THE DEMOLITION OF RIPPLE ROCK

by Mr. J.I.A. Rutley(*)

The Location

Lying off the Pacific mainland Coast of Canada are numerous islands that form a natural breakwater, behind which coastwise shipping makes sheltered passage. This « Inside Passage » is deep and free of serious navigational hazards. Until 5 April 1958, this was not the case. Some 110 air miles northwest of Vancouver, in the middle of Seymour Narrows, where Discovery Passage is constricted in width to about 2 500 feet between Vancouver Island on the west, and Quadra Maud Islands on the east, lay Ripple Rock (see figure 1).

The Rock

Ripple Rock, a steep-sided submerged hill, of volcanic basalt andesite formation, rose from the channel bed, from a depth of over 300 feet on its western side to a northern summit, with a depth of 9 feet at low water and a second summit, 410 feet to the south, with a depth of 21 feet at low water.

Menace to Navigation

Alone, neither Seymour Narrows nor Ripple Rock were too serious a hazard, but combined with tidal streams which attain a velocity at times of 15 knots, with dangerous eddies and cross currents, (see figure 2), was the fact that northbound vessels had to change course by nearly 90° to enter the narrows. If attempting passage during the northward ebb, the cross current could force a vessel onto the rock unless extreme caution was exercised. Coupled with these hazards was the fact that, due to the strength of the tidal streams, the majority of shipping was forced to make passage near slack water, resulting in heavy traffic at these times, with the attending danger of collision.

In view of the hazard, it is easily understood, how, since the first recorded disaster in 1875, twenty large vessels and many smaller craft have been sunk or severely damaged with the loss of 114 lives. Some 1 500

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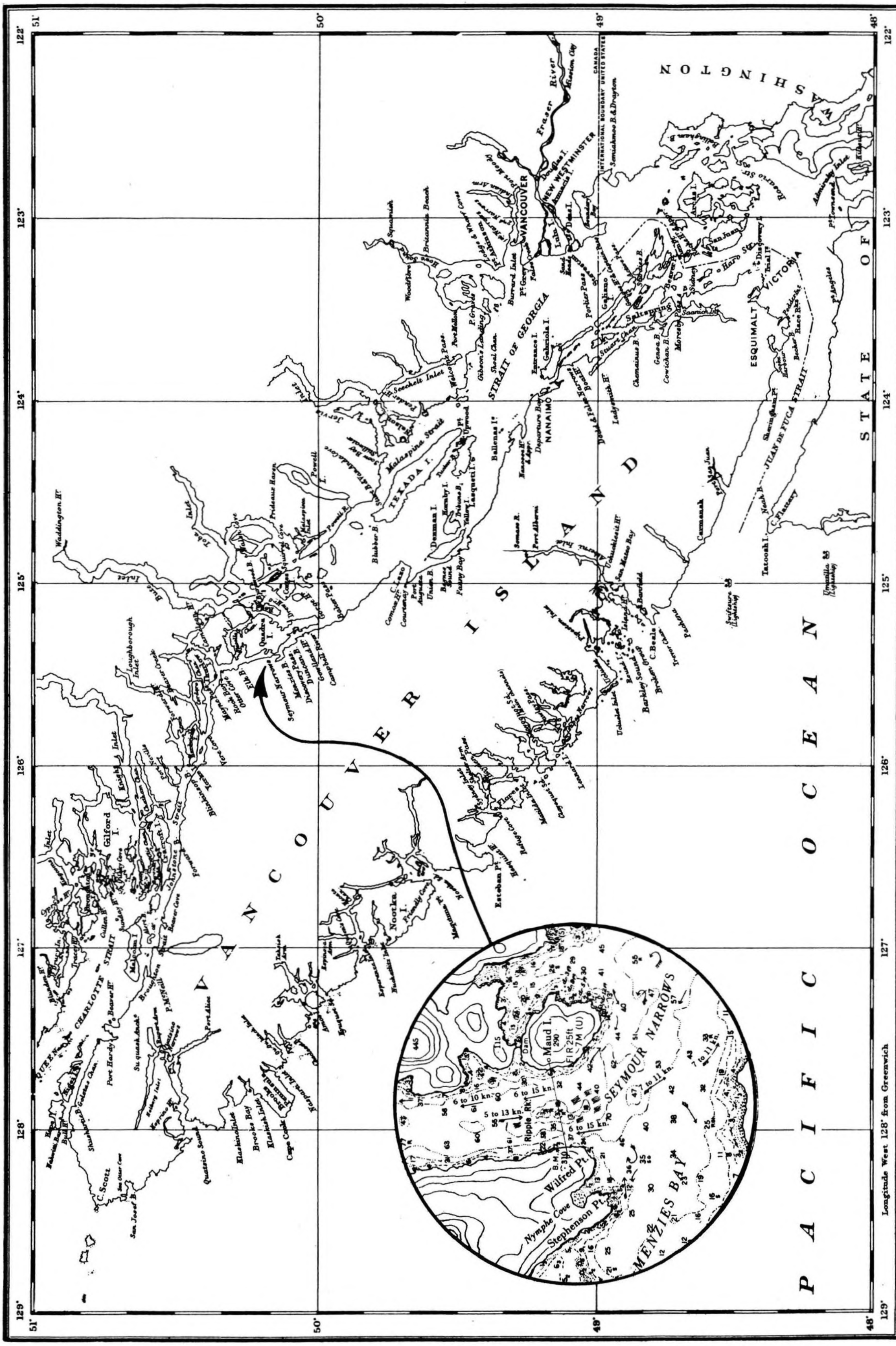

FIG. 1. — Location of Ripple Rock.

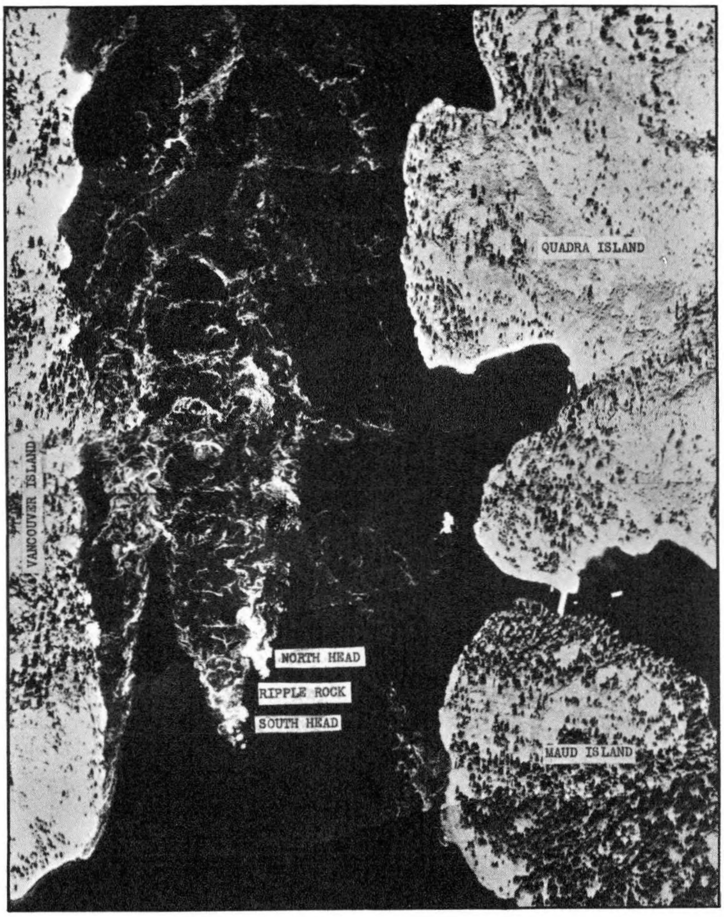

FIG. 2. — The ebb over Ripple Rock.

to 2 000 large ships and 4 000 to 5 000 smaller craft passed Ripple Rock each year with an estimated 175 000 passengers and 100 million dollars worth of cargo. As only ships having a good turn of speed, capable of overcoming the 12- to 15- knot tide, and fast manœuvrability, to cope with turbulence, eddies and cross currents, could attempt passage except at comparatively slack water, many thousands of man- and sailing- hours were lost each year waiting for favourable conditions.

Plans for Removal of Ripple Rock

The removal of Ripple Rock was a subject of discussion in shipping circles for years, the problem being methods and costs. In 1931 the Canadian Government held hearings concerning the rock's removal. Shipping interests were strongly in favour, but some business interests on Vancouver Island were in opposition, on the grounds that the rock was an ideal foundation for a railway bridge to the mainland.

Increased shipping during the Second World War gave such impetus for removal of the rock that, as a war measure, the Canadian Government ordered the Department of Public Works to undertake the task.

First Attempt at Removal

Methods for cutting the two peaks of Ripple Rock down to a safe depth had been under study for years. The method chosen for the first attempt was by drilling from a large barge, moored over the rock, and then blasting. A barge, 150 feet in length, was constructed and equipped with drilling gear. In the summer of 1943 the barge was moored over the rock, and held against the current by six concrete anchors weighing from 75 to 125 tons. There was trouble from the beginning. The strong tidal currents caused the anchor cables to vibrate excessively and the stresses set up thereby caused the cables to break. As the barge could not be held in position by this method, work was suspended.

Second Attempt at Removal

A second attempt at removal was made in 1945. On this occasion, two overhead cables were stretched across the channel from towers on high land on either side, and the barge moored over the rock by mooring cables attached to these two « high lines ». The current and turbulence again proved too much for successful drilling, and the project had to be abandoned. In this attempt, nine workmen were drowned when their small boat was capsized by the eddying current. Nine years were to elapse before any further attempt was made.

New Approach

As a result of continued pressure for the removal of Ripple Rock, the Canadian Government, in 1953, instructed The National Research Council to make a study of the problem and to make recommendations. As a frontal assault on the twin peaks of the rock had proved so unsuccessful, attention shifted to mining under the rock. Before such a project could be undertaken, it was necessary to gain definite knowledge of rock structure. To do this, test drilling was started on Maud Island. The drill hole had first to go down a sufficient depth to pass with safe clearance under the 325- foot-deep channel, between the island and the rock, and then to curve out, and upward, into the heart of the rock. The first attempt at this difficult drilling assignment was unsuccessful in that the curvature of the drill hole was not correct. A second attempt was successful. A hole 2 500 feet in length was drilled and most of the core recovered. The cores were sound and no significant underground flow of water encountered. As a mining problem, working in the rock was entirely feasible and could be done at reasonable cost.

As a result of these studies, the National Research Council reported that the two peaks of Ripple Rock could be removed and recommended tunneling into the rock and setting off one massive blast to dispose of the two hazardous summits. On the basis of this recommendation, the Canadian Government instructed the Department of Public Works to prepare plans.

Aim of Projected Plan

Plans were prepared with the aim of lowering the two peaks to a depth of at least 40 feet below low-tide datum in Seymour Narrows. In October 1955 the contract was let for $ 3 100 000, the project to be completed in 30 months.

Project Data

In line with plans for mining the rock, a shaft 572 feet deep with 7 by 18 feet cross section was sunk on Maud Island. (See figure 3). The shaft contained three compartments, one with a hoist for the miners, a second for rock removal, and a third for pump lines, power cables, ventilation

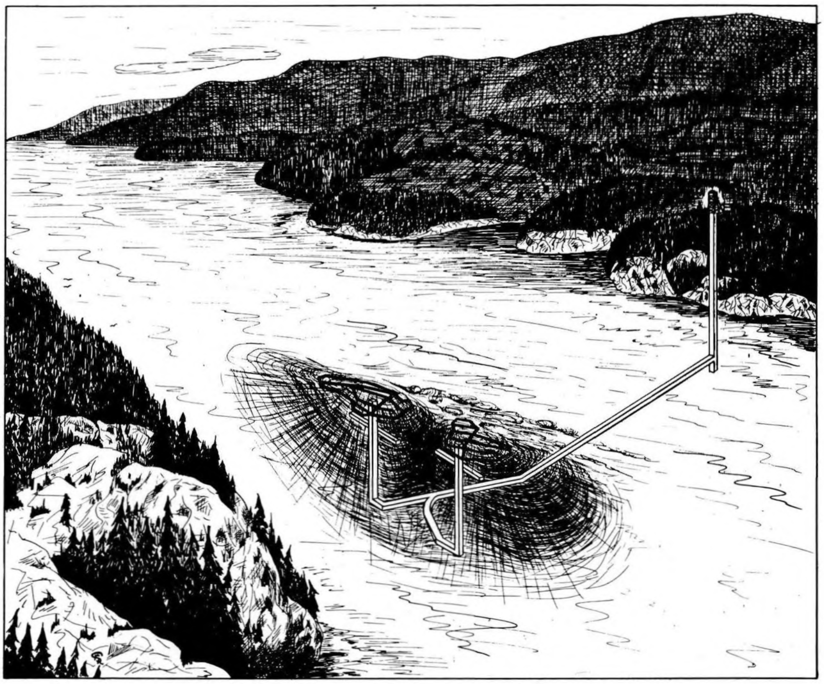

FIG. 3. — Schematic drawing showing the mining of Ripple Rock.

and other service lines. The main tunnel under the channel was 2 941 feet long with a 7 by 18 feet cross section. Rises in the two peaks were 640 feet, 320 feet upward into each peak, with cross section of 7 by 16 feet. Sub-level tunnels in the rock were 569 feet in length, with 6 by 7 feet cross section. Small tunnels, known as Coyote holes, spread in all directions through the two peaks; these had an aggregate length of 3 211 feet, and had a 4 feet by 5 feet cross section. In order to avoid the possibility breaking through the outer shell of the rock, exploratory drilling was kept well in advance of mining, and to determine the location of the outer surface of the rock, holes were drilled through and then plugged. In all, approximately 34 000 feet of exploratory drilling was done.

Choice of Explosive

The explosive chosen for demolition was « Nitramex » 2H blasting agent, an ammonium nitrate product prepared by Du Pont of Canada for blasting extremely hard rock. It has the added advantage of being water resistant, highly insensitive to shock and friction, and must be detonated with a primer charge; it also delivers a large amount of work per unit load. For ease in handling the explosive was packed in cans 6 inches in diameter and 2 feet in length.

Design of the Blast

For demolition of the two peaks of Ripple Rock down to the required depth, the blast was designed by Du Pont of Canada explosives technicians, to break up and disperse approximately 370 000 tons of rock, and at the same time to move 320 000 tons of water. To do this, 1 375 tons of explosive was used. This was packed into the tunnels and Coyote holes in the two peaks of the rock, together with 300 primer cans carefully placed to act as detonators.

Fusing to Detonators

To fuse the detonators, 5.3 miles of Primacord fuse was used to connect the detonators with the detonating station on Maud Island. Primacord is a plastic tube filled with high explosive which burns at the rate of 21 000 feet per second. To ensure detonation, double and in some cases triple fuses were run to the detonators. The detonation was designed to give maximum dispersal, the sides of the two peaks being moved out an infinitesimal fraction of a second ahead of the tops, and the northern peak 12/1 000 of a second ahead of the south peak. The site of the detonating station on Maud Island was about 2 500 feet from the nearest detonator. One fifth of a second was required for detonation of the entire blast.

Choice of Time for Demolition

A consideration in timing the blast, was the best tidal conditions to give a minimum load of water over the rock, and at the same time the maximum current to promote rock dispersal. The time chosen was 9.31 A.M. on Saturday, 5 April 1958, with an ebb tide velocity of 11.5 knots and the height of the tide of 2 feet above low water datum. The ebb was chosen to minimize the effect of shock waves travelling southward towards the town of Campbell River, 10 miles to the south. The effect the blast might have on migrating salmon was also considered. The spring season was chosen as a time when migration is close to minimum.

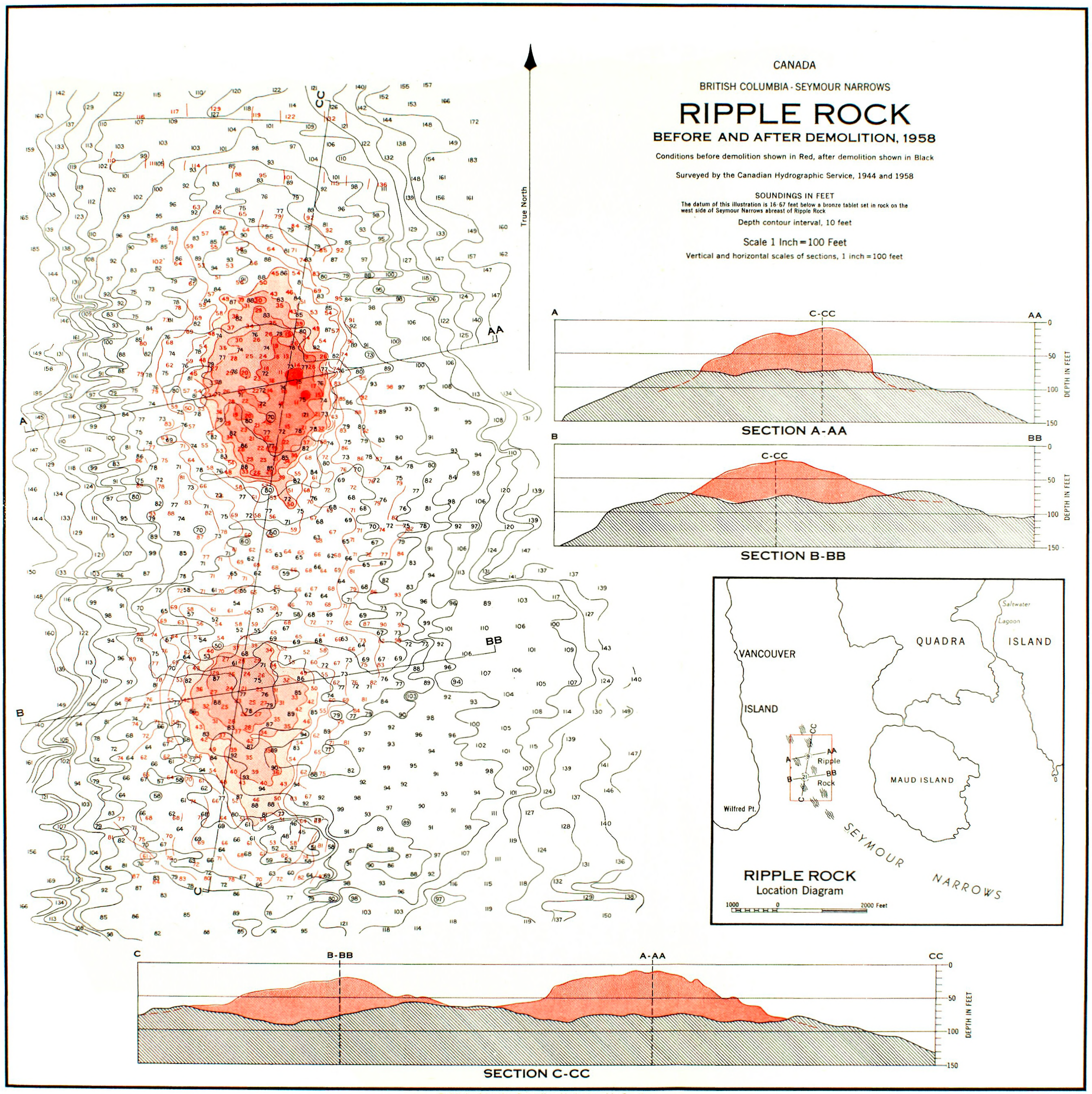

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FIG. 4

Safeguards against Damage

To safeguard life and property against possible damage, as a result of the blast, mariners were warned that an area in Discovery Passage, approximately 4 $\frac{1}{2}$ miles in extent, on either side of Ripple Rock, was closed to shipping. This area was patrolled by the Royal Canadian Mounted Police, before the time set for the blast, to make sure no shipping was within the prohibited area. As a further safeguard, an area, 3 miles in extent from Ripple Rock, was evacuated of all except officially authorized persons, and authorized observers. These latter, mostly representatives of various national and international news services, magazines, and radio and television networks, were required to sign a release from claim of damage while within the evacuation zone. They were also required to wear badges of identification and were to remain within observation shelters provided. As a result of the precautions taken no damage or injuries of any kind occurred.

Result of the Blast

That the result of this carefully planned and massive blast was entirely successful, is shown by a comparison of depths before and after demolition. (See chart fig. 4).

On the northern peak where there had been a depth of 9 feet, there is now a depth of 75 feet and over the entire area, formerly above the 10-fathom line, there is now a least depth of 70 feet.

On the southern peak, where previously there was 21 feet, there is now 77 feet, and little of the rock summit that rose above the 10- fathom line remains. The southern patch, extending above 10 fathoms, contains the shoalest depth on Ripple Rock, 45 feet, and as this is located in an area where there was formerly a depth in excess of 60 feet, this shoal consists of rock fragments dispersed by the blast. The larger northern area, extending above 10 fathoms is, in part, fragments of dispersed rock, as is the small 59- foot shoal close northward of it. Another shoal area with a least depth of 57 feet, consisting of rock fragments, lies about 180 feet southeast of the former southern head.

After demolition, following sounding and examination, the entire area was swept with a wire sweep to a depth of 41 feet at low water, to ensure that Ripple Rock no longer presented any danger to shipping.

Effect of Demolition on Tidal Currents

Investigation of change in tidal conditions in Seymour Narrows, as a result of demolition of the rock, is still incomplete, but certain changes were at once noticeable. The extreme turbulence over the rock no longer exists, and rips and eddies are now largely in the vicinity of the shores of the channel. Little change in the strength of the tidal streams through the narrows can be expected.

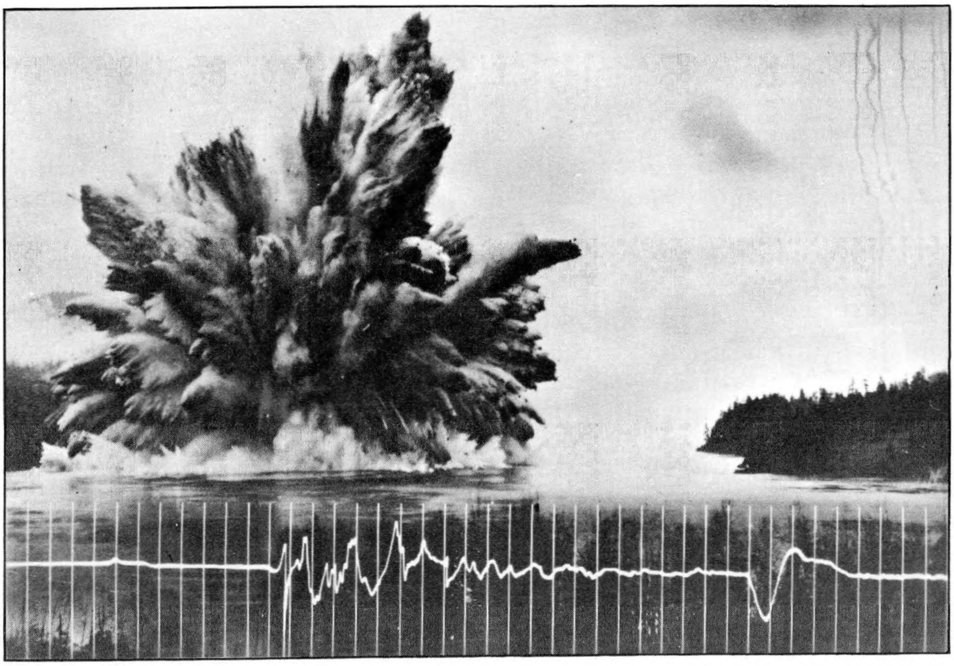

Fig. 5. — The 1 500-foot blast of 703 000 tons of rock and water with seismographic record of the blasts' earth shock superimposed.

Scientific Interest in the Blast

A blast of such unprecedented size created considerable scientific interest. The Seismological Service of the Dominion Observatory realized that the blast would have all the characteristics of a small earthquake with the added advantage that the exact time, location and depth within the earth were known. The Seismological Service undertook the project of measuring the time of travel of the seismic waves from Ripple Rock to seismograph stations located along an east and west line across British Columbia and into Alberta. These included 5 permanent, and 5 temporary seismic stations, as well as a number of similar stations operated in Alberta by oil exploration crews. The seismic wave took 16 seconds to reach the westernmost permanent recording station at Port Alberni, B. C. and 90 seconds to reach the easternmost permanent station at Banff, Alberta. The latter took 2 seconds longer than expected, which, according to the seismologists, is an indication that the high mountains along this route may have roots extending beneath the earth crust into the mantel. Analysis of the seismic records obtained is still incomplete.

A study of the effect of the blast on fish was conducted by the Department of Fisheries. This was done by placing caged fish at various distances from the blast.

The National Research Council carried out investigation on shock waves in the water, created by the blast. Wave recording stations were established at Bloedel Wharf in Menzies Bay, 1.2 miles (nautical) southwest of the blast, at Brown Bay 2 miles north of the blast, and at Duncan Bay

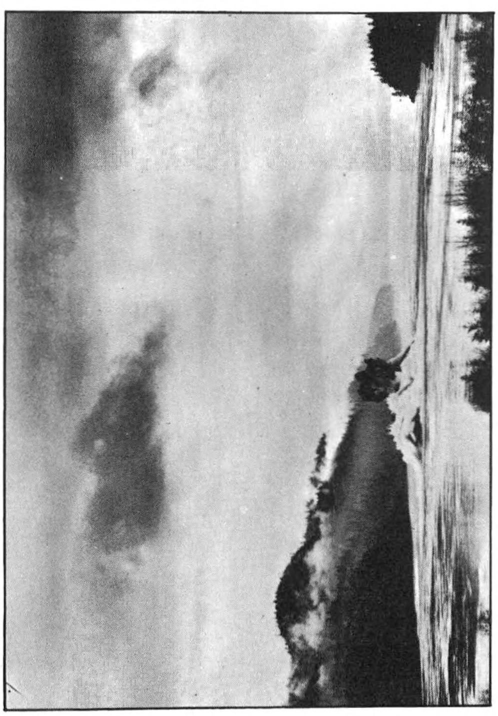

FIG. 6. — The blast at 9 31 02 a.m.

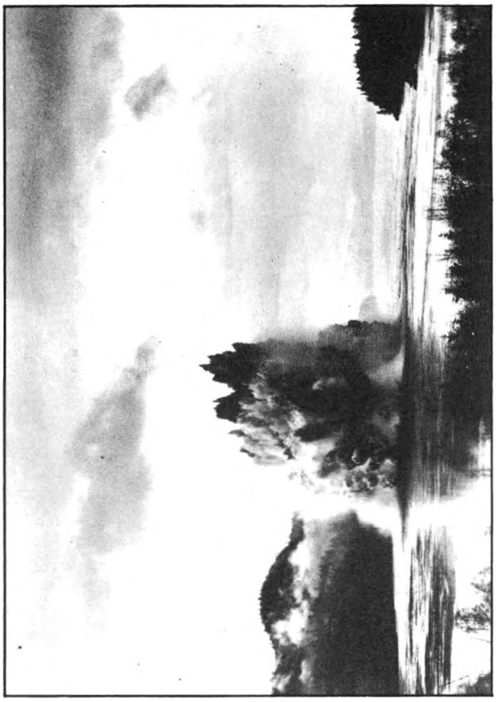

FIG. 7. — The blast at 9 31 04 a.m.

FIG. 8. — The blast at 9 31 07 a.m.

FIG. 9. — The blast at 9 31 09 a.m.

4.3 miles southeast of the blast. The maximum wave recorded on Bloedel Wharf recorder was the fourth wave, 3 minutes and 45.5 seconds after the blast. The height of this wave was 1.5 feet. Waves recorded at Brown Bay were negligible, the maximum being the eighth after the blast with a recorded height of 0.24 feet. No record of any wave was obtained at Duncan Bay nor was any evidence of the blast experienced other than a very slight earth shock which might have passed unnoticed had the time of the blast not been known.

A feature of this demolition project, having particular interest to explosives, mining and construction engineers, as well as the public, was its great size. It was the largest non-atomic blast ever set off (see figures 5 to 9), a total of 2 756 324 pounds of explosives with a theoretical force, estimated by Du Pont technicians, capable of lifting the Empire State Building a mile in the air. The blast provided information on large underwater explosions previously unknown.

Of interest, and also of concern, was the possibility that some failure of the blast might well increase rather than remove the hazard and at the same time make any second attempt at mining impossible.

The fact that the result achieved by the blast was completely successful, and was accomplished without damage to property or danger to life, and almost exactly as predicted by engineers and technicians in charge, has no doubt established a precedent that will be followed in future demolition work of a similar nature.