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THE GRAIN CYCLE AND A WINDMILL AT A VILLAGE ON THE AEGEAN

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INTRODUCTION

Depending essentially on the periodic chains on the Biosphere almost all functional features or support systems in human cultures are sustained in the form of cycles. The periods of these cycles are fundamentally determined by the processes that produce them. In rural settlements, as an effect of the "openness" or "closedness" of the (community,) as far as the required inputs to maintain the system is concerned, the community is classified to be self-supporting or dependant.

The cycles to support any rural community can be outlined as the cycles of water, food and various forms of energy. Apart from these physical chains there can be many other cycles having direct or indirect relationships with the other processes needed for the survival of the community as an integrated system.

In most of the traditional agrarian cultures almost all of these cycles are completed within the geographic and social context of those communities themselves. At instances when the cycles are completed with considerable inputs from outside the communal boundaries, the cycles are observed to be broken thus become intermittent. The intermittences bring new objects and sources into the system. As a consequence of these, various physical and cultural deformities are experienced as foreign issues.

Owing to her strong and definite morphological boundaries, Bodrum Peninsula protected the closed system characteristics until recently. Especially the limited and scarce water and energy resources, dictated the people to obey the absolute rules of the cyclic natural processes. They have made use of these cycles with an appropriate technology to maximise their benefits in terms of forces and energy resources. On the Peninsula water and grain cycles are among the most important; merely because they form the backbone of the inhabitants' physical existence. The grain cycle and related vernacular technology utilised at various steps are noteworthy.

THE GRAIN CYCLE

In the past and present cultures of Anatolia grain occupies a particularly important place as the fundamental nutrition element in people's diet. This importance has been particularly stressed and maintained by almost all of the social, cultural and religious institutions. The steady process of raising wheat, grinding or pounding it into flour or *bulgur* i.e. cracked wheat, and baking has evolved into a distinct tradition, ritualised and celebrated by all these institutions. Grain and bread have been praised by Anatolian cultures so much that under many circumstances they acquire a holy content, sometimes equivalent to that of Allah or Koran.

On Bodrum Peninsula, the geographical conditions do not allow grain to grow in abundance, as compared to other regions of Anatolia. The main sources of income of the inhabitants of the Peninsula are the olive and citrus plantation together with an intensive vegetable cultivation. Grain is limited in quantity, therefore there is a strong tradition of storing other food stuffs such as horse-beans (i.e. *fava*), dried beans and other vegetables, tomato and pepper concentrate, etc. in support of grain. Despite this wide variety of other kinds of food, the importance of grain both as the essence of their nutrition and as a cultural element determining many communal events has not been subordinated

The particular context of the present work is limited to the region comprising of the fields of the villages of Akçaalan, Karabağ and Karatoprak of Bodrum Peninsula. In this area the agricultural priorities are logically given in accordance with the quality of soil and the availability of water, The valley bottom, i.e. the plain of Karatoprak and Domalan, offers the major agricultural prosperity of these villages. Owing both to the irrigation facilities and to the fertility of the soil this area is reserved for tangerine orchards and early vegetable gardens. Apparently, the grain fields, being on the slopy skirts of the hills are at the same time quite appropriate for olive plantation and consequently, one observes the mutual existence of olive groves and grain fields within each other, on the less priviliged parts of the landscape. That the land to be spared for grain raising is scarce and limited in area makes grain particularly cherished by the peasants.

The round begins in late summer in the diverse wheat fields of the periphery of the valley. Sown in spring, the individual family plots are now ripe and ready for the harvest which is performed with tools and methods so old as to be Biblical. The grain is scythed, and the cut stalks are gathered in the center of the small field. The grain is then treshed by crushing beneath the hooves of an ox-or a couple- which is walked through the piled wheat in a continual circle. This practice is rather different from what has been exercised elsewhere in Anatolia. As far as the vernacular technology is concerned Central Anatolian treshing custom is completely different whereby threshing is facilitated by the utilisation of an ox or horse-towed gadget called *döven*. *Döven* is a sledge shaped wooden board with imbedded flint chips underneath protruding to produce a rough surface needed for threshing as the board towed by animals. This device at the same time breaks the wheat stalks into smaller particles thus stalks become ready for consumption as fodder. *Döven* is mostly pulled by a couple of blindfolded oxen. The reason for using hooves of the oxen instead of *döven* must not be explained as an underdevelopment in the vernacular technology. It is quite likely to be due to the quantity of grain harvested which cannot be so abundant as it happens in Central Anatolia to ratioanalise the usage of *döven*.

The farmer guides his ox on foot or accompanies it astride a donkey. When threshing is over, the grain is winnowed, flung into the air with a wooden fork *(yaba)* where the lighter chaff is carried off by the sea breeze. The remaining kernels of wheat are gathered up in heavy cloth sacks and brought to the family home to be placed in the food store.

The work is not easy, and each phase of the harvest will take a day or more depending on the size of the field and crop. While a suprising amount of the daily responsibility of agriculture is carried by the farm woman, harvesting is the traditional task of the male farmer. The woman may often drive the ox during threshing but the strennous reaping and threshing is her husband's job.

The harvest takes place entirely out in the open field. The paved and sheltered threshing floor prominent in the architecture of other rural cultures is not customary in Akçaalan, and it is probably the extreme parcelling of the land and the limited amount of grain that have made such a single, fixed place impractical. The family may have several plots of grain each distant from the next, and it is more reasonable for the farmer to take himself, his ox and his few tools to the wheat than vice-versa.

The wind[1] is of obvious importance during this first stage of the grain cycle, and both its strength and precise direction is crucial. Winnowing is usually done in the afternoon when the sea breeze is most steady, but the farmer will wait for the right day and and time when the wind is neither too strong nor too light. Where he will stand and where he will pitch his forkful of grain depends on the direction of the breeze. To assess both factors, the farmer makes use of a wooden windtoy that he places in the pile of grain by his feet. With a rotating vane and propellor, the toy imitates a windmill. Its spinning propellor indicates wind velocity and its vane direction. In the course of time, the windtoy has outgrown its very functional origin to become a part of the local folk craft, a device fashioned by boys and man for pure pleasure.

1. *The northerly winds of the Aegean and* the Mediterranean are called etesian. Etesian winds are said to be effective so far as Palestine but the area in which they are most effective is the Southern Aegean Islands and South-West Anatolia. The historical reference to the region is ancient Aeolia. Etesians occur yearly in *dies caniculares*, i.e. the period between mid-July and September known as dog-days. The name etesian is derived from its yearly (ετος : year) cyclic existence. Etesians have records for their existence back to Homeros and Aeolia. (Thanks to A.Cermen for drawing our attetion to etesians).

Milling takes place soon after the harvest, before the winter and rain sets in. Not all of the family's grain is converted into flour. Barley, for example, is not put into form of flour but crushed. The crushing is done again at the windmill -or at the power mill- with a loose spacing between the millstones. The product is whole barley grains crushed into flat pieces to enable animals to chew them easily during winter. Apart from barley, the total amount of wheat harvested is not ground into flour. Some of it is retained for consuption as *bulgur* which is coarsely-ground, in differing grain-sizes suitable for various kinds of dishes. For cracking a rotary stone quern or pounding pit carved of stone is needed. To obtain finely ground flour for bread the family looks to the communal facility of the windmill and to the services of its specialist-operator, the miller.

The windmill has a highly visible and a sentinel-like presence in Akçaalan. It is one of the three tightly spaced mills that sit lined against the sky on the crest of the exposed ridge above Karabağ, east of Doru Dağ. Actually, these three mills

Fig. 1 The windmills and grainfields of Karabağ, looking East from the edge of the village.

used to belong exclusively to Karabağ village, and only her inhabitants were priviliged to the services of these.Akçaalan's mills were situated again on a mountain ridge on the East of the settlement about a mile away from the village. There used to be another single windmill located, between Karatoprak and Akçaalan on top of the Değirmentepe (literally:Mill-hill), of which only a portion of drum survived like other mills of Akçaalan high up on the mountain. The single remaining windmill now extends its services to all three of the villages. Its siting is excellent. The ridge forms a sharp saddle between adjacent peaks thet help channel the sea breeze, which sweeps up from the valley floor and spills over the ridge with considerable force. The other neighbouring two mills were operating in the recent past, now their mechanism and caps are non-existent but drums occupy their space in the landscape as elements of a disappearing tradition. The ruins of a fourth mill lie nearby.The three mills above Karadağ are miniscule in the landscape, but once observed they become a fixed point in one's mind. They can be clearly seen from nearly everwhere in Akçaalan. They form a landmark and an ever-present reference to grain and to traditional agrarian ways.

The farmer must bring his family's grain to the ridge for milling. The climb is long and arduous in the August heat, and follows the ancient route up through Karabağ to the highlands. At stretches, the path is little more than a steep rocky track through the thorny macchia. Even camels cannot negotiate this, and so the grain at times is carried up with donkeys. At the top, by the mill and a nearby cistern, the route branches off into several directions that eventually lead to the old mountain villages with limited patches of arable fields. Although barren and uninhabited, this junction is an important nodal point in the transport network linking valley and the mountain. Both lowland and highland community, when extant, met at this point to use the mills, and travellers pack their trains moving between these communities in trade and communication pause here for water and rest before descending to, or having climbed from, Akçaalan. The junction, the cistern, and the mills work together with a balance and logic that is not accidental.

Having reached the mill, the farmer unloads his donkeys and turns his grain over to the miller who, from this point on, is in charge. The miller is a farmer or herdsman for most of the year and only assumes his special role for a few weeks of the year around harvest time. He is paid by each customer, in flour or with money, according to the amount of grain milled. The miller measures out the farmers grain, loads the mill hopper, sets the sails and begins grinding. He runs his mill from inside on the second storey platform where he squats by the grindstones, controlling various operations with ropes and levers. He makes frequent stops to reload the hopper or to trim the sails, or to rotate the mill turret more directly into the wind. Grinding several sacks of grain will take the better part of an afternoon. Throughout the farmer acts as the miller's assistant, aiding him in the various tasks of running the mill. His normal station is directly beneath the miller on the ground floor of the mill, where he reloads the sacks from the flour chute leading down from the grindstones. When grinding is completed, the miller and farmer take down the sails and together close up the mill. The donkeys are reloaded, the miller given his due, and the farmer heads back down the valley to his home. The sacks, now full of flour, are again carefully stored.

With the harvest and milling, the seasonal cycle is complete. A new year's supply of flour has been established and sufficient or not, it will have to last the family until next August's wheat crop. Baking, however, is not governed by a seasonal time-frame and occurs continually throughout the year on a weekly or fortnightly interval varying with the size of the family and their food needs. Baking brings the grain cycle back into the family realm and focuses on the farm woman. As with all food preparation, baking is solely her task.

Baking is done outdoors, at either the bread oven or a fireplace. The use of oven and fireplace depend particularly upon the type of bread that the family prefers to bake. The hearth is utilised for classical Anatolian type of unleavened bread in thin sheets. To make it, the dough is rolled out into thin round sheets on a specially devised low round wooden table, then sheets are stacked in layers. For baking fire is made in a small cavity on the floor and a round convex steel plate is placed on top of it. The thin sheets of dough-about 60cms. in diameter- are baked in a process roasting both sides. This bread is usually made in bulks and stored for winter consumption when roasting may be too troublesome in the winter cold. The sheets are moistened before meals for the convenience of chewing. Among many novelties of Anatolian diet this type of bread has been gradually disapperaing, as a consequence of the introduction of communal and commercial bakeries. The sheet bread has not been unanimously widespresd in Akçaalan but used to be in the tradition as a maintained line of diet culture of their Turkic origin. Presently, it is on the treshold of being extinct, so are the floor hearths with convex steel baking sheets.

The oven is a masonry structure of about a cubed meter in mass with a vaulted or arched cavity to receive the bread. Ovens vary in form, but whether free-standing or built into a garden wall, it is an architecturally strong and independent element of the house-yard. As the windmill is singularly visible, the oven is ubiquitous, and like the former continually emphasises the theme of grain and bread. Each house will commonly have its own oven in the yard but not always and, especially in the towns, several neighbours will borrow the use of another oven. Often, the women of the neighbouring families will arrange to use the oven together on a given day, both to share and lessen the share and to socialise.

When the loaves of bread are prepared and rising, the oven cavity is stuffed with brushwood and fired. When the masonry has built up sufficient heat the smouldering brushwood is pulled out with a hook, and the loaves are placed on a tile and inserted in the oven to bake. The wind that is so important in harvesting and milling is paid final attention in the siting of the oven, invariably placed so that excess heat and smoke will be carried off by the prevailing breeze, away from both the house and the baker.

The grain cycle ise a single thread within a larger cultural fabric. Its salient features, such as the dominance of seasonal forces, the socially differentiated roles and tasks and the ancient but balanced methods, are common characteristics of the agrarian tradition in Akçaalan in general. The meshing of the overall tradition and its parts occurs at different scales and levels. Agriculture, water and transport, for example, are more than merely adjacent infrastructures. Futher, the processes and attitudes underlying one aspect of the tradition are also present and operating in another The wheat harvest and the food cellar, the winter rains and the cistern and the daily sun and the earthen roof are all analogous systems.

While interlocks such as these are not unusual in a culture, the degree to which they are made manifest and apparent in Akçaalan is special. The tradition is cohesive, but it communicates this and in doing so, reinforces itself. To use the wind and other natural forces to his advantage the farmer must carefully observe and obey them, but such an avareness is only strangthened with continual use. Watering one's donkey at the cistern by the mill bring home the necessity of the cistern, which in turn insures that it will be maintained and kept up. A glance from the windtoy in the wheat field to the steadily rotating white sails of the mill on the ridge instantly assures the farmer that he and the miller are working together toward the same end, in the same world. The bread oven is so commonly important that it has become institutionalised in the domestic architecture, and so is made more visible and dominant than what it actually deserves. The tradition is a generator in itself, enriching and self-sustaining, and in this regard the powerful image of the windmill, as well as that of the windtoy and bread oven, has a symbolism and significance well beyond the grain cycle.

Like other aspects of traditional life in Akçaalan, the grain cycle is breaking down. In recent years a new mill, powered by a diesel engine has been installed in Karatoprak, and although some local people stubbornly prefer the windmill, the new device is heavily patronised. It is a relatively big establishment providing services other than grinding their wheat and barley. This new mill is equipped with a press to produce olive oil also processes other agricultural produces.

The people's choice for windmill's services is not purely rooted in nostalgia. The performance of the windmill allows this medieval machinery to survive despite its distant location and the definite opposition of the near and convenient powermill at Karatoprak. The preference for the windmill ground flour at Akçaalan is due to its richness. Because of the extremely rapid and mechanised method of grinding, the power-milled flour is prematurely baked during grinding. This is caused by the overheat originating from the uncontrolled friction and fast grinding process. As opposed to the powermill the windmill has a steady and finely controlled grinding process. The speed, friction and spacing of the millstones are more accurately inspected by the miller at the windmill when compared with the crude machinery of the busy powermill. The Akçaalan harvest yielding a limited amount of grain that is just sufficient for a family makes this amount ever more precious. The critical decision on the part of the farmer is to have it properly ground at the windmill. This much credit for the windmill is not sufficient to sustain the system of which the windmill is only one of the important parts. The cistern by the single remaining windmill has fallen in. For the first time in centuries, it appears as though it will not be fixed.

The deformation of the traditional grain cycle is not solely the result of the single technological innovation of the powermill. The change has general roots, involving the refocusing of settlement from hill and mountain to shores, the construction of Karatoprak as a local center, and the increasing availability of new utilities and sources of energy. As the people of Akçaalan experience greater outside contact and growing affluence, they are beginning to move away from the old necessity of subsistence farming and its inherent traditions. The new way has simple advantages. The old yearly climb to the mill may have rewarded one with a stunning panorama of the valley and sea, but it was strenuous. The powermill is more convenient and quicker, and it is in town, close to the teahouse and shops. It is also modern, less backward and peasant-like, and this is a very important factor. As families buy their bread from professional bakers in town, the farm woman's work is lightened, and socially perhaps she is freer. A final stage where families no longer grow their own grain is foreseeable. Like the old tradition, the new system is also self-sustaining. The difference is that the force, energy and pressure for the new comes from without the community.

Technological change and modernisation in Akçaalan appears inevitable. With this comes some advantages, such as a new profitable agriculture and disadvantages, such as ecologically dangerous water practices. With this also comes similarly inevitable cultural trauma. In the case of grain cycle, the loss of a rich and cohesive tradition, with beautiful symbol-machines, is especially poignant because what replaces it is of no clear economic or social benefit -it is mostly just new. At the same time, it is difficult to defend such a position as taken by the Halikarnassos National Park Plan,[2] which advocates the cosmetic restoration of all the windmills on the Peninsulaa in order to retain their culturally symbolic, romantic and tourist-luring qualities.

2. *Halikarnassos Sahil Milli Parkı, Uzun Devreli Gelişme Planı, Halikarnassos Seashore National Park*, Ankara, 1972.

Technological change brings cultural change, which in turn requires that old tradition's images and values be replaced with new ones. But this is inevitable, and must it be so complete? Our current notions and models of growth and development lead us to conclude so. But our models may be inadequate.

WINDMILLS IN RETROSPECT

When we look back at the emergence and the development of windmills we observe that they had been innovated independently both in the East and the West. Even though some scholars assert that the windmill is a western invention which was developed around 12th Centruy and spread dowards the East by the Crusaders[3] this does not particularly hold true, since some other researches into the history of technology furnish us with a vast evidence for the existence of windmills in Central Asia, China, Persia and Arabic Lands convincingly earlier than the earliest known referenc of the western windmill.[4]

The basic mechanical differences between the eastern and western windmills also reinforce this hypothesis suggesting two different independent lines of development in windmill technology. As far as the aerodynamic principles of converting wind energy into a rotary movement is concerned, the western and eastern windmills are almost completely different. The more efficient western type acts like a reversed airscrew and the total sail area made of rigid materials receive the wind energy at all times. While in the sailboat inspired eastern windmills only a part of the sails obtain wind energy; that is the cloth or bamboo sails connected to a rigid structure composed of masts and tensile members.[5] English, Dutch, Russian, Italian, French mills belong to the category of western windmills. Mediterranean, Persian, Chinese windmills are considered to be the eastern windmill types, developed in Persia and further east and spread so far west as Spain and Portugal through the Arabic cultures of North Africa.

The earliest known reference to windmills is around 400 B.C. by a Chinese traveller Fa-hsien.[6] Later Caliph Omar I's order to Persion Abu Lulua[7] to build a windmill is a significant source for the existence[8] of windmill in the East dating back Omar I's reign *i.e.* 634-644. There are quite a few references to the windmills of Seistan, Persia in 10th and 11th Centuries, used for both the purposes of grinding and pumping water.[9] "These windmills are of the 'horizontal mill' type, with sails radiating from a vertical axis standing in a fixed building which has an opening for the inlet and outlet of the wind diametrically opposite to each other."[10] A contemporary example of this type of windmill was spotted in the same region with almost the same organisation of the mechanism of converting wind force into a rotary movement.[11] The first description of a horizontal windmill construction is written and illustrated by Syrian cosmographer Al-Dimashqi (1256-7 - 1326-7).[12]

It can be clearly traced from various documents of 12th Century that at that time windmill was a well-known piece of technology,

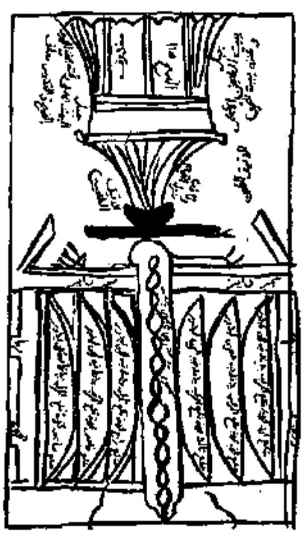


Fig. 2 Horizontal windmill description of Al Dimashqi, c.1300. From: AL-DIMASHQI, *Cosmographie,* ed A.F. Mehren, p.18, St.Petersburg, 1866 (c.1300). The sails are below the millstones. The direct rotary action of the sails rotate the upper stone above which a hopper is placed.

3. L. WHITE, *Medieval Technology and Social Change,* Oxford: Oxford University Press, 1964 (1962), p.87, is the most important defender of this view, and J.C NOTEBAART, *Windmuhlen,* Den Haag: Mouton Verlag, 1972, pp. 374f, agrees with him.

4. R. WAILES, A Note on Windmills, *A History of Technology,* eds. C. SINGER, *et.al.* vol. II. Oxford: The Clarendon Press, 1957 (1956), p. 623. gives first reliable date c.1180 for a windmill in Normandy basing this date to mention published in: L.DELISLE, *Journal of the British Archeological Association,* vol. 6, p. 403, 1850. The earliest illustration depicting a windmill is in the following century c.1270 R.WAILES, *Ibid.* after: PIERPONT MORGAN LIBRARY, *Catalogue of Manuscripts from the Libraries of William Morris, et.al. now Forming a Portion of the Library of J.Pierpont Morgan,* London: Chiswick Press, 1907, MS. 19.

5. R.J. FORBES, Power, *A History of Technology,* eds. C.SINGER, *et al.,* vol. II, Oxford: The Clarendon Press, 1957 (1956), pp.617f.

6. R.J.FORBES, Power, *A History of Technology,* eds. C.SINGER, *et al.,* vol. II, Oxford: The Clarendon Press, 1957 (1956), p.615. but L.WHITE, *Medieval Technology and Social Change,* Oxford: Oxford University Press, 1964 (1962) basing on a finding in: L.C.GOODRICH, The Revolving Bookcase in China, *Harvard Journal of Asiatic Studies,* vol. VII, 1942, p.154 asserts that Fa-hsien's account of windmills is incorrect as a result of mistranslation. But in a more developed and later work based on his previous chapter on power i.e. *ibid,* R.J.FORBES, *Studies in Ancient Technology,* Leiden: E.J.Brill, 1965, vol.II, p. 116. insists on this earliest reference to windmills. This leaves the dispute unresolved.

7. R.J. FORBES, *Studies in Ancient Technology,* Leiden: E.J.Brill, 1965, p.116.

8. This reference was also interpreted as a document for the non-existence of windmills at that time. The Caliph's order was taken as regards for to make impossible or absurd happen. His order was to construe his disbelief in the machine as such. L.WHITE, *Medieval Technology and Social Change,* Oxford : Oxford University Press, 1964 (1962), p.86 to prove this refers to: H.T.HORWITZ, Über das Aufkommen, die erste Entwicklung und die Verbreitung von Windrädern, *Beiträge zur Geschichte der Technik und Industrie,* vol. XXII, p.99, 1933.

9. R.J.FORBES, Power, *A History of Technology,* eds. C.SINGER, et al., vol. II, Oxford: The Clarendon Press, 1957 (1956), p.616.

10. R.WAILES, Windmill, *Encylopaedia Brittanica,* vol. 23, Chicago: E.B.Inc. 1971,

11. R.J. FORBES, *Studies in Ancient Technology,* Leiden: E.J.Brill, 1965,p.118.

utilised profusely in Low Countries and England.[13] By 13th to 14th Centuries, they became typical prime mover in German Plain, Latvia and Russia; used principally as water raising and pumping machinery. In the meantime, the eastern mill spread all around the Mediterranean.

To investigate the history of the development of the traditional Mediterranean windmill -a typical example of which was surveyed at Karabağ- it is needed to study the advancements made for the development of various parts of the windmills. The following parts performed the major steps in this development.[14]

1. Main body of a windmill
   a. Tower mills
   b. Post mills
2. Sails
   a. Canvas sails
   b. Rigid sails
3. Primary rotary movement
   a. Via Horizontal shaft
   b. Via Vertical shaft

The surveyed mill is a compostition of the elements outlined in the 'a's of the above list. In other words, it is a tower-mill with jib-sails having vertical sails and a horizontal shaft rotating by the wind force. A typical western windmill, as opposed to this, is a post- or tower-mill, rigid sails but with again a horizontal rotary shaft.

The Mediterranean type of windmill must have been matured by 17th or 18th Centuries. This can hardly be an absolute conclusion but when the improvements made for the three basic components of a windmill are taken into account a judgement as such excels a mere speculation.

The primary architectural and structural constituent of a windmill is the body. The body in the eastern mills is a building[15] with horizontal sails, while in the western mills it is a cabin mounted on a post.[16] In the former, the sails are exposed to wind blowing from all directions. The latter, however, has to orientate itself by rotating the whole building around the axis of the post, with the assistance of a leverarm. "There is no reference to a tower mill antedating post mill thus the tower mills are later than any of the post mills."[17] Tower mills being larger, more durable and more substantial structures are to be regarded as more efficient and advanced apparati. Even though there are some examples of tower mills with rotating cap directing the vertical sails towards the prominent wind published by Ramelli[18] in 1599, comparatively more Mediterranean examples of the tower mills in late 16th Century are of horizontal type. The works of Besson[19] and Veranzio[20] are well worth studying. Both of these windmills of the Europeans can be considered to belong to the category of Persian windmills with horizontal sails. Veranzio's windmill can be taken as one of the antecedents of Mediterranean windmills. This idea can be a bit more confirmed with the analogous details of this and the surveyed mill. The similarities in the mechanical parts deseve some attention.

The other important part of a windmill is of course the system that catches wind energy. In almost all windmills this is facilitated by sails. The horizontal sails, as discussed above,

12. To Al-Dimashqi's windmill R.J.FORBES, Power, in: *A History of Technology*, eds. C.SINGER, *et al.*, vol.II, Oxford: The Clarendon Press, 1957 (1956), p.615. refers from: Muhammed ibn Abi Talib AL-DIMASHQI, *Manuel de la Cosmographie du Moyen Age*, tr. A.F.Mehren, Leroux, 1874, p.247. L.White when proving his hypothesis on the spread of windmills from the west to eastern cultures in L.WHITE, *Medieval Technology and Social Change*, Oxford : Oxford University Press, 1964 (1962), p.87. quotes: AMBROISE, *L'Estoire de la Guerre Sainte*, ed. G.Paris, Paris,1897, 11. 3227-9, tr. M.J.Hubert, New York, 1941. but Ambroise's cheuvinistic account of the Third Crusade (Beginning of 13th Century) does not offer a convincing proof for the non-existence of windmills in the East early at 13th Century. R.WAILES, Windmill, *Encyclopaedia Brittancia*, vol. 23, Chicago; E.B.Inc., 1971 p. 570, states thet the spread of the windmills with Crusaders had occurred the other way around from the East to the West.

13. R.J.FORBES, *Studies in Ancient Technology*, Leiden: E.J.Brill, 1965, pp.122ff.

14. It is apparently needed to search the progress made in the mechanism of the windmill history. The cog-wheel and a differential system *vide.* figures 17 and 23. transmitting the horisontal rotary movement into a vertical one is of course, one of the most important improvements in mill technology. The historical development of this would cast a light onto the process of advancements in technological history of the windmills. Nevertheless, this is not proven to be valid. The utilised system in the Mediterranean windmills has records much earlier than the known references to the matured Mediterranean windmills. The cog-wheel is known to be existing back in time of Archimedes. The wheel with differential to transmit the movement into a perpendicular axis is recorded to be a utilised system in 12th Century watermills. B.GILLE, Machine, *A History of Technology*, eds. C.SINGER, *et al.*, vol.II, Oxford: Clarendon Press, 1957 (1956), p.648, provides illustrations for two watermills with a similar differential system, depicting 12th Century watermill in : H.De LANDSPERG, *Hortus deliciarum*, ed. J.WALTER, Strasbourg: Le Roux, 1952; and a 13th Century one at Palacio Episcopal Arcs de San Isidro, Madrid, *after:* W.W.COOK and J.F.RICART, *Ars Hispaniae*, vol.6, Madrid: Editorial Plus Ultra, 1950, fig. 261. Thus, the mechanism having been developed much earlier does not offer any substantial evidence to trace various steps in windmill technology.

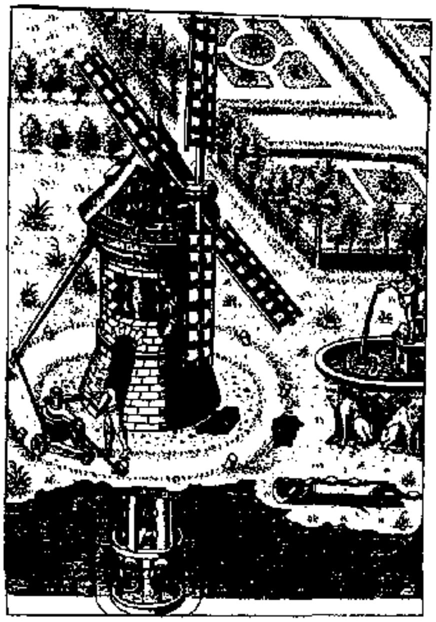
15. *cf.* the Persian windmill in: R.J. FORBES, *Studies in Ancient Technology*, Leiden: E.J.Brill, 1965, p.118.

16. R.WAILES, Windmills, *A History of Technology*, eds. C.SINGER, *et al.* vol. III, Oxford: The Clarendon Press, 1964 (1957), pp.91ff, 98, gives contemporary examples of surviving Russian post-mills.

17. R.J. FORBES, *Studies in Ancient Technology*, Leiden: E.J.Brill, 1965, pp.120f.

18. A.RAMELLI, *Le diverse et artificiose machine*, Paris: (Published by the Author), 1588.

19. J.BESSON, *Theatre des instruments mathematiques*, Lyons: B.Vincent, 1579.



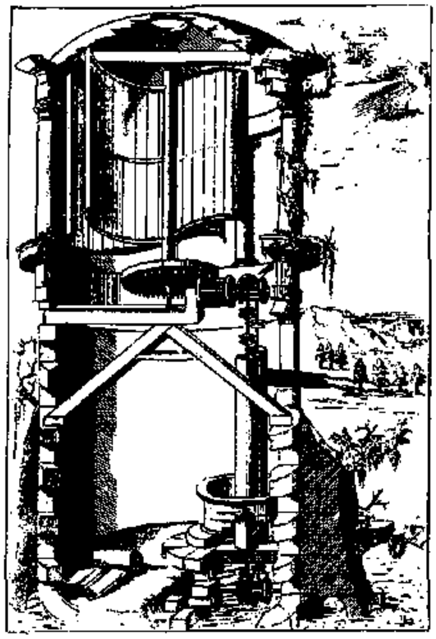
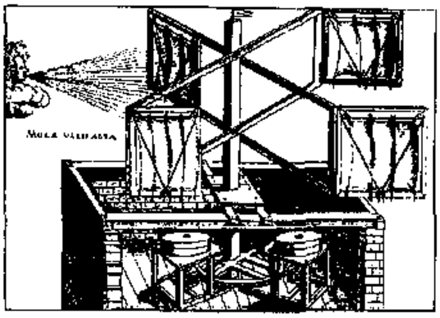


Fig. 3 A vertical tower-mill with a rotating cap. Designed for raising water. From: A.RAMELLI, *Le diverse et artificiose machine*, Paris, 1588, fig. 73. It gives a detailed account of the state of advancement in the windmill technology of the period.

Fig. 4 A horizontal tower-mill with canvas sails protected by a dome. From: J.BESSON, *Theatre des instrumens*, Lyons: B.Vincent, 1958, plate 1. The primary vertical rotary movement produced by the horizontal sails is transferred by a wheel and a differential. That is similar to the one surveyed at Karabağ. *vide*. Figure 17 cf. the reversed axis.



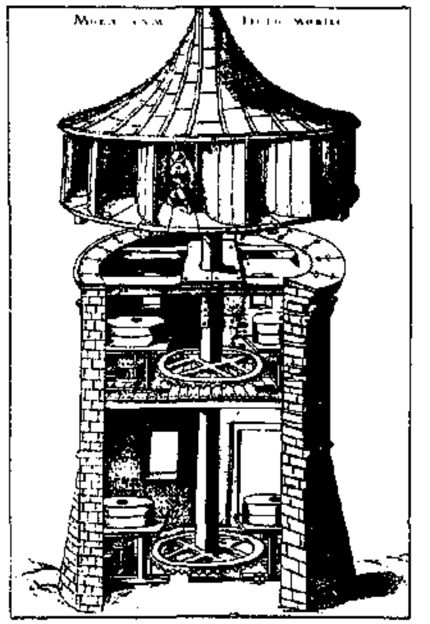


Fig. 5 A horizontal tower-mill with hinged sails by Veranzio 1595. From F.VERANTIUS, *Machinae novae*, Venice, 1620?.

Fig. 6 A horizontal tower-mill with wooden sails and rotating conical cap. From: F.VERANTIUS, *Machinae novae*, Venice, 1620?. The principal vertical rotary movement is not transferred into any other axis but utilised directly, cf. figure 7.

are not so efficient as the vertical ones. The latter having been totally directed into the wind to receive the maximum, they can catch a more substantial amount of wind. Vertical sails are most probably a western invention. The earliest pictorial reference and numerous succeeding examples that survived until present day, assure us that the vertical sails have a western origin. In western countries where windmill originated, we do not see jib-sails neither in the past nor at present. For the beginning of the use of jib-sails in the Mediterranean region there is no definite evidence available in the presently reachable documents. Two illustrations, depicting Byzantian windmills at Gallipoli in 1420[21] and windmills of Rhodes in 1486[22] offer a clear idea for the existence of tower mills with rigid sails in the region. These

20. F. VERANTIUS, *Machinae Novae*, Plates: xiii,xii,xi,ix,vii, Venice, 1620(?).

21. BUONDELMONTE, *De Insulis Archipelagi*, (Manuscript No. 18246 at Biblioteca Nacional, Madrid)

22. B. von BREYDENBACH, *Die heylingen reyssen gen Jerusalem*, Mainz: Erhart Reuwich, 1486.

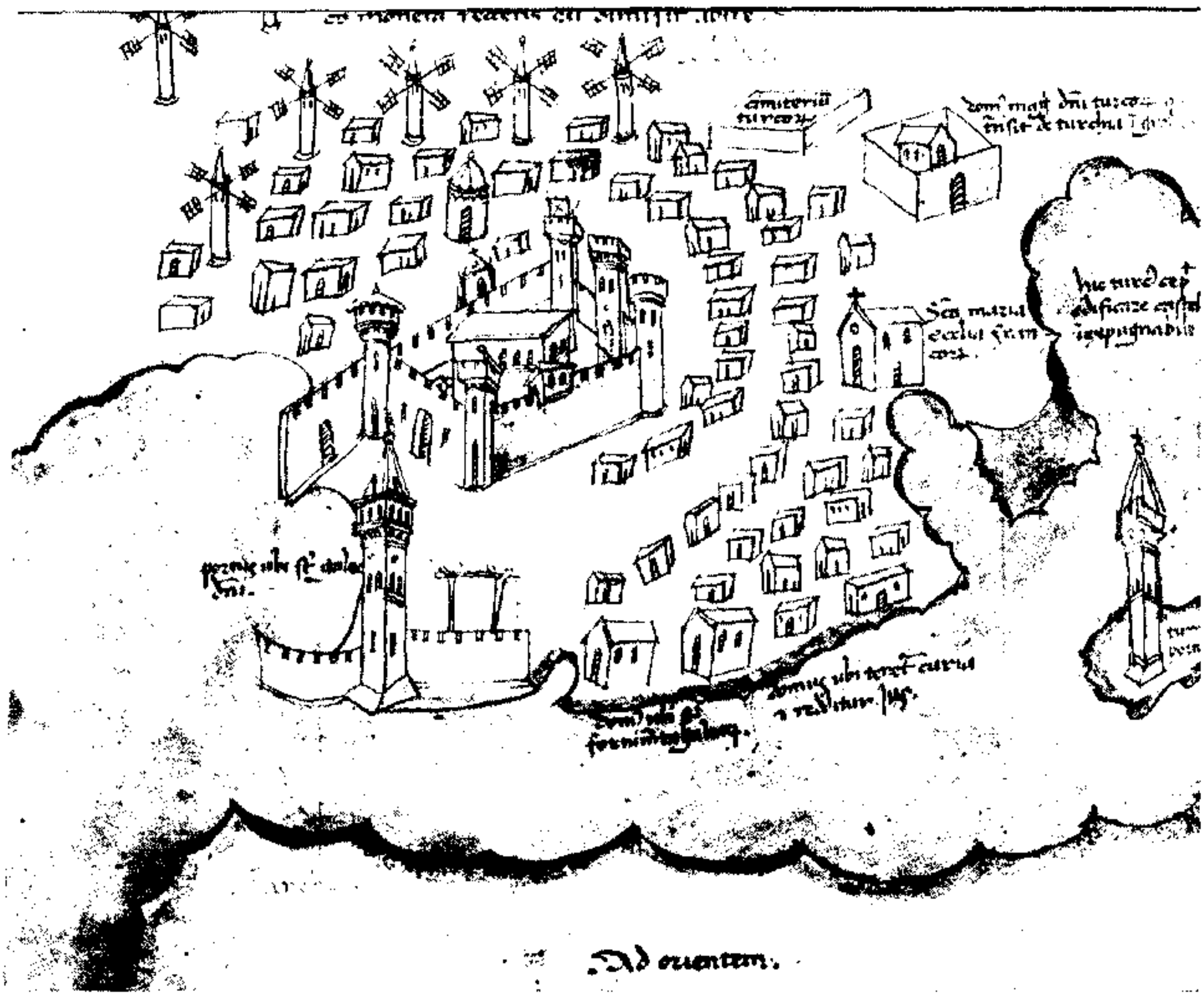


Fig. 7 The earliest pictorial reference to the windmills in Anatolia (Gallipoli), depicted in a traveller's account: BUONDELMONTE, *De Insulis Archipelagi*, 1420, from: Manuscript no. 18246, fol.51v, Biblioteca Nacional, Madrid. Even though the representation of the windmills may not go beyond being symbolic, the type of windmill is a vertical tower-mill with four-windged rigid sails. *Microfilm, Courtesy of Biblioteca Nacional Servicio Fotografico,* Thanks to *F.Javier NAVARRO de ZUBILLAGE* for obtaining.

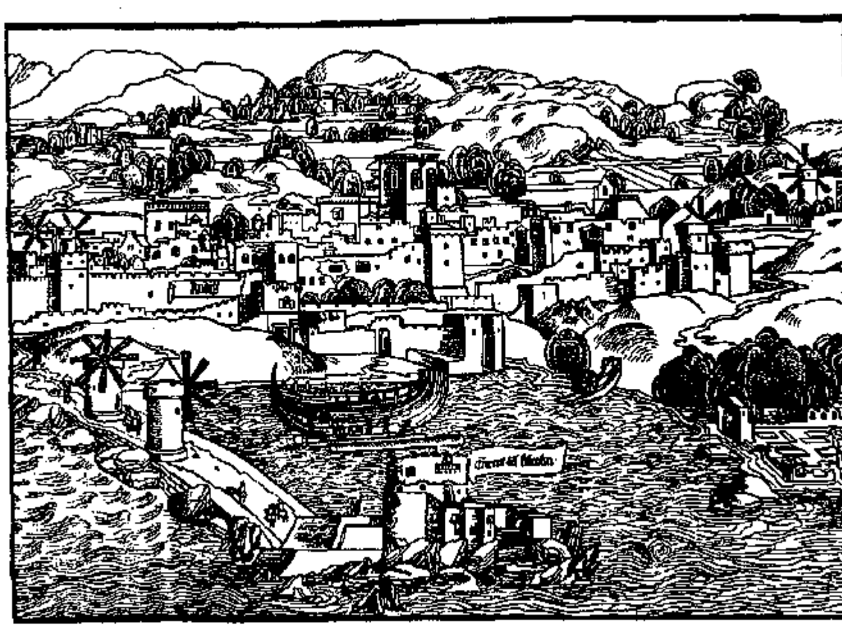


Fig. 8 A late 15th Century document on the windmills on the Aegean, as illustrated on a woodcut showing the harbour of Rhodes. B. von BREYDENBACH, *Die heyligen reyssen gen Jerusalem,* Mainz: Erhart (Reuwich), 1486.

documents do not exclusively prove the non-existence of jibsails then, but it is hard to defend that the travellers forgot or misillustrated the sails. Jib-sails owing to their triangularity are, of course, dominantly perceiveable and definitely memorable. Here, on the Aegean we are faced with an interesting transaction of technology on windmills as an amalgamation of eastern and western features. Apart from proving the spread of rigid sails so far east as Agean in 15th Century, these documents convince us that at that time Mediterransean windmills were so advanced enough to have tower body, orientating cap, vertical sails and consequently,horizontal primary rotary movement. Unfortunately, there is not much evidence for us to trace the path of development of windmills in the region, apart from the bits of information discussed above.

The Mediterranean windmill in past centuries matured into a stereotype that is efficiently utilised all around the Region. They have been spotted on almost all of the Dodecanese and other Aegean Islands, in Spain,[23] Portugal,[24] Majorca and North Africa. In Turkey they are seen at Foca, Bozcaada, on Taurus Mountains, and on Bodrum Peninsula. The number of windmills on Myndus Peninsula-which is the tip of Bodrum Peninsula from Bodrum-Torba isthmus westerly- is found to be 47. Among these 30-35 of mills are in functioning or intact condition, the rest is in the form of drums or in ruins.

23. P.OLIVER, Windmills of Murcia, *Shelter*, ed. L.KAHN, Bolinas, California: Shelter Publications, 1973, p.166.

24. L. COBBETT, Mediterranean Windmills, *Antiquity*, vol.XII, 1939, pp.458-461 and plates III-V.

The windmills grinding for the major town of the Peninsula, Bodrum (old Halicarnasus) have been superseded by contemporary sources of energy. Most of the 7 mills on Değirmentepe at the back of legendary Salmakis Fountain are reported to be functioning in a recent past; but none of them are working and some are in ruins. 4 other windmills of Bodrum sited 5-700m.

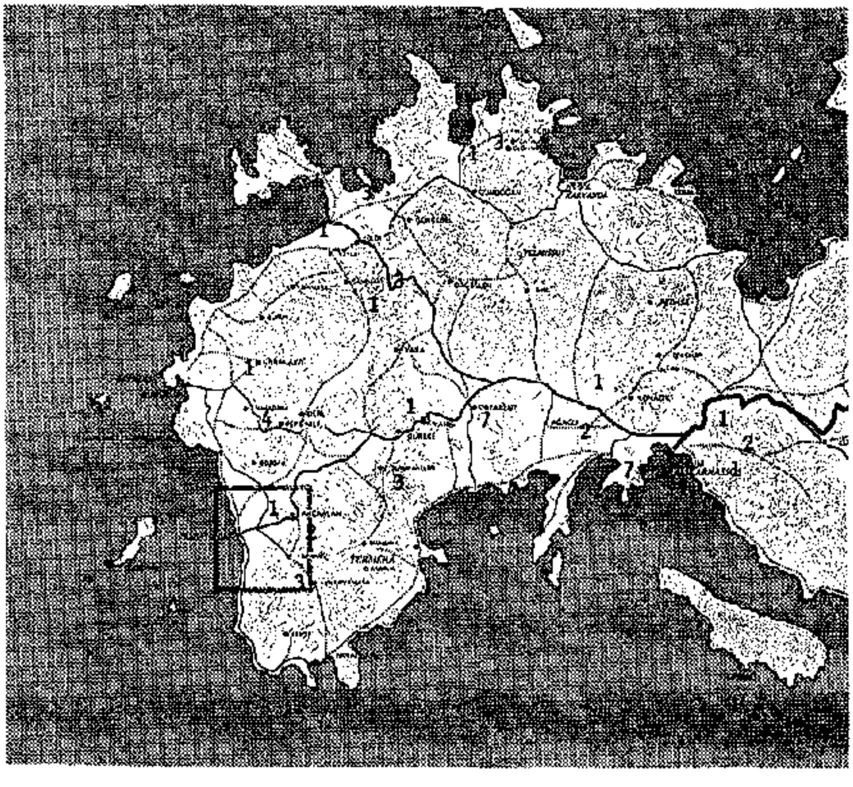


Fig. 9 A map of the Myndus Peninsula showing the locations of the 48 windmills. The figures indicate the total number of windmills on a site. The selected sites for the placement of the windmills, interestingly, indicate the pattern of etesian reception of the Peninsula.

apart from each other on hilltops within the forest in the East of Bodrum-Milas highway. Now, all of them are in ruins.

At almost the midway between Bodrum and Bitez two windmills belonging to Bitez are still functioning. They are situated on the South of the road about a kilometer away. A third windmill of the village is sited 500m. from the road on the opposite side. Now it is ruined. Müsgebi has 7 windmills located on a mountain crest parallel to the coastline. Only 3-4 of them are presently operative. On a saddle between Müsgebi and Yalıkavak, before descending for Yalıkavak there are 3 windmills in intact condition. They also from a complex complete with a cistern and sheds for animals and flour. There is another functioning mill in the South of this complex, 600m away on Keremler Sırtı. All these four mills mainly serve for Girelibelen and Sandıma villages. The single windmill on the shore at Yalıkavak is the most well-known and popular windmill in Turkey.It has spectacular siting qualities for being by the sea. As it is easily accessible it works almost all year round. Two kilometers distant from Yalıkavak on the way to Farilya 3 windmills are sited on Tilkicik Dağı on the western side of the road. Türkbükü used to have 4 windmills, a group of three mills on Değirmentepe and a single one on Mandira Tepe. Mandıra Tepe windmill about one kilometer apart from the others is now in ruins. The reserved and inaccessible village Karakaya has only one windmill that is on Hüseyin Dağı 800m. from the village. Peksimet and İslamhaneleri villages have 4 and 3 windmills respectively. Peksimet -the name of the village meaning ship's bicsuit,- to a local legend was supplying dried-bread for the fleet of the esteemed Ottoman Admiral Dragot (Turgut Reis) early in 16th Century. The Peksimet mills are only 200m. away from the settlement whereas the Islamhaneleri mills are located on Kargıboğazı at a distance of 600-1000m from the dispersed houses and farms of the village. Yahşiköy has only 1 windmill on the hill 200m. to the north of the village. This windmill also has a well accompanying it.

Even though the wind is the most important indigenous source of natural energy, water-power has not been disregarded completely in the area. For example, in the fields of Dereköy there are 2 watermills. On the plainland of Yakaköy there are 3 of those too, but this time in disused collapsed form.

THE WINDMILL AT KARABAĞ

Karabağ is one of the earliest settlements on the Peninsula. The oldest reference of Karabağ is in the book of Piri Reis (1470-1554) who mentions the area as being farmland and orchards.[25] In his description of the coast there is no report of windmills. This may imply the non-existence of them at that time, for Piri Reis gives very accurate account of the landmarks. Windmills with towers would have formed dominant points of reference -if they were there- for the navigators.

25. PİRİ REİS, *Kitab-i Bahriyye*, ed. Y.SENEMOĞLU, İstanbul: Tercüman 1001 Temel Eser, 1973 (1526), pp.206-208.

Karabağ is known to be a farming community with an extremely limited relationships with sea. Before the change of major crop into tangerines in early 1950'ies, the inhabitants of Karabağ were depending on animal husbandry at the highlands and growing grain in the flatter patches of land.

Hasan Muslu operates the single remaining windmill at Karabağ.He is 63 years old, a lean, spare man given to quiet introspection. Originally from mountains, he farms when not attending to his mill raising grain and a small herd of cattle at the 50 dönüm

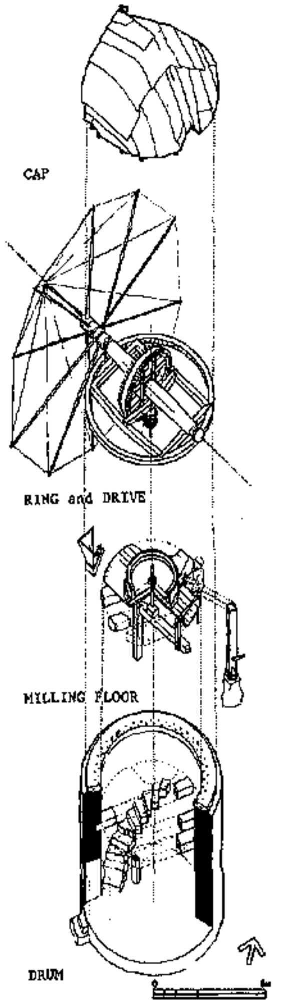


Fig. 10 An exploded-axonometric projection of the windmill of Karabağ. The detailed views of various sections are given at figures 15, 17, 21 and 22.

Fig. 11 A general view of the Karabağ windmill. A ladder and a spare seren can be observed in the foreground as a precaution for a probable fracture in the sails.

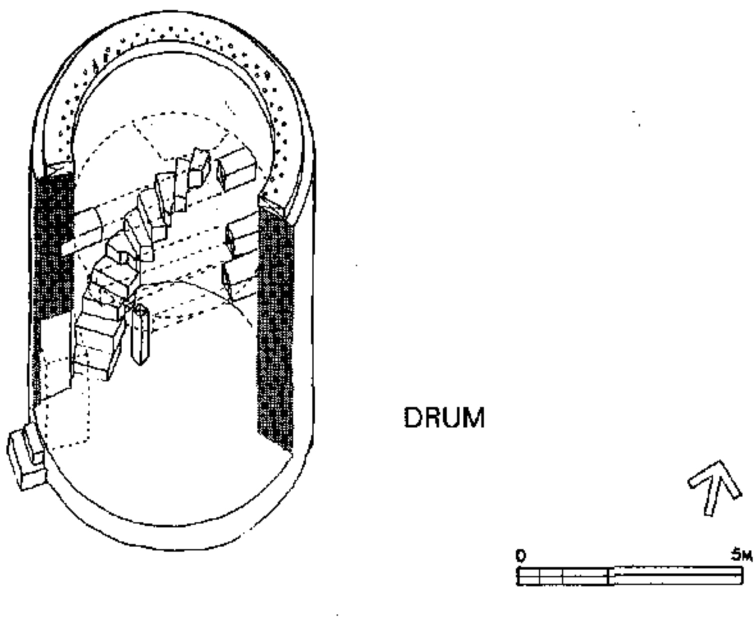


Fig. 12 An axonometric view of the drum showing the entrance, corbelling stairs and the structural placement of the milling floor with three timber beams. A wooden ring on top of the wall of the drum functions both as a bond-beam and a sleeper for the rotating cap. The peg holes are for levering the cap to orientate. *vide. infra* fig. 16.

parcel of land that he owns somewhere above the ridge. For the past two years, he and his wife have lived in Karabağ. Their former house in the highlands is now occupied by their son and his wife.

It seems that Hasan is a miller for the pleasure it brings him. There is little financial profit. He charges 15 krş. per kilogram of grain milled, just same rate as at the new power-mill in Karatoprak but last year made only 150 TL. Of this, about 100TL. was spent for the materials to repair the mill. Hasan's rewards for running the mill are found elsewhere, and are intensely personal.

The mill has been his for 13 years. He bought it for 1.000 TL. from a local family and apparently renovated it extensively. Implicit in Hasan's introspection is a distrust of strangers, exacerbated in recent years when a German tourist, having climbed the ridge, attemted to buy the mill from him. In following years these attempts from both Turkish and foreign outsiders have become a distasteful pressure for him. Now he is extremely reserved and inhospitable to anyone who aims to communicate with him.

Hasan's mill is a marvel of vernacular technology, its wooden machinery rough and unfinished in appearance but astonishingly smooth and precise in operation. The masonry shell of the mill is reported to be over 100 years old, having been built by a local Greek specialist builder. Throughout the period since, its machinery has continually been repaired and replaced. The vertical jib-sail-driven Karabağ mill with its cylindirical stone drum and rotating cap is a common type, found all over the Agean and Mediterranean.

Karabağ windmill consists of four main etructural elements and a variety of mechanism. The four main parts can be outlined as follows :

1. Drum
2. Milling floor
3. Ring and Drive
4. Cap

The stone drum[26] is the major element housing and supporting the mill. A winding stone staircase corbells out from the drum's inner side and provides access to the mill's upper floor, a platform carried on three beams that span the drum at mid-height. Keyed into the topmost edge of the drum is a flat, circular wooden track. The track provides a stable bearing surface for the loose, rotating wooden ring carrying the main drive gears and axle. A line of bore-holes and fat pegs on the face of the track keeps the ring aligned and prevents it from slipping off. A second, inner line of bore holes and pegs serve a different purpose, these provide a continuous line of fulcrum points so that the wooden ring can be rotated by simple levering with a wooden stave. In the western Mediterranean windmills ring rotation is achieved by the use of a long tail-like leverarm connecting the ring to ground at opposite side of the sails.[27] In these mills the miller or his assistant has to do this operation from outside. From ring rotation point of view this Aegean mill can be considered to be more refined and integrated machinery as compared with other Mediterranean mills, for example the ones in Iberia.

The ring carries the main drive gears, the axle with its masts

26. The cylindrical walls of the drum is built of the traditional rubble stone particular to Bodrum Region. The walls are 40-45 cms. thick. There are some vertical cracks filled with mortar to block the wind filtering inside. The entrance door is defined with some regular stones on both sides and a stone lintel is placed on top. There is only one window opening outside the drum to let light into the milling floor. The circular timber sleeper (or bond-beam) acts also as the lintel of this opening. The corbelling stairs lead to the second floor which rests on three timber beams imbedded into the wall at the ends. As the drum rests on a solid rock there is no foundation.

27. cf. The Spanish and Portugese windmills surveyed in: P.OLIVER, Windmills of Murcia, *Shelter*, ed: L.KAHN, Bolinas, California: Shelter Publications Inc., 1973, p. 166; L.COBBETT, Mediterranean Windmills, *Antiquity*, vol. XIII, 1939, pp. 458-461, and plates III-V.

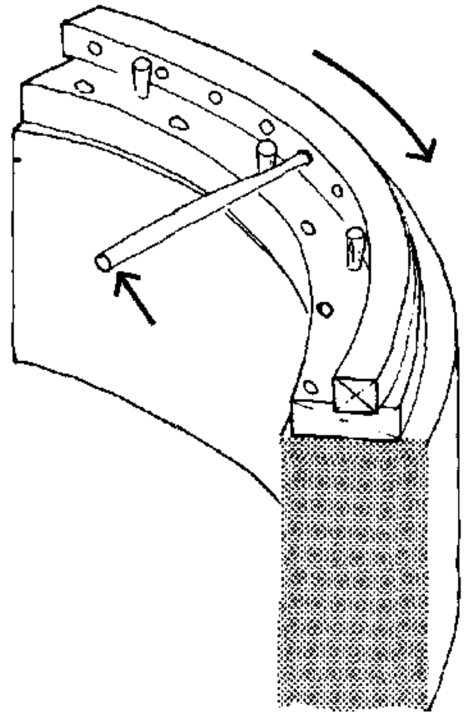


Fig. 13 A sketch explaining the ring rotation system facilitating the orientation of the cap and sails directly into the prevailing wind during milling.

and sails, and also carries the mill's cap, or roof. There is a definite relationship between the length of the masts and the height of the drum. In long term disassembly of the sails the masts are vertically stacked inside the drum leaning on the staircase. The masts are connected to each other by means of a rather heavy chain forming a decagon. This is the only place where chain is used on the sails. The reason must have been to produce a fly-wheel effect to minimise speed variation in the

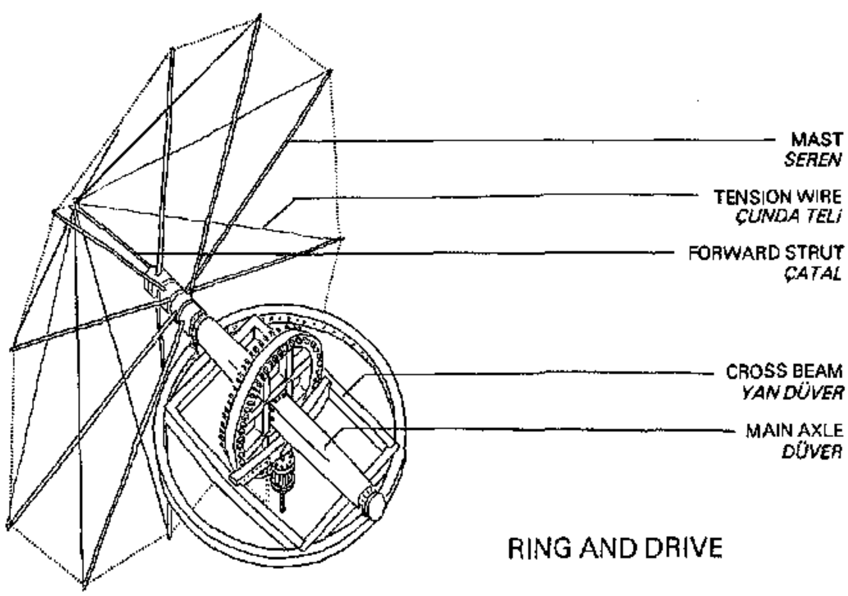


Fig. 14 An axonometric view of the ring and drive mechanism of the windmill. The terminology related to the sails seems to have been adopted from that of the sail-boats. *seren:* mast, boom, yard, spar; *yelken* sail (cloth); *cunda:* from Italian *quinta*, peak of a gaff; *cunda teli:* rope or wire connecting the ends of the masts. This mill has a typical transfer system from the horizontal rotary movement into a vertical one. The structure of the main wheel composed of four beams interlocking to from a matching square in the middle for the cross-section of the *düver*. The beds in which the *düver* rotates is continuously with natural or artificial grease. The fluid rythmically drops onto the shaft *(düver)* at the critical points i.e. beds where the friction and bearing are at their maximum.

Fig. 15 An interior view of the *çark*, *düver* and cap from the back towards the sails.

machine subject to fluctuation in drive and load. The jib-sails are rolled around the masts along their longer edge and the free corner is connected to the chain with a tension-rope tie. The decagonal chain forming the fly-wheel also allows the miller to connect the free end of the sails wherever he wants in the frequent intervals of the links. The exposed sail area is adjusted by rolling the excess canvas around the masts. In heavy drift the sail area is reduced whereas in the mellow almost the total sail area is exposed. It is not unusual to observe a windmill with sails less than 30cms but in an extremely fast movement of rotation. The adjustment of the sail area is done with pure intuition of the miller for which he would sometimes make a trial or two.[27]

The ring is spanned by a series of wooden cross-beams which tie it together structurally. The centermost of these serves as the

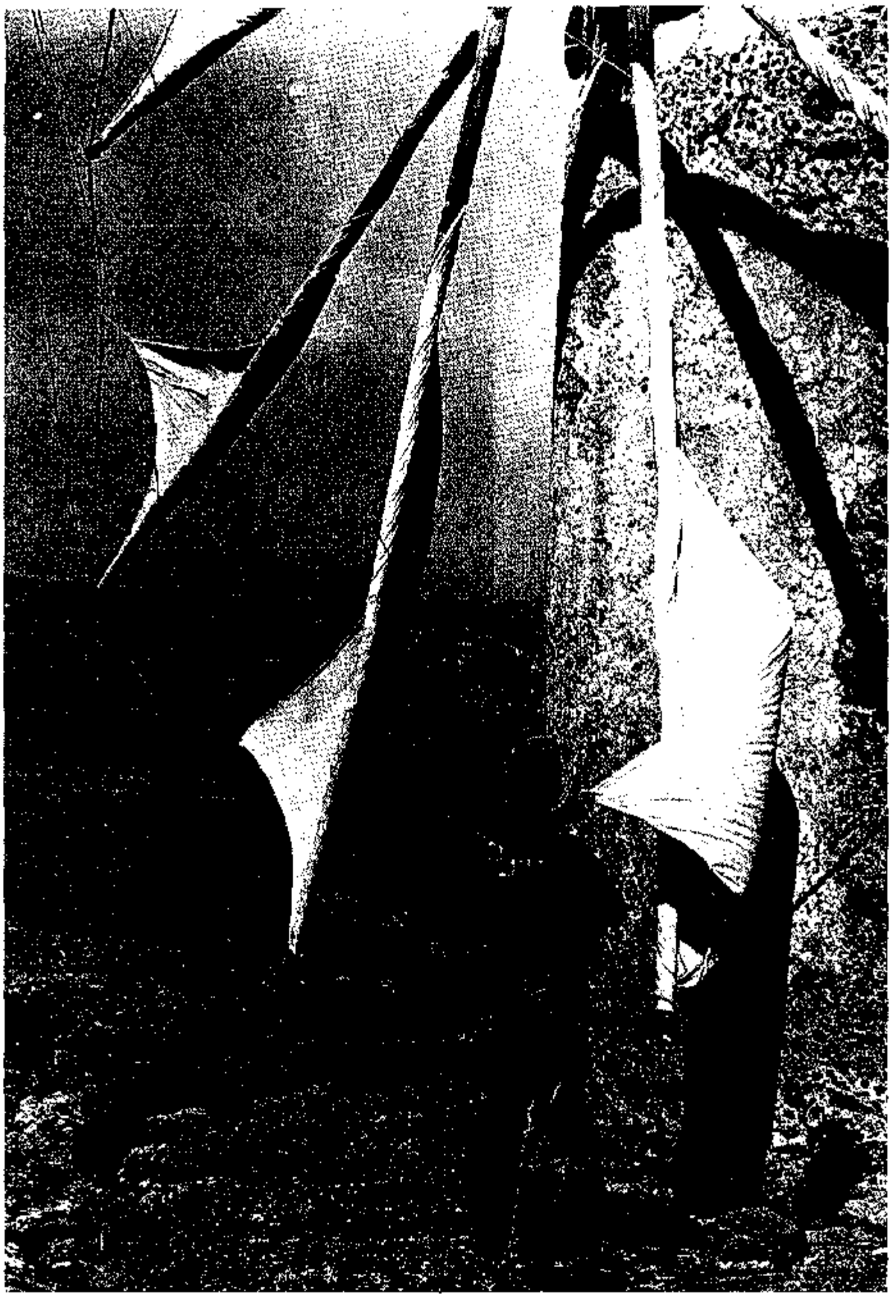


Fig. 16 The miller, Hasan Muslu, adjusting the canvas surfaces of the sails in accordance with the intensity of the sails in accordance with the intensity of the wind.

upper socket of the vertical steel drive shaft on which is fixed both the cylindrical differential gear, or pinion, and the rotating upper grind stone. The differential meshes with the big drive wheel, and converts the vertical rotation of the sails to the horizontal rotation of the mill stones. The huge main axle, with its big drive wheel, simply lays across the ring, held in place at either end with heavy pegs. At these bearing points, the axle is worn smooth as glass, and is kept lubricated with natural grease or oil. The ten masts radiate from the outer end of the axle in pairs and are tied tegether at their tips with the circumferential chain whose other functions are discussed above. When the mill closed down within the milling season, the sails remain outside, each wrapped around its mast. During milling, the sails impose a terrific inward thrust on the masts. To counteract this, a Y-shaped wooden strut extends out from the end of the axle, from

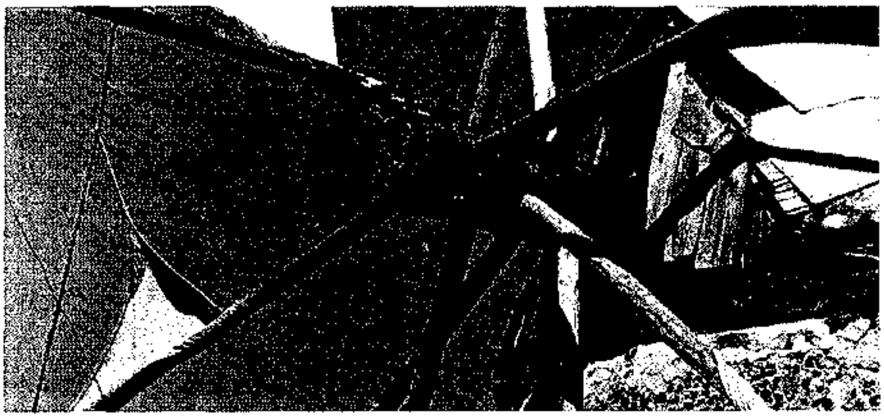


Fig. 17 A detail showing the connection of *serens* into the *düver* and the bed in which the *düver* rotates.

which tension wires are run back to the tips of the masts. The masts are nevertheless fragile -Hasan keeps a couple of spares nearby on the ground next to the mill.

The cap protects the mill from elements. It is quite aerodynamic in design, but derives its form from simple obvious construction -straight joist run from the edge of the supporting ring up to a central ridge pole, which angles to clear the big drive wheel within. The joists are usually covered with wood or thatch, but Hasan sheathed his cap with sheet tin, taken from metal cans, which are common. The tin is full of nail holes, but Hasan appears satisfied with his roof.

Like the farmer, the miller needs a windtoy to help him to gauge the breeze, and so one is built right into the mill at the forward edge of the cap behind the masts. A small wind vane and peg swivels through the roof at this point. A reciprocal vane is attached to the same peg on the inside of the cap, so that the miller can read the wind vane from inside his mill. A single glance at the ceiling tells him if the breeze has shifted, and if it is necessary to adjust the ring and cap.

The milling floor is the heart of the mill, where wheat becomes flour and where the grindstones and the various feed and control machanisms are located. The milling floor is Hasan's primary station during the grinding process.

The lower of the two grindstones is stationary, resting flat on

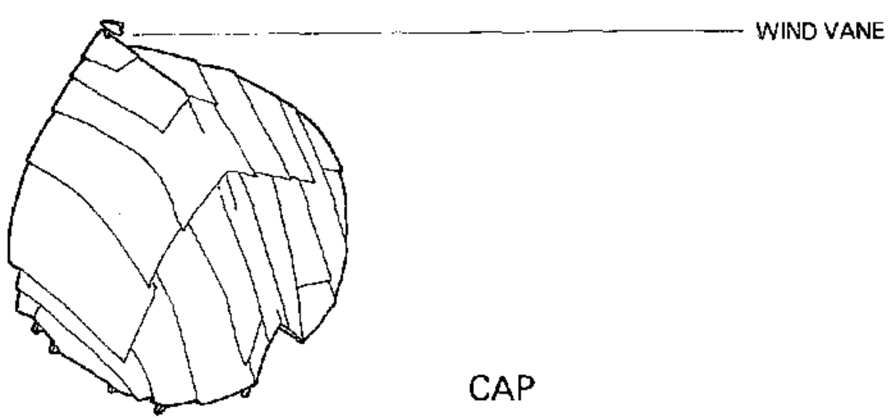


Fig. 18 The sheathing of the cap and the wind vane which has a parallel indicator inside to be observed by the miller.

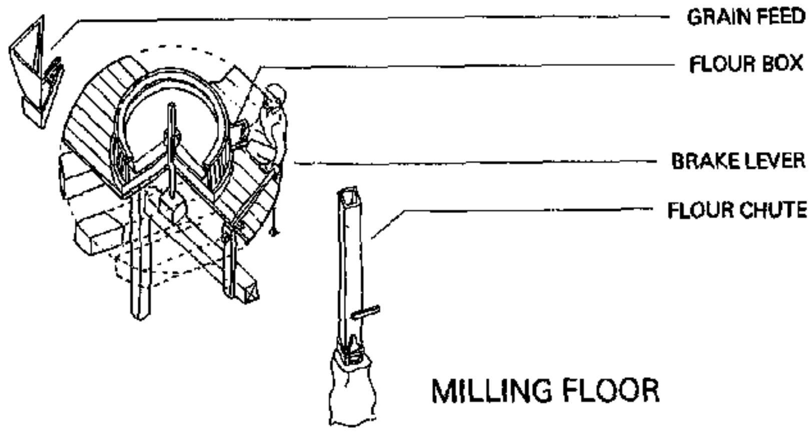


Fig. 19 An axonometric cross section of the milling floor.

the platform deck. The upper stone, smaller in diameter, rotates and is hung from the vertical steel shaft that drives it. Atop the lower stone, and surrounding the upper stone, is built a staved wooden container which serves to collect the flour as it passes out from between the stones. During milling, the container is usually kept covered with canvas to insure that no flour is lost.

The square-sectioned drive shaft with its fixed differential and upper millstone can be raised and lowered minutely to adjust the spacing of the stones and thus the quality of flour ground. The shaft spins freely through the overhead cross beam and through the lower stone, and is caught and socketed below the milling platform in a wooden block resting on a heavy beam. The beam, flexibly jointed to a nearby post, can be inclined up or down with a lever back up on the platform deck, and as the beam raises and lowers, so do shaft, upper stone and differential. Through an ingenious system of levers and a single counterweight, the considerable weight of a mill stone is neatly balanced off. Hasan need only touch the lever with his palm to adjust his stones. By lowering the upper stone completely on the other he effects a brake, halting the motion of stones, gears and sails.

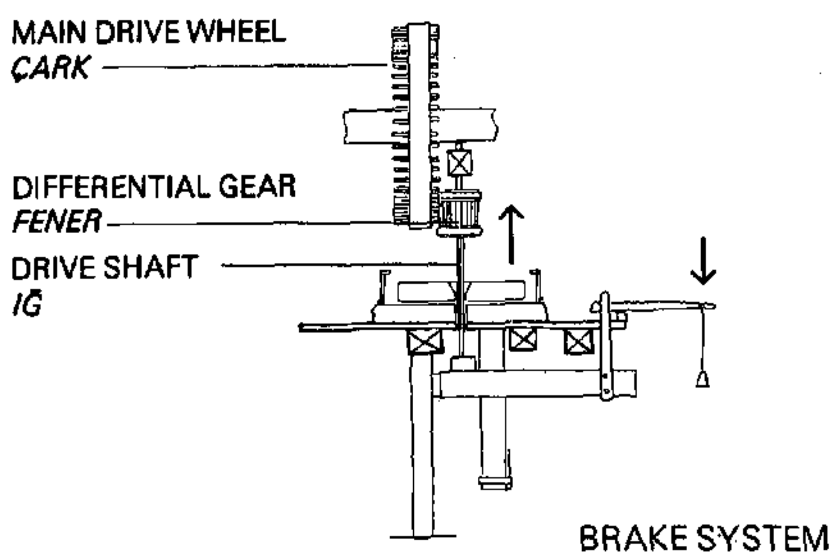


Fig. 20 A section through the brake system which releases upper millstone from the rotation of the iğ by the use of levers and arms.

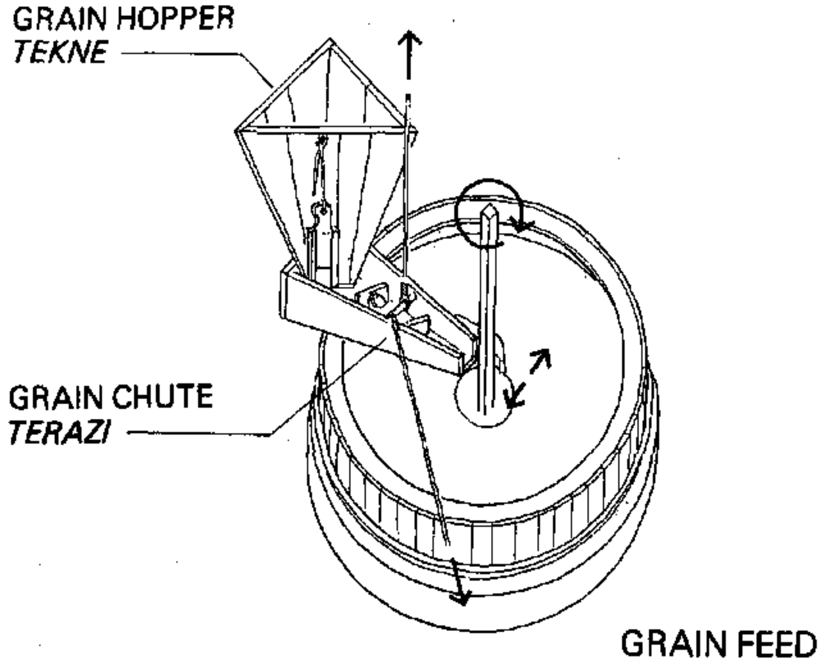


Fig. 21 An axonometric view of the grain feed system controlled with a shutter, an oscillator and inclination to feed the appropriate amount in between the stones to be ground. The slope of the terazi is adjusted and fixed by means of two opposite ropes.

Grain is fed into the mill through the central opening of the upper stone with the aid of the grain hopper and chute. The hopper, a tetrahedral wooden container, is suspended from the crossbeams of the overhead ring. The chute extends from the hopper towards the center of the millstones, and is held at a slight inclined by a vertical cord. A sliding trap door in the hopper and a series of baffles in the chute prevent the grain from tumbling too quickly into the millstones. From the tip of the chute extends a large wooden thumb which the miller keeps pressed against the drive shaft with a string. As the square shaft rotates it acts as a cam, steadily bumping the thumb and rocking the chute from side to side. As the chute rocks, the grain slowly trickles down into the millstones.

The grooved stones scissor the grain kernels as they rotate and so turn them into flour. As this passes from between the stones it is swept up by a scraper attached to the spinning upper stone and is deposited in the open flour box in the platform floor. During the milling process, Hasan continually reaches into his box and gauges the quality of the flour, passing and rolling it between his fingers. He adjusts his stones if is not satisfied. When enough flour has accumulated in the box, he pulls up its trap-door bottom and lets it fall through the flour chute to the ground floor of the mill where the farmer waits with his empty sacks.

In its own context the Karabağ windmill is a perfect machine. Handmade from local materials, it incorporates simple mechanical principles ingeniously, wasting nothing. In operation it is a strange mix of violence and calm. Hasan squats on the milling platform deck between the brake lever and flour box, his back against the stone drum. His right hand crumbles and sifts flour, and his left holds the chute-string or reaches for the brake, and throughout his eyes watch the stones, the gears, the wind indicator. All around him the mill wracks and vibrates noisily, parts turning with frightening speed. But the spinning stones and wheels, the wooden gear teeth melting into each other have a soothing, almost mesmerising effect. Hasan silently watches and sifts more flour. It is not too complicated to empathise why he mills.

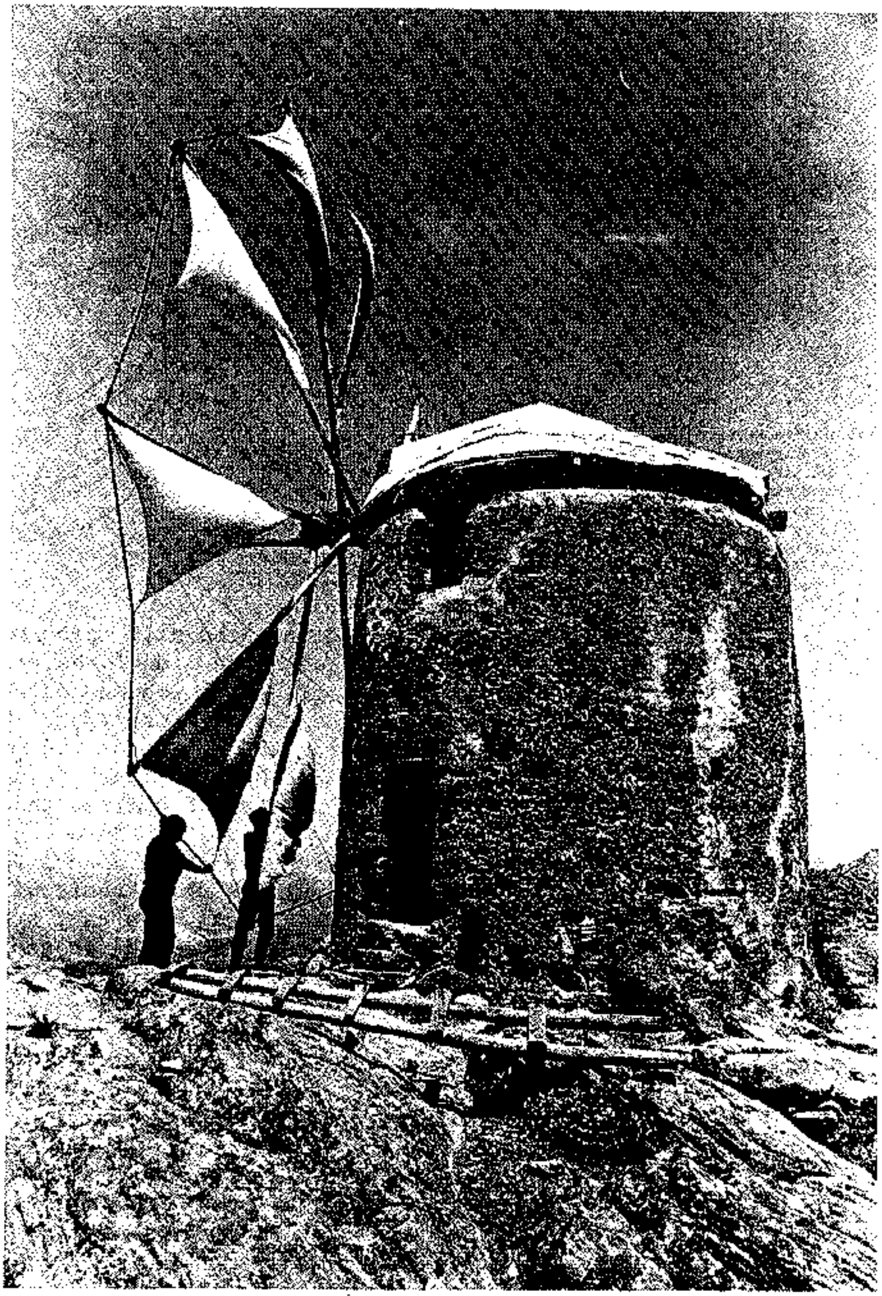


Fig. 22 The miller and a farmer roll up the canvas of the sails to close the mill after a session of grinding.

EGE'DE BİR KÖYDE, TAHIL DÖNGÜSÜ VE BİR YELDEĞİRMENİ

ÖZET

Muğla'nın Turgutreis Belediye örgütü içinde birleşmiş olan Akçaalan, Karabağ ve Karatoprak köylerindeki tahıl döngüsü ve bir yeldeğirmenini inceleyen bu yazı, alan çalışmaları 1974-1975 yıllarında yapılmış ODTÜ ve Columbia Üniversitelerinin ortak çalışmalarındaki bulgulara dayanmaktadır.

Bir ekinin *(culture)* yaşaması belirli döngüler aracılığı ile sağlanmaktadır. Genellikle su, enerji, besin, v.b. döngülerden oluşan süreçler özellikle "kapalı" kırsal topluluklarda kendi fiziksel süreçleri içinde tamamlanmaktadır. Dizgeyi sağlıyan döngüler ekinin toplumsal ve fiziksel kapsamının dışından gelen etmenlerle sağlandıkça dışa bağımlı olmakta, bu dışa bağımlılık doğal olarak dış dizgelerin bir dizi ögelerini sürece sokmakta, dolayısı ile dizgede hem ekinsel hemde fiziksel çarpıklıklar ortaya çıkarmaktadır.

Eldeki yazı, bir kırsal ekinin sürekliliğinin sağlanması için gerekli döngülerden en önemlisi olarak beliren tahıl döngüsünü bu sürece bağımlı yöresel teknoloji ile birlikte incelenmektedir. Özellikle, bugüne değin işler durumda olan bir yeldeğirmeninin işlevsel, fiziksel, toplumsal ve tarihi yönleri bir bütünlük içinde sergilenmeye çalışılmaktadır. Söz konusu köylerde ekimden öğütmeye değin geçen tahıl ile uğraşı anlatılmakta. Bu uğraşının değişik aşamalarında beliren fiziksel -yada mimari- yansımalara değinilmektedir. Bu yansımaların en önemlisi olarak belirin öğütme süreci ve bunun yöresel çözümü olan yeldeğirmeninde mimari ve teknik ayrıntıya inilmektedir.

BIBLIOGRAPHY

COBBETT, L. Mediterranean Windmills. *Antiquity*, vol. XIII, 1939, pp.458-461, pl. iii-v.

FORBES, R.J. Power. *A History of Technology*. eds. C.SINGER, E.J. HOLMYARD, A.R.HALL, and T.WILLIAMS, vol.II; Oxford: The Clarendon Press, 1957 (1956), pp.614-622.

FORBES, R.J. *Studies in Ancient Technology*. Leiden: E.J.Brill, 1965.

NOTEBAART, J.C.*Windmuhlen*. Den Haag: Mouton Verlag, 1972.

OLIVER, P. Windmills of Murcia. *Shelter*, ed. L.KAHN, Bolinas California: Shelter Publications Inc., 1973.

WAILES, R. Windmill. *Encyclopedia Britanica,* vol. 23; Chicago: E.B.Inc. 1971, pp.570.

WAILES, R. A Note on Windmills. *A History of Technology,* eds. C.SINGER, *et al.* vol.II; Oxford: The Clarendon Press, 1957 (1956) pp. 623-628.

WAILES, R. Windmills. *A History of Technology,* eds. C.SINGER, *et al.* Oxford: The Clarendon Press, 1964 (1957), pp. 80-109.