-products, and was then largely used for making iron and steel. I think it would be much better for Tyneside if this valuable coal were used more on Tyneside. If it were, there would be several advantages; we would have the benefit of the by-products; our iron and steel industry locally could be expanded, and we would have a surplus for export, and there would be additional employment for men. We have the facilities and the depth of water to discharge the largest ore-carriers.

If our coal shipments are not going to increase beyond the present figures, we must look for alternative sources of revenue. At the present time the Newcastle and Gateshead Chamber of Commerce is conducting an enquiry as to the quantity of cargo available locally which would encourage liners to come to this river. The Tyne Commission welcomes that enquiry, and is assisting actively in helping to obtain the required information. I do not wish to anticipate the result of this enquiry, but I think it is probable that it will disclose that although there is a considerable quantity of liner cargo which could be shipped from the Tyne it is not sufficiently large to attract liners without the addition of substantial quantities of heavy cargo. Liners are coming to the river now for our shipments of sulphate of ammonia, but this is only for certain destinations and the quantity available is not sufficient to attract liner traffic generally. We require a considerable addition in the weight of our exports of general merchandise and as I have indicated, I think the most likely source from which this could come is from iron and steel.

We welcome the new industries which are being started in the neighbourhood, and I would like to thank the different riparian authorities for their efforts in this direction; I would like specially to mention Tynemouth which has shown such praiseworthy enterprise in this direction. These are, however, only light industries,