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Water sawmills in the Pindos Mountains

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When carrying out anthropological and historical field research in Northern Greece, mountain populations engaged in forestry and woodworking-related occupations are often encountered, particularly in the western part. This is the main theme of this research, based on the area of the Pindos Mountains, and especially on the central and northern parts which are covered by extensive forests. Evidence of the involvement of the population of these areas in logging activity is available from 1500, when the Turks were supplied with oars for their war galleys (launched in Preveza), from the forests of the mountains of Metsovo.[1] The involvement of the Epirus-Macedonian populations with terrestrial Balkan trade during the 18th and early 19th century brought urban and architectural development to the residential centres on both sides of the mountain range, contributing to further development of the woodworking sector. This specialised work, practiced by several groups within the local population, turned woodworking craftsmanship into a stable, industrial occupation (besides providing building material and decorating winged altar pieces, we can identify Pindos lumberjacks involved in shipbuilding[2]).

During the 19th century, especially in the second half, the exploitation of the mountain forests was linked to an interesting transformation, which involved the transition from small-scale intensive exploitation of forest products, catering to the individual needs of local residents, along with low productivity local crafts, into

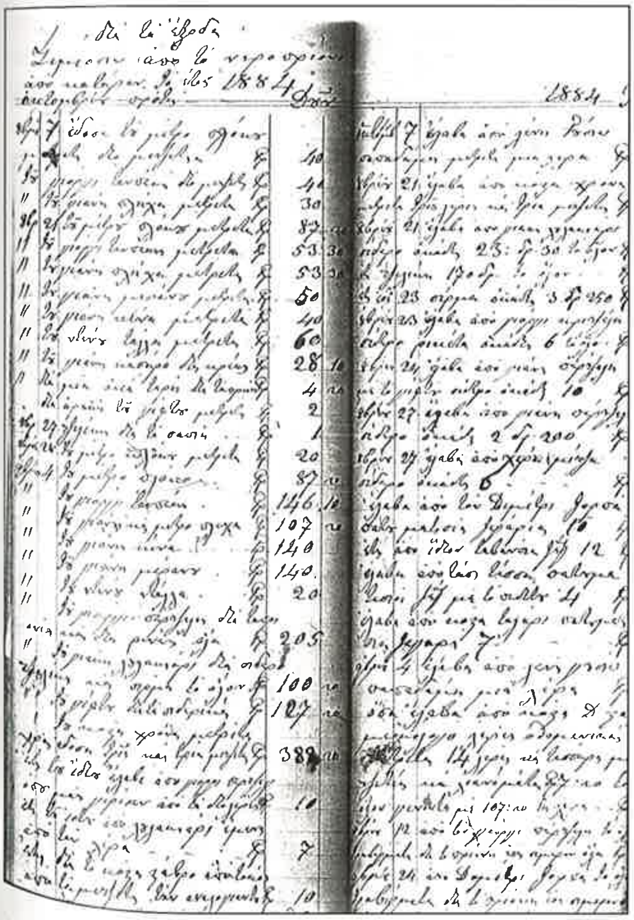

Fig. 1. Revenue and expenditure accounts of a forestry water sawmill installed at Katara region (year 1884), source Hrona family ledger, years 1877-1918.

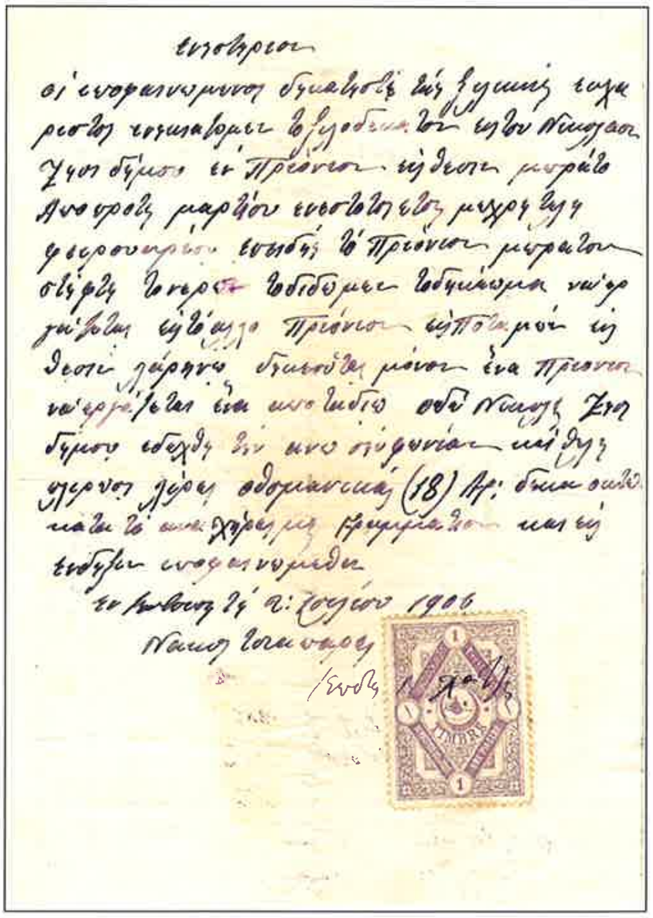

Fig. 2. Tax lease of water sawmills installed at Bradu and Larinu locations of Vovousa (year 1906), source Fanis Dasoulas Archive.

a large-scale trade in forestry products. The direct consequence of this change was to make woodworking production an important local economic community activity, which would redefine the structures of production to this day. This development, to some extent, is the result of wider economic processes during that period, connected with the first attempts at the industrialisation of Greece.[3] The sharp increase in growth in timber production at that time is related, as we will see below, to a significant technical factor.

In earlier times the only tool used for the sawing of logs was a type of hand saw, a method which had all the disadvantages of those which rely only on muscular strength. This was both tedious and time consuming; the products thus produced were of low quality and, moreover, brought about the waste of useful material since it required squaring of logs with the axe before sawing. All of these problems were close to being solved by the integration of the water sawmill into the production process. The water sawmill is a real machine in both the technical and economic sense, since it could achieve greater quantity and better quality products for less money, time and effort. Although water sawmill technology was known in Europe since the 13th century,[4] the time of its introduction in Greece remains unknown.[5] In the 19th century its extensive use is recorded from the mountainous areas of Epirus and Macedonia. At the same time, its use is also recorded from the forests of southern Greece, although the craftsmen employed there came mainly from the areas of southern Albania and northwestern Greece.[6] Essentially though, the continuous and extensive use of the water sawmill is recorded only from the Pindos Mountains, while in other regions of Greece its use was occasional.[7]

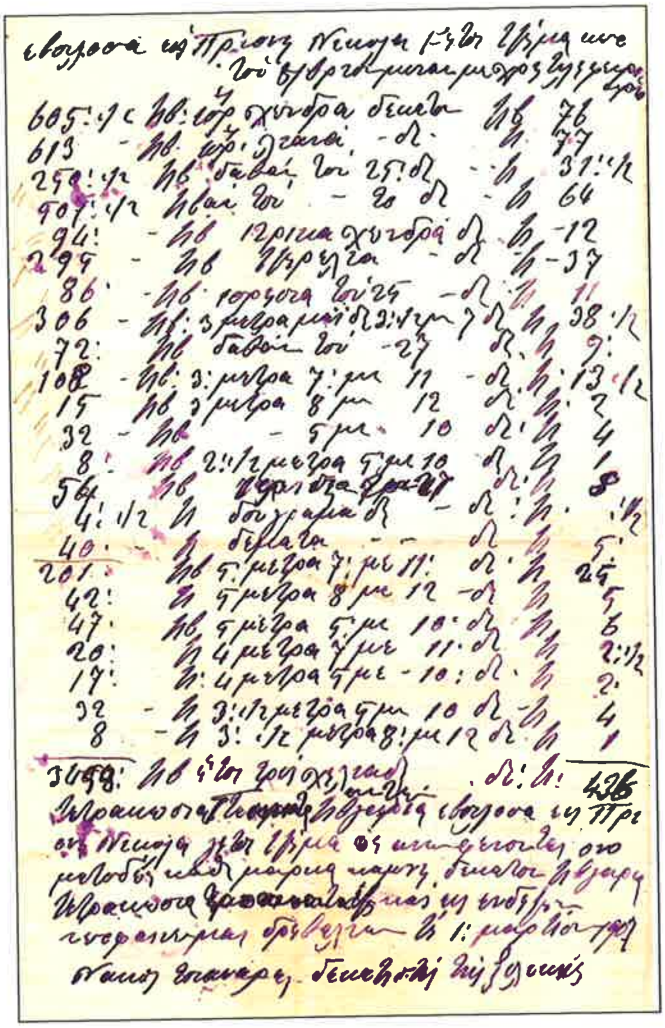

Fig. 3. Records on production and forest tax of water sawmill (year 1907), source Fanis Dasoulas Archive.

This evolutionary aspect, although based on an almost archaic technology when compared against the 'industrialised' world, cannot be ignored in as much as being a factor of social and economic diversification in rural communities in the Pindos Mountains. This was experienced as a shifting of a substantial part of the productive population into logging and woodworking activities. At the same time, forest over-exploitation upset some age-old residential and environmental balances. Defining the limits of the community forests turned to conflict issues, while the unrestricted felling gradually led to deforestation. At the borderline between the 19th and 20th century many parts of the forest of the Pindos mountains were on the verge of annihilation.[8]

The technical characteristics of the water sawmill identify it as the most sophisticated machine manufactured by the pre-industrial societies in the Pindos Mountains. At the same time, they reveal a technological ability relative to the knowledge of waterpower.

The infrastructure of water collection, transport and use of 'water drop energy potential' necessary for the water sawmill operation, is common to many relevant applications of traditional watermills, and not just the technical adaptations of this particular mechanism. Specifically, through an artificial channel dug in the ground, they channeled water from the nearest water source to the aqueduct, a sloping wooden tube adjacent to, and above, the main mechanism of the water sawmill. Positioned in this way it was intended to exploit the 'water drop', which due to gravity created hydrostatic pressure. The dynamic energy produced put into motion a water wheel which functioned as the driving part of the water sawmill mechanism. The length and diameter of the aqueduct was a component of the height difference of the drop, which in turn was a function of the available amount of water. The mechanism of the water sawmill combined simultaneously the operation of two separate mechanical systems mounted on two successive levels.

On the first of these the saw-driving mechanism was to be found. Here, a vertical water wheel was rotated by the water ejected from the bottom aqueduct nozzle, directly driving a horizontal axle. At the same time, a vertical shaft, connected by a crank through a connecting rod to the main shaft, changed the rotational motion into a reciprocating linear one, moving the vertical frame carrying the saw blade.

On the second level of the water sawmill the propulsive mechanism was situated. A wheeled carriage was pulled by a modular system of horizontal shafts and spindles and a vertical wheel. On this carriage the loaded trunk moved automatically towards the saw blade to be cut into predetermined dimensions.

The relationship of this mechanism with the production systems, as practiced by the Pindos lumberjack groups, allows us to distinguish between two different uses; that for forestry, and also an industrial one. In the first case we refer to a seasonally-used moveable machine. It was built in the forest intended for felling. It worked for as long as there was lumber for exploitation and then dismantled. In the second case we refer to a machine integrated in the production capability of a sawmill, i.e. a permanently installed machine. This diversified use, as we shall see immediately, reflects two different economic models of production.

The forestry water sawmill

The function of the permanently installed water sawmill depended directly on the annual fluctuations of water resources available at the specific forest location. This meant that the sawyer often had to exploit even small forest streams, which could be disadvantageous, since the small amount of water that flows through them is affected seasonally; i.e. at the end of spring they could be dry. The problem of short water supply was solved by the potential provided by the height differences of the mountainous topography (exploiting basic laws of hydrodynamics). The aqueduct was constructed as long as possible and made more narrow, to ensure the required potential energy. The height difference of water drop in forestry water sawmills usually reached 30 or 40 metres and in rare cases 70, which required construction of a 100 metre long aqueduct. Their typical diameter was 0.20 to 0.25 metres.

Of course if the felling area was close to a river, the abundant water supply made possible the operation of a sawmill, even with 3 or 5 metre long aqueducts during summer as other natural water reserves declined sharply. Often a several kilometre long artificial channel, dug in the ground, guided the water from the water source to the mechanism. In places where gaps on the ground surface existed, bridging wooden channels or wooden pipes were constructed.

Fig. 4. *Forestry water sawmill facilities in the area of Katara (early 20th century)*

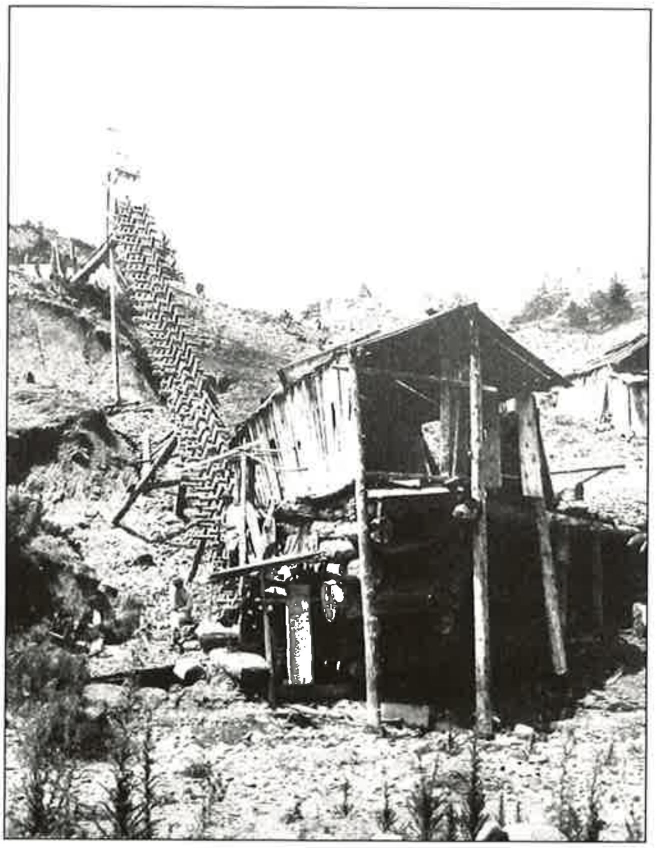

Fig. 5. *Water sawmill in the vicinity of Samarina (early 20th century).*

Fig. 6. Auxiliary facilities at forestry water sawmill (early 20th century).

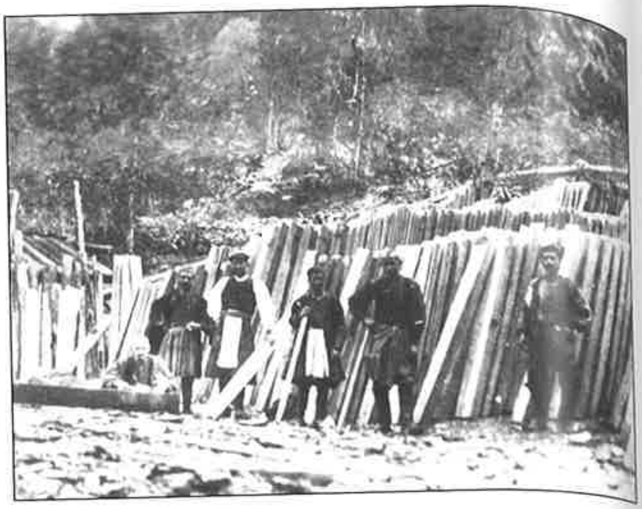

Fig. 7. Pindos sawyers (early 20th century).

An open square basin, or cistern, was constructed between the artificial channel and the sloping aqueduct, in which a spare amount of water was stocked. This was used mainly towards the end of the spring, when the normal water supply was not enough to drive the mechanism (see Fig.13. for details).

The construction and operation of water sawmills was a specialised occupation practiced by the inhabitants of certain villages. Particular villages are recorded in the valley of Aoos (in Epirus, northwestern Greece), as being almost 'one trade' villages, since the majority of their inhabitants were occupied in this profession (as at Vovousa and Distrato). The sawyers of Distrato were active in the forests of Grammos and Smolikas, while those from Vovousa worked in the forests of central Pindos. This did not mean, however, that they did not move into other areas[9].

The 'bouloukia' (occupational groups) were the basic productive unit. These consisted of small groups of specialised craftsmen, who leased their labour and craftsmanship to lumber traders. The initiative for the establishment of a working group was with the sawyers, i.e. manufacturer-operators of water driven saws. Each lumber merchant leased from a community the felling rights of a forest area, then came to an agreement with a master craftsman to undertake the felling and cutting of logs produced. Then the master craftsman organised a team of four, five or six people, depending on needs; he would be older and more experienced and had a leading role in the working group. He gave all the technical advice for the set-up of the sawmills and other auxiliary facilities; he organised the work and fixed the amount which would be paid to each team member. The needs were determined by the terrain, but also by the distance to the site of tree felling. Each fall and spring they set up the water sawmill mechanism at the harvesting site, along with any auxiliary accommodation and production facilities. During the spring period work was always assured, since the springs always had water at the end of winter. On the other hand, the autumn season was not guaranteed but depended on the amount of the autumn rains. The river water sawmills were the only exception, where a continuous and satisfactory water supply enabled them to operate throughout summer. The felling of logs was always in the fall and the lumber was left unprocessed until spring to undergo natural drying. The transportation of timber from the felling site to the water sawmill was done by rolling or dragging logs. Where there were cliffs or other crevices they built wooden walkways to roll the logs over them.

The poor transport infrastructure and the relatively primitive production methods set limits on the water sawmill products, although the forestry water sawmill was a sophisticated wood working tool. With the exception of the very few rivers which offered a means of transporting felled tree trunks, the only method of timber transportation from the inaccessible Pindos forests to the traders' warehouses was by mule. Under these conditions the sawyers, producing basically building lumber, were forced to saw the logs into boards at the felling sites; the transport by these by mules limited their dimensions. The boards were transferred to the warehouses of lumber traders, or in other places, by leased pack animals. This last issue highlights the value of the forest as an important factor in the local economy.

The industrial water sawmill

A different water sawmill manufacturing operation is recorded in the Metsovo area, in the central part of the Pindos mountains. This refers to a 'technical-economic process', i.e. the mechanisation of local woodworking craft through the creation of water driven workshops.[10] The beginning of this development, occurring in the early 20th century, is directly linked to the mechanism of the water sawmill since this was the first machine integrated into the productive capacity of these units. Despite the relatively primitive technology in the early stages, this established a standard for the technical infrastructure of the later woodworking industry of the region.

The conversion of the water sawmill from an outdoor seasonally-used machine producing sawn wood, to an industrial machine, brought some modifications to the structure of the forestry water sawmill (see fig.14 for details). Specifically, the upper part, on which the wood sawing mechanism is mounted, was fixed on the floor boards separating the two levels

Fig. 8. Water powered wood working workshop building.

Fig. 9. Water powered wood working workshop – driving belt system.

Fig. 10. Water powered wood working workshop – wheel of the carriage driving mechanism.

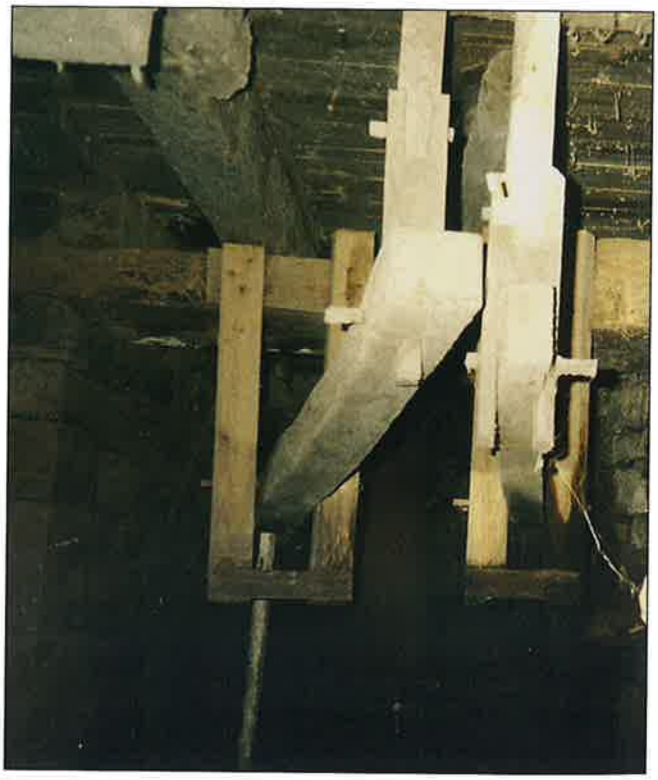

Fig. 11. Water powered wood working workshop - water supply cut off system.

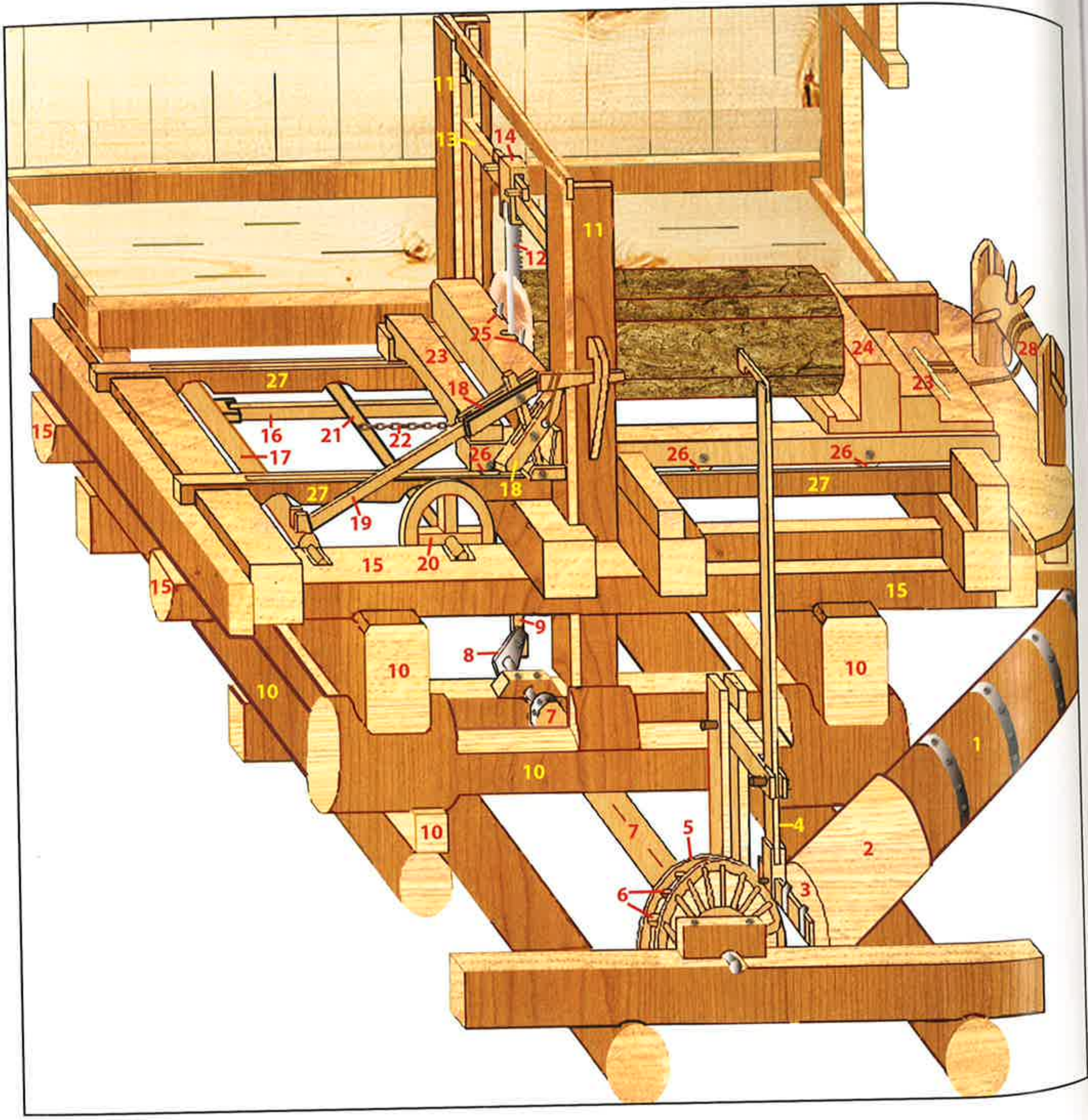

Fig. 12. Forestry water sawmill mechanism, drawing by F. Dasoulas.

Forestry Water Saw Mill Reconstruction

	Local Terminology	Technical Description
	Driving System	
1.	cărute	water duct
2.	bitşu	water trapping system in the water duct
3.	sope	spout discharging water from the aqueduct
4.	condinătoru	water flow breaker
5.	fterotire	water wheel
6.	cupe	water wheel blades
7.	fusu	rotating crank shaft
8	scĺopu	crank - mounted on the edge of shaft converts the rotary motion into linear reciprocating
9.	furcă de la scĺopu	vertical connecting rod- transmits the movement of the crank to the sawing system
	Sawing System	
10.	themeaĺe	mechanism mounting beams
11.	colońi	pillars supporting sawing mechanism
12.	şară	saw blade
13.	arizboiu	saw blade mounting frame
14.	dzave	saw blade fastening bolts
	Carriage Driving System	
15.	tsăchi	log transporting carriage system mounting beams
16.	furcă	horizontal rod - drives the propulsion system by the sawing system
17.	fusulu di la pĺacu & fusicu	transmission shaft for the propulsion mechanism
18.	pĺacu	wheel thrust propulsion mechanism subsystem
19.	veargă & veargă di pĺacu	rod of wheel thrust propulsion mechanism subsystem
20.	tşarche	propulsion mechanism wheel, by rotating it tows the log transporting carriage
21.	fusulu di tşarche	propulsion mechanism wheel axle
22.	alisidhă	log transporting carriage traction chain
23.	arăbă	wheeled log transporting carriage
24.	măxilari	log placement seats
25.	că(î)ndjî	log stabilizing hooks
26.	arocute	log transporting carriage wheels
27.	arăbucanaĺi	rolling rails of the wheeled log transporting carriage
28.	aneme	log transporting carriage reset cylinder

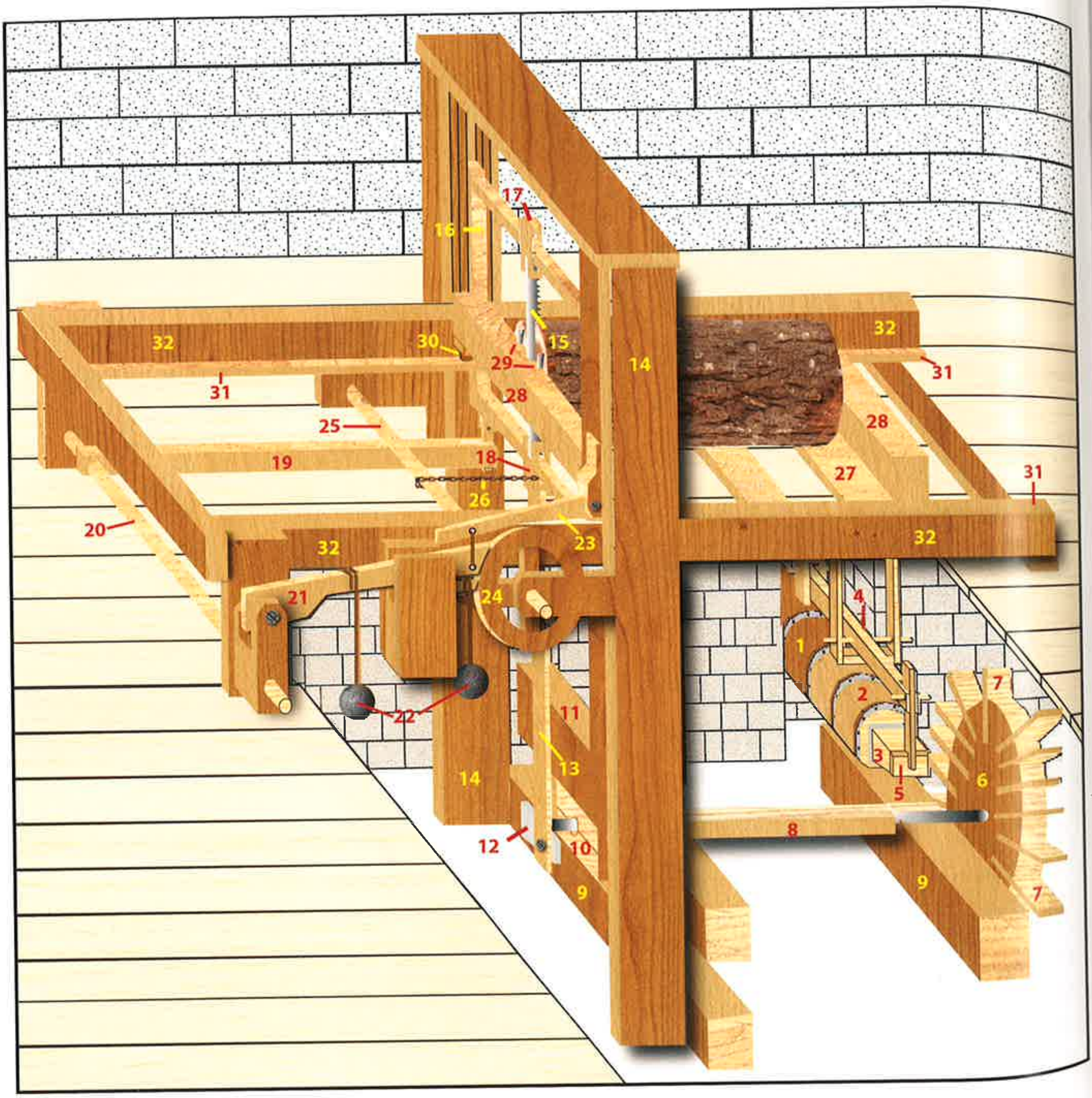

Fig. 13. Industrial water sawmill mechanism, drawing by F. Dasoulas.

Industrial Water Saw Mill Reconstruction

	Local Terminology	Technical Description
	Mechanism Driving System	
1.	căruță & canalu	water duct
2.	musure	water trapping system in the water duct
3.	xifune	spout discharging water from the aqueduct
4.	stămătiră	water flow breaker
5.	ocană	water outflow pipe cutoff board
6.	fterotire	water wheel
7.	arpe	water wheel blades
8.	fusu	rotating crank shaft
9.	căpităńi	support bearing the crankshaft
10.	capele	bearings - blocks supporting and driving the rotating shaft
11.	templă	beam pressing the bearings
12.	strîmbu	crank - mounted on the edge of shaft converts the rotary motion into linear reciprocating
13.	furcă	vertical connecting rod- transmits the movement of the crank to the sawing system
	Sawing System	
14.	colone	pillars supporting sawing mechanism
15.	prione & șară	saw blade
16.	rizboiu	saw blade mounting frame
17.	zavă	saw blade upper fastening bolts
18.	djugu	saw blade lower fastening bolts
	Carriage Driving System	
19.	furcă	horizontal rod - drives the propulsion system by the sawing system
20.	fusu	driving shaft to the propulsion mechanism
21.	papĺacu	wheel thrust subsystem of the propulsion mechanism
22.	ghiuledzî	counterweights - preventing ejection of the wheel thrust subsystem rod
23.	mănușă	handle moving the thrust subsystem
24.	tșarche	propulsion mechanism wheel, by rotating it tows the log transporting carriage
25.	fusu	propulsion mechanism wheel shaft
26.	sirte	log transport carriage traction chain
27.	arăbă	wheeled log transport carriage
28.	căpităńi	log placement seats
29.	căndjî	log stabilising hooks
30.	căruĺi	log transport carriage wheels
31.	căĺuri	rolling rails of the wheeled log transporting carriage
32.	plătări	beams framing the rails of wheeled log transporting carriage

The local terminology used in both tables is in the local language as explained in "Milling Systems in Central Pindos" (Chapter 70 of this book).

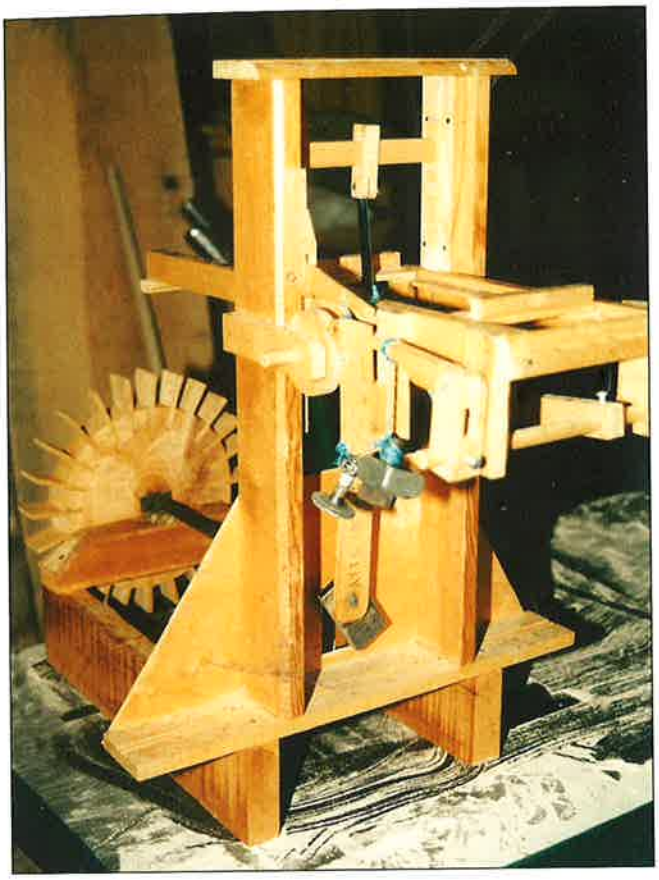

Fig. 14. Industrial water sawmill model.

of the water sawmill, instead of the foundation logs of the forestry water-saws. Also, the two pillars flanking the wood-sawing mechanism were extended downwards into the basement. This improvement brings about corresponding technical adjustments to the driving components mounted into the basement. Technical differences are noticed in the modular system pulling the wheeled carriage carrying the logs to be sawn. Finally, some wooden components were replaced by metal, while in the last period of use, additional mechanical improvements are noticed. For example, the addition of ball bearings on the transmission from the vertical connecting rod to the saw frame and the automatic reset of the carriage carrying the logs.[11]

The search by the local woodworking industry for technical means to maximize production resulted in changes to the productive usage of the industrial water sawmill of Metsovo. Besides sawing logs into boards, the water sawmill now was used for the production of wooden plates. In this way the first stage of wood for saddles production was mechanised, which led to the abandonment of lengthy and laborious work and the unnecessary stockpiling of raw materials. Thus the basis for the integration into the production process of sawmills and other machinery was set. This led to a complete change in their technical infrastructure and the transformation of traditional wood working workshops into industrial units. This was a development requiring not only greater water power capacity but also a new way of water kinetic energy transmission, since more machines were needed to be operated. The water sawmills were in operation in the wood working workshops of the region until the early 1950s when they were abandoned permanently. The forestry ones were used, it is recorded, until the 1960s. Individual use of this mechanism is recorded up to the 1980s.

Regardless of its original provenance, the water sawmill can be viewed as a mechanism belonging to the technical history of pre-industrial Pindos, since it was constructed entirely by local craftsmen. At the same time, it signals the highest stage of technological opportunities available to the rural society of this region. The processes that the use of the water sawmill triggered, reveal that the economic development of the pre-industrial world in the mountains was not only based on the exploitation of certain old rural sectors in the region, such as farming, but also on knowledge and development of specialised know-how. Therefore, one can observe that the rural communities of Greece attempted sometimes to develop the technical infrastructure, but that fact does not negate the broader technological and consequently economic backwardness characterising these peripheral economies.

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