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BY

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The Jones Falls Dam on the Rideau Canal, Ontario, Canada

BY

ROBERT F. LEGGET,* M.Eng., M.I.C.E.

(*Read at the Science Museum, London, 19 November 1958*)

SUMMARY

A masonry dam 62 ft. high, arched in plan, 350 ft. long at its crest, is located at Jones Falls in eastern Ontario, about 30 miles north-east of Kingston. The dam is one of the control structures for the Rideau Canal, linking Ottawa with Kingston, which was constructed by the Royal Engineers between the years 1826 and 1832 as a military work. When built, the dam was higher than any similar structure in North America. The fact that it was constructed in the middle of virgin forest, and without the aid of any modern construction facilities, gives added interest to this monumental early Canadian civil engineering structure.

That a Canadian should have been asked to present a Paper to the Newcomen Society must be a matter of surprise to some members, so young a country is Canada still regarded. The completion of the Canadian Pacific Railway through the western mountains in 1885 has been so well publicised that it is natural that many should think of this great feat as the first major engineering undertaking of the Dominion. Long before that, however, the building of the Grand Trunk line linking Montreal with Chicago, now a main line of Canadian National Railways, had involved impressive civil engineering works. And before this early railway construction came the first commercial canal building, the successors of the first little St. Lawrence canals being especially newsworthy today in view of the pending completion of the modern St. Lawrence Seaway which will now supersede them. Earlier still were the military works considered necessary for the proper settlement and defence of the young colony after the victory of Wolfe in 1759 and the ensuing Treaty of Paris, which really marks the start of the history of Canada as a part of the Commonwealth. To begin with these were fortifications, notably the great bastion of Quebec. Further to the west, the fortress of Kingston (at the eastern end of Lake Ontario) was strengthened and enlarged, all these works being pioneer endeavours of the Royal Engineers, always important units in the British garrisons overseas. When, in 1812, war broke out between Great Britain and the fledgling United States of America, Kingston came into its own, playing an important part not only as a fortress but also as the site of an important naval dockyard. Much of the war of 1812 was fought on the waters of the Great Lakes. Sir James Yeo, the British commodore, flew his pennant in a three-decker vessel on Lake Ontario more powerful than Nelson's flagship at Trafalgar.

The war finished in 1814, the Treaty of Ghent being signed in that year, since when the international border has never again been the scene of martial dispute. But hard feelings persisted long after the fighting stopped; contemporary records show how strong was the fear of further conflict.

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This sense of alarm was communicated to the British Government in London. Army strategists were concerned at the vulnerable position of Kingston, should hostilities recommence. A glance at Fig. 1 will show that in order to reach Kingston from Montreal, the full length of the international section of the St. Lawrence has to be negotiated. All supplies for Kingston and the little settlements to the west, including all naval stores and equipment, and even—on one occasion—two small gunboats made in England and dismantled for transhipment, had to be brought up the rapids of this famous waterway in small river boats. Why the Americans did not ambush this vital supply line during the 1812 war is almost a mystery even today. Evidence has been found, however, which showed that they intended to take this step if war had again broken out. The British, therefore, had to find an alternative water route from Montreal to Kingston, there being naturally no convenient land communication between these points at that time because of the thick virgin forests. Fortunately, an alternative route was already known, one long used by the Indians and shown by them to early explorers. A survey of the route was made by a young officer of the Royal Engineers (Lieutenant French) as early as 1783, as a part of the early exploration of the new colony. He had proceeded 120 miles up the Ottawa River to the great rapids already known as the Chaudière, thence up a river that entered the Ottawa on its south bank until he reached a group of lakes. Shown the way through these interlocking bodies of water, and crossing the old Indian portages, he had come to the headwaters of the Gananoque River, descending which he came to the St. Lawrence River and sailed down this back to Montreal. Later explorers followed the same route as far as the Rideau Lakes but then descended the Cataraqui River, which also had its source in the Lakes, finding that this led them directly to Kingston. It was therefore decided by the British authorities that the possibility of using this route as an alternative military supply line between Montreal and Kingston should be investigated. Various estimates of cost were prepared, all roughly approximate. Discussions were held with the government of the colony of Upper Canada but no agreement as to the division of cost could be reached. The British Government finally decided to construct the waterway itself, with no financial contribution from the local government, almost certainly at the direct orders of the Duke of Wellington.[1]

The Rideau Canal

The Rideau Canal is not a canal in the normally accepted engineering sense of the word, but a canalised river system, since it follows the Rideau River from the Ottawa River to the Rideau Lakes and the Cataraqui River from the Lakes down to Kingston on Lake Ontario. Its location is shown in Fig. 1 upon which is also indicated the outline of the Precambrian Shield. This is the name given to the great mass of Precambrian rock which makes up about one-half of the land area of Canada, stretching from Labrador in the east to the Mackenzie River in the west. The map shows the extreme southern part of the shield. It will be seen that a narrow neck (the "Frontenac Axis" to geologists) crosses the St. Lawrence River and forms the Adirondack Mountains of northern New York State. The Rideau Lakes are flooded depressions in the glaciated surface of this ancient rock massif, which rarely has more than a very thin cover of soil; in this they are similar to the tens of thousands of lakes which so distinguish the Canadian northland. The two rivers drain from this lake system, the Rideau River dropping about 270 ft. to its confluence with the Ottawa, which is made over a fine waterfall, its course of about 60 miles passing through flat country, now agricultural but originally virgin hardwood forest. The Cataraqui drops through 160 ft. but does so in less than 40 miles. Originally a turbulent rushing stream with many falls and rapids, it is today submerged

[1] Robert Legget, *Rideau Waterway*, University of Toronto Press, 1955, 249 pp.

beneath the waters of the land flooded by the dams necessary for forming the canal, for all but its last few miles in Cataraqui Bay at the level of Lake Ontario.

The Canal was built with locks 134 ft. by 33 ft., with a 5 ft. 6 in. draft over the lock sills. In order to achieve clear sailing from the one end to the other, it was necessary to construct forty-seven locks. Thirty-two of these are between the Ottawa River and Lower Rideau Lake; two are between

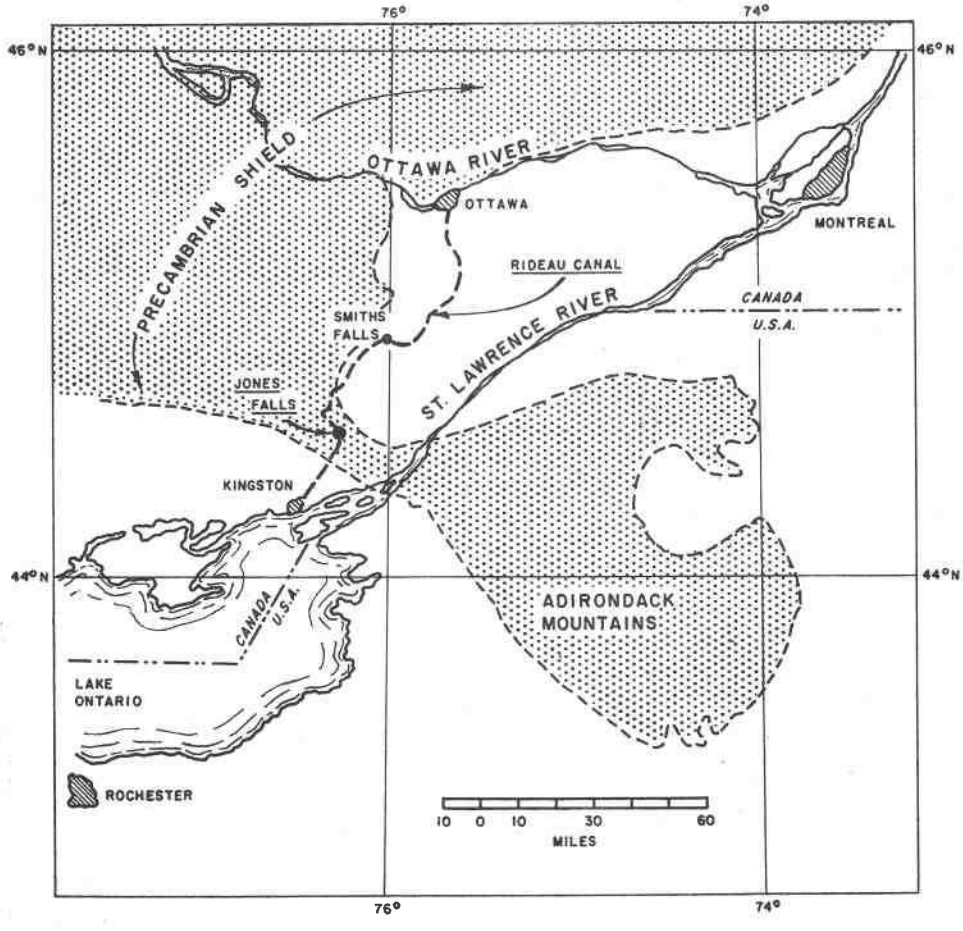

Fig. 1. LOCATION OF RIDEAU CANAL

the lakes that were linked together to form part of the waterway; and thirteen lie between Indian Lake and Cataraqui Bay. In order to raise the natural water level of the rivers and lakes the requisite distance to provide for navigation between and into the locks, fifty-two dams had to be constructed. These range all the way from simple earth embankments a few feet high to several massive masonry structures, the largest of which is the subject of this Paper. The most troublesome of all the dams to build was the Hog's Back Dam, now within the limits of the city of Ottawa, which was first built

as an earth fill dam but which had to be rebuilt as a rockfilled timber crib after a serious failure of the initial structure. That this was the only failure of any sort during construction is but one of the many features of the work which testify to the professional skill and ingenuity of the builders. Lieutenant-Colonel John By, Royal Engineers, was selected for the great task of directing the work, once the decision to build had been made. He had served for 11 years in Canada as a junior officer but was brought from retirement (almost certainly by the Duke of Wellington) to return to Canada at the age of 52 in order to construct this canal through a forest wilderness. He arrived in Canada in May 1826; the first sod was turned in September of the same year in the presence of the Earl of Dalhousie, Governor in Chief. Colonel By sailed through the completed canal, from Kingston to Bytown (now Ottawa) in early May 1832. Almost immediately, he was recalled to England, not to receive the honours which he had so surely earned, but to face an inquiry initiated by the Lords of His Majesty's Treasury with regard to alleged expenditure of about £22,000 without authority. By was exonerated but retired from public life and just 4 years later died at Shernfold Park, Frant, Sussex, worn out by his exertions in the forests and swamps of Canada and certainly not encouraged by the reception he received on his return to his native land.

Although the general route had been selected on the basis of earlier surveys and reports, Colonel By had to select the final route to be followed, decide upon all water levels, design all the dams and locks, and direct and supervise all construction. He was assisted by a group of unusually able young assistants (at least three of whom eventually became full Generals in the British Army) and by two companies of the Royal Sappers and Miners. He was fortunate in having the services of four reliable contractors for his masonry work, his satisfaction being shown by the silver cups which he presented to each firm at the end of the work, theirs by the modest fortunes which they established as a result of their efforts. By was much less fortunate in the contractors he obtained (always through public tenders) for his excavation work. The popular belief, at that time, that excavation was a simple job led to innumerable troubles as a result of low bids and thorough incompetence. Despite all such difficulties, the job was finished in less than 4 years and at a total cost of only £800,000; the figure is mentioned if only to counter any wrong impression that may have been created by the reference to contractors' profits.

The full significance of Colonel By's achievement can only be appreciated when the setting of the canal building is realised. The only settlement of any kind on the entire route was Kingston, and it was little more than a small military and naval fortress. There were no more than a dozen settlers' cabins along the 130 miles of waterway, the shores of all rivers and lakes being thick forest to the water's edge. Two trails only came through the forest as far as the canal route from the shores of the St. Lawrence upon which one or two small settlements had been established. Apart from the few settlers, the only other inhabitants were Indians, fortunately friendly and helpful. The climate ranged from sub-zero weather during the winters, when work had to stop because of the intense cold and deep snow, to the tropical heat and humidity of high summer. Surprisingly, the heat of summer caused Colonel By far more trouble than the winter cold.

All construction materials had to be obtained locally, with the exception of the ironwork for sluices and gate fittings. Timber was cut from the surrounding forests. Stone was quarried at sites as close to the locks and dams as possible. Cement, for grouting masonry was made near the Ottawa end of the canal, by burning limestone from a quarry which is still in use today; it now provides raw material for one of the main plants of the Canada Cement Company Ltd. Supplies, including most of the necessary food, had to be brought from Montreal either up the Ottawa River to Bytown, or up the St. Lawrence to Kingston, thence by canoe to the work camps along the waterway. Even the pay for the workers had to be carried in this way (usually as silver coin in kegs) since the local Paymaster General objected to Colonel By's very reasonable suggestion that the men should be paid by cheque.

Of construction equipment as it is known today, there was none. All the power used was man-power, except in a few locations where oxen were used for long haulage. Horses seem to have been used only for riding; Colonel By on his black charger became almost a legendary figure around Bytown. (This was the name given, almost jokingly at first, to the small construction camp on the Ottawa where Colonel By made his headquarters; thus was Ottawa, the nation's capital, founded.) Earth excavation was by pick and shovel, earth transport by wheelbarrow. Rock drilling was by hand; blasting by means of "black powder." Stone cutting was similarly all the hand work of masons, Scottish and French Canadian; stone handling was done by means of wooden "stone-boats" and hand derricks. By such simple means were built, in the midst of the virgin forests of Canada, masonry dams that exceeded in size all that had hitherto been constructed in the New World and most of those in the Old. Of the Rideau dams, that at Jones Falls was and still is pre-eminent.

The Dam at Jones Falls

Before the building of the Canal, water drained from Clear Lake down to Whitefish Lake (about 35 miles north-west of Kingston) through a rocky gorge. There is available a description of this, the most difficult part to be canalised of the entire Rideau route in an account written by John McTaggart, published in London in 1829. McTaggart served as Colonel By's first Clerk of Works; some of his writing seems to have been tinged by his singularly vivid imagination, but his description of this natural feature of the Canal route can be accepted as reasonably accurate.

> "These [Jones's Falls] are the greatest in the least distance that are met with in the whole route, rolling down a narrow ravine scarcely a mile in length, and having a 60-foot fall. The banks of this narrow and crooked ravine are lofty, averaging 90 feet in height; and on the west side there are deep bogs, surrounded by high land. . . . It is also an objection that as the ravine is crooked, and cannot be straightened, from the nature of its steep freestone banks, the locks can not be placed in such a manner as not to have their entrances awkwardly set for boats to get in and out of them."[1]

This was the natural barrier that had to be circumvented. McTaggart advanced several ideas to his chief as to how this could be done but they were generally impracticable. Following his own examination of the site, Colonel By, with his fellow engineer officers, devised the scheme which they carried successfully to completion but which must have seemed foolhardy at the time. This was to dam the gorge right up to the level of Clear Lake and to use "Macdonald's Gully," a natural depression in the general rock profile about 3,000 ft. to the south, with some additional excavation, in order to build the four locks necessary to get boats up and down the difference in water level of 58·5 ft. between the two lakes (Fig. 2). The locks themselves are fine examples of masonry work, arranged as a group of three with the fourth (upstream) lock separated from the chain of three by a large basin. They are similar in design to the other locks on the Canal. Attention must be concentrated upon the dam which made their operation possible and which is still a unique feature of the Waterway.

The downstream face of the dam is arched in plan, concave downstream, so that it appears to be a true arched dam. It is formed of hand-hewn sandstone blocks, each about 6 ft. by 4 ft. by about 18 in. The blocks are arranged in vertical, not in horizontal courses (Plate XXI, Fig. 1). The joints are so tight that it is impossible to state whether they are mortar joints or not. There is certainly some mortar in the masonry work, however, as became evident when the dam had to be cut into some years ago. The masonry was carried right up to the crest of the dam which measures 350 ft. from abutment to abutment. The masonry is built solidly into the bedrock that forms the slopes of the

[1] John McTaggart, *Three Years in Canada etc.*, H. Colburn, London, 1829, Vol. I, p. 148.

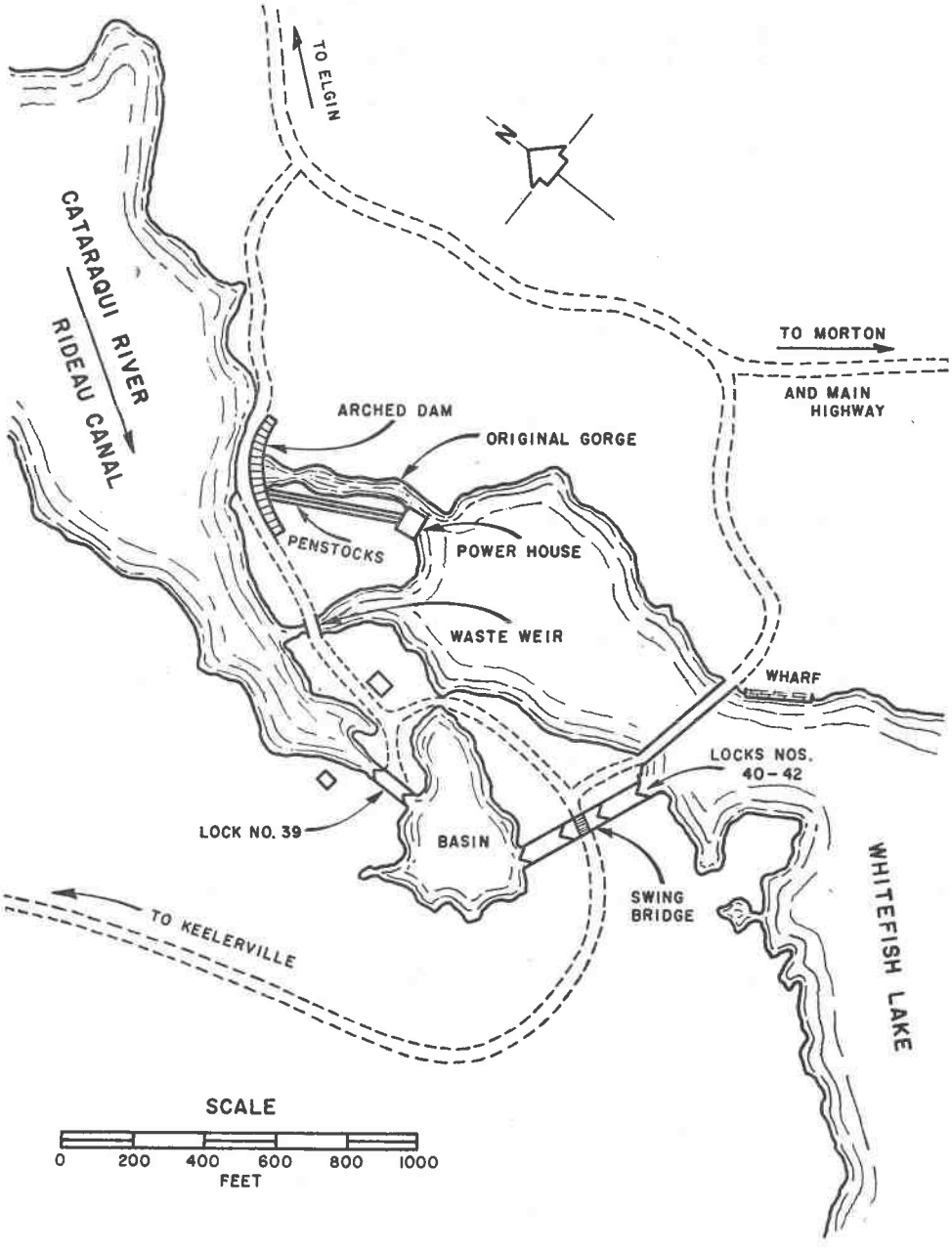

Fig. 2. Location of Dam and Locks at Jones Falls

gorge so that the structure is, in fact as well as in appearance, a true arched dam. Analytical design methods were not available to Colonel By when he had to design this structure and so he chose not to rely on the masonry entirely but to use it as a means of retaining an earth dam upstream. Although it cannot be seen today, nor has it been seen since the dam was built, this earth dam is shown in an old sketch of the structure which is all that has yet been discovered in the way of any record drawing of the dam as constructed. The dam consists of the masonry structure, backed by the earth fill, and between them a puddle core (Fig. 3). At its maximum cross-section the masonry is 27 ft. 6 in. wide at rock level, decreasing in width to 21 ft. 6 in. at water level, which is 56 ft. 6 in. above lowest rock level. With freeboard of about 5 ft., this gives a maximum height for the dam of between 61 ft. and 62 ft. No record has yet been found of any dam standing in North America in 1832 which approached this height. The construction of this dam at Jones Falls antedates by a few years that of the famous dam near Aix-en-Provence (1843) designed by Zola and frequently referred to as a pioneer structure. At its maximum section the earth fill extended upstream 127 ft. out from the masonry structure. It was finished off at an underwater slope of $2\frac{1}{2}$ to 1. Along the crest of the dam the earth is level for a width of 25 ft. and stands about 3 ft. higher than the crest of the masonry. The separation of the masonry and the earth fill by a clay puddle core is a feature probably drawn from British engineering practice of the time. Scattered references in contemporary accounts suggest that it was not possible to found the masonry solidly on the bedrock in the bed of the gorge so that the puddle core was almost certainly intended to ensure the watertightness of the completed structure. During the course of construction, the clay was replaced by broken stone grouted with cement mortar, as explained in this note which appears on the sketch to which reference has been made:

> "The broken stone grouted was an afterthought and therefore does not actually reach the bottom everywhere; however, the Puddle was taken out wherever it could be replaced with grouted stone; the back or the Key Work was also jointed with mortar. As the grouted stone does not *extend quite* to the bottom everywhere, it is certainly a disadvantage as it will probably prevent the Clay from settling properly close to the base."[1]

The concern of the writer of this note was dissipated, it may be hoped, before the officers of the Royal Engineers left the Canal works, for the dam has performed quite successfully through all the intervening years. The crest of the earthwork is today used as part of a local road which crosses the dam. The masonry crest remains exposed, the sandstone exhibiting no signs of deterioration. With its crest curved to a radius of about 175 ft., the masonry blends almost imperceptibly into the bedrock at the sides of the gorge; the dam stands today as a singularly graceful structure in its woodland setting.

Building the Dam

The initial reaction of civil engineers when they see the dam at Jones Falls for the first time, is one of admiration for the structure itself. When the date of its construction is known, initial reactions are displaced by surprise at the fact that such a structure was built so many years ago in a narrow and confined gorge with no obvious possibility for the necessary control of the river which flowed through the gorge, river control being always so critical a part of dam construction. Here are no large diversion tunnels, no convenient spillway opening to be gradually closed up as the dam rises to its full height. Fortunately, the way in which this construction operation was carried out can be described in the words of one of the most remarkable of Colonel By's assistants, Lieutenant William

[1] Lieut. W. Denison, "Rideau dams" in *Papers on Subjects connected with the Duties of the Corps of Royal Engineers*, J. Crane, London, 1838, Vol. II, pp. 120–1.

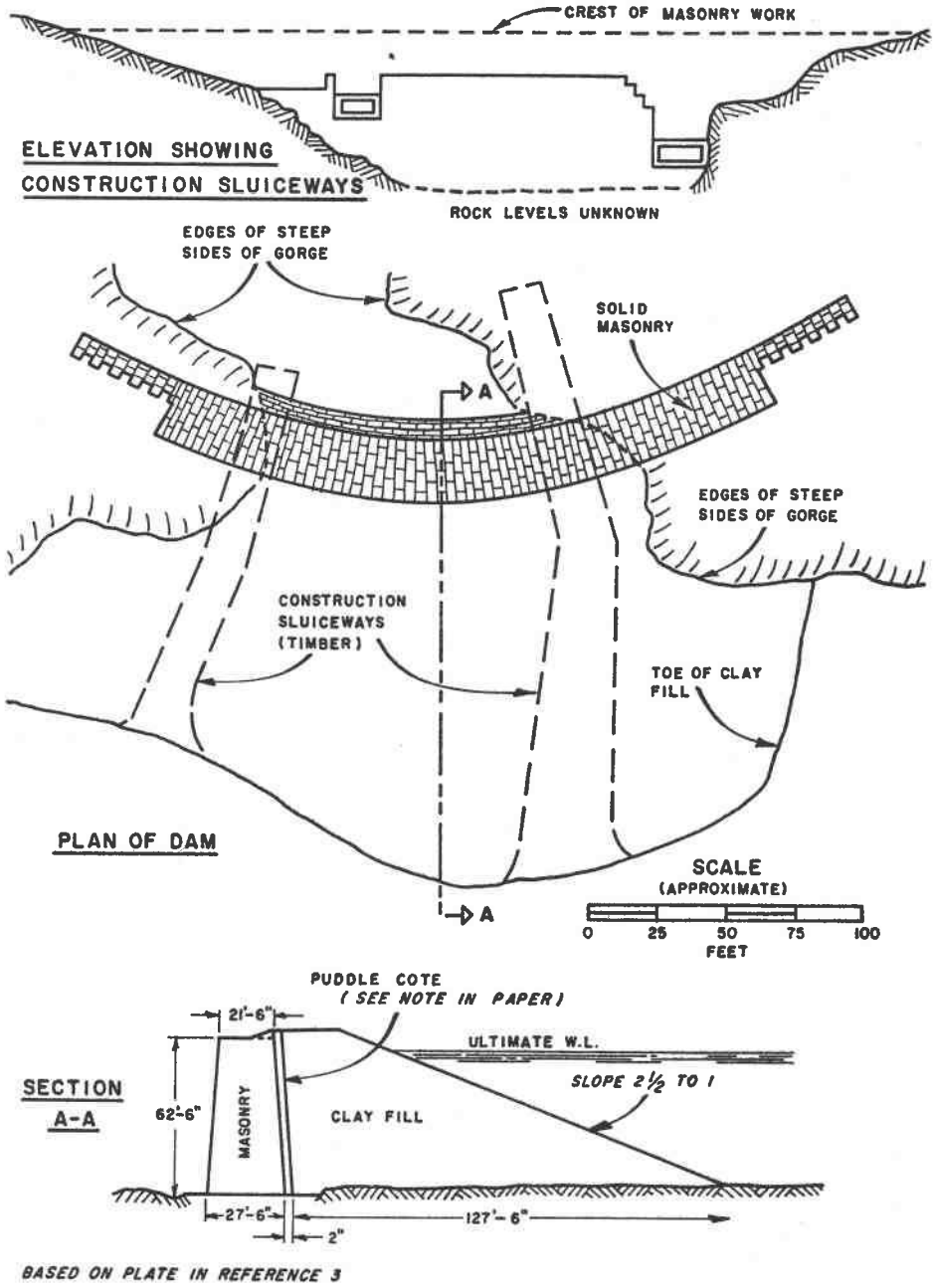

Fig. 3. Sketches of Arched Dam at Jones Falls

Denison who, although not the resident officer at Jones Falls, must have visited the works during the course of construction while on some of the special missions he undertook for his chief. He recorded that—

> "The work was commenced by erecting a wooden temporary dam at the mouth of the gully, by which, when necessary, the outlet of the lake could be stopped, and the works kept free from water for about a week in the dry season, without any fear of raising the water in the lake so high as to do any mischief. A temporary wooden sluice-way . . . was then constructed close to one side of the ravine, at the spot where the dam was to be constructed; and this being made of sufficient width and depth to carry off all the water that usually passed down the gully, the remainder of the passage was blocked up with earth, and rubbish, behind which the key-work was built to the height of about eighteen or twenty feet. At this height, on the opposite side of the dam, a fresh sluice-way was made, the part through the key-work being framed of wood, and the remainder of masonry; sheeting piles were driven in several places, to prevent the water working its way beneath the floor of this sluice, which was carefully planked. As soon as this sluice-way was completed, and the key-work and remainder of the dam raised some height above it, the outlet of the lake was stopped, and every exertion made to close the old sluice-way filling in the opening with rubbish, and building the key-work behind. The water being then allowed to pass down the ravine, rose in front of the dam, and discharged itself by the second sluice-way. After this, the work went on as before, and a permanent waste-channel having been excavated in the rocky bank of the ravine, provided with sluices, and everything requisite to regulate the height of water when this second temporary sluice-way was closed, the water was turned into this permanent channel, and the dam was then completed to the requisite height without any further trouble."[1]

As thus described, the operation (known to construction men as "leap frogging") appears to be deceptively simple, but it requires little reflection to appreciate that it must have been the work of a master builder. Colonel By was fortunate in being able to award the contract for this work to an experienced firm of masonry contractors who had already carried out important masonry contracts in the Montreal area. Thomas McKay and John Redpath were partners; together, they carried out some of the most important of the canal works. By agreement, John Redpath took the responsibility for the dam at Jones Falls; the records show that he gave to it his continuous personal attention. It has been the writer's privilege to examine at McGill University (where the name of Redpath appears on several notable buildings) the old account books of John Redpath. Many are the human touches there revealed (such as the repetitive item "Expenses to see the men off at Lachine," men for the job at Jones Falls about to proceed up river by canoe from the famous wharf at Lachine). These records also show the total volume of masonry in the dam, for which the partners were paid at the rate of 1s. per cubic foot, to have been £426,161.70.

The primitive setting for the dam works has already been sketched—the virgin forest, with no settlements of any kind within 25 miles. Accordingly, a camp had first to be built in forest clearings; this was ready by the early summer of 1828, accommodation being provided for 200 men. So simple were the tools to be used that there would be no trouble in bringing them up to the site of the work by canoe, or even on men's backs along the forest trail from the tiny settlement of Brockville on the St. Lawrence. Wood would be cut from the forests around for the hand cranes which appear to have been the only "mechanical" equipment used in any way on the work.

Perhaps the most surprising aspect of the building operations is the fact that the stone for the dam was not taken from the vicinity of the works, as was the clay for the puddle and earth fill, but from a quarry about 6 miles from the dam. The dam site lies on Precambrian rock of extreme hardness,

[1] Lieut. W. Denison, *op. cit.*

not easily "workable" by masons, so that it would not have been a suitable stone for building. It so happens that the boundary between the Precambrian of the Shield and the palaeozoic rocks of the St. Lawrence lies about 5 miles to the east of the Falls. The boundary is not normally exposed and there is only one major exposure of the Beekmantown sandstone to be seen within convenient distance of the site. How the builders of the dam at Jones Falls knew that such stone could be found, and how they found the one exposure which must have been in the midst of unbroken forest when the work commenced are questions the answers to which can only be left to imagination. The sandstone was found, however, and all the stone for the locks and the dam was obtained from this quarry (now located between the little towns of Elgin and Philipsville) hauled by oxen over an improvised track through the forest, unloaded on to scows and floated down Clear Lake to the site of the work. The quarry may still be seen today, with some blocks of stone in semi-finished state, just as they were left by the canal builders. Since little masonry building has subsequently been done in the district, the quarry has never been worked for other purposes.

Even though all construction operations involve some hardships, mention must finally be made of the hardships encountered on this work. Not only had they to contend with the rigours of winter, without the advantage of modern heating, but far worse was the heat of summer with the fetid and humid atmosphere generated from the swamps on the canal route and the accompanying "swamp fever." It is reported that so bad was the fever at Jones Falls that at one time "no one . . . was able to carry water to a sick friend, because all were overcome, including the doctors." Mortality among the Irish labourers, and the Scottish and French Canadian masons, was heavy; for many years a small graveyard nearby bore mute testimony to the toll in human lives taken by this construction job. By the winter of 1831 the work was complete. A watchman was left to guard the work until it was officially taken over in 1832; some of his letters testify to the extreme loneliness of the location.

The Dam Today

Unlike so many older engineering structures of historic significance, the dam at Jones Falls stands today in perfect condition, still performing its intended function despite the changes that have come to the land that is now Canada, and the way in which the course of time has taken the history of the Rideau Canal almost through full circle. Constructed as a defence measure in view of fears in the young colony of invasion by American troops, the Canal is today well used every summer by a steadily increasing invasion of American visitors, who come to enjoy the beauties of the Rideau Waterway (as it is known to some), the delights of the Rideau Lakes, and the excellence of the local fishing. The Canal was used, for more than two decades from the time of its completion, for the conveyance of troops, military supplies, and even of small naval vessels from Montreal to Kingston. Gradually, however, the fear of war disappeared, concurrently with the steady opening up and development of the colony of Upper Canada. As military traffic diminished, civilian traffic on the Canal increased. Until the opening of the final section of the St. Lawrence canals in 1855, the Ottawa River and Rideau Canal together constituted the first St. Lawrence Seaway, for small ocean-going vessels did use the Canal. As through traffic from Montreal diminished, local traffic in coal, timber, cheese and other farm products increased, as also did passenger traffic along the Canal. The coming of the railways, of highways and the automobile, eventually led to the disappearance of all this traffic; use of the Canal reached its nadir in the 1930's. In recent years, however, summer traffic has shown a surprising increase but entirely of pleasure craft, Canadian and American; the increase continues. Vessels that come through connecting American inland waterways from as far away as Florida and New Orleans are now not uncommon on Rideau waters. Through all these vicissitudes, the great dam has continued to maintain the water level necessary for the approach to the flight of locks at Jones

Falls. Today, the "narrow and crooked ravine" of John McTaggart is filled with large trees, its undergrowth almost impassable because of dead wood and thick brush. It is, therefore, difficult to obtain any photographs which give any real impression of the size and quality of the structure; those which accompany this Paper are about as good as can be obtained (Plate XXI). Standing remote even from the little side road that connects the locks with the main highway two miles away, the dam is seen only by the few. Most of those who now sail the Canal do not even realise its existence since all they see is its grassy crest as a break in the wooded shore line which they pass as they turn into or out of the narrow channel past "The Quarters," so called since at this location the resident Royal Engineer officers were quartered.

Throughout its 130 years of service, the dam has required practically no maintenance. There is today a small leak through its base, but this appears to have been constant for many years. The masonry is just as good as it was when first placed. In one way it is really better, the mortar having taken on a really rock-like consistency. This was demonstrated in 1947, when a strangely modern addition was made to the ancient structure. The Gananoque Electric Light & Water Supply Company Ltd. obtained permission from the Federal Government of Canada (which owns and administers the Canal through its Department of Transport) to use the normal flow of water past the Jones Falls dam and locks for generating water power to be fed into its small local supply system. The dam was therefore breached close to its western end, and a small concrete intake structure was erected; as many as possible of the masonry blocks were restored to their original position in order to preserve the appearance of the dam. A wood stave penstock was connected to the intake, led down the side of the old gorge and into a small concrete power-house located on the edge of the pool at the foot of the locks. The head of approximately 60 ft. was thus made available for power purposes. The one water turbine and electrical generator initially installed were soon supplemented by three more units fed by two additional penstocks, so that the little station now has an installed capacity of 4,000 kW. The power-house is remotely controlled from the station at Kingston Mills, 25 miles away. Near to the little building is a television aerial. What contrast these modern features provide to the nearby dam will be apparent to all who have any feeling for history. Standing on the crest of the dam, however, they can easily be forgotten as the significance of the old structure is again appreciated and silent tribute paid to the men of the Royal Engineers, and their contractors, who gave this early work, and so much more, to assist in the founding of the land that is now Canada.

Discussion

Professor A. W. Skempton recalled with delight the day he and Mrs. Skempton had spent with Mr. Legget seeing the Rideau Canal. There could be no doubt that it was a master work, and that John By was a great engineer.

The Jones Falls dam, however, could be claimed neither as the first arch dam, nor as the highest masonry dam of its period. A gravity dam at Elche, in Spain, built by the Moors in the tenth century, had been replaced in 1590 by an arch dam, the dimensions of which were given in the table. Only 4 years later a gravity dam with a height of 135 ft. was completed at Alicante, also in Spain. Nevertheless, the Jones Falls dam is a most notable structure of extreme importance in the history of civil engineering in America.

Mr. Legget writes of Jones Falls that "it appears to be a true arched dam." Since the ratio of base width to height is only 0·44, whilst for gravity dams this ratio is never less than 0·75 and is usually about 0·90, there is no need for caution in accepting its true function as an arch dam. The clay bank was necessary in construction and also served to increase the watertightness of the base of the dam. Its presence slightly increases the total pressure which the masonry arch has to withstand, above the pressure due to the water alone.

EARLY ARCH DAMS

Dam	Completion date	Height ft.	Base / Height	Length / Height	Radius ft.	Engineer
Elche, Spain	1590	76	0·51	3·0	205	—
Jones Falls, Canada.. ..	1831	62	0·44	3·6	175	John By
Zola, France	1843	120	0·35	1·7	158	M. Zola
Bear Valley,* U.S.A. ..	1884	64	0·31	4·7	335	F. E. Brown
Sweetwater, U.S.A... ..	1888	90	0·51	4·2	222	J. D. Schuyler
Barossa, Australia	1903	94	0·36	5·0	200	Alex Moncrieff

* Considered dangerous, and replaced 1910.

Dr. A. P. THURSTON remarked that his brother-in-law still owned land round one of the locks and that he himself still actually had money from it. They would probably remember that Napoleon offered Louisiana to the fledgling United States if they would pay £3 million, and they could have Canada if they liked to take it. That was in 1803, but in 1805 Nelson won the battle of Trafalgar, and that changed things. In 1812 Napoleon took Moscow and the War Hawks thought the old country was done and they crossed the Niagara and St. Lawrence rivers and invaded Canada; but we had a loyal Canada and the invasion was repulsed. Subsequently we crossed the border, took Detroit, New York, Washington and Philadelphia and burned The White House: then Napoleon fell and we had peace.

The Rideau Canal originally was strategically important for it enabled the rapids on the St. Lawrence to be by-passed and gave easy access to Kingston from Montreal. It was its military value as a line of communication with an important town which led to its being built.

When the railways were first introduced to Canada they were built round the portages on the rivers. One of them, the Carillon–Grenville Railway, was built in 1843. It was 14 miles long, the second oldest in Canada and continued to run until 1910. The railways followed the canals and were ultimately linked together to form a complete system. The whole question of transport in Canada wanted to be thoroughly thrashed out. Much of it was greatly to the honour of the Royal Engineers to whose excellent work there were but few and fragmentary monuments. There was one at the cross roads in Hawksbury near the Perley Bridge, which carried an inscription: "Designed and constructed by the Royal Engineers: commenced in 1819; completed in 1833."

Much of the early exploration of means of communication and transport had been done by the Indians and the early pioneers. On one occasion he had visited an Indian church, far and far away from civilisation, and had found that the communion plate they were using there had been a gift from Queen Anne. It was great gentlemen like Colonel By of Frant, near Tunbridge Wells, whose devotion had helped to make Canada and the United States.

Mr. A. STOWERS recommended members to read a book, edited by Frank N. Walker and called *Daylight through the Mountain*, published in 1957 and reviewed in *The Newcomen Bulletin*, June 1959. In it about 400 letters between two brothers describe a great deal of pioneering work in Canada from 1836 onwards. They were two engineers, Walter Shanly (1817–99) and Francis Shanly (1820–82). The title of the book refers to the Hoosac tunnel, 5 miles long, through which was established the direct railway route between Boston, Mass., and Lake Ontario. Mr. Stowers asked Mr. Legget to convey to the Engineering Institute of Canada the congratulations of the Newcomen Society for its good work in starting to publish accounts of the pioneer Canadian engineers and their civil engineering works.

Mr. H. CLAUSEN said he was struck by the fact that that dam had been conceived merely as a piece of utilitarian engineering and with no idea of impressing anyone as an achievement over the forces of nature or anything else. It had a close parallel in that respect in the Roman Aqueduct at Pont du Gard, built about 40 B.C. simply as a piece of utilitarian engineering to carry water across a valley.

The tools used and the means of lifting the stone blocks into position must have been very much the same on the Falls dam as in building the Pont du Gard. The problem of cutting pieces square that measured 6 ft. by 2 ft. by 4 ft. was a formidable one in itself. He would like to know how Colonel By and his party did it.

Professor A. F. BURSTALL said he would like to know how Colonel By felt when the water first went into his dam. How did he know that he had designed to the right dimensions; but apparently he had. Was the structure ever designed? If so, what data did he go on, seeing that that was the first real dam of its kind? How did he know his abutments were secure? Did he make calculations based on theory, or did he work to empirical rules which were well known to civil engineers of that day? He (Professor Burstall) was not a civil engineer. To him it seemed most important to know to what extent Colonel By could have had confidence in his work when the thing was finished. He was sure that many novelists would be able to write a good story on it; the anxious Colonel standing on top of the dam as the water slowly rose; just not quite certain or absolutely sure.

Mr. J. FOSTER PETREE referred to the question which had been asked concerning the use of winches by the Romans and mentioned that Professor F. M. Feldhaus, in his book, *Die Maschine im Leben der Völker*, gave an illustration from a monument which showed builders using something very similar to a winch, operated by a tread-wheel.

The PRESIDENT (Mr. L. E. HARRIS) said what had been to him so remarkable was that a lecture on civil engineering achievements had produced so much interesting evidence about the country of Canada itself. It was also very gratifying to see that so much interest was being taken in the history of engineering in Canada itself and in the preservation of ancient buildings, as had been particularly exemplified in the slide which Mr. Legget had shown of one of the locks on the Rideau Canal.

Following the President's remarks, a film was shown which had been made expressly for Canadian Television on the period during which Colonel By was working in Canada.

Mr. LEGGET, replying to the points raised, said the tunnel to which some speakers had referred that built by the Shanlys, those two most remarkable engineers, was still in use as a main railway tunnel. He had visited it about 6 months ago. It was the longest tunnel to be built in North America at the time and for many years after. Many American firms had tried to do it and given up in disgust before the Shanlys took it over and completed it.

The comparison of the Roman work at the Pont du Gard and the Rideau Canal fascinated him, for he had never thought of it in that way. As far as he could see there had been no significant difference at all between the Roman construction methods and those of Colonel By, apart from his use of black powder. He did not know whether the Romans used hand winches, but they knew from sketches, that Colonel By's stones were moved by means of heavy winches made from tree trunks cut from the forest. He hesitated to say more, but one of the baffling things to him was that the Romans did not use circular units in their construction except as pipes.

Finally, a conjectural answer to the most interesting question about Colonel By's design. Most of the letters he wrote (and he wrote many) suggested that he did not make any calculations as such in his designs, but based them on his own engineering knowledge and skill. Being the man he was, he had almost certainly packed away at the back of his mind experience and memories of other works which he had visited. It was the same with his other structures—locks, for example. The lock walls were built up with masonry, at first without any grouting in between the stones; when they put

the water in they found the leaks. By then found suitable limestone and started to make his own cement for the grouting of the lock walls.

In another place, he built an earth dam with which he was not satisfied. He had not realised that the clay which was used had been frozen before it was consolidated. The dam was about 30 ft. high and performed quite satisfactorily throughout the winter, but in the spring when the snow began to melt, the clay unfroze and the dam began to leak. There was a very interesting letter in which he described his experience on the top of the dam when he saw it was going to fail; indeed, he only just escaped being carried out on the flood water.

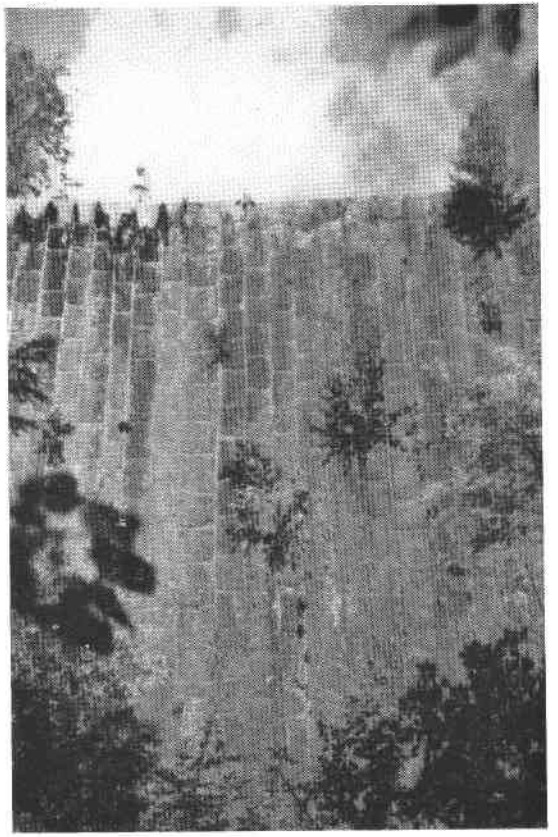

Fig. 1. SEEN FROM THE RAVINE

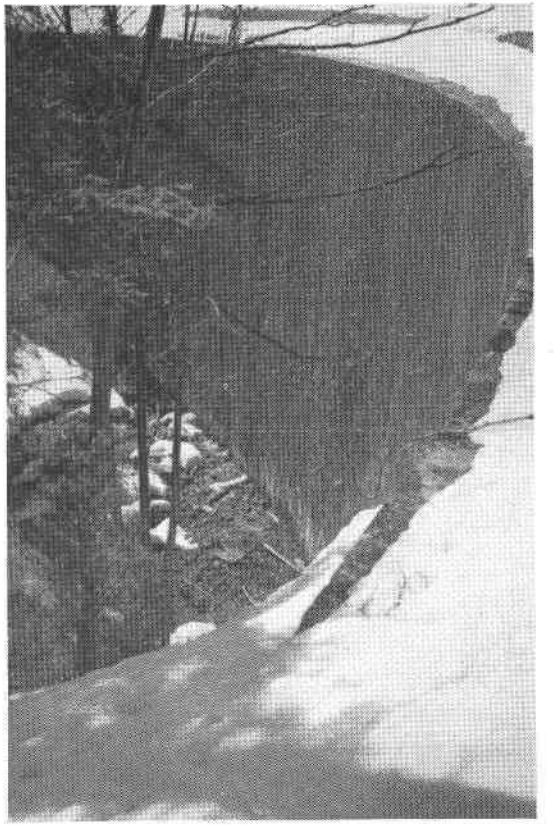

Fig. 2. SEEN FROM ABOVE

THE DAM AT JONES FALLS, THE RIDEAU CANAL, ONTARIO