THREE CANAL PROJECTS, ROMAN AND BYZANTINE

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IN HIS official correspondence as governor of Pontus and Bithynia with the Emperor (*Epist.* 10.41) Pliny suggests to Trajan a canal to obviate vehicular transport between a lake in the territory of Nicomedia, lying to the east of that city, by connecting this Lacus Sunonensis[1] with the Propontis (fig. 1). The Emperor's reply (42) shows that he would not be deterred by the elevation of the lake even if the army technicians (*libratores*[2] or *architecti*) to be obtained from Moesia, or sent by himself from Rome (cf. 41.3), should establish a higher figure than the 40 cubits (60 feet) tentatively claimed by local talent. Trajan's one concern at the moment is the danger of draining the lake away[3] by opening such a canal down to salt water (42).

Turning to Pliny's second letter on this subject (10.61), and comparing its 2nd section with the 3rd and 4th, we see that he was weighing alternative projects:

(1) He would construct a canal merely to reach the bank of a river flowing into the Sinus Astacenus, that arm of the Propontis at the east end of which lay Nicomedia. He is proposing to leave a narrow dyke between canal and river, so that the heavy freight of 41.2 (marble, farm products, firewood, timber) could be lowered or rolled down to boats on the river. He must have had in mind a slipway (*diolkos*, 'haul-over'),[4] much used to overcome differences of level. If the canal was at that point parallel to the river, it could be closed by a single floodgate regulating outflow into the river lower down. This plan may have been advanced as an entering wedge, involving a minimum of time and outlay. In both respects it would be likely to commend itself to Trajan, along with other preparations for the war with Parthia then impending. It might well prove the preliminary step towards a navigable canal from the lake down to sea-level in the harbor of Nicomedia.

(2) Better still, to ignore the small river that emptied into the Bay but brought down no water from the lake, and to dig a canal for the whole distance (18 km.). That the Emperor's concern lest the lake be drained away might be relieved, Pliny makes it clear that he plans a narrow canal (*fossam . . . artius pressam*, 61.4); that he would completely close the natural outlet of the lake at its east end, 6 km. due west of the Sangarius, thus supplying his canal with sufficient water from the lake, thereafter flowing westward. The need of an engineer being obvious, he will write to the governor of Moesia Inferior, the nearest commander of an army, requesting him to send a *librator*.[5] In case the volume of water in the

[1] This is the better supported form of the name according to the MSS of Ammianus Marcellinus 26.8.3, in place of Sumonensis on most of our maps. The modern name is Sabanja Göl; 16 km. in length with a breadth of $4\frac{1}{2}$ km. For a hasty and quite impossible identification with the Ascania Lacus, on which Nicaea lies, see below, p. 110.

[2] I.e. 'engineers,' not 'levellers'; for while the word is derived from *libra*, the levelling instrument, usage took account of his wider range. Often he served as an architect, being at times indistinguishable from *architectus*, an engineer officer little above the low rank of a *librator*. Both were usually veterans. Cf. Cagnat, *L'Armée romaine d' Afrique* 189 f.; Domaszewski, *Bonn. Jahrb.* 117 (1908) 25.

[3] How sixth century engineers were planning to avoid that risk will be shown below, p. 109.

[4] W. L. Westermann, *Pol. Sci. Quart.* 43 (1928) 383. Cf. Strabo 8.2.1; 8.6.4 and 22 for its employment at the Isthmus of Corinth, so that the word became a proper noun: also Polyb. 5.101.4; 4.19.7–9. For Chinese canals with haul-overs, often using oxen or water buffalo, cf. L. S. Yang, *HJAS* 12 (1949) 240 f. For facts concerning canals and locks in China I am indebted to my colleague Prof. L. Carrington Goodrich Cf. n. 15.

[5] Correspondence with a governor in such a matter (42; 61, 5 and 62) is best illustrated from a long inscription at Lambèse in Numidia, including even quotations from letters. Nonius Datus, *librator* of the IIIrd legion, had been sent over into Mauretania to plan and construct an aqueduct for a seaport east of Algiers. A tunnel to carry the water through a mountain was begun, two crews working from opposite sides. Datus was unable to be there when the borings failed to meet. He was recalled by a letter to the legatus of Numidia, returned to Saldae, and completed the work. It was dedicated ca. 152 A.D., 40 years after Pliny's request for an engineer. Cf. *CIL* viii, 2728; Cagnat *op. cit.* 190.

canal should prove excessive, he thought the current could easily be checked by *cataractae*.

With that device to make a river or a canal more serviceable he may have been familiar from journeys in the upper valley of the Tiber to and from his Tuscan villa. For in the *Natural History* 3.53 we find his uncle describing efforts chiefly in summer. At that season there was probably little upstream traffic, reserved generally, we may suppose, for seasons when dams would be under water, and vertical gates[6] raised high enough to clear passing boats.

On a close examination of the passage just cited one is struck by the inconceivable waste of

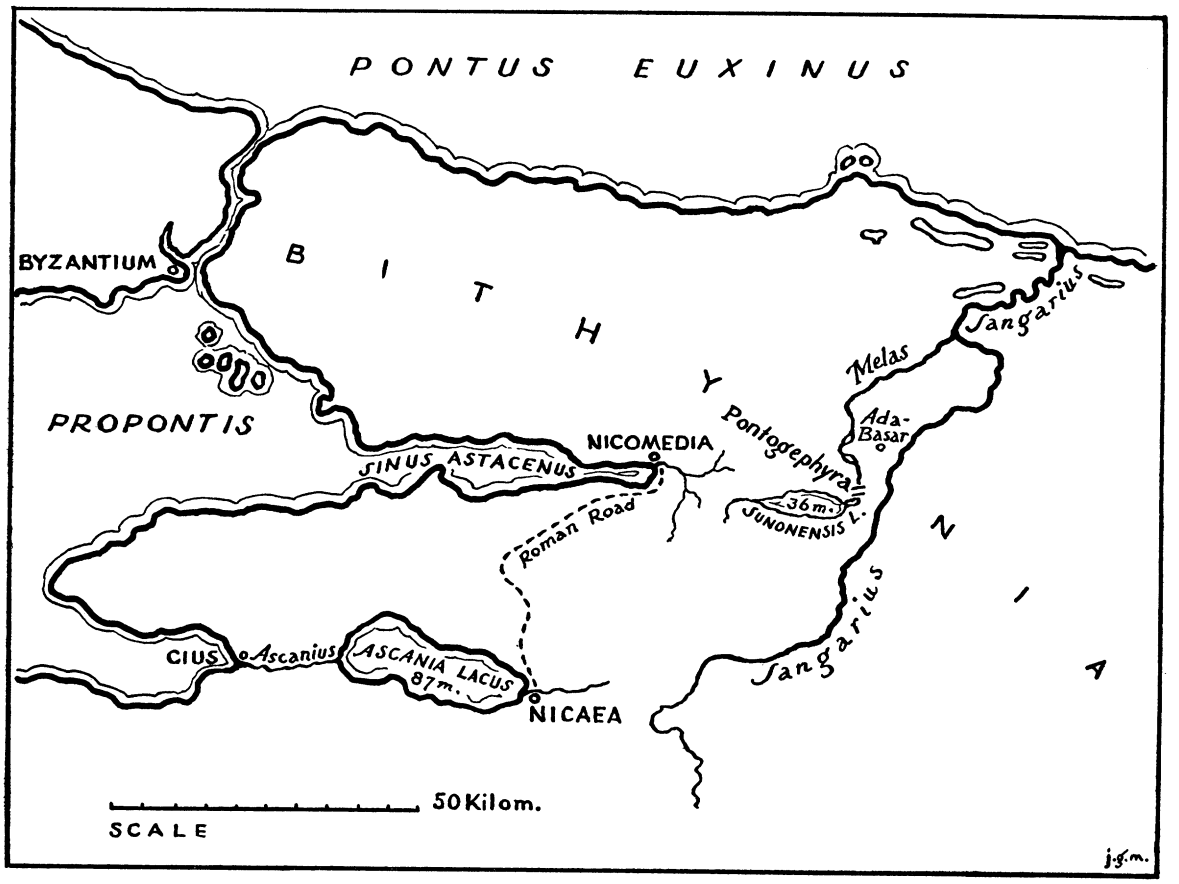

FIG. 1

to make that stretch of the river navigable by means of *piscinae*, in which water was accumulated and then released, obviously by some form of sluice-gate. The use of *piscinae* in the plural has been explained as intimating that at several low spots in the Tiber the same method was applied in dry seasons, to keep downstream traffic in motion.

To introduce such a system had of course required permanent dams, one *agger* (or *moles*) for each *piscina*, though gates might be used water involved in the process which at first sight might appear to be described by a man of practical bent and trained in the counsels of the thriftiest of emperors. One cannot however reasonably suppose the Elder Pliny to mean that water at such a time was slowly stored up for days by means of a single gate that held back the flow of a certain stretch of the river; and then that at the proper time, when the gate was suddenly opened, hoarded water was wastefully allowed to run away all at once. In that

[6] For portcullis-like gates see below, pp. 99, 102, 105.

case he could not venture to speak of the Tiber as navigable, with such evident risk to craft, cargoes and boatmen suddenly projected pell-mell through a single gate, not to mention possible damage to the gate itself at the critical moment.

There is in fact no escape from an inference that sluices designed for such a purpose must have been provided with two *cataractae*, vertical gates, one at each end of the *piscina*, to be raised and lowered by a windlass, after the manner of a portcullis,[7] to which they evidently owed their name, and not to the very temporary waterfall produced when such a gate was raised. The same method was applied seasonally to help boats, barges and rafts navigating two tributaries of the Tiber in the same region, viz. (1) the Clanis (Glanis), now Chiana, south of Arretium and formerly reaching that river east of Volsinii (Bolsena); and (2) the Tinia, rising near Nuceria in Umbria and emptying into the Tiber south of Perusia.[8] Our authority for these is the same passage in the Elder Pliny.

While in Bithynia Pliny the Younger is waiting for the arrival of the army engineers, to give their opinion on his projected canal, it will not be out of place to pause and briefly consider his most ancient precedent in what were in his time its more modern phases.

For the Ptolemaic restoration of the older Nile-Red Sea canal of the Pharaohs we have conflicting statements. Diodorus Siculus (1.33.11) says Ptolemy II completed it, with a gate at the most suitable place, to be opened and closed quickly, ταχέως. Completion of the canal at that time is confirmed by Ptolemy Philadelphus' own hieroglyphic inscription, set up in 265/4 B.C. at Herōopolis (Pithom) and discovered by the eminent Genevan Egyptologist Édouard Naville in 1883 (cf. his *The Store-city of Pithom* [3rd ed. 1888] 18 ff.).[9]

It is evident that not only Diodorus but also our other authorities on the canal paid no attention to Red Sea tides, although Herodotus (2.11) had mentioned them in a single brief sentence, nor to seasonal variations in the level of a canal which rose and fell with that of the Nile. If the tide amounted, as it does today, to more than six feet, it seems obvious that the mariner had only to wait for the tide to reach the proper level, and could then sail out or in without nervous haste.[10]

Strabo (17.1.25) states that the Ptolemies, on cutting their canal through, "made it so that it could be closed" (κλειστὸν ἐποίησαν τὸν εὔριπον; see below, p. 101), and nothing is said about haste, which would certainly have been considered not only a hindrance but even a hazard. Yet he says they could sail out and in again without hindrance. Of course that was possible only in case the canal was closed by a lock, that is, by two gates (*cataractae*) enclosing a basin (*piscina*) of suitable length (cf. pp. 98, 102, 104).

Pliny the Elder (*Nat. Hist.* 6.165) has Ptolemy II starting his canal at *Daneon portus*, a harbor not certainly identified, on the Sinus Herōopoliticus, which was the extreme north end of the Sinus Arabicus, whose waters, as has now become evident, at that time extended many miles farther to the north than they do today. He represents Philadelphus as carrying the

[7] Cf. Dion. Hal. 8.67.7; Livy 27.28.10 f.; Vegetius 4.4. The same words served for 'sluice-gate,' as in Heliod. *Aethiopica* 9.8.5, or for the entire sluice, e.g. in Ammianus 24.1.11. Such vertical lock-gates were used on the Early Renaissance canals; cf. p. 105 and note 32; J. P. Richter, *The Literary Works of L. da Vinci*, 2.181; 360 fin.

[8] Strabo 5.3.7 *sub fin.* mentions these smaller rivers and their service to trade at Rome; cf. 5.2.10. Before the middle ages the valley of the Clanis had become through neglect a most unhealthy region with pestilential marshes. In Leonardo da Vinci's time there was a long lake there (larger with its marshes than was Trasimeno), as he represents it on his colored map; cf. Richter, *op. cit.* 2, pl. CXIII. In more recent times the course of the Chiana has been altered so that it drains into the Arno; Nissen, *Italische Landeskunde*, 1, 305; 2.314 f. For a defence of "temporary freshets" as a possible explanation of the *Nat. Hist.* passage see the article of Professor G. H. Allen of Lafayette College in *CW* 27 (1933) 67 fin.-68.

[9] Also his "La Stèle de Pithom," *Zeitschrift f. Aegyptische Sprache* (1902) 1 ff.; Brugsch and Erman, *ibid.* (1894) 74 ff.; Koehler, *Sitzber. d. Berl. Akad.* (1895) 965 ff.

[10] For the Suez Canal no locks are required. But it does not connect a sea with a river subject to great changes of level. Hence the problem is a different one, especially for ships with modern power.

canal toward the Nile, but only to stop at the *Fontes amari*, formerly supposed to have some connection with the Bitter Lakes. But Naville's discovery of the canal inscription (cf. above, p. 99) at Herōopolis has resulted in radical changes in our maps of the region for ancient times. These now show the site of that city near the eastern end of the Wady Tumilat, and not far from the northernmost of those lakes (Timsah); and below it a fairly straight inlet some fifty miles in length down to the present Suez, for the topography of the region has been altered by changes of level. A canal of the 3rd century B.C. to connect the Nile with the nearest arm of the Red Sea did not have to be carried below the Bitter Lakes of today.

For the alleged, but quite inconceivable, abandonment by Ptolemy of his purpose to reach the Nile a reason is assigned by Pliny,[11] viz. the fear of inundation, for the Red Sea was found to be three cubits higher than Egypt. Some of his authorities, he says, gave a different reason—the fear that Nile water would no longer be potable. The latter alarm, according to Aristotle (*Meteor.* 1.14.352b) had caused Darius I to give up his canal; and Strabo (*loc. cit.*) confirms the abandonment of operations at that time.

Although Pliny is quite mistaken in denying that Philadelphus' canal ever reached the Nile,[12] he is correct (§167) in stating that he gave his own name to the *amnis* which flowed past Arsinoë, and the word can here be understood only in the narrower sense in which ποταμός was used, particularly in the papyri. He certainly does not mean a river[13] whose name Ptolemy had changed.

Arsinoë was to be the seaport at the mouth of Philadelphus' Great Eastern Canal, but in time suffered the fate of many another city founded by the sea but later stranded as its waters receded. In Strabo's time Arsinoë was still there, near Herōopolis, "in the inmost corner of the Arabian Gulf" (17.1.26). Its successor for trade and travel came to be Clysma; cf. *Itin. Anton.* 170.

Among modern authorities who have accepted the hydraulic lock as placed by Ptolemy II at the lower end of his canal may be named:

Dr. John Ball, an eminent engineer who gave over forty years of his life to geographical and geological exploration in Egypt, the Sudan, and adjacent regions. In his *Egypt in the Classical Geographers* (Cairo, 1942), p. 48 f. we find him summarizing Diod. Sic. 1.33.11, on the completion[14] of the canal by Ptolemy, "who provided it with a lock"; cf. 81 ff.

E. H. Warmington, *The Commerce between the Roman Empire and India*, p. 8, after mentioning the Heröopolite Gulf, says "where the second Ptolemy, who cleaned out the wide and deep canal-channel and added locks to prevent flooding from the Red Sea, had founded Arsinoë." Cf. 331, n. 7.

G. Hanotaux, *Hist. de la Nation Égyptienne* 1.147 speaks of Philadelphus' "écluse à deux portes."

A. Calderini, "I Precedenti del Canale di Suez nell' Antichità," *Aegyptus* 20 (1940) 224, summarizing Strabo 17.1.25, says that the

[11] How he imagined the canal could have been operated without a continuous supply of water from the Nile remains an unsolved puzzle. Similarly we have our doubts when a Pharaoh or a Darius is said to have left his canal incomplete, especially if the Bitter Lakes had been sweetened by influx from the river, as in Strabo, who informs us (§26) where the canal (obviously in operation in his day) left the Nile; also that it was 100 cubits broad with a depth suitable for large vessels.

[12] Cf. J. O. Thomson, *Hist. of Ancient Geography* (1948) 137, n.; 273, n. 3.

[13] As might be inferred from Rackham's translation (*LCL*), perhaps influenced by the *Thesaurus L. L.*, in which Ammianus alone (24.4.8) furnishes a solitary instance of *amnis* = 'canal.' Mention is there made of two unnamed cities *quas amplexi facerent insulas*, "which were in islands made by the winding river" (?). So Rolfe's translation. But in the *Thes.* article the canals are understood to be those connecting Euphrates with Tigris. Strange is the omission from the same article of another example in the passage just cited from the *Nat. Hist.* One might well add a cross-reference to *Augustamnica* (Ammian. 22.16.1 and 3; *Not. Dign.* Seeck, *Or.* 1.127; 23.7; 28.37). For that province derived its name from Trajan's restoration of the Ptolemaic canal, i.e. indirectly from Τραϊανὸς ποταμός, often mentioned in papyri and in Roman Law texts; in official language *Traianus amnis*. Cf. Ball, *op. cit. infra* 82, n.; Ptol. 4.5.24.

[14] More correctly it was "restored after disuse," Thomson, *op. cit.* 136.

Ptolemies, having completed the excavation, closed the canal "con una doppia porta."

A. Bouché-Leclercq, *Hist. des Lagides* 1.241 f. says, apropos of Arsinoë, just where the canal "pourvu d'une écluse de marée, débouchait dans le golfe d'Héroopolis."

C. H. Oldfather, Diodorus Siculus (*LCL*) *loc. cit.* translates διάφραγμα 'lock'; and one may find support for this word in the definition 'lock in a canal' in Liddell and Scott, citing *Petrie Papyri*, Mahaffy, 3. p. 343 (3rd cent. B.C.).

J. Toutain, *L'Économie Antique*, 187 f., includes a passage translated from Strabo *loc. cit.* containing the words "pour fermer par une double porte l'espèce d'euripe ainsi formé," with a note: "Cette double porte n'est autre chose qu'un système d'écluses." Both in the original and in the English version 'a closed passage' (p. 146) for 'espèce d'euripe,' there is an unnecessary avoidance of what is really meant, viz. 'écluse' and 'canal lock' respectively. In using the word εὔριπος Strabo evidently meant the canal itself (cf. above, p. 99), and was making no comparison with *the* strait or any other.

Thus it would seem clear that the hydraulic lock was in use as an aid to navigation in Egypt at least by 260 B.C., while there remains no real doubt that the invention had by that time had a long history under the Pharaohs.

For example, a voyage down the Red Sea to the Land of Punt, in the far South (Somali Coast), and a return voyage with rare and precious cargoes, to be unloaded at the capital on the Nile, not long after 1500 B.C. (XVIIIth Dynasty), was commemorated by a series of monumental reliefs near Thebes. These adorned the walls of the temple of Der el-Bahri, dedicated by the young queen Hatshepsut, under whose nominal direction the expedition had been carried out.[15]

In order that the large vessels portrayed should use the Nile to reach Thebes, it is obvious that a canal from the Red Sea must have been in operation; also that a lock at the seaward entrance was indispensable. It has sometimes been supposed that these ships were built on the Nile and used the canal both going and coming, but this question is quite immaterial. That knowledge of locks could remain limited to Egypt and never find its way to the rest of the Hellenistic world and the Roman West is simply incredible.

To return at last to our governor of Pontus and Bithynia, we must at once concede that his preferred project for a canal to reach the port of Nicomedia was an undertaking quite inconceivable without a series of locks.

When his second letter on that subject (61) reached Rome, what decision was the Emperor to make, as between two contrasted projects? One of these (above, p. 97) may be described as an emergency measure, promising its aid for the armies soon to be advancing in the East, whereas the second, demanding much more time and expense, could hardly be completed without serious delay. For an answer to that question we look in vain for the merest hint. Whatever further letters touched upon this subject—and one cannot believe that there were none—appear to have been deliberately suppressed by the editor of this collection of official correspondence, himself perhaps an official, who may have received explicit instructions in this instance. We may guess that Trajan, under the weight of more pressing cares, lost his interest in Pliny's two distinct projects on receiving further details. His military *libratores* or *architecti* possibly declined to approve, pointing to this objection or that, perhaps in particular the elevation of the lake. It is clear, however, that when he was dictating *Ep.* 62 he was not deterred by the tentative figure of 40 cubits furnished to the governor by *artifices regionis huius* (41.3) for the difference of elevation between Lake Sunonensis and the Bay at Nicomedia. We may surmise that (1) he was preparing to accept the first alternative proposal with its important saving of time

[15] Cf. H. Kees, *Aegypten* (1933) 121 f.; J. H. Breasted, *A History of Egypt*, 2nd ed. (1916), 276 f.; *Ancient Records of Egypt*, 2, 102 ff.; E. Meyer, *Geschichte des Altertums* (1928) 2, 2nd ed. part 1.116 ff.; Maspero, *Histoire ancienne* (1897) 2.247 ff.; cf. 1.495 f.; E. Naville, *The Temple of Deir el Bahari* (Egypt Exploration Fund, 1894) 21 ff.; pls. VII–X; also the larger pls. LXXII–LXXV in part III, with pp. 11 ff.; G. Steindorff and K. C. Seele, *When Egypt Ruled the East* (1942) 101 ff., 167 ff. In China also invention of a 'double lock' (*fu-cha*) was certainly ancient. By the eleventh century it was replacing the haul-over; cf. n. 4 fin; *HJAS* 12.241.

and outlay, presuming possibly that boatmen would at first accept the hardships of the *diolkos* method of transhipment; or else (2) that he had actual knowledge of canals where an even greater *dislivello* had been overcome by sluices having a gate at each end of the *piscina*, in other words by locks, even a series of locks, each closed at both ends by a *cataracta*, closely resembling a portcullis, with which every Roman soldier was familiar, both in permanent camps and in city gates.

But when the army engineers from Lower Moesia and Rome arrived, figures for the level of the lake must have taken an upward turn—not 60 feet but possibly 118 (36 metres by our modern maps)[16]—and objections to a work on such a scale mounted if anything like a series of 10 or 12 locks was to be required. Higher figures for the elevation of the lake, once established, cannot have failed to be reported by Pliny, and the same must be true of other serious objections, if raised by army engineers. Of all this, however, nothing has survived, nor of further correspondence if the matter was under consideration for some time.[17]

Trajan had remained long enough on the Rhine to be well informed on canals constructed by legionaries on its lower course, notably that first of Dutch canals,[18] finished by Drusus in 12 B.C. and used by him in that summer for his first German campaign, when he sailed along the coast as far as the mouth of the Weser. His canal connected the Rhine with the Yssel, leaving the former above Arnhem. At Doesburg (15 km. northeast of Arnhem) it seems to have met the Old Yssel, which flows northward into the Zuiderzee (Flevo Lacus), now called the Ysselsee, near Kampen. Further digging must have been necessary to connect the lagoons mentioned by Tacitus, or to make the *ingens lacus* of Mela 3.24 navigable, also to provide a seaward exit, so that the fleet could pass out into the North Sea.

Drusus' second and third campaigns against the Germans required no use of his fleet, but in 9 B.C., a few months before his death, orders to improve the canal were being carried out. This time a dyke (*moles* or *agger*) was being thrown up, to divert the main current of the Rhine (i.e. the Vacalus, now the Waal) away from the south side of the delta. Thus he would supply much more water to his canal and at the same time attach the Insula Batavorum more closely to Roman territory. The dyke seems to have been progressing[19] a dozen kilometres southeast of Arnhem and the same distance from the entrance of the canal. But it was left unfinished, not to be completed until 55 A.D. by Pompeius Paulinus, who then commanded the army of the Lower Rhine. In 70 A.D. Civilis, the Batavian, destroyed the dyke in order to make Germany less accessible in the north to Roman armies, by restoring conditions which Drusus had planned to change.

Meanwhile another canal 23 miles long had connected the Meuse (Mosa) near its mouth with what is now the Old Rhine at Leyden. The latter was in ancient times the principal mouth of the river, now a minor stream which is pumped into the North Sea, while the great volume of the combined Meuse and Rhine reaches the sea at the Hook of Holland, not far from the south end of the Roman canal of Corbulo, constructed in 47 A.D., after Claudius had obliged him to give up further campaigning in Germany (*Annals* 11.20.2; Cassius Dio [Xiph.] 61.30).

Pompeius Paulinus, not content with his completion of Drusus' work in its final stage, the

[16] There remains the possibility that levels may have changed somewhat in this earthquake belt, in which these very cities suffered seriously several times over, e.g. under Hadrian, Marcus Aurelius, and Julian.

[17] In that case suppression of pertinent letters of later date may well have seemed advisable, to avoid the appearance of extensive preparations for an invasion of Armenia and Parthia. Cf. Cuntz in *Hermes* 61 (1926) 201 f. This may perhaps suggest that book 10 was published before the war actually began in 114 A.D.

[18] The Fossa Drusiana of *Annals* 2.8.1. and Suet. *Claudius* 1.2 (in plur.); cf. Jullian, *Hist. de la Gaule* 4.142. For operations against the Chauci see Livy *Epit.* 140; Cass. Dio 54.32.2. Drusus' canal was used by his son Germanicus in A.D. 17. He had sent four of his legions through it two years before; used by Corbulo in 47; *Annals* 2.8.1; 1.60.3; 11.18.2.

[19] Just where the river forks into a right arm (Nederrijn, farther down known as the Lek) and a left arm (the Waal, Vahalis in Tacitus), in other words at the eastern (acute) angle of the Insula Batavorum; cf. *Annals* 2.6.5. For the destruction of the dyke see *Hist.* 5.19.

diversion of the Vacalus to the north side of the Rhine delta, was now ready to cooperate with the general in command on the Upper Rhine in his project for a far more impressive waterway, namely to connect the Arar (Saône) with the Mosella, in other words the Rhone with the Rhine, if Nero's approval could be secured. Son of a senator from Arelate (Arles), as it appears from *Nat. Hist.* 33.143, he was doubtless well acquainted with canals in the lower Rhone country, e.g. the Fossae Marianae, which connected Marius' camp at Arles directly with the Mediterranean while he was preparing in 103 B.C. for the coming of the Germanic invaders, and required a more navigable channel than that of the Rhone.[20] In that region we seem to know of no ancient canal that had to be carried over a watershed, differences of level being insignificant in the Bouches-du-Rhône.

Very different was the planning of a canal intended to surmount the ridges which separate the sources of the Mosella from those of the Arar, a problem for whose solution it would have been necessary, according to our hydraulic engineers, to wait until the fourteenth or fifteenth century. An obvious truth, provided it can be *proved* that in antiquity no one had ever seen a lock in operation—the only known means of overcoming such differences of level. Yet we have here Roman army engineers serving on the Rhine seriously proposing to carry a canal over a range west of the Vosges, presumably at the lowest practicable elevation. And if *libratores* and *architecti* were rash enough to propose what could never be carried out, there were their superior officers, the *praefecti castrorum*, to restrain them. Months of preparation in a preliminary survey, to determine exactly the route to be followed, and in planning the entire operation, to be begun at the same time from both sides, would have given the two generals-in-command ample time to veto the project if they found it something absolutely unheard-of. Certainly if they knew of no means to surmount the watershed we are entirely at a loss to explain how the generals could present their project to Nero without the most positive assurances that the thing could be done with the resources at their command. Furthermore it is equally difficult to believe that Tacitus could deplore the abandonment of a noble undertaking if he knew that it was from the start impossible, doomed to defeat, as all would have admitted if such a thing as a lock did not exist.

In that year, 55–56 A.D., the four legions of the Upper Rhine were commanded by Lucius Antistius Vetus, one of Trajan's predecessors[21] in that region, and it was Vetus[22] who originated a plan to unite the two principal tributaries of the Rhone and the Rhine. But obviously the full cooperation of Paulinus was indispensable.

In *Annals* 13.53 we read that these two generals, disgusted by lavish distinctions bestowed on other commanders (i.e. by Claudius), "were anticipating greater glory from the maintenance of peace . . . But not to keep their troops unemployed, Paulinus finished the dyke to control the Rhine, a work which Drusus had begun 63 years before [cf. above, p. 102]; and Vetus was planning to link the Arar with the Mosella by constructing a canal, so that commodities[23] received by sea, carried then up the

[20] This canal was just east of the delta, and gave its name to the port at its entrance, now represented by a village still called Fos.

[21] Trajan may well have heard of the Rhone-Rhine project at Moguntiacum (Mainz). The archives of his headquarters there must have contained not a few letters in which the proposal was mentioned.

[22] He was still in command on the Upper Rhine in 56 A.D., when his soldiers were building a bridge over the river at Mainz, as is shown by an inscription from one of its piers, bearing his name with that of a consul; *CIL* xiii, 6820. Vetus' son-in-law Rubellius Plautus, great-grandson of Tiberius (descended also from Octavia Minor, sister of Augustus) and feared as a possible pretender, was executed in the year 62 (*Annals* 14.59). Nevertheless in 64–65 Vetus was proconsul of Asia (*ibid.* 16.10). Long provincial service had given him opportunities to accumulate a store of geographical knowledge of wide range, brought to book in *commentarii* which he left at his death by suicide in 65, after returning from Asia (16.11). Upon these the Elder Pliny drew to such an extent that he names Lucius Vetus as one of his sources for all four of his geographical Books (3–6). To these works of Vetus we may surmise that Tacitus was in part indebted for his brief account of the canal project and its fate. Nero's rejection may have been due primarily to the general's relations with Rubellius.

[23] No doubt including military supplies, but not troops (as some have taken *copiae*), certainly not in

Rhone and Saône, might make their way by that canal, then down the Moselle river into the Rhine and so to the Ocean; and also so that, with the hardships of transport by roads removed, the coast of the Western Sea and that of the North Sea might be connected by shipping. This project roused the jealousy of Aelius Gracilis, governor of Belgic Gaul, who dissuaded Vetus from bringing his legions into the province of another,[24] and seeking to win the favor of the Gallic provinces; and he kept repeating that it would alarm the Emperor, a method by which noble undertakings are very often brought to nought."[25]

So far Tacitus, who unmistakably considered it a project of the first order, even though nothing was really accomplished. It is clear that what they proposed was to his mind an actual waterway from the Western Mediterranean to the North Sea, without any resort to portage. Witness the emphasis with which he adds that the coasts of two widely separated seas were to become *navigabilia inter se*,[26] a phrase uniquely applied to *litora*, as shores imagined to reach one another through an artificial channel in a remote inland. And this after noting that there would be none of the wear and tear of road-transport. Can we suppose the historian to have given no consideration to the problem and to the means which the generals and their engineers were proposing for its solution? Obviously no continuous waterway could possibly be carried over such a watershed without repeated use of a device capable of overcoming important differences of elevation, in other words a series of *piscinae* (cf. pp. 99, 102), each presumably provided with a vertical gate (*cataracta*), to be raised and lowered at each end of the enclosed basin. Certainly Tacitus gives no intimation of the least doubt that such a canal could have been carried up to the required elevation and down again.[27] To him it would have been a noble undertaking, by no means an impractical dream.

Modern engineers incline to believe that the hydraulic lock was first invented in the Italian Renaissance; that antiquity had no adequate means of overcoming any considerable difference of levels in rivers or canals. Thus, for example, General William Barclay Parsons, chief engineer of the Cape Cod Canal and of other notable public works, devoted years of scholarly research to the achievements of his profession in the inventive period just named. The results of these labors appeared seven years after his death.[28] On the first page of his fully illustrated chapter on Locks (pp. 372–398) he sums up his opinion in these words: "The lock is unquestionably of Italian origin and is the greatest single contribution to hydraulic construction ever made." After mentioning the medieval use of "single barriers, or weirs" in canals for irrigation,[29] together with more recent examples, he adds: "The first device intended primarily and solely to permit boats to overcome, on their own bottoms, a difference in elevation was constructed

large numbers, for they were recruited in the region. Advantage to the army is evidently subordinated to commercial expansion, a sop to the Gauls, as also to Roman merchants.

[24] This "bringing his legions into the province of another" (within which limits the whole Rhine army had long been stationed) was a diplomatic pretence quite transparent at the time; cf. p. 106.

[25] A thorough discussion of this passage, of the entire project, and what it implied, appeared in *CW* 27 (1933) 65–69. Its author, Professor George H. Allen, gives much information concerning the Canal de l'Est of today and its numerous locks. An interesting paragraph describes inland navigation in Pennsylvania of the 1830's, with a series of inclined planes on each side of the watershed, to reach the summit level of the Alleghenies (p. 69), each series a modern *diolkos* operated by steam-power.

[26] This has been rendered 'internavigable' by Professors G. G. Ramsay (1909) and Allen (*loc. cit.* 66) – a coinage aptly expressing the novelty of the original but unlikely to find its way into circulation.

[27] What information was available as to the elevation of the watershed above that of the head of navigation on the rivers is unknown. If the province governed for four years (89–93 A.D.) by Tacitus was Gallia Belgica, as is commonly supposed, his knowledge of the region including its rivers may well have been extensive.

[28] *Engineers and Engineering in the Renaissance*, Baltimore, 1939.

[29] For irrigation such weirs were, of course, widely used in antiquity, notably in Egypt, Mesopotamia, and the plains of the Po. On navigable canals in Egypt and elsewhere no ancient evidence appears to have been presented to show that locks were never in use.

in the Naviglio Grande in 1395."[30] It was used in bringing marble and granite from the shores of Lago Maggiore for the Milan cathedral. A later date (1438–39) is given by Guido Ferro, professor in the engineering school at Padua and author of the article *Conca* (1931) in the *Enciclopedia Italiana*. For the first detailed description now available of a canal lock we are referred to Alberti's famous *De re aedificatoria*.[31] According to Mancini, *La vita di Leon Battista Alberti*, 2nd ed. 281, the book was virtually completed before 1450 and already winning favor from his patron Nicholas V. It was not printed, however, until 1485, in Florence, thirteen years after the death of its author.

In the description just mentioned one finds nothing in its language to suggest that Alberti thought the step from one gate to two was a momentous novelty. As to the form of the gates, he describes two kinds: (1) vertical, raised and lowered by a windlass; (2) "most convenient of all," horizontal, turning on a spindle in the middle, "a broad square valve, like the square sail of a barge." So Leoni's quaint English, combined with Bartoli's Italian version in a London folio of 1739 (book 10, ch. 12).

What is true of Alberti's ample writings is even more conspicuously true of the voluminous works of Leonardo da Vinci. No one appears to have discovered in all his numerous references to canals and his directions for their construction and maintenance any claim for his age in even a reinvention of the hydraulic lock.

Catanaeus, a younger contemporary of Leonardo, and an early editor of Pliny's *Letters* (2nd ed. Venice, 1519), has a note on *Ep.* 10.61.4 which shows his understanding of *cataractae*. Of their use as aids to navigation he gives a Renaissance example, viz. the canal from the river Adda to Milan. There follows a comment on Diod. Sic. 1.33.11 f. in these words: "in fossis vero manufactis per cataractas non difficiles ascensus et descensus," implying that to his mind locks were an ancient invention.

The Laurentian Library in Florence possesses a valuable MS (Ashburnham 361) of unknown authorship, but dating from the last third of the fifteenth century. This book has been hastily attributed by some to Alberti, by others on no better grounds to Leonardo, who at one time had it in his hands and added remarks of his own in that unmistakable right-to-left script. None of these, however, touches upon canal locks. The book contains numerous drawings, one of which shows locks with a vertical gate (*cataratta*) at each end, to be operated by a windlass above an arched gateway.[32]

From antiquity no similar representations in reliefs, frescoes, or otherwise seem to have survived, although ancient civilizations undoubtedly had many centuries of experience in the construction of navigable waterways. Nor can we cite detailed descriptions comparable to that of Alberti from a remote past. Yet it is unsafe to conclude that no evidence of the kind will ever be brought to light by the archaeologist's spade or a magnifying glass in the hand of a papyrologist. Equally unsound is it to discard such evidence as we have in inscriptions and ancient texts, simply because details are sparingly given, and in some cases not without palpable error.

Another kind of evidence for the traditional use of hydraulic locks in antiquity is furnished by each of the three projects treated in this paper. When under Nero two of his generals on the Rhine were proposing to connect the Arar with the Mosella not far from their sources (in the Monts Faucilles and the southern Vosges respectively), it is no mere probability that they knew of the one and only means to overcome intervening high levels.[33] They cannot possibly

[30] This navigable canal connected the river Ticino with the moat of Milan; *op. cit.* 367 f.

[31] *Op. cit.* 374 f., a somewhat condensed translation of Alberti's Latin directions for making a lock with two gates, one at each end.

[32] Parsons, 373 ff. with fig. 132 and others, including some of Leonardo's sketches; also on the Laurentian MS, pp. 373, 376; Mancini *op. cit.* 287 (editor also of this MS with its numerous drawings). For Leonardo's interest in canals and locks see J. P. Richter *op. cit.* 2. 181 ff. Cf. A. E. Popham, *The Drawings of L. da V.* 299; E. MacCurdy, *The Notebooks of L. da V.* 2.141 ff. and elsewhere. That interest continued even in the last two years of his life, when at Amboise he proposed a canal to connect the Saône with the Loire, as is known from a British Museum MS; cf. MacCurdy, *The Mind of L. da V.* 149 f. This canal was designed to furnish both irrigation and transportation; O. Sirén, *Léonard de V.* 1.169.

[33] See just below for approximate figures.

have been ignorant of their problem or ready to leave to their engineers its solution. No such ignorance or indifference can be attributed to Trajan in his replies to Pliny in Bithynia; still less to Justinian,[34] whose proposed revival of the same project on a more imposing scale must necessarily have presupposed a series of locks.

One observes that Tacitus, in abridging his sources for the passage in the *Annals* cited on pp. 103 f., does not mention the important share which would certainly have been assigned to Paulinus in the execution of any project for a canal between the Saône and the Moselle, if work was actually to be begun during his command of the Lower Rhine army. For necessarily a second base of operations would have to be established somewhere along the Moselle, preferably in its lower course, conveniently reached from the Rhine below the confluence. Construction would inevitably be begun from that side as well, so that work could proceed upward from north and from south until the summit-level of the water-shed should be reached, some 360 metres above the sea (1180 feet).[35] Vetus could not possibly assume responsibility for construction on both sides of the divide. The mere problem of supplies would of itself dictate that progress be begun in the upper valleys of the two rivers, and should be continued to a meeting-point in still higher regions of virgin forest inaccessible by roads.

It consequently becomes necessary to assume that Paulinus, or his successor as legatus in command of the legions of the Lower Rhine, would take charge of the whole section of the canal which was to drain into the Mosella. Hence the presumption that he cooperated also with Vetus in devising the plan, and then in developing a schedule of operations. All the major details may well have been settled even before the completion of the Fossae Drusianae (p. 102), a minor work in comparison with middle links in the chain of what was to have been an imposing waterway from the Western Mediterranean to the North Sea.[36]

The claim of Aelius Gracilis, governor of Gallia Belgica, that if legionaries were brought into his province to dig a canal, it would be an encroachment upon his territory, had no validity in the very special circumstances of that province in relation to the Rhineland. He had no authority to countermand, or to prevent the project from reaching the Emperor for his decision. For after the defeat of Varus in 9 A.D. Augustus had given up the idea of a frontier at the Elbe and a military occupation of the entire territory between that river and the Rhine. Accordingly the eight legions had been stationed on the left bank in the province of Belgic Gaul for 45 years already, but not under the command of the governor of that province, who in fact as a *legatus pro praetore praetorius* was lower in rank than the two generals-in-command. For they were *legati consulares*, whose permanent headquarters were respectively at Vetera (near Xanten, not far from the borders of Holland) and at Mogontiacum (Mainz). Meanwhile any organization of an Upper and a Lower German province was being indefinitely postponed. Until such long-deferred readjustment was to take place, in fact not before the reign of Domitian,[37] the two generals responsible for the maintenance of order in Gaul and its defence from a possible German invader were stationed, each with his four legions within the bounds of Gallia Belgica, nominally ruled by a governor who had no army. Yet the generals had all necessary authority to intervene wherever and whenever an emergency called for military action. This unique situation, in which a large province was under the direction of three men, one of them to our minds a civilian governor, and of lower rank than the other two, was liable at times to produce friction,[38] all the more that precise geographical bounds to their

[34] For the evidence, in Justinian's case literally tangible, in fact monumental, cf. p. 109.

[35] I.e. if the highest point was to be anywhere near that of the modern Canal de l'Est. Cf. Allen *loc. cit*, 67.

[36] Professor Allen, after weighing other partial solutions of the problem, concludes "that the designer, or some contemporary with whose idea he was familiar, had devised the hydraulic lock, anticipating in this by almost fourteen centuries the course of technical progress"; p. 69.

[37] One of the early *legati consulares* of the then newly created province of Germania Superior was the eminent jurist Javolenus Priscus in 90 A.D.; *CIL* iii, 2864 (=9960), from Dalmatia, probably near his birthplace; cf. A. Riese, *Das rheinische Germanien in den antiken Inschriften*, No. 326.

[38] None seems to have been caused in a somewhat

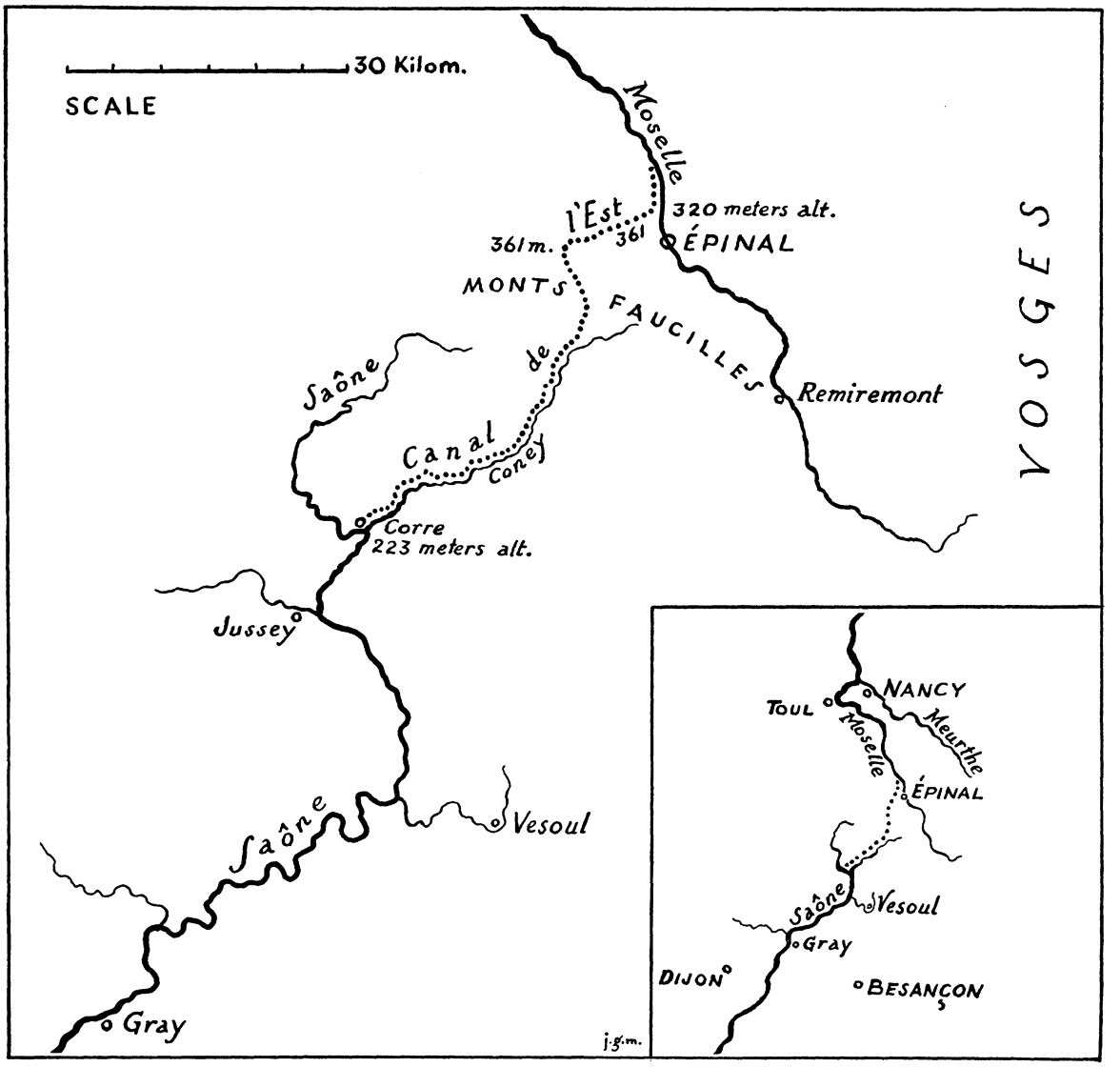

FIG. 2

spheres of activity were lacking. It is natural for us to speak of Upper and Lower Germany, at that time merely regions of Belgica, and in no sense provinces as yet. Nevertheless in a period of transition some administrative and judicial functions fell to the commanding generals as well as to the governor (Mommsen *ibid.* 153 f.).

In such circumstances we have to think of the generals as burdened with a wide range of responsibilities for peace and order among tribes prevailingly Celtic, but with some Germanic elements also in the narrow strip between the Vosges mountains and the left bank of the Rhine. As for Paulinus and Vetus, their provisional border was drawn, it would seem, where their regions actually adjoined—a surprisingly short

similar situation in North Africa, when a road was needed to connect Carthage, in the unarmed province of Africa, with Tebessa (ancient Theveste), in Numidia, an imperial province governed by the legatus of the IIIrd legion. His soldiers were, of course, ordered to construct the road in both provinces. Hadrian's milestones of 123 A.D. (e.g. *CIL* viii, 10048) bear the name also of the legatus. The road was 191 m.p. long, and still shows extensive remains. Cf. Mommsen, *Ges. Schr.* 8.136.

line from the Vosges across to the Rhine at the diminutive Abrinca, 11 km. above Remagen (Rigomagus).[39]

The watershed which the proposed canal would have to surmount, if it was to follow the most available route, i.e. perhaps nearly identical with that of the Canal de l'Est,[40] interposed its barrier between two Gallic tribes, the Lingones on the south and Leuci in the north (fig. 2). Langres (ancient Andematunnum) preserves the name of the tribe whose chief town it was. Tullum (now Toul, on the Moselle) was the chief town of the Leuci, and connected with Andematunnum by a north and south road (*Itin. Ant.* 385), of great importance as the main line of travel from Lugdunum (Lyons) to Augusta Treverorum (Trèves, Trier) and the lower Rhine. It lay well to the west of the modern canal.

At that time unbroken forests covered a vast area in and near the Vosges, where canals are now operated under very different conditions, owing to extensive deforestation. Both Moselle and Saône in their winding courses have accordingly been canalized in recent times on an extensive scale, with numerous locks even far below the watershed, to expedite the movement of larger craft and heavier cargoes than antiquity required. Thus the Saône has fifteen locks between Gray, northeast of Dijon, and Lyons, eleven of them below Auxonne.[41] Higher up the head of navigation on the river is at Corre, where the canal leaves the river at the confluence of the Coney, 223 metres above the sea, to make its way up the valley of that small stream. After rising for 50 km. and through 46 locks it reaches the maximum level of 361 m., to continue for 13 km. more at that elevation. Then begins the descent, 14 locks[42] in 3 km. to 320 m. at its junction with the Moselle, 3 km. below Épinal.

Reverting to Pliny's second and more studied plan for his projected Bithynian canal, it will be remembered that in this he introduced one novel feature, nothing less than a reversal of the current in Lacus Sunonensis (cf. p. 97). This was to be accomplished by stopping up the normal outlet of the lake at its eastern end, namely a small river, later called Melas[43] and now Tschark-Su. This is a tributary of the Sangarius, into which the lesser stream, after ca. 50 km. in its own valley, separated by a ridge from that of the great river, finally empties at about 35 km. from the Black Sea. The plan was to provide a new outlet at the western end of the lake, namely a canal directly to the harbor of Nicomedia.

Whatever may have been the experts' opinion on that new feature of the project, it is interesting to note that the same proposal to reverse the current by converting an outlet into an intake was revived after almost 450 years, near the end of Justinian's reign. Much more impressive, however, is the scale of that undertaking. Its apparent purpose was to add immensely to the commerce of the same seaport by diverting the Sangarius itself to the west, and then (probably near the present town of Ada-Basar) again to the southwest, to deliver at least the larger part of its waters into the east end of the lake. From its west end down to the sea the canal was evidently to be no narrow channel, such as Pliny proposed (p. 97; *Ep.* 10.61), but one adapted to larger vessels which should sail down the diverted river into the lake, and so to Nicomedia, bound

[39] Cf. Ptolemy, who places the boundary still at the same brook (Vinxtbach), 2.9.9 Miller; or 2.8, p. 61 Stevenson.

[40] Not to be confused with the Rhône-au-Rhin canal, which at St. Symphorien (Côtes d'Or) leaves the Saône for the Doubs at Dôle, and continues up the valley of that river, to reach the Rhine near Mulhouse and again at Strasbourg.

[41] Cf. P. G. Hamerton, *The Saône, A Summer Voyage* 163. Below Auxonne the river was navigable, he says, in the thirteenth century, and had a towpath used by crusaders' chargers all the way to Lyons. Based on de Joinville, *Hist. de Saint Louis*, sec. 123.

[42] This makes a total of 60 locks with an average lift of 3 m. (9 ft. 10 in.). For the figures above I am indebted to Allen, *loc. cit.* 67, who has added a rare familiarity with European inland waterways. He had used French official maps, superior for such details to War Department maps of the same region, which have been widely distributed to our libraries. For practical convenience a Carte Taride (Est de la France, section Nord, No. 6) can be recommended, as clearly showing the route of the canal maintained for traffic of today. Useful also are maps issued jointly by the British War Office and our War Department, e.g. GSGS 2738, Nos. 17 and 23; on a larger scale (1:100,000) GSGS 4249 = AMS 661, Nos. 242, 302.

[43] For this name the earliest authority cited is Pachymeres, early in the xivth century; cf. p. 109.

for the capital or the Aegean. Incidentally there could be no danger of draining the lake away—a risk which may have contributed to Trajan's abandonment of a less ambitious project. Thus shipments from the interior of Asia Minor would be able to reach the Propontis directly, instead of through the gorges of the lower Sangarius, with their cascades and rapids, and then by a coastwise voyage requiring transshipment to larger craft, in order to reach the Bosporus.

The one remaining proof that what Trajan had rejected commended itself to Justinian and his advisers is an imposing bridge across the diminutive Melas, 3 km. northeast of the lower end of the lake. This well-preserved bridge is 435 m. long (1427 feet)[44] and has eight arches of 23 m. (75 ft.) span. Its most conspicuous feature is the disproportion between this monumental structure and the small stream which ambles idly beneath its towering arches for most of the year. Not less striking to careful observers has been the plan of all the piers; for they have sharp angles to the north (downstream) and rounded surfaces to the south (upstream, toward the lake). Here then we have tangible proof (even in the literal sense) that Justinian's engineers were well acquainted with locks. For the elevation of the lake, at present 118 feet, did not deter them from finishing a monumental bridge[45] under which the water of a great river was some day to flow into its eastern end, but only after the whole elaborate project had been completed. Not until then was the original small outlet to be reversed and united with the broad current of a huge intake—nothing less than the diverted Sangarius.

That river still continued to flow towards the Black Sea, but at the nearest point it ran ca. 5 km. to the east of the bridge, as it does today, in a level country always subject to serious floods. These may have caused it more than once to shift its bed to the west as far as the bridge for a time. It is clear, however, that they have never been able to produce a reversal of the current, to flow into the lake, which since geological ages has never had an outlet to the west.

Procopius, writing at the time the bridge was under construction, in 559–560 A.D., relates that Justinian had lately undertaken the first substantial bridge over the Sagaris (Sangarius).[46] He does not say that Justinian diverted the river before building the bridge.[47] It is Theophanes who makes that statement,[48] adding that the Emperor made "five stupendous arches," which shows that the name had been corrupted to Pentagephyra,[49] for they are eight in number. Evidently no one had enlightened Procopius as to what was intended in addition to the bridge. He had no idea of a proposed reversal of the current, to be preceded by construction of a great bridge, with all its piers in reverse, nor any conception of the grandiose project as a whole. He must have thought of the river as still flowing northward.

Obviously the proposed change of direction from northeast to southwest was not to be made until every feature of a complicated project had been carried to completion. Surely it was never Justinian's intention to leave a minor tributary in possession of the portentous bridge over which the traveller from Nicomedia, following the north shore of the Sunonensis, could reach Paphlagonia and Pontus. Hence probably came the name Pontogephyra, of which we first hear in Pachymeres,[50] in a narrative of events occurring in 1296 A.D., 736 years later. To his mind apparently the Sangarius had been flowing under the bridge long enough to have that called its old bed, in contrast to the channel in which (some 5 km. farther to the east) it had flowed in ancient times, as it does today. Or was there confusion in his sources?

[44] In comparison one notes that the Pont du Gard is 269 m. in length (883 ft.).

[45] For Justinian's bridge see von Diest in *Petermanns Mitteilungen*, Erg.-Heft 27.125 (1898) 70, citing von der Goltz on the plan of the piers and what that inevitably implies; also *ibid.* 20.94 (1889) 94 f. Von Diest's map is valuable (Bl. II). Cf. Ramsay, *Hist. Geog. of Asia Minor* 214 f., 460. South of this bridge lies an island crossed by a Roman road with two small bridges of which there are remains.

[46] *De aed.* 5.3.8 ff. Cf. Downey in *TAPhA* 78.181, n. 11. Permanent it remains but not permanently over the Sangarius; cf. p. 110.

[47] As von Diest incorrectly has it, p. 70, cited above.

[48] *A.M.* 6052 (de Boor 1.234; Migne, *P.G.* 108.513; *Corp. Scr. Hist. Byz.* 41. 362). It is repeated by Landolfus Sagax in his additions to Paulus Diaconus, *Hist. Rom.*, Migne, *P.L.* 95. 992 B.

[49] Landolfus shows the same corruption of the name in the *arcus mirabiles quinque* (*loc. cit.*).

[50] Migne, *P.G.* 144.364; *Corp. Scr. Hist. Byz.* 2.330 f.

The entire project shared the fate of Pliny's proposal to Trajan, as of that of the Rhine generals to Nero, whether complete abandonment of his great plan came in the last years of Justinian, or immediately after his death. Certainly the two rivers were left where they had been, the little Melas as sole outlet of the lake, and flowing under the immense bridge. On the other hand the Sangarius was free to roam in a level plain, when its flood-waters, retarded by the narrow gorges nearer the Black Sea, could for a time shift to the Melas valley, after passing under the bridge which was to have been theirs alone. But they have never made their unaided way westward into the lake, to cut a new channel down to the nearest arm of the Sea of Marmara.

As for a canal to connect lake and sea, the lack of any remains of such operations west of the lake forces us to conclude that not even a beginning had been made. Nor are there any indications that dykes or dams, necessary to a reversal plan, were ever in progress in the region northeast of the lake, that is, near Ada-Basar. Hence we can be quite certain that the bridge was the one and only part of that great project to be carried out. It was merely by anticipation of what was contemplated but never achieved that Procopius could speak of it as a bridge over the Sangarius, still some distance away.

Reverting to Pliny and his modest canal project, we may not overlook certain misguided efforts to shift the scene of operations to a different lake, i.e. the Ascania, in spite of a positive statement in *Ep.* 41.2 that his *amplissimus lacus* was *in Nicomedensium finibus*, which cannot possibly be diluted into "in the neighborhood" of that city. It was, of course, the provincial capital, Nicomedia, that was to profit by this public work, while the lake with which Trajan and Pliny were alone concerned at the moment belonged to that seaport exclusively.

Nothing could have been more certain to rouse the bitterest feeling in Nicaea than any proposal to connect the harbor of their rival with the very lake on which their own city lay, in undisputed possession of its much ampler expanse of water. And that at a time when internal peace and quiet in Bithynia were mandatory for Trajan in his preparations for a foreign war in Armenia and Parthia, inasmuch as Pliny's province would soon lie across main lines of communication with the front.

For another reason also it is absurd to drag Ascania Limne, the lake of Nicaea, into the study of these particular letters. In 41.4 Pliny, on a visit to the region of the Nicomedensian lake, had found evidence of an unfinished canal, begun probably by some former king, to connect the lake, it would seem, with a river nearer to Nicomedia and salt water. As for Ascania, which poured its waters into the Propontis down its own natural channel, which Vergil pointedly describes as *sonantem Ascanium*,[51] no king would have undertaken a different outlet. At most it demanded canalization—no easy task, to be sure—on account of its sharp descent into the Bay. It was obviously in a quite different locality that Pliny made his archaeological find, not less than 30 miles away (as the crow flies) from Ascania Lacus at Nicaea.

A fourth reason for avoiding Sölch's preposterous identification is furnished by certain facts concerning the eastern end of the two lakes. In that direction Pliny's lake had its single outlet in an unnamed stream (later Melas, pp. 108 f.), emptying eventually into the Sangarius. He proposed to stop that outflow, no doubt by a dyke near the lake. Ascania, however, at its east end has no outlet at all, nothing in fact but small streams flowing into the lake! Yet such contradictions had no deterrent effect upon Sölch's theory,[52] unaccountably espoused as a probability by Lehmann-Hartleben[53] without attempting to defend it. No more did the imagined necessity of surmounting a considerable watershed between Nicaea at 87 m. (hemmed in on that north side by mountains) and Nicomedia at sea-level by means of a canal to reach that harbor. Meanwhile Ascania, the larger lake, must be closed at its seaward end, and the roar of the river Ascanius was to be permanently hushed![54]

If Pliny's project was rejected or indefinitely

[51] *Georg.* 3.269 f.; and well might it roar in reducing 87 m. to zero in less than 18 km.

[52] *Klio* 19.169 ff.

[53] *Plinio il Giovane, Lettere Scelte* (with archaeological notes), 1926, pp. 20 ff.

[54] E. G. Hardy in his much used edition of the *Epis-*

postponed, possibly without much delay, the other two give evidence of careful and no doubt long-continued study, but only to end in frustration. That of Paulinus and Vetus, generals-in-command on the Rhine, promised great results by linking that river with the Rhone, if only Nero had not refused to approve. Justinian's purpose to revive the proposal of Pliny on a far larger scale might have brought prosperity to a whole region of Asia Minor nearest to the capital. Unhappily both of these came to nothing. One of them found its epitaph in an eloquent passage in a historian of whom it is almost certain that some 35 years later he was governor (above, n. 27) of the very province in which the work would have been carried on. The other still has its enduring monument in a maximum of bridge pathetically spanning a minimal stream.

For us there remains the assurance virtually given by these three proposals that the lock was known and used in Roman and Byzantine times. To believe that these projects were the merest paper-work from the hands of men who had never seen or heard of a lock is a strain upon the credulity of any one of us, be he a practical engineer of wide experience, or only a scholar delving in books "with the secular dust on."

Cleveland, Ohio
November 1949

tulae ad Traianum (London, 1889) was probably misled by an inaccurate map of the smaller Lake Sabanja. For he says (p. 143): "At present" that lake "is connected . . . and also with the Gulf of Ismid on the west." His "present river connecting the lake with Nicomedeia," later described as possibly "Pliny's canal carried out," is absent from every map known to the writer.