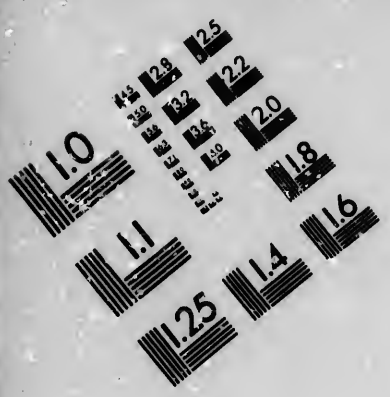


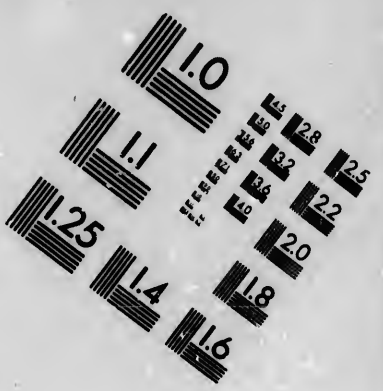
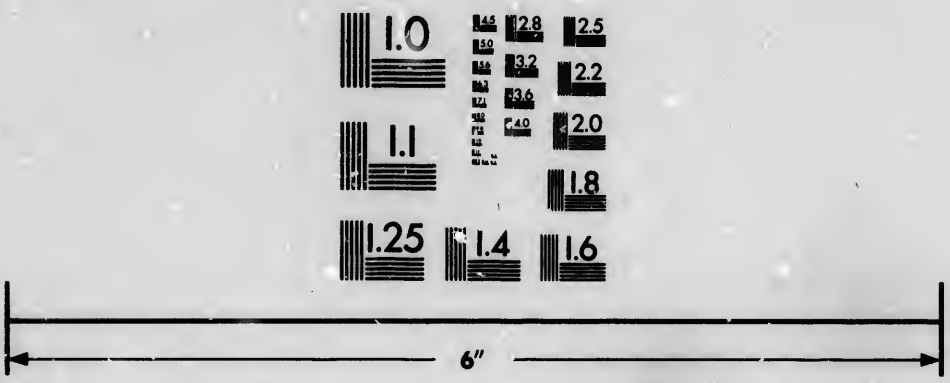
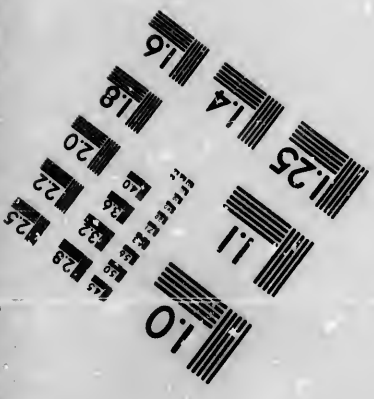


IMAGE EVALUATION TEST TARGET (MT-3)





Photographic Sciences Corporation

23 WEST MAIN STREET
WEBSTER, N.Y. 14580
(716) 672-4503

Technical and Bibliographic Notes/Notes techniques et bibliographiques

The Institute has attempted to obtain the best original copy available for filming. Features of this copy which may be bibliographically unique, which may alter any of the images in the reproduction, or which may significantly change the usual method of filming, are checked below.

- ☐ Coloured covers/ Couverture de couleur
- ☐ Covers damaged/ Couverture endommagée
- ☐ Covers restored and/or laminated/ Couverture restaurée et/ou pelliculée
- ☐ Cover title missing/ Le titre de couverture manque
- ☐ Coloured maps/ Cartes géographiques en couleur
- ☐ Coloured ink (i.e. other than blue or black)/ Encre de couleur (i.e. autre que bleue ou noire)
- ☐ Coloured plates and/or illustrations/ Planches et/ou illustrations en couleur
- ☐ Bound with other material/ Relié avec d'autres documents
- ☐ Tight binding may cause shadows or distortion along interior margin/ La reliure serrée peut causer de l'ombre ou de la distorsion le long de la merge intérieure
- ☐ Blank leaves added during restoration may appear within the text. Whenever possible, these have been omitted from filming/ Il se peut que certaines pages blanches ajoutées lors d'une restauration apparaissent dans le texte, mais, lorsque cela était possible, ces pages n'ont pas été filmées.
- ☐ Additional comments:/ Commentaires supplémentaires:

L'Institut a microfilmé le meilleur exemplaire qu'il lui a été possible de se procurer. Les détails de cet exemplaire qui sont peut-être uniques du point de vue bibliographique, qui peuvent modifier une image reproduite, ou qui peuvent exiger une modification dans la méthode normale de filmage sont indiqués ci-dessous.

- ☐ Coloured pages/ Pages de couleur
- ☐ Pages damaged/ Pages endommagées
- ☐ Pages restored and/or laminated/ Pages restaurées et/ou pelliculées
- ☑ Pages discoloured, stained or foxed/ Pages décolorées, tachetées ou piquées
- ☐ Pages detached/ Pages détachées
- ☑ Showthrough/ Transparence
- ☐ Quality of print varies/ Qualité inégale de l'impression
- ☐ Includes supplementary material/ Comprend du matériel supplémentaire
- ☐ Only edition available/ Seule édition disponible
- ☐ Pages wholly or partially obscured by errata slips, tissues, etc., have been refilmed to ensure the best possible image/ Les pages totalement ou partiellement obscurcies par un feuillet d'errata, une pelure, etc., ont été filmées à nouveau de façon à obtenir la meilleure image possible.

This item is filmed at the reduction ratio checked below/
Ce document est filmé au taux de réduction indiqué ci-dessous.

10X	12X	14X	16X	18X	20X	22X	24X	26X	28X	30X	32X
					✓						

The copy filmed here has been reproduced thanks to the generosity of:

Library of the Public
Archives of Canada

The images appearing here are the best quality possible considering the condition and legibility of the original copy and in keeping with the filming contract specifications.

Original copies in printed paper covers are filmed beginning with the front cover and ending on the last page with a printed or illustrated impression, or the back cover when appropriate. All other original copies are filmed beginning on the first page with a printed or illustrated impression, and ending on the last page with a printed or illustrated impression.

The last recorded frame on each microfiche shall contain the symbol → (meaning "CONTINUED"), or the symbol ▽ (meaning "END"), whichever applies.

Maps, plates, charts, etc., may be filmed at different reduction ratios. Those too large to be entirely included in one exposure are filmed beginning in the upper left hand corner, left to right and top to bottom, as many frames as required. The following diagrams illustrate the method:

L'exemplaire filmé fut reproduit grâce à la générosité de:

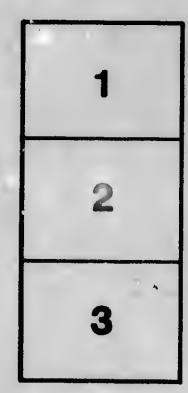
La bibliothèque des Archives
publiques du Canada

Les images suivantes ont été reproduites avec le plus grand soin, compte tenu de la condition et de la netteté de l'exemplaire filmé, et en conformité avec les conditions du contrat de filmage.

Les exemplaires originaux dont la couverture en papier est imprimée sont filmés en commençant par le premier plat et en terminant soit par la dernière page qui comporte une empreinte d'impression ou d'illustration, soit par le second plat, selon le cas. Tous les autres exemplaires originaux sont filmés en commençant par la première page qui comporte une empreinte d'impression ou d'illustration et en terminant par la dernière page qui comporte une telle empreinte.

Un des symboles suivants apparaîtra sur la dernière image de chaque microfiche, selon le cas: le symbole → signifie "A SUIVRE", le symbole ▽ signifie "FIN".

Les cartes, planches, tableaux, etc., peuvent être filmés à des taux de réduction différents. Lorsque le document est trop grand pour être reproduit en un seul cliché, il est filmé à partir de l'angle supérieur gauche, de gauche à droite, et de haut en bas, en prenant le nombre d'images nécessaire. Les diagrammes suivants illustrent la méthode.



Gorge
chap. in Niagara

ADVANCE COPY.

First proof, subject to correction. This copy is mailed to you with the hope that you will take part in its discussion, either in writing or orally.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

TRANSACTIONS.

NOTE.—This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

(Vol. XXXI.— , 1894.)

A FEW REMARKS ABOUT THE NIAGARA GORGE.

By L. L. BUCK, M. Am. Soc. C. E.

TO BE READ AT THE ANNUAL CONVENTION, JUNE, 1894.

Various scientific societies have discussed this gorge and in some cases attempts have been made to estimate the length of time required by the river to excavate the chasm as it now exists. But there are some of its features which appear to have been overlooked in such papers as have come under the writer's observation, and which he has thought might be of interest to our members while they are here, where they will be able to examine and study the question for themselves. It presents abundant opportunities for the development of theories. The writer has had various theories about it, but should any of them become evident in this paper he warns anybody who attacks them that he may suddenly find him on his side regarding them.

To simplify the following description, the gorge has been divided into six parts, as follows:

A B, 11 500 ft. long; *B C*, about 4 000 ft.; *C R*, about 1 200 ft.; *R D*, 2 000 ft.; *E F*, 3 200 ft.; *F H*, 3 700 ft. These distances are but roughly approximate, and obtained by scaling. The portion *A B*, beginning at the falls, is generally about 800 to 1 200 ft. wide at the water surface, has but slight descent and a rather slow current, and along its axis, as shown by the soundings, depths of 120 to 190 ft., the latter depth being toward the upper portion. This is the only portion in which soundings have been taken.

B C, at the water surface, has a width of about 400 ft., a descent of about 26 ft., and, as would be expected, a tremendous current, very much broken up and about 10 or 12 ft. higher in the middle than at the edges.

C R, at the water surface, has a width of about 600 ft., a descent of about 2 ft., current decreasing and becoming smoother at *R*.

R D, the portion known as the Whirlpool, has at the surface a length of 2 000 ft.; width, 1 100 ft. The outlet *E*, on the right-hand side, is about midway between *R* and *D*. The axis of the current from *R* approaches the right side, and while some of the water flows directly through the outlet, the greater part flows past the outlet, impinges against the shore at the right of *D*, turns to the left and circles around till nearly opposite the outlet, where, meeting the portion coming down the left side, both currents are driven toward the outlet, and, passing under the former current, come boiling up at the outlet and flows through it in a new direction at an angle of over 90° from its former direction. Beyond *D* is a ravine, down which a small brook flows and empties into the Whirlpool at *D*. *E F* has a surface width of 600 ft., a descent of 4 or 5 ft., and a considerable current.

At *F* the surface suddenly narrows to about 300 ft. in width, with an increasing current and a descent of 7 or 8 ft., to *H*, where the width becomes about 900 ft.

Throughout the whole distance the sides of the gorge are vertical at the top, and next to the Horseshoes the vertical portion extends nearly to the lower surface. Below this point the banks are vertical or overhanging, with heights of 30 to 60 ft. Below this, a slope formed of the débris from the sides with inclinations of 35 to 45°, extends to the water's edge. The upper stratum of rock is generally 10

to 15 ft. thick of limestone, possessing considerable strength, but flakes off slowly by exposure to the atmosphere. This is succeeded by limestone shale, blue shale, more finely stratified limestone and red sandstone, red shale and limestone strata with clay seams. The existence of the great falls is due to this arrangement of the formation. The water falling over the edge of the top stratum excavates the softer materials below, until the top stratum projects so far out that its own weight and the superincumbent water causes it to break off.

From the soundings below the falls, as well as from a study of the Genesee Falls at Rochester, where the formation is very similar, it appears that generally the fall excavates to a depth below the lower surface about equal to the height of the fall above that surface.

Judging from the generally uniform conditions existing from *A* to *B*, it is reasonable to suppose that the excavation throughout the 11 500 ft. has gone on at about the present rate. If so, it would have occupied a period of about 4 000 years.

At *B* the conditions are abruptly changed. The chasm becomes but about half as wide as at *A B*. Although no soundings can be taken, there is good reason to suppose that the depth does not exceed 80 ft. Then there is the rapid descent of the surface. One feature exists in the formation in this portion which does not occur in the former portion, in the fact that here we have a second strong stratum of rock about 12 to 14 ft. thick, located about 115 ft. below the top one, and suggesting that it may have caused the fall to be divided into two parts, the lower following the upper. This argument is also supported by the fact that immediately overlying this second strong stratum is a stratum of blue shale 50 ft. thick, and which would be rapidly disintegrated by a heavy volume of water falling upon it, or if, with a fall of 115 ft., it suddenly brought up against the second smooth stratum, which would deflect a considerable portion of it laterally and violently against the shale. The excavation here would be much more rapid, and consequently make the gorge narrower.

The Whirlpool appears to indicate that there must have been a great cavity in the rock, although some writers have advanced the theory that at one time the river continued in the direction of *R D* produced, and after excavating the gorge up to about the present outlet became dammed by glacial action or some natural convulsion, which diverted

the water into its present course. This may be the most reasonable theory.

The third striking feature is that at *F H*, where the great protuberance *G* juts out from the left bank, with a considerable ravine between it and the bank, and extending from the lower end about half way to the upper end.

There may have been a long, narrow island about over the highest part of this protuberance before the falls reached this part. This would divide the stream, the larger channel to the right. Such larger channel would cut more rapidly and deeper than the other one, so that by the time the smaller had cut about half way up, the larger would have reached the upper end of the island, and would then divert the water from the smaller channel to itself. The island afterwards would crumble down to its present form.

It must be constantly borne in mind that at whatever point the falls have been, the river above them has spread over a much greater width than that of the present gorge, and that the falls themselves always left the gorge narrower than we now find it, to be afterward widened by atmospheric influences.

In the remaining two miles the gorge presents some features of minor interest, but none so striking as those described.

sonable

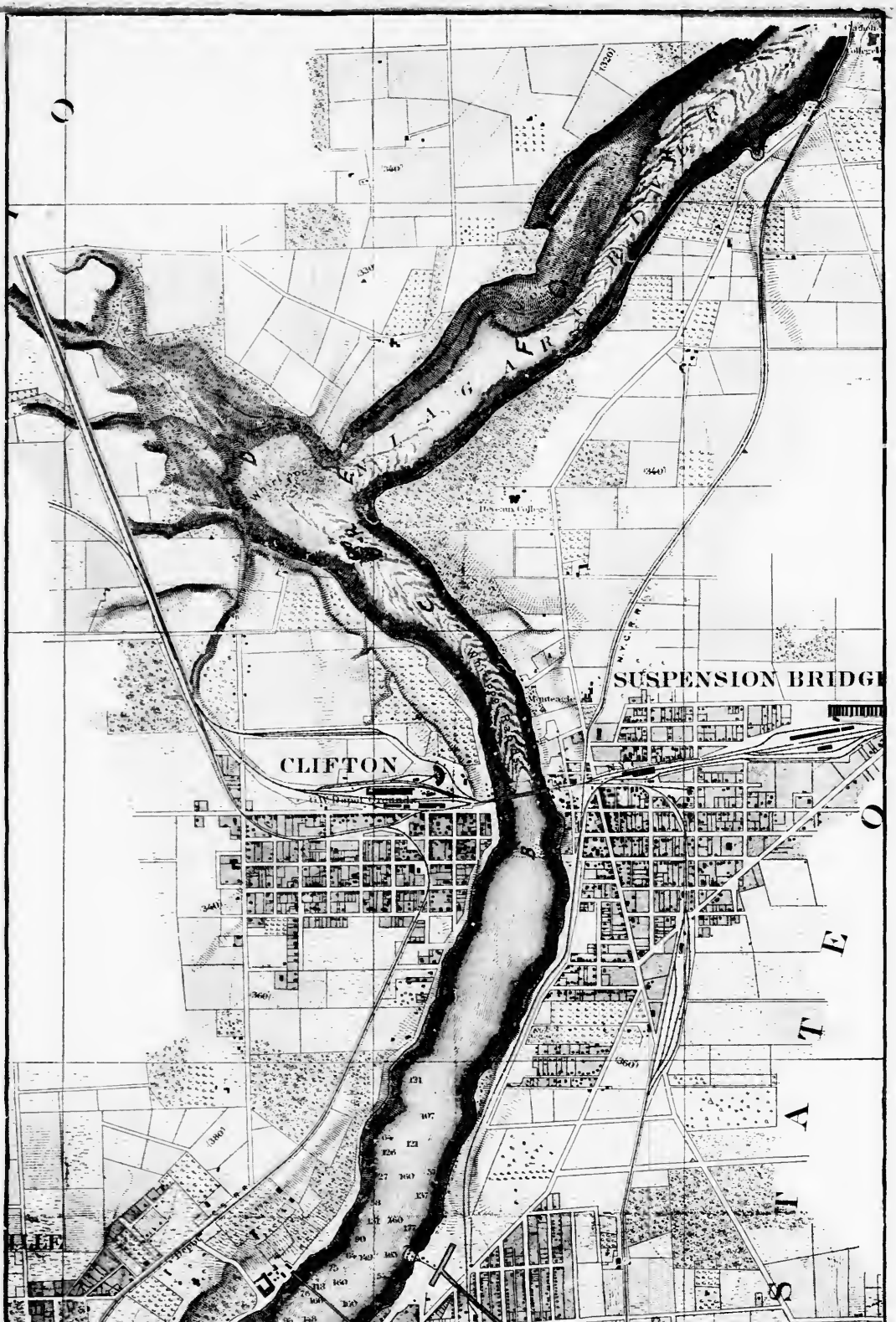
otuber-
between
way to

highest
t. This
h larger
, so that
er would
ivert the
ls would

the falls
er width
s always
widened

atures of


NIAGARA FALLS
GOAT ISLAND
Three Sisters
Grass Island
NIAGARA RIVER
CHIPPEWA
Chippewa Creek
Hydraulic Canal
Erie Depot
ERIE R.R.
N.Y.C. R.R.
the elevations
the intersection
es 20 feet apart,
Niagara at
the level of
ssistant Eng.-
5 and drawn
chart depend
nawanda NY
bserved in 1875.
2275.
Magnetic declination 2°24' West
At Suspension Bridge N.Y.
July 1875
SCALE OF FEET
SCALE OF METRES
SCALE OF MILES


NIAGARA RIVER
Whirlpool
SUSPENSION BRIDGE
CLIFTON