For Departmental use.

Survey of India.

DEPARTMENTAL PAPER—No. 8.

REPORT

ON

RUBBER OFF-SET FLAT-BED MACHINE PRINTING

BY

CAPTAIN S. W. SACKVILLE HAMILTON, R.E.,
OFFG. DEPUTY SUPERINTENDENT,
SURVEY OF INDIA.

PUBLISHED UNDER THE DIRECTION OF THE SURVEYOR GENERAL OF INDIA.

CALCUTTA,
Printed at the Photo.-Litho. Office, Survey of India.
1915.

PREFACE.

In 1910, the subject of Rubber Off-set Printing was selected by the Surveyor General for report by a Survey of India officer attending the Chatham Course of that year. On the recommendation of the Chatham report, which is printed as an Appendix to Captain Hamilton's Departmental Paper, one Mann's Flat-bed Rubber Off-set machine was obtained for the Photo.-Litho. Office, in order that the suitability of the method for Survey of India purposes should be thoroughly tested. Captain Hamilton's paper has been prepared by him from his report on the tests he carried out. On the results of these investigations it has been decided not to introduce rubber off-set printing in the Photo.-Litho. Office.

The most recent views of the Ordnance Survey on the question of rubber off-set printing for maps are given on pages 174 and 175 of the Text Book of Topographical Surveying, Second Edition, 1913.

W. M. COLDSTREAM, *Major, R.E.*,
Superintendent, Map Publication.

20th October 1914.

REPORT ON RUBBER OFF-SET FLAT-BED MACHINE PRINTING IN THE PHOTO.-LITHO. OFFICE, CALCUTTA.

1. *First trial, 1913.*—Five Standard sheets were selected for trial by Rubber Off-set Flat-bed Machine Printing in 1912. Unfortunately four of these were delayed owing to unforeseen corrections being necessitated in the Circle Office. It was not considered that the trial would be sufficient if only one Standard sheet was printed in this manner and its printing by the rubber off-set method was accordingly delayed also.

The test was not therefore carried out until November 1913.

2. Two Standard sheets were then printed both by the direct and off-set methods, the same plate being used for each method.

It was at once seen that the print by off-set was dull and flat and thicker than that by the direct method which is sharper, denser, and has a more luminous appearance.

Every effort was made to produce a better effect. Different kinds of ink were tried, new helios called for, plates rubbed down, and finally a new blanket, but no satisfactory result was obtained.

Prints were also pulled by both methods of an engraved atlas sheet and an inspection shows that the work is brought out much more thickly and heavily throughout, whereas the direct method, though weaker in the fine lines, has more relief.

These results were no doubt in part due to the inexperience of the printers in rubber off-set work but the thickness in the results was also credited to the "give" in the rubber when picking up and parting with the impression.

The conclusion arrived at after this first trial in 1913, was that the method could not be used without finer helios.

3. In England, some firms consider it of importance that the zinc plates for use in rubber off-set machines should receive a rather coarser grain than those used in direct printing machines, while others have not found any difficulty in printing from plates with the same grain as they apply for direct printing. (*Vide* Appendix para. 9*(d)*, page vi).

Contrary to the former experience, I am inclined to favour a medium fine sharp grain.

A coarse sharply grained plate holds more water than one with a fine sharp grain and the rubber in picking up the impression from the plate also picks up more water and thus deadens the ink, and is, I consider, one of the causes of the absence of luminosity and depth of colour in the majority of impressions by the

off-set method. Even more so would this be the case with a very finely grained plate, due to the increased amount of superficial water it must carry, especially in very hot weather when the necessity for an excessive quantity of water is unavoidable.

The coarser the grain, the easier the printing, and the finer the grain, the sharper the impressions, consistent with its not being so fine as to "bung up" in printing; thus, these relative disadvantages of a coarse or a too fine grain point to the medium fine sharp grain as the best and I am accordingly of opinion that it would be difficult to improve the grain now used in the Photo.-Litho. Office which meets the photographic and zincographic requirements as nearly as is practicable for their combination in Heliozincography.

4. *The production of finer negatives by the use of varying methods of Development and Intensification.* As stated above the conclusion arrived at was that finer helios were a necessity, and treating the word "finer" as having a separate relation to the graining, attention was turned to the improvement of the negatives, the details and results of which are given following hereon, pending which printing experiments by the rubber off-set flat-bed machine were temporarily placed in abeyance.

The helio. depends largely on the negative.

The difficulty of retaining the very finest lines of a drawing and at the same time keeping the heavy work open and clear is of course well known. Theoretically, a line should reproduce exactly in proportion to the amount of reduction, but this is not so in practice, owing to the "spreading" action which takes place during (*a*) Exposure, (*b*) Development, and (*c*) Intensification.

(*a*) By irradiation or scattering of light in the film during exposure, (this should be distinguished from "halation", which is the property of light passing through the film being reflected back on to the film from the glass and rarely occurs with wet collodion).

The problem of overcoming irradiation has never been satisfactorily solved; some experimental work has been done in the Photo.-Litho. Office and promising results obtained by the use of Picric acid. These experiments are stopped meantime, pending the receipt of the microscope indented for last year.

(*b*) Spreading action during development, owing to the fact that the particles of silver haloid acted on by light, have, during development, the property of reducing or acting on adjoining particles which have not been exposed to light; this was proved by Abney and is easily and conclusively demonstrated.

(*c*) Spreading action during intensification. This is unavoidable when great density is required, as for helio. work, but as the spreading or closing action during intensification is almost directly proportional to the density given by any particular formula, this can be partially remedied by varying the exposure.

5. With the object then of producing finer negatives, but at the same time bearing in mind the difficulties explained above, eleven negatives were taken of a One Inch Standard sheet and were intensified with the various formulæ given in the tabulated statement below:—

When using Lead Ferricyanide and Sodium Sulphide and Mercury Bichloride and Ammonia which are the two extremes of the formulæ given in the table, the exposure is as 1 to 4, the other formulæ occupying an intermediate place as regards density and exposure.

	Bleached with	Blackened with	
No. 1	Lead Ferricyanide ...	Sodium Sulphide.	
No. 2	Mercury Bichloride ...	Ammonia.	
No. 3	Copper Bromide ...	Silver Nitrate ...	Repeated.
No. 4	Redevelopment followed by Mercury Bichloride.	Ammonia.	
No. 5	Mercuric Iodide ...	Sodium Sulphide.	
No. 6	Copper Bromide ...	Schlippes Salt.	
No. 7	Copper Bromide ...	Silver Nitrate followed by Sodium Sulphide.	
No. 8	Copper Bromide ...	Silver Nitrate followed by Iodine & Schlippes Salt.	
No. 9	Mercury Bichloride ...	Sodium Sulphide.	
No. 10	Copper Bromide ...	Silver Nitrate followed by Potassium Ferricyanide & Sodium Sulphide.	
No. 11	Redevelopment followed by Mercuric Iodide.	Sodium Sulphide.	

No. 3 though not quite so good as No. 2 is the formula in general use on account of its reliability, freedom from stain, and its lasting qualities. No. 2 though producing excellent results is unreliable and the negative fades after a time; it and No. 4 are used occasionally, while No. 7 is employed for the preparation of half-tone and line blocks. Nos. 5 and 6 are unreliable. These conclusions are supported by the printed results.

6. The above experiments, in addition to their original object, form a record, and are the outcome of many previous similar experiments carried out in the Photo.-Litho. Office by Mr. R. Taylor, Photo. Manager, during the past few years. An inspection of the results is gratifying in many ways as it proves that the existing formula, as at present used, is the best all round method for the work of the office. It is, however, disappointing in another, as the original object of producing finer negatives has failed, and from these results I have formed the second conclusion arrived at, as the result of the rubber off-set experiment, that finer negatives cannot be produced without finer originals.

The experience of the Photo.-Litho. Office during the last few years tends to show that the best results are obtained when the originals are drawn for reduction by one-half; one-third reduction also gives good results but by a greater or less reduction than these the results are inferior.

7. *The production of finer helios by printing with the aid of a mirror by parallel rays of the sun instead of by direct sunlight.* Having found that the negatives could not be improved, attention was directed to the possibility of obtaining finer helios by some other means.

The graining of the plates presents itself for examination.

The best photographic results are obtained on polished zinc, but a "grain" is necessary for printing purposes to enable the plate to carry sufficient water to prevent the ink "catching" during the return passage under the machine rollers. As the photographic and printing requirements are thus diametrically opposed to each other, many experiments have been made from time to time to get a grain suitable for both. The moisture carrying capacity of a plate does not depend on the actual roughness of the grain but on the sharpness of it. A plate grained with a very hard sand or emery may be smoother in surface than one grained with

soft sand, yet have much better printing qualities. In England pumice powder used with glass, china, or wooden balls is commonly used, but in Calcutta it has been found that zinc balls and sharp fresh water sand give the best results.

Pumice powder has been tried, but although the plates were excellent for the photographic part of the work, and passed the proving stage satisfactorily they gave great trouble in the machine. The grain was too "smooth" and could not carry sufficient water to prevent the ink "catching". Plates grained thus were used for a short time and then abandoned.

So far no sand has been obtained in India of sufficient hardness for the purpose, as a sand which grinds down to mud quickly is useless for graining printing plates.

8. The graining of the plates being considered and found to be satisfactory, we turn to the sensitizing solution.

The Helio. or direct photozinco. process (as distinguished from the transfer process) was first introduced in the Survey of India Department by Sergt. J. Harrold, R.E.

His process was as follows:—

The plate was desensitised with a solution of gallic and phosphoric acid and gum arabic, then coated with Bichromated albumen, exposed under a negative and then developed in water and dried, after which it was coated with a thin film of litho. printing ink by means of a lithographic roller.

On sprinkling the plate with water and continuing the rolling the image gradually clears up, leaving an image composed of light hardened albumen coated with a more or less greasy ink.

The fatal defect of this process was, that, as the zinc was desensitised before coating, the image was only retained on the plate by the mechanical adhesion of the light hardened albumen.

This meant that any abrasion, friction, or absorption of water by the albumen image during printing would spoil the plate.

Latterly, the process was modified by inking up after exposure before development. This simplified the work but did not get over the defect caused by the previous desensitizing. The true cause of this defect was not understood and was attributed to decomposition of the albumen film owing to the moist heat of Bengal. Acting on this supposition, experiments were made to obtain a process by which the ink image would be in direct contact with the metal with no intervening layer of albumen or other colloid. The result of these experiments was Mr. Turner's "ink" process. In this process the *desensitised* zinc plate was coated by means of a sponge with a thin film composed of a mixture of Transfer ink, Fish glue, Soap, and Ammonium Bichromate.

The plate was then exposed under the negative and developed in water. This process had the same defect as the previous one and several of its own. The ink process was in use up to the end of 1905. From January 1906 at the instance of Mr. Taylor, the use of Fish glue in the albumen solution and the preliminary desensitizing of the plates, which was the cause of all the previous trouble and difficulties with helios, were abandoned, and since then the albumen process has been exclusively used.

The formula at present in use is as follows :—

Dry egg albumen	...	150 gms.
Ammonium Bichromate	...	60 gms.
Potassium Bichromate	...	30 gms.
Ammonium Carbonate	...	50 gms.
Water	...	3,000 C.C.
Alcohol	...	60 C.C.

Dry egg albumen is used because it is much more reliable than fluid albumen and is also cheaper in use.

The mixture of Potassium and Ammonium Bichromate is designed to give the greatest possible ink holding capacity to the film. It is a fact well known to collotype workers that a plate sensitised with Ammonium Bichromate alone is liable to give glazed shadows which take ink with difficulty or not at all. This tendency is counteracted by the addition of Potassium Bichromate.

Ammonium Carbonate is used to increase the solubility of the albumen and at the same time improve the keeping qualities of the coated plates. Liq. Ammonia serves the same purpose, but being more volatile is less permanent in its action.

A small quantity of alcohol reduces the tendency for air-bubbles to form when coating the plate.

This formula has been varied and improved from time to time through continued experiment.

The Potassium Bichromate was added some two years ago and the Ammonium Carbonate substituted for Liq. Ammonia in October 1913. Since then, it has been accepted as the best possible formula and any deviation from its principles and quantities has been found to cause immediate trouble. This is not intended to imply that it should be taken as final.

9. We now turn to the printing of the helio. from the negative.

To obtain the best possible helio., it is essential that the zinc plate should be in absolute contact with the negative. This contact is obtained as far as possible with the aid of the pneumatic printing frame but observation will at once make it apparent that this contact is not absolute due to the thickness of the duffing medium on the negative. The duffing medium is laid on the negative as lightly as is consistent with its purpose, but a certain thickness is unavoidable, the effect being that the resultant want of absolute contact between the negative and the zinc plate permits diffused light to enter at the edges of the lines and produces a thickened line on the helio.

To obviate this difficulty in the making of half-tone helios, the helio. is printed with the aid of a mirror, which reflects parallel rays of the sun on to the negative in the printing frame, which is placed in shade and at exact right angles to the path of the reflected beam, and as a possible solution of the difficulty it was decided to try this method for printing ordinary helios.

A tint negative was prepared from a half-tone screen and helios printed therefrom, one in the ordinary manner by direct sunlight and the other with the aid of the mirror by parallel rays of the sun.

The printed results of the latter show a very marked superiority over the former. These were considered so satisfactory and of such interest, that orders were issued to print Degree Sheet 38 P and One Inch Standard sheet 83 $\frac{B}{2}$ by both the old and the new methods, and a distinct improvement was obtained.

Helios prepared by the new method are found to be easier to print from than those by the old; they can carry more ink and there is also less tendency for work to thicken and "bung up" on the plate.

10. Having progressed thus far in a note on the helio. process, it is not out of place to add a few remarks on helio. ink.

The ink used in making a helio. is nearly, if not quite, as important as the sensitising formula and must have the following properties:—

(*a*) It should form a perfect resist to the etching or desensitising solution used by the lithographic printer.

(*b*) It should contain the greatest possible amount of colouring matter, for the reason that the best results are obtained when the film of ink is used extremely thin, which means that if the colouring matter is not great, the lines will appear grey, and on the grey surface of the zinc plate are difficult to see during development and final examination.

(*c*) It should adhere tenaciously to the light hardened albumen and at the same time show no tendency to smear or repeat on the work.

Formerly the opinion was held that a helio. ink should contain a considerable proportion of greasy matter, such as wax, stearine, soap, &c. This idea is now exploded, as better results are obtained by using a simple solution of the best quality lithographic chalk ink. The ink is dissolved in a mixture of Benzole and Turpentine, and by varying the proportions of these two solvents, the ink can be made to conform to any required condition, climatic or otherwise. Lavender oil is added to prevent the ink oxidising or drying too quickly on the finished helio. and serves that purpose well without interfering with the working qualities of the ink.

11. The methods of development have also been subjected to searching enquiry and, given a thoroughly practised hand and eye, it is doubtful if they can be bettered though rather more light is required for the purpose than is now obtainable, and action has been taken to remedy this defect in the immediate future.

12. *Second trial, 1914.*—Having succeeded in obtaining a finer helio. by the aid of parallel rays of the sun from a mirror, we return to the experiments on Rubber Off-set Machine Printing.

13. Two sheets were printed by the various methods given below :—

(*a*) Rubber Off-set,—from a helio. by direct sunlight, ordinary lithographic ink being used for printing.

(*b*) Rubber Off-set,—from a helio. by direct sunlight, litho. off-set ink being used for printing.

(*c*) Rubber Off-set,—from a helio. made with the aid of a mirror, ordinary litho. ink being used for printing.

(*d*) Rubber Off-set,—from a helio. made with the aid of a mirror, litho. off-set ink being used for printing.

(*e*) Direct,—from a helio. by direct sunlight, ordinary lithographic ink being used for printing.

(*f*) Direct,—from a helio. made with the aid of a mirror, ordinary lithographic ink being used for printing, one impression with the ordinary and the other with the fullest quantity of ink.

For purposes of comparison with the first trial in 1913, prints were also again pulled from the same engraved atlas sheet by both the Rubber Off-set and direct methods.

Dealing first with the last named, we find a very decided improvement in the prints by the Rubber Off-set method as compared with the first trial, due in all probability to the greater experience of the printer in Rubber Off-set work, but also partly attributable to the fact that the rubber blanket used has been in use for the direct method for some seven months and consequently the stretch it contained has been eliminated and there is less "give".

The work lacks luminosity and depth of colour and no doubt is also heavier throughout than the direct method, but rather than express it as heavy, it would, perhaps be more correct to denote the fine work which is apt to be lost by the direct method as being brought out more clearly and definitely, and, though the hills are heavier and thicker than is suitable, there is little doubt that a further experience on the part of the printer would produce a result which gave the necessary relief in the hills and yet retained a clear, continuous, and sharp definition of the finer lines.

To compass this, however, entails the use of a still less quantity of ink and a further loss in the luminosity and depth of colour of the impression.

14. Having seen that the printing has improved as compared with the first trial, we turn to a consideration of the results of the One Inch Standard sheets as printed by the various methods described. Those printed with litho. off-set ink may be at once eliminated when compared with prints in ordinary Lithographic ink. The off-set ink contains no "body" and gives a bluish and transparent tinge to the ink on the printed copies and cannot at all compare with the black and definite lines of prints in ordinary ink.

This leaves us with three comparisons as below:—

(*i*)—The relative merits of the prints by the Rubber Off-set method from helios by direct sunlight or by the aid of the mirror.

(*ii*)—A similar comparison of prints by the direct method, and;

(*iii*)—A final comparison of the best prints from the two different classes of helios both by the Rubber Off-set and by the Direct methods.

Taking these in the order given, it is noticeable that the finer detail is well brought out in both the prints from Rubber, but that detail has distinctly thickened in that from the helio. by direct sunlight, whereas this is very slight in that from the helio. taken with the aid of the mirror, and, with the exception of the want of luminosity and a certain greyness due to the lack of depth of colour in the ink, the latter may be said to be excellent. Fine detail is sharp and clear and lettering has not appreciably thickened, while the general result is pleasing to the eye.

On a similar comparison of the prints from the two helios by the direct method, the great superiority of the print from the helio. with the aid of the mirror is at once apparent.

This brings us to the final comparison of the prints by the Rubber Off-set and direct methods. The Rubber Off-set print from a helio. by direct sunlight may be set aside, but that from a helio. with the aid of the mirror, though there is a slight thickening of the lines, is undoubtedly superior to the print by the direct method from a helio. by direct sunlight, due to much of the fine detail being broken and lost in the latter, and this leaves us with a comparison of the prints by the two methods, both from helios taken with the aid of the mirror.

Taking the light impression by the direct method, there is little to choose between it and the Rubber Off-set. Every detail is brought out on both and though the Rubber Off-set print lacks luminosity and is slightly heavier and thicker, and I am inclined to the fineness of the general appearance of the direct print, yet the lines of the former are brought out slightly better than the latter.

Turning however to the dark impression by the direct method, I consider it brings out every detail, is sharp, luminous and of full depth of colour and proves that the new helio. has if anything, where impressions with a full luminosity and depth of colour are required, made the direct method superior to printing by Rubber Off-set.

15. One great lesson from the Rubber Off-set method is apparent throughout, and that is its capacity, no matter what the helio. of bringing out fine work in a manner which the direct method from a helio. by direct sunlight is quite unable to achieve, and this might lead one to acknowledge its superiority. Before doing so, however, I hold that it should be very carefully considered as to whether the direct method from a helio. taken from parallel rays of the sun with the aid of a mirror, or from an arc lamp with a parabolic reflector, is not better or at least equally good. This new helio. has splendid printing qualities,—the work does not come away on the plate nor does it "bung up", and it is capable of carrying the full amount of ink without spreading, thus insuring perfect blackness of the impression.

For the Rubber Off-set Machine it has been stated that the abolition of a reversing prism reduces exposure and should tend to give slightly better definition. The Photo.-Litho. Office is equiped with the very best lens and prisms and we have not found any difference required in the exposure, nor has any appreciable improvement been noticeable in the definition.

As regards printing from Rubber, there is no great difficulty in the actual operation but it requires a longer time to start the machine and to register colour work, the register being quite as good as the direct method but troublesome, while there is the additional disadvantage that, for any shift in the registration the blanket has to be washed each time it occurs.

It must also be remembered that any dents or marks on the rubber are permanent faults on every copy and on all subsequent work printed from the same blanket.

There is no doubt that the method is most suitable for flat commercial work and black jobs with long runs, using hard or rough paper, but for the reproduction in colours, of maps where runs are short, and the registration of each impression requires minute examination, and where the impressions are pulled on good printing paper, it is extremely doubtful whether the results, though equal, are appreciably better than those obtained from the direct method; nor does Rubber Off-set Flat-bed Machine Printing offer any gain in rapidity of printing.

16. In the event of the Rubber Off-set being admitted as superior to the direct method, the extent of its introduction will require very careful consideration and it is probable that, for the sake of convenience and expedition, it would be necessary to convert at least all the smaller machines in the Office for use by both methods or replace some of the older machines with new ones from Home.

The Studio would require enlarging and re-arrangement of the cameras and plan boards, though probably the alteration in position of two cameras and their plan boards would be sufficient; at any rate, it would be undesirable to re-arrange more than this number without a full experience of the advantages of the new method. At first much inconvenience would result from the use of both reversed and direct helios though this would eventually disappear.

17. The printing of layered maps by the Rubber Off-set method has been tried.

Using the same tints and rulings as for the direct method, there is not any large difference in the two results though, if any thing, those by the direct method give a sharper and clearer impression.

18. Were it a question of Rubber Off-set Rotary Machine Printing, there is no doubt that its equality of results and the enormous increase in rapidity of outturn gains for it a vast and immediate superiority where long runs are required.

19. This Report would not be complete without an acknowledgment of the excellence of the Mann's Rubber Off-set Printing Machine both for Rubber Off-set and for direct work.

SACKVILLE HAMILTON, *Captain, R.E.*,
Officer in charge Photo.-Litho. Office.

29th May 1914.

APPENDIX.

REPORT ON RUBBER OFF-SET PRINTING FOR MAPS PREPARED AT THE SCHOOL OF MILITARY ENGINEERING BY MAJOR W. M. COLDSTREAM, R.E., IN 1910.

SUBJECTS OF PARAGRAPHS.

APPENDIX.

——:o:——

REPORT ON RUBBER OFF-SET PRINTING FOR MAPS BY MAJOR W. M. COLDSTREAM, R.E. 1910.

(1) General.—The principle of rubber off-set printing is that the impression, instead of being transferred directly on to the paper from the stone or zinc, is received from the stone or zinc on a rubber blanket and thence transferred to the paper.

This principle has been in use for many years for printing on tin, but it is only during the last few years that it has been adopted for ordinary lithographic or zincographic work on paper. It is now coming into general use in the printing trade all over the world, and the Ordnance Survey have begun to use it largely for printing maps.

(2) Reasons for the general adoption of the method by the printing trade.—Leaving for later consideration the special requirements of map printing, the grounds on which so many printing firms have adopted rubber off-set printing are:—

(i) The impressions from the rubber blanket can be transferred in great perfection to any paper however hard or rough, whereas an impression on rough or hard paper taken directly from the stone or zinc is very imperfect.

(ii) The rotary off-set rubber machines work very rapidly. Black impressions can be delivered at the rate of 5,000 to 12,000 or more per hour and even with high class work requiring very exact register, such as Ordnance Maps, the colour impressions are delivered at about 1,300 per hour.

(iii) In heliozincographic work, rubber off-set printing does away with the necessity for a reversing prism attached to the lens; thus saving initial expense, reducing exposure, and tending to give slightly better definition.

(iv) In both black and colour printing, as only a very small amount of ink is necessary to give even the fullest solid, there is considerable economy in ink.

These advantages are obtained at the cost of certain disadvantages:—

(i) As the work on the old plates is not reversed, they can not be used in all rubber off-set machines, unless this is specially provided for, or unless reversed prints will meet requirements.

(ii) The large number of rollers in the rotary rubber off-set machines, (these alone have the great advantage in speed of printing), entails a considerable increase in the labour and time required for change of colour.

(iii) A minor drawback is that proofs obtained in ordinary presses without special arrangements are reversed.

(iv) There is generally some trouble at first with the off-set machines while the printers are getting used to them. (This is incidental to all new machinery.)

These disadvantages are of little importance in the lithographic printing trade, because:—

(i) Only a comparatively small number of ordinary printing jobs are reprinted from the original plates.

(ii) The average "run," or number of copies printed, is so high (several thousand copies), that the delay in changing colour is more than compensated for by the rapidity of printing.

(iii) Special reversing beds allow of non-reversed proofs, being obtained in ordinary presses, and in many cases reversed proofs meet requirements. Most rubber off-set machines are being made to print either as off-set or as direct printing machines.

(iv) Once a good printer has become accustomed to the new method it offers no special difficulties for ordinary work.

(3) Special features in map printing which affect the use of rubber off-set printing.—While there is no doubt as to the solid advantages in rubber off-set printing to the lithographic trade generally, there are special features in map printing which affect the introduction of the method for that work.

Such special features are:—

(i) Quality of impression is most important. Illustrations, trade circulars, &c., may be quite as useful if the impressions are not absolutely clear and sharp and unbroken, but if maps are to be clear and legible, the impressions must be very good.

(ii) Maps, especially Indian maps, are printed in much smaller runs than trade jobs.

(iii) Maps must "register" exactly.

(iv) As a rule maps require careful scrutiny, if not examination, at proof stage.

(4) Quality of impressions.—Private firms in adopting the new method do not seem to have expected to get better impressions by it on good printing paper, their object being to be able to print well on any sort of paper, and to print rapidly. Maps are practically never required to be printed on rough materials; good printing paper can generally be used. Handkerchief maps are an exception, but not an important one, because specially strong paper with a good printing surface is obtainable, and is now, I believe, being used in India to replace cloth for manœuvre maps.

It is, however, claimed for rubber off-set printing, that even on the best paper, better impressions can be obtained from the rubber than by direct printing, and the experience of the Ordnance Survey at Southampton substantiates the claim.

The blanket allows of a minimum supply of ink being applied to the plate and it takes up practically all the ink from the plate and transfers it to the paper without squashing or spreading, leaving both the thick and the thin lines clear and sharp and unbroken and reproducing on the paper the very finest line or dot shewn on the plate; also the helio. plates, being printed from nonreversed negatives without the use of a prism, may be expected to be slightly better in definition than ordinary helios.

Colonel Hedley, R.E., the officer in charge of Map Reproduction at Southampton, has found that rubber off-set printing has effected a marked improvement in the quality of the impressions, and this was evident on a comparison of the impressions, which were being delivered by the off-set machines at the time of my visit, with those printed in direct printing machines.

Opinions of the private firms I consulted as to the superiority of rubber off-set impressions over directly printed impressions on the best printing papers are not quite unanimous.

While Messrs. Sprague & Co., of 148, Upper Thames Street, London, Messrs. Blades, East and Blades, Finsbury, and Messrs. Suttley and Silverlocks, have also arrived at the same conclusions as the Ordnance Survey on this point, Messrs. Brown & Co., of St. Mary Axe, London, do not consider that on good paper rubber printing yields better impressions than direct printing. It is difficult to understand why the experience of this firm should be different, because there can be no question that elsewhere the impressions have improved since the introduction of off-set printing.

Messrs. Blades, East and Blades, and Messrs. Suttley and Silverlocks have experienced some difficulty in getting their black impressions absolutely black, although they are sharp and unbroken, but no difficulty has been found in this at Southampton. Again Messrs. Suttley and Silverlocks and I believe, some other firms, have found some difficulty in obtaining sufficient brilliancy in their colours from rubber, and are getting over this by grinding the colours very fine. Messrs. Blades, East and Blades, however, do a great deal of colour work on their off-set machines, using trade colours, and find no difficulty in securing brilliancy, the colours of the map I saw being printed from rubber at Southampton were good, and Colonel Hedley informs me that no difficulty has been experienced in this direction.

The well-known cartographer Mr. J. S. Bartholomew is considering the advisability of adopting the new method, but Messrs. W. & A. K. Johnston have not tried it and apparently do not intend to at present.

None of these firms, however, do exactly the same kind of work as that of the Indian Survey, or as that for which the Ordnance Survey use the new method; both Messrs. J. S. Bartholomew, and W. & A. K. Johnston engrave their maps by hand on copper, and print them from stone, while the other private firms do comparatively little work of the same description as map printing.

The Indian maps are reproduced by heliozincography, a much cheaper and simpler process than is used by the majority of civilised Governments for their topographical maps; it is inferior to hand engraving, copper etching, or drawing on stone, but the results of rubber off-set printing at Southampton show that with rubber off-set printing this inferiority is greatly reduced, and the quality of an impression obtained by rubber off-set printing from a first-class helio. approximates to that of an engraved map.*

(5) Speed as affected by the average size of "runs" in map printing.—The average "run" of a map printed in the Calcutta Survey Office is 500 copies. This is so small that the time spent in changing plates or changing colour, swamps any advantage gained by rapidity of printing.

Rotary machines which, though they print at a very high speed, require over 4 hours† to change colour, are therefore unsuited for Indian map printing. Changing plates to print in the same colour takes practically the same time on a rotary as on a flat-bed machine, but even with big runs, the full speed of a rotary machine is not available for printing maps in colours, because the necessity for very exact register reduces the rate at which it is possible to "lay on" or feed the sheets into the machine.

---

*Note (1).—It can never equal it so long as a line can be cut more firmly and smoothly on copper than it can be drawn on paper, but provided the following requirements are obtained, it is not always easy to detect the difference between first-class heliozincography and ordinary engraving.

(i) Good drawing and lettering, executed for reduction.
(ii) The best quality of lens.
(iii) A good helio.
(iv) Impressions from rubber.

The drawing of our Indian maps is still improving, our helios are good and can perhaps improve still further, we are obtaining the best lens procurable from Zeiss at a cost of £ 500; it would therefore seem a mistake to be unable to do full justice to these improvements by printing from rubber.

† Note (2).—Messrs. Suttley and Silverlocks' foreman told me that, even with separate sets of rollers for the different colours, it takes 3½ hours to clean and change colour.

Mr. Allen, an employé in the Ordnance Survey Office at Southampton, has invented and patented an ingenious automatic feeder consisting of a slide plate which automatically brings each sheet gently but rapidly against the guides; but even with this contrivance, register would suffer if a rate of about 1,300 impressions per hour were exceeded. A rotary rubber off-set machine with an automatic feed can deliver 5,000 copies per hour, if register has not to be attended to.

The two principal makers of rubber off-set machines in England have recognised that there is work for which the high speed rotary machines are unsuited, and although the mass of rubber off-set work in the trade is done by rotary machines, they also make flat-bed machines which are used for smaller runs.

On these machines, changing plates and changing colours takes practically no more time than on an ordinary direct flat-bed machine. They are very little more complicated in construction than an ordinary flat-bed machine, and cost little more, whereas a rotary rubber off-set machine costs more than double a direct printing flat-bed machine of the same size, and is a complicated piece of machinery requiring some skill as a mechanic on the part of the printer.

From the above it will be seen that, where the runs are small, rubber off-set printing offers no advantage as regards speed.

(6) "Register."—Map printing requires more exact register of colours than is necessarily aimed at by private firms, who do comparatively little work in colour, that suffers if the register is 'out' by one eightieth of an inch.

The Ordnance Survey have put their rubber off-set machines to the very severe test of printing the orange lines that fall exactly within the fine black lines representing the margins of roads on their maps, and the number of copies rejected owing to the orange not fitting in exactly has been very small. The register obtained by rubber off-set machines may therefore be considered as good as that obtained by direct printing.

(7) Necessity for non-reversed proofs and prints for colour guides.—The plates used for rubber off-set printing being non-reversed, yield reversed proofs, when proofs are pulled in an ordinary press. As non-reversed proofs are essential in the case of maps, either of the following methods must be employed:—

(*a*) Special reversing beds are made to fit an ordinary press. These beds are provided with rubber tympans, on which the impression is taken, and from which it is then transferred to the paper. So far, reversing beds appear to have been made in small sizes only, and do not seem to be in general use.

(*b*) The proofs can be printed on a transparent material and examined from the reverse side. Ordinary tracing paper is too flimsy for proofs and tracing cloth is expensive and loses its transparency. A suitable material is "glasseine" or Halden's tracing paper. Messrs. Sprague & Co. use the former material for their proofs. The latter is used for trace prints and instead of ordinary tracing paper generally, by Mr. T. S. Bartholomew.

Reversing beds for Indian maps would have to be specially made, and unless proofs on Glasseine or Halden's tracing paper were found to be unsatisfactory, would not be necessary.

Grey or blue prints from the complete outline plates, for the preparation of colour guides from which to duff the negatives, can be obtained the print being examined from the impression side when being used by the "duffers", or cyanotypes may be used.

(8) Effects of the Indian climate on rubber blankets.—Rubber blankets cost from £1 to £2-10 according to size, they appear to be fairly durable. At Southampton one blanket was spoiled before an efficient cleaning mixture was obtained (see paragraph 9), but since then the blankets now on the machines have been in constant use for about a year without serious deterioration. At one private firm I visited, the rubber blankets last over 8 months without deteriorating, and at another over 6 months.

I have been unable to procure any data as to the effects of a hot climate on the blankets, but Messrs. Mann & Co. write :—

"We find that the warmer climate does not affect them to any serious extent. We have machines running in 22° and 24° latitude and no complaints from *(sic)* rubber blankets have been rceived."

As one of Messrs. Mann's rubber off-set machines has lately been supplied to the Survey Department of Ceylon, I have written to Colombo to enquire whether the rubber blankets have deteriorated seriously there.*

(9) Difficulties experienced in the introduction of rubber off-set printing by the Ordnance Survey.—Any good printer can learn to print well with rubber off-set machines, but the rotary machines are considerably more complicated than ordinary flat-bed direct printing machines, while even with flat-bed rubber off-set machines the printers require some time to get used to the method.

At Messrs. Sprague's and at Southampton it took about two months to train the printers to off-set printing and some difficulties were experienced at the start, other firms put the time required for learning at a month to six weeks.

The following are the special points which required attention at Southampton :—

(*a*) The rollers, more especially the damping rollers, supplied with the new rotary machine, did not work properly up to the edges of the plate, owing to the packing being bevelled off at the shoulders. It was found necessary to repack the rollers in order to square the ends at the shoulders. This defect has been brought to the notice of the makers and the rollers supplied with new machines by Messrs. Mann should be free from it.

(*b*) Trouble was experienced in washing the rubber blankets, and one was spoiled before the adoption of the following washing mixture :—

½ Methylated spirits.

½ Benzole.

Messrs. Furnival recommended for this :—

Washing first with water, then with ordinary paraffin, and then wiping with lamb's wool, dipped in a powder made of French chalk, flowers of sulphur, and magnesia. This restores the surface of the rubber. The paraffin should be kept on as short a time as possible.

(*c*) It was found that in order to obtain the best impressions, little or no varnish should be added to the ink. The only reducing medium now used is boiled linseed oil.

---

* The reply was to the effect that the rubber blankets had stood the climate well.

At Southampton, ordinary litho.-printing ink is used, (Stoehr's), but Messrs. Furnival recommended the use of the following special off-set ink :—

For black—Messrs. Nicholson', (London).

For colours—Messrs. Alton and Wiborg, (New York and London).

They do not, however, consider that there is much radical difference between these special inks and ordinary inks.

(*d*) It is found to be most important that the zinc plates for use in the rubber off-set machines should receive a rather coarser grain than those for use in direct printing machines.

A specimen of the grain found to be most suitable was produced. This grain is obtained with glass balls, and moulder sand from the New Forest, (Messrs. Lancaster, High Street, Southampton). The sand is passed through a 60 mesh screen, that used for graining ordinary plates being passed through a 100 mesh screen.

Plates for off-set printing receive 45 minutes graining in the machine. A small supply of sand is put in with the plate, and fresh supplies are added after 20 minutes and 40 minutes.

Curiously enough, Messrs. Blades, East and Blades, who do a large amount of high class printing from zinc, have not found any difficulty in printing from plates with the same grain they apply for direct printing, which is extremely fine, considerably finer than that used either at Southampton or Calcutta. Mr. Blades, who took me to see his graining machine at work, believes strongly in the advantages of a very fine grain, and has had no trouble in printing from the finest grain he can obtain. Almost all his work is transferred to the zinc by means of transfers from hand-engraved copper plates.

Mr. Blades' plates are grained in an ordinary graining machine, but the balls employed to give the grain are porcelain, and instead of sand powdered pumice is used.*

(*e*) When inserting the plate in the rotary machine, it was found that if the screws are tightened with much force, the plate is stretched: to avoid this the use of the spanners is forbidden, and screws are tightened by hand.

With the rotary off-set machine, the arrangements for bringing paper up to the guides in laying on, were found to be inadequate to insure exact register when the machine was run at a normal speed. To remedy this, Mr. Allen, an employé in the office, invented the ingenious automatic feeder, referred to above in para. 5. Before this was introduced, it was not possible to get the very exact register required, at any but a very low rate of speed, as with the arrangements supplied by the makers, the paper was brought up against the guides with such force, when the machine was running fast, that it rebounded again. Mr. Allen has been allowed to protect his invention.

No trouble is now experienced with register. I saw the blue impressions of an Ordnance ½″ map, which is a larger sheet than any of our standard maps, with much blue detail requiring exact register, being delivered by the rotary off-set machine at the rate of 1,280 per hour.

(10) Conversion of direct printing flat-bed machines for rubber off-set printing.—The Ordnance Survey, Messrs. Sprague, and Messrs, Blades, East & Blades, have had one or more direct printing machines converted to rubber off-set printing, and the makers of rubber off-set machines are converting large numbers of ordinary flat-bed machines.

*Note.—In Calcutta, when we experimented with a fine grain obtained by pumice, we found the work apt to come away, when printed. And Southampton has found the same difficulty with any but a coarse grain when printing from rubber, but there is, Colonel Hedley informs me, a great difference in this respect between transfers from copper and helios.

The conversion of the Southampton machine, (a Furnival), was carried out at a cost of £120. The machine works satisfactorily, except that the delivery is not perfect, and is kept for rubber off-set work, although it is still available as a direct printing machine. The conversion of Messrs. Sprague's flat-bed machine, (a Mann's), was carried out by Messrs. Mann whose charge for converting a double demy is £150: it works satisfactorily, both as a rubber off-set and direct printing machine. Messrs. Blades, East & Blades had their machines converted by Messrs. Eyre & Co. of Manchester.

Messrs. Mann informed me that they could not undertake to convert Furnival machines in India, by sending out the additional parts to be fitted and adjusted locally. They would however be prepared to supply new flat-bed rubber off-set machines, (price for a double demy, without any extra fittings, £320), and to take Furnival machines in part payment; they would allow £75 to £100 for a Furnival double demy under 10 years old, and pay its carriage to England, provided it were put on board the ship at the cost of the Indian Government.

As a rule printing machines do not stand dismantling and reassembling well, and the extra cost of new machines would probably be worth paying, unless the conversion could be carried out at Calcutta.

Messrs. Furnival of Reddish, however, consider that there would be no difficulty in our carrying out the conversion of their machines at Calcutta: the additional parts being sent out from Reddish, with drawings and full particulars. In arranging for this, Messrs. Furnival should be supplied with the numbers, dates, and size of the machines to be converted.

Messrs. Furnival charge about £130 for converting a quad-demy machine.

The price of a new flat-bed rubber off-set machine by Messrs. Furnival is £500.

(11) Principal makes of English rubber off-set machines.—The principal English makers of rubber off-set machines are Messrs. Mann of Leeds; Messrs. Furnival of Reddish, and Messrs. Lockett, the makers of the "Waite" off-set press, London.

Both Messrs. Mann's and Messrs. Furnival's rotary machines have the following ingenious adjustments. The inking rollers are automatically thrown out of contact, if an impression is not taken, so as to avoid the plate receiving a double charge of ink. The amount of water transferred to the plate by the damping rollers is subject to control. When the machine is running, the rubber cylinder can be instantaneously thrown out of printing contact with the impression roller, thus letting the paper run through unmarked.

Messrs. Furnival's rotary machine is a one-revolution machine, that is, there is one revolution to each impression; in Messrs. Mann's rotary machines, there are two revolutions of the small cylinder to each impression.

At Messrs. Blades, East and Blades, I saw an American high speed rubber off-set rotary machine which prints over 12,000 impressions per hour; it has an automatic feed requiring practically no work on the part of the layer on, and is said to yield very exact register. This machine cost £1,200; it is used only for very long runs, and is a rather complicated and delicate piece of machinery, requiring the attention of a fitter or mechanist, rather than a printer. The same firm has English rotaries and converted flat-beds in use, the former for long runs, the latter for short runs.

The following will give an idea of the comparative prices of the three firms. The prices are approximate only :—

Machines, double-demy, to take a plate, 32" × 24".

		£
Rotary off-set machines	Messrs. Mann ...	650
	Messrs. Furnival ...	600
	Messrs. Lockett ...	550
Flat-bed machines	Messrs. Mann ...	350
	Messrs. Furnival ...	500
Converting flat-bed direct printing machines to off-set printing.	Messrs. Mann ...	150
	Messrs. Furnival ...	130

Either of these flat-bed machines are suitable for map printing.

Were it a question of purchasing 2 or 3 new machines, I am inclined to think that perhaps Messrs. Mann's machines should be selected. Messrs. Mann are the pioneers of the new principle in England and have kept in touch with the work of their rotary machine in Southampton. They claim that all the working parts are cut, whereas in other machines, some of the working parts are cast. Opinions among practical printers differ as to the relative advantage of the two makes.

(12) Conclusions arrived at.—(I). Rubber off-set printing yields better impressions than direct printing whatever be the material printed on, and registers quite as well as direct printing.

(II) For printing large "runs", say several thousand copies, the rotary off-set machine, which has a speed of 2,000 to 12,000 impressions, if exact register is not required, and of 1,200—1,300 impressions if exact register is essential, offers great advantages, both as to speed and in the small compact size of the machine; but it is not suitable for small runs.

(III) Flat-bed rubber off-set machines offer all the advantages of rubber off-set printing as regards quality of impression, but have no advantage over direct printing as regards speed.

(IV) Flat-bed rubber off-set machines are no more difficult to run than flat-bed direct printing machines, once the printer has become accustomed to them.

(V) A good English printer takes about two months to get into the way of printing from rubber. An Indian would probably take longer.

(VI) The experience of the Ordnance Survey shows that the following points require attention in rubber off-set printing.

(a) A coarse grain is required on the plates.*

(b) The rubber blanket should be cleaned only with a mixture of ½ methylated spirits and ½ benzole.

(c) Boiled linseed oil is the only safe reducing medium for the ink.

(d) Special care must be taken to see that the rollers are well packed.

(e) For fast running in an ordinary rotary machine, Mr. Allen's automatic feeding arrangement is essential to secure good register.

(f) Care must be taken not to stretch the plates, when inserting them in the rotary machine.

* NOTE.—But see also second part of para. 9 *(d)* of this report.

(VII) So far as could be ascertained, the rubber blankets will stand a hot or damp climate sufficiently well.

(VIII) Ordinary flat-bed machines can be converted for rubber off-set printing at a cost of £130 to £150 in England, for a double demy machine.

(IX) New flat-bed rubber off-set machines cost only about £60 more than flat-bed direct printing machines.

(X) Rotary off-set rubber machines cost about £600 to £650 (double demy). All three of the principal makes of rubber off-set machines are apparently satisfactory.

(XI) A flat-bed rubber off-set machine can also be used for direct printing; this would allow of the new machines being used both for new editions and reprints, if the new method of printing were introduced at Calcutta.

(XII) Rubber off-set printing by doing away with the use of the prism, reduces the exposure in photography by about half, and must tend to improve definition.

(XIII) It would not be advisable to introduce rubber off-set printing for all standard maps at once. One new machine might be purchased, and one of the Furnival machines converted, and a year later, when the printers had been trained in off-set printing, the other old machines, or some of them, could then be replaced or converted.

There is work and room at Calcutta for an additional machine, and I believe that one of the replaced machines could be usefully employed at Dehra Dun.

During the year, while some of the standard sheets were being printed direct from zinc and some from rubber, we should suffer from the inconvenience of having either to use different lenses for each class of work, or of continually having to remove and readjust the prism on the best lens. This however would be less serious than having to do without three or more machines for several months, during this conversion, all at the same time, and then having to face arrears of work with men untrained in off-set printing.

(13) Acknowledgment of assistance received in compiling these notes.—For the information contained in this report, and for courteous permission to see there offices or works, I am indebted to:—

(1) The Director General, Ordnance Survey.

(2) Mr. J. S. Bartholomew, The Geographical Institute, Edinburgh.

(3) Messrs. W. & A. K. Johnston, Edina Works, Edinburgh.

(4) Messrs. Blades, East & Blades, Leonard Street, Finsbury, London, E.C.

(5) Messrs. Suttley & Silverlocks, London.

(6) Messrs. W. W. Sprague & Co., Upper Thames Street, London, E.C.

(7) Messrs. Furnival & Co., 32—34, St. Bride's Street, Ludgate Circus, London, E.C.

(8) Messrs. Mann & Co., 31—32, Kirby Street, Hatton Gardens ½, London, E.C.

(9) Messrs. Lockett & Co., Dean Street, Fetter Lane, London, E.C.

(10) Messrs. Brown & Co., St. Mary Axe, London, E.C.

Captain Brown, D.S.O., R.E., who accompanied me in my visits to most of the above offices, has very kindly given me his notes made during his visit to Messrs. Furnival's works at Reddish and they have been embodied in this report.

To Colonel Hedley, R.E., of the Ordnance Survey, I am especially indebted both for giving me his experience of off-set printing and for many other items of information, which his knowledge of the Calcutta Survey Offices enabled him to select as of particular interest to me.

W. M. COLDSTREAM, *Major, R.E.*

September 1910.

Colonel Hedley, R.E., to whom I sent a draft of this report, has very kindly made the following criticism and remarks :—

(i) He considers that ordinary rotary machines are really no more difficult to manage than flat-bed machines once the printers know them.

(ii) He points out that there is an advantage in printing from rubber which I have overlooked: it does not damage the plate, and there is not the same scum when printing from rubber as from zinc direct; for this reason there are fewer stoppages to etch or rub the plate, and there is less necessity for care and skill on the part of the printer in watching and "doctoring" the plate.

(iii) He considers I am right in recommending flat-bed machines, but would suggest that two *new* machines should be bought.

W. M. COLDSTREAM, *Major, R.E.*

22nd September 1910.