CHART PRINTING

by

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This Bureau, in its Circular Letter N° 1-H of 13th January 1927, requested information of its States Members as to *Methods of Chart Printing*, and particularly as to the following points:

" (*a*) whether it is considered useful for each Office to exchange dry proofs with the others; (*b*) of the practice as to dry printing and exchange in each of the Offices of the States Members of the Bureau ; and (*c*) requests that an expression of opinion be added as to the relative merits, cost and utility of the various methods of chart printing as demonstrated by actual experience, in order to bring about an exchange of ideas on the subject for mutual benefit. It is claimed that the use of zinc plates is cheaper than that of aluminium plates, and that the use of the latter is cheaper than the use of stone. Any information along these lines will be acceptable. "

I. — *REPLIES TO* (a) *AND* (b).

The replies have been diverse and a summary of them should be of interest to the Hydrographic Offices of the various States Members. The replies to (*a*) and (*b*) so far received may be summarized as follows:

Argentine: (*a*) Affirmative.

(*b*) Charts are lithographed, the original chart being transferred to zinc and preserved in this form. If other Hydrographic Offices desire a dry proof, it is taken from the stone and not from the zinc plate.

Australia: (*a*) and (*b*) Negative.

Brazil: (*a*) and (*b*) Chart-printing section is being improved in order to provide for proof exchange with other hydrographic offices.

Chile: (*a*) Affirmative.

(*b*) If a dry print is requested it is pulled either from a copper plate or a zinc plate, according to circumstances. If only a drawing is in existence it is dry printed either from a zinc plate or from an aluminium plate transferred by the photographic process. The dimensions of the original plate are always given with the dry print, and this is recommended in all cases.

China : (*a*) Negative.
(*b*) Negative.

Denmark : (*a*) Negative.

(*b*) On request a dry proof on special paper is furnished from the copper plate.

France : (*a*) Affirmative.

(*b*) Affirmative, but very costly and should be restricted.

Germany : (*a*) Negative.

(*b*) Dry proofs from copper plates are furnished on request, but these retain their correct measurements only for a short time, due to the dampness of the atmosphere. " The expression 'a dry proof, which retains its measurements' is, strictly speaking, erroneous. The transfer of a dry proof onto a copper plate, to be the exact scale of the chart, can only be accomplished bit by bit, the expansion and contraction being allowed for by the engraver. The transfer of a dry proof by photography appears, after experiments carried out in the GERMAN HYDROGRAPHIC OFFICE, to be impossible, because, to the mistakes in the measurements of the dry proof which cannot be eliminated by the camera lens, are added the distortions which take place in rinsing and developping the plates and also the print paper for transfer on the stone. "

Great Britain : (*a*) Affirmative.

(*b*) It is the practice of the HYDROGRAPHIC DEPARTMENT OF THE ADMIRALTY "automatically to supply each national Office with exchange copies of all new charts, including dry proofs, where so desired, and of all new editions of charts except in cases of certain Offices whose wishes or requirements are confined to particular cases. The possibility of affecting a reduction in the number of charts supplied is, however, at present under consideration. "

Italy : (*a*) Affirmative.
(*b*) Affirmative.

Japan : (*a*) Affirmative.

(*b*) The HYDROGRAPHIC DEPARTMENT, Tokyo, "uses principally zinc plates as original plates and therefore its charts may practically be regarded as dry printed. "

Netherlands : (*a*) " Dry printing from the copper plate is rather difficult work and strenuous for the plate, consequently the sending of dry proofs printed directly from the copper plate should be restricted to those offices which really want them. "

(*b*) " The NETHERLANDS HYDROGRAPHIC OFFICE does not want to receive any dry proofs, neither does it send specially dry proof copper prints to any country. "

Norway : (*a*) Negative
(*b*) Negative.

Spain : (*a*) Affirmative.
(*b*) Dry proofs sent only on request.

Sweden : (*a*) Affirmative.
: (*b*) Affirmative.

U. S. of America :

(1) *U. S. Coast and Geodetic Survey :*

(*a*) " Insofar as this Office is aware, the lithographic chart, as regularly printed, possesses none of the disadvantages which make dry printing desirable when printing is done direct from the copper plate. "

(*b*) Copies of all charts and new editions of old charts corrected to date, are furnished to all Hydrographic Offices on request. As its charts concern only the waters of the UNITED STATES and its possessions and dependancies, exchanges with other Hydrographic Offices are only to a limited extent.

(2) *Hydrographic Office, Navy Department :*

(*a*) Affirmative.
(*b*) Affirmative.

II. — *REPLIES TO* (c) :

" *Opinions as to the relative merits, cost and utility of the various methods of chart printing as demonstrated by actual experience.* "

Argentine : " The lithographic system is best on account of its low cost and celerity of operation. The permanent standard plate is zinc. "

Australia : " The production of charts in AUSTRALIA is of a temporary nature only. The work of final production from surveys carried out by HIS MAJESTY'S AUSTRALIAN SURVEYING VESSELS is done by the Hydrographer of the BRITISH ADMIRALTY. "

For the local demand the copper plate method is considered too costly and the results obtained by zinc are considered just as good provided the draughtsmen do their work well.

Zinc plates are regarded as better than aluminium, " being cheaper and easier to handle. "

The greatest number of any one chart so far printed to meet local requirements is only 50, the cost of each copy being 12-6d. It is estimated that 500 additional charts could be printed at a total cost of 2-3d each.

The Government Printing Office at Melbourne states :

" The original chart is given to our photographer, who makes an enlarged wet plate negative, say twice the size, fitted exactly to a plotted graticule. He then prints on to a sheet of zinc direct from the impression in light blue, which will not photograph, on a sheet of Whatman's Drawing Paper mounted on zinc to prevent distortion.

" The draughstman then draws over this light blue impression (which acts as a tracing) in black ink. It is then sent back to the photographer who reduces it to fit a graticule drawn to the required size. He then makes a negative and prints direct on to a zinc plate which is sent to the Rotary Offset Machine and the required number of proofs printed.

" It would be impossible to copy the original charts direct, as they are generally coloured in different tints, therefore the draughstman has re-drawn them. The idea of enlarging the original in the first operation is that it gives him a better chance in his drawing and when finally reduced, sharpens up the work considerably. "

Brazil : (*c*) The direct method of zinco-lithographic reproduction for drawings will be adopted because it is deemed more rapid and economic and as giving a reproduction free of distortions.

Use of copper plate gives entire satisfaction as far as fineness and neatness of work are concerned, which are even excellent ; however, too slow, much more expensive and proors, requiring to be wet, are more subject to distortion.

Zinc plates are preferred to aluminium plates ; they are cheaper and gave entire satisfaction in trials at the Naval Printing Office.

Chile : " The photographic reproduction of the drawing of a chart, in one or more sections, is reproduced upon zinc plates by means of the bichromated-albumin process, the printing being done by a rotary press. This is regarded as the most economical of all the methods of printing, the accuracy and quality of the chart being " sufficient for the necessities of Hydrography and Navigation ; should no rotary machine be available, a zinc or aluminium plate obtained by the bichromated-albumin process gives a dry print for transfer onto stone and the printing of charts is then done by lithography. This method entails extra work for the printing of the colours. In any case, the photo-zincographic or the photo-aluminographic method is without doubt the most economical, but it is possible to effect greater economy if the glass negatives are stored with the object of effecting future corrections on them. "

" The most exact method is undoubtedly that of engraving by hand on copper plates, but it has the inconvenience that the manual work is very expensive and that subsequently transfers have to be made for the colours and for the printing for sale. Its exactitude becomes less with the transfers. The work of retouching and correcting is done more easily upon zinc than upon aluminium plates.

" If the photographic apparatus is not capable of producing the dimension of the chart, there exists the inconvenience of the overlapping (calzaduras), but by exercising due care, economical work can always be effected.

" In this Office the following method has been practised : when the photographic apparatus does not give the required dimension, the drawing is made on transparent paper and from it is printed the zinc or copper plate sensitized with bichromated glue, the design is developed with violet coloured aniline and allowed to dry. The engraver passes (pasa a vuril) over the sketch and the plate is ready for dry-printing or for transfer on stone or

zinc, according to whether or not a rotary machine is available. This method is more economical than engraving by hand alone, but does not give such good results with regard to exactitude and finish.

" In works for which the photographic apparatus is or has been employed, the model is always drawn a third or a quarter larger, as the apparatus reduces to the definitive dimension. The lines are drawn without any increase of thickness. "

China : (*c*) Zinc plates only are used at present.

Denmark : " Printing directly from the copper plate is very expensive as the process is very slow, but the demand is so small that we cannot print more than 20 copies of each chart, otherwise the task of keeping the charts corrected up to date, which is done by hand, would be too great. It does not pay to transfer the chart to zinc, aluminium or stone because the demand is so small. As far as possible we keep the copper plates corrected up to date and take the prints directly from them. Some charts are photographed directly from the finished drawing onto aluminium plates and the charts are printed directly from these plates as dry prints. These are only for charts of small areas and large scale and, as the corrections are few, the charts are printed by a fast working press, from 200 to 300 at a time. This method is of course cheaper than copper plate printing. "

France : " The FRENCH HYDROGRAPHIC OFFICE uses copper plates as standards. For a number of prints inferior to 100, engraved copper plates are used : for a number of prints above 100, flat printing from a zinc transfer is used.

" The best printing is that done by the rotary machine with a zinc plate on a flat bed. The rotary machine is expensive (about 200,000 francs) but its output is very great and, also, hard paper can be used, which makes the charts very durable. The zinc plate is prepared through chemical action with the aid of a drawing (tracing of otherwise). Its preparation and keeping up to date, as well as those of the tracing by means of which it is done, are very economical.

" It is a matter of indifference whether zinc or aluminium plates are used.

" Stones are cumbersome and their considerable weight renders their handling rather costly. On the other hand, when they are corrected they require considerable retouching. The FRENCH HYDROGRAPHIC OFFICE makes use of stones now on hand, but is not buying new ones. "

Germany : Wet prints pulled from copper plates approximately 120 centimeters in length have been found to shrink as much as 2 centimeters and the shrinking does not take place equally in length and breadth.

(*c*) Undoubtedly the best chart for use on board ship is made from a copper plate. The paper used for charts made from copper plates wears better than the double-sided surfaced paper which is used for stone proofs. Also the ink used for copper plates is of a different composition from the one used for flat stone proofs. The ink stands out in relief with a copper plate and is hardly affected by the use of a rubber, provided the sheet is dry and the paper is good, so that a proof made from the copper plate has

a longer lease of life than a stone proof which is in flat print with a thin layer of ink.

The cost of a chart made from the copper plate is considerably higher than that of a chart made from a stone proof. The cost of a copper plate is, however, less than the cost of mechanical photography, because the design from the point of view of drawing does not have to be so finely done. The cost of the copper plate itself is considerably greater than that of mechanical photo-reproduction, but the copper printing plate has the advantage that by applying galvanized storage (current) it is possible to correct it indefinitely and has in many ways a comparatively longer lease of life if it is always hardened before an edition is printed.

For charts made by mechanical photography, we use here lithographic blocks for black print, and aluminium plates for colour tones. Stone is by far the best but also the most expensive substance for flat prints. On stone it is possible to correct the designs several-times at the same spot, having previously polished off the old designs. However, if the stone is subjected to corrections too frequently on the same spot, hollows are formed which no longer register in printing, and therefore necessitate the making of a new printing block and usually a colour plate as well, because in most cases the latter does not fit the new block.

On stone, corrections can be done easily and cleanly, whereas correcting an aluminium plate is fraught with difficulties. The aluminium plate corrodes easily and is thus rendered useless. We use aluminium plates here because we have the necessary appliances for them instead of for zinc plates. Apart from this, zinc has the advatage that it can be finely etched whereas the same cannot be said about aluminium.

Here the charts are printed from the original plates; in other words, the charts from copper plates on copper and the charts which were done by the process of mechanical photography on stone. If a copper plate has to go and be set right for any length of time, immediately a reprint on aluminium is made and in such a case, the edition of this chart will be printed for the time being with the aluminium plate. These proofs are as good as the stone proofs.

We do not recommend for small editions of charts always to use reprinting plates because in this instance either the copper and aluminium plates would have to be corrected or else, before printing each new edition, a new aluminium reprinting block would have to be made of the copper plate which had been previously corrected.

Great Britain:

A. *LITHOGRAPHIC PRINTING.*

" GENERAL. For such work as the printing of navigational charts, where the smallest symbol (*e.g.* a rock) may be of first class importance, it cannot be too strongly emphasized that all lithographic work is somewhat in the nature of a gamble; with highly skilled and conscientious workers no fault

may occur, but a slight slackness in perfect preparation on the surface may cause work to disappear in the course of printing — 'walking'. For example, in a run of 200 copies, a buoy or a rock may show clearly on the first 50 or 60 copies and then will begin to get faint until with the last 50 or 60 it would hardly print at all.

" One advantage of printing by lithography, in addition to more obvious factors, such as rapidity, is that the impression represents the actual size of the surface from which it is printed.

" Considerations affecting the different materials mentioned in I. H. B. Enquiry, may be classified roughly in the four following categories:

" (*a*) Cost and Storage.
(*b*) Suitability of surface.
(*c*) Permanence.
(*d*) Adaptability for corrections.

" (a) *Cost and Storage.*

" There appears to be little to choose between zinc and aluminium on these grounds, but the demands of stone upon money and space seem to be prohibitive, if used on any considerable scale.

" (b) *Suitability of Surface.*

" Technical views differ as to the relative merits of zinc and aluminium, but the balance of opinion seems undoubtedly in favour of zinc for work of a fine nature, the harder surface of aluminium being less sympathetic; the latter is used chiefly for large scale work, such as posters.

" Zinc has an important advantage over aluminium as it is much less liable to oxidization; the greatest care has to be exercised in drying an aluminium plate after " gumming up " and if left ungummed it will be quickly affected by a damp atmosphere.

" Lithographic stone has a great advantage over the metals as regards surface, and the nature of this surface does not offer that chance of thickening found in the metals, which is due to their granulated surfaces becoming worn smooth by repeated contact with paper in printing. But difficulties of handling, such as weight, and liability to split and chip—if dropped—form an important consideration where repeated use of stones is called for.

" (c) *Permanence.*

" There seems to be no question as to the superiority of stone where permanence is a vital factor; the tendency to " spread " is less than on the metals, but even with stone, it is necessary to keep the work carefully cleaned and gummed-up, and each successive time of use must encourage a thickening of the work.

" (d) *Adaptability for corrections.*

" Although in correcting work on stone there is less liability for ' sprea-

ding' and 'walking' than with metals, it is not suitable for correction over a long period for two reasons :

" (*I*) To correct a stone a thin ' film ' of the surface has to be removed : repetitions of this in one place will leave a hollow into which the paper will not be pressed when printing is done, with a consequent loss of work in that area.

" (*II*) With work long established on a stone, the grease tends to penetrate more deeply and thus, though apparently removed when a correction is made, may show up when printed.

" On the other hand, metals are not so suitable for frequent correction. The action of preparing the surface has two disadvantageous effects :

(*i*) It affects the granulated surface and produces a smoothness upon which the water cannot hold.

(*ii*) It affects the surrounding work and causes spreading.

B. " *COPPER TO LITHO.*

" The general observations made above upon lithographic printing apply with additional force when a transfer is taken from a copper plate to be la id on a lithographic surface. The work may, and usually does, all get down on the plate or stone, but the element of risk of something failing to ' take ' is always present. It should also be borne in mind that although the impression on the plaster surface is taken dry from the copper and is therefore the same size, it is thoroughly damped when transferred to the lithographic surface and that hence there is no guarantee that the latter will be the same size as the copper. In practice it is found that the difference is seldom great and never comparable to the great shrinkage that takes place in a ' wet proof ' from a copper plate.

C. *ENGRAVED COPPER PLATE.*

" For any work where permanence of the record is necessary, the method of engraving upon a copper plate offers overwhelming advantages. It is not affected by the atmosphere ; by the protection of a steel surface, the engraved work is practically indestructible. The plates can be stored and handled with comparative ease. A good copper plate can be corrected almost indefinitely if carefully treated and thin patches filled up from behind. The tendency to " crack " in a much corrected plate can be met by electrolytic methods ; either in repairing the area or producing a facsimile plate.

" Although the rate of printing a copper plate is individually very slow, compared to a lithographic machine when the latter is once ' made ready ', yet for printing a number of sets of charts (*e.g.* a dozen sets of the same folio) the copper machines have a great advantage. The greatest drawback to copper plate printing as such is that the paper has to be damped and so shrinks on drying ; in the case of a long sheet this amount may be consider-

able and in all cases it distorts the work. For these reasons also it cannot be employed at all for printing in colours where correct register is required.

D. *SUMMARY.*

1. " There does not appear to be any suitable substitute for the engraved copper plate as a permanent record.

2. " While it seems essential to retain at all events a nucleus for copper plate printing, the most suitable way of producing copies under ordinary circumstances is by transferring the copper to a lithographic plate for printing.

3. " Zinc is preferable to aluminium as a medium for lithography for charts; but stone should be used in all quasi-permanent cases ".

The following is a list of what the BRITISH HYDROGRAPHIC DEPARTMENT wishes to receive from other national Offices on a basis of reciprocity :

PUBLICATIONS REQUIRED BY BRITISH HYDROGRAPHIC DEPARTMENT.

NATURE OF PUBLICATION.	No. OF COPIES.	REMARKS.
CHARTS :		
All new charts and plans which are based or partially based on original surveys made by the issuing country.	2	One copy should be a dry proof if chart is printed from an engraved plate.
All new editions of charts and plans which are based or partially based on original surveys made by the issuing country.	2	One copy should be tinted to indicate the new work and/or alterations ; the other, if from an engraved plate, should be a dry proof.
Index sheets of chart limits. List of signs and abbreviations Other special charts and diagrams.	2	
All corrections issued in the form of chartlets or slips to be pasted on the charts.	2	
Catalogues of charts and hydrographic publications	4	
Sailing Directions	2)	
» » (Supplements)	2)	
Light Lists	5)	Required only where the issuing country is the original authority or the books contain at least *some* original matter.
» » (Supplements)	5)	
Buoy Lists	5)	
» » (Supplements)	5)	

Italy: (*c*) The following methods of chart printing are employed in the ROYAL NAVAL HYDROGRAPHIC INSTITUTE AT GENOA:

1) Engraving of a copper plate with a burin (graver) and reproduction by tracing.

2) From a copper plate engraved by the photogalvanic method.

3) From a lithograph made by hand on stone.

4) Photolithography.

5) Photozincography.

6) From a transfer from a copper plate on stone or zinc. N° 1 is considered the best method of obtaining a good chart, as much for the artistic result, the precision and clearness of the print, as for the facility of the methods of correction and the possibility of printing a great number of copies from the same plate.

On the other hand, the engraving of the plate and the printing from the same take an excessively long time,

For this last reason the printing from copper plates is actually employed only after extensive corrections have been made to the plate in getting out a new edition. There is still always the drawback of having to wet the paper.

Methods N° 4 and N° 5 are those which are generally employed for the production of new charts, being more rapid and less expensive than other methods, besides giving good results both in accuracy and in quality. Method N° 3 is rarely employed because of the length of time it takes and the expense of engraving, as compared with photolithography. Experiments with method N° 2 have been very successful. This method is often employed because it is more rapid than N° 1, for which retouching is always necessary.

Methods N° 5 and N° 6 are used when it is desired to produce quickly a chart which has already been engraved on copper. The first cost of stone is naturally more expensive than zinc, but the cost of printing is about the same.

Japan: " In printing from copper plates, if the paper is not moistened the resulting impression lacks clearness. In printing from zinc plates, the printing, being independent of the use of water, causes no distortion of the paper and is, on this account, ideal, but no method so far discovered can claim absolute perfection.

" Zinc plates cost less and are easier to engrave than aluminium or stone and have the advantage of being used on a cylindrical press. The comparative shortness of the life of zinc plate and the care requisite for its preservation are some of its drawbacks. "

Netherlands: The letter of the Hydrographer is published in full because in the first half of the letter the argument is in favour of copper printing and the second half seems to ascribe superior advantages to the zinc process.

" My opinion concerning the printing of charts is that for those charts which have to be corrected and reprinted often, copper engraving is always to be preferred. Its disadvantages viz., relatively great expense and the long time for its execution, are amply covered by its advantages, viz., easy and

unlimited correction of the standard plate, cheap and quick reprinting if only a very few charts, or a very small edition, are wanted.

" The disadvantages of copper printing are: *a*) distortion of the charts; *b*) relatively great expense of printing; *c*) the printing of large editions demands much time. The distortion of the chart is deemed of but little or no importance for the mariner.

" The great expense of printing is not important for my office as the sale and use of our charts is not big enough to print large editions. The number of charts printed never exceeds 450 copies at a time and for this number the costs of copper printing in HOLLAND are but little higher than printing from litho, zinc or aluminium.

" The great advantage of printing directly from copper engravings for charts is deemed that it gives clear, strong, contrastfull, black pictures in paint, not in more or less gray ink, which pictures offer much resistance to the use of the chart by the mariner, who draws pencil lines as courses and bearings and writes notes on it, to erase them again after the voyage. This advantage is thought of more importance than the small disadvantages mentioned above.

" For these reasons I maintain copper engraving and copper printing, although I understand perfectly well that hydrographic offices which have a big sale of charts, and therefore print large editions, are forced towards zinc or lithographic printing ".

This letter continues with an argument in favour of the use of zinc, as follows :

" As regards printing from litho, zinc or aluminium which is still executed for my Bureau, the Van DYKE or the Helio process is mostly followed for the making of the standard plate, for which a zinc plate is used. The printing itself is done mostly from the stone, the original zinc plate being kept as standard.

" Aluminium plates cost about two and a half times more than zinc plates. (Stone is, of course, much more expensive and, moreover, the big stones needed for large charts—supposing that they exist—are very expensive, difficult to handle and to stow away, and liable to breakage). Aluminium plates are preferred to zinc plates by the printer if the Van DYKE or Helio process is applied, because they reflect the light better, but are deemed less fit as standard plates because aluminium does not last.

" At present a test is made with direct drawing on the zinc plate in positive writing, which is made possible by the use of the rubber press (offset press) for the printing. This method of course means a gain of time and money, because neither transfer nor photo have to be made. Moreover, the drawing on a grained zinc plate can be made much finer than on paper and afterwards the plate can be corrected quite easily, because the drawing can be easily erased and the new correction drawn in the same place.

" It is expected that such a standard plate can be preserved for an unlimited time, and its making and correcting is quick, easy, cheap and fine, The only inconveniences are that the drawing on the gray plate is more trying

on the eyes of the draughtsmen than drawing on white paper and that this is the reverse of engraving on copper, viz., a positive instead of a negative."

Norway: "Nearly all of our charts are now reproduced by electro-typing, but as a rule we print only a comparatively small number—the first edition— from the copper plate. A transfer is taken on a fine-grained aluminium plate for printing the chart in the flatbed (fly-) press, an arrangement that is necessary in order to be able to meet the demand, often up to 100 copies at one time.

"Engraving by hand is obviously considered the ideal method of reproduction of charts, but on account of the considerable disasdvantage in regard to time and expense, we have at present almost entirely done away with this method.

"Besides the electro-typing we also reproduce charts by means of photography where the drawing is transferred direct on the aluminium plate. This method is much cheaper and quicker than electro-typing, but is liable to give somewhat coarser results. It is therefore by preference used in connection with the 'temporary editions.'

"Lithographic stones are not in use any more at this office.

"As to the use of zinc in lieu of aluminium I have no experience, but according to my opinion zinc will have to be very cheap to compensate for the obvious advantages of aluminium."

Siam: The ROYAL SIAMESE HYDROGRAPHIC DEPARTMENT does not use copper plates in printing charts "but photo printing is carried out on zinc plates for lithographic printing on dry paper. This method proves to be the cheapest and therefore the most suitable for a small Navy such as SIAM'S."

Spain: Charts are printed only from the engraved copper plate by the usual system of wetting the paper and applying pressure in the press.

Sweden: The Hydrographic Office is experimenting with different methods of chart printing and is not yet prepared to make a report.

U. S. of America. Coast & Geodetic Survey (1).

"The relative merits of the various alternative processes of chart reproduction available will depend on the nature of the problems with which each office must deal. The factor which determines the methods used by this office is the frequency and extent to which our charts must be revised in order that they may correctly show the results of the constant natural and artificial changes occurring along our coasts, particularly those of the CONTINENTAL UNITED STATES. Charts of our important harbours are printed from four to six times a year and before each reprinting more or less extensive amendments to the plates are made. The average frequency of printing of all charts is about twice a year

" This office considers copper an excellent medium on which to prepare the original chart for reproduction. However, the qualities inherent in copper which make it desirable for this purpose also make its correction a time-consuming and laborious process. In consequence, the trend of this office has been toward an increasing adoption of photo-lithographic methods of reproduction which we now apply even to those charts which were originally engraved on copper.

" Briefly, our methods of chart reproduction are as follows :

" 1. The cartographer makes an engineering drawing called a compilation. This compilation contains all the accuracy but none of the artistic quality necessary in the finished product.

" From this point either of two alternative methods is used, depending on whether the chart is to be engraved. Considering first the engraved chart :

" 2. Glass matrices are made from the compilation, which are then applied by staining to the copper plate, thus furnishing an exact copy for the engraver to follow. Any distortion existing in the compilation as the result of changes in the dimensions of the paper is eliminated by fitting the matrices in small sections to the projection previously engraved on the plate. The chart is then engraved by the usual processes.

" An impression is then pulled from the engraved plate on a specially prepared, highly glazed paper. This paper has previously been coated on the back with an adhesive substance and allowed to dry. In the wetting necessary to printing this substance becomes sticky ; the paper is run through the press with a sheet of dry blotting paper on the back ; the two adhere closely and the blotting paper prevents the other from changing its dimensions either during the process of printing or in the subsequent drying.

" This proof furnishes an ideal subject for photo-lithographic reproduction. The copy is so sharp and clear and the contrast so good that little or no retouching on the negatives is required. Thus, while the method may at first glance seem to be an indirect one, it is in fact only a little more expensive and produces a much better product than that resulting from the usual methods of transfer from the copper to the lithographic printing plate.

" If the chart is not to be engraved, the compilation is photographed on either 20 by 24 or 25 by 30 inch plates. Each plate is flowed with a solution of asphaltum which is impervious to light in the contact printing frame but sufficiently transparent for the lithographic artist to see the legend on the glass when a light is placed behind it. This legend is then recut by the artist. who adds a finished artistic quality lacking in the compilation. Soundings, bottom characteristics, etc. are cut through the film on the glass by machinery similar in character to that used for engraving them on copper. From these negatives the printing plate is produced by the usual methods.

" The principal advantages from the methods described are attained in the course of the subsequent changes in the chart. Minor corrections are made directly on the printing plate but as new plates must be made up from time to time in any event, extensive corrections are made on the glass negatives. Only in unusual cases are they made on the copper plate. A few strokes of a brush on the glass will eliminate the old work and make the plate ready

to receive the new, whereas in the case of copper, even where the electrotype process is used, the same result would require from ten days to two weeks of elapsed time and perhaps two or four days of actual work.

" It has never been feasible for this office to make an exact comparison of the relative cost of the engraving and the photo-lithographic methods. It considers that in the original production of the chart the difference is slightly in favor of the latter method, while in the case of the subsequent amendments this difference becomes pronounced.

" This office uses aluminium plates in preference to zinc for its photolithographic printing.. These plates cost about fifty percent more than zinc, but in our opinion possess certain merits which amply justify the increased cost. They are lighter weight; their whitish colour affords an effective contrast with the contained legend and thus facilitates the work of the lithographic draftsnan; and they are believed to be less subject to oxidation.

" The use of lithographic stone is impracticable by reason of the desirability of retaining the subject for subsequent use ".

(2) **Hydrographic Office** :

" The relative merits and utility of the various methods of chart printing as demonstrated by actual experience are set forth in the accompanying description of practice of this Office. Through the application of various mechanical devices charts may be engraved on copper plates at a cost slightly in excess of that of preparing a finished smooth drawing for photolithography. The greater accuracy, sharpness of delineation, and permanence of the copper chart plate more than offsets the additional cost.

" The use of zinc plates for lithography is cheaper than that of aluminium plates, merely from the fact that zinc is cheaper than aluminium. Otherwise the process and cost are the same.

" The use of stone is not economical as compared with zinc or aluminium, except in small plants equipped only with stone presses, and printing only comparitively few charts.

METHODS OF PRINTING CHARTS.

" In the early days of nautical chart reproduction, before the advent of modern lithographic and printing processes, it was the practice to reproduce nautical charts by engraving on copper or steel plates and hand-printing directly from the engraved plates. This practice was followed by the Hydrographic Office until 1912 when its first lithographic offset press was installed.

" With the development and perfection of photo-lithographic processes, the chart producer naturally turned to lithography as a means of reproducing charts more rapidly and more economically. Also, it was found that the lithographed reproductions of charts were superior to those printed directly

from the engraved plates, in that the distortion found in plate printed copies, due to printing on wet paper, could be entirely eliminated in lithographic printing. The ability to print in various colors by lithography also enhanced its value as it provided a method of emphasizing distinctive features, a matter of great importance to the navigator in using nautical charts.

" From the foregoing, one would logically assume that the reproduction of charts by engraving and plate-printing would be abandoned in favor of the photo-lithographic process. Experience has shown, however, that because of the labour required in preparing a complete and perfect chart original for photo-lithographic, and because of the necessity of continually altering and bringing up to date for frequent editions, the engraved copper chart plate provides the best original for photo-lithographic reproductions. The Hydrographic Office has, therefore, adopted the policy of engraving its nautical charts on copper as rapidly as possible and then reproducing by lithography, using the engraved plate as a base or original.

" Within the past three years a mechanical instrument for engraving chart plates has been developed in the Hydrographic Office. This instrument known as the " pantograver " is the result of inventions by two employees of this Office. (See *Hydrographic Review*, Vol. II, May, 1925, and Vol. IV, May, 1927). The pantograver is constructed on the pantograph principle and is employed in the engraving of outlines, soundings, and lettering on chart plates. An attachment to the pantograver automatically compensates for any distortion existing in the data sheets from which a chart is engraved. From seventy to ninety per cent of the work on an engraved chart plate can be produced with the pantograver and the remainder engraved by hand

" After the engraving of a chart on copper is completed copies may be printed direct from the engraved plate. This is accomplished on a plate printing press which consists of a bed plate on which the engraved plate rests and which passes between two cylinders under pressure. The cylinder which presses against the face of the engraved plate is covered with a heavy wool blanket.

" In the operation of plate printing the engraving is first filled in with ink. The surplus ink is wiped from the face of the engraving with cheese cloth and then the surface is given a final wiping and polishing with bare hands. The paper which has previously been thoroughly wet is laid over the face of the engraving, and run through the press under pressure. The wool blanket causes the wet paper to be pressed into the lines of the engraving, thus picking up the ink and giving a clear cut and black impression of the engraving.

" This method of chart printing is slow and laborious. Seventy-five to one hundred copies per day is the average output for one press. The resulting charts are considerably distorted. The paper being wet when printed shrinks unevenly in drying, the shrinkage in one dimension of the sheet frequently being double that in the other direction.

" In 1912 the Hydrographic Office adopted the lithographic offset process for printing its nautical charts. This process allows of printing on dry

paper at the rate of from one to four thousand impressions per hour, thus producing a more accurate chart at considerably less cost.

" At the time the lithographic process was adopted the Office had over sixteen hundred engraved chart plates. These have gradually been transferred to zinc plates for lithographic printing until there remain only about three hundred plates which have to be plate printed by hand. These remaining plates are mostly worn to such an extent by constant printing that they are unfit for transfer to zinc, and must be replaced sooner or later by new engravings. However, the engraved copper plate is still considered the best base or original from which to produce charts and the engraving of such plates from which to pull impressions for photo-lithographic reproduction is continued.

" In order to produce photo-lithographed charts free from distortion a special process of pulling an undistorted impression from an engraved plate has been developed. For this purpose an unsensitized photographic paper is used. The paper is first coated on one side with a specially prepared paste and allowed to dry. Just before an impression is to be taken this paper is laid between two moistened sheets of paper until only sufficient moisture is absorbed to render the paste tacky. The paper is then laid face down on the engraved plate which has previously been inked in the same manner as for ordinary plate printing. A sheet of blotting paper is then laid on in contact with the paste-coated surface and the whole run through a plate printing press. The pressure thus applied causes the photographic paper to adhere firmly to the blotting paper and a sharp and clear impression of the engraving is obtained on the face of the photographic paper. The next day, after the ink is dry, another sheet of paste-coated paper is applied under pressure to the back of the blotting paper, thus forming a sort of cardboard. Impressions taken in this manner are found to be free from distortion and their dimensions are practically the same as the engraving itself. Such impressions are known as mounted originals.

" When editions of charts were printed entirely by plate printing from the engraved plates it was necessary to engrave every feature appearing on the charts. There are certain features such as compass roses with magnetic variation, variation curves, light sectors, and restricted areas, which are subject to frequent change. The erasing and changing of such features on the engraving is exceedingly costly and injurious to the engraved plates. In the present practice of engraving charts for photo-lithographic reproduction such changing features are omitted from the engraving and supplied either by drafting on the mounted original or by lithographic transfer. Also, all standard notes, such as light notes, conversion tables, publication notes, and seals are not engraved on the copper plates, but are supplied by lithographic transfer.

PHOTO-LITHOGRAPHIC REPRODUCTION OF CHARTS.

" After a mounted original has been pulled from an engraved plate and the necessary features added by a draftsman, it is ready to be photographed. The camera used for the purpose is a wet plate process camera, adapted for

negatives 25"×30" in size. As most charts are larger than the size of a single negative it is necessary to photograph a chart in sections which are later accurately assembled in photo-printing to a lithographic zinc plate. For this purpose match marks are placed on the mounted original in such positions that two or more marks are common to the adjacent negatives. Great care is necessary in keeping the camera and copy board in proper adjustment to prevent distortions and inaccuracies in the negatives.

" After the negatives have been made they are placed in the hands of a negative cutter who paints out all defects such as pin holes and dust marks in the background and recuts any weak or defective work. Paper photo-prints are then made from the negatives and thoroughly revised before photo-printing on zinc.

The zinc plates used in lithographic offset printing are approximately twelve-thousandths of an inch thick and have one surface grained. The grained surface is obtained by placing the plate in a graining machine which consists of a flat tray in which the plate rests. The plate is firmly clamped in place and covered with porcelain marbles about one inch in diameter; The tray is mounted on excentric bearings and geared to a motor in such a manner that an oscillating motion is imparted to it, causing the marbles to roll continously over the surface of the plate. A very fine quartz sand and water are sprinkled over the marbles which, while in motion, cause the sand to cut into the surface of the zinc plate, thus producing the grained surface. About forty-five minutes is required for the operation of graining a plate.

" A zinc plate is prepared for photo-printing by coating the grained surface with a sensitizing solution composed of albumen and bi-chromate of ammonia. The solution is poured onto the surface of the plate which is clamped in a whirler and revolved so as to spread and dry the sensitized coating uniformly. The plate is then ready for printing.

" In photo-printing the chart negatives on the plate, a vacuum printing frame is used. The negatives are laid on the surface of the plates and printed one at a time by exposing before arc lamps, the surface not covered by a negative being blocked out and protected with opaque paper. After the first negative has been printed the match marks are developed and the next adjacent negative laid on the plate with its match mark fitted perfectly over those printed from the first plate, and so on with as many negatives as are required to complete the chart.

" The effect of light on the sensitized coating is to render the portions exposed to light insoluble in water. After the photo-printing is completed the plate is covered with a dye solution and placed under a water tap. The water dissolves and washes off all the coating on the plate which has not been exposed to light leaving the design of the chart. The lines of the design consist of an insoluble skin adhering firmly to the surface of the plate and visible in the color of the dye used.

" The zinc plate is now ready to receive lithographic transfers, of compasses, notes, seal, etc... A lithographic transfer is an impression or print made on a paste-coated paper with a greasy ink specially adapted to the purpose. The print is made on the paste-coated side of the transfer paper so

that there is a layer of paste between ink and paper, thus preventing the ink from penetrating the paper. Standard plates containing compass roses and other features common to charts are used to pull the transfers from.

" The operation of transferring consists of inking up a standard plate, laying a piece of transfer paper over the design, and running it through a press under pressure. The transfer paper is then stripped from the surface of the standard plate and the design appears in greasy ink on the paste-coated surface of the paper. The paper transfer is then ready to lay down on the chart plate. The desired positions of the work to be transferred are carefully laid out on the chart plate and the transfers laid on face down in the positions required. Great care must be taken to properly orient transfers of compass roses. The plate is next run through a press under pressure which causes the transfers to adhere firmly to the plate. Water is then applied to the back of the transfers which soaks through the paper and dissolves the paste coating. The paper is then readily removed, leaving the transferred design in greasy ink, clear and sharp on the surface of the chart plate.

" After the transfer of compass roses, marginal notes, etc., has been completed the zinc plate goes to a lithographic draftsman who draws the border lines of the chart and touches up the design along the joining lines of the several negatives. This is done with a greasy substance known as lithographic tusche, which is applied to the plate in the same manner as drawing ink on paper drawing.

" The plate is now ready for etching and preparing for the press. The etching is done with a gum solution containing phosphoric acid which is applied to the surface of the plate with a brush. After being etched the plate is rolled up in ink with a hand roller, the surface of the plate being kept moist with water to prevent the ink from adhering other than to the lines of the design. The surface of the plate is then fanned dry and benzine and asphaltum applied, which removes the ink and leaves in its place an asphaltum coating on the lines of the design. The plate is now ready for the perss.

" The principle of lithographic printing is a separation between grease and water. During printing the lithographic plate passes alternately under dampening rollers which keep the surface of the plate moist and ink rollers which supply ink to the lines of the design. The lithographic offset press contains three cylinders. The plate is wrapped around and clamped to the first cylinder, a rubber blanket is stretched around and fastened to the second cylinder, and the paper on which the printing is done passes around the third cylinder. While printing, the cylinders are in contact. The rubber blanket takes the impression from the zinc plate and imparts it to the paper. The design on the plate is direct or forward. It becomes reversed on the rubber blanket, and direct again on the paper.

" In the early days when charts were hand printed direct from the engraved copper plate the land areas were covered with a stipple tint consisting of parallel lines of dots spaced equi-distant apart. The ruling of this tint was exceedingly laborious and costly and very difficult to replace neatly when corrections within the tinted area were necessary.

" In the lithographing of charts a flat color tint is used over the land areas. This is printed in the same manner as the base design using ink of any desired color. The plate for a land tint is prepared by blue printing the chart design on a zinc plate using the same negatives as were used for the base plate. A ferro-prussiate solution is used for this purpose instead of the bi-chromate sensitizing solution used in photo-printing the base plate. The print thus obtained will not work up and print in the lithographic press, but serves as a guide to the lithographic draftsman who fills in the entire land area with lithographic tusche. The land plate is then etched and prepared for the press in the same manner as the base plate. Similarly plates are prepared for tinting water areas blue out to the three or five fathom curves.

" On Hydrographic Office charts printed by lithography the color scheme adopted is black for the base, buff tint for the land, blue tint for water areas out to the three or five fathom curves, green tint over areas dry at low water and orange circles at lights. The green color over dry at low water areas is obtained by an overlay of the blue and buff tints. "

DISCUSSION

The engraved copper plate still remains the standard or master plate in nearly all Hydrographic Offices, but there is a growing tendency in some few Offices to substitute zinc or aluminium plates for copper as standard plates because, after special preparation, they seem to stand storage quite as well as the copper plates and seem to be quite as accurate. It would not be surprising if further experiments along these lines will cheapen the methods of chart production without sacrificing accuracy and durability. Skilled copper plate engravers are not as plentiful as formerly, especially outside of Europe, and some form of mechanical engraving of copper plates would seem to have a promising field in case zinc or aluminium are not found to fulfil all the exacting requirements of modern conditions.

In a considerable percentage of the copper plates in the possession of Hydrographic Offices the soundings are still engraved in fathoms and, if the metric system is ever adopted universally, there will have to be some way of avoiding the necessity for changing the soundings on the copper plates because it would involve very great expense and years of labour. It would be possible, in this case, to reproduce from a drawing of all the new soundings a zinc or aluminium plate on which could be reproduced, in addition, all the features of the copper plate other than soundings. This could be done by making a celluloid positive of the desired portion of the copper plate and photographing it onto a zinc or aluminium plate, subsequently etching it on with acids.

No definite data as to the actual relative cost of copper, stone, zinc and aluminium has been submitted, but the following figures have been recently obtained from the U. S. OF AMERICA. The U. S. COAST & GEODETIC SURVEY pays for an aluminium plate :

$38 \times 50 \times 0.025$ inches, viz. $965.2 \times 1270 \times 0.635$ millimeters, –3.60 dollars viz., gold francs 18,66.

The HYDROGRAPHIC OFFICE OF THE NAVY DEPARTMENT pays for a zinc plate from which it prints pilot charts :
32,5×43×0.022 inches, viz. 825.5×1092.2×0.5588 millimeters, —1.45 dollars or gold francs 7.41.

The Hydrographic Office pays for a large zinc plate :
77×53×0.022 inches, viz. 939.8×1346.2×0.5588 millimeters, -2.00 dollars or gold 3ancs 10.37.

It seems to be the impression in some Hydrographic Offices that the mariner should be satisfied with whatever is produced and sold to him. Naturally its method of chart printing is considered the best under all circumstances, otherwise it would change its method. It would be, however, much more satisfactory to know what those who actually buy and use the charts think of the different methods and paper used. The statement that the subsequent distortion of a chart pulled wet from a copper plate is deemed of but little importance to the mariner needs some qualification, as otherwise one must admit at once that the supposed greater accuracy of the copper plate, as compared with lithography, is relatively unimportant. As to the distortion of a copper print chart, it is self-evident that, during all the years in which it has been used, there must have crept into the discrepancies in the differences between the dead reckoning and observed positions of ships, many errors due to the unequal distortion of the chart and which have been charged to other causes.

As to the statement " it cannot be too strongly emphasized that all lithographic work is somewhat in the nature of a gamble... ... ... For example, in a run of 200 copies, a buoy or a rock may show clearly on the first 50 or 60 copies and then will begin to get faint until with the last 50 or 60 it would hardly print at all", there are many Hydrographic Offices which print hundreds of charts by the zinc or aluminium process and which consider that the last copy is just as good as the first one, and further data might clear up this matter.