TOM Reel 175 (Navy Reel 5895-1)
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OPERATING INSTRUCTIONS FOR THE LINDE FRANKEL OXYGEN UNIT

Description of the Apparatus

This unit separates the main components of the atmospheric air, oxygen and nitrogen, from one another by liquification and re-evaporation. The accompanying sketch BCG SIV/63 will be used to describe the operation.

The entering low pressure air (at 4.5 atms. ga.) is cooled down to about -150°C in two of the four regenerators I or II and III or IV, operating in alternate cooling cycles by contact with their cold surface. These regenerators obtain their "cold" from the purified exit gas streams. The water vapor and carbon dioxide in the incoming air are removed and remain entrapped in the regenerators until it is removed in the reheating cycle. The low pressure air now enters the lower or high pressure section of the distillation column where it mixes with an oxygen rich liquid (about 40% strength) and commences to boil. The vapors rise through the sieve type trays and are scrubbed by cold descending liquid nitrogen, so that the largest part of the oxygen falls to the tower bottom as liquid. This is due to the higher boiling point of oxygen over nitrogen and results in the oxygen ehrichment of the bottom liquid.

To guard against negative heat loss, high pressure air (200 atms.) is expended through a throttle valve into the base of the lower or high pressure tower. This high pressure air has already been cooled in exchangers (3 and 4) to about -160° to 170°C by exchange against cold exit nitrogen. As a result of this expansion, part of the air is liquified by the Joule Thompson effect. The oxygen-rich liquid from the base of

the lower column is next passed over one of two gravel filters, which are alternately warmed for drying, and then through a heat exchanger (5) before entering the upper column feed tray. The exchanger (5) is cooled by the pure gaseous nitrogen leaving the top of the upper column. The two gravel filters remove any traces of water vapor or $CO_2$ as snow.

The upper and lower columns are connected together by the main condenser, which acts both as the overhead condenser for the lower column and the reboiler of the upper column. Since the upper column operates at 0.5 atms. ga. and the lower at 4.5 atms. ga., it is possible to liquify the overhead product of the lower column (nitrogen) and reboil the oxygen at the base of the upper column, thereby stripping any entrained nitrogen that might be contained therein. Some of the condensed nitrogen falls back down into the lower column where part is collected in a liquid catchpot or draw-off tray and taken to the top of the upper column as cold reflux, while the remainder stays in the lower column as reflux for the same. Contact with the entering high pressure air re-evaporates the reflux causing it to rise again. In this manner, very pure nitrogen is drawn off from the top of the lower column. The gaseous nitrogen which did not fall back in the lower column, but which passed on through the condenser, is cooled and liquified in auxiliary condenser (7) and sent to the top of the upper column as a second reflux stream.

The liquid nitrogen from both the catchpot and the condenser acts as reflux in the top column, scrubbing the rising oxygen-rich vapor which enters at the middle of the column. The nitrogen contained therein is vaporized while the oxygen falls down into the main condenser. As previously mentioned, the heat exchange from the lower column causes

some of this to boil and allows for the stripping of entrained nitrogen. A very complete separation of oxygen and nitrogen is obtained thereby.

The liquid oxygen product is now withdrawn and passed through the auxiliary condenser (7) where it gives up its latent heat of vaporization to the high pressure gaseous nitrogen that has left the main condenser and after liquification joins the other reflux stream at the top of the upper column.

Some of the gaseous nitrogen from the main condenser is drawn off prior to entering the auxiliary exchanger and goes to the high pressure exchanger — cold branch (4) where it cools the entering high pressure air. The heat which it picks up in the exchanger is removed in the next step when it enters the expansion turbine. Part of the exhausted nitrogen is used to precool the high pressure air in exchanger (3) — warm branch. The remainder joins the gaseous nitrogen stream from the top of the upper column and is used to cool regenerator I or II.

By maintaining a definite pressure on the oxygen side of the auxiliary condenser or the acetylene separator (9), all of the oxygen is not vaporized on leaving the same, but a small amount remains liquid. This liquid is drawn off from the acetylene separator as it contains the acetylene in solid form resulting from the foregoing liquification of air. Removing the acetylene is a most important item for the safe operation of the unit. To remove acetylene adhering to the surfaces, it is necessary to take the separator and auxiliary condenser out of service from time to time and dry them out with warm air or nitrogen which can be done while the main unit is in operation.

From the upper part of the main condenser a small quantity of gaseous oxygen can be removed. This and the gaseous oxygen from the acetylene separator are taken to regenerators III or IV where it gives up its cold to the large storage capacity there found. From here the oxygen is conveyed by the oxygen piping to the oxygen compressors.

The gaseous nitrogen product from the top of the upper column is passed through exchanger (5), joins the nitrogen from the expansion turbine exhaust and returns to the nitrogen regenerators I or II where it gives up its cold to the same, exactly as the oxygen does in regenerators III or IV. This warms it up to almost room temperature.

The oxygen and nitrogen regenerators are periodically changed from cooling the entering air to warming up and drying, in cycles of about 3 minutes. The control of the change-over valves is accomplished by an electrically operated timing device by means of compressed air (low pressure air, or air from the first stage of the high pressure compressor).

As a result of the low pressure under which the oxygen and nitrogen products enter the regenerators, it is an easy matter to pick up the water and $CO_2$ deposits which are collected there from the entering air. This allows for relatively long operating periods without clogging the regenerators.

Atmospheric air contains small amounts of helium as well as the main components. The boiling temperature of helium is below the coldest found in the unit. It must be continually drawn off from the auxiliary condenser in order not to disturb the equilibrium within the same

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# OPERATING INSTRUCTIONS FOR THE LINDE FRANKEL OXYGEN UNIT

(See BCG S IV63)

Notice: The following instructions refer to the numbers of equipment as given in sketch BCG S/IV63.

## A. Starting up the Unit

### a. Purging the unit and setting all valves for cold operation.

1) Close all warming up valves (bright blue in flow sheet).

2) Open blowdown valves under regenerators, (35, 36, 40, 41.) Open blowdown valves on lower pressure column 31, main condenser 21, auxiliary condenser 54, acetylene separator 45, low pressure piping between regenerator and pressure column 34, high pressure exchanger warm branch 26 and 7, high pressure exchanger cold branch 25. Open all analysis and Hampson cocks.

3) Open the valve for low pressure air entrance into high pressure column 32 and bypass of turbine, 8.

4) Both high pressure exchangers (warm and cold branch) should be well blown down by closing the high pressure air entrance valve before high pressure column 2, by opening valve 57, and then closing blowdown valves 25 and 26.

5) Nitrogen and oxygen cocks after regenerators should be set open to the atmosphere.

6) Throttle valve, 55, in nitrogen piping of the upper column to the regenerator should be completely open.

7) The following valves on the unit must be closed: liquid from high pressure column over the filter to the upper column, 3, liquid nitrogen from liquid drawoff tray on catchpot of the pressure column to the top of upper column, 4.

Liquid nitrogen from auxiliary condenser to top of upper column, 5.

Entrance of low pressure air into the expansion turbine, 9.

Liquid oxygen between main and auxiliary condenser, 19. Bypass of low pressure air before the high pressure column to the turbine, 30.

8) Line up both liquid filters for flow. Entrance and exit valves should be open, 13, 14, 15 and 16.

9) Main low pressure cock in the unit should be open.

10) Open slowly both compressed air cocks to the nitrogen regenerators, 1 and 2, and place the nitrogen regenerator and high pressure column under pressure.

11) All blowdown valves of the low pressure air system can be closed when the exhaust air appears dry.

12) By manipulating regulating valves, 3, 4, 5, part of the low pressure air will be admitted to the upper column whereby all attendant piping will be blown dry. After blowing out the upper column the auxiliary condenser and acetylene separator can be blown out until the exit air from the vessels and test cocks appears dry. These latter will then be closed.

Blow out for a short time the nitrogen side of the high pressure exchanger warm-branch by opening valves 28 and 7.

13) Open for a short time the low pressure cock of the oxygen regenerator and blow out the same. Then close the blowdown valve of the oxygen regenerators, 40 and 41. The entrance air cock and the valve of the low pressure air inlet to the pressure column, 32 must be closed.

14) The pressure column bypass valve 30 should be open.

B. Cold operation of the Unit

15) Start up the expansion turbine according to the special instructions therefore.

16) Connect up the motor of the cycle timing machine and cut in the operating low pressure air by valve 11.

17) Check the cycle period of the nitrogen regenerator. Close the bypass valve of the turbine, 8. Then slowly open the inlet valve to the turbine, 9, till 2 atms. ga. pressure is reached. After checking, if everything is all right on the turbine, the entrance valve, 9, may be completely open.

18) All additional nozzles on the turbine should be open in order to give maximum flow therethrough.

19) Open entirely the entrance valve, nitrogen side, 28 in order to get maximum performance of the high pressure exchanger warm branch and regulate the quantity of nitrogen to a maximum of 20 cu.m. per hour by valve 6.

20) If necessary, start up the ammonia compressor and set one of the precoolers on the line.

21) After approximately two hours of operation set the rate of high pressure air at 200 cu.m. per hour by opening valve 2. The quantity of high pressure air can be raised to 450 cu.m. per hour after another one or two hours. By simultaneously increasing the quantity of nitrogen to the exchanger 6, the temperature of the high pressure air before the Joule-Thompson expansion valve should be quickly brought to at least -150°C and held there, whereby the temperature of the high pressure air before entering the precooler should not be less than +5°C. If necessary, regulate this temperature with valve 2.

The temperature of the expanded gas after the turbine should not fall under -170°C. A lower temperature is undesirable because of possible danger to the turbine due to liquid formation in the same.

22) The expanded high pressure air in the high pressure column (valve 2) is conveyed to the upper column by opening valve 4 and from there through the open throttle valve 55, to the nitrogen regenerator.

23) Observe the temperature in the center and lower end of the regenerators. If unequal, stop the cycle timing machine. A pause longer than 10 seconds is not desirable.

24) This operation will be continued until liquid appears in the high pressure column and has risen to a height of approximately 20 cm.

25) A further rise of this liquid level is controlled by opening the oxygen regulating valve 3 which allows the liquid to flow through the filter into the upper column. The liquid level of 20 cm. in the high pressure column must be held constantly.

26) Put a gravel filter on the line by closing valves 13 and 14, or 15 and 16.

27) Throttle the flow of nitrogen from the lower column to the upper column by holding the nitrogen regulating valve 4 to 1/4 of its total opening.

28) Take care to hold the pressure to the upper column to a maximum of 0.4 atms. ga. by controlling throttle valve 55. As they get colder, the regenerators will take more low pressure air so that the pressure in the upper column will rise slowly. Consequently, throttle valve 55 still has to be adjusted as operation continues.

29) As soon as liquid appears in the main condenser, a sample must immediately be taken and analyzed for acetylene by opening valve 21.

30) Now must valve 32 be slightly opened allowing low pressure air to enter the high pressure column and the bypass 30 completely closed. With this the temperatures at the lower end of the nitrogen regenerators must be carefully observed. They should be approximately -160°C.

31) As soon as liquid in the main condenser reaches a height of 20 to 30 cm, the oxygen regenerator must be slowly put into operation by opening valve 19 between the main and auxiliary condensers. Previous to this, valve 44 between the acetylene separator and the oxygen regenerator must stand open. The quantity of oxygen should not be more than 25% of the incoming low pressure air quantity.

32) The resulting oxygen should be examined for its purity. If this is above 95%, the oxygen may be sent into the operating pipelines.

33) Open slightly the valve allowing liquid nitrogen from the auxiliary condenser to the top of the upper column. Check to see if the Hampson meter is clear. Valve 22 must be open.

34) The nitrogen regulating valve 4 from the drawoff tray of the high pressure column to the upper column should be open to approximately 1-1/2 flow.

35) When the temperature in the oxygen regenerators is below -160°C, while at the center is -10°C, then open slowly the low pressure air entrance cock into the oxygen regenerator in such a way that the temperatures at the center of all 4 regenerators is approximately the same.

36) Open the nitrogen regulating valve 5 from the auxiliary condenser to the upper column sufficiently wide so that the liquid height in the auxiliary condenser remains constant at about 15 cm.

37) Open slightly the Helium valve from the auxiliary condenser 17.

38) The action of the throttle valve 55 influences considerably the purity of the nitrogen. This should be 99% or better while at the same time a pressure in the upper column greater than 0.4 atms. ga. is not allowable. If the nitrogen is sufficiently pure it can be sent into the collecting pipe system.

39) The oxygen yield will increase slowly with an increased liquid heighth in the main condenser. Care must be taken to regulate both the temperature in the oxygen regenerator as well as the low pressure air quantity to meet the increased oxygen flow.

40) With the increased liquid level in the main condenser, the starting nozzles in the expansion turbine should be gradually cut out. If this is not sufficient, then the pressure before the turbine can be reduced by throttling the pressure by valve 9.

41) Regulate the nitrogen valve 4 on the high pressure column so that the analysis of the nitrogen in the high pressure column contains approximately 1% of oxygen.

## B. THE OPERATION OF THE EQUIPMENT

1) The temperatures in the center of the four regenerators is to be kept the same.

The temperatures in the oxygen regenerators can be regulated by increasing or decreasing the amount of low pressure air.

The temperature of the nitrogen regenerators can be regulated by stopping the cycle timing machine. It is to be stopped only when the cold regenerator is under pressure.

2) Make sure that the excess liquid (app. 10 to 12 liters/hour) accumulates on the acetylene separator. This can be achieved by increasing the pressure in the separator by throttling valve 44 behind the acetylene separator. When too much liquid accumulates in the separator, even when valve 44 is entirely open, the liquid level in the supplementary condenser should be checked. Excessive amounts may be taken care of by means of valve 5. Furthermore, it is possible that the resistance of the oxygen regenerators is too high, thus causing a higher pressure in the separator. Finally, it is possible that the supplementary condenser gets clogged up, thus interfering with the cooling.

3) The resistance in the four regenerators should be measured once every four hours. This is done when removing the nitrogen or oxygen. Care should be taken that this is always done at the same time.

4) The filter for the liquid oxygen between the high pressure column and the upper column is to be changed every 3 or 4 days. In case of switching trouble, the filter should be replaced immediately, because larger amounts of $CO_2$ then get into the filter.

5) The high pressure air is maintained at a constant pressure by means of valve 2. Valve 4 serves to maintain the amount of nitrogen in the high pressure column at 1%. Opening this valve results in a decrease of the nitrogen purity. Valve 3 maintains the liquid level in the pressure column at 20 cm. Valve 5 keeps the liquid nitrogen in the supplementary condenser at a level of approximately 5 cm.

Valve 9 controls the cooling performance of the turbine. Valve 19 regulates the amount of liquid oxygen removed from the main condenser. Valve 1 controls the amount of gaseous oxygen.

Throttle valve 55 is to be used to maintain the pressure on the column at 0.35 atmospheres (gage pressure). The purity of the nitrogen depends on the pressure; too low pressure causes impure nitrogen.

6) The following is to be done, if the liquid level in the main condenser decreases:

1. Check if the high pressure air is at least at a pressure of 200 atmospheres (gage). If necessary the amount of high pressure air has to be increased.

2. See if the cooling effect of the turbine cannot be increased by opening valve 9 or by using more nozzles.

3. Check whether the cold branch of the high pressure exchanger is operating, and see if the temperature of the high pressure air just in front of the Joule-Thompson valve has climbed to-160 to 170°C. If necessary the high pressure exchanger 5 has to be heated up. (See special instructions).

7) In addition to the fixed (printed) data, the following information is to be recorded on the data sheet:

1. The acetylene content in the separator is to be determined once each shift. If the content is high, at least two tests should be made for each shift. Check whether the air intake tower has to be changed; or if necessary remove larger amounts of liquid oxygen over the acetylene separator.

2. Record the lubrication of the switching valves and the control cylinder by means of the Bosch oiler.

3. Record the flowing down of water from the water separator of the low pressure air piping.

4. One analysis per shift after the oxygen regenerators is to be made.

8) The ammonia pre-cooler is to be exchanged once every 18 hours.

9) The supplementary condenser and the acetylene separator have to be warmed up after four weeks operation because of the acetylene danger; the auxiliary condenser—acetylene separator and the oxygen regenerator have to be warmed up after another four weeks. This is usually done on a Sunday.

10) Containers which are subjected to pressure are officially authorized for operation at the pressures listed below:

| | |
|---|---|
| The $N_2$ valve casing | 5.0 atm. gage |
| " $N_2$ regenerator container | 5.0 " " |
| " $O_2$ " " | 5.0 " " |
| " High pressure column and condenser | 4.5 " " |
| Auxiliary condenser | 4.5 " " |
| Filter pots | 4.5 " " |

11) The following pressures do not have to be checked:

| | |
|---|---|
| 1. Upper column | 0.5 atm. gage |
| 2. Acetylene separator | 0.5 " " |

## C. DISTURBANCES

a) In case of complete failure of flow

Cease Operation:

1) Close valves 1, 19, 2, 3, 4, 5 and 9.
2) See if turbine also stopped; if not turn it off.
3) Switch the nitrogen and oxygen into atmosphere.
4) Close off the supply of air to the four regenerators.
5) Turn off the lower Hampson meter cock of the main condenser and the high pressure column.

Starting:

1) Start the ammonia compressor.
2) Start the high pressure air compressor; blow out the pre-cooler.
3) Start the low pressure air compressor.
4) Admit high pressure air to the apparatus by means of opening valve 2. Open valves 3 and 4.
5) Open the low pressure air entrance cock to the nitrogen regenerator slowly.
6) Start up the turbine and regulate it (open valve9).
7) Draw off oxygen by opening valve 19.
8) Put valve 5 into the operating position.
9) Turn on the Hampson meter cocks again.
10) Admit the low pressure air to the oxygen regenerators.
11) Analyze the oxygen and the nitrogen. If the analysis is satisfactory, admit them to the collecting pipe system.

b) Failure of the high pressure compressor

1) Close valves 2 and 9.
2) Turn off the turbine
3) Turn off the high pressure exchanger by closing valve 6.
4) The apparatus may remain in operation for several hours without a high pressure air supply.
5) Starting up is done in the reverse order.

c) Failure of the ammonia compressor

Proceed as shown in part (b).

d) Failure of the cycle timing machine

Switch by hand every 1-1/2 minutes.

## D. TURNING OFF AND HEATING UP THE APPARATUS

1. Switch the nitrogen and the oxygen into the atmosphere.

2. Close off the intake of liquid oxygen to the auxiliary condenser (19) and the intake of nitrogen to the turbine.

3. Turn off the turbine.

4. Turn off the entrance valves of low pressure air to the four regenerators; the cycle timing machine continues running.

5. Turn off the high pressure air (57).

6. Draw off all liquids from the filter (46, 51), from the pressure column (31), from the main condenser (21), from the auxiliary condenser (54), and the acetylene separator (45).

7. Close the following control valves: high pressure air intake to the pressure column (2), gaseous oxygen passage from the main condenser to regenerator (1).

8. Open the following warmup or exhaust valves if they are closed: 2, 3, 4, 5, 7, 9, 10, 13, 14, 15, 16, 19, 21, 22, 25, 26, 28, 29, 31, 34, 35, 36, 40, 41, 44, 45, 46, 50, 51, 54, 56, 59, 60, 61. Also open throttle valve 55. Furthermore, open all Hampson meter and analysis valves.

9. Switch the nitrogen valves to the regenerators. The oxygen switching valves are to remain open.

10. Admit the gas for warming up purposes to the apparatus. The gas enters through valve 29 from where it passes to the upper column, to the main condenser via the oxygen branch of the auxiliary condenser and to the acetylene separator. The gases leave the apparatus through quick opening valve 21, through valve 45 (for emptying the separator), and through the oxygen regenerator. The gas also enters through valve 50, into the nitrogen part of the auxiliary condenser, from where it passes through the high pressure column (22) to the filters and to the cold and warm branch. The gas is removed by emptying the high pressure column (31), the auxiliary condenser (54), and the two filters (46 and 51); also through the turbine vent (10) and valve 7. Finally, the gas also enters through valve 56 in order to warm up the high pressure section. The gas leaves through valves 25, 26 and 31.

11. Turn off those parts of the apparatus which have been warmed up already by closing off the respective blowdown valves.

12. After the entire apparatus has been warmed up, the nitrogen regenerators are also warmed up by opening the switching valves.

13. The warm and cold branch and the regenerators may also be warmed up separately.

14. The temperature in the apparatus should not exceed 55°C when heating up.

15. After the apparatus has been warmed up it should be carefully blown out.

16. The individual parts of the apparatus are to be examined for leaks by means of air pressure tests.

17. The apparatus is now again ready for operation.

## E. CLEANING THE AUXILIARY CONDENSER

1. The auxiliary condenser and the acetylene separator should be warmed up every four weeks.

2. The amount of oxygen is to be brought down to approximately 1200 $m^3$; the oxygen is to be passed through valve 1 in the gaseous state; the liquid valve (19) is to be kept closed.

3. Valves 44, 5, and 22 are to be closed.

4. Valves 50 and 53 for the intake and valves 45, 54 and 58 for the exhaust are to be opened up.

5. Start warming up the condenser. This process has to be continued until valves 54, 58 and 45 are completely warmed up.

6. Cease passing the heated gases and close valves 45, 50, 53 and 54.

7. Open valves 44 and 22 completely. It is recommended that valve 19 be opened momentarily before heating up the auxiliary condenser, in order to remove any possible impurities. Valve 15 is to be switched to the half open position.

8. If liquid nitrogen accumulates in the condenser, it is to be drawn off through valve 5 to the upper column.

9. Valve 19 is to be opened slowly, while valve 1 is to be closed.

10. The unit may be operated again at desired capacity.

## F. WARMING UP THE OXYGEN REGENERATORS

1. The oxygen regenerators are to be warmed up every eight weeks.

2. The apparatus is to be shut off.

3. Nitrogen and oxygen are to be vented into the atmosphere.

4. The liquid in the acetylene separator is to be drawn off through valve 45.

5. Valves 19 and 9 are to be closed.

6. The turbine is to be shut off.

7. The air intake cocks of the four regenerators are to be closed.

8. Valve 57 is to be closed in order to shut off the high pressure air supply.

9. The time cycling machine should continue to run.

10. The liquid in the auxiliary condenser is to be blown down through valve 54.

11. Valves 44, 22, and 5 are to be closed.

12. Valves 54 and 45 are to be opened.

13. The heated gas is to enter through valves 50, 53 and 43.

14. When valves 54 and 45 are heated up enough, they are to be closed; valve 50 is also to be closed; valve 44 is to be opened.

15. When an exit temperature of approximately +10°C has been attained, the heating up process is to be concluded and the apparatus may be operated again.

16. Cease heating up; valves 43 and 53 are to be closed.

17. The air intake of the nitrogen regenerators is to be opened up.

18. Turn on the turbine and open valve 9.

19. Admit high pressure air through valve 57.

20. Increase the amount to the standard operating valve.

21. Open valve 19 slowly and increase the amount of oxygen to approximately 1000 $m^3$/hour.

22. Open valve 22. The accumulating liquid nitrogen is to be drawn off through valve 5.

23. When a temperature of approximately -22°C has been attained in the center of the oxygen regenerators, the low pressure air is to be admitted to the oxygen regenerator.

24. The apparatus may be readjusted to the desired production.

G. HEATING UP THE WARM AND COLD BRANCH OF THE HIGH PRESSURE EXCHANGERS

1. Close the high pressure air regulating valve in front of high pressure column (2) and the high pressure air intake valve (57).

2. Shut off the turbine intake valve (9) and the nitrogen supply for the warm branch (28) and the nitrogen pre-cooler (6). Shut off the turbine.

3. Open up the exhaust valves, the warm branch (26) and the cold branch (25) of the high pressure side of the exchanger and the warm branch on the nitrogen side.

4. Open valves 56, 27, 24 and 23.

5. Close the exhaust valves, when the warm gas starts passing through them.

6. When warm air or warm gas has passed through all exhaust openings, the process is finished.

7. Open valve 57 in order to put both exchangers under high pressure.

8. Open nitrogen valve 28 in order to start cold operation of the warm branch of the exchanger. Fix intake at about 20 $m^3$/ hour by means of valve 6.

9. Operate the turbine without the auxiliary nozzles; open the nitrogen intake to the turbine (9).

10. When the nitrogen from the turbine has reach a temperature of -120°C admit some high pressure air to the high pressure column by means of opening the regulating valve. 2.

11. When the high pressure air reaches a temperature of approximately -150°C, the amount of high pressure air is to be increased to the standard amount. The turbine load is to be brought up to standard by opening the supplementary nozzles. The supply of nitrogen to the warm branch is to be increased to such a value that the normal operating temperature of the high pressure air reaches +5°C before entering the nitrogen exchanger.

12. In case a considerable amount of liquid has been lost during the heating up process, it is permissible to pass up to 450 $m^3$/hour of high pressure air to the apparatus.

## H. MISCELLANEOUS

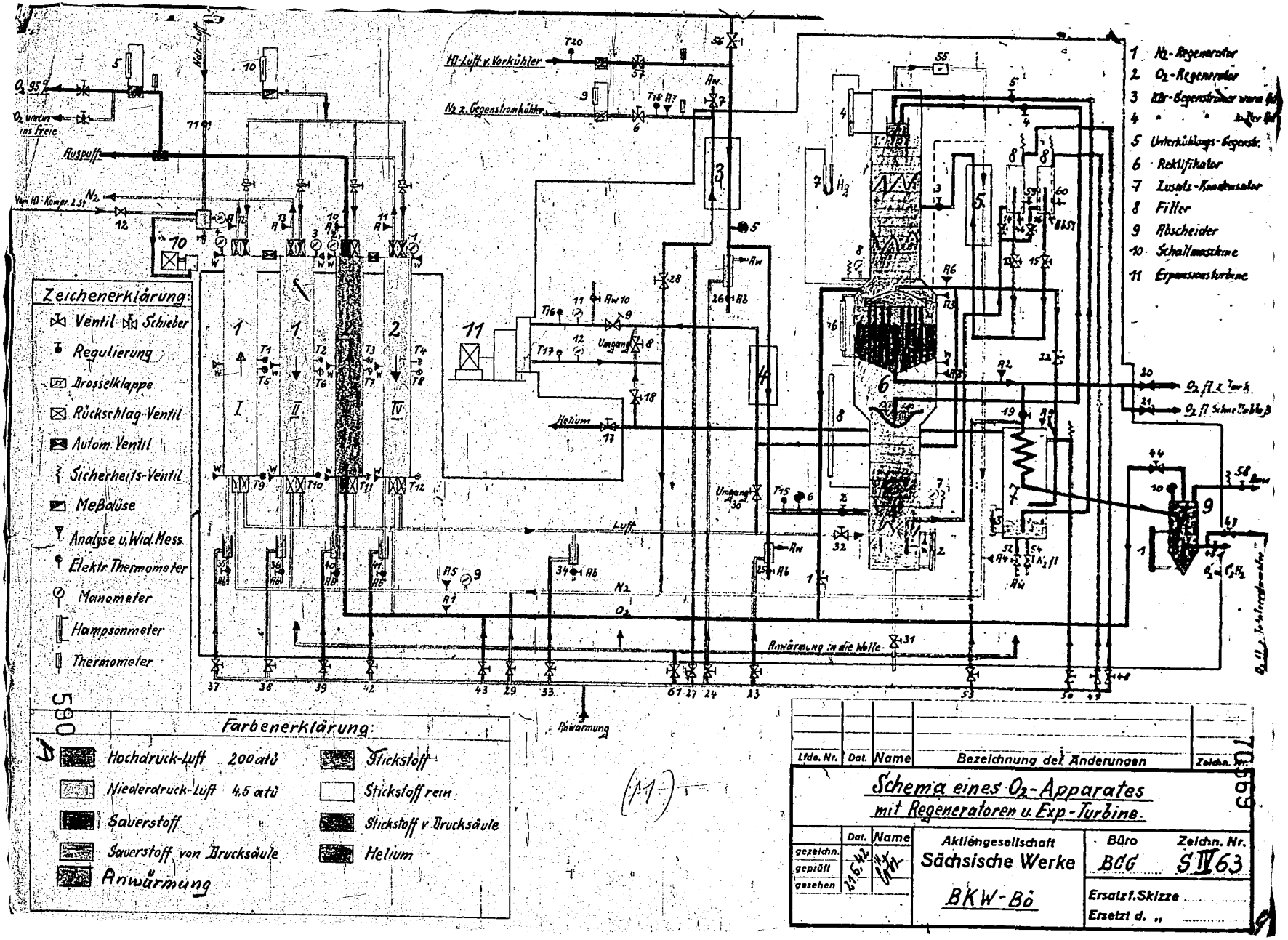
1. The presence of oxygen is a prerequisite for combustion. In the concentrations such as occur in this apparatus, oxygen would accelerate the combustion to a very high degree; a great deal of caution is in order. All parts which come into contact with oxygen must be free of oil, in particular armatures, fittings and packings. Care should also be taken that the clothes of the machinists are not dirty, because they are liable to catch fire in oxygen rich air.

2. The effect of oxygen increases with increasing pressure. For instance the reaction at 20 atmospheres occurs 20 times as fast as with atmospheric oxygen. Thus in the presence of high pressure oxygen the most minute ignition might cause iron to burn. Particular care should therefore be taken to insure appropriate packing of high pressure oxygen pipings.

3. In this oxygen and nitrogen production process, liquid oxygen and nitrogen are also obtained. Because these liquids are at extremely low temperatures, the danger of serious accidents on contact with these liquids exists.

4. It is not permissible that liquid oxygen be poured in any considerable amounts inside the workshop; oxygen would evaporate immediately, which in turn would cause an extreme local increase of the oxygen concentration.

5. Liquid oxygen and nitrogen evaporate very easily. They are to be transported and stored only in specially constructed or completely open containers. Closed containers would explode because of the increase in gaseous volume or vaporization.


Zeichenerklärung:
Ventil
Schieber
Regulierung
Drosselklappe
Rückschlag-Ventil
Autom. Ventil
Sicherheits-Ventil
Meßdüse
Analyse u. Wid. Mess.
Elektr. Thermometer
Manometer
Hampsonmeter
Thermometer
Farbenerklärung:
Hochdruck-Luft 200 atü
Niederdruck-Luft 4,5 atü
Sauerstoff
Sauerstoff von Drucksäule
Anwärmung
Stickstoff
Stickstoff rein
Stickstoff v. Drucksäule
Helium
1 N2-Regenerator
2 O2-Regenerator
3 Rür-Gegenstrom
4 " "
5 Unterkühlungs-Gegenstr.
6 Rektifikator
7 Zusatz-Kondensator
8 Filter
9 Abscheider
10 Schalldämpfer
11 Expansionsturbine
Ruspuff
Helium
Luft
Anwärmung in die Kolle
Schema eines O2-Apparates
mit Regeneratoren u. Exp-Turbine.
Aktiengesellschaft
Sächsische Werke
BKW-Bö
Büro BCG
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gezeichn. 26.6.42
geprüft
gesehen

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## APPENDIX TO THE OPERATING INSTRUCTIONS FOR THE OXYGEN UNIT

### List of Valves and Cocks for Same

### Description

1) Gaseous oxygen from main condenser to oxygen regenerators III and IV.

2) Regulation of high pressure air before entering high pressure column.

3) Liquid oxygen from high pressure column after the filter before entering the upper column.

4) Liquid nitrogen from catchpot before entering upper column.

5) Liquid nitrogen from auxiliary condenser before entering upper column.

6) Nitrogen after the high pressure exchanger — warm, branch, before nitrogen precooler.

7) Blowdown for drying out high pressure exchanger — warm branch, nitrogen side.

8) Bypass of the expansion turbine.

9) Nitrogen before the expansion turbine.

10) Blowdown for drying out turbine.

11) Low pressure air for cycle timing machine.

12) High pressure air for cycle timing machine.

13) Filter exit, left filter, for liquid oxygen after high pressure column.

14) Filter entrance, left filter, for liquid oxygen.

15) Filter exit, right filter, for liquid oxygen after high pressure column.

16) Filter entrance, right filter, for liquid oxygen.

17) Helium blowdown auxiliary condenser.

18) Nitrogen from the auxiliary condenser to the nitrogen regenerator exchanger — warm branch.

19) Liquid oxygen from main condenser before auxiliary condenser.

20) Liquid oxygen from main condenser to tank.

21) Liquid oxygen from main condenser to atmosphere and vaporizer

22) Gaseous nitrogen from main condenser to auxiliary condenser.

23) Warming up for blowdown for high pressure air before high pressure column.

24) Warming up of blowdown for high pressure air between both high pressure exchangers.

25) Blowdown for warming up high pressure air between high pressure exchanger — cold branch and high pressure column.

26) Blowdown for warming up high pressure air between both exchangers.

27) Warming up high pressure exchanger — warm branch nitrogen side.

28) Nitrogen from expansion turbine before high pressure exchanger — warm branch.

29) Warming up of nitrogen regenerator — nitrogen piping from upper column to regenerator.

30) Bypass of pressure column for low pressure air while starting up unit.

31) Exit of liquid oxygen from high pressure column.

32) Low pressure air entrance into high pressure column.

33) Blowdown for warming up low pressure air piping between regenerator and high pressure column.

34) Blowdown of low pressure air piping between regenerator and high pressure column.

35) Blowdown for warming up cold and regenerator I.

36) Blowdown for warming up cold and regenerator II.

37) Thawing of blowdown nitrogen regenerator I.

38) Thawing of blowdown nitrogen regenerator II.

39) Thawing of blowdown-pipe, oxygen regenerator III.

40) Blowdown of thawing, oxygen regenerator III.

41) Blowdown for thawing, oxygen regnerator IV.

42) Thawing blowdown-piping oxygen regenerator IV.

43) Thawing of oxygen regenerator below oxygen piping between separator and regenerator.

44) Gaseous oxygen after acetylene separator to regenerator.

45) Liquid exit of acetylene separator to atmosphere.

46) Liquid exit, left filter to blowdown.

47) Liquid exit of acetylene separator to vaporizer.

48) Warming up of left filter.

49) Warming up of right filter.

50) Warming up of auxiliary condenser, nitrogen side.

51) Liquid exit, right filter from inner space.

52) Blowing down of warming up, auxiliary condenser nitrogen side.

53) Warming up auxiliary condenser, oxygen side.

54) Liquid exit auxiliary condenser nitrogen side to atmosphere.

55) Throttle valve for nitrogen from upper column to regnerator.

56) Warming of higher pressure exchanger, warm and cold branch, high pressure side.

57) Entrance high pressure air, before unit.

58) Blowdown of warming-up, acetylene separator.

59) Liquid exit left filter from outside.

60) Liquid exit right filter from outside.