Engineering and Technology
2015; 2(3): 95-117
Published online April 30, 2015 (http://www.aascit.org/journal/et)

American Association for Science and Technology

Keywords
Wood,
Drying of Wood,
Air Humid,
Gas Pressure,
Evaporation,
Kilowatt-Hour

Received: March 26, 2015
Revised: April 13, 2015
Accepted: April 14, 2015

Simple Camera for High-Quality Wood Drying

F. F. Mende, I. A. Shurupov

Research Institute for Cryogenic Instrument Engineering, Kharkov, Ukraine

Email address
mende_fedor@mail.ru (F. F. Mende)

Citation
F. F. Mende, I. A. Shurupov. Simple Camera for High-Quality Wood Drying. *Engineering and Technology.* Vol. 2, No. 3, 2015, pp. 95-117

Abstract
The wood is one of the most common building materials. It is widely used not only in the structures, but also for preparing of furniture and number of technological articles. For preparing the furniture is used the dry wood of high quality, in which there are no stresses and cracks. For obtaining this wood the drying chambers, which ensure the high quality of drying, are used. Special difficulties causes the drying of the wood of such solid rocks as oak, ash, maple, beech. By questions of development and production of drying chambers the occupied huge number of firms and production organizations, but is up to now located number of the problems, which require their solution. The complete automation of drying process is one of such problems, and this problem entirely up to now is not solved. The majorities of the cameras produced by industry require the interference of operator in the drying process and a constant correction of drying regime. In this article is described simple automated drying chamber for the high-quality drying of wood, which in all time of drying does not require the interference of operator. Camera is simple in the production and does not require complex technological equipment for its production. The automation of process is achieved by the way of using the cyclic drying regime.

1. Introduction

The wood is one of the most common building materials. It is widely used not only in the structures, but also for preparing of furniture and number of technological articles. For preparing the furniture is used the dry wood of high quality, in which there are no stresses and cracks. For obtaining this wood the drying chambers, which ensure the high quality of drying, are used. Special difficulties cause the drying of the wood of such solid rocks as oak, ash, maple, beech. By questions of development and production of drying chambers the occupied huge number of firms and production organizations, but is up to now located number of the problems, which require their solution [1-11]. The complete automation of drying process is one of such problems, and this problem entirely up to now is not solved. The majorities of the cameras produced by industry require the interference of operator in the drying process and a constant correction of drying regime. In this article is described simple automated drying chamber for the high-quality drying of wood, which in all time of drying does not require the interference of operator. Camera is simple in the production and does not require complex technological equipment for its production. The automation of process is achieved by the way of using the cyclic drying regime.

2. Essence, Purpose and the Value of the Drying of the Wood

In 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 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, T. e. 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, 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 noted that in the very damp lumber of some wood species (beech, pine tree) with the vertical position in 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.

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, i.e. 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.

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 mm of 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 than 100° 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 physic mechanical 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, physic technical, 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, structural wooden elements are surprised by fungi. In the winter time this building, which lost airtightness, is 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, 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 no uniformity 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. 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_{Π} 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 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 P_H, which is called or saturation 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/m³. Is used also this concept as the moisture content of humid air d, which indicates the quantity of water, which is contained in one kilogram of dry air $d = \frac{m}{M}$, where m is mass of water in the grams, which is contained in one kilogram of dry air, and M is 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 φ,which is measured in the percentages $\varphi = \frac{P_П}{P_H} 100\%$, where $P_П$ and P_H - partial and pressure of water vapor at this temperature.

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.

Table 1. *The data about the moisture content of humid air depending on relative humidity*

T	Air humidity, φ %											
	100	90	80	70	60	50	40	30	20	10	5	0
	d	d	d	d	d	d	d	d	d	d	d	d
0	3,8	3,5	3,1	2,7	2,3	2	1,5	1,1	0,8	0.4	0,2	0
10	7,8	7,0	6,2	5,4	4,6	3,9	3,1	2,3	1,5	0.8	0,4	0
20	15	13.5	12	10,4	9	7,4	5,9	4,4	3	1,5	0,7	0
30	28	25	22	19	16	14	11	8,1	5,4	2,7	1,3	0
40	50	45	39	34	29	24	19	14	9,4	4.7	2,3	0
50	88	78	69	59	50	41	33	24	16	7,8	3.9	0
60	156	137	119	102	85	69	54	40	26	13	6,3	0
70	268	246	210	176	145	116	90	65	42	20	10	0
80	571	471	387	314	251	196	148	104	66	31	15	0
90	1509	1097	818	616	463	344	248	169	103	48	23	0
100	-	5754	2559	1488	955	635	423	271	158	70	33	0

Table 2. *Determining the relative air humidity of the atmosphere*

Ii Indication d dry termometer,°C	Difference in the indications of dry and moist thermometers, °C										
	0	1	2	3	4	5	6	7	8	9	10
	Air humidity, φ %										
12	100	89	78	68	57	48	38	29	20	11	-
13	100	89	79	69	59	49	40	31	23	14	6
14	100	89	79	70	60	51	42	34	25	17	9
15	100	90	80	71	61	52	44	36	27	20	12
16	100	90	81	71	62	54	46	37	30	22	15
17	100	90	81	72	64	55	47	39	32	24	17
18	100	91	82	73	65	56	49	41	34	27	20
19	100	91	82	74	65	58	50	43	35	29	22
20	100	91	83	74	66	59	51	44	37	30	24
21	100	91	83	75	67	60	52	46	39	32	26
22	100	92	83	76	68	61	54	47	40	34	28
23	100	92	84	76	69	61	55	48	42	36	30
24	100	92	84	77	69	62	56	49	43	37	31
25	100	92	84	77	70	63	57	50	44	38	33

Table 3. *Determining the parameters of the drying agent (air) in the drying chambers*

T dry	**Difference in the indications of dry and moist thermometers, °C**														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
	Air humidity, φ %														
30	93	87	79	73	66	60	55	50	44	39	34	30	25	20	16
32	94	87	80	73	67	62	57	52	46	41	36	32	28	23	19
34	94	87	81	74	68	63	58	54	48	43	38	34	30	26	22
36	94	88	81	75	69	64	59	55	50	45	40	36	32	28	25
38	94	88	82	76	70	65	60	56	51	46	42	38	34	30	27
40	94	88	82	76	71	66	61	57	53	48	44	40	36	32	29
42	94	89	83	77	72	67	62	58	54	49	46	42	38	34	31
44	94	89	83	77	73	68	63	59	55	50	47	43	40	36	33
46	94	89	84	78	74	69	64	60	56	51	48	44	41	38	34
48	95	90	84	79	74	70	65	61	57	52	49	46	42	39	36
50	95	90	84	79	75	70	66	62	58	54	50	47	44	41	37
52	95	90	84	79	75	71	67	63	59	55	51	48	45	42	38
54	95	90	84	80	75	72	68	64	60	56	52	49	46	43	39
56	95	90	85	80	76	72	68	64	60	57	53	50	47	44	41
58	95	90	85	81	77	73	69	65	61	58	54	51	48	45	42
60	95	90	86	81	77	73	69	65	61	58	55	52	49	46	43
62	95	91	86	81	78	74	70	66	62	59	56	53	50	47	44
64	95	91	86	82	78	74	70	67	63	60	57	54	51	48	45
66	95	91	86	82	78	75	71	67	63	60	57	54	51	49	46
68	95	91	87	82	78	75	72	68	64	61	58	55	52	49	47
70	96	91	87	83	79	76	72	68	64	61	58	55	53	50	47
72	96	91	87	83	79	76	72	69	65	62	59	56	53	50	48
74	96	92	87	84	80	76	73	69	65	63	60	56	54	51	49
76	96	92	87	84	80	77	73	70	66	64	61	57	55	52	50
78	96	92	88	84	80	77	73	70	66	64	61	58	55	53	51
80	96	92	88	84	80	77	74	70	66	65	61	59	56	53	51
82	96	92	88	84	80	77	74	71	67	65	62	59	56	54	52
84	96	92	88	84	80	77	74	71	68	66	62	59	56	54	52
86	96	92	88	84	80	78	75	72	69	66	63	60	57	55	52
88	96	92	89	85	81	78	75	72	69	66	63	60	57	55	53
	Difference in the indications of dry and moist thermometers, °C														
Tdry	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	Air humidity, φ %														
30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
32	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-
34	14	15	-	-	-	-	-	-	-	-	-	-	-	-	-
36	21	18	14	-	-	-	-	-	-	-	-	-	-	-	-
38	24	20	17	14	-	-	-	-	-	-	-	-	-	-	-
40	26	23	20	16	-	-	-	-	-	-	-	-	-	-	-
42	28	25	22	19	16	-	-	-	-	-	-	-	-	-	-
44	30	27	24	21	18	-	-	-	-	-	-	-	-	-	-
46	31	28	25	22	20	18	16	-	-	-	-	-	-	-	-
48	33	30	27	24	22	20	17	-	-	-	-	-	-	-	-
50	34	31	29	26	24	22	19	17	14	-	-	-	-	-	-
52	36	33	30	27	25	23	20	18	16	-	-	-	-	-	-
54	37	34	32	29	27	24	22	19	18	16	14	-	-	-	-
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	14	-	-
62	41	38	36	33	32	28	27	25	23	21	19	17	16	-	-
64	42	39	37	34	33	30	28	26	24	22	20	18	17	16	-
66	43	40	38	35	34	31	29	27	25	23	22	20	18	17	15
68	44	41	39	36	35	32	30	28	26	24	23	21	19	17	16
70	45	41	39	37	36	33	31	29	27	25	24	22	20	18	17
72	46	42	40	38	37	34	32	30	28	26	25	23	21	19	18
74	47	43	41	39	38	35	33	31	29	27	26	24	22	20	19
76	48	44	42	40	38	36	34	32	30	28	27	25	23	21	20
78	49	45	42	40	39	37	35	33	31	29	27	25	24	22	21
80	49	45	43	41	40	38	36	34	32	30	28	26	25	23	22
82	49	46	44	42	40	38	36	34	32	30	29	27	26	24	23
84	49	46	44	42	41	39	37	35	33	31	30	28	26	25	23
86	50	47	45	43	42	40	38	36	34	32	30	28	27	26	24
88	50	48	46	44	42	40	38	36	34	33	31	29	28	27	25

Table 2 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.

4. Hygroscopicity of the Wood

The water to be found in the wood two basic structural elements: in the volume of cells - this the so-called 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 atmospheric pressure is 2260 kJ/kg (540) kcal/kg. In order to evaporate one kilogram of water, it is necessary to consume 1. 6 kilowatt-hour 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. Thus, the limit of 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.

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 30%, then with 60° C about 26%, and with 90° C are reduced approximately to 20%.

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) [12].

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. 1. Is here along the vertical axis plotted the relative humidity of air, and on the horizontal - its temperature.

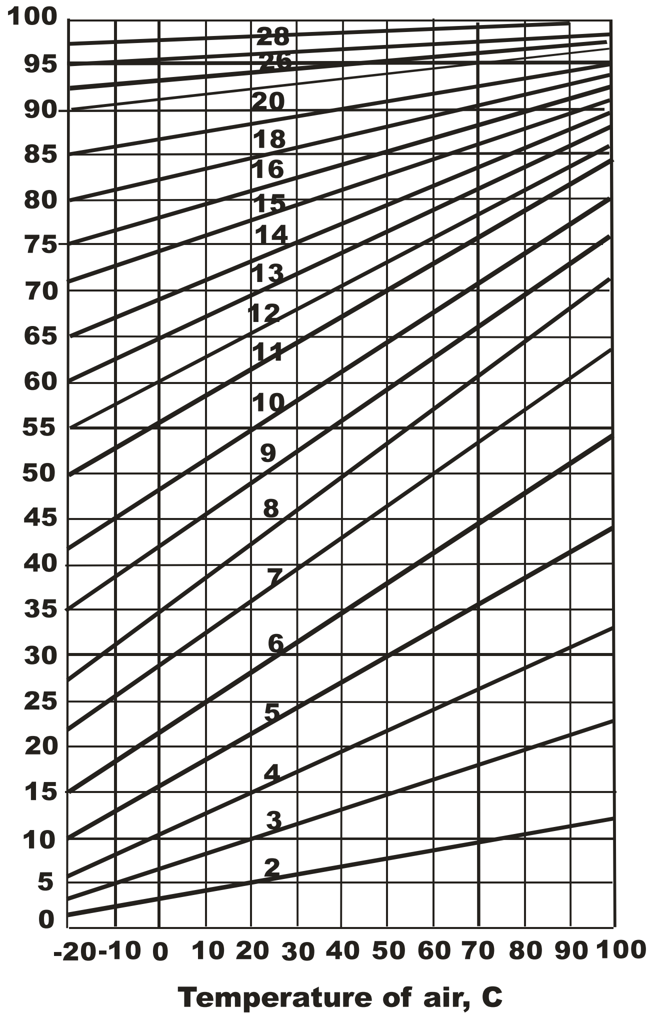

Fig. 1. Diagram of the equilibrium moisture [12].

As to use this diagram? For finding the relative humidity of the ambient atmosphere it follows to use the psychometric Table2 and Table 3. 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 gotten wet lumber should be packed in the dry accomodation on the padding and after a certain time it is possible to release them into the 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 another roofing. 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.

5. Properties of Moist and Dry Wood and the Processes, Proceeding in 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 elastic of the deformation of wood, which include with the prolonged drying the deformation of elastic after-effect (called sometimes resilient-elastic), and not reversed, residual of with 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. 2- A), having and then fastened in pairs their ends and heating wood, it is slow, into several stages, to unwedge in the middle (Fig. 2 - 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. 2- B)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 internal - stretching 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 external - compressions, 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.

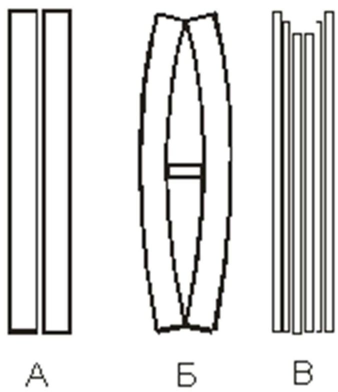

Fig. 2. *Diagrams of the elasto-compressible deformations of wood during the drying.*

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 process - swelling - 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 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, hornbeam 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 production. 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 ρ_y (kG/m^3), by which is implied the ratio of the mass of wood in the absolutely dry state m to its volume V with the humidity of higher than 30%: $\rho_y = \frac{m}{V}$.

Using a concept the conditional density of convenient to find a quantity M(kg/m^3) of the moisture, moved away 1 m^3 of wood, in spite of a change in this case in its volume: $M = \rho_y (w_н - w_к)/100$, where $w_н$ is wood moisture content to the drying (%); $w_к$ - wood moisture content after drying (%). The value of shrinkage, in reference to 1% of decrease of a quantity of connected moisture, is called the coefficient of shrinkage, and it is designated by the letter *k*.

Table 4. *The values of conditional densities and humid characteristics of the wodof basic wood species are given*

Wood species	Density			Coefficient of shrinkage in % to 1% of humidity			Wood moisture content on the root	
	Humid.12%	Abs. dry	Humid. conditi	Radial	Tangential	Volumetric	Heart-wood	Sap-wood
Birch	630	600	500	0.28	0.34	0.64	78	78
Beech	650	620	530	0.18	0.35	0.55	64	64
Hornbeam	800	760	630	0.24	0.35	0.61	60	60
Oak	700	650	550	0.19	0.29	0.50	64	72
Spruce	450	420	360	0.17	0.31	0.50	40	118
Cedar	440	410	350	0.12	0.28	0.42	70	115
Maple	690	650	550	0.20	0.32	0.54	51	51
Linden	500	470	400	0.23	0.33	0.58	63	60
Larch	660	630	520	0.20	0.39	0.61	82	82
Alder	530	490	420	0.17	0.30	0.49	84	84
Aspen	500	480	400	0.15	0.30	0.47	82	82
Fir	380	350	30	0.12	0.31	0.44	101	101
Pine	500	470	400	0.18	0.31	0.51	33	112
Poplar	460	430	360	0.14	0.28	0.44	110	110
Ash	690	650	550	0.19	0.31	0.52	35	36

The percentage of the shrinkage U according to this direction will be determined by the multiplication of the coefficient of shrinkage by the value of the decrease of humidity in the hygroscopic state (ie is below 30%) $U = K(30 - w_к)$. For example, the thin, slowly dried pine board with the width 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.

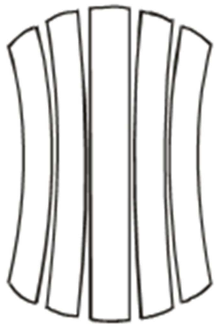

Fig. 3. *End form of boards after their drying.*

The 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. 3.

6. 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 regimes are represented in the form the timetable of the temperature of air, its psychrometric difference and the state of material, which are changed in the 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, φ-humidity of air in the camera.

Table 5. *Modes of humidity in the chamber*

R	Wood moisture	Mode number and humidity in the chamber,φ %														
		1			2			3			4			5		
		T	t	φ	T	t	φ	T	t	φ	T	t	φ	T	t	φ
	≥ 30	90	4	85	82	3	88	75	3	87	69	3	87	63	2	91
A	30 – 20	95	7	76	87	6	78	80	6	77	73	6	76	67	5	78
	≤ 20	120	32	32	108	27	35	100	26	35	91	24	36	83	22	36
	≥ 30	90	5	81	82	4	84	75	4	84	69	4	83	63	3	86
C	30 – 20	95	9	70	87	8	72	80	8	70	73	7	72	67	6	75
	≤ 20	120	34	29	108	29	32	100	28	32	91	25	34	83	23	34
	≥ 30	90	7	75	82	6	77	75	5	80	69	5	79	63	4	82
B	30 – 20	95	11	65	87	11	66	80	9	66	73	8	69	67	7	71
	≤ 20	120	36	26	108	21	30	100	24	30	91	26	33	83	24	32
	≥ 30	90	9	69	82	8	71	75	7	73	69	6	76	63	5	78
G	30 – 20	95	13	60	87	12	60	80	11	61	73	10	63	67	9	64
	≤ 20	120	37	25	108	33	27	100	31	27	91	28	30	83	25	30
	≥ 30	90	11	63	82	10	65	75	9	66	69	8	68	63	7	70
D	30 – 20	95	15	54	87	14	55	80	13	55	73	12	56	67	11	58
	≤ 20	120	38	24	108	35	24	100	33	25	91	30	20	83	27	28

Table 6. *Recommended drying mode for different types of wood.*

Wood specie	Drying mode	Recommended drying mode for various thicknesses						
		20 mm	22-30	30-40	40-50	50-60	60-70	70-80
Pine Tree	S	6 - D	6 - G	7 - G	7 - B	7 - B	7 - C	7 - C
Uhl	N	2 - D	3 - G	3 - B	4 - B	4 - C	5 - C	6 - C
Cedar, Fir	F	1 - D	1 - G	1 - B	2 - B	2 - C	3 - C	-
Larch	N	3 - B	4 - C	5 - C	5 - A	6 - A	8 - C	9 - C
Aspen	N	3 - G	3 - C	4 - C	5 - B	6 - B	7 - B	8 - B
Linden, Poplar	F	2 - G	2 - C	3 - C	4 - B	-	-	-
Birch	N	3 - D	4 - G	4 - B	5 - B	6 - C	7 - C	8 - C
Alder	F	2 - D	3 - G	3 - B	4 - B	-	-	-
Beech	N	4 - G	5 - B	6 - B	6 - C	7 - C	8 - C	9 - C
Maple	F	2 - G	3 - B	4 - B	-	-	-	-
OakTree	N	5 - G	6 - B	6 - C	7 - C	8 - C	9 - B	9 - C
Elm	F	3 - G	4 - B	5 - B	-	-	-	-
Nut	N	5 - B	5 - C	6 - G	6 - C	7 – B	8 - B	8 - C
Ash, Hornbeam	N	6 - B	6 - A	7 - C	8 - C	8 - C	9 - B	9 - C

In the Table 6 by letters S, N and F are designated drying regimes: soft, normal and forced respectively, are also given the recommended drying regimes of different species of the woods, which are selected in accordance with the Table 5. In this table in the column R of the capital letters A, B, C, G and D designated the categories of drying, and in the second line from above by numbers are indicated the numbers of regimes. The recommended regime corresponding to this category consists of nine numbers, which indicate the temperature of air in the camera, a difference in the temperature between the dry and wet-bulb thermometer and the humidity of air with these values of temperatures. The numbers indicated are located on the intersection of the line of the category of drying and column of the number of regime. Entire cycle of drying is divided into three stages. The first stage corresponds to the removal of the free moisture and it is not connected with a change in the dimensions of wood due to its shrinkage. In the second and third stage the removal of the connected intracellular moisture begins, and this stage is most critical. The disturbance of drying regime in this stage can lead to the marriage.

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.

7. Constructions of the Drying Chambers

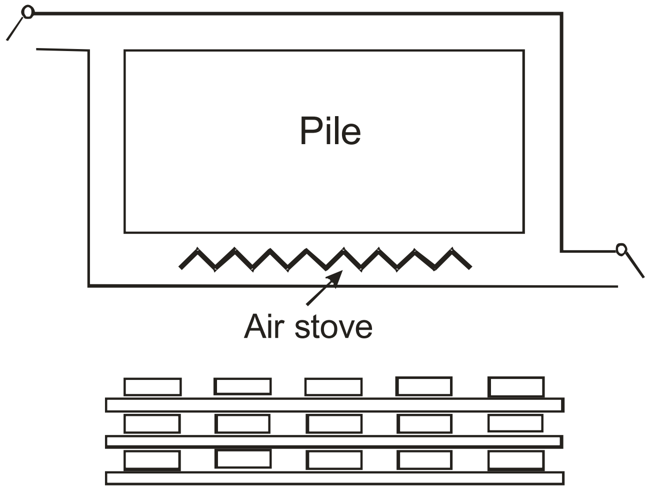

Fig. 4. Diagram of drying chamber with the free convection and the principle of piling pile.

The basic task of drying chambers is the guarantee of the necessary circulation of the drying agent with its simultaneous preheating and maintaining its assigned humidity. The circulation of the drying agent can be achieved in two ways either due to the free convection or by way of the forced scavenging of the pile, when with the aid of the fan is created excess pressure from one side of pile and lowered - with another. The process, when in the gravitational field warmer air due to the smaller specific weight rises upward, is called free convection, and colder - descends. With the use of free convection the air stoves are established under the pile, and pile itself is plotted so that between the boards there would be sufficiently large spaces the allowing possibility free passages of the flows of the drying agent. The adjustable tributary and exhaust vent openings are established for maintaining the necessary humidity of air in this camera in its lower and upper part. Regulating their section, they attain the desired operating mode. The diagram of this camera is shown in Fig. 4. In practice adjustable can be only exhaust opening, while lower it can be always opened. Since the specific weight of the warm humid air is more than of cold, air leave will not be through the lower opening, and the ventilation of camera can be regulated only by exhaust opening.

In the lower part of the figure is shown the principle of piling pile. The size of spaces between the boards depends on the height of pile, and the higher it is, the greater their width must be. Usually the width of spaces is selected in the limits of the half-width of board. Significant clearances between the chamber walls and the pile must be provide ford with this method of drying, their width from both sides must comprise to the half-width of the sum of the widths of spaces. Such wide clearances are necessary for the realization of the free convection of the drying agent in the zone of the arrangement of boards. In the cameras of this construction there are two main disadvantages. They have very small load factor (ratio of the volume of the loaded wood to the volume of camera itself). This coefficient composes order 0.1. The second drawback is that in connection with the low speed of the convection currents in such cameras is difficult to ensure the severe drying regimes of the soft rocks of wood. Ease of fabrication and reliability of operation is advantage. Advantage is the fact that in this camera can be plotted immediately several piles boards and this does not lengthwise worsen the parameters of drying. Much more effective are camera with the forced scavenging of the pile, when this scavenging is achieved with the aid of the fans. One of the primary tasks, which costs before the designers of such cameras, appears a maximally effective scavenging of pile with the minimum expenditures of electric power. There is a very large number of modifications of such cameras, the diagrams of work of which, are given below.

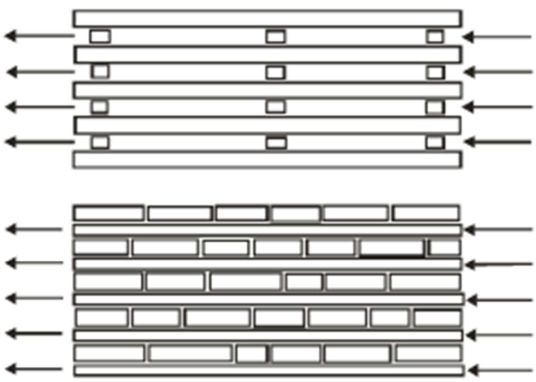

Fig. 5. Diagrams of the scavenging of pile.

Exists two diagrams of the scavenging of the pile: transverse and longitudinal. They are shown in Fig. 5. On these diagrams the direction of scavenging is shown by pointers. Upper position in Fig. 5 correspond to the longitudinal scavenging, when air moves along the boards. In this case between the boards must be observed the spaces in the sum the equal to ~ 20% spans of boards, since otherwise the padding between the boards will prevent the passage of air between the layers of boards. This method can be used only with the small length of boards and in the presence in camera not more than two piles. Lower position in the figure corresponds to transverse scavenging. This is more effectively method of scavenging, and with its use boards can be plotted close. The coefficient of piling occurs above with the longitudinal scavenging, since the clearances for the passage of air are not necessary between the chamber walls and the pile, and this method of piling with the small-scale production is simpler. With this method of piling the load factor can be brought to the values ~ 0.25. In the case of transverse scavenging between side walls and pile must be observed the clearance, that also decreases the load factor. The optimum section of padding composes ~ 30 - 40 mm.

There is a very large number of modifications of the cameras with the forced scavenging, whose most common diagrams, are given below.

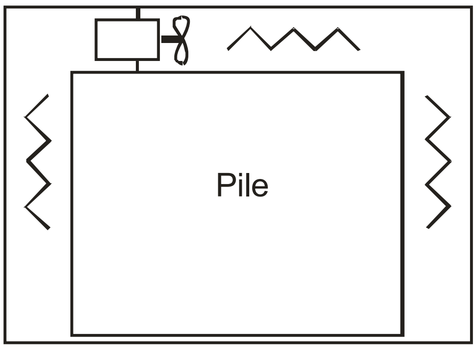

Fig. 6. *Diagram with the upper arrangement of fan.*

The diagram of camera with the upper arrangement of fan is shown in Fig. 6. Heating elements with this scavenging can be located both in its upper part and along the sides. This construction possesses the following deficiencies. First, fan is located in the zone of hot and humid air; therefore the construction of the engine used must satisfy such operating conditions. A drawback in this scavenging is the fact that is difficult to remove the by-passes of the passage of air, especially with the transverse scavenging of pile. In addition to this, during the drying the height of pile changes due to the shrinkage of wood and between the partition, which divides zones with different air pressure and upper edge of pile it is formed clearance. Also with the manual piling of pile directly in the camera it is easy to damage both fan and partition.

The more rational diagrams of scavenging are those, with which the electric motor is located out of the zone of camera. One of the versions of this scavenging is shown in Fig. 7.

This diagram possesses that advantage that any engine can be used. However, essential drawback is the presence of the extension shaft, one of bearings of which nevertheless to be located inside the camera. In all these constructions the axial-flow blowers, which be inferior to fan blowers, are used from their parameters.

The rational diagram of scavenging is the diagram, with which both the engine and fan are located out of the zone of camera. In this case heating element can be located both in the zone of camera and beyond its limits. The diagrams of this scavenging are depicted in Fig. 8 and Fig. 9.

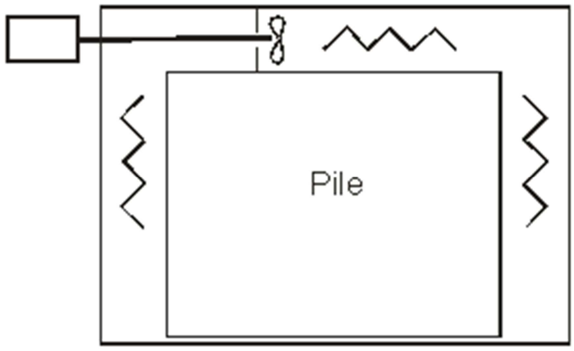

Fig. 7. *Diagram of camera with the external arrangement of engine.*

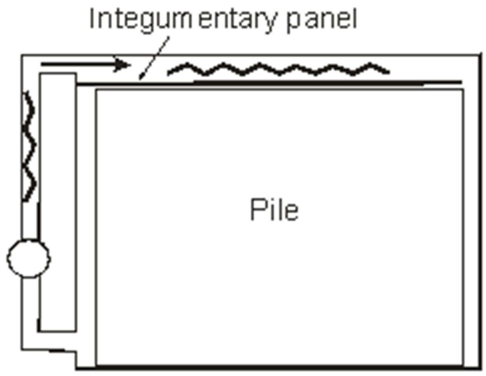

Fig. 8. *Camera with the external arrangement of fan.*

During this construction engine and the fan blower (in the figure it is designated by number 1) are located beyond the limits of camera. A certain drawback in this method of scavenging is the fact that be required the additional channels for the supply into the camera of air and its recovery conversely to the fan, which require additional heat insulation. The additional joints of channels with camera itself, are also its technological drawback. Essential advantage is that with the decrease of the height of pile is not formed the additional slots between the zones with different pressure. This is reached with the aid of the integumentary panel, which is plotted above the pile. With a change in the dimensions of pile, edge of panel they slide through the end and lateral chamber walls, without creating additional slots for the reverse overflow of air. For the tighter fit of panel to the chamber walls, to its edges can be fastened the strips of sheet rubber. For convenience in the arrangement of panel it can be prepared from several separate sections, begun to move consecutively.

The diagram of camera during the external arrangement of engine, which does not require additional shaft, for the transfer of rotation to the camera, with which the fan blower is located in camera itself, it is shown in Fig. 9. Heating elements during this construction are located in camera itself between the chamber wall and the partition, which separates ventilator it cut off from the pile.

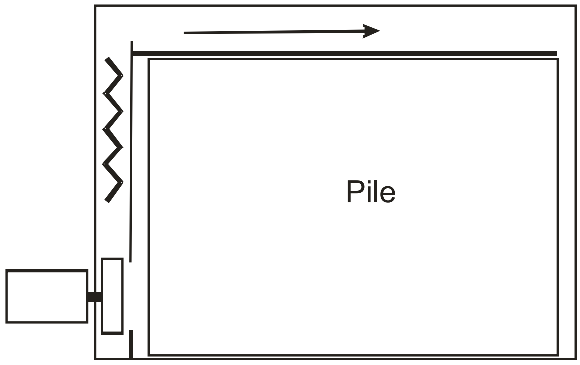

Fig. 9. *Camera with the external arrangement of engine and the internal arrangement of fan blower.*

The camera, depicted in Fig. 9, possess a number of advantages, in comparison with versions examined above. Fan blower is mounted directly to the axis of engine and is located inside the camera, while engine itself it is located beyond its limits. There is a sufficiently large space for the arrangement of the heating elements, which due to the effective scavenging provide a good heat exchange with the drying agent. With a change in the height of pile integumentary panel prevents the by-passes of the passage of air, ensuring the high efficiency of the scavenging of pile. A drawback in the construction is that in the case of failure of engine during the chamber operation is necessary to unload wood from it in order to remove fan blower from the axis of engine.

Volume air-blown through the pile to every 10 m^3 of wood must compose depending on drying regime from 3 to 10 t in hour. To determine this volume is possible, knowing the power of heater and the difference of the temperature of air before the heater and after it. Because the heat capacity of air $1\frac{kJ}{kg\ K}$, the mass flow rate of air at the famous $P(kW)$ heater power and temperature difference is determined by the formula ΔT

$$m = \frac{P}{\Delta T}(kg/s)$$

It is separately simple to carry out such measurements, if the electric heater with the known power is used as the heater.

Electrical energy for preheating air can be used not only for the warming-up of electric heater. There are the so-called aerodynamic cameras, in which the fans fulfill two functions, achieve scavenging of pile and convert mechanical energy into the thermal. The power of this heater is equal to the power, consumed by the electric motor of fan taking into account efficiency engine. So if the efficiency of engine composes 80%, then in the aerodynamic version, it is heater with the same efficiency. Therefore very importantly it will learn to use an aerodynamic method of preheating air in such a way as to completely use that energy, which consumes the engine. For these purposes it is possible to use additional preheating of air, suck ined into the camera from the atmosphere, passing it along engine cowling. This version is shown in Fig. 10.

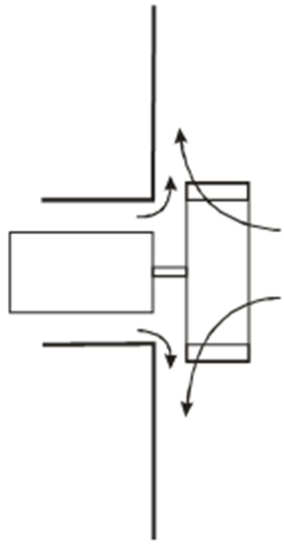

Fig. 10. *Use Bernuli effect for air suction into the camera.*

Knows that the pressure in a moving stream of gas or liquid is smaller than the fixed gas flow in the surrounding. Therefore a moving stream of podsasyvaet gas from the environment. InFig. 10 are shown as Bernulieffectcan be used for the sucking into the camera of air from the atmosphere. Fan blower creates airflow as shown in figure. These flows induced air from the atmosphere. Passing along engine cowling, it select in it that thermal energy, which is not expended on the rotation of fan. This effect, as it will be shown below, can be used also for air suction in the usual drying chambers.

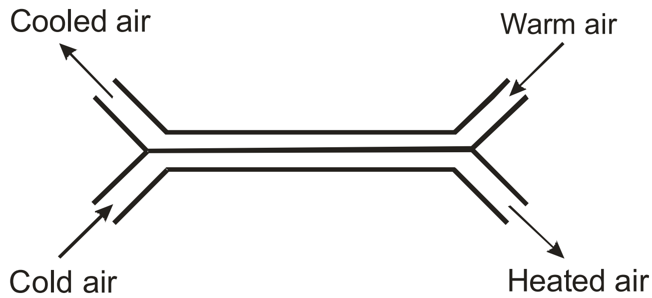

Fig. 11. *The action plate.*

The savings of energy can be achieved by the way of applying the recuperators, when heated air ejected from the camera returns its energy to air, suck ined from the atmosphere. The operating principle of recuperator is shown in Fig. 11.

There are two in the recuperator oncoming airflow, one warm air coming out of the camera and the other is cold air is drawn into the cell from the atmosphere. Passing along the channels, which have the overall heat-conducting wall, warm air returns its energy to the counter flow of cold air, preheating it. In the practice the recuperators of different constructions are used, the simplest of them - pipe-casing. It consists of the pipe of large diameter, through which are passed the tubes of smaller diameter. Through these pipes (large and small diameters) they pass air in the counter direction, as it is indicated in Fig. 11. Steam boiler of locomotive is built according to this principle. The shell-and-tube heat exchangers are used when along the pipes necessary to pass gas under the large pressure, which is not in the drying chambers. In this case it is possible to use the simplest heat exchangers, which consist in all of two flat pipes of rectangular cross section, whose heat exchange is achieved through the general partition. Application of recuperators gives savings in the energy consumption to 30%.

The realization of the process of drying is connected with the fact that the part of moist heated air, blown through the pile, it is ejected outside, taking away with itself the moisture, which was evaporated from the wood. For these purposes in the cameras the additional weak exhaust fan, which achieves this of operation, is established. The temperature in the camera is regulated by the selection of the power of heater, and its relative humidity in the camera is regulated by the way of the standardized ejection from the camera of humid air. Using these two operations, they attain those regimes, which are indicated in the Table №6.

8. 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 necessary to replace the malfunctioned engines, but 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 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.

Let us formulate the basic tasks, which were placed with the development of the camera indicated:

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.

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.

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.

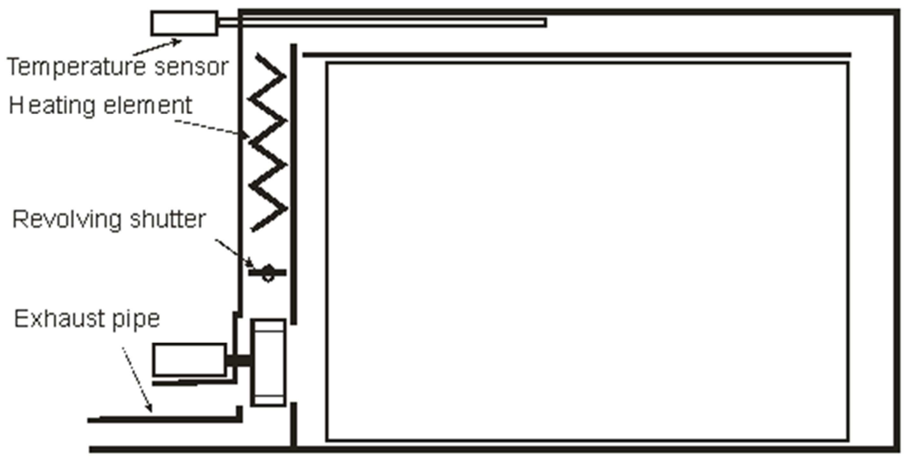

Fig. 12. *Diagram of universal drying chamber.*

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. 12), and let us then describe its separate units and methods of their production.

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 L-shaped 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 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 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. The operating principle of this sucking is shown in Fig. 10. For the adjustment 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. 13.In the lath there are 5 openings with a diameter 30 mm.

Fig. 13. *Planck with the openings.*

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 possible to pour the earthen pillow with a thickness ~ 10-15 cm, having preliminarily packed it.

Since in the given construction air into the camera is forced, with the no acceptance of the corresponding measures, can become unsuitable steel framework and thermo insulation 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 cross-sectional 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.

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 heat-insulated boxing, whose internal and external casing 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.

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 cross-section 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.

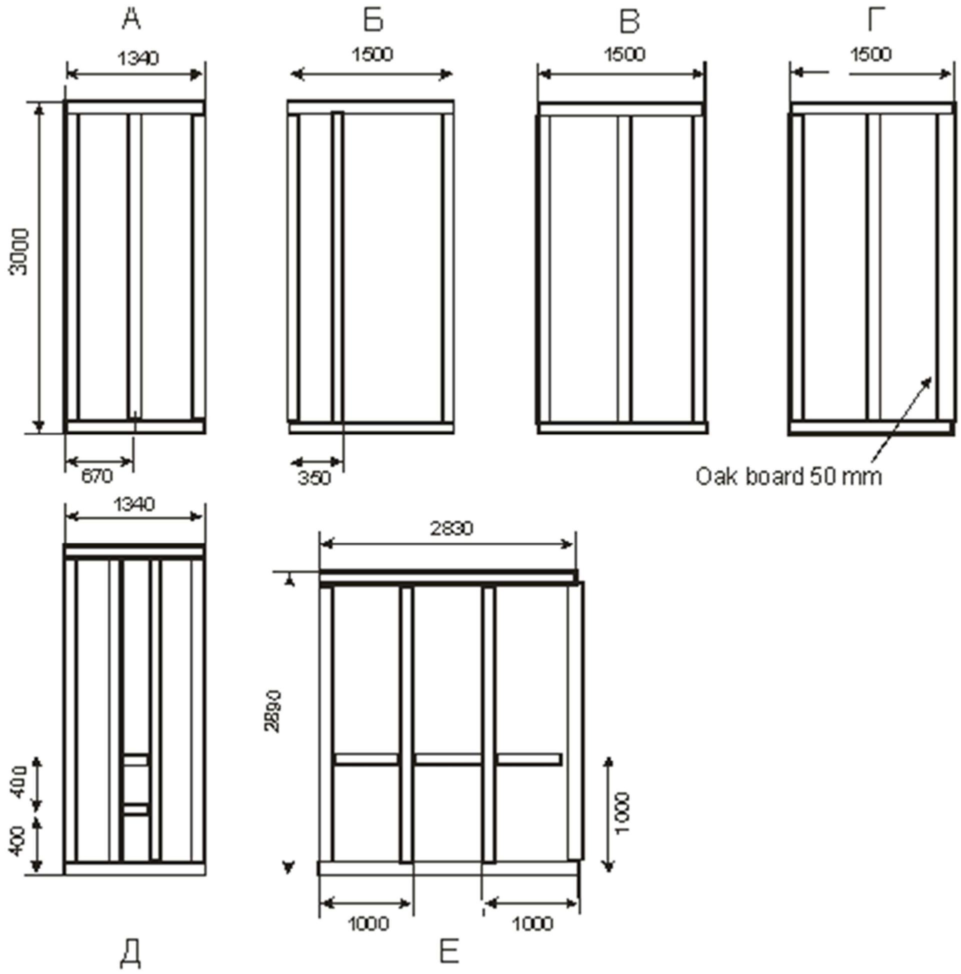

Fig. 14. *Sketches of frames for preparing of walls, ceiling and door of camera.*

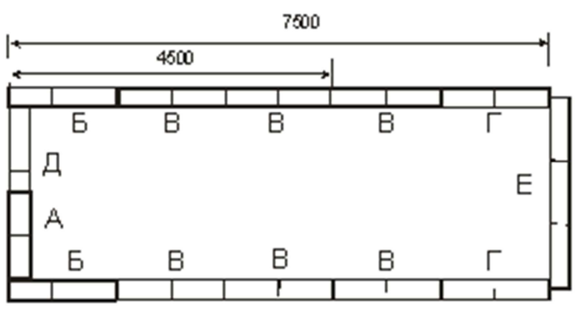

Fig. 15. *Sequence of the installation of the blocks of camera.*

The sketches of all blocks of entering the assembly are given in Fig. 14. In all blocks there is a central partition, necessary for the rigid fastening of the sheets of internal and external casing.

In Fig. 15 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 Г 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 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 adjacent to the door, is exception, the block Г, 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 section30x140 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 size1500x3000mm. 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 this 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 temperature in the camera. Opening under the head of 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 heat-insulating 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 2 mm. With the aid of these brackets the hose is fastened along the periphery of door frame, as shown in Fig. 16. 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.

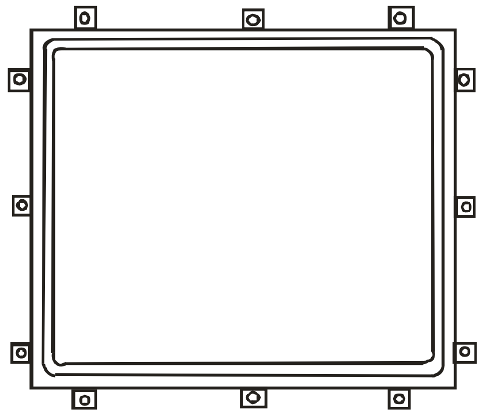

Fig. 16. *Schematic of fastening the sealing hose and corners of the delay of door.*

In Fig. 16 are shown also the corners, which are attached to the lateral ends of door with the aid of the wood screws (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 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.

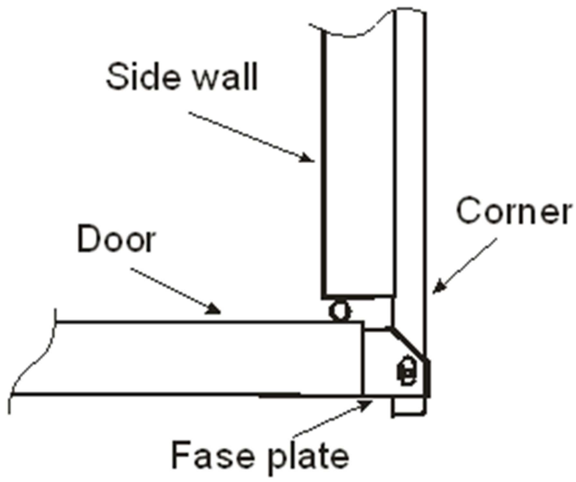

Fig. 17. *Unit of the suspension of door to the chamber wall.*

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 face plates are made by oval, as shown in Fig 17. 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. 17.

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.

In the lower part of the front chamber end with this end be fastened to in range oak board with the thickness 50 mm (Fig. 18).

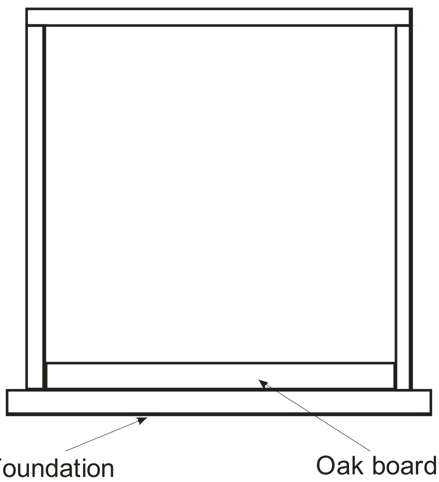

Fig. 18. *Form of camera on the foundation from the side of door.*

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 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 315 mm, which is mounted to the axis of engine. Engine is established on the steel platform 5x360x400, as shown in Fig. 19 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 300x355 mm. Engine is established in the aperture of block d. The form of aperture is shown in Fig. 20 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 Г 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. 19. Openings can be stopped up by different quantity of plugs how is regulated the intensity of sucking.

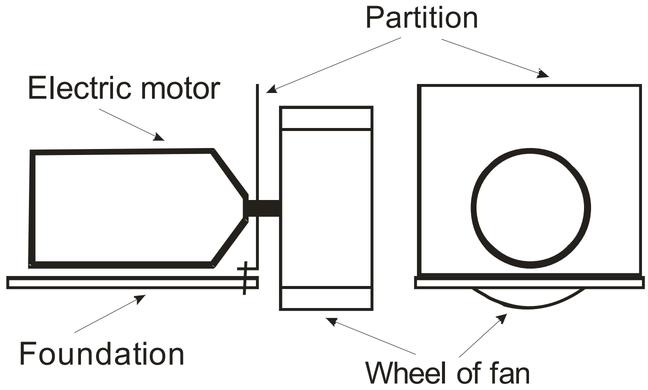

Fig. 19. *Layout of fan on the platform.*

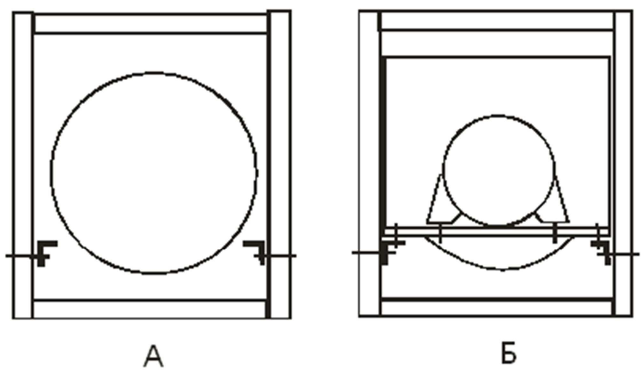

Fig. 20. *Aperture for the installation of fan (form A) and the fan, established in the aperture (form Б).*

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.

Let us give the parameters and the construction of the effective safe heater, made from strip that not corroding they became 12X18H10T(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 8 kW 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 the camera two piles are located, then should be established two such electric heater.

For the drying of the soft rocks, where it is necessary to increase the power of heaters approximately two times, electric heaters are 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 heaters are established between two slate partitions and of direct contact with the wood have they cannot.

The tape of electric heaters is located on the holders (hooks) with zigzag means, as shown in Fig. 21. 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 heaters are 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.

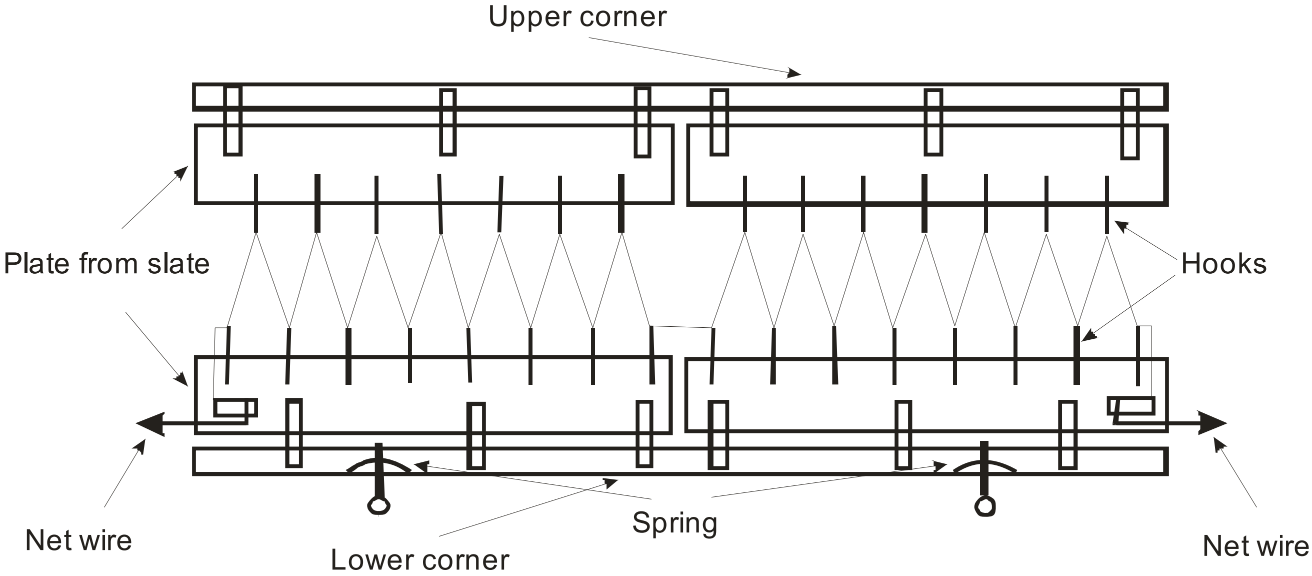

Fig. 21. *Construction of electric heater.*

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. 22.

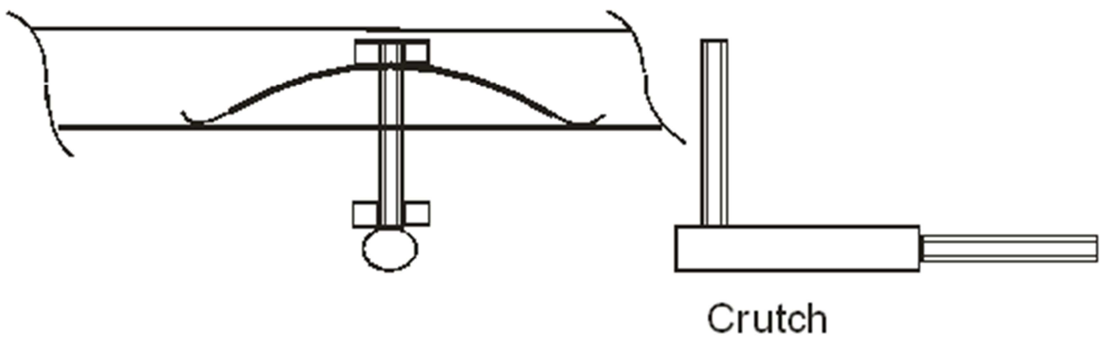

Fig. 22. *Construction of spring unit.*

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 heater lower 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 heaters themselves in the camera is shown in Fig. 23.

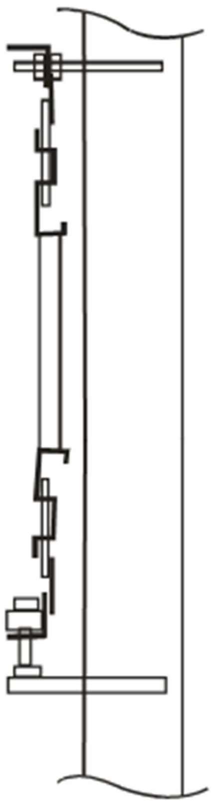

Fig. 23. *Fastening the hooks on the slate plates and of electric heater themselves in the camera is shown in fig.*

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.

9. Cyclic the Methods of the Drying of Wood and Its Realization

In this camera is selected the special duty-cycle 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 firstcycle 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, moistening 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. 24.

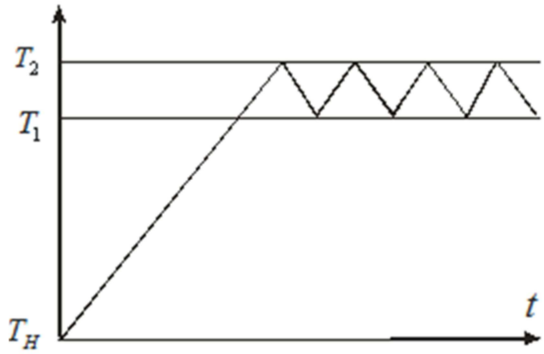

Fig. 24. *Temperature graph of cyclic drying regime.*

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. 25.

Fig. 25. *Temperature sensor.*

In the polyethylene tube (in the figure it it is shown by black color) is located the steel bar, fixed to one of the ends of the tube. With the length of the sensor of 2000[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.

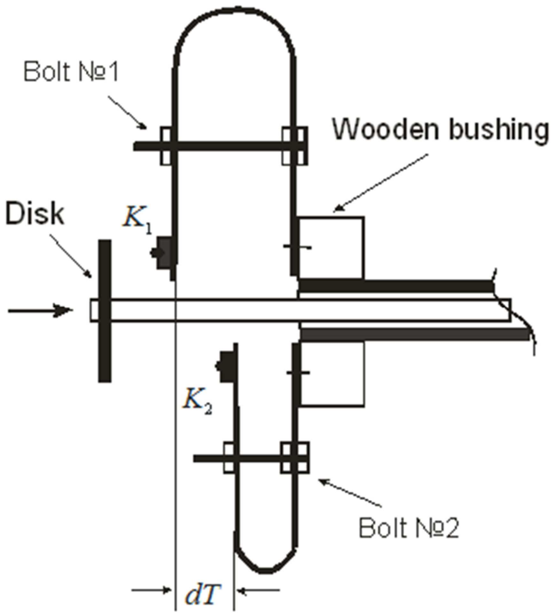

Fig. 26. *Actuating mechanism of temperature sensor.*

The schematic of the actuating mechanism of temperature sensor is shown in Fig. 26. 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.

10. Electrical Circuits of the Cameras

The electrical circuit of camera with a length 4500 mm, intended for the drying of hardwood is represented in Fig. 27. 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.

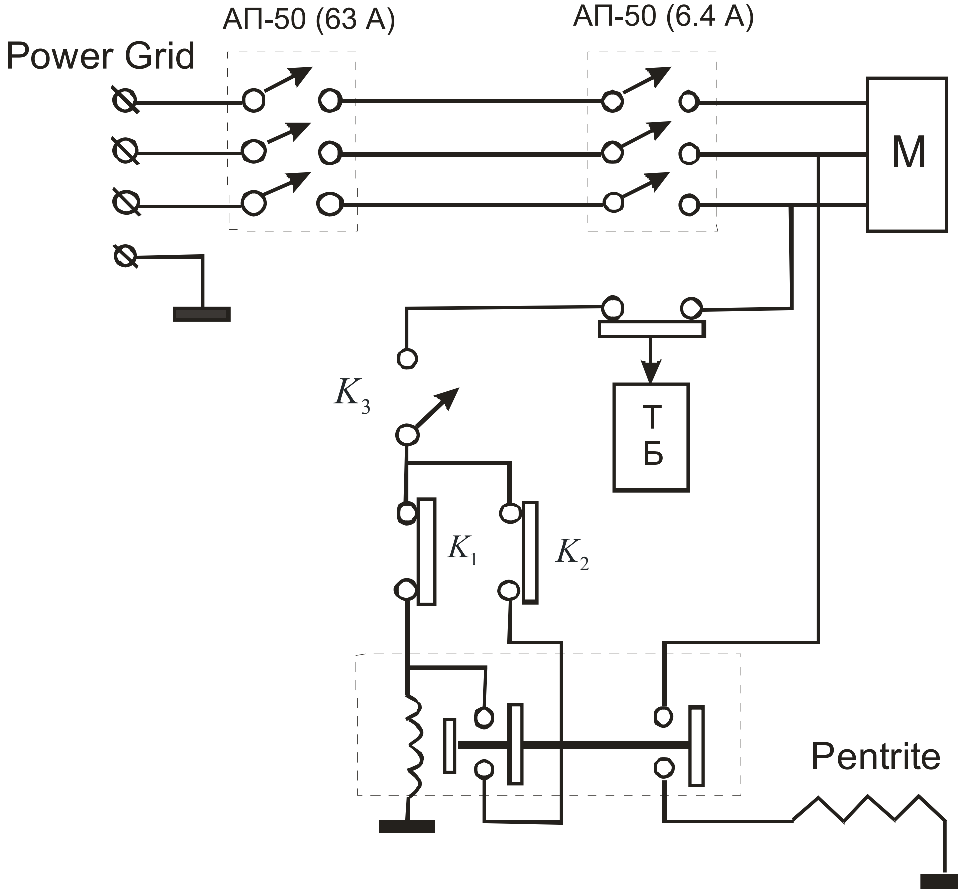

Fig. 27. *Electrical circuit of camera for the drying of one pile.*

Key K_3, as which is used toggle switch, serves 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. 26), and also starter PME-211. Its weak-current 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 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. These temperatures are established with the aid of the nuts on the bolts of spring. During the arrangement of bolts on the springs of regulator, one should follow the fact so that the openings in the springs would be more than the diameters of bolts and they did not prevent free compression of spring with the tuning and work of system.

The diagram of the universal camera with a length 7500 mm intended for the drying both of solid, and soft rocks, it is shown in Fig. 28.

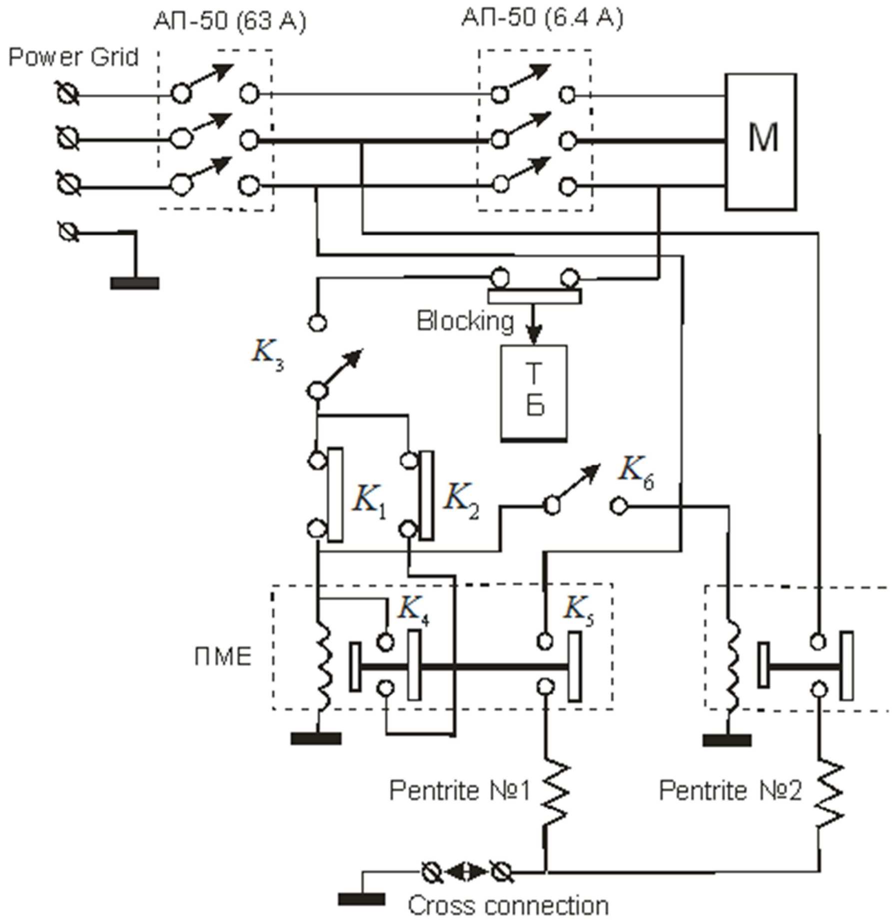

Fig. 28. *Electrical circuit of universal camera.*

In contrast to the diagram, depicted in Fig. 27, in the camera are two electric heaters which provide the possibility to work in three regimes. In the first regime when are torn the contacts of key K_6, to the network is connected only electric heater №1 and the power required by it is 8 kW. In this case the cross connection depicted in the lower part of the diagram, locks terminals. With closing of key K_6 occurs the connection of second electric heater №2, and the power required is 16 kW. In the case of breaking the cross connection both PETN electric heaters prove to be those switch one between two phases consecutively, and the power required by them is 24 kW. These three regimes make it possible to dry in the camera both one pile and two piles of wood both solid and soft rocks. One pile of solid rocks is placed with the nominal power of 6 kW in the camera. With the nominal power 12 kW in the camera can be placed either two piles of solid rocks, or one pile of the soft rocks. Two piles of the soft rocks are placed with the nominal power 24 kW in the camera.

For the passage to the drying regime of the soft rocks one ought not each time to reconstruct the block of the control of temperature, but should be prepared separate sensor, after disposing it to the appropriate regime. Channel switch should be produced with the aid of the switch of regimes. For this it is possible to use three toggle switches, with the aid of which should be three conductors from one sensor thrown to three conductors of another. In this case it is necessary to perform still one operation, after removing the cross connection, indicated in the lower part of the diagram. With the drying of solid rocks should be upper temperature established ~ 65-70 ^{0}C and lower ~ 50-55^{0}C. With the drying of the soft rocks these intervals 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 kilowatt-hour, while with the drying of solid rocks~ 900-1000 kilowatt-hour.

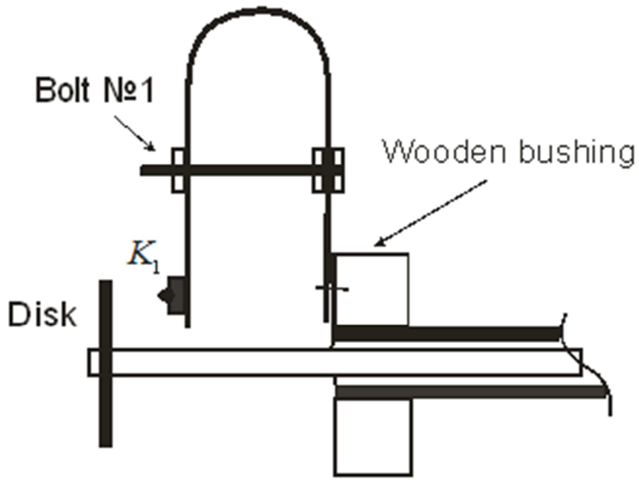

Fig. 29. *Schematic of blanking sensor.*

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. 29.

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.

The 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. 30.

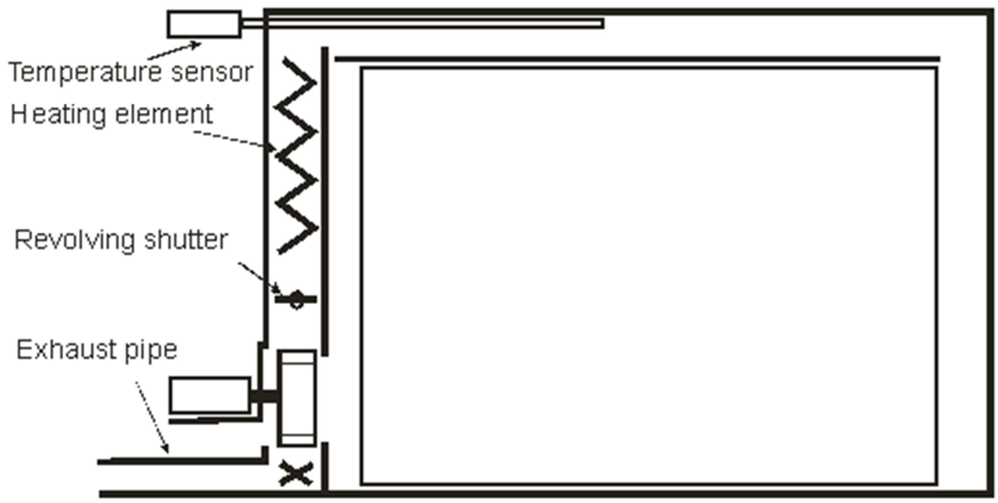

Fig. 30. *Diagram of condensing chamber.*

This diagram is differed from the diagram, depicted in Fig. 11, 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.12) 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. 27 with the only difference that instead electric heater is 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 hot-water boiler is strongly reduced because of by the small difference between the temperature in the camera and the temperature of water. With the work with the hot-water boiler the surface of batteries must be ~ 15 m^2, while with the use electric heater 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.

11. Conclusion

The wood is one of the most common building materials. It is widely used not only in the structures, but also for preparing of furniture and number of technological articles. For preparing the furniture is used the dry wood of high quality, in which there are no stresses and cracks. For obtaining this wood the drying chambers, which ensure the high quality of drying, are used. Special difficulties causes the drying of the wood of such solid rocks as oak, ash, maple, beech. By questions of development and production of drying chambers the occupied huge number of firms and production organizations, but is up to now located number of the problems, which require their solution. The complete automation of drying process is one of such problems, and this problem entirely up to now is not solved. The majorities of the cameras produced by industry require the interference of operator in the drying process and a constant correction of drying regime. In this article is described simple automated drying chamber for the high-quality drying of wood, which in all time of drying does not require the interference of operator. Camera is simple in the production and does not require complex technological equipment for its production. The automation of process is achieved by the way of using the cyclic drying regime.

References

[1] Lamb F.M., Wengert E.M. Hard wood drying test evaluates new methods, Forest Ind.- 1982.- Vol. 109, №13.- pp. 21-22.

[2] Gryshchenko S. I. Deform ability and cracking during drying of lumber, Woodtechnology.-L.,1989.-pp.8-11.

[3] Gluchich V. N. To a question about the quality of drying lumber, Kososloynyh Larch, -Krasnoyarsk, 1984.-pp.66-71.

[4] Golenishtchev A. N., Dobrynin S. V., Andreev A. A. Drying and protective treatment wood.-M.: Forest Industry, 1984.

[5] Kulakov V. V., Gernet M. G. Qualitylumber drying chambers continuous with increased height of the stack. Integrated use ofwood.-Arkhangelsk, 1984.-pp.8284.

[6] Krechetov I. V. Drying of wood, Textbooks for higher education, M .:Breeze, 1997.

[7] LebedevV. A. Device for controlling the humidity of lumber in the process of drying chamber, Woodindustry-1986.- №12.- pp.5-6.

[8] MerkushevI. M. Analysis of the energy intensity of non-traditional methods of drying lumber, Wood working industry-1989.- №10.-pp.31-35.

[9] Nikolov S. Comparative studies Moist wood during, Woodworking industry-1981.- №6-pp.29-31.

[10] Svilen N. Stress and strainin dried wood at the finalhy drothermal treatment. Wood and Furnitureindustry.-1989.-Vol. 31, №5,pp.15-18.

[11] Sergovsky P. S., Fakhretdinov H. A. New modes of drying of aspen lumber, Woodindustry.-1991.- №1.-pp.4-7.

[12] KrechetovI. V. Drying of wood, M., Forestry, 1980.