9. AIR DRYER

Z. Osmanov, A. Bashiashvili
School № 42 named after I.N. Vekua

To solve this problem, let's at first solve such a sub-problem. We have vessel with water vapor at given humidity and on given temperature, and the question will be: how much shell we decrease temperature for water vapor to condense? This problem has direct connection with our one, because we also get water from atmosphere air by condensing it and we need low temperatures of condensing surface. So let's go directly to solution of our sub-problem.

Humidity determination is:

$$f = \frac{P(T)}{P_s(T)}$$

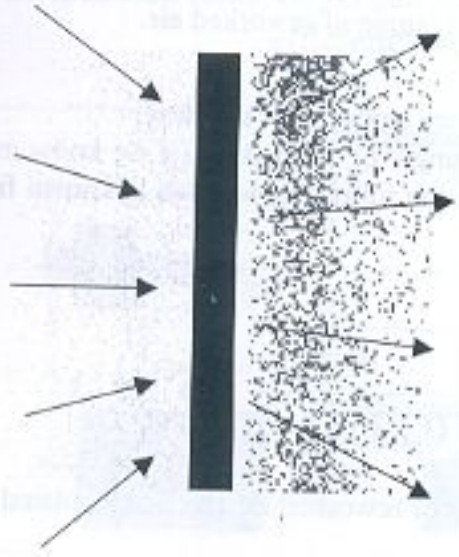
Where P(T) – is water vapor pressure on the given T temperature and P_s (T) – saturated vapor pressure on the given temperature.

So, the condition for the water vapor condensation is following:

$$\boxed{fP_H(T_0) \geq P_H(T)}$$

Let's write Klausius-Klaperon equation for the saturated vapor pressure on the given temperature:

$$\frac{dP}{dT} = \frac{\mu q}{RT^2} P$$



Because T and P alternation is small, one can assume:

$$\frac{dP}{dT} \approx \frac{P_2 - P_1}{T_2 - T_1} \Rightarrow$$

And get, that:

$$\frac{T_2 - T_1}{P_2 - P_1} = \frac{RT_1^2}{\mu q P_1}$$

Finally applying following conditions:

$$P(T_1) = fP_H(T_1) = fP_1$$

$$P_2 = \frac{T_2}{T_1} fP_1$$

One can get:

$$T_2 - T_1 = -3{,}3K$$

So, it's enough for temperature to change on 3,3K for dew to fall, but really in experiment we have much bigger temperature alterantion: about 20-25K.

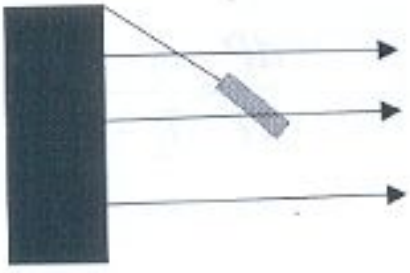
After these calculations we can choose the way of cooling condensing surface: it can be ether vaporisation or solution of ammonium nitrate. We've constructed both type of devices and it was very interesting to estimate their efficiencies. So we input such definition of efficiency: since we can get hov much air we've "refined" we can calculate how much water potentially we could get (on given humidity) and from experiment we know how much water we've got so let's call ratio of experimentally got water to potentially "refined" water efficiency:

$$\boxed{\eta = \frac{m_e}{m_p}}$$

$$m_p = v\mu$$

where μ — mass of a water per volume unit. v — volume of reworked air.

Now our problem is to get, how much air we reworked, we can solve it this way:
If we hang small plate over the air flow we can get by angle of inclination (if we know mass and surface square of the plate) velocity of the air flow, the following formula is known from Jukowski's SOCHINENIYA.



$$v = \sqrt{\frac{mg}{0{,}135 S tg\alpha}} \approx 6 \quad m/s$$

Then volume of reworked air can be calculated so:

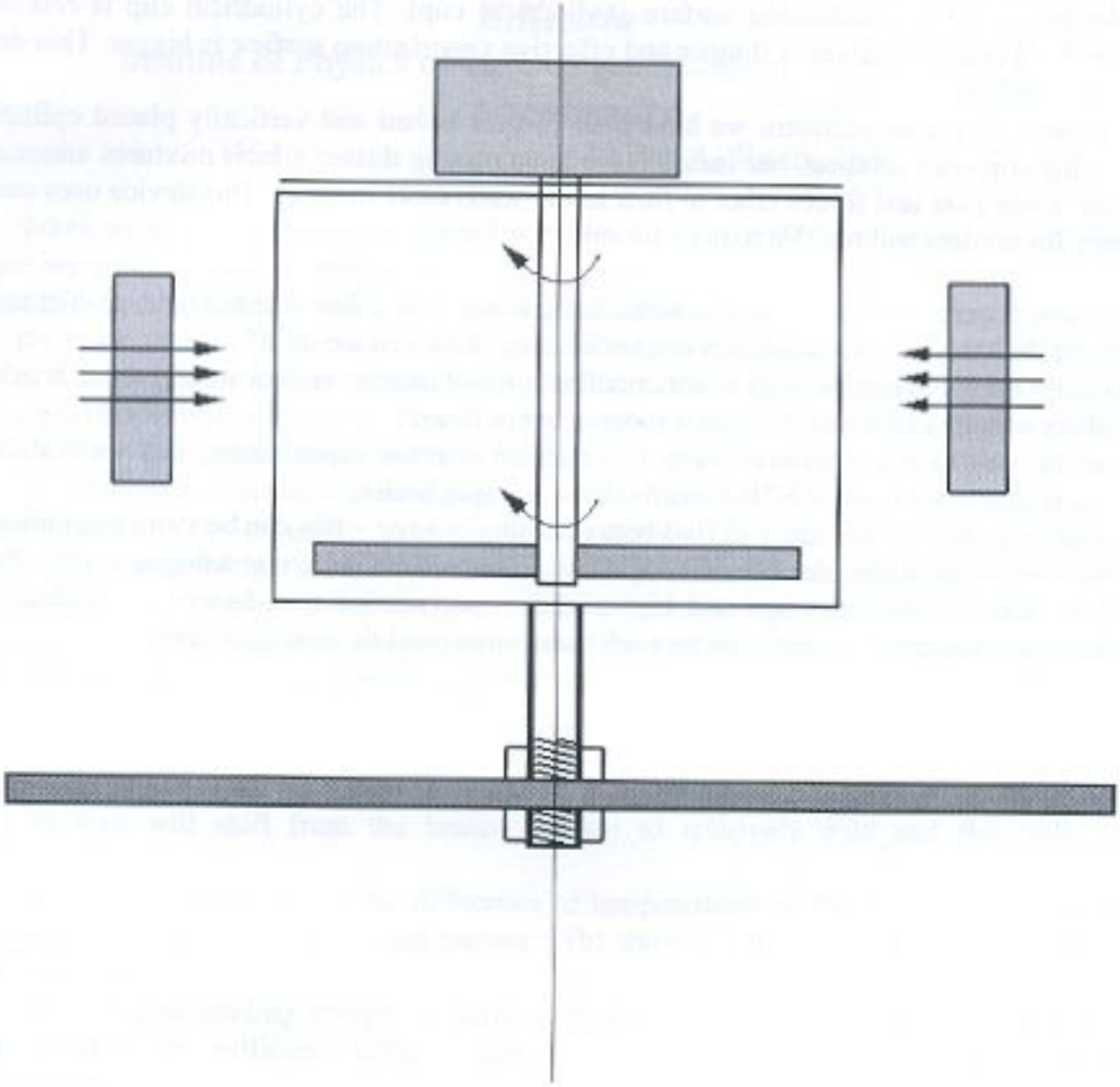
$$V = NSvt$$

where t is 4 mins and N – number of air emitting coolers.

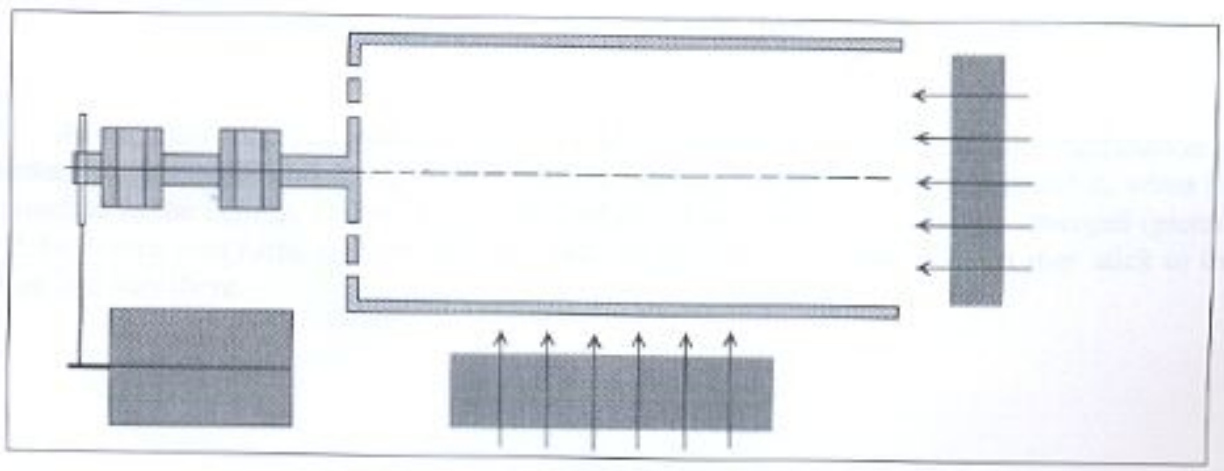
So, efficiencies for both two devices are:

Here are schemes of our devices.

$$\eta_1 \approx 6\% \quad \eta_2 \approx 3\%$$



This device (side view) can be used both with ammonium nitrate and ether, efficiency coefficient before is for ether.



And this device (top view) can be used only with ether.

Now I want to describe our devices.

In first we have a platform where are bolted: motor, two coolers and cylindrical cup in horizontal position (due to its symmetry axis). This cup has holes in bottom – it's for vaporized ether to flow out. Job of one of the coolers is to make ether flowing out and other cooler brings air to condensing surface (cylindrical cup). The cylindrical cup is rotated by motor, by this ether is layer is thinner and effective vaporization surface is bigger. This device uses 18V battery.

In second device on platform we have four coolers bolted and vertically placed cylindrical cup. This cup isn't rotating, but inside it we have mixing device which mixtures ammonium nitrate in one case and forces ether to flow to the walls ether in other. This device uses one 9V battery for coolers and one 3V battery for mixer.

And now I want to make a short conclusion and say just a few words about problems with usage of this devices. We need to rise up efficiency: how can we do it?

The main minus in exploitation is water collection, we used to collect water rubber brush and to collect water by this way it's better to have water freeze.

Also the way to rise efficiency is to rise surface of ether vaporization, this we realized in second device – we made REZBA inside the rotating cylinder.

Another way to rise efficiency to find better cooling source – this can be Peltier modules, but for us they were unusable, because the device mass limit was one kilogram and Peltier modules require small voltage and big current – we needed transformer to produce such output, but it's extremly hard to make such transformer and fit in weight limit.