Cameras for the Drying of the Wood

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Abstract

In the book are examined different methods of the drying of wood, and also construction of drying chambers for their realization. The universal drying chamber, which ensures the high quality of drying with the minimum expenditures of energy, is in detail described. Camera is fully automated and in all time of drying does not require the interference of operator. In spite of high characteristics, camera is so simple that for its production it does not require special equipment and expensive completing.

Index terms— wood, drying, cameras, wood moisture, heat of evaporation.

I. Essence, Purpose and the Value of the Drying of the Wood n the growing tree is contained a significant quantity of moisture. It is necessary for maintaining the vital activity of the cells of tree. Under the natural conditions of life of forest the moisture plays positive role also in each extinct tree. It contributes to development in the wood of microorganisms, therefore, to its timely biological destruction and to fertilizer of soil.

With the use of the felled and processed wood appears the need for averting of its biological destruction, giving to wood the resistance to rotting. Most simply this is achieved by removal from the wood of almost entire moisture. Thus from the unstable raw material wood is converted into the very valuable material, which is been preservable long time. However, moisture in an excess quantity frequently is used for the protection of wood from the rotting. It is known from the practice that the underwater part of the piles, the flooded logs and T. p. remain long time -ten and hundreds years. The method of the flood of wood raw material for its seasonal storage widely is used in the plywood production, and the artificial overhead irrigation of the piles of logs -in the saw-mill.In this case of the wood by moisture air (including oxygen), necessary for the vital activity of the wood-attacking fungi, is displaced. Especially rapidly (in 1-2 months) in the summer time spoils felled, but not dressed and, therefore, not dried up in a short time, the wood of beech, birch and aspen; rot the damp boards, packed in the dense piles. Therefore it is necessary the log of these wood species, and also maple, ash, alder-tree, linden and others to urgently saw and then boards immediately to dry with the maximum permissible intensity. Basic factors of rotting the wood: the moderate temperature (5-40° C), atmospheric oxygen and its significant (but not close to maximum) humidity. For retaining the wood it is desirable so that as a result the dehydration in it would remain the less fifth part of the moisture with respect to the mass of wood itself, and in the case of storage the method of additional moistening the mass of moisture must be more than the mass of wood itself. The ratio of the mass of moisture to the mass of wood itself is called its humidity of. In the noted examples the wood moisture content is 0.2 (20%) and more (more than 100%). If wood will be found under operating conditions on open air, by atmospheric precipitations preliminary drying for the protection of wood from the rotting is useless in view of the inevitability of repeated moistening.

The most economical and extended method of the dehydration of wood -this is its drying, achieved due to the supply to the moist material of heat by heated air (or combustion products) and the removal of the evaporated moisture by the same, but by partially moistened and cooled air. For transforming one kilogram of water into the vaporous state with the atmospheric pressure be required to spend about 2300 kJ (540 kcal) of energy. The process of evaporating the moisture with the aid of air can occur without its artificial preheating, which is characteristic for the atmospheric drying, when the heat of the surrounding air heated by the sun is used. Since the volume of the separating from the material vapor at a usual temperature of drying (50-100° C) approximately in 1,2 -1,7 thousand once is more than the volume of the evaporated water, vapor is fixed from the heated wood into the ambient air. Consequently, for the drying it is necessary with air to bring energy and to take away vaporous moisture, T. e. to accomplish air circulation using the material. The duration of the process of the drying of lumber in the special cameras is completely significant (1-60 days) depending on thickness and species

of lumber.Since with the blowing lumber burst by dry air, the process of drying is carried out in the moist medium. For these purposes the moisture, which was evaporated from the wood, is used: left the pile moistened air repeatedly is preheated in the air stoves (or they add hot combustion products) and for a second time they direct into the same pile of material, the method of the recirculation of air uses.

A quantity of moisture, which is contained in the freshly-felled or floatable wood, decreases because of runoff of it in the liquid state (mechanical dehydration) or the transformation of liquid into the vapor, ie change in its state of aggregation. Is most tempting the removal of moisture from the wood precisely in the liquid state, without the heat expenditure for its vaporization. It is the summer time the part of the moisture inside the wood overflows it downward and even emerges outside. With heating of wood this effect grows.

If vaporization in the moist material occurs at a temperature of equal or higher than 100° C, the process of drying is called evaporation. If vaporization occurs at a temperature of moisture lower than 100° C, process is called evaporation. Since at a temperature lower than 100° C the pressure of vapor it is equal to the atmospheric pressure (0,1 MPa, 1 bar, 760 mmof mercury), under the atmospheric conditions of pairs intensively it can be removed from the material only together with air.

Evaporation from the medium dry material (when moisture is in hygroscopic state)occurs at a temperature of moisture and material higher than100° C.

In the winter time wood partially gets dry in open air (method of sublimating), when moisture passes from solid state to vaporous.

Thus, by the term the dehydration of imply removal from the wood of moisture in any form of it and by any possible methods.

The wood, utilized in the form of boards and billets in building, machine building, which work woods, furniture and other productions, after the proper drying only acquires biological resistance to rotting, ability to preserve form and sizes of components in the articles, maximum mechanical strength with the smallest density, it is processed well, has minimum thermal conductivity, electrical conductivity and other The mechanical strength of wood sharply grows in proportion to the decrease of a quantity of moisture in the range lower than 30%, moreover it grows continuously to the removal of entire moisture; simultaneously wood becomes more easily. In a number of cases (for example, with the delivery of logs by alloy) the mass of the very moist wood as a result of drying decreases doubly. In proportion to the drying out of wood to a comparatively low humidity are improved its technological properties -cleanliness of sawing, planing, grinding, strength of gluing, fineness and others Simultaneously rises its heat of combustion, which is substantial with the use of wood wastes as the fuel.

Depending on the conditions of using the wood the purpose of drying and requirement for the separate properties of the dried wood are different: with the mass drying of lumber at the saw-mill plants this averting of the subsequent biological destruction of wood and the decrease of transport loads with the delivery to user; for the building and the wood processing, furthermore, averting the subsequent deformation and premature wear of different devices and articles made of it, and also an improvement in its physicomechanical properties; in the furniture production, besides that indicated, giving a number of positive technological properties; in the special productions (plywood, match, wood boards) -giving to material additional properties in accordance with the requirements of the technological processes of these productions; in the musical industry, besides of entire enumerated, reaching quick aging (stabilization) of wood. In all cases the purpose of drying -transformation of wood from the natural raw material into the industrial material with radical improvement in this case in its biological, physicotechnical, technological and consumer properties. As a result drying is obtained the refined material, more qualitative and more valuable, which corresponds to the varied high demands, presented to it under different production and living conditions. The economic value of the drying of wood is great. The drying of wood in enterprises usually is carried out to the assigned magnitude of its humidity in the special drying plants.An essential deficiency in the unseasoned wood -its subsequent second shrinking in the perpendicular direction to the fiber length, which leads to the appearance of clearances in the mating parts, their warping in different directions, splitting. Because of this article after production sharply in a short time reduces its quality indicators or it becomes unsuitable. Consequently, the increased moisture content in the wood during the production from it of production is inadmissible; production will be low-quality, with the small resource of service. For example, furniture (everyday, school, etc) that prepared from the insufficiently dried wood, becomes unsuitable in 2-4 years; the analogous furniture, prepared from the well dried material, serves 20-40 years and more, ie it is approximately 10 times longer.

The woodworking and furniture enterprises will work in the large measure ineffectively, if the drying of wood on them is unsatisfactory and the manufactured production under operating conditions rapidly becomes unsuitable. Doors, window boxes, flooring and overlaps, prepared from the insufficiently dried up wood, after a certain time crack, in them the slots appear; doors and door casings be distorted, the floor boards and the elements of overlap are warped, plastering is destroyed,

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Year 2019 © 2019 Global Journals ( ) Volume XIx X Issue II Version I J noted that in the very damp lumber of some wood species (beech, pine tree) with the vertical position in By studies is established that with the steaming

of beech lumber of the on Wednesday saturated vapor with the temperature near 100° C the substantial part of the moisture is moved away from the wood in the liquid phase during the horizontal addition of boards or billets , ie with the transverse current of moisture. Their humidity with the temperature near 100° C, the atmospheric pressure and the duration of steaming not less than 10 h is reduced from the initial 70-by 80% to 40%, but in the drier simultaneously steamed beech it rises almost to this value. The advance of moisture coincides in this case with the direction of heat flux in the wood, moisture is moved from the greater temperature to smaller. moreover immediately, and it is desirable in the common flow with the sawing. The process of their drying it is necessary to consider as the integral part of the technology of the production of boards and billets. To users must dispatch dry lumber, since with the transport of moist wood superfluously are expended means on the transportation of huge quantities of water, which is about half of the mass of wood itself. Furthermore, moist wood in the way frequently spoils. The incorrect process of drying leads also to the significant losses because of the appearance of stresses, warping and cracks in the material. Unsatisfactory drying and output of rejected product in the drying shop can remain for a long time unnoticed, since the results of the defective drying in the absence of proper control (after the nonuniformity of the humidity of the dried material or its incomplete drying) are shown after the significant time after the production of the production, when it is paid by user and is in operation itself. Drying bypasses inexpensively -of about 10% of the cost of the dried wood. Expenditures for the construction of drying plants in the time of their action (about 10 years) are equal to 1% of the cost of the wood dried in them.

3 II.

4 Humid air and its Property

In nature there is no dry air, in which there are no vapors of water. Such an air can be obtained only by special methods having, for example, passed the humid air through the coil, located in liquid nitrogen. With this procedure with the passage of air through the coil the vapors of water are condensed on the internal walls of coil, and dry air will be obtained at its output.

If is located the mixture of any gases, then each separate gas in this mixture is characterized by partial pressure. The partial pressure ? P this the gas pressure, which it will render it the wall of vessel, if we from this vessel remove all the remaining gases. The sum of all partial pressures of gases, which compose the atmosphere, is equal to atmospheric pressure. Since the water vapors, which form part of the atmosphere are also gas, they have their partial pressure. At an assigned temperature the unit volume of dry air can dissolve in itself only specific quantity of water in the pressure of water vapor. The absolute and relative humidity of air is distinguished.

Absolute humidity this a quantity of moisture, which is contained in one cubic meter of air. Is calculated this humidity into g/m^3. Is used also this concept as the moisture content of humid air of d , which indicates the quantity of water, which is contained in one kilogram of dry airm d M =

, where m -mass of water in the grams, which is contained in one kilogram of dry air, and M -mass of one kilogram of dry air.

In connection with the fact that at a specific temperature of air in it can maximally be contained only specific quantity of moisture (with an increase in the temperature a maximally possible quantity of moisture it increases, with the decrease of the temperature of air it it decreases), it is introduced the concept of the relative humidity? .which is measured in the percentages100% ? ? P P ? =

, where ? P and ? P -partial and pressure of water vapor at this temperature. The data about the moisture content of humid air depending on relative humidity are cited in the table1.

For determining the relative humidity of air are used the psychometric charts, in which by a difference in the indications between the dry and moist thermometers it is possible to determine the relative humidity of air. Year 2019 form pair. And the higher the temperature, the greater the quantity of water vapor will be in the obtained mixture. If, at an assigned temperature, they will reach the limit of this solubility, then such an air is called the saturated humid air. To such an air corresponds the well defined quantity of water, which feels per unit volume of dry air and the well-defined partial pressure of vapors of water of ? P , which is called or saturation ( ) Volume XIx X Issue II Version I J blown through by wind. Soon it is necessary to overhaul after its construction. In this case the losses usually many times exceed the basic cost of wood. Almost all lumber should be dried on the spot their sawing, structural wooden elements are surprised by fungi. In the winter time this building, which lost airtightness, is Humidity air,? %30 - - - - - - - - - - - - - - -

In the Table **??** and Table3 are cited the data for the determination of the moisture content of air from a psychrometric difference in temperatures of the dry and moist thermometers over wide limits of a change in temperature and humidity of air.

Table **??** is used for determining the relative humidity of the atmosphere, while Table **??** is used for determining the parameters of the drying agent (air) in the drying chambers.

5 III. Hygroscopicity of the Wood

Thewater to be found in the wood two basic structural elements: in the volume of cells -this the socalled free moisture and in the walls of cell walls. This moisture is called hygroscopic or connected.

The maximum quantity of connected moisture, which can be found in the wood, approximately equally for all wood species comprises at room temperature of about 30%.

Entire moisture of higher than 30% is free. The evaporation of the free moisture from the wood occurs with the same energy losses and from free surface water. Heat of vaporization of water with the atmo spheric pressure is 2260 kJ/kg (540) kcal/kg. In order to evaporate one kilogram of water, it is necessary to consume 1.6 kV tchas of electric power.

The maximum value of wood moisture content, with which is possible the absorption (absorption) by it of moisture from that saturated the ferry boat of air, determines the limit of the hygroscopic state of wood and it can be the defined limit of the hygroscopicity of. Thus, the limit of With an increase in the temperature the limit of hygroscopicity is reduced. Thus, if at room temperature the limit of the hygroscopicity of the wood of all species in any part of the stem of about hygroscopicity designates the boundary value of humidity between the located in the cells of wood at room temperature hygroscopic (to 30%) and free (higher than 30%) moisture.

The evaporation of the connected moisture, which is located in the cell walls, is hindered, and for its absorption air must be drier, and the expenditure of heat increased. In this case the heat of vaporization of the connected moisture can increase to 3600 kJ/kg (860 kcal/kg)[1]. 30%, then with 60° C about 26%, and with 90° C are reduced approximately to 20%.( ) Volume XIx X Issue II Version I J 32 16 - - - - - - - - - - - - - - 34 14 15 - - - - - - - - - - - - - -

Fig. **??**: Diagram of the equilibrium moisture (?.?.????????) **??**1].

Dry wood possesses large hygroscopicity, and it is, being placed into the moist atmosphere, it rapidly absorbs moisture. Equilibrium wood moisture content corresponds to each value of temperature and humidity of air. Equilibrium moisture this is that humidity, which in the course of time acquires the wood, being found in the humid air with the assigned temperature and the humidity. Thin lumber reach equilibrium moisture faster than thick. The process of absorbtion of moisture bears exponential nature, and lumber absorb a basic quantity of moisture or they return in the first day of a stay under the new conditions.

For determining the equilibrium moisture is useful to use diagram which is given in Fig. **??**. Is here along the vertical axis plotted the relative humidity of air, and on the horizontal -its temperature.

As to use this diagram ? For finding the relative humidity of the ambient atmosphere it follows to use the psychometric Table2 and Table **??**. Using these tables, on a difference in temperatures between the dry and moist thermometers the relative humidity of the atmosphere finds. Moist thermometer is made, winding by its thin layer of cloth and then dipping into the water.

For the more rapid establishment of temperature both dry and wet-bulb thermometer is desirable to blow out with the aid of the fan or by other or what method. If the temperature of air and its humidity is known, then the equilibrium value of wood moisture content is located on the intersection of the lines of the assigned temperature and humidity of air. One should consider that, so that the preliminarily dried wood would reach equilibrium moisture with the ambient atmosphere, is required time and, the thicker the lumber, the greater the time for this is required. For the assortment with thickness about 50 mm to this be required near the 2nd day.

But the surface layers of dry wood, as they collect, so also return moisture very rapidly. Even having fallen under the rain, which occurs during the transport of dry wood, the gotten wet lumber rapidly acquire equilibrium moisture with the atmosphere of that accomodation in which they are located. The ( ) Volume XIx X Issue II Version I J production.

To before load lumber into their drying chamber is very desirable to dry up in fresh air. For this the lumber stack on the padding with the thickness 25-30 mm. For the purpose of the more intensive free convection of pile one ought not to make wider than the 2nd meters. With piling of boards it is desirable to plot them not close to each other, but to leave between them clearances (spaces) 3-5 cm. If piles are plotted not under the shed, then as the last layer should be used the rejected boards or slabs. To avoid the soakings of piles during their rain conceal by slate or by anotherroofing. To avoid the entries of solar rays on the edge of piles,them also guard.

In the summer time this preliminary drying must last approximately one month, in the winter time one-and-a-half two times longer. The measure indicated gives the possibility 2 times to approximately reduce power consumption.

6 IV. Properties of Moist and Dry

Wood and the Processes, Proceedingin the Wood During the Drying by

The wood, as natural polymer, possesses the elasto-compressible properties: in the heated moist state it easily is deformed as elasto-compressible body, while in the dry state in the larger measure -as elastic.The characteristic property of lumber during their desiccation-appearance in them of deformations and stresses. Deformations are manifested in the direction transverse to the fiber length. Deformations over the section of material appear without the application of external forces; therefore they can be named internal. Are distinguished the reversible elasticof the deformation of wood, which include with the prolonged drying the deformation of elastic after-effect (called sometimes resilient-elastic), and not reversed, residual ofwith their simultaneous flow in the time in the cross section of the dried assortment. The appearance of internal cracks and microscopic cracks is the most dangerous marriage with the drying of solid rocks. The manifestation of such properties of wood during the drying can be represented by the following experience, which clearly reflects laws governing entire drying process. If we cut off the small piece of damp board, to cleave it longitudinally to two layers (Fig. **??**-A),having and then fastened in pairs their ends and heating wood, it is slow, into several stages, to unwedge in the middle (Fig. **??** -B),the layers as a result of application of force will be bent, ie in them will arise the deformations and

the stresses, which outside stretch (sign +), which inside compress (sign -). The dried slightly stressed layers will remain bent even after effort will be removed.In spite of bend, in the wood will not prove to be elastic deformations and, therefore, it will not be stresses. If we then both bent layers longitudinally cut into the plates and to even them from one end, plates will prove to be the different length: in the middle it is shorter, and on the edges are longer (Fig. **??**-?)although their humidity will be identical. Is explained this by the fact that tensile elastic stresses acted outside the layers and deformation, after extending their external zone. In the inner zone were manifested the compressive elastic deformations, which also passed into those not reversed, residual, after reducing the size of wood (independent of shrinkage, additionally to it). Hence it follows that under the action of elastic deformations wood behaves as elasto-compressible body, it can permanently be extended or be compressed, especially in the moist and heated state. In this case the elastic deformation spontaneously passes into the residual, fixing new size. Is such the characteristic of the first stage of the drying, when the danger of appearance in the lumber of external cracks appears.

If we without cutting both bent layers into the plates, attempt ourselves to straighten them, in the outer zone will appear those compressing, but in the internalstretching elastic deformations. In the case of the application of significant force, the stretching elastic deformations in the inner zone of layers can lead to the internal cracks. If wood was compressed having gradually, preliminarily moistened heating its, internal cracks will not appear and the dried layers stopped up in the flat state will gradually become straight lines. After cutting them to the plates, it is possible to establish that the length of all plates is identical as at the beginning of experience. This means that residual dilitational strain arose in the inner zone of layers, and in the externalcompressions, ie occurred the phenomenon, opposite earlier to that observed. In this schematically consists the characteristic of the second stage of the drying, when there is a danger of appearance in the thick lumber of the internal cracks, which resemble shells in the metal-casting. ( ) Volume XIx X Issue II Version I J But this is the only mechanism of the formation of internal cracks. It is experimentally known that with the slow drying the coefficient of shrinkage is greater than with the rapid. If the rate of drying is too high, then the outer layers of board dry more rapidly, while inner layers they remain still moist and they continue slowly to dry. In this situation in the board is formed the box of outer dry layers, whose coefficient of shrinkage is less than in those inner layers, which will dry more slowly. This leads to the fact that the longitudinal cracks and microscopic cracks begin to appear during the continuation of drying inside the board.

Of the property of wood as elastic body must be known because one of the basic defects of drying (internal cracks and shell) can be explained only by formation and accumulation of residual deformations in the heated moist wood. For this reason external cracks at lap-time frequently do not appear even with a large drop in the humidity on the thickness of assortment. Furthermore, as a result of the manifestation of residual deformations changes the value of shrinkage and warping the correctly packed (fixed between the padding) material is prevented. This important property of wood must be correctly used for purposes of its more qualitative drying.

With the decrease of the content in the wood of connected moisture, T. e. with the humidity it is lower than 30%, intracellular moisture begins to evaporate and wood dries. With the presence in wood of the free moisture, when its humidity exceeds 30%, the sizes of the cells of wood are kept constants.Thus, the limit of hygroscopicity (30%) -this simultaneously the limit of the shrinkage of wood. Shrinkage and reverse processswelling -the inherent properties of natural wood.

in connection with the anisotropism of structure the shrinkage of wood is unequal in different directions: lengthwise fibers it smallest (of about 0,1% with the removal from the wood of entire moisture). Large longitudinal shrinkage is characteristic only of wood, which grew in the inclined state, (to 5%). The greatest shrinkage (to 8 12%) occurs in the direction of annual h or nbeam and as it is characterized by larger shrinkage than the wood of fir tree, poplar, alder-tree. Exception from this rule is the shrinkage of the wood of aspen and linden, which approximately corresponds to the shrinkage of oak. It is characteristic for the wood of linden, furthermore, the small difference in the value of radial and tangential shrinkages, in consequence of which this wood they prefer with the production of critical components, for example in the pattern p roduction. On the contrary, in the wood of cedar and fir tree radial shrinkage is small in comparison with the tangential (1: 27).

In the practice of the calculation of drying plants use the not depending on the shrinkage conditional density of the wood of ? ? (kG/m 3), by which is implied the ratio of the mass of wood in the absolutely dry state of m to its volume of V with the humidity of higher than 30%:? m V ? = .

The values of conditional densities and humid characteristics of the wood of basic wood species are given in the table ? 4.

Using a concept the conditional density ofconvenient to find a quantityM (kg/m 3) of the moisture, moved away 1 m 3 of wood, in spite of a change in this case in its volume: layers, ie in the tangential direction. Shrinkage along a radius of stem composes 4-8%, ie almost 2 times less than in the direction of annual layers. The wood of alburnum dries somewhat more than the wood of nucleus. Shrinkage on the end area and also by the volume of assortment, is approximately equal to the sum of shrinkages in the radial and tangential directions. For example, if shrinkage in tangential direction 10%, and on radial 6%, wood dries both in the cross section and by the volume approximately to 16%, independent of the form of pieces. The value of the shrinkage of wood by the volume approximately corresponds to the volume of the connected moisture evaporated from the wood. Since the wood of more compact rocks contains per unit of volume more than the connected moisture, it more dries. Consequently, the wood of oak, maple, below 30%)(30) ? U K w = ?

. For example, the thin, slowly dried pine board with the width of 200 mm, tangential sawing, with the initial humidity is higher than 30% and by final 10%, with k=0,31 will dry to the value in 0, 31 (30 -10) =6,2%, ie its width in the dry state will be 187,6 mm. The lateral deformations of lumber, which are manifested with the drying, have great significance for the effective use of wood.

V.

7 Drying Regimes of Lumber

Drying regime is called the totality of the actions of the drying agent (air) on the material,which ensure the assigned quality and the speed of its drying. Drying ( ) Volume XIx X Issue II Version I J regimes are represented in the form the timetable of the Tables 4: Process of drying. They provide for three stages of drying and they are represented in the table 5.In the table are accepted the following designations.

T -the temperature of air in camera, t -difference in the temperature between the dry and wet-bulb thermometer, -humidity of air in the camera.

8 Humid. 12%

Abs as a result of the larger shrinkage of wood in the tangential direction, than in the radial, the boards, sawn from the log, acquire after drying form shown in Fig.

2 The disturbance of regime in these stages with the drying of solid rocks is separately dangerous. The upper layers of lumber begin to dry up with too intensive a drying, forming the rigid crust, which not only prevents the removal of moisture from the lumber, but it does not give to be compressed to the inner layers of the woods, which dry more slowly and therefore they have the larger coefficient of shrinkage. This regime leads to the appearance of internal microscopic cracks, and, therefore, to the marriage.

9 Universal Lumber-kiln Camera

The described methods of the drying of wood, which foresee its three stages,do not yield to automation and require a constant interference of operator. Moreover, any disturbance of regime, can lead to the irreparable consequences, whose price is very great, as wood, especially solid rocks, stands not cheaply. Now we will in detail describe the fully automated camera, which in entire cycle of work does not require the interference of operator.Moreover in the camera with the identical success can be dried both soft and solid rocks of wood. Such cameras are exploited by us and our customers of more than 10 years, and in them it was not serious breakdowns. In several cameras it was

10 Humidity the wood

The number of regime and the humidity of air in the camera ? % J fulfilling contradictory requirements and to find between them a compromise. It is known that any universal device, capable of carrying out several functions, always more complex and is less reliable than the device, intended for fulfilling one function. And rarely it succeeds to reach this compromise that this would be not thus.

The described camera presents that rare case, when to make this it was possible.

these are not our fault, but the fault of the producers of engines. With the construction of any complex article always is necessary to be encountered with the need for necessary to replace the malfunctioned engines, but 1. The first and main condition is this obtaining of the high-quality dry wood, which possesses the assigned humidity, the absence in it of the external and internal cracks in the absence of warping and the guide of assortment. These conditions correspond to the first category of drying.

Let us formulate the basic tasks, which were placed with the development of the camera indicated: 2. Simplicity into operation and independence of regime from possible turning offs of electric power. This requirement is especially important with the operation of cameras in the rural locality, where such stoppages not rarity. 3. Ease of fabrication not requiring the specialized equipment and expensive completing. 4. Simplicity of assembling and dismantling, and portability in the dismantled state in the cargo machine.

11 VI.

5. Simplicity of replacement all completing, that malfunctioned in the process of operation, without the unloading from the camera of wood. 6. Correspondence to ecological requirements with respect to that locality, where the camera is used, and since cameras can be used in the habitable zone, this observance of noise characteristics and the absence of harmful ejections. 7. Camera must be flame-resistant and this one of the most important requirements.

12 Fig. 4: Diagram of universal drying chamber

In the literature very box of camera accepted to call enclosures and subsequently we will use this terminology.

Let us at first draw the overall diagram of camera (Fig. 3), and let us then describe its separate units and methods of their production. In the lower part of the end wall is an exhaust pipe, through which is achieved the ejection of humid air. Pipe must be made from stainless steel aluminum or plastic, since with the drying of oak

the condensate, which is formed in the pipe, contains the tannic acids, which destroy usual steel. Diameter of pipe 60-70 mm. Established it should be with a certain inclination downward so that condensate resultant in it would not enter back the camera. The exterior of the pipe should be warmed so that it would not get chilled in the very cold weather. The height of the foundation of camera is selected in such a way that the external end of exhaust pipe would be above the level of soil. For this purpose before the filling of foundation and for the purpose of the savings of the utilized expendable material it is ( ) Volume XIx X Issue II Version I J On the rear end chamber wall is established the engine, to axis of which is mounted the fan blower of the type squirrel wheel. Opening in the rear wall is executed this diameter that the wheel of fan would resemble through it. This construction makes it possible to extract fan and engine in the case of failure of engine, without unloading from the camera wood. The Lshaped shutter, which is adjacent to the chamber wall, overlaps the part of this opening. The lower part of the shutter is done made of steel with a thickness of 5-7 mm and the engine is fastened to it. This shutter with the aid of the corners is attached to the end chamber wall. The vertical part of the shutter is made made of the sheet stainless steel with a thickness of 0.5 mm. If we look at the engine from the end-face, then under G with descriptive shutter is visible the semicircular part of the opening, through which is put the wheel of fan. During the work of the fan through this opening air suction from the atmosphere occurs. For the adju stment of the intensity of sucking this opening is shut by lath with the openings (in the diagram it it is not shown), which can be stopped. Necessary air suction from the atmosphere is established by the selection of a quantity of open openings. The diagram of this lath is shown in Fig. 4.In the lath there are 5 openings with a diameter of 30 mm. possible to pour the earthen pillow with a thickness of ~10 -15cm. having preliminarily packed it.

Since in the given construction air into the camera is forced, with the nonacceptance of the corresponding measures, can become unsuitable steel framework and thermoinsulation of enclosures. With the elevated pressure in the camera the humid air through the uncontrollable slots in the inner casing can penetrate the interwall space, will be there condensed moisture, which can spoil the steel framework of enclosures. Thermo-insulating material will be also saturated by moisture, losing its properties. In the given construction this problem is solved with the aid of the swivel damper. Turning it, it is possible to create additional obstacle to the air flow, whose circulation ensures fan. Therefore the highest air pressure will be observed in the ventilator section, where the wheel of fan is located. In all remaining parts of the camera, the air pressure will be lower than in this section. But since that indicated cut off connected with the atmosphere with the aid of the exhaust pipe it has atmospheric pressure, pressure in all internal parts of the camera there will be below atmospheric.

The turning of shutter must be selected in such a way that it would overlap the approximately 1/3 crosssectional areas of ventilator section. This shutter is necessary still and in order to ensure the uniform blowout of heaters, located in the upper part of the section. In the case of its absence the straight airflow, rejected by fan blower, unevenly blow out heaters. In those places, where the tape of electric heaters is located in immediate proximity to the wheel of fan, intensive blowout can lead to its vibration, which with the prolonged operation can lead to its impulse. For the purpose of simplification the shutter can be made stationary, after fastening it to the rear chamber wall, or to the panel, which separates camera from the ventilator section.

Thus, one fan fulfills the immediately four functions: it achieves scavenging of pile, induced air from the atmosphere, ensures the ejection of humid air into the atmosphere and the reduced pressure in camera itself. must correspond to definite requirements. External casing must be long-lived, not requiring a constant withdrawal and maintain the action of environment (rain, frost, the action of sun rays). The requirement of airtightness is not presented to the external casing. Inner casing must be airtight and maintain the action of the aggressive media, which the pairs of oak, which contain tannic acids, are. The thermal insulation material, which ensures high heat insulation, must be placed between the external and inner casing. One ought not to be fascinated by the excessively high heat-insulating properties of this layer, since. this leads to the rise in price of camera. Thermal insulation properties are selected so that the energy consumption due to the withdrawal of heat into the environment with the strongest frost it would compose ~2% of the general energy consumption of necessary for the realization of process drying. In this camera is used the foam plastic with a thickness of 40 mm, which is plotted between the skins of camera in two layers. Adaptation for cutting the foam plastic is given in the application ?1. Above the shutter are established the heating elements, which can be as electrical heater, so the batteries of water heating boiler.

In the upper part of the camera is established the temperature sensor, which ensures its automatic work. Its construction and operating principle we will examine, when we will describe the regime of chamber operation.

The diagram of chamber operation we examined, now let us describe the construction of its separate units and elements. And let us begin from the enclosures, which present the hermetically sealed heatinsulated boxing, whose internal and external casing The camera in question can have two overall dimensions: 3000x3000x4500 and 3000x3000x7500 mm. The first overall size is intended for the drying of wood with an overall working volume 8 m 3 and with a length of the assortment 3 m, in this case in the camera is placed one pile and is used longitudinal scavenging. With the second overall size in the camera are placed consecutively two piles of the same assortment. The requirement of the rapid assembling of camera and portability in the cargo machine forces the elements of enclosures to make with unit type. The bodies of these blocks are made from the pine board with a crosssection of 30x140mm. One of the boards of lateral chamber walls, to which fits closely the door of camera, it is carried

out from the oak board with the section of 50x140. The nuts, utilized for the sealing of door against the edge of camera, are fastened to this board. Ceiling blocks are made according to the same principle.

The sketches of all blocks of entering the assembly are given in Fig. 5. In all blocks there is a central partition, necessary for the rigid fastening of the sheets of internal and external casing. In Fig. 6 is shown the sequence of the installation of the blocks of enclosures (top view). By thin lines on the blocks is indicated the arrangement of partitions. The units of lateral walls are established specularly. This must be considered with their production. Block Ð?" is mounted in such a way that the oak board would fit closely to the door. In the case of the camera with a length of 4500 mm of two first of wall block from the side the doors are not mounted. All sections of the ceiling of camera are mounted from the blocks of the type v. The section, which is ad jacent to the door, is exception, the block Ð?", turned by oak board to the door, is used for this section.

Of frame and partition in them are made from the pine board by the section of 30x140 of mm. With the cut of boards it is desirable to use mounts, since. even insignificant deviations from the size significantly complicate assembling. The sizes of the frames of blocks are selected in such a way that in them as the external and inner casing it would be possible to use sheet slate with the size of 1500x3000. In this case should be considered the circumstance that sheets themselves are not precise rectangles, but they present parallelogram. Therefore before the skin of blocks should be sheets cut in such a way, that their diagonals would be identical. In th is case the length of sheet can somewhat be reduced, that it is necessary to consider with the production of frames. Therefore the size of frames lengthwise, indicated on the sketches is reference. Sheets to the frames are attached with the aid of the wood screws. With drilling of holes under the wood screws should be the diameter of opening selected on 2 mm more than the diameter of wood screw. This is necessary in order to avoid the break of slate with a change in its size during a change in the temperatu re in the camera. Opening under the head of ( ) Volume XIx X Issue II Version I J wood screw it must be produced so that during its tightening its upper edge would be below plane of slate. After assembling of block and tightening of fastening wood screws this opening is filled up with sealing compound, this is necessary so that the aggressive pairs of oak would not destroy wood screw.

To avoid of the cancerogenic influence of internal slate skin on the wood camera from within is colored with nitrocellulose enamel. During assembling of camera all possible slots between the blocks also are sealed with the aid of the sealing compound, white or transparent silicone sealing compound for these purposes is used.

Space between the internal and external casing is filled up with heat insulation. For this is used the foam plastic with a thickness 40 mm, which is plotted in two layers. With cut and piling of foam plastic one should follow the fact so that the joints of foam plastic in the lower and upper layer would not coincide. This is necessary for that reason, that with the continuous operation the foam plastic can shrink, and if we this rule do not observe, then through seams worsen the heatinsulating properties of heat insulation.

It is possible to use other materials for the internal and external casing. For example, inner casing can be made from the sheets of stainless steel, or aluminum, which substantially raises in price camera. With the use of this skin and the standard sizes of blocks can be changed for the purpose of the more economical utilization of standard standard sizes of sheets. It is important only so that the overall dimensions of camera strongly would not exceed the limits indicated.

The important element of enclosures is the door of camera, it is its front end wall. Door must easily be opened, and with the discovery ensure the free load of camera with lumber. During the closing it must ensure the reliable hermetic sealing of camera. The reinforced rubber high-pressure hose with a diameter 20 mm, used in the hydraulic systems, is used for this. It is fastened with the aid of the U-shaped wire brackets, made from the stainless steel. Diameter of wire 2mm. With the aid of these brackets the hose is fastened along the periphery of door frame, as shown in Fig. 7. The longitudinal section on the width of bracket is done for this in the place of the choking of brackets, in the hose. With this method of fastening the hose remains elastic for entire its elongation and provides the airtight adjoining of door to the end blocks of camera during its closing.

In Fig. 7 are shown also the corners, which are attached to the lateral ends of door with the aid of the wood screws (small small squares along the sides of door). In these corners, cut out from corner 50, are openings with a diameter 25 mm, through which are passed the steel bolt with screws M16, with the aid of which the door is attracted to the chamber end. Opposite these openings to the ends to the blocks of walls and ceiling of camera are attached the reciprocal nuts, into which are screwed up the draw bolts. These nuts present the squares of 20 x35x50, on to center which is cut the thread M16, and on the edges there are four openings, with the aid of which with wood screws the nut is attached to the oak board of wall blocks and block for the ceiling. The operation of fastening nuts must be produced with the aid of the mounts, since. the absence of the coaxiality of the threads in the nuts and of openings in the corners will not make possible to screw up draw bolts after closing of door.

As the loops of door, on which is accomplished its suspension, serve the faceplates, screwed on to the upper and lower end of door with the aid of the wood screws. These faceplates will be joined with the reciprocal corners, which are attached to the lateral chamber walls. In the faceplates and the corners there are openings, through which are passed the fastening bolts. Opening in the faceplates are made by oval, as shown in Fig 16 **??** This form of opening is necessary for that reason,that with the delay of the bolts, which force door against chamber end, occurs the shrinkage of the sealing hose; therefore loops must have the appropriate degree of freedom. The schematic of the upper and lower unit of the suspension of door to the chamber wall is shown in Fig. 8.

13 Side wall Corner Door

14 Fase plate

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The camera is established on the foundation, which presents plate from the keramzit concrete with a thickness 7-10 cm. dimensions of which are selected in such a way that its edges would fall outside the edge of camera 5-10 cm. In the absence keramzit concrete as the material for the foundation can be used cement mortar with the relationship of cement to the sand 1:6. For piling the foundation it does not be required the special preparation of soil, area must be purified of grass and levelled so that there would be the small inclination to the side of the door of camera. This inclination gives the possibility to emerge to the condensate, which in the first stages of chamber operation is condensed on the foundation. Fig. **??**: Form of camera on the foundation from the side of door.

In the lower part of the front chamber end with this end be fastened to in range oak board with the thickness 50mm(Fig. **??**).

The nuts for the bolts of the delay of the lower part of the door are attached to this board.

The first row of the padding, to which is plotted the pile to the foundation, has a thickness not less than 70 mm, the section of the remaining padding of 30x40 mm. The first pile is plotted so that between it and partition, after which is located ventilator section, would remain clearance not less than 200 mm.

Let us examine the diagram of installation of fan in the block d.As the fan is used the fan blower of the type the squirrel wheel with the diameter of the wheel of 315 mm, which is mounted to the axis of engine. Engine is established on the steel platform 5x360x400, as shown in Fig. **??**1 to the left. The type of layout is from behind shown on by right figure. Between the engine and the wheel the descriptive partition, made from the sheet stainless steel, which is attached to the platform with the aid of the bolts, is established by G. Size of the partition of 300?355 mm. Engine is established in the aperture of block d. The form of aperture is shown in Fig. 12 a. In the place of aperture in the inner casing of camera is an opening along the diameter of the wheel of fan. There are also lateral corners, on which is established and is fastened the platform of engine. When on these corners as on the sleds, fan begins to move to the adjusting place, the wheel of fan, it occurs inside the camera, and Ð?" descriptive partition shuts the large part of the opening for the wheel of fan. There remains only the part of the open opening under the platform. Through this opening occurs air suction into the camera.For the adjustment of the intensity of sucking under the platform is established the lath with the openings, shown in Fig. **??**1. Openings can be stopped up by different quantity of plugs how is regulated the intensity of sucking.

16 ? ?

Fig. **??**1: Aperture for the installation of fan (form A) and the fan, established in the aperture (form ?).

As the heating elements in the camera can be used both the batteries, fed from the gas hot-water boiler, and electric heater. As the water heating elements it is best to use the steel tubes, supplied with the spiral heat exchanger, made from aluminum. Such tubes are produced by industry and of them it is possible to collect batteries. Camera can be supplied with electric heaters. Is undesirable the use of plant which to high temperatures, and this is dangerous.

For the effective drying the heaters must ensure approximately with 1 kW of power to each cubic meter of wood with the drying of solid rocks and it is twice more as with the drying of soft. With an increase in the temperature of belt it is enlarged in order to compensate for this expansion they are used the spring units, which shift lower corner with this expansion. The construction of spring unit is shown in Fig. 14.

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( ) Volume XIx X Issue II Version I J For the drying of the soft rocks, where it is necessary to increase the power of heaters approximately two times, electric heatersare included between the phases, which gives this increase in the power. The temperature of the belt of this heater with the power indicated does not exceed 200 0 C, which is completely safe, since. dry wood begins to be charred only at a temperature 350 0 C. Furthermore, electric heatersare established between two slate partitions and of direct contact with the wood have they cannot.

The tape of electric heatersis located on the holders (hooks) with zigzag means, as shown in Fig. 13. The slate plates, to which are fastened the hooks, are attached to the upper and lower corner with the aid of the strips made of the sheet stainless steel. The ends of electric heatersare soldered to the lamellas from sheet copper, to the same lamellas are soldered the net wires, which through the openings in the chamber wall depart to the switchboard.

Let us give the parameters and the construction of the effective safe heater, made from strip that not corroding they became 12?18?10?(it is possible to use other stamps). The tape with a thickness 0.3 mm with the width 20 mm. is necessary for this. With the presence in camera of pile with a volume 8 m 3 for guaranteeing the power of heater 8kW the resistance of tape must be 6 Ohm, in this case its length will be 30 m. Unfortunately, this tape industry does not let out and it is necessary to cut out by hand it from the roll assortment.If in th camera two piles are located, then should be established two such electric heater.

18 Crutch

Fig. 13: Construction of spring unit.

On the crutches, which with their shank screw themselves into the rear wall, is located the pintle with the thread, on which are located two nuts. Brass flat spring is located between the upper nut and the shelf of lower corner.During assembling of electric heaterlower nut turns upward to the support, completely compressing spring. After assembling it descends to the lower position, ensuring the necessary motion to lower corner with the expansion of the tape of electric heater. Openings for fastening of crutches on the rear chamber wall are bored opposite the central wooden cross connections, then in them thread is cut, and crutches screw themselves. Thus are accurately fastened the pins, to which is fastened upper corner. The length of shank in crutch and pins must be order 50-60 mm so that it reliably would be held into the board.

Fastening the hooks on the slate plates and of electric heatersthemselves in the camera is shown in Fig. 15. Hooks are made from the copper or aluminum bar or the wire with a diameter 3-5 mm.

If necessary of arrangement in the camera of two electric heaters, they are fastened in parallel to each other. In this case into the rod of crutch screw themselves two vertical pintles with the thread, and pins to which are fastened upper corners they are done such length that on them between the nuts it would be possible to fasten two corners. Fig. 14: Fastening the hooks on the slate plates and of electric heaterthemselves in the camera is shown in fig.

In this camera is selected the special dutycycle operation, which gives equally good results both with the drying of soft and solid rocks. The idea of this method consists in the fact that moisture under any conditions always strives into the colder zone. This regularity is used in the cyclic regime. Technically it is achieved as follows. After the warming up of pile and reaching in the camera of the assigned temperature of the drying agent it passes to the duty-cycle operation. With the first cycle the wood heated to the specific temperature, after reaching by which, the heaters are turned off and the temperature of wood begins to fall. In this case the cooling begins from the outer side of lumber, while its internal parts they remain more heated. In this case the moisture begins to pass from the inner layers of boards to the surface, moist ening them. The external overdried crust is not formed with this regime and the uniform decrease of humidity throughout the entire thickness of board occurs. The temperature graph of this drying regime is represented in Fig. 16. For the realization of this regime is necessary the corresponding temperature sensor and the executive system,with the aid of which is achieved the assigned cyclic regime. The corresponding temperature sensor is necessary for this. On this sensor, utilized for the realization of cyclic regime, much depends. Failures in its work can lead to the failure of regime with the irreparable consequences. Especially this concerns those cameras, in which is required the long operating time without the control from the side of operator. One should say that there are no simple and reliable thermometers, which would ensure 100% guarantee of the reliability of operation. Therefore was developed the simple and reliable temperature sensor, which possesses such qualities. Its work is based on the use of a difference in the coefficients of the linear expansion of steel and polyethylene. The principle of the work of sensor is shown in Fig. 17 [mm] the difference in the reduction of tube and rod is 0.3 mm to one degree, which is completely sufficient for temperature control the accuracy 2-3 degrees. The tube with a diameter 20 mm, utilized for the hot-water heating, adapts as the polyethylene tube. This sensor possesses the highest reliability and the system leave cannot, with exception of any extraordinary situations. The schematic of the actuating mechanism of temperature sensor is shown in Fig. 18. To the end of the polyethylene tube is dressed the wooden bushing, to which are fastened two V -descriptive springs, at ends of which are established limit switches K 1 , K 2 . From the left side from these switches is located the disk, fastened to the steel bar, that is been the part of the temperature sensor.

19 VIII.

20 Electrical Circuits of the Cameras

The electrical circuit of camera with a length 4500mm, intended for the drying of hardwood is represented in Fig. **??**9. Input automatic switch AP -50 on 63 A serves for the connection to the control panel of supply voltage. Still one AP -50 on 6.4 A serves for firing of the engine of the fan, which is in the diagram designated by letter M. Power of engine 3 kW with the rotational speed to 1400 turnover/minute. The diameter of the squirrel wheel of fan is 315 mm.

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22 32

Year 2019 © 2019 Global Journals for the switching on of control system of the temperature conditions of camera. This system includes two normally locked limit switches K 1 , K 2 located on the actuating mechanism of temperature sensor (Fig. 18), and also starter PME-211. Its weakcurrent normally extended key K 4 is connected by one end to the booster coil of starter, and by another end to the key K 2 . Key K 5 is three power contact pairs of starter, connected in parallel. These contact pairs serve for the connection electric heater to one of the phases of network. Nourishment to the actuating mechanism of temperature control system will be given from one of the phase wires, which go after AP -50, which includes engine. This connection ensures turning off

electric heater in the case of the wear and tear of this starter in the emergencies during the malfunction of the engine of fan.

Works temperature control system as follows. At an ambient temperature the disk of temperature ( ) Volume XIx X Issue II Version I J Fig. 18: Electrical circuit of camera for the drying of one pile.

23 ??-50 (63 ?)

??-50 (6.4 ?)? ? ? 1 K 2 K 3 K Power Grid

Pentrite Key K 3, as which is used toggle switch, serves sensor is located in the end left position. In this position electric heater is connected to the network, and the temperature in the camera rises. In this case the disk begins to displace to the side indicated by pointer, also, at a specific temperature, concerning the button of end key K 1 tearing up contact between its contacts. But turning off electric heater in this case does not occur since. The contact pairs of the end normally locked keys K 2 and to K 3 remain locked and the temperature in the camera continues to rise. In this case the disk as before continues to move to the side, indicated with pointer, compressing the spring, on which is located the key K 1 .

With further increase in the temperature in the camera the disk reaches the button of key K 2 and it tears up its contacts. In this case nourishment the coils of starter will be opened, and proceeds turning off electric heater from the phase, is torn up also contact between the contacts of key K 3 . The temperature in the camera begins to fall after this. With the reverse wobble at first are locked the contacts of key K 2 , but this does not lead to the starting of starter, since the contacts of key K 3 are thus far still extended. And only after the decrease of temperature to value dT, disk releases the button of key K 1 , including starter. The cycle is repeated after this. Thus the position of key K 2 determines the upper temperature of cycle, and the position of key K 1 lower. must be ~85-90 0 Cand 65-70 0 C respectively. The readiness of wood is determined on the difference between the dry and moist thermometer, which must be 29-30 0 C. In this case the relative humidity of lumber will be within the limits 6-8 percent. With reaching of this temperature they turn off camera. For the more rapid cooling of wood it is possible to open slightly the door of camera. With the reaching in the camera of the temperature ~35-40 0 Cthe wood can be unloaded. The cameras examined do not require the interference of operator in entire cycle of their work independent of the initial humidity of the loaded wood. The only parameter, which in the end of the drying cycle is subject to control from the side of operator, this is difference boundary by the indications of dry and moist thermometers.

With the drying of the freshlyn-saw down softwood the expenditure of electric power per one cubic meter of the loaded wood composes ~700-800 kWchas, while with the drying of solid rocks~900-1000 kWchas.

For turning off of temperature control system from the power source in the case of exceeding in the camera of the temperature of higher than the assigned limits (emergency) serves blocking. For its work as the sensor are used separate temperature -sensitive element, the same, as in the temperature control system, it shown in Fig. **??**1. In the sensor is used the normally locked key K 1 . With the aid of the nut on the bolt ?1 the position of key is established so that the wear and tear of blocking would occur at a maximum permissible temperature in the camera.

Heat of vaporization of water with the atmospheric pressure is 2260 kJ/kg (540) kcal/kg. But if we calculate the quantity of water, which is contained in the wood and the quantity of energy, expended for its evaporation, then even taking into account the ideal heat insulation of camera, specific expenditure occurs 1.5 -2 times more. This connected with the fact that for the elongation of entire cycle of drying into the camera is sucked atmospheric air, which is then, being heated to the operating temperature of camera, it is ejected outside. It is essential to decrease these unproductive losses possible in the condensing chamber, whose diagram is depicted in Fig. **??**2. This diagram is differed from the diagram, depicted in Fig. 3, by the presence of heat exchanger in the lower part of the ventilator section (it is shown by fatty cross). With the work in the condensational regime in the lath, located under the engine (Fig. 4) all openings are stopped, and sucking into the camera of atmospheric air ceases. If we through the heat exchanger pass cold water, then on it will be condensed water, which will flow through the exhaust pipe. The application of this diagram of drying with the presence of the artesian well, where the temperature of water is about 9 0 C and practically does not change during the year, is especially rational. For purposes cooling heat exchanger it is possible to use tap water. With a difference in temperatures in 20 degrees between the water, which enters the heat exchanger and the water, which escapes from exhaust pipe, for the drying 1 m 3 of wood be required ~10000 kg of water. The regime indicated to rationally use, when wood moisture content is not lower than 15% and the humidity of air in the camera is relatively high. With the values of wood moisture content of lower than the value indicated should be switched the camera to the cyclic regime, examined above. Application of the regime examined gives to 25% of savings according to the expenditure of electric power.

As the heating elements in the camera can be used both the batteries, fed from the gas hot-water boiler and electric heater. In the water outline of this boiler it must they stand the pump, which must be included according to the same diagram as electric heater. In this case is used the diagram of the electric power supply of camera, depicted in Fig. **??**9 with the only difference that instead electric heateris connected the electric motor of pump. With the use of hot-water boiler it is necessary to reduce the temperature of the drying of softwood to 80 0 C, since. With the use of higher temperatures the effectiveness of the use of hotwater boiler is strongly reduced because of by the small difference between the temperature in the camera and the temperature of water. With

653 the work with the hotwater boiler the surface of batteries must be ~15 m 2 , while with the use electric heater
654 their surface it is ~1 m 2 . This a difference in temperatures between air in the camera and surfaces of batteries and electric heater connected with the fact that differs approximately 15 times. [1]

	56	38	35	33	30	28	25	23	21	19	17	15	-
	58	39	36	34	31	29	27	25	22	20	18	17	15
	60	40	37	35	32	30	28	26	24	22	20	18	16
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	78	49	45	42	40	39	37	35	33	31	29	27	25
	80	49	45	43	41	40	38	36	34	32	30	28	26
	82	49	46	44	42	40	38	36	34	32	30	29	27
	84	49	46	44	42	41	39	37	35	33	31	30	28
	86	50	47	45	43	42	40	38	36	34	32	30	28
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Figure 1:

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Figure 2:

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[1]