THE DRAWING AND PRINTING OF MARINE CHARTS AT THE ISTITUTO IDROGRAFICO DELLA R. MARINA

(From an article by CAPTAIN ROMAGNA-MANOIA, DIRECTOR OF THE ISTITUTO IDROGRAFICO DELLA R. MARINA, published in the *Revista Marittima*, Rome, June 1931, pp. 319-333).

All charts published by the Hydrographic Institute of the Royal Italian Navy were originally reproduced from copper plates; the chart, prepared by calculators, topographers and draughtsmen, was handed, in the form of a fair-sheet, to the engraver, who engraved it on copper, reproducing the drawing reversed. These engravers were master-gravers, remarkable calligraphists and, sometimes, real artists, especially in the representation of mountainous regions, as is proved by the splendid charts of the coasts of the peninsula.

It may be recalled with what care and initiative, based on his great knowledge of the subject, the founder of the Institute, Admiral MAGNAGHI, secured the collaboration of eminent draughtsmen and engravers.

Later, however, the Hydrographic Institute, after having gained a well-merited reputation through the energy of its founder, was unable to maintain the standard of cartographic activity which had earned for it its great reputation. It was only several years after the war that renewed activity commenced, through the efforts and high competence of some of its Directors.

This article concerns the question of the production of marine charts only. The increase in the demand for charts due to the increase in maritime traffic brought out the disadvantages of the slow process of printing from copper plates, *i.e.*, by the process of calcography. These disadvantages are incontestable, insufficient consideration was given to applicable remedies, and it was decided to abandon the process and to try new methods. This was, without doubt, a mistake; more especially as it had to be proved whether the new methods were as efficient as the old.

Reproduction on zinc, *i.e.* by means of a zinc plate on which the drawing is reproduced photographically after the plate has been sensitized, is, without any doubt, more rapid than reproduction on copper. The calcographic production of the Hydrographic Institute has been maintained in recent years at an average of 30 copies per diem, whilst by means of lithography it is possible to produce at least 2,000 copies in the same 8 hour day.

Reproduction on zinc, however, necessitates:

1. — A perfect drawing of the chart. The work of the engraver, who formerly carefully traced the shore, mountains, rocks, soundings, depth contours, etc., on the copper plate has to be replaced by an equally carefully made drawing.

2. — The photographing of the drawing and its transference to the zinc. This requires competent photographers and adequate equipment and installation.

3. — Zincography. Here again competent operators in zinc work and its touching up are required, for it must be added that zinc (which has the same properties as the lithographic stone for the printing process) must be treated with great care.

The use of copper was thus almost completely abandoned, and in consequence the Institute lost a staff of first class engravers. It was not recognised at first that a sufficient number of able draughtsmen, photographers and lithographers would be required. Thus the transfer from the old system to the new was carried out by simply entrusting the new work to certain draughtsmen, photographers and lithographers who were not prepared for it. In this way the excellent engravers and draughtsmen, experts with the graving-tool and the pen, who had given their first famous "style" to the cartographic productions of the Institute, disappeared little by little and the draughting room and the photomechanical section passed gradually into the hands of a staff which was not up to the standard of such an important task.

The Officers appointed to the Institute, including the Director, being obliged to follow the usual Naval routine, were unable to remain at the Institute longer than the

short period of two years, which was entirely insufficient, even for those of that particular competence and aptitude which is indispensable for work of this nature, to be of lasting use to the Institute or to ensure the production of charts which would not lower its prestige. If it be really necessary to replace the Director periodically, the Heads of Sections, at least, should hold permanent positions and, as it is a question of cartography, the Chief Cartographer should be given a permanent appointment.

The quality of the paper employed, although its production does not come within the sphere of the Institute, has a considerable influence on the aesthetic and even on the intrinsic value of our marine charts.

The quality of paper obtained today bears comparison with the best foreign qualities and the pulp is suitable to the requirements of a good marine chart, although the technique of paper-making in Italy had reached a high standard several years ago.

The defective quality of the paper used caused the charts to tear frequently and sometimes did not allow even light pencil marks to be erased with indiarubber though of good quality; the surface of the paper came away at each erasure and the drawing disappeared. For zincographic and lithographic processes it is necessary to use a paper with a smooth surface and thus well calendered. Even though calendering diminishes the resistance of the paper, a more satisfactory type of paper should have been found. At the present time one type of paper only is used in the Institute, viz :— the type employed for calcography which is strong and slightly rough-surfaced. In fact, the smooth surface, which results from heavier sizing of the paper and which is often the cause of these regrettable defects, is no longer necessary for the immediate needs of printing from zinc or stone.

The finest lines of a delicate drawing can be perfectly reproduced on paper of a coarse rough texture, and even on cardboard, if the impression be made not directly from the zinc plate, but from rubber. For this process, which is not a new discovery, it is unnecessary to change the present methods, which are well-known, for it suffices to cover the roller of the machine with a rubber sheet (at very small expense). The drawing on the zinc plate is imprinted by one turn of the roller onto the rubber and by a second turn onto the paper, which, owing to the elastic pressure of the rubber covering, "takes" better than would be the case if a smooth highly glazed paper were employed with a bare metal cylinder.

But for the reasons mentioned above, no particular interest was manifested for several years in the art of photomechanics, which was being actively developed elsewhere.

The Cartographic Section of the Institute, in so far as methods of drawing and printing were concerned, was in the following position :—

A few elderly copper engravers were employed and printing was done from copper plates, an average maximum output of 30 copies per day per press being reached.

A drawing office, staffed by inexperienced draughtsmen, with rare exceptions; but even these, being untrained, without technique and lacking guidance on account of the continual change of officers in charge of the Section, who , themselves, had not the necessary experience nor the desirable competence in drawing, and whose position was more often than not vacant.

A photographic section, equipped with a camera the objectives of which were incapable of dealing with the large dimensions of our charts; wanting the lighting arrangements necessary for photography at any hour and in any weather; in short, an entirely defective installation.

Finally, a lithographic section, with an operator who had been at the Institute for years, but who employed the methods of thirty years ago.

In order to remedy this state of affairs, the following measures were necessary :—

1. — The creation of apprentice-engravers on copper and apprentice-draughtsmen. Competitive examinations were held during a whole year, about 50 young men, between the ages of 15 and 18, presented themselves, of whom 6 were chosen. Among these, are several who are already able to engrave fairly well and to whom the unimportant retouching can be entrusted; the others are already employed for the preparation of the rough drafts (to which reference will be made later) of the charts.

2. — A search for competent artist draughtsmen and cartographers. These were impossible to find in Genoa, either among the young people or the more elderly (this poverty in artistic inclination is characteristic of Genoa), but they were found in Florence and Milan.

3. — A search for lithographers. This again was a problem difficult to solve. Cartographic lithographers must be able to touch up a zinc plate where mountains are

represented or where a name or number is inscribed. They must be calligraphists and be able to write in reverse direction, and also possess a certain artistic sense.

But the greatest difficulty in this branch is to find competent lithographic "transferers", that is to say, those capable of undertaking the very delicate work of assembling on a single zinc plate various drawings and often mosaics of drawings, or several parts of the same drawing photographed separately.

It is not easy to describe the fundamental difficulties of this subject, but it is sufficient to say that the most serious difficulties were encountered in this part only of the technique of lithography, in the effort to obtain an improvement in the photomechanical methods of the Institute; it is still hoped that improvements will take place in the work of the lithographic "transferers".

The most accurate drawings, perfect calligraphy, lines and figures of such fineness as to have necessitated months and months of expert and patient work (1), a costly photographic outfit and all the skill of the photographic operators may be ruined by a single manipulation of an inexperienced lithographer. The handling of a drawing covering a square metre with a net of meridians and parallels and with scales of longitude and latitude without deforming them or altering or enlarging the definite impression is a difficult undertaking, as the difficulties inherent in the sharp reproduction of a delicate drawing by zincography increase considerably when dealing with sizes such as those recently adopted by the Institute for its marine charts. The staffs, although very expert, of certain highly developed lithographic firms and even of cartographic establishments have had enormous difficulties, often insurmountable ones, when work was entrusted to them.

4. — Acquisition of new apparatus for the photomechanical work. Without any hesitation a large Zeiss objective was purchased, as also were 4 arc lamps for photographic work, of recognised exposure time, independent of atmospheric conditions. Pneumatic presses for the printing of negatives, a machine for graining the zincs and numerous other accessories were purchased.

5. — Finally, a new section was created: the "Revision of Charts" Section. Those who do not know how easy it is to miss errors, often of importance, in the accuracy of soundings, in the spelling of place names, in information concerning navigation, in the values of the variation, in the accuracy of scales, of the net systems, of meridians and parallels, etc., etc., do not realise the amount of work necessitated in order to produce a perfect chart for printing.

Those who have once witnessed the competence of an experienced proof-reader in picking out typographical errors and "gaps" where the author or another reader would have noticed nothing, have some idea of the difficulties in correcting marine charts, the errors on which are very different from the spelling of the mother-tongue or the meaning of a phrase. When a sounded area, on which, for example, only 100 soundings are shown on the chart, is represented by 10 different sheets of soundings, drawn on different scales and including 10 times the number of soundings, the operation of verifying the accuracy of any single depth represented demands unremitting concentration; and to check whether the trace of the coastline corresponds to the Sailing Directions, to the views of the coast, or to aerial photographs, or, again, to ascertain that the contours are properly drawn and whether dangers are accurately shown constitutes a work of patience and demands, above all, great experience.

This Section, which formerly did not exist officially, its work being done by a clerk simultaneously with much other work, is now in independent Section, located in separate and quiet quarters. It is under the direction of a Technical Chief with six technical assistants or Captains of the Mercantile Marine, who do this work exclusively.

Without demanding financial assistance from the Treasury, funds were mainly provided by promoting the sale of charts to the public, by every possible means, not only by endeavouring to meet the requirements of navigators by making more suitable sections of charts (for example, the abolition of charts 290 *a*, *b*, *c*, 164 *a*, *b*, and the production of charts 650 *a* and 650 *b*), but also by the publication of good editions of Nautical Tables, logarithmic tables, etc., and in another direction, by more rigorous economy in the financial resources of the Institute.

After having provided for the primary needs of the Cartographic Section, viz., a staff and equipment, it was necessary to secure a Chief of the Section and to improve the methods of production of charts.

(1) *One chart of the Gulf of Sidra, recently published, represents 6 months' work on the drawing alone.*

The Minister definitely appointed as Chief of the Cartographic Section a Senior Officer, who, to the technical ability due to his rank and his long service, added unusual artistic ability. Thanks to this Chief and to the means placed at his disposal, the production of charts, the fundamental work of the Institute, was destined once more to attain its former level.

Thus, quietly, provision was made for any emergency which might arise, with the certainty that the authorities, and more especially the General Direction of the Staff, would give all requests their full approval.

The methods recently elaborated and applied by the Hydrographic Institute for printing the set of charts of the Gulf of Sidra will now be reviewed. These methods are the result of the continuous progress made in the last two years.

The charts referred to are, in my opinion, worthy of comparison with those printed from copper plates, with the added advantage of the rapidity of printing by the zincographic method; they are even comparable to recent charts of foreign production, also produced by the zincographic process.

But first a few words must be said on the hydrographic expedition to the Syrtis, the exceptional results of which, both in quantity and in quality, have led to the production of such numerous and accurate charts.

In July 1929, the author represented to the Ministry of Marine the necessity of completing the hydrographic survey of the Lybian coasts.

Although the coast from Misurata to the western frontier had been completely surveyed, and there remained, in the portion of the coast between Bengasi and the eastern frontier, only a small area in the vicinity of Tobruck to be done, there was still a serious gap in the central zone of the Colony, *i.e.*, in the Gulf of Sidra (Syrtis major). Navigators in these waters were obliged to use charts based on foreign surveys 50 or 60 years old whose accuracy was doubtful. Although this great Gulf is not of capital importance from the point of view of traffic, the rapid completion of its survey was a question of national prestige; especially as this gap was in striking contrast to the accurate knowledge which had been acquired much earlier of the waters of adjacent areas, Tunisia and Egypt; and also because, as a consequence of wishes expressed at various International Geodetic Congresses, the linking up across Lybia of the triangulations of Egypt and Tunisia with those of Europe had long been awaited.

The Ministry of Marine was in entire accord with the proposals made, and, in view of the importance of the work to be carried out, the Ministries of War, of the Colonies and of Air were invited to cooperate with the Royal Navy in the work which it was preparing to undertake.

As soon as this cooperation had been obtained, operations were begun in the spring of 1930 under the direction of the Hydrographic Institute.

The work included :—

1. — Operations on land, *i.e.*, astronomical determination of the geographical coordinates of numerous important points on which the long triangulation would rest; triangulation of the coastal area; a particularly accurate topographical survey of maritime localities of any importance; air photographs of the shore.

2. — Operations at sea; this constituted by far the most extensive and important work, consisting of the survey of a submarine area covering 30,000 square miles, and the collation of all data of use to navigation, of magnetic and meteorological information, of information regarding currents, etc.; in short, all data necessary for the elaboration of Sailing Directions.

Three surveying vessels took part in the operations at sea: the *Magnaghi* of 2,000 tons, and the *Dardanelli* and *Azio* of 800 tons each, carrying a total of 32 officers and 400 men.

These vessels, of fairly good speed and of great fuel endurance, were equipped with the most modern apparatus and specially with sonic and ultra-sonic sounding appliances.

Two parties from the Royal Navy and one from the Military Geographic Institute took part in the land work, particularly in the topographical surveys.

Aeroplanes of the Colonial Air Service made a photographic survey of about 400 km. of coast.

By October 1930 the survey from Misurata to Bengasi was completed; in all 5,000 sq. km. of triangulation, and topography was done along a coastal belt 750 km. long and 10 km. wide on scales of 1:5,000, 1:10,000, 1:20,000, 1:100,000; the ships covered about 30,000 sea miles, and took about 250,000 soundings, whilst their boats covered

about 9,000 miles and took 125,000 soundings in the vicinity of the coast. Five precise astronomical determinations were made with the most up-to-date instruments, which served as basic points for the long triangulation.

Although 3 vessels equipped with LANGEVIN appliances participated in these undertakings, no previous expedition has resulted in a total amount of survey which bears comparison with a third of the amount accomplished during the last; attention must also be directed to the number of soundings taken by the boats, in which no new methods and no new instruments were employed.

The new factors in this laborious campaign were the meticulous preparations for the expedition and, particularly, the previous preparation of the ground before the vessels left Italy. Preparations had been made on the spot by officers dispatched two months in advance, and the vessels, on arrival, were able to commence sounding immediately. Those working on land kept always ahead so that the ships had nothing to do but to carry on sounding continuously, which is, of course, their principal function. The whole expedition in the Gulf of Sidra was conducted with the idea of maximum utilisation of all means and resources and it is to the efforts thus coordinated that these unprecedented results are due.

The Italian Military Geographical Institute contributed to the survey of the Gulf of Sidra by carrying out work on land, triangulation and topography all along the coasts of Tripolitania.

In preparation for this campaign, the question of the projection to be used was carefully considered. As it was a case of surveying an extended coastal belt, the conformal conical (LAMBERT) projection on a cone passing through two suitable selected parallels in the zone was chosen in agreement with the Hydrographic Institute of the Royal Italian Navy.

As the area was limited to parallels of 30°00' and 32°50' North latitude, the middle latitude was about 31°15' N.; the central meridian of the projection was in longitude 17°50' East of Greenwich.

The hydrographic chart was drawn up on the projection described by Admiral TONTA in *Hydrographic Review*, Vol. VII, N° 1, May 1930 (page 35), taking as the secant parallels those of latitudes 32°08' and 30°22'. At the extreme latitudes, this selection limits the deformation to about twenty centimetres per kilometre.

It was decided to utilise the International Ellipsoid as the ellipsoid of reference for this work (instead of BESSEL's ellipsoid which has been used for calculations in earlier geodetic work in Lybia); a new astronomical base station was established at Misurata Marina, and a base was measured.

In the new triangulation net, one of the sides of the old triangulation made in 1914 was used in order to connect the new triangulation with the old one and to make it possible to adjust the extremities of the net from Homs to Misurata Marina. The complete net extended over about 360 km. (= 195 naut. miles) of coast and, at its eastern limit on the Marsa El Auegia side, it linked up with the similar triangulation along the coast of Cirenaica made by the Italian Royal Naval Expedition.

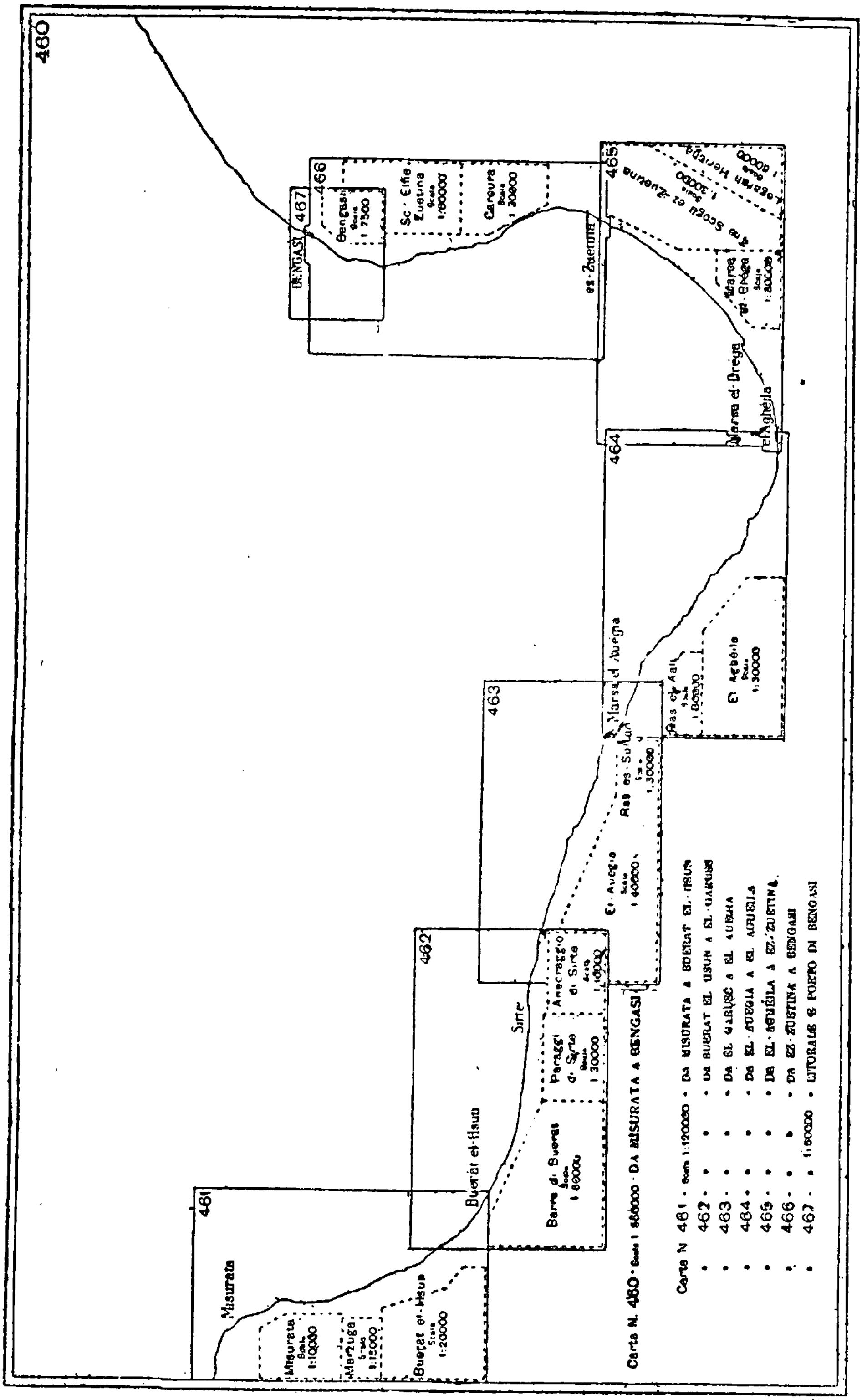
Generally speaking, the sides of the triangles are from 10 to 15 kilometres in length. The *Starke* theodolite reading to 2" was used and the triangulation depended on three bases, one at each extremity and one in the centre: Misurata-Marina, Marsa El Auegia and Buerat el Hsun. The bases were each about 1000 metres (= 3280 ft.) in length and were measured by means of a N° 369 invar tape, 24 m. (= 78.75 ft.) long, which was frequently checked.

The hours devoted to astronomical observations were very limited and it was not always possible to choose as appropriate ones as might have been wished as far as the coefficient of refraction was concerned. The mean theoretical value of this coefficient (0.12) was found to be inappropriate for the object in view and, therefore, the coefficient of refraction was specially determined by the BOUGUER method during the course of the work. Generally, the values found were round about 0.05.

Provisional geodetic elements for the triangulation were calculated during the survey and it was found possible, during the expedition, to draw the fair sheet of the survey which was published on a scale of 1:100,000.

The published charts of the Gulf of Sidra from Misurata to Bengasi are 8 in number (Fig. 1): a general chart, on a scale of 1:550,000 and 6 detail charts on a scale of 1:120,000; and one on a scale of 1:60,000. Each detail chart has, in insets, two or three plans of ports or anchorages, thus bringing the total number of charts up to 24.

All the charts were drawn on a scale one-third larger. For example, the six detail charts on the scale of 1:120,000, which are of the maximum dimensions of our chart


460
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Misurata
Buerat el-Hsun
Sirte
Bengasi
Marsa el-Brega
es-Zuetina
Carta N. 460 · Scala 1:660000 · DA MISURATA A BENGASI
Carta N 461 · Scala 1:120000 · DA MISURATA A BUERAT EL HSUN
462 · DA BUERAT EL HSUN A EL MARUSC
463 · DA EL MARUSC A EL AUEGIA
464 · DA EL AUEGIA A EL AGHEILA
465 · DA EL AGHEILA A EZ-ZUETINA
466 · DA EZ-ZUETINA A BENGASI
467 · 1:60000 · LITORALE E PORTO DI BENGASI

Fig. I

boxes, *i.e.*, 1.14×0.75 m., were drawn on sheets nearly 2 m.×1.30 m., on the scale of 1:80,000. On these large sheets, which were ruled and then graduated on MERCATOR'S projection, all triangulation stations were inserted by means of their coordinates, then the topography from the various sketches, all the details shown by the air photographs and finally all the soundings.

It is not necessary to go into the details of this method of reproducing the ground from the sketches with the various data collated during the survey, as this is not the object of the present paper. But it is interesting to note that for these new charts, contrary to previous practice, the drawing thus made was not the definitive drawing, *i.e.*, the one which is photographed (reduced in scale — in the case under consideration with a reduction of one-third — from 1:80,000 to 1:120,000) and then transferred to the zinc for the final printing, but a drawing intended solely as a rough draft of the chart.

This drawing, since it is but a rough draft, can be made by draughtsmen chosen from other categories than that of skilled draughtsmen, though it is to the latter that the final drawing must be entrusted; the rough draft can be more rapidly made without loss of accuracy. For example: contours, coast-line, etc., can be rapidly reproduced, indicating by short annotations and with occasional conventional symbols the characteristic forms of mountains, whether the coast is of a sandy or rocky nature, etc. Lines of equal depth can be drawn in and particularly, as the scale is large, all soundings can be clearly indicated without the necessity of employing an experienced calligraphist.

The method of inscribing soundings has been one of the problems which has engaged the attention of the Institute in studying the improvements to be introduced in the methods of drawing charts and, therefore, in drawing the charts of the Gulf of Sidra now under consideration.

On these charts more than 50,000 soundings (of the 400,000 taken) have been inscribed, *i.e.*, more than 50,000 numbers composed, on an average, of three figures each. How could a draughtsman have written all these? How much time would he have spent on it? And how many calligraphists would it have needed? And would the figures inscribed by one have been identical with those inscribed by the others?

One of the greatest defects of our charts produced before 1918 is the manner of inserting soundings; they were inserted by hand and sometimes by an inexperienced hand. Quite recently certain foreign Hydrographic Services still inserted soundings by hand; this method, even when it is done by an artist, is very slow and will never be accurate. The Institute determined to replace hand by machine work; this has been done by the method described below.

On the rough draft, referred to above, any necessary corrections can be made at leisure as and when the Chief Cartographer observes errors or desirable modifications, or when the insertion of more, or the weeding out of, soundings is necessary.

Corrections and additions are *inevitable* during the drawing of a chart no matter how carefully the work is carried out; the more difficult on and *detrimental* to the definite drawing, the *more easily* can they be made on the rough draft, and the more so on account of the larger scale. This, of course, in no way affects the accuracy of the work as each operation is made on the rough draft with great care and precision.

After the draft has been completely revised, it is reproduced photographically for the first time. The detail charts of the Gulf of Sidra to be published on a scale of 1:120,000 were drawn in rough draft on a scale of 1:80,000 and then photographed to the same scale. Thus photographed, the charts are transferred onto zinc as if for printing; only a few copies, some in black and others in blue, are pulled on stout paper. These copies are known as *tracings* (calchi). Those in blue are known as *pale tracings* (calchi pallidi). These copies, and especially those in black, are distributed to the correctors, so that each one, independently of the others, may revise the chart, in the same manner as press proofs are revised.

The advantage of thus easily multiplying the revision will be readily understood. This possibility was not recognised under the old system, as all revision had to be done on the final drawing and therefore on a single copy, which must not be damaged. It is true that the first proofs pulled could have been used for this revision, *i.e.* the first copies of the chart; but had errors or imperfections been discovered on these, it would have been necessary to correct the zinc on which the final drawing had already been photographed. Correction on the zinc is a long, delicate and difficult operation, and, above all, is apt to mar the zinc thus spoiling all the prints of an entire edition of the chart. Thus it is desirable that the drawing should be photographed in its definite and perfect form so that the photographic transfer on the zinc may go to the press without undergoing further manipulation.

After collating all the corrections of the various correctors, two black tracings are taken and, on one of them, all corrections to coastline and land are inserted; on the other all corrections concerning soundings, or rather the sea. The first proof is entrusted to a master draughtsman, the other being given to any member of the staff, draughtsman or not, but capable of understanding and carrying out the very simple work described below. It is to this person that the delicate and important work of the soundings is entrusted.

Only a few proofs (one is sufficient) of the *pale tracing* (blue) are pulled on pure white glazed paper, and these are used by the master draughtsman who makes the final drawing on this pale tracing from the rough draft, which stands out clearly in blue on the white glazed paper. He has before him the black tracing on which are inserted all the corrections made by the various correctors; Sailing Directions, aerial photographs, etc., in short, everything necessary for his work is at his disposal; and, using all the technique of artistic draughtsmanship, he inserts, with a pen and black ink, the coast line, place names, mountains, islands, reefs, etc.

This draughtsman is in no way concerned with soundings; these constitute an enormous piece of work, the results of which are not always satisfactory in so far as uniformity and accuracy are concerned, even when entrusted to experts.

This work is now entrusted, as has already been said, to *any member* of the staff of the Hydrographic Institute.

Very careful consideration has been given to the type of figures to be employed for the representation of depths, in order that they shall be sufficiently clear, not too large, fine, etc. Unfortunately, nothing satisfactory has been found in any of the catalogues of commercial type foundries. However, on part of the charts of the Gulf of Sidra, the depths have been inserted in the most appropriate type of figures selected from those made by a well-known firm in Turin. Sometimes, however, the figure 2 shows defects and the loop of the figure 4 is often solid. For this reason specially designed figures, drawn by hand, have been employed for the rest of the charts of the Gulf of Sidra. They were drawn at the Institute in such a manner as to resemble as closely as possible the type already employed, with modifications to the figures 2 and 4.

Figures 0 to 9 were drawn about 1 decimetre in height; they were then reduced by photography to various sizes to suit the scales of the charts for which they were required; thus great sharpness and fineness were attained.

Transferred either onto stone or zinc, a sufficient number was then printed to give all possible combinations from 1 to 200, 0.1 to 0.9, 1.1. to 1.9; from 2.1 to 2.9, etc... from 19.1 to 19.9; so that a zinc or stone was obtained which produced printed sheets.

As many copies as desired can be pulled on a special waxed paper (transfer paper), which is then cup up with a slide knife. Each number is placed in a type-case, similar to a typographic compositor's case.

Thus the problem of the inscription of soundings on charts may be taken as solved.

The operation of inserting the soundings can, as has already been stated, be entrusted to any one, for example to an able seaman. He is given a black tracing on which are all the corrections to soundings made by the correctors. He sees all the figures representing soundings clearly written on the rough draft, together with all the corrections and additions. With parallel rulers he draws close parallel lines in pencil on the black tracing in the direction of the parallels of latitude. These parallel lines serve as guide for placing the various numbers which he takes from the type-cases, so that all numbers run properly East and West (or stand North and South) and do not slope one way or the other, as sometimes happens when the work is done by hand, even by the most experienced draughtsmen.

It is for this reason that small horizontal lines appear under the numbers printed on the transfer paper. This line serves as a guide for the alignment of the figures with the horizontal lines (parallels) drawn on the tracing.

The person entrusted with the insertion of the soundings, helped by an assistant, uses two small sticks, shaped like a pencil, terminating in a pin; he takes the number for which he has asked with these sticks, from his assistant who hands them to him with another small stick after having pricked it up from the case; he then fixes the figure at the corresponding place on the black tracing by means of three or four pricks which he places on the edges of the number (See Fig. 2).

With a little practice, about 500 soundings can be inserted in 8 hours.

As soon as this operation is completed, the small horizontal lines beneath the figures are covered with opaque water colour so that they shall not appear in the reproduction.

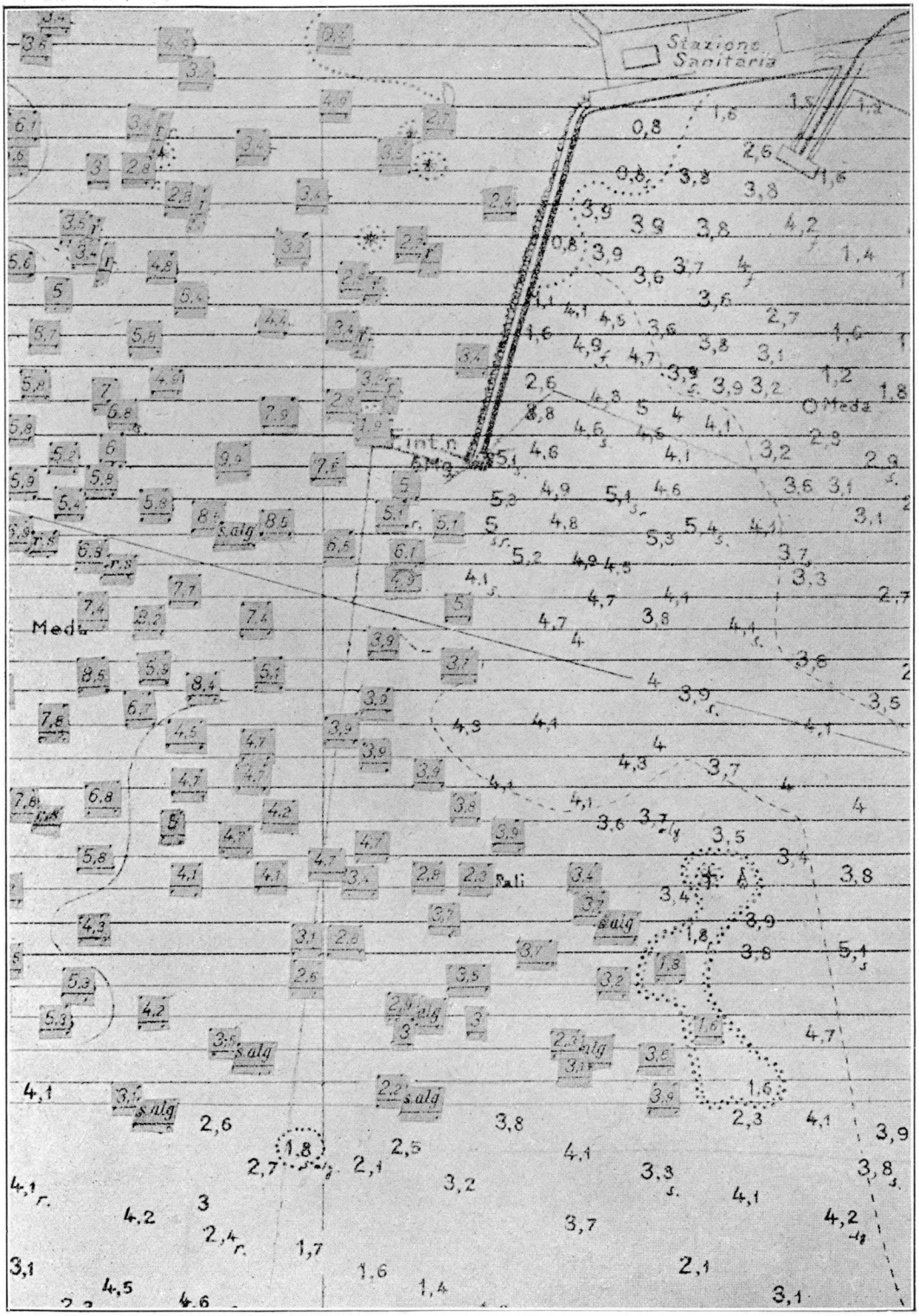

Fig. 2

The tracing is then applied to the zinc plate. In this way, all the soundings are transferred to the zinc as the thick black ink used for printing the figures on the tracing paper stands out slightly on the zinc itself.

The blue tracing is then taken, on which the master draughtsman has (or has not) completed the drawing of the land; both the blue tracing and the black tracing used for the soundings have register lines; when the blue tracing is applied to the zinc the soundings in black ink are printed immediately in their exact positions on the blue tracing, thus perfectly completing this important part of the final drawing of the chart.

To terminate his work, the master draughtsman has only to complete the marine portion of the drawing by inserting the depth curves, and any names which lie among the soundings as well as sundry other minor details. Finally the Mercator net (the accurate drawing of which, used for making the rough draft, is still visible in blue), the title, etc. are added.

The complete drawing, being thus prepared in black ink, is sent to the photographer for final reduction, *i.e.*, in the case of our charts, from the scale of 1:80,000 to 1:120,000, and this reduction is transferred to the zinc. As is well known blue does not appear on the photograph and the sharpness of the drawing, of names and figures, etc. is augmented by the photographic reduction, although this must not be excessive. A reduction to 2/3 gives the best results (See Chart N° 467).

The system described above can certainly be more widely used and greatly improved: for example, after the selection of a certain type of characters has been made, all the names on a chart could be typographically composed and inserted on the blue tracing as is done in the case of soundings, thus gradually eliminating all calligraphy. Much may be expected from lithographic methods; it is hoped that, shortly, we will have coloured charts (as have already appeared), and that, for example, depth contours may be replaced by differences in intensity in blue colouring of the sea.

But is it necessary to abolish calcography entirely? We do not think so — copper has infinite advantages which we will not stress here, but, if photogravure is perfected, as may be expected, it might be better, when photographing the final drawing, to transfer onto copper, by chemical etching, that which to-day is inscribed in relief on the zinc with lithographic ink.

The slowness of printing by hand from copper (when it is a question of small numbers) could be avoided by doubling the staff working the same press: it is a question of the staff available.

It is difficult to find good cartographic draughtsmen and good lithographers, and it is necessary to train them. But it is not true either that calcographic printing is as slow a process as was asserted at the beginning.

The Hydrographic Institute of Genoa, without having two or three gangs, and working only during working hours, quadrupled its calcographic output, even before it was necessary, in order to meet the demand, to start new presses. With the present daily routine, the printing of all the numerous charts from copper suffices for the needs of the Mercantile Marine and the Navy; it is not necessary therefore to abandon copper. On the contrary, it has again come to the fore, recently, for example for the charts of Venetia, the Mediterranean, Brindisi, Leghorn, Marsala, the Black Sea, the Tyrrhenian Sea, the Adriatic, Italy and Lybia, etc., which have replaced the older charts 209 *a*, *b* and *c*, 164 *a*, 200 etc.

One of the reasons for this return to copper plates is the possibility of "transferring" from them onto zinc in the case of large printings, and this with many advantages over the purely zincographic process.

A good typographical appearance is not, as one might imagine, a useless and costly luxury in a chart; it is, on the contrary, an indication of the perfection of the methods employed, shows accuracy and gives an assurance that the chart has been drawn up under careful supervision and consequently inspires confidence.

But all this is difficult to realise and it may even be said that no chart is free from errors in the eyes of an experienced critic.

If one considers the responsibility attaching to the marine information given by a chart and the ease with which the navigator sometimes tries to blame it for errors which arise mostly from his own inexperience or inattention, the delicacy and importance of marine cartography will be easily comprehended.

This fact is rarely recognised. May we then express the wish that the work undertaken for the gradual elimination of all imperfections in charts be continued with perseverance and that the varied and complex work of the Hydrographic Institute may receive suitable recognition?