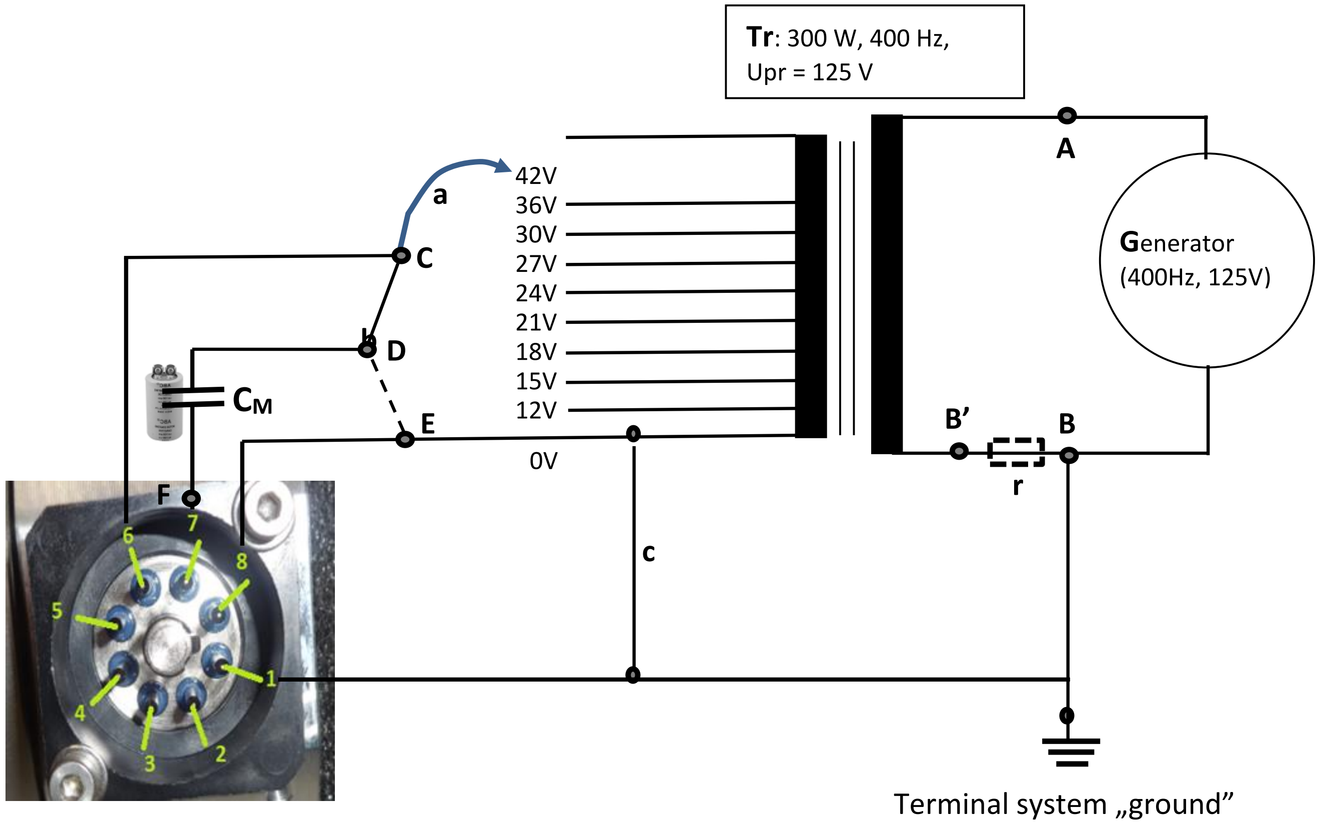
**Switching diagram for supplying the turbo pump for the gas stripper**
**(author Bela Sulik [sulik@atomki.mta.hu](mailto:sulik@atomki.mta.hu) - 6/10/2014)**




Terminal system „ground”

Turbo pump **TMP151**

Remarks.

1) The „black box” of the generator:

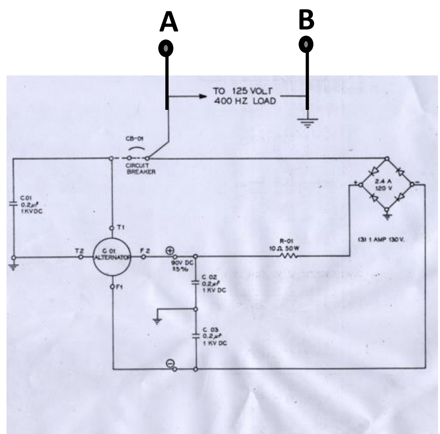
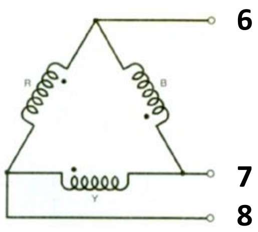



FIGURE 5. TYPICAL ALTERNATOR/RECTIFIER WIRING DIAGRAM

2) What is inside the turbo:




Actually, it does not matter, whether it is a delta or star, if the common point of the star is not used, and we have no connection to it.

3) Wire **a** should be connected to that end of the secondary coil of the transformer, which gives a reasonable pumping speed, but not a full-power run. It should be found by trial and error.
   The suggested starting value is 12 V.
   **Note, that different voltages need different values for the capacitor (see below)!!**

4) Wire **b** should connect ***either*** **C** and **D** ***or*** **D** and **E.** It will determine the turning direction. The correct way should also be found experimentally at 12V.

5) The value of the capacitor **$C_M$** is determined by the formula (your Greek reference):

$$C_M(\mu F) = 10^6 \frac{P}{2\pi f\ 0.87\ U^2 n} \qquad (1)$$

where $P$ is given in watts, $f$ in herz, and $U$ in volts. The question is, how $n$ should be determined?

For 230V, 50Hz systems, a value of

$$C_M = 70\ \mu F/kW$$

is suggested in some cookbooks. This implies $n$=1.

In other cookbooks people say that a smaller value is better for a balanced steady state, but the starting torque is smaller in this case. Actually, it is in contradiction with $0<n<1$, but it is stated in many works.

$$C_M = 35\ \mu F/kW.$$

I could not figure out how it works. I read a lot of papers, but I could not find a clear recipe, probably because the value strongly depends on the load and the switching transients. In any case, I suggest to use Eq. (1) with $n$=1, and keep in mind that $C_M$ is slightly higher this way than the optimum value for steady state.

At a nominal 360W, 400Hz operation Eq. (1) provides us with the $C_M$ values as follows:

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| $U$(V): | 12 | 15 | 18 | 21 | 24 | 27 | 30 | 36 | 42 |
| $C_M$(µF): | 997 | 638 | 443 | 326 | 250 | 197 | 156 | 111 | 81 |
| suggested: | 900 | 600 | 400 | 300 | 220 | 180 | 150 | 100 | 80 |

Since the most likely value for the voltage is 15*1.73= 26V, the capacitor should be 200 µF, with a nominal AC voltage of 125V. I strongly recommend this oversizing, because it makes a longer lifetime. If you would buy let us say 5-10 pieces of it, and 5-10 pieces of 100 µF, you could put together almost all the values in the above list.

**So please buy 5-10 pieces of 200 µF, 125V AC, class A (>30000 hours service time) [2]**
**and 5-10 pieces of 100 µF, 125V AC, class A**

**These are motor run capacitors, with usually of metal-polyester structure.**

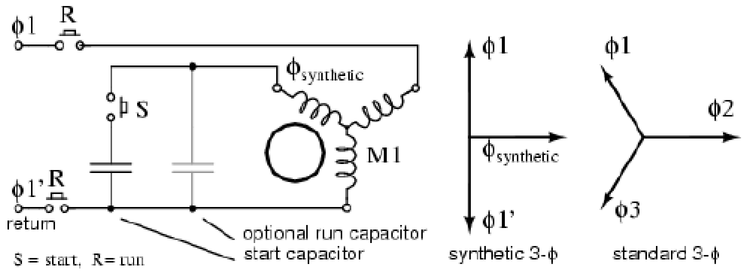
**You can buy it in a professional shop of electronic elements, who can order it for you.**

**Please buy the best ones, they are not very expensive.**

6) Final remark: It is not easy to find a reasonable compromise. It is better to do all steps on a desk, with open tandem, and cables from its generator. The HV side of the turbo should be **closed with a robust, transparent, "plexy-glass" window**, for controlling the direction of the rotation, when it starts. The pre-vacuum side should be pumped with a rotational pump, or a dry pre-vacuum pump.

The electrical connections should be set by fitting the value of the capacitance to the voltage from the transformer.

I recommend you to view the voltages on points C and F with a two-channel oscilloscope. If $V_F \approx V_C/2$, and $V_F$ is shifted by about +90° compared to $V_C$ in the stabilized state, the setting is OK. Of course, it is not so easy. For explanation, look at this nice figure [1]:




*Starting a three-phase motor on single phase.*

At this point, one can play around with changing the value of the capacitor.

One should also measure the power consumption by measuring and viewing the voltage (by an oscilloscope) at point A, **and** the current at point B (by measuring the voltage on point B' which drops on the small, series resistor, *r* of 0.01-0.05 ohm. This resistor we do not need later.) . Not only the values are important, but also the phase counts here.

GOOD LUCK!

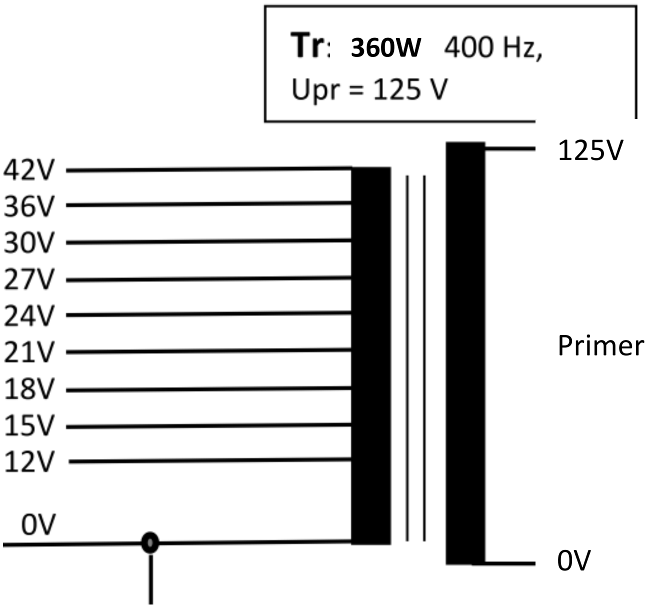
References: I put all of them to a references.zip file.

**THINGS TO ORDER:** (by Theo Zouros based on previous discussion by Bela and by final corrections by Bela)

1. **360W 125V 400 Hz single-phase Transformer**
    - **$U_{primary}$ =125V AC 400 Hz**
    - **$U_{secondary}$ = 12V, 15V, 18V, 21V, 24V, 27V, 30V, 36V, 42V AC 400 Hz.**

**Note:** Nominal value of **400-450 VA and an isolation voltage of 2000 V (test voltage).** The transformer will work in a few bars of SF6, so cooling is not a problem, but it should be pressurized without problems (closed cavities in the construction could be dangerous). It will work in continuous operation for many weeks.

A schematic can be seen below:




Note: The secondary coil can be made of just one wire, which can bear 30 A (12V). If it is too large, one can use 30 A wire for the 12, 15 and 18Vcoil region only, 18A for 21, 24 and 27V, and 12A above.

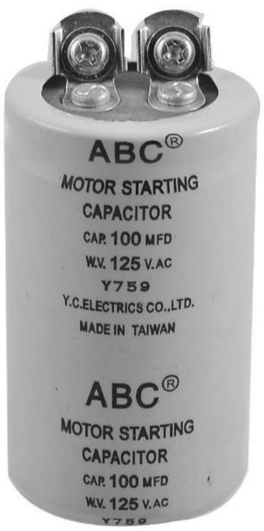
Will order from Antonis Stavrou a local transformer specialist.
(ELVIM - A **ΣΤΑΥΡΟΥ** ΚΑΙ ΣΙΑ ΟΕ
**Μετασχηματιστές** & Ανορθωτές, Αθήνα ΑΤΤΙΚΗΣ
tel: 2105233762, e-mail: astavroumet@hotmail.com)

2. **CAPACITOR $C_M$ (MOTOR START TYPE)**
   - **5-10 pieces of 200 µF, 125V AC, class A (>30000 hours service time)**
   - **5-10 pieces of 100 µF, 125V AC, class A**
   - robust, solid capacitor (metal-paper, or equivalent type, e.g., metal-polypropylene), specified as motor-run or motor starting capacitor. Not a DC (electrolytic) type!
   - Such capacitors are usually specified as "motor starting" or motor-run capacitors

**Just ask for 125 V AC. If it is a motor run capacitor, you do not need to tell more.**

**Note: Once we find the right value for $C_M$ we could order a few with just this value!**

**The one shown below from Amazon costs $7.65.**




3. **9-pin TURBO CABLE for Leybold TMP 151C pump**
   **Already ordered! (3/10/2014 – e-mail Koukios)**
4. Clear, **robust Plexiglas (POLY-METHYL-METACRILATE) window** for the High Vacuum side of the Turbo (with supported O-ring) to be able to view instantaneously the rotation direction and make the appropriate connection.
5. **Resistor r, *r* = 0.01-0.05 ohm, 2W**
   **(This can be a piece of constantan, or other standard resistive wire.)**
   **You also can buy it, e.g.,:**
   **http://hu.mouser.com/Passive-Components/Resistors/_/N-5g9n?P=1z0x79oZ1z0wo8t&gclid=CjwKEAjw-8ihBRD2t9qT3NaW7igSJAD3_sNVj8T6dvkYXQ7pbfgpXX1swHTtpbxQylJB12nIlhixnxoC65Tw_wcB**
6. **You also need a pre-vacuum system (pump, valves, pirani), and it would be nice the high vacuum value at the HV side (Plexiglas side).**