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BYZANTION

REVUE INTERNATIONALE DES ÉTUDES BYZANTINES

fondée en 1924

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Organe de la Société belge d'Études byzantines

TOME LIII
(1983)

Fascicule 1

Publié avec le concours du Ministère de l'Éducation nationale et de la Culture française, et de la Fondation Universitaire de Belgique

BRUXELLES
BOULEVARD DE L'EMPEREUR, 4
1983

THE BYZANTINE EARLY WARNING SYSTEM

Several of the Byzantine chronicles and Constantine VII Porphyrogenitus give it as a ground for censure against the Emperor Michael III (842-867 A.D.) that he ordered the dismantling of the beacon system which gave warning in the capital of hostile Arab movements on the eastern frontier in Cilicia. The story, which is probably only a *ψόγος* against him, goes that Michael was busy with one of his horse-races (in which he won) when the beacon nearest to the city indicated that an Arab invasion had taken place. So as not to upset the crowd for the next day he commanded that the beacons should not operate thenceforth.

The amount of detail given by the sources varies, but the fullest circumstantial account of the system is given by the chronicle of Pseudo-Symeon (referred to hence as "Pseudo-Symeon" for convenience). The text of the passage in question is as follows (1).

> *ὁ φιλόσοφος Λέων ὁ Θεσσαλονίκης γενόμενος πρόεδρος, τῷ βασιλεῖ Θεοφίλῳ συμβουλεύσας, ὡς ὡρολόγια ἐποίησεν δύο ἐξ ἴσου κάμνοντα · καὶ τὸ μὲν ἓν ἐπὶ τῷ φρουρίῳ τῷ κατὰ Κιλικίαν τῇ Ταρσῷ πλησιάζον ἀπέθετο, τὸ δὲ ἕτερον ἐν τῷ παλατίῳ ἐφυλάττετο, ἅπερ εἶχον γεγραμμένα εἰς*

(1) (Pseudo-Symeon =) Symeon Magister et Logotheta (ed. I. Bekker, *CSHB*, Bonn, 1838), pp. 681-2 = *PG*, 109, col. 743 B-D.

On the Byzantine beacon system generally see :

W. M. Ramsay, *The Historical Geography of Asia Minor* (London, 1890), pp. 187, 351-3 and addition, p. 20 ;

J. B. Bury, *A History of the Eastern Roman Empire* (London, 1912), pp. 246-81 ;

P. Lemerle, *Le Premier Humanisme Byzantin* (Paris, 1971), pp. 154-5 ;

A. Toynbee, *Constantine Porphyrogenitus and His World* (London, 1973), pp. 290-300 ;

P. Dvornik, *Origins of Intelligence Services* (New Brunswick, 1974), pp. 142-3, with a map, pp. 144-5.

These works are referred to hereafter by the surname of the author only. There is also a brief account in L. Bréhier, *Les Institutions de l'Empire byzantin*[2] (Paris, 1970), pp. 268-70 and notes pp. 526-7 (= ed. of 1949, pp. 331-3).

> *ἑκάστην ὥραν τὰ ἐν Συρίᾳ γενόμενα, οἷον τὴν πρώτην ὥραν εἰ ἐκδρομὴ τῶν Σαρακηνῶν γέγονε, τὴν β΄ εἰ πόλεμος, τὴν γ΄ εἰ ἐμπρησμός, τὴν δ΄ εἰ ἄλλο τι, καὶ εἰς τὰς λοιπὰς ὁμοίως. ἐκ τῶν γεγραμμένων οὖν δώδεκα ὑποθέσεων εἴ τι κἂν συνέβη ἐν Συρίᾳ, ἐν τῇ ὥρᾳ ἐν ᾗ ἡ ὑπόθεσις γέγονεν, ἀνάπτων ἀπὸ τῶν ἐκεῖσε φανός, ἐπεὶ καὶ οἱ φυλάσσοντες καὶ ἀτενῶς καὶ ἀκριβῶς βλέποντες τὰ τετυπωμένα ἐν αὐτοῖς ἦσαν, μετεδίδοτο εὐθὺς ὁ φανὸς ἀπὸ τοῦ φρουρίου τοῦ λεγομένου Λούλου τοῖς κατὰ τὸν Ἀργαίαν βουνὸν καὶ αὖθις τοῖς κατὰ τὴν Σάμον καὶ τοῖς κατὰ τὸ Αἴγιλον, εἶτα τοῖς κατὰ τὸν Μάμαντα πάλιν βουνόν, ἀφ' οὗ ὁ Κύριζος, εἶτα ὁ Μώκιλος, ἀφ' οὗ ὁ τοῦ ἁγίου Αὐξεντίου βουνὸς τοῖς ἐν τῷ παλατίῳ κατὰ τὸν ἡλιακὸν τοῦ Φάρου διαιταρίοις ἀφωρισμένοις ἐν βραχεῖ ἐποίει φανερόν. ἱππευομένῳ οὖν τῷ βασιλεῖ Μιχαήλ, ὡς εἴρηται, ὁ φανὸς ἐσήμανεν ἐκδρομὴν τῶν Σαρακηνῶν. αὐτὸς πρὸς τὸ μὴ τοὺς θεατὰς τοῦ ἱπποδρόμου χαλαρωτέρους τῇ αὔριον γενέσθαι, προσέταξεν μηκέτι τοιούτους φανοὺς ἐνεργεῖν.*
>
> "Leo the Philosopher, who became bishop of Thessalonica (2), acting as adviser to the emperor Theophilus, made two sorts of timepieces which worked at the same rate. The one he set up in the fortress in Cilicia near to Tarsus and the other was kept in the Palace. They had marked on them against each hour what was going on in Syria. For instance if an Arab raid had taken place, that was against hour 1 ; if it was war, against hour 2 ; if there was general arson, against hour 3 ; if something else, against hour 4 ; and likewise against the remaining hours. So if any of the twelve occurrences which had been marked by pre-arrangement should happen in Syria, at the hour where the occurrence came they lit one of the beacons there. As watchers were looking out intently and carefully for what was indicated by them, the beacon was immediately passed on from the fortress called Loulon to the men on the hill of Argaias and straightway to those on Samos and on Aigilos, then further to those on the hill of Mamas. Thence Kyrizos ; then Mokilos, thence the hill of S. Auxentios quickly gave the news to the palace stewards appointed for the purpose up on the balcony of the Pharos.
>
> So the emperor Michael was staging a horse race, as was said, when the beacon indicated an Arab raid to him. But he, in case the spectators should be less orderly the next day, commanded that such beacons should no longer operate".

Leo the Philosopher is none other than the professor also known as 'the Mathematician', the outstanding scientific scholar and elder contemporary of Photius. He has often been attributed with the

(2) 840-3 A.D. cf. Lemerle, p. 150.

invention of the fantastic devices, such as the hydraulic throne, the mechanical tree with its birds and the roaring lions and griffins which provided such an impressive setting for the Emperor at the Magnaura Palace (3), though he presumably knew how to follow the instructions in the treaties of Hero of Alexandria on hydraulics and mechanics. We are, however, concerned here with Leo's beacon system more than Leo himself.

The other accounts of the stations in the system, in Theophanes Continuatus, Constantine Porphyrogenitus (*De Ceremoniis*), Scylitzes, George Cedrenus and Zonaras (4), are briefer : all have close verbal parallels, a reflection, no doubt, of the common ground of the Byzantine chronicles for much of their material. No other source besides Pseudo-Symeon mentions either Leo as the inventor or the *ὡρολόγια*, and in each there are small variants in the names of the beacon points. We shall look later at the sources and differences amongst them went it comes to the report of what Michael III did with the beacons and at what time of day the message came to him.

Constantine Porphyrogenitus (5), before describing the beacon system says the following :

(3) On Leo see Lemerle, chapitre VI, pp. 148-176. On the automata at the Magnaura (which Lemerle doubts should necessarily be attributed to Leo), see *ibid.*, p. 154, n. 27.

(4) Theophanes Continuatus (ed. I. Bekker, *CSHB*, Bonn, 1838, pp. 197-8 = *PG*, 109, col. 211 C-D) has *Ἀργαῖον* for *Ἀργαίαν* : *Ἴσαμον* for *Σάμον*.

Constantine Porphyrogenitus, *De Ceremoniis* (ed. J. J. Reiske, *CSBH*, Bonn, 1829, I, pp. 492-3 (*Appendix ad Librum Primum*) = *PG*, 112, coll. 932C-933B) has *Ἀργέας* for *Ἀργαίαν* : *Ὄλυμπος* for *Μάμαντα* ; *Μούκιλος ἐπάνω τῶν Πυλῶν* for *Μώκιλος*.

Ioannis Scylitzae, *Synopsis Historiarum*, ed. J. Thurn (Berlin, New York, 1973), pp. 107-8 has *Ἀργαίῳ* for *Ἴσαμον* for *Σάμον*, and is copied by Cedrenus (ed. I. Bekker, *CSHB*, Bonn, 1839, II, pp. 174-5 (= *PG*, 121, col. 1060 A-C), with *Ἀργαίῳ* for *Ἀργαίαν* : *Ἴσαμον* for *Σάμον* ; *Αἰγιαλὸν* for *Αἴγιλον*, *Κίρκος* for *Κύριζος* ; *Μόκιλλος* for *Μώκιλος*.

Zonaras, ed. L. Dindorf (Teubner, Leipzig), IV (1871), p. 16, (= ed. M. Pinder (*CSHB*, Bonn), III (1897), pp. 404-406 = *PG*, 135, 28B-29A) has *Ἀργαίῳ* for *Ἀργαίαν* ; *Ἴσαμον* for *Σάμον* : *Κύζικον* for *Κύριζος*. He does not mention the Pharos and says that the signal came to the emperor from Mt. S. Auxentios, which may mean the same thing as the other sources but might reflect a later state of the system after Michael stopped at least the Pharos beacon working.

(5) Constantine Porphyrogenitus, *De Cer.* (*CSHB*), p. 492 (= *PG*, 112, coll. 932C-933A). (The addressee is his son, Romanus II).

ἐπεὶ οὖν τὴν πρὸ ἡμῶν σοι προεκτεθεῖσαν βασιλικῶν ταξειδίων ἔκθεσιν, πατρὶ κατὰ πάντα πειθόμενος, ἀνέγνως καλῶς, προσῆκον ἄρα σοι καὶ τὰ πρὸ τῶν ταξειδίων γινόμενα διελθεῖν τε καὶ ἐκμαθεῖν, ὅπως διὰ φανῶν τινων καὶ λαμπάδων τῶν ἐκ διαδοχῆς πρὶν ἀνημμένων ὁ βασιλεὺς ἐν μιᾷ ὥρᾳ τὴν τῶν ἐχθρῶν εὐθὺς κατεμάνθανεν ἔφοδον. ἀλλ' ἐκ τῶν προκειμένων σοι κεφαλαίων ταῦτα τρανώτερον δηλωθήσεται.

"Now since, obeying your father in all things, you have diligently read the account of the imperial military expeditions before Our time which We set down for you, it is appropriate that We should explain for your instruction what happens before the expeditions ; that is, how the emperor used to learn of an enemy invasion as it happened *in a single hour* by means of beacons and flares which had been lit in succession. This will be shown more clearly from the sections of this book which you have before you".

The important point here is that the message arrived at Constantinople *in one hour* – *ἐν μιᾷ ὥρᾳ*. After the details of the beacons, Constantine goes on to add (6) some details of how the message was dealt with once it reached Constantinople :

ἰστέον, ὅτι, τῶν φανῶν τούτων πάντων ἀψάντων, εὐθὺς οἱ χαρτουλάριοι τῶν ἔξω στάβλων καὶ σαφραμεντάριοι ἐκαλίγουν τὰ βασιλικὰ ἄλογα, καὶ τὰ βασιλικὰ σαγμάρια εὐτρεπίσαντες εὐθὺς ἐκίνουν, καὶ κατήρχοντο εἰς τὴν τοῦ βασιλέως ἀπάντησιν ἐν Πύλαις. ὁ δὲ βασιλεὺς ἐξήρχετο μέχρι τῶν Πυλῶν, τὰ δὲ βασιλικὰ σελλάρια καὶ οἱ ἄρχοντες καὶ οἱ λοιποὶ οἱ ἀπὸ τῆς πόλεως ἐξερχόμενοι τῆς ξηρᾶς, προελάμβανον τὸν βασιλέα εἰς Πύλας, καὶ ὅτε τὸ τῶν Σαρακηνῶν φοσσάτον ὤφθη τισὶ πρὸς τὰ τῆς Ῥωμανίας συστάμενα, ἦν ὁ βασιλεὺς εὐθὺς εἰς ἀπάντησιν αὐτοῦ.

"You should know that, when all the beacons had been lit, the *chartularioi of the outer stables* and the *saphramentarioi* immediately shoed the imperial horses, set ready the imperial pack-horses and got them moving straightway, then went down to meet the Emperor at Pylai (7). The Emperor went out as far as Pylai, and the imperial cavalry and its commanders and the rest in the city set off from the mainland and waited for the emperor at Pylai. When someone spotted the encampment of the Arabs against the established boundaries of the Roman Empire, the emperor was immediately there to encounter it".

(6) *Ibid.*, pp. 492-3 (= *PG*, 112, col. 933B-C) ; cf. *ibid.*, p. 474 (= *PG*, 112, col. 909C).

(7) Pylae on the south shore of the Propontis, see Ramsay, p. 187.

To this we might add that Theophanes Continuatus says that the reporting of the message was the duty of the *παππίας*, an officer of the Imperial Palace (8).

Theophanes Continuatus says that Michael ordered the beacons near the City not to be lit henceforth (*μηκέτι τοὺς πλησιάζοντας φανοὺς ἐνεργεῖν προσέταξεν*). Skylitzes (cf. Cedrenus) likewise reports that he only curtailed the lighting of the beacons nearest the capital (*προσέταξε μηκέτ' ἐνεργεῖν τοὺς τῇ βασιλίδι γειτονοῦντας φρυκτούς* [*vel* (Cedrenus) *πυρσούς*]). This is perhaps the truth of the matter, a less rash action on his part than the pejorative accounts of the Chronicles actually suggest. Zonaras also speaks of a ban *τῶν τῇ βασιλίδι γειτονούντων πυρσῶν* (9).

There are two aspects to the beacon system : (i) the beacons themselves ; (ii) the method of operation of the system. The former has been investigated already, but the latter seems not to have been given much thought. First, however, we should consider the details of the siting of the beacon fires.

(i) The Beacons

The early warning system consisted of a row of nine beacons beginning at a point in the Taurus mountains which commanded a view of the roads and passes north of Tarsus and ending at Constantinople right next to the Palace on the Pharos. Watchers were engaged at each beacon but the first to observe constantly the previous beacon in the chain : at the easternmost beacon the Arabs themselves were watched. At each ends of the chain, Loulon in the east and Constantinople in the west, a *ὡρολόγιον*, or timepiece, of some sort was kept : the two *ὡρολόγια* worked together in some way and were equipped with marks which indicated certain messages against each hour.

The details of the beacon chain and the sitings of each beacon were worked out by Ramsay at the end of the last century. He placed Loulon on a thousand-foot peak above a plain four thousand feet above sea level in a position commanding the pass and roads

(8) Theophanes Continuatus (*CSHB*), p. 198, ll. 2-3.
(9) Cf. Bury, p. 285, esp. n. 3.

between the Cilician Gates and Tyana, north of Faustinopolis and said that its ruins lay to the north-east of the later, Turkish, ruin of Ulukışla at Porsuk. Faustinopolis has been identified more recently further north as the now abandoned village of Başmakçı. From the now known configuration of the roads from Podandos to Tyana, one via Faustinopolis, one via Tynna, Loulon would better have lain between Faustinopolis and Aquae Calidae, where both roads are commanded and an Arab inroad up the Tynna route would not have been missed. This is the view taken by Hild. He points out that Ramsay's location will not work since it is not possible to gain the necessary view to the next beacon, which, with Ramsay, he takes as Hasan Dağı (but cf. *infra*). Hild locates Loulon south of Faustinopolis (Başmakçı), about 4 miles north of Çakıt-Tal, 8 miles north-east of Porsuk between Çanakçı and Gedelli on an isolated peak 6.300 feet higher, which rises above the other ridges of the Taurus in this region and provides an excellent view over the road through the Cilician Gates and north-west to Hasan Dağı, the second beacon. Ruins of a Byzantine town have been found here. Ramsay goes on to say that it must have been captured in or some time after 782 A.D. and held until at least 811. However, from the campaigns of Hârûn-al-Rashîd in 806 as recounted by Theophanes it is probable that Loulon was not a major post at that date, since he does not mention it with other captured places as he certainly would have done had it then enjoyed its later importance ; its construction therefore may only date to after 806. In Arabic the place is known as Lu'lu'a ("pearl") or (As)sakāliba (10).

(10) On the beacon system, see Ramsay, pp. 187, 351-3 and addition, p. 20. Loulon is modified by Ramsay in the *Geographical Journal*, XXII (1903), pp. 403-5, with a photograph, p. 404, and a map, opposite p. 484. Cf. A. A. Vasiliev, *Byzance et les Arabes*, I (Brussels, 1935), p. 116 and n. 1 ; E. Honigmann, *Die Ostgrenze des Byzantinischen Reiches* (= foregoing, vol. III) (Brussels, 1935), p. 45 and nn. 4, 5.

On the identification of Faustinopolis see M. H. Ballance, *Derbe and Faustinopolis*, in *Anatolian Studies*, XIV (1964), at pp. 140-2 ; on the roads to Tyana, cf. *ibid.*, pp. 142-5, with a map, p. 143. Hild's views on the site of Loulon are in F. Hild, *Das Byzantinisches Strassensystem in Kappadokien* (= *Tabula Imperii Byzantini*, ed. H. Hunger, 2) (Vienna, 1977), pp. 53-54, with a sketch map, p. 55, and photograph, Abb. 22. He says (p. 54) that the name Loulon is not, as Ramsay said (p. 353), derived from the ancient Halala, but from Mount Lolas. On the frontier generally, see J. F. Haldon, and H. Kennedy, *The Arab-Byzantine*

At all events it was back in Byzantine hands and lost by them to Al-Mamûn in 832 (11). We next hear of it in A.H. 245 (8th April, 859-27th March, 860), when the contemporary Tabarī, whose account is the fullest, says that the inhabitants prevented their governor from entering the city for thirty days. The Emperor, Michael III (the same bogey-man who stopped the beacons working in our Byzantine chronicles), sent them a patrician and a thousand dinars to surrender Loulon to him. They allowed the patrician (a "logothete") to enter the town but, on receiving their pay, then surrendered him to Balkāğūr (between 27th February and 27th March, 860). The envoy was then taken away and imprisoned. As a ransom the emperor offered a thousand musulman prisoners. Then, in A.H. 246 (28th March, 860-16th March, 861) an Arab envoy arrived at Constantinople. Before long, Tabarī says from the account of this envoy, a deputation arrived at the capital from Loulon. They said that they wished to adopt Christianity and come over to the Emperor's side. Meantime the Arab envoy was ignored for four months, but when the emperor heard that Loulon had ejected his patrician envoy and surrendered to the Arabs he entered into negotiations between the men of Loulon and this Arab envoy. This resulted in the exchange of prisoners already mentioned, though the numbers involved were higher than stipulated there. This occurred

Frontier in the Eighth and Ninth Centuries : Military Organisation and Society in the Borderlands, Zbornik radova Bizantološkog Instituta, XIX (1980), pp. 79-116.

On the 806 campaign of Hârûn al-Rashîd, see THEOPHANES, p. 482 (ed. de Boor) and M. CANARD, *La Prise d'Héraclée et les Relations entre Hārūn ar-Rashīd et l'Empereur Nicéphore Ier*, in *Byzantion*, XXXII (1962), pp. 345-379 (= M. CANARD, *Byzance et les Musulmans du Proche Orient* (Variorum Reprints, London, 1973), XVIII.

On the Arabic name of Loulon see RAMSAY, p. 353, HONIGMANN, *op. cit.*, p. 45.

Constantine Porphyrogenitus says elsewhere of Loulon that it was in *μικρὰ Καππαδοκία* (*De Them.*, in CONSTANTINUS PORPHYROGENITUS, ed. I. Bekker, III [*CSHB*, Bonn, 1840], p. 19 = *PG*, 113, col. 76 B1-5). Anna Comnena mentions it (*Alexias*, XIII, 12 : ed. A. Reifferscheid, [Teubner, Leipzig, 1884], II, p. 271, l. 1. Anne COMNÈNE, *Alexiade*, XIII, 12, ed. B. Leib, t. III, Paris, 1945, p. 133, l. 22.

In the ensuing paragraphs I have taken my orthography and heights for the peaks, etc. from *Turkey, Official Standard Names Approved by the United States Board on Geographic Names ... Gazeteer No. 46* (Washington, D.C., 1960).

(11) This date is argued by BURY, p. 474 ; cf. VASILIEV, *op. cit.*, I (1935), pp. 117-118 : RAMSAY, p. 354.

either between 27th April and 25th May, 860 or between 24th July and 22nd August of the same year.

Vasiliev has understood this passage to mean that Loulon was in Byzantine hands again in 860 and that the governor whom the inhabitants prevented from entering the place was the Byzantine governor. However Tabarī does not say that Loulon had a Byzantine governor, indeed he implies that there was an Arab governor (who would have been sent from Tarsus). Further the fact that the deputation from Loulon (which had a strong Slavonic population planted by the Arabs) spoke of a desire to adopt Christianity implies that the inhabitants were Muslims, and hence almost certainly Arab subjects at the time. The Emperor, in sending a patrician envoy, a high-ranking logothete, and a promise of money, was evidently aiming to profit from the rising at Loulon against its *Arab* masters, but his efforts misfired in the end.

It looks as though Tabarī's account may have misleadingly combined two sources. The story makes best sense if we see the sequence as follows :

(i) The Arab envoy arrives at Constantinople.
(ii) The inhabitants of Loulon refuse to admit their Arab governor because they have not been paid. They send a deputation to Constantinople offering the fortress town to the Emperor and to accept Christianity.
(iii) The Emperor, keeping the Arab envoy waiting the while, sends a logothete with an offer of money if the inhabitants will deliver the place to him.
(iv) The men of Loulon get paid by the Arabs, accept their Arab governor and hand over the logothete to the Arabs.
(v) The Emperor then begins negotiations with the Arab envoy at Court and arranges for Muslim prisoners to be exchanged for his logothete.
(vi) This was done and Loulon remains in Arab hands.

We should thus see this as a placated revolt against not the Byzantines but the Arabs, and should understand that Loulon was still in Arab hands in 859/860 (12). Of course, it may have been

(12) Tabarī translated in VASILIEV, *op. cit.*, I (1935), pp. 319-22 : comment : *ibid.*, pp. 237-240. Other sources summarised : p. 237, n. 3.

under Byzantine control earlier or later than this date – yet the evident presence of a Muslim population would suggest a settled state of affairs which had existed for some time.

If the first post of the beacon chain was not in Byzantine hands after 832 and perhaps not at all during the reign of Michael III (843-67), the beacons would not, it would seem, have been working, so he could not have stopped them. However, we shall see that it is possible that the system was in use even if Loulon was not in Byzantine hands. The reason for his stopping the system is most unlikely to have been the frivolous one given in our Greek sources by chroniclers working under the succeeding Macedonian dynasty aiming to blacken his name and his, or his uncle Petronas' military achievements. A possible explanation for the cessation of the beacons is to be found in the great victory of Petronas over the Arabs at Poson in 863 : perhaps there was no longer felt to be need for the rapid intelligence of Arab movements or for the speedy intervention of the army of the capital which that implied. Under those circumstances Michael may well merely have ordered the beacons *near the capital* (which is what several of the sources other than Pseudo-Symeon specify) – *i.e.* not the ones near the frontier – to be put out of use, or he may have taken the system off "red alert" and put it into cold storage. The defence of the frontier could be entrusted to the Anatolian army. There is separate evidence of local warning systems on the frontier zone (13). Loulon was recaptured by Basil I in 876/77, when the Slavic population revolted against the Arab governor of Tarsus, again because they had not received

(13) Cf. NICEPHORUS PHOCAS, *De Velitatione Bellica*, 2 (ed. C. B. Hase, *CSHB*, Bonn, 1828), at p. 188, ll. 4-12. Here the author is dealing with the *χαμινοβίγλ(ι)α*. Here at ll. 7-10 the comma in l. 9 should be read instead before *διά*, thus : *ὅπως, ἤνικα κίνησις τῶν ἐχθρῶν γένηται, καὶ οἱ βιγλάτορες ταύτης αἴσθωνται, διὰ τῶν καμινοβίγλων καὶ ὁ στρατηγὸς τὴν ἐξέλευσιν τῶν ἐχθρῶν προγινώσκῃ* ... The *βιγλάτορες* and *ἐκσπηλάτορες* then see to the evacuation of persons and livestock. E. A. SOPHOCLES, *Lexicon*, s.v. *χαμινοβιγλάτωρ* (cf. – *γλια*) takes the *χαμινο* – element to be cognate with Italian *camino* (cf. Med. Latin *caminus*, *e.g.* A. BLAISE, *Lexicon Latinitatis Medii Aevi* (Turnhout, 1975), s.v. II [saec. xiv] and R. E. LATHAM, *Revised Medieval Latin Word List* (London, 1965), s.v. 2 [saec. xiii-]). Yet Sophocles must be wrong here, misled by the Bonn edition's Latin translation. Surely *χαμινο* – refers to the Greek *κάμινος*, an *oven*, *furnace*, *kiln* (*LSJ*[9]) – hence *χαμινοβίγλ(ι)α* are "fire-watchers" and refer to beacon stations and lookouts.

money due to them, this time because it had been expropriated by the Tarsans, themselves in revolt. The story is in Ibn Al-Aṯīr, who comments that the loss of Loulon to the Byzantines was the desolation of Tarsus because it was like a fishbone in the enemy's gullet and the Romans could make no sally by land or sea without being seen from this fortress and being immediately heralded to the Arabs. Though Loulon can hardly have been a lookout post to sea, we do here have evidence that the Arabs somehow made use of the beacon system in reverse (14). According to Ramsay Loulon was still under Byzantine control c. 900 and remained so until the Turkish conquest in the later eleventh century (15).

As for the second beacon, he identified *τὸν Ἀργαίας βουνὸν* as Has(s)an Dağı, at a height of 10.673 feet above the plain of Lykaonia to the north-west of Loulon. However, it might have been expected that the reference would be to the well-known Mount Argaeus, Erciyas Dağı, a volcano standing 12.848 feet above sea level by Caesarea Mazaca (Kayseri). This is north-north-east of Loulon and Ramsay evidently excluded it as beacon 2 because it is in the wrong direction for a message travelling to Constantinople. Yet direction does not matter so much as ease and speed of sighting for this purpose. It could be that the excellent visibility (if it indeed is so) both from and of Mount Argaeus would mean that the interval distance from beacon 2 to beacons 1 (Loulon) and 3((I)samos) would

(14) VASILIEV, *op. cit.*, II, i (1968), pp. 79-81 ; CONSTANTINE PORPHYROGENITUS, *Vita Basilii* (= THEOPHANES CONTINUATUS, V), p. 277 (ed. I. Bekker, *CSHB*, Bonn, 1838) = *PG*, 109, col. 2948 B-C ; SCYLITZES, ed. Thurn (cf. *supra*, n. 4), p. 141. Ibn al-Aṯīr *apud* VASILIEV, *op. cit.*, II, ii (1950), pp. 135-136 ; cf. A. MEZ, *Die Renaissance des Islâms* (Heidelberg, 1922), pp. 470-1 (= translation of Salahuddin Khuda Bukhsh and D. S. Margoliouth [London, 1937], pp. 502-3). Cf. also below, p. 270.

(15) The beacon system summoned Basil II from Bulgaria to Aleppo in 995 according to DVORNIK, p. 143. I have not been able to find the source for this use of it : cf. J. H. FORSYTH, *The Byzantine-Arab Chronicle (938-1034) of Yaḥyā B. Sa'īd Al-Anṭākī* (unpublished Ph. D. dissertation, University of Michigan, 1977), p. 492, where the author says that the best account of Basil's campaign at Aleppo is in al-Shimshati, who gives the period that it took Basil to cross Anatolia as seventeen days. This was in mid-winter : cf. G. SCHLUMBERGER, *L'épopée byzantine à la fin du dixième siècle : 2e partie : Basile II* (Paris, 1900), pp. 86-87, and H. GRÉGOIRE in *The Cambridge Medieval History*, IV, Part 1 (Cambridge, 1966), p. 182.

be great and hence speed the message on its way. Strabo (12.2.7, C538) says that those who ascend Mount Argaeus claim that in clear weather both seas, both the Pontus and the Bay of Issus, can be seen from it. He himself had not tried it out, as it seems, but if what he says is true and the Bay of Issus, some 120 miles south, could be seen, then Loulon, about 80 miles away and raised up 6.300 feet on the plain on which it stands, might well have been. Only an experiment on site will tell. Erciyas Dağı also commands excellent views of the Anti-Taurus mountains to the east and north-east and from this point any raid from the direction of Armenia could readily be detected. It is tempting to wonder, when Loulon was captured, were Erciyas Dağı the Ἀργαίας βουνός, beacon 2, whether signals would have been sent on the chain starting from here until Michael III stopped the system (16). No source says specifically that the signal for the ἐκδρομή began at Loulon, though all imply it.

The third beacon, (I)samos, was, according to Ramsay, a peak in the desert west of the north end of Lake Tatta (from where even Erciyas Dağı would be visible down the valley of the Halys). He put Αἴγιλον, beacon 4, in the hills south of the River Tembris near Dorylaion. The other beacons, if we start at Constantinople, are as follows. Beacon 9 is, of course, at Constantinople : beacon 8, the hill of S. Auxentios, was ten miles from Chalcedon. Ramsay suggested (17) that "it is more difficult to flash the news accross the broken country between Dorylaion and Constantinople, and hence more beacons are needed in the latter half of the way". He identified Mokilos with Samanlı Dağı (Dağları) and Kyzikos with Katırlı (Kurban) Dağı. Olympos he thought was "some point on the south-eastern skirts of Keşiş (Ulu) Dağı rather than the main summit" (18). For a message to be sent on a beacon chain, the distance between beacons is not so important provided that one beacon is clearly visible from the next. The greater the distance the better, as the news will travel faster since fewer beacons will be used and hence there will be fewer delays in the relay. By the beacon route deduced by

(16) This was the view of Bury, (p. 285, n. 2) though he was thinking of the Ἀργαίας βουνός as Hasan Dağı.

(17) Ramsay, p. 353.

(18) Ramsay, p. 187, F. 56.

Ramsay it is about 450 miles from Loulon to Constantinople (but more if Mount Argaias was Erciyas Dağı) (19). Beacons 1 to 5 were on average about 65 miles apart ; each of beacons 5 to 9 only separated from its neighbour by around thirty miles.

(ii) Method of Operation

What seems not to have been properly considered about the beacon chain was the evident innovation of its inventor, Leo, and the significance of the two ὡρολόγια.

Beacons had, of course, been known since remote antiquity (20). Who does not instantly think of the watchman in Aeschylus' play who waited κυνὸς δίκην on the roof of the palace at Mycenae waiting for the beacon to signal the end of the siege of Troy and the νόστος of Agamemnon (21) ? The Assyrians used beacons at fixed distances of two hours' journey, and, since lighting a beacon of itself can carry no detailed message, a fast courier was despatched with the news at the same time. As his arrival was expected at each beacon post his journey was assisted. Herodotus (IX, 3) talks of the Persian beacon system set up from the coast of Asia Minor across the Aegean by way of the islands to Attica during their invasion of Greece in 480 B.C. Mardonius used this means to get the news to Xerxes at Sardis on his way to Susa that he had occupied Athens for a second time. [Aristotle] in the *De Mundo* (6 : 398a ad fin.) says that the Persian beacon system extended from the Persian frontier to Susa and Ecbatana and that the king received the same day the news of all that was happening in Asia.

The use of fire signals by the Greeks became common by the time of the Peloponnesian War (22). The Macedonians and later the Seleucids imitated the Persians. That the Romans also used fire signals seems to be shown on the columns of Trajan and Marcus

(19) The road distance was said to be 431 miles : see Toynbee, p. 108.

(20) These antecedents are listed in Dvornik, pp. 19-20 (Assyrians) ; 31-33 (Persians and Greeks) ; 42-43 (Macedon) ; 44 (Seleucus) ; 67 (Scipio), 87 (Caesar) ; 117 (Romans).

(21) Aeschylus, *Agamemnon*, ll. 1-39, 281-316. The play dates from 458 B.C.

(22) For references see *ΑΙΝΕΙΟΥ, Πολιορκητικά*, ed. L. W. Hunter & S. A. Handford (Oxford, 1927), p. 121 ; Aeneas Tacticus, ed., trans. The Illinois Greek Club (L.C.L., 1923), pp. 46-7, n. 1.

Aurelius, whose soldiers are apparently signalling with flaming torches from frontier towers to warn of barbarian approach, but this was on a smaller scale than the Persian beacons. Later the Arabs made some, but only restricted use of fire signals ; though there was evidently a chain of beacons using flame by night and smoke by day in conjunction with couriers or carrier pigeons which ran from Syria via Damascus and Gaza to Cairo in the eleventh century. The Arab geographer, Al-Muqaddasī (floruit c. 985 A.D.) says the following of Palestine in his day :

> "Along the sea-coast of the capital (Ar-Ramlah) are watch stations (Ribāt), from which the summons to arms is given. The war-ships and the galleys of the Greeks come into these ports, bringing aboard of them the captives taken from the Muslims ; these they offer for ransom ... At the stations, whenever a Greek vessel appears, they give the alarm by lighting a beacon on the tower of the station if it be night, or, if it be day, by making a great smoke. From every watch station on the coast up to the capital (Ar-Ramlah) are built, at intervals, high towers, in each of which is stationed a company of men. As soon as they perceive the beacon on the tower of the coast station, the men of the next tower above it kindle their own, and then on, one after another ; so that hardly is an hour elapsed before the trumpets are sounding in the capital, and drums are beating from the city tower, calling the people down to that watch-station by the sea ; ... And the watch stations of this District where this ransoming of captives takes place are : Ghazzah, Maimās, 'Asqalān, Māḥūz- (the Port of) Azdūd, Yubnā, Yāfah and Arsūf".

However, the most distant of these points, Gaza, is only separated from Ramleh by about forty miles as the crow, if not the beacon signal, flies, so that the transmission of the message in "hardly ... an hour" is not very impressive when compared with the performance of the Byzantine chain across Anatolia which could allegedly cover over ten times the distance in about the same time. There is also evidence of other beacon systems in medieval Greece, though it seems that the longest chain was that from Thermopylae to Thebes (about 62.5 miles) from the late Byzantine period ; the Venetians, after 1204, had short arrays of towers, etc. to give warning of seaborne attacks on Euboea (23).

(23) (Arabs) : cf. Dvornik, pp. 219, 233 and map, p. 232 ; (Al-Muqaddasī) : slightly abbreviated and modified from *Ahsanu-t-Taqāsīm fī Ma'rifati-l-Aqālīm* *known as Al-Muqaddasī translated from the Arabic and edited by G. S. A. Ranking and R. F. Azoo, Bibliotheca Indica, Asiatic Society of Bengal*, N.S. No. 899 (Calcutta, 1897), p. 291 (on Ar-Ramlah, see *ibid.*, p. 270) ; (Greece) : cf. J. Koder and F. Hild, *Hellas und Thessalia* (= *Tabula Imperii Byzantini*, ed. H. Hunger, I) (Vienna, 1976), pp. 112-3, though few details are given.

The advantage of a beacon system is obviously that news can be communicated much more quickly by this means than it can be by a horseman, even a fast one. However, the news has to be pre-arranged, *e.g.* "Victory" or "Defeat" in battle for the transmitting side (24). Herein lies the big disadvantage of fire signals, which the Assyrians aimed to combat by the use of simultaneous couriers, namely how to send variable messages. It is all very well to send a courier when the beacons are on a good fast road, but with variable messages the very sending of the courier obviates the point of the beacon signals, as the ultimate recipient of the news, though he will see or learn of the fire signal quickly, will only be kept on the edge of his throne while he waits for the arrival of the horseman. There is little gained over fast riders unless only one message is ever to be sent. Beacons alone are not sufficient for variable messages and must be used with some other pre-arranged signal code.

Leo's special contribution to beacon technology was the provision of not only a code of differing messages but one which could be transmitted at a distance of around 450 miles or even more, in theory. He was not the first to think of using a timing device to modify fire signals ; this had already occurred to the ancients. The earliest evidence which we have of such a modification is that of Aeneas Tacticus. The passage in which the method is described is alluded to in his *Poliorcetica* (25), as being in his now lost *Παρασκευαστικὴ βίβλος*. It is uncertain if this system was ever put to use. The details are reported by Polybius, though he felt that the improvement *βραχὺ μέν τι προεβίβασε, τοῦ γε μὴν δέοντος ἀκμὴν πάμπολυ τὸ κατὰ τὴν ἐπίνοιαν ἀπελείφθη* (26).

(24) The Greeks used to raise torches and keep them still for "Friend", but hold them up and wave them about for "Foe" : cf. Hunter & Handford, *loc. cit.* (above, n. 22).

(25) *Poliorcetica*, 7.4.

(26) Polybius, *Historiae*, X, 44, 1.

Aeneas suggested as follows :

"Let those who wish to communicate any matter of pressing importance to each other by fire-signals prepare two earthenware vessels of exactly equal size both as to diameter and depth. Let the depth be three cubits, the diameter one. Then prepare corks of a little shorter diameter than that of the mouths of the vessels : and in the middle of these corks fix rods divided into equal portions of three fingers' breadth, and let each of these portions be marked with a clearly distinguishable line : and in each let there be written one of the most obvious and universal of those events which occur in war ; for instance in the first 'cavalry have entered the country', in the second 'hoplites', in the third 'light-armed', in the next 'infantry and cavalry', in another 'ships', in another 'corn', and so on, until all the portions have had written on them the measures on the part of the enemy which may reasonably be foreseen and are most likely to occur in the present emergency. Then carefully pierce both the vessels in such a way that the taps shall be exactly equal and carry off the same amount of water. Fill the vessels with water and lay the corks with their rods upon its surface and set both taps running together. This being done, it is evident that, if there is perfect equality in every respect between them, both corks will sink exactly in proportion as the water runs away, and both rods will disappear to the same extent into the vessels. When they have been tested and the rate of the discharge of the water has been found to be exactly equal in both, then the vessels should be taken respectively to the two places from which the two parties intend to watch for fire-signals. As soon as any one of these eventualities which are inscribed upon the rods takes place, Aeneas bids raise a lighted torch, and wait until the signal is answered by a torch from the others ; then, when both torches have been simultaneously visible, lower them, and then immediately set the taps running. When the cork and rod on the signalling side has sunk low enough to bring the ring containing the words which give the desired information on a level with the rim of the vessel, a torch is to be raised again. Those on the receiving side are then at once to stop the tap, and to see which of the messages written on the rod is on a level with the rim of their vessel. This will be the same as that on the signalling side, assuming everything to be done at the same speed on both sides" (27).

(27) Translation of the Illinois Greek Club in AENEAS TACTICUS (L.C.L., 1923), pp. 201, 203, 205. For commentary see HUNTER & HANDFORD, *op. cit.* (above n. 22), pp. 121-123 (with illustrations). Cf. DVORNIK, pp. 42-3.

A lot depends on how quick the men are in raising the second torch, how rapid their co-ordination of sight and voice as the lookout shouts "stop" to the man in charge of the water device and how rapidly the water flows and the rod sinks. If the signal is to travel more than the distance over which a raised torch can be seen (not as far as a beacon can be seen in any case) one or more intermediate stations between transmitter and receiver would be required – not, however, that Aeneas, as reported by Polybius, mentions this problem. If the signal is relayed there will be a time lag in the transmission which, unless allowed for (and it would be hard to ascertain how much delay to interpolate), would confuse the message being sent. The holes in the vessels must be very small or confusion about the messages will in any case soon arise when the receiver is uncertain when the transmitter's sinking rod was stopped. Aeneas' method has a restriction in that only specified messages can be sent. There is also considerable difficulty if one wishes to send a message after the space for it on the rod has sunk into the jar. How does the transmitter tell the receiver to start the jar afresh so as to get back to a message which has passed ? There could be a specific position in the rods to say just that, but it would mean a long time delay while two messages were sent to cope with one. One could have the series of messages on the rod repeated, but Aeneas does not tell us to do that.

Polybius, after describing Aeneas' method, goes on to say that the "most recent method" was invented by Cleoxenus and Democlitus and had been perfected by Polybius himself : it involves something analogous to modern semaphore (28). The letters of the words of the message are sent by means of a code related to the letters themselves. The Greek alphabet is divided into five series of five letters. By the use of torches indicating the number of the letter being transmitted in its section of the alphabet a complex message can in theory be sent, albeit very laboriously.

The Carthaginians used a method very like that suggested by Aeneas. Polyaenus (mid-second century A.D.) related the following in his *Strategemata* (29) :

(28) POLYBIUS, *Historiae*, X, 45, 6 to X, 47, 4. See the commentary by F. W. WALBANK, *A Historical Commentary on Polybius*, II (Oxford, 1967), pp. 259-61 ; cf. DVORNIK, p. 43.

(29) POLYAENUS, *Strategemata*, VI, 16, 2 (ed. E. Woelfflin, J. Melber ; Teubner,

"When the Carthaginians were laying waste Sicily, in order that what they needed might be carried over from Libya quickly, they made two clepsydrae equal in size and drew equal circles in each with the same labelling. The labelling was 'need of' (a) 'warships', (b) 'cargo boats', somewhere else 'need of gold' and in another place still 'need of siege equipment', then 'need of grain', then 'need of beasts' and 'need of' (a) 'arms', (b) 'infantry', (c) 'cavalry'. Thus they labelled every circle. They kept one clepsydra in Sicily and sent the other to Carthage with the order that if they [the Carthaginians at home] saw a beacon fire in Sicily they should look out for when the second beacon was shown and note at which circle this happened". [*i.e.* they should set the clepsydra going at the moment they saw the first beacon and note where the water had fallen to when the second appeared]. "They should read the label on the circle and send what was indicated by the inscription as soon as possible. In this way the Carthaginians had a supply if what was needed for the war in the quickest way possible".

By *clepsydra* here we are certainly meant to understand a jar with a hole in the base which was filled with water and allowed to empty when the hole was unstopped : such devices had been employed for regulating forensic and dramatic activities in fifth-century Athens (30).

The fire and water telegraph of Aeneas Tacticus and the Carthaginians, and the semaphores of Polybius are really only useful or practical for one beacon to a receiving station or vice versa. Leo had the problem of how to send variable messages over a long distance using a relay of seven intermediate stations. Clearly the use of two instruments marked with the messages and a time lapse between messages is derived in theory from Aeneas and perhaps, though less probably, in practice from the Carthaginians or elsewhere. It could be that Leo read about the latter in Polyaenus and that gave him, from the clepsydra or water-clock, the idea of using ὡρολόγια. Leo overcome some of the problems of the method of Aeneas and of the

Stuttgart, 1970, p. 293). Cf. Dvornik, pp. 56-7, on whose translation the present one is based.

(30) See *e.g.*, S. Young, *An Athenian Clepsydra*, in *Hesperia*, VIII (1939), pp. 274-284 ; H. A. Thompson & R. E. Wycherley, *The Agora of Athens* (= *The Athenian Agora*, XIV : Princeton, 1972), pp. 52, 55, 202.

Carthaginians as follows. The previous methods required that the water-devices had to be started by pre-arranged signal : this was impracticable where full-size beacons had to be used over such a distance. He therefore had this water devices either running continuously or set in motion at a pre-agreed time daily (we shall discuss this later) and so tied them to the passage of the hours, one hour to a message. Though he could not arrange to send a command to receive a message at some time after its mark on the ὡρολόγια had passed, he did, however, ensure that the signal mark in question would automatically return in the natural course of the day.

The Greek word ὡρολόγιον covers any device used for measuring time : it could mean a sun-dial – though it was a general word for any timepiece (31). There is little doubt in Leo's beacon telegraph that it refers to water-clocks, especially in view of the antecedents and the words Pseudo-Simeon uses – ἐξ ἴσου κάμνοντα – that the devices worked (*i.e.* had movement in them) at an equal rate. Leo thus had two identical, presumably tested, water-clocks made. One was sent to Loulon and one kept at the capital. They were not meant primarily to shew the time but a specific signal against each hour. Thus the commander at Loulon would order this beacon to be lit when the clock indicated a certain hour and hence at the sign for a specified, pre-agreed message in order to send that message. From the time at which the Loulon beacon was lit the emperor's men at the Pharos would know the message sent by comparison with their clock.

It was in this that Leo's cunning lay. At first sight it would seem that the clocks are little help in decoding the message sent. The Loulon commander may have his beacon alight exactly when his clock shewed the hour for the message, but the watchers at the hill of Argaias had to spot the beacon and get their beacon alight smartly, and similarly the men at the next beacon had to act quickly to pass the fire on. With nine beacons and eight sets of watchers there are ample chances for delay. The watchers may become inattentive ; the beacon may be wet, it may not catch fire quickly. However, if we assume that the system was working at maximum

(31) C. B. Hase, G. Dindorf, *Thesaurus Graecae Linguae*, VIII (Paris, n.d.), coll. 2071-2.

efficiency then we might perhaps allow a minimum of five minutes at a station from the sighting of the previous beacon to the moment of burning of the transmitting beacon at the receiving station such that it can be sighted from the next post in the chain. (For ease of reference we shall call this period the *relay interval*).

The message could thus be passed on in forty minutes. Constantine Porphyrogenitus does, in fact, say that the message arrived ἐν μιᾷ ὥρᾳ – though there is more to these three words than might at first be thought, as we shall see.

If the διαιτάριος at the Pharos looked at this clock and made allowance that the message may have been sent two-thirds of an hour previously, then, of course, he could decode the news accordingly. Even here, however, there is a problem with reading the time signal code, to which we shall return later. Yet suppose that the lookouts were not so efficient – perhaps the weather or visibility was bad – and the relay interval at the posts was ten minutes. The Pharos commander would then receive the message one hour and twenty minutes after transmission. He could misread it. Consider how very misleading it would be if most relay intervals were ten minutes but at even four beacons the interval was fifteen minutes. The message would arrive one hour and forty minutes after transmission from Loulon. He could then well ask whether he had received a fast or slow transmission and could confuse the actual message with the one programmed for before or after what the commander of Loulon had intended. It seems that such problems did not arise or the system would not have worked well and the distinction of messages would have been useless. Constantine Porphyrogenitus clearly states that the message was transmitted and received ἐν μιᾷ ὥρᾳ.

In fact the total transmitting time may have been quite short. In order to gain some estimate of this we may validly draw comparisons with other arrangements in other lands, some many years later and one in modern times, on which more detailed information is available than what is provided by our sources for the Loulon-Constantinople chain. Not much later than the ninth-century Byzantine Anatolian system is one which has been discovered in south Russia from the Kievan period. It has been estimated that a distance of fifty-six miles, having one intermediate beacon, which, of course, halves the gap to be bridged, from Kanev to Kiev along the Dniepr, could have been covered by a message in ten to fifteen minutes (32). This time would be taken up chiefly at the intermediate station for the relay interval. We might, however, say that a liberal estimate for the amount of time taken under normal conditions for the relay interval on this reckoning is about 7-8 minutes. The Russian chain used towers and was, of course, along a river valley. Further two beacons spanned the fifty-six mile gap, which means that the fires could be smaller and the sighting perhaps made easier than it was on the first half of the Anatolian chain (to Olympos/Mamas) where the average space between beacons was twice this figure and the longest distance from post to post was probably around three times that on the Kanev-Kiev link. Against this and in favour of the Byzantine chain is the fact that the Dniepr beacons were low down, making it difficult to cover longer distances because of the curvature of the earth, while the Byzantine fires were clearly on high mountain sides enabling much better visibility over a distance, at least in theory and in good weather, but requiring that in order to be sighted the fire in itself probably needed to be bigger than the Russian ones, or else to have reached a greater intensity after a longer time.

If we look forward in time and westwards there is considerable information about beacons used in medieval England. These beacons formed a coastal defence system, dating in its basics from at least Saxon times, which, though details vary at different periods, in its most sophisticated form involved the use of three fires at coastal lookout points, two fires on hills just inland and one fire on hills further inland. If enemy ships were sighted one fire was lit and the message not passed on but local action taken; if two were lit invasion was imminent and the message was relayed to the seaboard counties; if three fires were lit the enemy had landed and the whole country was raised. The form of these beacons, as a result of an ordinance of Edward III, had come to be, in most cases, a rough

(32) See B. A. Rybakov, *Vladimirovy kreposti na Stugne*, in *Kratkie soobščenija Instituta Arkheologii*, 100 (1965), pp. 126-129 (with map, p. 127). This article is followed up with more forts by V. I. Dovženok, *Storozevye goroda na juge Kievskoj Rusi*, in *Slavjane i Rus'*, *Sbornik k 60-letiju B. A. Rybakova* (Moscow, 1968), pp. 37-45, esp. p. 40 (map, p. 38); estimate of the relay interval at Rybakov, *art. cit.*, p. 129.

hewn tree trunk set vertically with a single-bar ladder and surmounted by a cauldron containing pitch or tar and flax. Sometimes towers with pots of pitch attached to them fulfilled this function, sometimes church towers were used, notably in the flatlands of central England. There is considerable information about the manning and financing of these beacons, but little or nothing seems to have been recorded about timings from which the relay interval under whatever weather conditions could be deduced. There is a vague remark of the ambassador of Charles V to his sovereign in 1545 that in two hours an army of 25,000 to 30,000 men could be mustered by the use of the beacons. This information does not help very much and the ambassador can hardly have meant that the men were mustered anywhere but at muster points, certainly not all at one place under transport conditions of the period. The most famous and intensive use of these beacons was against the Armada in 1588. Clearly the Elizabethan beacons had as one of their chief functions the effect of a deterrent, because the enemy knew that he could not take the English by surprise. Evidently no such factor bothered the Arabs because they invaded the Byzantine territory so regularly that it must almost have been possible to set Leo's *ὡρολόγια* by them, so predictable were they. The English system was suspended during the winter months when the coasts were too stormy for the frail shipping of the period to land in coves or inlets, when even if the enemy had managed to land undetected by beacon watchers he would have had immense difficulties in transporting his men anywhere on the appalling mud-choked roads of the country at that date (33).

(33) On the English beacons in the Middle Ages see H. J. Hewitt, *The Organisation of War under Edward III* (Manchester, 1966), pp. 4-5, 9. On the beacons used to warn of the Armada, see L. Boynton, *The Elizabethan Militia, 1558-1638* (London and Toronto, 1967), pp. 132-9 and Plates 10 and 11 ; at p. 134 are interesting details of problems in keeping the watchers alert. Full details for two maritime counties at this period and before and after occur in two articles by H. T. White : (i) *The Beacon System in Hampshire*, in *Hampshire Field Club and Archaeological Society*, X (1926-30), pp. 252-78 (Plate opp. p. 252 shews beacons : p. 258 materials used : pp. 259-67 operational method : p. 261 ambassador's report : p. 277 construction) ; (ii) *The Beacon System in Kent*, in *Archaeologia Cantiana*, XLVI (1934), pp. 77-96 (pp. 83-4 operational methods ; p. 92 materials and construction : plates I and III shew beacons).

The English beacons were revived at the time of the Jacobite rising in 1745 and again against threatened invasion by Napoleon's forces. The final chapter of Sir Walter Scott's *The Antiquary* (with a long note by the author) recalls the effects of a false alarm which actually took place in the Scottish Borders in 1804 (34).

However, the best information on running a beacon system undoubtedly comes from very modern times. On June 6th, 1977, the old beacon system was revived in England, with relays out to Wales, the Western Isles and Shetlands, to commemorate the Silver Jubilee of Her Majesty Queen Elizabeth II. The triangulation data of the Ordnance Survey was used by the Royal Institution of Chartered Surveyors to work out a pattern of beacons to cover the whole United Kingdom. The average spacing of beacons was around thirty miles and some of the old beacon sites were used. An optimum construction for the fires was worked out by experiment in the Great Park at Windsor and the recommanded pattern was a cone made of stackwood surrounded by brushwood (though in practice some beacons contained a lot of refuse and old motor tyres, etc.) of base diameter thirty feet and height thirty feet containing approximately thirty tons of materials. Some beacons were built larger, but this size proved adequate for sighting over the distance required in clear weather. Each beacon was equipped with rocket flares to be launched simultaneously with the ignition of the fire.

The Queen lit the first beacon at Windsor at six minutes past ten o'clock at night, and at eleven o'clock, less than one hour later, the most distant beacon in Shetland, a distance of over six hundred miles as the crow flies and much more by beacon route, was ignited on a sighting of the previous fire on Fair Isle, between it and Orkney. There is considerable detailed information available on not only the time taken for the apparent relay interval at various points in the chain but also of the prevailing weather conditions and

(34) Revival of the beacons : White, *op. cit.*, in the last note, (ii), p. 91. A secret document on the arrangements against the Armada was prepared for the Cabinet (only 25 copies printed) in 1798, when the whole system came out of mothballs : < John Bruce > , *Report on the arrangements which were made, for the internal defence of these kingdoms, when Spain, by its Armada, projected the invasion and conquest of England ; and application of the wise proceedings of our ancestors, to the present crisis of public safety*, < London, 1798 > .

height above sea level of the beacon posts. However, not all this information can be used without certain allowances being made. In full knowledge of the British weather the organisers knew that adverse conditions could ruin the whole scheme and so arranged it that each beacon should be lit at a pre-arranged time three minutes after its predecessor, irrespective of whether the earlier one had been sighted or not. We must add to this the psychological factor that the watchers were in full expectation of a fire on the horizon at a specific time, unlike the Byzantine watchers, who would only be able to expect the signal at certain given times an hour apart, if it ever came, and would only know these times for sure if the men at intermediate posts were supplied with a timepiece working at the same pace as that at Loulon, to which there would be further complications as we shall see, and which we are not told was the case. Nevertheless in the Jubilee chain there is clear reporting in a number of cases that the fire at the previous beacon was spotted at or even just before the beacon was lit at its appointed time; in at least five cases it was waited until a light was seen before the fire was started. In two of these cases distances of twenty-four and twenty-five miles were covered in within the three minutes required. In two others distances of twenty-five and thirty-three miles were covered in one and two minutes respectively with suspiciously quick timing. In the fifth case, for a distance of about thirty-eight miles across water in the Western Isles, where it was still light at that time of the year and latitude, which would make sighting more difficult, twelve minutes was the interval. In all these cases the weather was not ideal; well-broken cloud with scattered showers prevailed, especially over high ground – a permanent hazard for beacon sites in these climes. Unfortunately, however, as a result of mist, fog, sleet, rain and snow, especially in the north and in Scotland, many of the beacons could not be lit from sightings and many were ignited either on sighting the flares from the previous station or just because the time due for lighting had been reached. The Windsor beacon itself went off late, after those which were in theory to be lit from its signal had already been fired. The weather hazards would probably not have been as great for the Byzantine watchers in Anatolia and experience would undoubtedly have made for better efficiency in positioning the fires. The use of flares may not have been unparalleled; it is known from the illustrations in the

Madrid Scylitzes that the Byzantines used to siphon Greek fire in the manner of a flame gun, at least at sea; they could well have sent a jet of flame upwards when the fire was lit, though not as high as a thousand feet [35].

There is no known evidence for such use, but if the Byzantines had used Greek fire or naphtha on ready-prepared bonfires a rapid conflagration could well have ensued at a beacon station in a very short time [36]. The bonfire materials would, of course, have needed to be kept dry, but this is not an impossible feat. In bad conditions of snow and driving rain one Jubilee beacon (at Skiddaw in the Lake District) took twenty minutes to get started, but this ought to be an exceptional climatic requirement. Of more consequence, as trial in 1977 shewed, is the problem of raising large quantities of combustibles up mountainsides. The Byzantines did not have helicopters to assist in this task and wood was perhaps not so readily available in central Anatolia as it is in Britain. Yet the beacons must have been of the bonfire type: the elevated pitch-filled cauldron of the medieval English pattern could hardly have worked for the Byzantines – the English beacons at the time of the Armada were only around twelve miles apart on average, such was their limited flame size. It would certainly not have been beyond the Byzantines

(35) On the Jubilee Beacons see R. Steel, *Silver Jubilee Beacons* (The Royal Institution of Chartered Surveyors, London, 1977). I have also had some further confirmation of the details of timing the beacons in correspondence with Mr. Steel, who organised the system. The booklet contains full details of the beacon construction and sitings with a table of timings, a report of events at each station and a map with weather conditions. The beacons cited here are Ditchling (from Duncton), 24 miles (3 mins); Sumburgh (from Fair Isle) 25 miles (3 mins); Cold Ashby (from Charwelton) 25 miles (1 min): Alport Heights (from Beacon Hill) 33 miles (2 mins); Rhum (from Tiree) 40 miles (12 mins). The surveyors arranged another, similar, but simpler set of beacons for the Royal Wedding on 29th July, 1981. Madrid Scylitzes illustration: see S. C. Estopañan, *Skyllitzes Matritensis*, Tomo I (Barcelona & Madrid, 1965), p. 249, no. 77, f. 34vb and p. 65. On Greek fire see now J. Haldon and M. Byrne, *A Possible Solution to the Problem of Greek Fire*, in *Byzantinische Zeitschrift*, 70 (1977), pp. 91-9, esp. p. 97, n. 19 on non-naval battle usages.

(36) There is evidence that the Russians, at least, used naphtha in this way: cf. finds in Novogrudok *apud* M. V. Malevskaja, *Amfory Novogrudka XII-XIII v.v.*, in *Gezisy dokladov k konferentsii po arkheologii Belorussii* (Minsk, 1969), pp. 185-191, at p. 190. (This was seen abroad and verified for me by Dr. J. Shepard).

to have filled their fires with containers of naphtha which would have burst into flame on the ignition of the beacon much as the Windsor Jubilee beacon had diesel oil inside. Old motor tyres were a different matter.

From these analogies we might make a not unreasonable estimate that over the distances which the Byzantines were aiming to cover, given the fact that to be sighted the fire will need to be going more fiercely if the distance to the next beacon is larger than that taken as the average for the Jubilee beacons, a relay interval of seven to eight minutes on average is what was to be expected on the Anatolian chain. If this generous figure, which could have been as low as five minutes, is taken as the relay interval for each beacon the whole transmitting time from Loulon to Constantinople would have been approximately one hour, much as Constantine Porphyrogenitus had said.

The message did not, however, actually take an hour to be received, if considered from the Constantinople end. Leo must have realised this and saw that as a consequence his system would work. He would have known that Loulon is around four hundred and fifty miles south-east of Constantinople. If we accept either Ramsay's or Hild's views (37) on the site of Loulon, it still falls at about latitude 37,5° N and longitude 34,5° E of Greenwich. Constantinople is at latitude 41° N and longitude 29° E. The difference in longitude corresponds to twenty-two minutes of time (38) ; *i.e.* if the time is noon at Loulon, it is only 11.38 at Constantinople. Consequently if the commander at Loulon lights up at hour 1, the *ὡρολόγιον* at Constantinople will have twenty-two minutes to go before it is hour 1 there. The message should have reached the beacon on the hill of Aigilos (post 4) and be about to be received by that on Mount Olympos (post 5) by the time the *ὡρολόγιον* at the Pharos shews hour 1. It will in that case be over half-way to the capital while the difference in local time between the ends of the chain is made up. There are, however, more beacons in the final section of the series than in the earlier part. So the Pharos commander might actually receive the message about half an hour after his *ὡρολόγιον* indicated

(37) Ramsay, pp. 351-4 ; and addition, p. 449 ; cf. also above, n. 10.
(38) One whole day is one revolution of the earth. Therefore 360° = 24 hours : 1° = 4 minutes.

the hour number and message code at which the Loulon beacon was actually lit.

Yet here we must come back to the clocks themselves. What does *ἐξ ἴσου κάμνοντα* really mean ? Presumably that their movements operated at the same speed. Does it have to mean that they shewed the same hour together ? If Leo realised, as he must have done, that the difference in longitude between Loulon and Constantinople was enough to separate them in time as well, then he could have had the Constantinople clock set to Loulon time, and made it fast of Constantinopolitan local time. However, given that the beacons might have been delayed this would not necessarily help a lot if the message took more than the time gap. It would actually be sufficient for the *διαιτάριος* at Constantinople to see *during which hour* the message arrived : he would then be able to tell when it had been sent. The time gap gave a safety margin for inefficiency even if the message took as much as eighty minutes to send. We may reasonably assume that *ἐξ ἴσου κάμνοντα* means that the clocks were regulated to run at the same speed. It is also important to remember that a water-clock had to be set against the correct time given by a local sun-dial. It is only since the middle of the nineteenth century that standard time has existed and has been transported by railway and wireless time signal to enable mechanical clocks to be set correctly. There is, however, nothing to stop, and perhaps a lot in favour of the Constantinople clock's being set to what was believed to be Loulon time.

Though Leo must have known about the difference in time between the ends of the beacon chain there is another factor to consider. The ancients and, of course, the Byzantines, were unable to measure longitude and hence time diference with ease, and seem to have made no concerted attempt to do so. Ptolemy's *Geographia* gives latitudes and longitudes against localities as if they were all scientifically worked out. However he first began with certain figures for some known places and worked out the rest from a knowledge, often hopelessly imprecise, of the linear distance of places from each other. This is why maps based on his figures are so distorted. He was particularly bad on longitude, which he reckoned from a place west of Gibraltar, the 'Fortunate Islands' (39). If Leo had

(39) On this whole question see E. H. Bunbury, *A History of Ancient*

consulted Ptolemy's figures (40) he would have found that Tarsus (the nearest place to Faustinopolis, which Ptolemy did not list) is at the Ptolemaic latitude 36° 50′ and longitude (from the 'Fortunate Islands') 67° 40′. Byzantium appears as latitude 43° 05′ and longitude 56° 00′. The difference in longitude between Constantinople and Tarsus is thus 11° 40′ or forty-seven minutes of time. If Leo had used this figure he would have had an exaggerated view of the compensatory element in the eastward displacement of Loulon. However, if the Constantinople clock had been set behind the time of the Loulon one by three-quarters of an hour – more than twice the true figure – the degree of compensation for the transmission time of the signal would have been greatly enhanced.

The only effective way that anyone had of measuring longitude until the eighteenth-century perfection of the chronometer was by observing the same lunar eclipse simultaneously at two places and noting the difference in time. One hour of time corresponds to one twenty-fourth of the day at the equinoxes. Ancient geographers were not prompt to apply this method to their map making, though Hero of Alexandria in his *Dioptra* describes, in apparently hypothetical terms, the method with relation to an eclipse, evidently that of March 13th, 62 A.D. We only know of any figures being derived from one lunar eclipse, that of September 20th, 330 B.C., which was observed simultaneously and only by chance in Arbela (before the famous battle there) at the fifth hour and Carthage at the second hour (41). Though there were plenty of lunar eclipses in the

Geography (London, 1879), II, chapter XXVIII, esp. pp. 546-71 and O. Neugebauer, *A History of Ancient Mathematical Astronomy* (New York, 1975), Part II, V.B.8,8, pp. 934-40, esp. pp. 938-40. (Cf. Part I, I.E.6,3B, pp. 337-8).

(40) Claudii Ptolemaei, *Geographia*, ed. C. Müller, I_1 (Paris, 1883), p. 475 ; I_2 (Paris, 1900), p. 900.

(41) Hero, *Dioptra*, 35 (ed. H. Schöne, Teubner, Leipzig, 1900), pp. 302-7, cf. J. G. Landells, *Engineering in the Ancient World* (London, 1978), pp. 200-1 ; A. G. Drachmann in C. Singer et al., *A History of Technology* (Oxford, 1957), III, pp. 609-12. In the eclipse of 330 B.C. it is fortunate that the two places of observation were on more or less the same latitude and the eclipse occurred very near to the autumnal equinox : however the times cited are practically useless without more detail than the hour in which they occurred. Cf. Bunbury (*op. cit.*, *supra*, n. 39), I, p. 633 and n. 4 ; Neugebauer (*op. cit.*, *supra*, n. 39), Part II, p. 938 ; on the eclipse method for longitudes generally, *ibid.*, pp. 667-8.

ninth century (42) for Leo to have used to determine the difference in time and longitude between Loulon and Constantinople, it is most unlikely that he did so. We should not forget the almost adulatory respect which mediaeval writers paid to Ptolemy's figures (43). Equally we have already suggested (p. 260) that Leo may well have been influenced by Hero's mechanical writings when he devised the automata in the Magnaura Palace ; he may have put Hero's eclipse method for finding longitude into practice. Further Leo did have knowledge of eclipses in general, as a treatise attributed to him (though evidently only edited and amplified by him) suggests (44).

There are, however, additional complications to the hours on the clocks. A lot depends on whether the signals were sent by day or by night. The only indications of when the messages were expected in this sense is in the descriptions of why Michael III is said to have stopped the system working. The fullest account of this is in Theophanes Continuatus.

> *ποτὲ γοῦν τοῦ Μιχαὴλ κατὰ τὸν εἰρημένον τοῦ μάρτυρος Μάμαντος ναὸν ἱππάσασθαι μέλλοντος καὶ τὸ σύνθημα τῆς ἱπποδρομίας δεδωκότος, ἐπεὶ κατὰ τὴν ἑσπέραν ὁ ἐκ τοῦ Φάρου φανὸς διὰ τοῦ παππίου ἐδήλου τὴν τῶν ἐθνῶν ἐκδρομήν, εἰς τοσοῦτον ἦλθεν ἀγῶνα καὶ φόβον ὁ βασιλεὺς δέει τοῦ μὴ παροφθῆναι τὴν ἡνιοχείαν αὐτοῦ παρὰ τῶν θεατῶν τῆς τοιαύτης ἕνεκεν ἀγγελίας, εἰς ὅσον ἄλλος τις ἦλθεν κινδυνεύων ὑπὲρ τῆς ψυχῆς καὶ τοῦ μὴ πλησιάσαι τούτους μᾶλλον ἀγωνιζόμενος. οὕτως ἐκεῖνος ἐθεατρίζετό τε καὶ οὐκ ᾐσχύνετο. ὅθεν ἵνα μήτε τις τῶν αὐτοῦ ἀγώνων ἀπολιμπάνοιτο μήτ' ἄλλο τι τῶν ἐκεῖθεν ἀνιαρῶν προσπῖπτον χαλαρωτέρους ποιήσῃ τοὺς θεατάς, μηκέτι τοὺς πλησιάζοντας φανοὺς ἐνεργεῖν προσέταξεν, ἀλλὰ σιγῇ βαθείᾳ καὶ λήθῃ τὰ τοιαῦτα παρακαλυφθῆναι μακρᾷ.*

As we have seen above (p. 259), Pseudo-Symeon says :

> *ἱππευομένῳ οὖν τῷ βασιλεῖ Μιχαήλ, ὡς εἴρηται, ὁ φανὸς ἐσήμανεν ἐκδρομὴν τῶν Σαρακηνῶν. αὐτὸς πρὸς τὸ μὴ τοὺς θεατὰς τοῦ ἱπποδρόμου*

(42) Cf. V. Grumel, *La Chronologie* (Paris, 1957), p. 463.

(43) Cf. Bunbury (*op. cit.*, *supra*., n. 39), II, pp. 553, 560 ; Neugebauer (*op. cit.*, *supra*, n. 39), Part II, p. 934.

(44) *περὶ ἡλιακῆς ἐκλείψεως τῆς ἐν τῷ βασιλικῷ τριγώνῳ τοῦ σοφωτάτου Λέοντος*, ed. F. C. Hertlein, *Hermes*, VIII (1874), pp. 173-176 ; but see Lemerle, p. 171 and n. 88 ; cf. Bury, p. 442, n. 1.

χαλαρωτέρους τῇ αὔριον γενέσθαι, προσέταξεν μηκέτι τοιούτους φανοὺς ἐνεργεῖν.

He begins the account of the whole affair as follows :

Τῷ δὲ Σεπτεμβρίῳ μηνὶ τῆς ιε΄ ἐπινεμήσεως ἐγεννήθη Κωνσταντῖνος ὁ βασιλεὺς ἐκ Μιχαὴλ καὶ Εὐδοκίας τῆς Ἰγγηρίνης ἔτι περιόντος τοῦ Μιχαήλ · καὶ ἱππικοῦ γενομένου ἐν τῷ ἁγίῳ Μάμαντι ἵππευσεν ὁ βασιλεὺς βένετος, Κωνσταντῖνος δὲ ὁ ἐξ Ἀρμενίων ὁ πατὴρ Θωμᾶ πατρικίου καὶ Γενεσίου δρουγγαρίου τῆς βίγλας λευκός, πράσινος δὲ Ἀγαλλιανὸς καὶ ῥούσιος ὁ Κρασσός · νικᾷ δὲ ὁ βασιλεύς. καὶ τί συμβαίνει ἐντεῦθεν; καὶ τοῦτο γὰρ τῆς αὐτοῦ τοῦ βασιλέως τοῦ Μιχαὴλ κακίας ἐστίν, εἰς ὅσον τὴν τῶν Ῥωμαίων ἰσχὺν ἠλάττωσεν.

Scylitzes (copied by Cedrenus) says :

συνέβη ποτὲ τοῦ Μιχαὴλ κατὰ τὸν τοῦ μάρτυρος Μάμαντος ναὸν ἡνιοχῆσαι μέλλοντος τὸν ἐκ τοῦ Φάρου ἀναφθῆναι πυρσόν. ὃν οὗτος θεασάμενος εἰς τοσοῦτον ἐνέπεσε φόβον, δέει τοῦ μὴ παροφθῆναι τὴν αὐτοῦ ἡνιοχείαν ὑπὸ τῶν θεατῶν διὰ τὴν ἀπαίσιον ἀγγελίαν, εἰς ὅσον ἄλλος τις ἦλθε κινδυνεύων ὑπὲρ ψυχῆς. οὕτως ἐκεῖνος θεατριζόμενος οὐκ ᾐσχύνετο. ἵνα δὲ μή τι τῶν προσπιπτόντων ἀνιαρῶν δηλούμενον μαλακωτέρους ποιήσῃ τοὺς θεατάς, προσέταξε μηκέτ᾽ ἐνεργεῖν τοὺς τῇ βασιλίδι γειτονοῦντας φρυκτούς.

Constantine Porphyrogenitus :

ἰστέον, ὅτι οἱ προρρηθέντες φανοὶ διεκράτουν μέχρι τῶν ἡμερῶν Μιχαὴλ βασιλέως τοῦ ἐκ Θεοφίλου. ὄντος δὲ αὐτοῦ ποτε ἐν τῷ τοῦ ἁγίου Μάμαντος προκένσῳ καὶ μέλλοντος ποιῆσαι ἱπποδρόμιον, ἐν ᾧ καὶ ἀντὶ βασιλέως ἡνίοχος ἐγνωρίζετο · (καὶ γὰρ ἐν ταῖς ἱππηλασίαις ἀντὶ ἡνιόχου ἱππηλάτει ·) συνέβη τοὺς συνήθεις ἅψαι φανούς, καὶ εἶπε τοῦτο διαλογισάμενος, ὅτι «εἰ κατάδηλος γένηται ἡ ἔξοδος τῶν Σαρακηνῶν, λυπηθήσονται οἱ πολῖται, καὶ οὐ μὴ ἐξέλθωσιν εἰς τὸ ἱπποδρόμιον πρὸς τὸ τὴν ἐμὴν ἱππηλασίαν θεάσασθαι.» καὶ ἐκ τότε διετάξατο μὴ ἅπτειν τοὺς φανούς (45).

The most circumstantially detailed account of the beacon system, by Pseudo-Symeon, says that Michael was in the process of staging a horse-race, *ἱππευομένῳ* – unless this is merely a case of the loose use of the participle so often found in this type of Greek. The others

(45) Further, less detailed references in GLYCAS, *Ann.*, iv (ed. I. Bekker, *CSHB*, Bonn, 1836), pp. 542-3. (= *PG*, 158, col. 543C-D). Pseudo-Symeon reports another occasion when news came of the Thrakesion Theme's being ravaged as Michael was about to run a chariot race, much to the latter's annoyance : p. 660 (*CSHB*) = *PG*, 109, col. 721B-C.

all say that he was *μέλλοντος* – "about to", or "intending to", "was going to". Theophanes Continuatus says that he had given the signal – *σύνθημα* – for the horse-race. However Theophanes Continuatus also says that the beacon came *κατὰ τὴν ἑσπέραν* – "in the evening" and Pseudo-Symeon says that Michael was concerned that it would put the spectators off racing "on the morrow" – *τῇ αὔριον*, though he does not say at what time of day the message came.

Now the meaning of all this is easily explained from reference to the same work of Constantine Porphyrogenitus as describes the beacon system. The horse-races were an important part of life in the capital, the only place where they look place on any scale by the ninth century, and occurred quite frequently, the most important event being held on May 11th, the anniversary of the inauguration of New Rome in 330. The formalities are described in a passage, much of which is now obscure to us because of the allusive nomenclature, in the *De Ceremoniis*. It appears there from the ritual to be observed on the occasion of a race day that a "meeting" lasted only one day,with four races in the morning (*πρωΐ*) and four in the afternoon (*δείλη*). However, the ceremonies normally began the day before with the raising of the *βήλαριν* or pennon (this must be what Theophanes Continuatus means by the *σύνθημα*), which was followed by the rounds of the stables of the Factions and the choosing by lot of the starting order. The *βήλαριν* might, from reasons of inclement weather, be up several days before the actual day of the races ; if it was brought down the meeting was understood to have been cancelled – hardly a desirable move for the supporters. The various ceremonies of the preparation day, as we might call it, lasted into the period of the day described as *δείλη*. The court assembled for the races the next day before dawn. After lengthy acclamations the morning races began, with acclamations between each race. Then the Emperor went for a private luncheon (*ἀριστᾷ*) followed by a brief rest period (*μικρὸν ἀναπαύσας*). Then he returned to the Cathisma and the afternoon races were preceded by and punctuated by the acclamations as before. After the races everyone went home (46).

(46) Ceremonial described : CONSTANTINE VII PORPHYROGÉNÈTE, *Le livre des Cérémonies*, ed. A. VOGT, II (Paris, 1939), 78 (69) – 82 (73) = *PG*, 112, coll. 577C-664C = I, pp. 303-369, ed. J. J. Reiske (*CSHB*, Bonn, 1829). In Vogt's text the

From this description it is clear that on the occasion when the notorious beacon message came in Michael's reign it must have arrived on the preparation day towards or after the end of the ceremonies when Michael and everyone else was expecting a good day's entertainment to come. Pseudo-Symeon says that the horse race took place (*ἵππευσεν ὁ βασιλεὺς βένετος*) and that he won (*νικᾷ δὲ ὁ βασιλεύς*), but then says *καὶ τί συμβαίνει ἐντεῦθεν* ; "And what came" either "next ?" or "out of this ?". He then describes the beacon system as quoted on pp. 258-259 above. Depending on how we take *ἐντεῦθεν*, this could mean that the races had taken place and a second day's fun was expected when the message came, yet since the pattern of race meetings seems to be generally clarified by Constantine's accounts, Pseudo-Symeon is probably saying "He raced and won and a result of that meeting was the stopping of the beacons". This is certainly congruous with what Theophanes Continuatus has to say. Of course Michael might have been so keen on the races that his lasted two days instead of one. Writers other than Pseudo-Symeon may not have known of this departure from the norm. At any rate the indication of Theophanes Continuatus that the message arrived *κατὰ τὴν ἑσπέραν* would suggest something later than Constantine's temporal indication of *δείλη* for the ceremonies on preparation day and on race day for the p.m. races. *Δείλη* is not an easy period to define ; the examples for its classical usage in LSJ[9] are not very conclusive even for the Hellenistic period. Such words have a way of shifting their times according to changing social customs, like the names for meal times (cf. Homer's *ἄριστον* and above, *ἀριστᾷ*). Yet the surest way of determining what time is meant ought to be from information contemporary with the writings under discussion ; we can do better than this since the *De Ceremoniis* itself provides information. As this is not a work of atticising pretensions we might expect that its indications are correct for the period of composition.

Δείλη on race day is obviously meant to be after the siesta but before sunset ; *i.e.* mid- to late afternoon. Despite the early start, the

points referred to in the paragraph above this footnote are : – *βήλαριν* : pp. 118, 142 : court assemblies before dawn (*ἐννύχιον*) : p. 112 ; *ἀριστᾷ* : p. 115, l. 19, p. 117, l. 4 ; siesta : p. 115, l. 29 ; "went home" : p. 117, l. 21. See also Vogt's *Commentaire*, ii (Paris, 1940), pp. 114-117.

morning races could not have got under way all that soon given all the ceremonial preceding them, so that the gap between the end of the forenoon and the beginning of the afternoon races could not have been tediously long. At one point (47) Constantine is describing the ceremonial for a *βοτόν*. Here specific mention is made of the time of day on the preparation day when the Factions went to their demes. It was *ἑσπέρας ὥραν θ' ἢ ι'* : *i.e.* "hours 9 or 10 in the evening". In the ancient and medieval system of temporary hours (on which see the next paragraph but one) this would, at Constantinople, have been in modern terms, in mid-summer 3.45 p.m. or 5.00 p.m., at the equinoxes 3 p.m. or 4 p.m., and in mid-winter 2.15 p.m. or 3.00 p.m. The designation *ἑσπέρας* must be seen in relation to sunset, which, in Constantinople, comes at 7.31, 6.00 and 4.29 p.m. on the respective dates mentioned. We would not call times this early in the day "evening", but for Constantine Porphyrogenitus *δείλη* must have ended around this time, though *δείλη* and *ἑσπέρα* may well have overlapped in the usage of different speakers, as do our "afternoon" and "evening".

The fact that Theophanes Continuatus says that the message came *κατὰ τὴν ἑσπέραν* suggests that *δείλη* was by then over and with it the ceremonies preparatory for the races the next day. We should, however, notice that the message received "in the evening" indicated an Arab *raid* (if the sources in their unanimity report it correctly and not merely as a vague and general term). This was, of course, the message for hour 1 according to Pseudo-Symeon, which would suggest other than a morning code, which is what Pseudo-Symeon implies. The message which came to Michael came certainly in the late afternoon, if not later. The scant facts might indicate that the beacon messages were expected by night. A beacon flame is, of course, more easily visible in the darkness of night than when it can be confused with other light by day. However, smoke signals, though not mentioned by any source, could have been used by day, but would have been less visible on the horizon at distance, especially if heat haze or cloud had obscured them (48).

(47) *De Cer.*, 81 (72), ed. Vogt, II, p. 160, l. 6.

(48) This is the opinion of LEMERLE, p. 155 and n. 29 and of TOYNBEE, p. 299, though he does not give his reasons for thinking so. Cf. *supra*, p. 270.

By the indication of hour 1, hour 2 and hour 3, Pseudo-Symeon probably meant the first, second, third *temporary* or *seasonal* hour. He does not mean one o'clock, two o'clock, etc. as on our modern reckoning, which is what some recent writers on this subject seem to have envisaged (49). In the same way by ἐν μιᾷ ὥρᾳ Constantine Porphyrogenitus meant "in the space of one [temporary] hour". The ancients and, as far as we can tell, the Byzantines, certainly still in the ninth century, used for ordinary purposes the temporary or seasonal hour system whereby the period of daylight was divided into twelve equal portions, each an "hour", on every day of the year. Sunrise was hour < 0 > and sunset hour 12. Likewise the hours of darkness were divided into 12 night hours from sunset to sunrise, or into four watches. These hours varied in length according to the time of year. By hour 1 Pseudo-Symeon means the first hour after sunrise (if by day) or the first after sunset (if by night). Our modern hour system is really the temporary hour system for two days in the year only : the equinoxes (March 21st, September 23rd), when the periods from sunrise to sunset and from sunset to sunrise each equal half the period from one noon to the next. Each period, sunrise to sunset and sunset to sunrise, is divided into twelve to form an hour. The day hours and the night hours are hence equal and the two series of twelve form together the twenty-four *equinoctial hours*.

The provision of water-clocks does not help decide any better whether day or night temporary hours are meant. Night measurement may seem more probable with water-clocks, as at night the sun could not be used to find the time by means of a sun-dial. Yet by day it does not always shine and a water-clock would be needed as an adjunct to a sun-dial for an operation like this one with the beacons where the right time is essential. It is no good if the signal comes and no-one can interpret it.

If the signals were sent at the first, second, etc. temporary hours, the exact time of the signal relative to our equinoctial hour system with its twenty-four equal hours would vary with the time of year. In midsummer at the latitude of Loulon a day-time temporary hour is $1^h\ 13^m$ of equinoctial time long while a night hour has only 47

(49) Bury, pp. 247-8 ; Dvornik, pp. 142-3.

minutes. By midwinter the positions are reversed : a night hour is 1^h 13^m long and a day one 47^m. In Constantinople the corresponding figures are $1^h\ 15^m$ and 45^m. The negligible difference is the result of the higher latitude (by three and a half degrees) of Constantinople. Any mechanical clock has to be made to measure these differing hour lengths. The ancients could do this with water-clocks and there is no reason to suppose that the knowledge was lost to the Byzantines. It was, however, quite complicated (but would not be impossible) to have a water clock shewing both day and night hours continuously, since the length of hour has to change on the temporary system at sunset and sunrise (50). Pseudo-Symeon speaks of only twelve possible messages, so evidently we are dealing only with day or night (or maybe both as two series). We should also note that it was an "hour" of length not less than 45 minutes and not more than 75 minutes which Constantine Porphyrogenitus meant by ἐν μιᾷ ὥρᾳ for the total transmission time of the messages.

Thus the logistics of running the two ὡρολόγια are not as simple as they might seem at first sight. If the two clocks were made to shew variable day hours they would both have to be set in motion at sunrise each day – a point in time not always easy to determine with accuracy from observation in poor weather. If they were to shew night hours the same thing would have to be done at sunset, with the same problems. It is a simple matter to set a water-clock from the shadow on a sun-dial, which is as unerringly accurate as its maker has constructed the dial, but if one requires the time with precision and the sun cannot be used because it is not yet or no longer in the sky, or cloud obscures it, the task is no simple one.

(50) For a discussion of such water-clocks, see H. Diels, *Antike Technik* (7th Ed., 1920 ; repr. Osnabrück, 1965), pp. 204-232 (cf. Vitruvius, *De Architectura*, IX, 8, 2-15 and comment. of J. Soubiran (Paris, 1969), pp. 270-308). But we should not forget the ὡρολόγιον of S. Sophia in Constantinople. This had, it seems, some kind of tower with twenty-four doors which had the hours of the day and of the night. As one hour was ended a door closed and the door for the next hour opened and remained open during the whole of that hour. See A. Vogt, Constantine VII Porphyrogenitus, *Le livre des cérémonies, commentaire* (Paris, 1935), I, pp. 57-8 (= *De Cer.* (ed. Vogt), I, p. 10, l. 23 = p. 14, l. 12 (*CSHB*, ed. Reiske, I) = *PG*, 112, col. 154A5). Cf. also the night clock of Gaza which also had doors – Diels, *op. cit.*, pp. 219-227.

However, if the *ὡρολόγια* shewed not the customary temporary hours, but our equinoctial hours, a system sometimes used by Hellenistic astronomers in antiquity (51), the job is easy. The two clocks are set to run on a simple twenty-four hour system (2 × 12) and checked at the same time daily against a sun-dial whenever possible, at both ends of the beacon chain. Of course this does mean that the messages are sent at varying times relative to sunrise or sunset according to the season of year.

Another way of synchronising *ὡρολόγια* which marked temporary hours would be for the Loulon commander to have a "fire-practice time", or particular time each day when he lit his beacon and the signal was relayed to the capital. The clock would then be set at the Pharos. This does not, however, seem to be how the system worked, since Michael III would not have been so worried at the crowd's reaction to the beacons if a trial run occurred daily. Equally it would have made for a great deal of daily bonfire building in Anatolia. Pseudo-Symeon's account does, however, record the state of alert in that he speaks of a number of beacons in readiness at Loulon (cf. *supra*, p. 259).

We might now look again at the time of day when Michael III received the message for "Arab raid". If we assume that the sources have reported this accurately and not merely given *ἐκδρομή* as a loose rendering of an alarm message, then according to Theophanes Continuatus this, the message for hour 1, came *κατὰ τὴν ἑσπέραν*. It is hard to interpret this phrase exactly. Does it mean before or after total darkness had fallen ? I suspect the former. It would help if we knew the time of year at which the event took place. Pseudo-Symeon (cf. *supra*, pp. 285-286) certainly narrates the horse-race directly after he announces the birth of Michael's (illegitimate) son Constantine as though these events were connected,and they both appear to take place in September. However, this was when the indiction year began, and Pseudo-Symeon's chronology is so unreliable (cf. *infra*, pp. 294-295) that, though these time data may be correct, we cannot place any trust in them. The other sources for the story do not specify a time of year. However, in looking for a

(51) See S. Gibbs, *Greek and Roman Sundials* (New Haven & London, 1976), p. 10.

rough date, there are some guidelines available. First, if the equinoctial hour reckoning was in use for the beacon clocks and they were using the night system, the *ἐκδρομή* signal (hour 1 after 6 p.m., halfway between mid-day and midnight) would, if we assume that it left Loulon promptly at 7 p.m., arrive at the Pharos at about 8 p.m., after having taken just about one equinoctial hour in transit, at a relay interval of 7-8 minutes, making 56-64 minutes in all. The time of arrival, *κατὰ τὴν ἑσπέραν*, must be before night itself and so would be no later than around dusk.

The Arabs are known (52) to have made their raids across the eastern frontier regularly at three set times of the year : spring, summer and winter. The spring raid always ran from mid-May to mid-June, when sunset at Constantinople falls between about 7.10 p.m. and 7.31 p.m. ; the summer raids came from mid-July to mid-September, when the sun sets between about 7.20 p.m. and about 6 p.m. ; the winter raids, which were much less common, were at the end of February and in the first half of March, when sunset is between about 5.21 p.m. and about 6 p.m. (53). The period of dusk may be taken as the time between sunset and when the horizon is no longer visible by reflected sunlight (54). At Constantinople the end of evening twilight comes at 8.25 p.m. in mid-May, it is at its latest at 8.51 p.m. on June 21st, and falls at 8.37 p.m. in mid-July and 7.04 p.m. at the autumn equinox, September 23rd. At the end of February it is about 6.26 p.m. and by the spring equinox, March 21st, is again at 7.04 p.m.

Clearly the events described cannot have occurred during a winter raid, as it would be well and truly dark by 8 p.m. The most likely time would be during a spring or early summer raid, from mid-May to late July. It is then, at the most usual time for the raids, that this *ἐκδρομή* probably took place.

(52) Cf. A. A. Vasiliev, *Byzance et les Arabes*, I (Brussels, 1935), p. 97 ; Toynbee, p. 380.

(53) In the figures for sunset and twilight, and above 289-290 for "hours 9 or 10", $\varphi = 41°$ N ; "mid-May", $\delta = +19°$; "mid-June", "June 21st", $\delta = +23°27'$; "mid-July", $\delta = +21°30'$; "mid-September", "Sept. 23rd", "mid-March", $\delta = 0°$; "end of February", $\delta = -11°$. Cf. the methodology in the *Explanatory Supplement to the Astronomical Ephemeris, etc.* (3rd impr., London, 1974), pp. 25-26.

(54) This is the period called "nautical twilight" from sunset until the sun is 12° below the horizon : cf. *ibid.*, pp. 399-400.

The system of Leo has a distinct advantage over previous systems in that twelve different messages can be sent – the import of only three is given by Pseudo-Symeon. It must, however, have had disadvantages for the commander of Loulon. He had to wait at least half the day (if twelve messages could go by day and twelve by night) or a whole day (if messages went only by day or only by night) before he could send word to the emperor. If the enemy attacks after hour 1 almost a whole day may have to pass before he can call for appropriate help. Obviously, with good intelligence sources if an Arab leader had his wits about him he could invade at such a time that the Byzantine commander at Loulon could not get his message transmitted. If Loulon were captured (no easy matter) after hour 1 but before the next hour 1 no accurate message could get through to Constantinople. However, it is just possible that Pseudo-Symeon may mean us to understand that there were only four messages :

(1) invasion (ἐκδρομή) ;
(2) war (πόλεμος) ;
(3) general arson (ἐμπρησμός) ;
(4) other event unspecified (ἄλλο τι).

and that these messages were spread over the rest of the hours likewise. Thus "invason" comes at hours 1, 5, 9 ; "war" at 2, 6, 10 ; "arson" at 3, 7, 11, and the other message at 4, 8, 12. This would have avoided a circumstance whereby the Loulon commander was desperate to send to the capital for aid, yet could not get the message off for very many hours.

We ought finally, however, to return to the sources. Clearly all are to some extent interrelated, but the account in Pseudo-Symeon, the most detailed for the most part of the description of the beacon system, has had to form the foundation for much of the preceding argument. Fascinating as this account is, we must beware of the fact that this chronicle is, as a whole, based on other, mainly known sources ; for the period in question Theophanes Continuatus is the main one (55). The chronology of Pseudo-Symeon is known to be

(55) Cf. H. HUNGER, *Die Hochsprachliche Profane Literatur der Byzantiner* (Munich, 1978), I, p. 355 ; G. MORAVSCIK, *Byzantinoturcica*², I (Berlin, 1958), pp. 500-501, cf. p. 503.

erratic – "His chronology is wrong nine times out of ten, and if he is right the tenth time, he is so by mere accident", in the words of Romilly Jenkins (56) – though no exact dates are involved here. Given the nature of Pseudo-Symeon's work, some caution must be reserved for details of the beacons, notably the inventor's name, Leo, the ὡρολόγια, and the hour code, which do not appear in other sources. Nevertheless, Pseudo-Symeon may here be giving the correct information without confusion or fabrication. Yet some scrutiny into the chronology of Pseudo-Symeon's account is inevitable. Loulon, after recapture from the Arabs at some unknown date, was again lost by the Byzantines in 832 (57). Leo the Mathematician is said by Pseudo-Symeon to have devised the beacon telegraph for the emperor Theophilus, who ascended the throne in October 829 (and died in 842). So Leo must have put his idea into effect between 829 and 832 (58). It is quite possible that Pseudo-Symeon or his source is here conflating two pieces of evidence, one which gave the details of the beacon system and its inventor, and another which contained the ψόγος against the emperor Michael III. The fact that Pseudo-Symeon's dates are often wrong does not imply that his information on the details of the beacon system is also erroneous.

We might presume that if the beacon system had been any good it would have been put back into action by Basil I after the recapture of Loulon in 876/7. There is no clear evidence of what happened after 876/7, and the tone of the chronicles, all written in the tenth, eleventh and twelfth centuries (though the documents used would have been older), is such as to make the beacon telegraph seem a thing of the past. Certainly Constantine Porphyrogenitus, writing the *De Ceremoniis* at various times before he died in 959 (59), speaks of it as something not employed in his day, as a thing maintained of old (cf. *supra*, p. 261). If it had been an efficient system, we may ask, why was it not in use during the reign of an emperor like himself, so

(56) In *Dumbarton Oaks Papers*, XIX (1965), p. 91, n. 3.

(57) Cf. *supra*, n. 11.

(58) Leo was still alive in 869 (cf. LEMERLE, p. 159) ; it is just possible that he made the telegraph for Michael but that the Macedonian chronicles suppressed the latter's name.

(59) Cf. TOYNBEE, p. 577.

keen on antique practices ? Perhaps the answer is that it was too complex to work effectively or unambiguously : perhaps the instructions were lost or there were no men trained to run it after Michael's decree. Probably it was no longer necessary to have an early warning system. Equally, as the experience of the English later shewed, such a system must have been costly to maintain.

And so, though it appears simple at first sight, the Byzantine Early Warning System still conceals many of its secrets, particularly about what time system the clocks used and the programmed frequency of messages. It does, however, seem well within the capacities of Leo to have utilised the simple potential of longitudinal time lag to compensate for relay intervals. If the caliph Mamûn had been able to persuade the Emperor Theophilus to loan him Leo for a while as he had wanted, perhaps he would have learnt more from him than just geometry (60).

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My thanks are due to the following persons for reading drafts of this article and offering valuable advice : Dr. J. D. Howard-Johnston, Professor C. Mango, Dr. J. Shepard and Mr. N. G. Wilson.

POSTSCRIPT

Since the above article was written, the volume of the *Tabula Imperii Byzantini* by Hild and Restle dealing with Cappadocia has appeared (*Tabula Imperii Byzantini* heraus. H. Hunger, Band 2, *Kappadokien* ... von F. Hild and M. Restle [Vienna, 1981]). The following references may now be added to the above article : Loulon, (described) pp. 223-4 (cf. p. 115 – it was first mentioned as a bishopric in 879), (Slavsat) p. 71, (Al-Mamûn in 832), p. 78, (Surrender to the Byz., 877) p. 82 ; Erciyas Dağı (Ἀργαῖος, etc.) p. 149, s.v. 1 ; Hasan Dağı (Ἀργαῖος, etc.), pp. 135-7 (s.v. al-Ağrab [STRABO, 357 = XII, 2, 6, Ἄργος] – taken as beacon 2 by Hild) and p. 149, s.v. Ἀργαῖος 2 : Faustinopolis pp. 258-9. On p. 80 he follows the

(60) LEMERLE, pp. 151-2 ; BURY, pp. 436-8.

theory that the inhabitants of Loulon expelled a *Byzantine* governor under Michael III.

At p. 80, n. 188 and p. 224, n. 38 he mentions a monograph of which notice seems not to appear elsewhere, I had not seen, and so was not considered in the article above :

V. ASCHOFF, *Über den byzantinischen Feuertelegraphen und Leon den Mathematiker* (Deutsches Museum : Abhandlungen und Berichte, 48 (1980)/1.

The piece is in five parts and a conclusion, and covers twenty-eight pages of print with thirteen tables or diagrams. The first section introduces the system from secondary sources, the second lists (in translation) what the primary sources say. There are a number of small slips here. Section three tackles the questions of (a) the positions of the beacon stations, and (b) how the system may have worked. The locations are illustrated by two diagrams of the route and another of the profiles of the peaks. He comments on the sitings of the Ἀργαίας βουνός and Ὄλυμπος, noting (p. 12) that the height of Erciyas Dağı and Ulu Dağı (cf. *supra*, pp. 267-268) are covered in snow and ice all of the year and in all but a few months in the summer respectively thus making permanent provision of a watch and the task of bonfire-building an unlikely proposition. He discusses (pp. 10-12) other localities without partisan views except for a wrong idea (p. 12) which he thinks he has derived from Bréhier (cf. *op. cit.*, *supra*, n. 1, at p. 269 [= p. 332 of 1949]). Bréhier in fact says "La ligne, obliquant au nord-ouest, passait ensuite par le colline d'Isamos, par celle d'Aigilos, *par la station militaire de Dorylée* ...". This leads Aschoff to believe that Bréhier was positing an intermediate beacon post, not mentioned by any of the sources, at Dorylaeum. This is not the necessary implication of this phrase and certainly nowhere in the reference to Bréhier's writings used by Aschoff (his n. 7 = as above) does Bréhier put forward this idea. The extra station appeals to Aschoff partly because it lies on the main road from Pylae and Nicaea to Tarsus via the Cilician gates, convenient for the encampment at Dorylaeum.

More significantly it leads Aschoff (pp. 14-17 and *Bilder*, 6, 7) to consider a point dealt with above, but not in the same theoretical way. He provides information on the loss of brilliance of a light source over distance according to atmospheric viability. In the normally extremely good visibility of the Anatolian highlands he finds that an optimum size pyramidal bonfire is c. 5 m high (cf. the Jubilee fires twice this size, *supra*, pp. 279-280) and that it is in theory possible to sight a wood fire of that size, depending on how much light it is emitting, under the Anatolian conditions over a distance of about 150 km (nearly 94 miles). [This is roughly the maximum distance between beacon points anyway and is that between Aigilos and Olympos/Mamas without an intervening relay at Dorylaeum.] Significantly, he finds that the less good visibility over the land near the Sea of Marmara results in shortening of the range to about 35-55 km (= about 22-35 miles), which is, in fact, roughly the spacing of the stations on the section from Olympos/Mamas to the capital. He envisages only that the signals could have been sent by night. While on p. 14 he had expressly excluded the use of mirrors or lenses to direct the light as not possible in the ninth century, on p. 17 he admits for the sake of completeness reference to the use of mirrors directing sunlight by day and cites the use of a mirror 1 m^2 to do just this in 1883 over the 215 km (135 miles) from Réunion to Mauritius. He feels (p. 17, n. 4) that if this had been done in the ninth century, we should have been told. He is surely right that mirror-making was not up to nineteenth-century standards by the ninth century, but does not seem to be aware that in antiquity the Pharos lighthouse at Alexandria, for example, was equipped with a reflecting mirror (*). There is no reason to think that the Byzantines could not have done the same, either using the sun as a light source or as a back-up to the beacon fires. Then again, the sources do not mention anything like this. Aschoff (p. 16) makes a valid point (cf. *supra*, p. 281) that the size of the wood fires needed would have made construction quite a burden and he has little faith in their ability to be raised to flame quickly. Though on p. 14 he says that he use of bellows would increase the luminous density by twenty per cent and the addition of plant oils would augment it by a further factor of 2,5, he does not seem to envisage the effects of Greek fire/naphtha.

Section four deals with Leo and his clocks and aims to reconstruct, at least in theory, the two possible telegraph clocks. His ideas are illustrated in his figures 9 and 10 ; they are, as the author admits (p. 18, n. 5.), highly speculative. He mentions the temporary hours (cf. *supra*, p. 290) and the difference of longitude in minutes (cf. *supra*, p. 284). He takes (p. 20) the transmission time "in one hour" (cf. *supra*, p. 290) rather literally as 65 minutes at the equinox and 55 in mid-summer, but how he gets these figures is not clear. He disputes (*ibid.*) that a bonfire can be in full flame in six minutes – yet the experience of the Jubilee beacon makers cited above (pp. 279-280) shews that this is possible. He does, however, note (*ibid.*) the

(*) Cf. R. G. Goodchild, in Singer *et al.*, *op. cit.* (*supra*, n. 41), II (1957), pp. 521-2 ; P. M. Fraser, *Ptolemaic Alexandria* (Oxford, 1972), I, pp. 17-20 and notes thereunto in II, pp. 44-54, esp. p. 47, n. 102. The Arab sources for the mirror are set out in A. J. Butler, *The Arab Conquest of Egypt* (2nd ed. by P. M. Fraser, Oxford, 1978), pp. 389-98 and notes by Fraser, pp. lxxiv-v.

continuous need for atmospheric clarity and the psychological problems of a continuous watch. He is led to conclude (p. 21) that the ὡρολόγια could have been used with the beacons as described in the sources.

He moves on (pp. 21 ff.) to repeat about Leo what the secondary sources say and feels that Lemerle (cf. *supra*, n. 3) should doubt not only the automata as Leo's invention but also the beacon system as recorded. He thinks that the whole business reported by the Byzantine chronicles is an elaboration on the device of Aeneas (cf. *supra*, pp. 271-272) and does not believe that the distance from Sicily to Carthage could be covered as described by Polyaenus (*supra*, pp. 273-274). He does not allow for the fact that though it is 140 miles from Carthage itself to the nearest point of Sicily, near Lilybaeum, from the Sicilian coast to the promontary east of Carthage (Cap Bon), it is only about ninety-five miles, within Aschoff's transmitting distance (cf. *supra*).

Section five of his work is devoted to the demand for a beacon system like that attributed to Leo. He admits (p. 24) that the historical material exceeds his competence as a scientist. Nevertheless, a potted history of the Byzantine Empire follows. He thinks (pp. 26-7) that it is doubtful that it paid the Byzantines to keep such a system manned in the almost inaccessible mountains of Asia Minor. He suggests (p. 27) that the system actually grew out of a local relay network with sub-stations and doubts the value of a multiple-message arrangement. He does not believe in the existence of the chain and clocks as our sources describe it and regards the beacon telegraph of Leo as a legend.

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