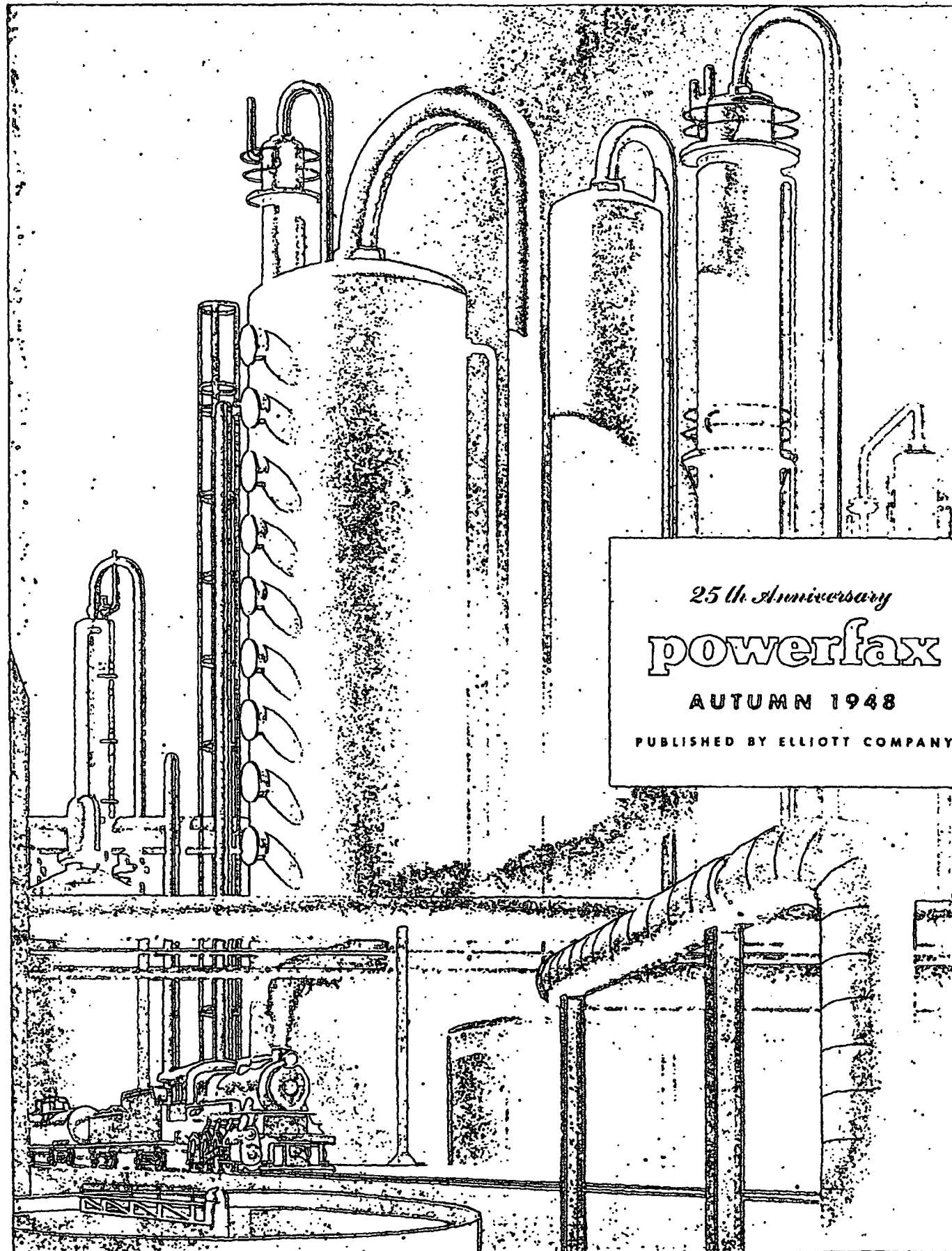




25th Anniversary

powerfax

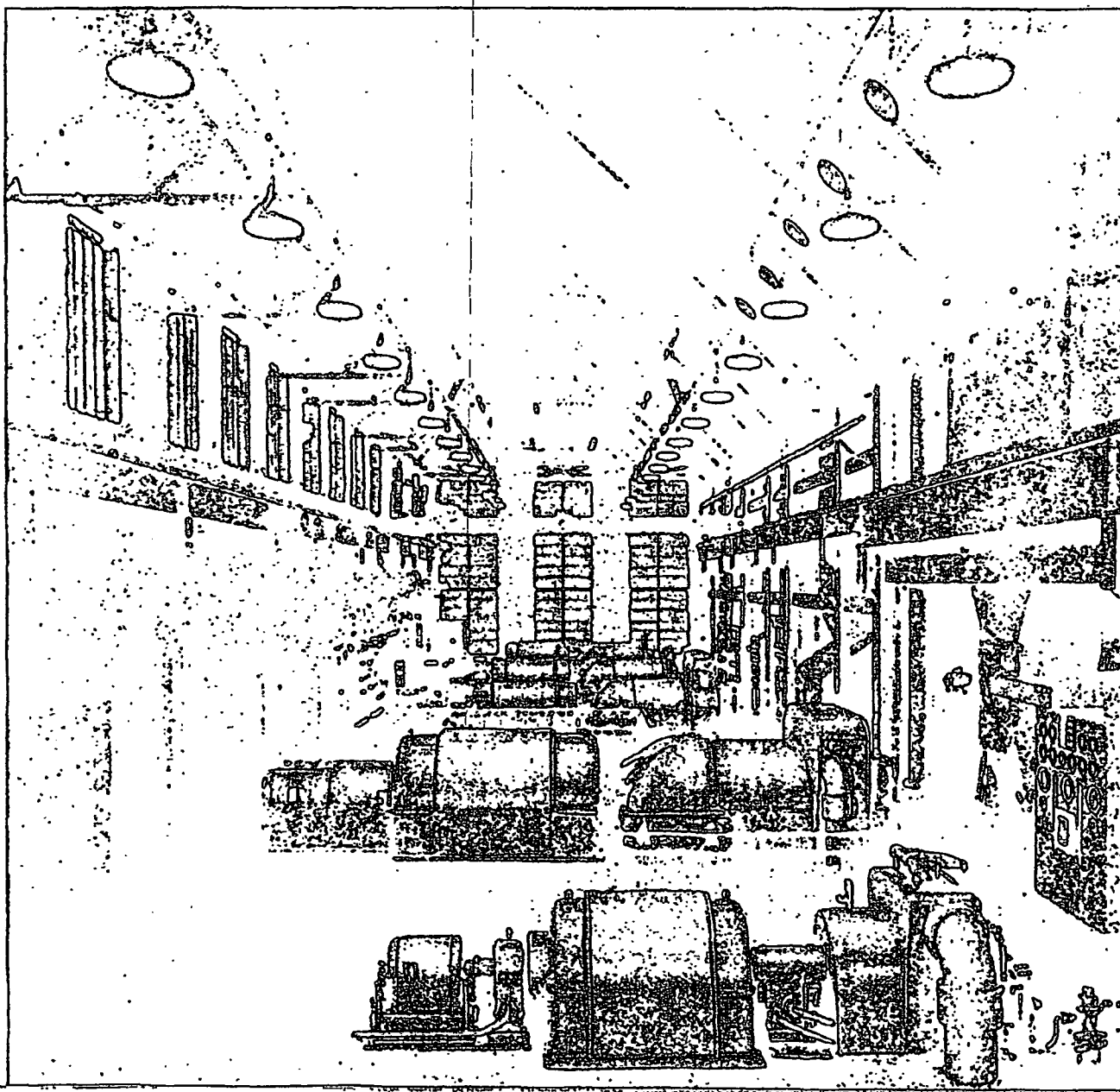
AUTUMN 1948

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Below is shown the handsome turbine room of the Piqua Plant, which is described in the article beginning on Page 16. The line-up includes five Elliott turbine-generator units. In the immediate foreground is the new 1000-kw noncondensing unit. The second unit is the new 7500-kw turbine-generator. These two units went into service just a few months ago. The three 4000-kw units in the background were installed in 1933 and 1939.



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25th

••••• ANNIVERSARY •••••

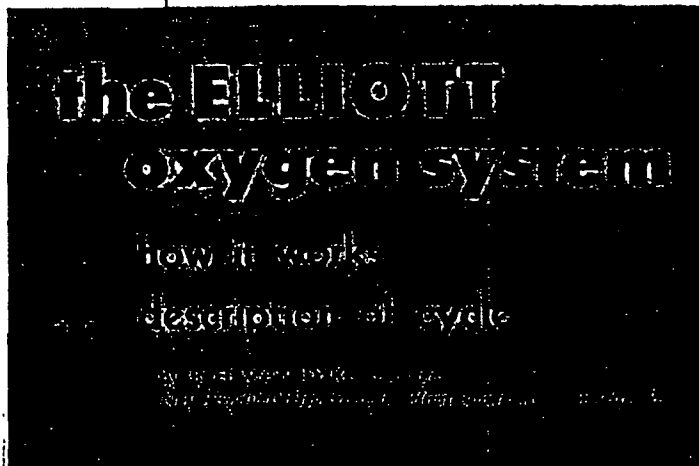
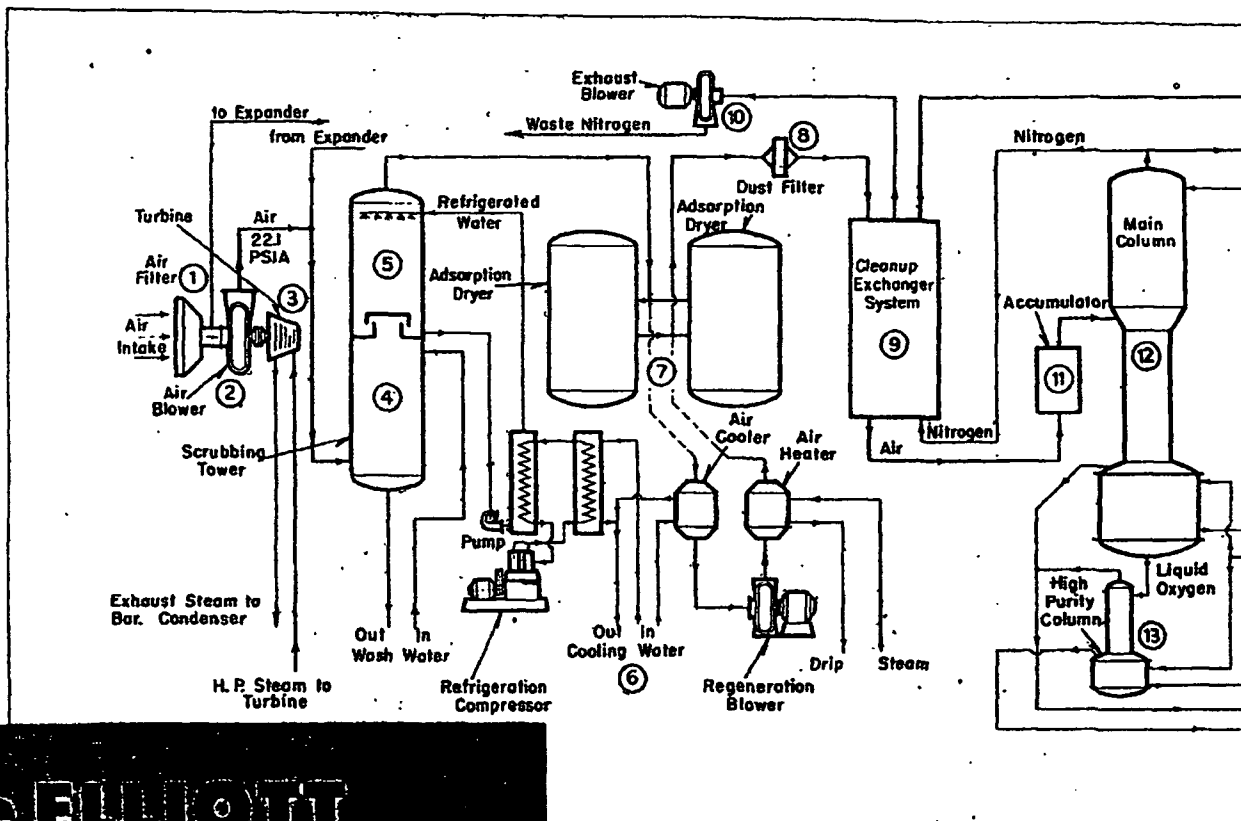
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editorial



*** 3 ***



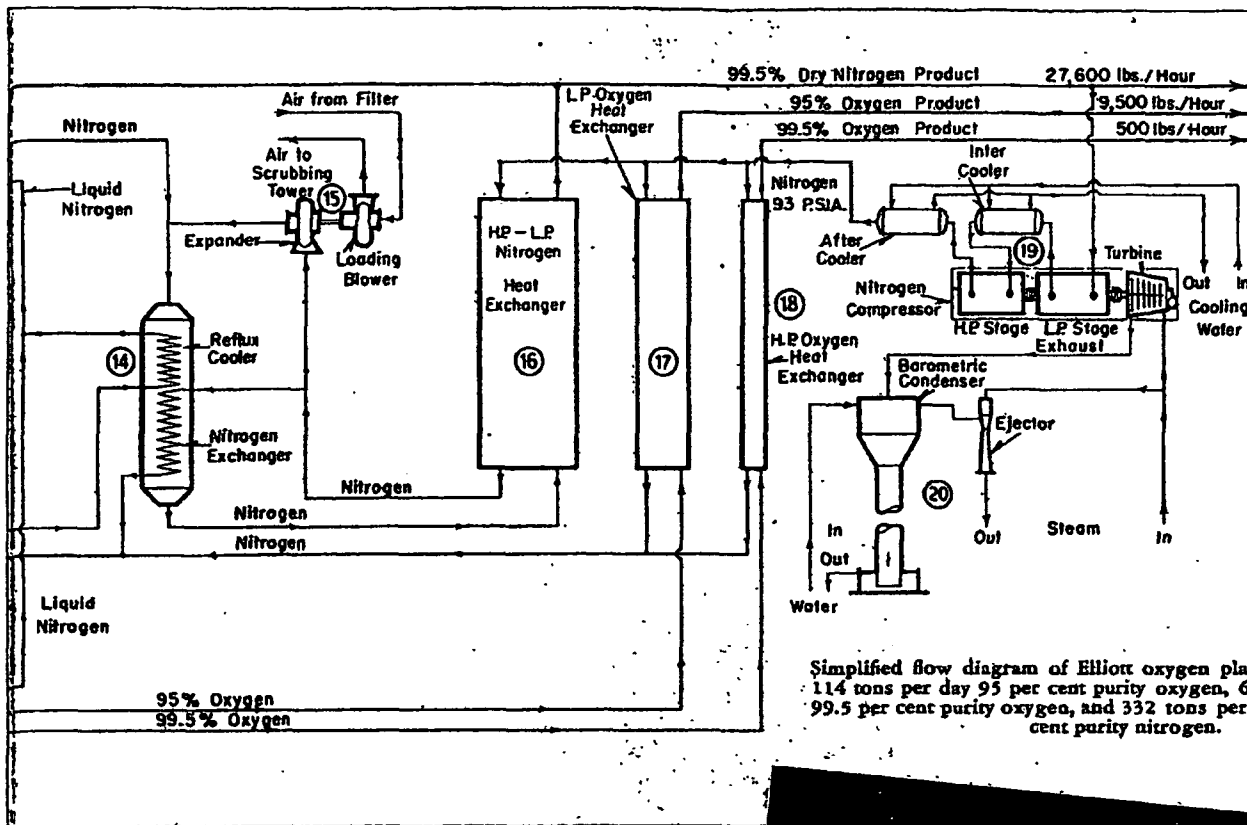
● In an article in the Summer 1948 *Powerfax* the new Elliott oxygen process was unveiled. The general principle of the cycle was described, its features and advantages enumerated, and the successful operation of a pilot plant was cited as proof of the practicality of the design.

The Elliott cycle is an atmospheric pressure air distillation system, combined with a nitrogen liquefaction and refrigeration system in such a manner as to provide a unique combination of features and an unusual degree of safety and flexibility in the operation of the plant.

The following features are enumerated and further described herein:

1. The plant is not subjected to the necessity for periodic shutdowns for deriming.
2. The system is completely immune to possible dangers of acetylene explosions.
3. The system operates at reduced loads without sacrifice of efficiency.
4. The system is mechanically simplified.
5. All controls are automatic. They can be set to maintain constant purity over the entire range of operating conditions, or the purity can be varied at will by a simple adjustment.
6. The recovery of oxygen from the air charged to the system is over 97 per cent. The nitrogen leaving the process is over 99.5 per cent pure.
7. Oxygen of any purity can be made.
8. A plant designed for 95 per cent purity can also simultaneously produce 99.5 per cent welding grade oxygen in quantities as required for this purpose.

The simplified flow diagram, shown, is for a plant designed to produce approximately 114 tons per day of 95 per cent purity gaseous oxygen, plus



approximately 6 tons per day of 99.5 per cent high-purity gaseous oxygen, plus 332 tons per day of 99.5 per cent purity dry nitrogen. The recovery of oxygen from the air charged to the plant is approximately 97.5 per cent. The nitrogen product may be used for chemical synthesis without further purification. If a nitrogen product of higher purity is desired, it may also be obtained. The supplemental high-purity oxygen product is made without increasing the horsepower per total unit of oxygen produced by the plant. This has the effect, in many instances, of making it possible for the user to obtain his full requirement of high-purity oxygen at the same cost per ton as the low-purity oxygen.

Starting at the left-hand side of the diagram, outside air enters through filter (1) and is compressed in an Elliott single-stage centrifugal blower (2) to a pressure only sufficiently above atmospheric to overcome friction loss in the equipment. In this diagram this pressure is shown as 22.1 psia. This pressure may be increased or decreased as an economic balance against pressure drop, which in turn is related to capital cost of the plant. This blower may be turbine or electric motor driven; greater flexibility may be obtained with turbine drive. A portion of the incoming air is compressed



Pilot oxygen-generating plant in Elliott Company's Jeannette works.

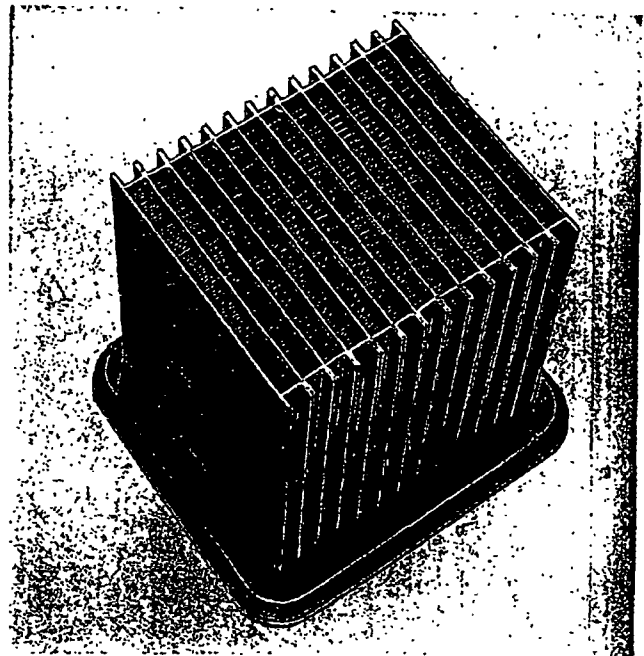
to the same pressure through the expander blowers (15), which parallel the air charging blower (2). The discharge from the expander blower joins with the discharge from the air-charging blower and flows into the bottom of a double scrubbing tower (4).

The air is dehumidified and freed of dust before entering the clean-up heat exchangers. This is accomplished by the use of a scrubbing tower in two stages (4) and (5). In section (4), river or other circulating water is used. In section (5) recirculating refrigerated water is employed so that the air leaving the top of the scrubbing tower will be at approximately plus 40 F, dust-free and saturated with water vapor. The power required for the refrigeration system (6) is a small item charged against the total power for the production of the low- and high-purity oxygen products.

The air is next further dehumidified by passing through an adsorption drier (7). This is a conventional system using activated alumina or similar desiccant and is provided in duplicate for regeneration. The air leaving the drier will be at a temperature of approximately plus 70 F, and a dewpoint of minus 40 F. A dust filter (8) is provided to remove traces of dust which might break loose from the drier during the early stages of operation.

In the clean-up heat exchanger system (9) the air is cooled to a temperature of approximately minus 310 F. Nitrogen from the top of the column (12) is used as the cooling medium and enters the heat exchangers at approximately minus 318 F. In the process of cooling, water vapor, carbon dioxide, and other impurities contained in the air will be frozen out on the heat exchanger surface, which eventually will plug the passages unless some provision is made for cleaning.

The nitrogen leaving the warm end of the clean-up heat exchanger will be at a temperature approximately 8 to 10 deg lower than the entering air. This nitrogen is bone dry and is used in quantity as required to regenerate or remove deposited impurities from the heat exchanger. The system is arranged so that, through a combination of automatic valves on a fixed time cycle, one heat exchanger bank at a time is switched from service and purged of deposited impurities. Experimental operation of the pilot plant indicates that approximately 10 per cent of the effluent nitrogen is required for this purpose. Since the flow of nitrogen through the heat exchanger being cleaned will be in series with the flow of nitrogen leaving the heat exchanger in service, it is necessary to provide sufficient additional pressure head from some source



Section model of gas-to-gas heat exchanger.

to overcome the pressure drop of the clean-up nitrogen through the exchanger. Rather than supply this horsepower to 100 per cent of the air charged, it has been found more economical to install an Elliott exhaust blower (10) to suck the small amount of nitrogen which is required for the clean-up operation through the exchanger being cleaned. The nitrogen discharging from this blower will then carry to waste all of the impurities previously deposited from the air.

The exchangers are automatically switched out of service for purging approximately every four hours. By reducing the dewpoint of the air to minus 40 F before entering the clean-up heat exchanger system the time of cleanup of the exchanger with respect to water vapor is brought into balance with the time for carbon dioxide. No economic benefit will result from further reduction of the dewpoint of the entering air.

By accepted concepts of heat transfer, such as would be obtained with conventional shell and bare tube surface, over 100,000 sq ft would be required to perform the air-to-nitrogen exchange. Such a heat exchanger would not be practical. The cost would be prohibitive, the amount of metal to be cooled before the process could operate would be tremendous, and the exposed cold surface which would have to be insulated would be so large that it would not be possible to provide sufficient refrigeration to make the plant operable. From this, it can be readily seen that the design of suitable heat exchangers is imperative if a low cost tonnage

oxygen plant is ever to become a reality. This has been the subject of intensive engineering development and has resulted in a heat exchanger surface which can be built in standardized sections at moderate cost. The heat exchanger lends itself to mass production techniques and the same standardized sections may be used for any plant regardless of capacity. This minimizes the replacement problem and lowers the plant investment. The heat exchanger consists essentially of thin copper fins furnace bonded between brass plates. The exchanger is manifolded so that one fluid will flow in one direction through every alternate passage and the other fluid will flow in the opposite direction through the intermediate passages. This arrangement of surface provides over 300 sq ft of effective surface per cubic foot of heat exchanger volume and corresponds to over 3.5 sq ft per pound of metal.

The fact that the air leaving the clean-up heat exchanger is at approximately 18 psia and minus 310 F constitutes the basis for the extremely effective removal of impurities by the Elliott oxygen system.

By contrast, in Linde-Fränkl type oxygen plants, the air at the corresponding point in the system is at a temperature of approximately minus 270 F, and a pressure of approximately 90 psia. The difference in temperature of about 40 F is of great importance since in these tower temperature ranges the vapor pressure of carbon dioxide and other impurities decreases very rapidly with temperature. The vapor pressure of carbon dioxide, for example, is cut in half for each approximate reduction in temperature of 8 F. Thus the amount of carbon dioxide which can theoretically remain in the air leaving the clean-up heat exchanger of the Elliott plant is approximately one five-hundredth the amount which can remain in the air leaving the clean-up heat exchanger of a Linde-Fränkl system. Operating experience and the literature indicate that Linde-Fränkl type plants must shut down at regular intervals for deriming. This involves shutting down the plant and warming up the equipment so as to remove the accumulated deposits of carbon dioxide which otherwise, after a certain length of time, will foul the fractionating column, reboiler surface, reversing valves, the nozzles of the turbo-expander, etc., until the plant becomes inoperable. There has been much speculation about how frequently these shutdowns are required, but the best information indicates that the plant will have to be out of service approximately two days out of every 60. Since these shutdowns are ap-

parently caused by accumulated deposits of carbon dioxide and since the Elliott clean-up system reduces the quantity of carbon dioxide by a large ratio over other systems, the Elliott system should be able to run many times longer, or for all practical purposes indefinitely, without the plant having to shut down for the same cause. By this means, and as confirmed by the performance of the pilot plant, the Elliott plant will not have to shut down for process reasons, and can run indefinitely except for periods of regular maintenance of the turbines, compressors, and other rotating machinery.

An accumulator (11) is provided in the air stream between the clean-up heat exchanger system and the main column to balance out the pressure and temperature fluctuations which occur to a slight degree when a heat exchanger is switched. Plants of the Linde-Fränkl type must switch the clean-up heat exchangers or regenerators on an average of every two or three minutes. By virtue of the higher air pressure (95 psia, approximately) the surging resulting from switching poses a severe problem. In the Elliott system the differential pressure between the two sides of the heat exchanger which are being switched is only a few pounds gage; thus the surge is very slight, and the operation takes place only once every four hours instead of every few minutes. Nevertheless, the accumulator does serve a useful purpose in minimizing disturbances on the feed tray during these periods. Also it acts as a safety factor in the removal of acetylene.

The high initial and maintenance cost of switching valves common to other systems is minimized in the Elliott system. Simple butterfly type valves, which are noted for low maintenance characteristics, are used. These valves are designed for operation only slightly above atmospheric pressure and a few pounds differential. The switching valves on other systems, functioning every few minutes, must be designed for a relatively high pressure and will always have a cycling differential pressure of 60 psi or more to seal against.

The air leaving the equalizer or accumulator enters the main column (12) at the appropriate feed tray corresponding to the air composition.

Essentially pure liquid nitrogen is supplied to the main column as reflux. The quantity is controlled to effect the most economic separation of oxygen from the air charged. The overhead gas from the top of the main column will be at a few pounds gage pressure and at a temperature of approximately minus 318 F, and a purity of approximately 99.5 per cent. A portion of this nitrogen is used in the

clean-up heat exchanger to pre-cool the air. Another portion passes through heat exchanger (14), which is a combination reflux cooler and high-pressure nitrogen exchanger. This heat exchanger warms up the nitrogen a few degrees and, in so doing, sub-cools the reflux to minimize flashing before it enters the main column. The nitrogen exchanger section provides a means of cooling high-pressure nitrogen to liquefaction temperature. The low-pressure nitrogen leaving this heat exchanger passes into another gas-to-gas heat exchanger (16), is warmed up to approximately 60 F, and joins with the nitrogen which is under the same conditions of temperature and pressure leaving the clean-up heat exchanger. A portion of this high-purity dry nitrogen stream is delivered as useful product. The remainder is recycled to the process for making reflux and refrigeration. This portion passes downward into the suction of the nitrogen compressor (19).

The nitrogen compressor is the principal user of power. It is an Elliott multi-stage centrifugal compressor, either turbine or electric driven, with a conventional inter- and aftercooler. The nitrogen gas is compressed to approximately 93 psia. This main compressor always operates on clean, dry nitrogen gas, and accordingly, will be favored from the standpoint of minimizing maintenance cost. The maximum plant flexibility can be obtained by steam turbine drive since the speed may be varied so as to increase or decrease the amount of refrigeration and reflux for the most economic operation of the plant under any condition of product demand.

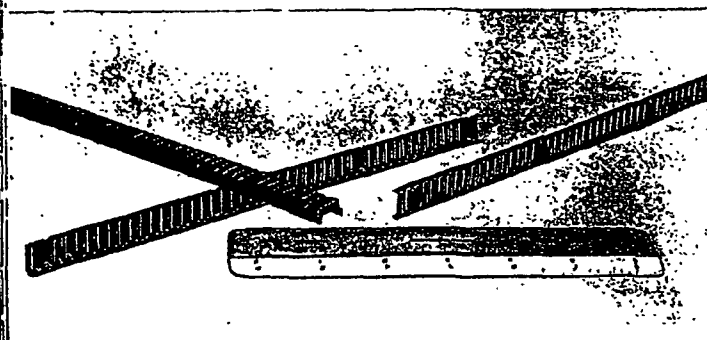
The compressed nitrogen stream leaving the aftercooler is split into three streams, one through each of exchangers (16), (17), and (18). The bulk of the flow is through exchanger (16) in which heat is exchanged against the low-pressure cold nitrogen leaving the top of the fractionating column and

exchanger (14). This high-pressure, low-pressure nitrogen heat exchanger is simply a "bootstrap" device for the purpose of raising the temperature level of the low-pressure cold nitrogen gas to a point where it can be conveniently handled in a compressor, then putting the cold back into the high-pressure stream.

A sufficient quantity of the nitrogen leaving exchanger (16) passes through the turbo-expander (15) as required to produce the entire amount of refrigeration for the plant. The temperature to the expander is approximately minus 253 F, leaving at approximately minus 318 F. The energy from the expander drives an integral centrifugal blower which parallels and correspondingly reduces the power required by the charging air blower. It has been confirmed by the operation of the pilot plant that a deficiency of refrigeration will always reflect in a lowering of the oxygen liquid level in the reboiler of the main column and that a surplus of refrigeration will reflect in an increase of this level. This relationship is utilized to control the flow into the expander by means of a liquid level controller in such a manner that the operation of the expander becomes completely automatic and will adjust itself to changes in plant demand. The expander discharge joins with the stream of cold, low-pressure nitrogen coming from the top of the main fractionating column.

The remainder of the high-pressure nitrogen stream leaving exchanger (16), which is not diverted into the expander, passes down through the nitrogen exchanger section of heat exchanger (14) and joins with the cold high-pressure nitrogen streams coming from exchangers (17) and (18). The combined streams then enter the nitrogen sides of the reboilers of the main and high-purity columns. At this point the nitrogen is liquified by condensing against the liquid oxygen on the other side of the reboiler tubes. This provides the heat to boil off the oxygen products and to provide vapor loading for the columns. The liquid nitrogen is controlled by a liquid-level controller and passes up to the top of the main column as liquid nitrogen reflux. No pump is required since the top column pressure is always considerably less than the pressure in the nitrogen side of the reboiler. The quantity of reflux may be varied simply by increasing or decreasing the speed of the nitrogen compressor. This function is entirely independent of the amount of air charged to the system. It is this separate control over the making of nitrogen reflux and the supply of refrigeration that gives the Elliott system its extremely high

Fin stampings for gas-to-gas heat exchanger.



percentage of oxygen recovery and a wide latitude in operational flexibility. The quantity of liquid nitrogen required for the distillation can be related to a temperature difference between the top of the column and a point approximately five trays further down. This phenomenon can be utilized by means of a temperature difference controller to control the speed of the turbine driving the nitrogen compressor so that under any condition of operation of the plant the amount of liquid nitrogen supplied as reflux will always be the optimum quantity equivalent to the lowest total horsepower per unit of useful product.

Distillation takes place in the column and results in liquid oxygen collecting in the reboiler at a purity corresponding to the purity of the principal oxygen product, which for the case being described is 95 per cent. The gaseous oxygen product is taken off at approximately 5 psig and the corresponding saturation temperature, and warmed up to room temperature through heat exchanger (17). Thus the cold from the oxygen product is returned to the system via the high-pressure nitrogen stream.

The purity of the oxygen product bears a definite relationship to the temperature distribution between the liquid oxygen in the reboiler and a point in the column approximately five trays higher which can be utilized to control the oxygen purity either by regulating the valve on the oxygen product stream or by controlling the speed of the turbine which drives the air-charging blower.

The system can make both high-purity and low-purity oxygen simultaneously. A smaller stripper column (13) is situated at a level beneath the main column in such a manner that 95 per cent purity liquid oxygen feeds as overhead to the top of the high-purity column. The overhead gas from this column will be essentially 95 per cent purity gaseous oxygen and simply joins with the low-purity gaseous oxygen stream. The high-purity oxygen product is taken off above the liquid level of the oxygen in the reboiler of the high-purity column and gives up its cold by exchange against some of the high-pressure gaseous nitrogen from the nitrogen compressor through exchanger (18), and is delivered at essentially room temperature as the high-purity product. The nitrogen side of the reboiler of the high-purity column parallels the nitrogen side of the reboiler of the main column. The condensing of nitrogen in this reboiler provides the heat to boil off the high-purity oxygen product and the vapor loading for the operation of the column. The liquid nitrogen condensed in the reboiler flows

by its own pressure head and joins with the liquid nitrogen going into the top of the main column. In this manner the high-purity column can deliver any quantity of high-purity oxygen within the design limits and virtually floats on the system with the main column.

This combination of functions in the Elliott cycle makes it possible to obtain an unusual degree of flexibility in operation. The plant can deliver any quantity of product required over a wide range of variable conditions within the design limits of the plant while maintaining constant purity irrespective of weather conditions, seasons of the year and other factors which effect the performance of a low-temperature process. The various functions will automatically adjust themselves to the lowest horsepower per unit of oxygen product. The plant can operate down to approximately two-thirds of full capacity without any sacrifice of horsepower per unit of oxygen product.

To illustrate how the controls on the Elliott system will respond, suppose the plant is operating at reduced capacity and more oxygen is demanded. The oxygen product valve will open and more gas immediately is withdrawn. While the plant is adjusting itself the need will be satisfied by working on the reserve of liquid oxygen stored in the reboiler. The tendency will be to slightly drop the purity. This indication will be picked up on the temperature difference controller which will increase the speed of the air-charging blower. This increases the flow of conditioned air charged to the main column and immediately requires more liquid nitrogen reflux to effect a distillation. The temperature difference controller at the top of the column picks up the signal that the plant is deficient in reflux and speeds up the nitrogen compressor. The plant will again come into balance for the new operating condition in approximately 30 minutes. When reducing in capacity the reverse procedure will take place.

There is a long history of explosions in oxygen plants resulting from the accumulation of acetylene, which is almost always present in minute quantities in the air, and concentrates in the liquid oxygen in the reboiler of the fractionating column. In the Linde-Frankl type oxygen plants the air can only be precooled to a saturation temperature corresponding to the air pressure, and this is not low enough to remove any acetylene while the air passes through the clean-up heat exchanger or regenerator. Thus the acetylene works its way ultimately into the column. A concentration

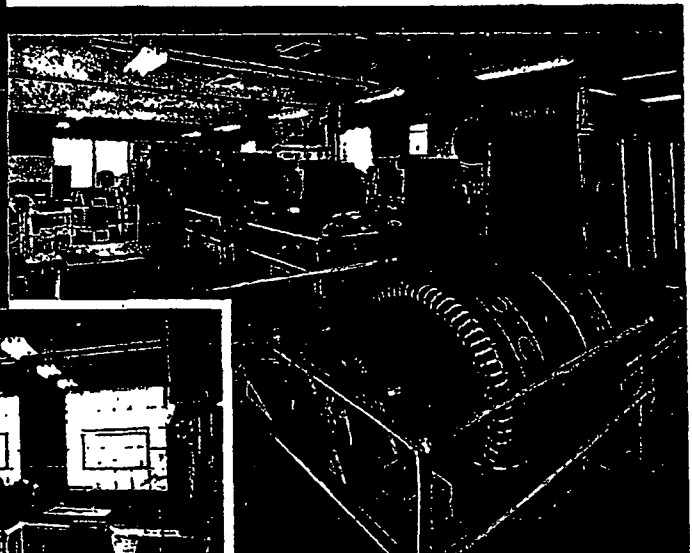
of from 5 to 6 parts per million of acetylene in liquid oxygen is said to be dangerous, and according to the best opinions is the cause of the explosions which occur. There are several methods proposed for minimizing this problem, but the mental hazard always exists, and the methods which must be used are costly from the standpoint of power and depend to a great extent on the human element. The analysis of the quantity of acetylene in the liquid oxygen must be frequently determined so that by blowing down, the concentration may be kept to within safe limits.

In the Elliott system, by virtue of starting off at a lower pressure, the air is cooled to a considerably lower saturation temperature. It has been confirmed by operation of the pilot plant that acetylene is actually frozen out on the clean-up heat exchanger surface in exactly the same manner as the carbon dioxide and water vapor. The air leaving the clean-up heat exchanger is saturated with acetylene under the conditions of temperature and pressure. This quantity is considerably less than the quantity which the gaseous oxygen product can always remove continuously from the system with the result that a dangerous concentration cannot build up in

the liquid oxygen in the reboiler. As a further safeguard, the accumulator (11) is filled with silica gel so as to take advantage of the excellent absorptive ability of this material for acetylene at low temperature, should the operators through some mal-operation permit the temperature of the air leaving the clean-up heat exchanger system to rise above the level required for acetylene removal. The size of the accumulator is such that it will adequately take care of the acetylene which will reach that point for at least six months without attention. The accumulator is installed with a by-pass system so that every six months, without otherwise disturbing the operation of the plant, it may be removed from service and purged with warm dry effluent nitrogen. This is a "fool proof" combination of functions to remove acetylene, which has been thoroughly demonstrated in the operation of the pilot plant. After nine weeks of continuous operation, analysis showed no traces of acetylene in the liquid oxygen in the reboiler, although traces were found in the entering air and other parts of the system ahead of the main column.

A series of technical papers is now in preparation to describe from an engineering point of view the technical aspects of the cycle and its various components and will be available to supplement this general but relatively nontechnical discussion. The Elliott Company has applied for patents on the overall cycle as well as on the details of the clean-up system and various other features.

○ These two views of the interior of the Direct generating light Plant at Spenterville, Ohio, show three Buckeye engines installed in 1941 (two 100 kw. 400 rpm and one 240 kw. 160 rpm). The latest and biggest unit is a Cooper-Bessemer engine rated 475 kw. 400 rpm and installed here last year. Three 6-phase, 60-cycle, 2400-volt generators serve all four engines (the largest unit is a four-wheel type).

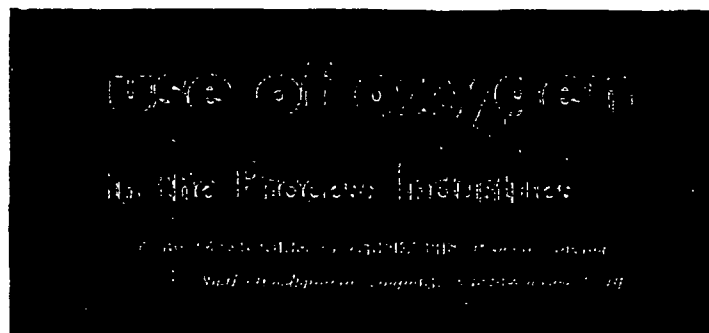


● Recent announcement of the new Elliott process for *low-cost oxygen* stimulates the imagination of the process engineer in envisaging the many uses to which oxygen can be put in the process industries. One of the most sensational of the new uses in which *low-cost oxygen* will play a major part is the Fischer-Tropsch process for converting natural gas and coal to liquid fuels. To those people who shivered through last winter's fuel oil shortage or who have worried about a curtailment of their summer driving because of the announced possibility of a gasoline shortage, this method of extending our liquid fuel reserves has very real importance. In addition, the United States has recently become a net importer of crude oil, and if war should cut off our major sources of foreign oil supplies, this process might prove to be a savior. Two such plants are already being built, one at Brownsville, Texas by Carthage Hydrocol, Inc. and the other at Garden City, Kan., by Stanolind Gas and Oil Company (temporary suspension of this project has recently been announced). Each of these plants will consume about 2000 tons per day of oxygen, an amount greater than the present national consumption of oxygen for *all* purposes.

A second important use to which low-cost oxygen is being put is in increasing the output of the steel industry. Again, to those of us who have been irked by the unavailability of automobiles, refrigerators, and other items dependent on the basic steel supply, this application has a very real meaning. Briefly, in making open-hearth steel, the use of oxygen gives a more rapid combustion and decreases the production time, thus increasing production from the present open-hearth furnaces. In making steel in Bessemer converters, an oxygen-enriched blast enables the amount of scrap melted to be materially increased and also improves the metallurgy. For blast furnaces, the use of oxygen is most attractive with processes which require an unusual amount of high-grade heats (ferrosilicon and ferromanganese) but is also likely to give fuel savings and increased output in ordinary iron-making. It has been estimated that if all the blast furnaces in the United States were to be converted to the use of enriched air, it would take approximately 35 times the present national production of oxygen to supply these needs.

With oxygen production figures like those above being quoted, the imaginative process engineer conjures up a picture of the chemical plant of the future where oxygen will be as readily available for processing needs as steam and cooling water are in

the present plant areas. There are many chemical processes in which the use of oxygen is now marginal, requiring only availability at a reasonable price to make its use a reality. We have only to look at reports on the former German chemical industry to see what a few of these uses might be. The Germans used oxygen in the cracking of ethane, a waste refinery gas, to ethylene, a very important starting material for such useful chemicals as ethyl alcohol, ethylene glycol (antifreeze) and vinyl chloride (vinyl plastics). They used oxygen to convert methane to formaldehyde (Bakelite plastic), coal to city gas, acetaldehyde to acetic acid (acetate rayon), and methane to hydrogen. In this country, oxygen has been talked about for use in converting sulfur or pyrites to sulfur dioxide, sulfur dioxide to

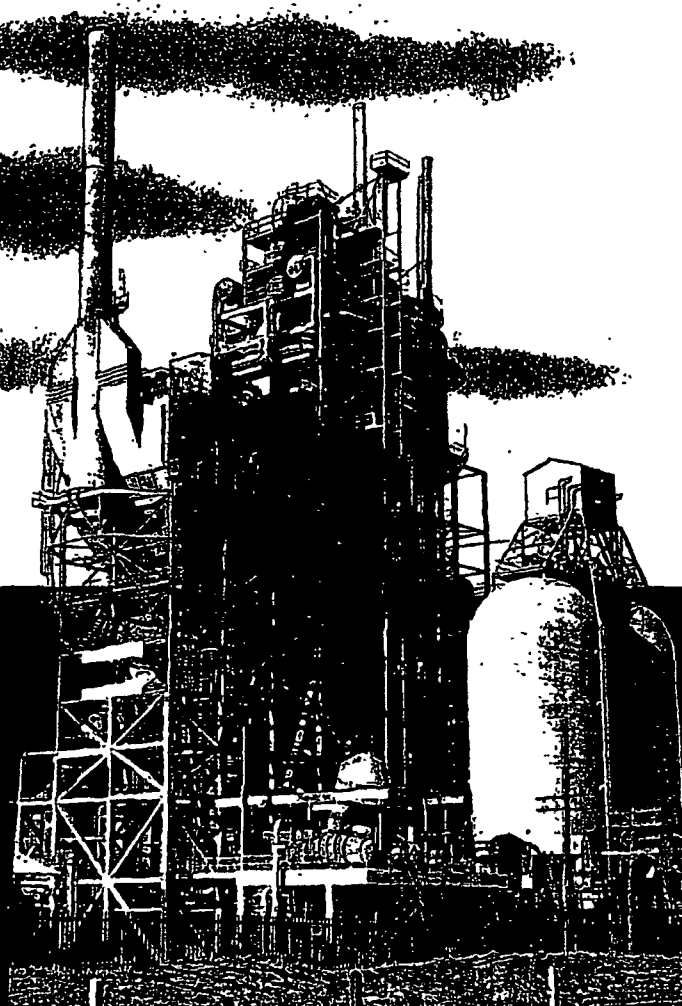


sulfuric acid, hydrogen chloride to chlorine (Deacon process), coke to carbon monoxide to alcohols and aldehydes (oxo process), and many others.

The waste product of the new oxygen processes, nitrogen, will also come into its share of usefulness. Nitrogen is the most important ingredient of fertilizers and our present technology includes many methods of fixing raw nitrogen gas into the nitrogen-bearing compounds that are used for this purpose. It is anticipated that some of the nitrogen produced concomitantly with the oxygen will be so used. In addition, nitrogen is excellent for blanketing processes where it is important to exclude air—undoubtedly the plant areas having oxygen facilities available will make good use of part of the waste nitrogen for this purpose. Whatever credit can be taken for nitrogen will lower the cost of oxygen.

The appearance of oxygen as a heavy chemical leads to a broad review of the whole field of oxidation reactions. There will be the possibility of new processes along with improvements and economies in old processes. Tonnage oxygen means a revolution in a large segment of chemical industry.

NEW RECORD CONTINUOUS RUN for Tide Water Associated Oil Company



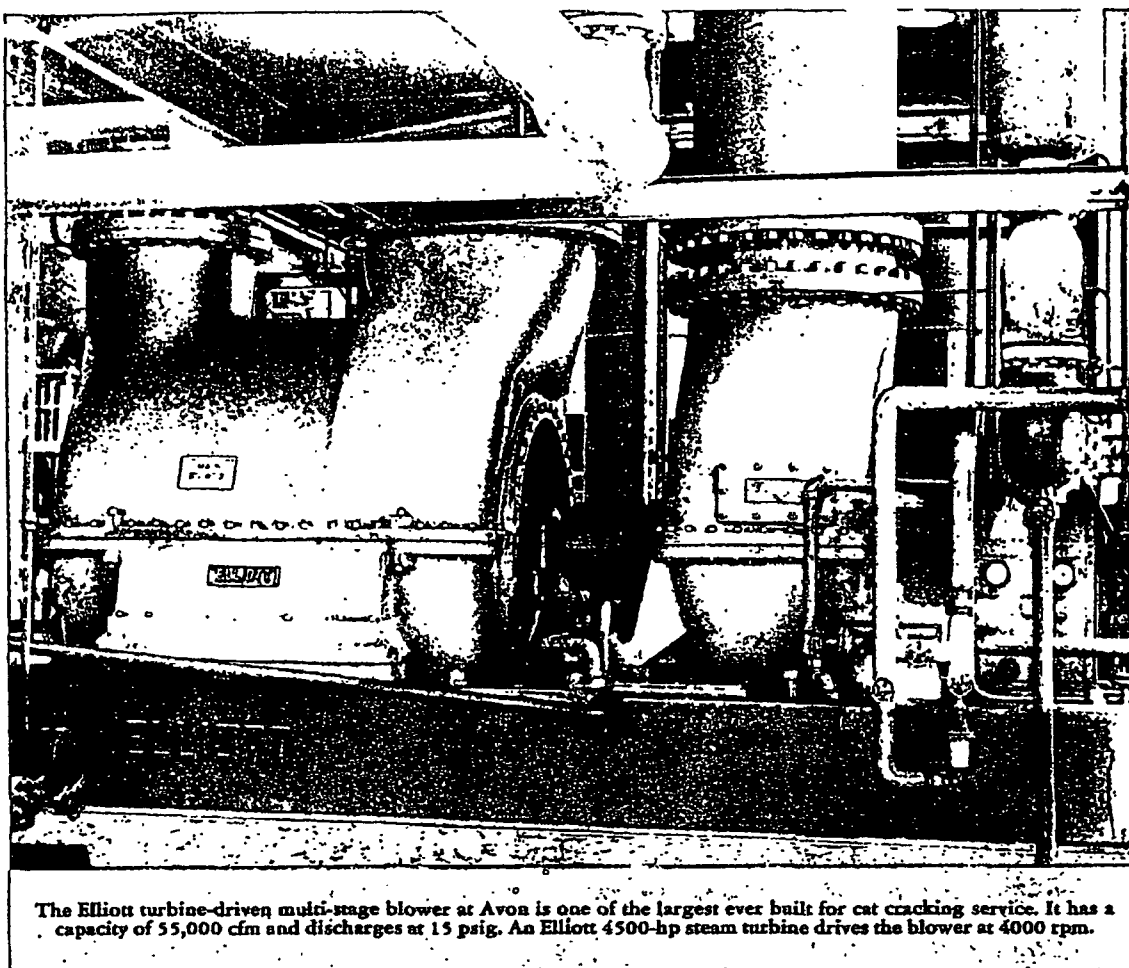
The Avon Fluid Catalytic Cracking Plant. The Elliott turbine-driven blower shown on the opposite page is located underneath the surface condenser in the lower foreground of the picture.

● Since down time is very expensive, oil refineries strive for long periods of continuous operation. They rightly regard long runs as a tribute to the design of the unit, its operation, and the reliability of its moving parts.

The Fluid Catalytic Cracking Plant of Tide Water Associated Oil Company at Avon, Calif., completed a record-breaking run of 610.5 days in continuous operation at 3:25 P.M. on June 12, 1948, when it was shut down as planned for scheduled maintenance and repairs. This new record is 48.5 days more than the previous longest run of 562 days, established by Cities Service Fluid Unit at Lake Charles, La. Since October 11, 1946, when Tide Water started this record-breaking run, about 11,000,000 barrels of fresh feed as heavy waxy

distillate of about 23 deg API gravity were charged to the unit at an average rate of approximately 18,000 barrels per day. Liquid recovery in the amount of 10,550,000 barrels was obtained, including 4,720,000 barrels of high octane catalytic gasoline and alkylation plant charge stocks. In addition, dry gas was produced and steam generated.

This is the third turnaround of the Avon Fluid Unit, erected in 1944 by C. F. Braun and Company and initially placed on stream December 29, 1944. Through constant improvements in operating technique, it has been possible to increase the on-stream time of each succeeding run, the initial run



The Elliott turbine-driven multi-stage blower at Avon is one of the largest ever built for cat cracking service. It has a capacity of 55,000 cfm and discharges at 15 psig. An Elliott 4500-hp steam turbine drives the blower at 4000 rpm.

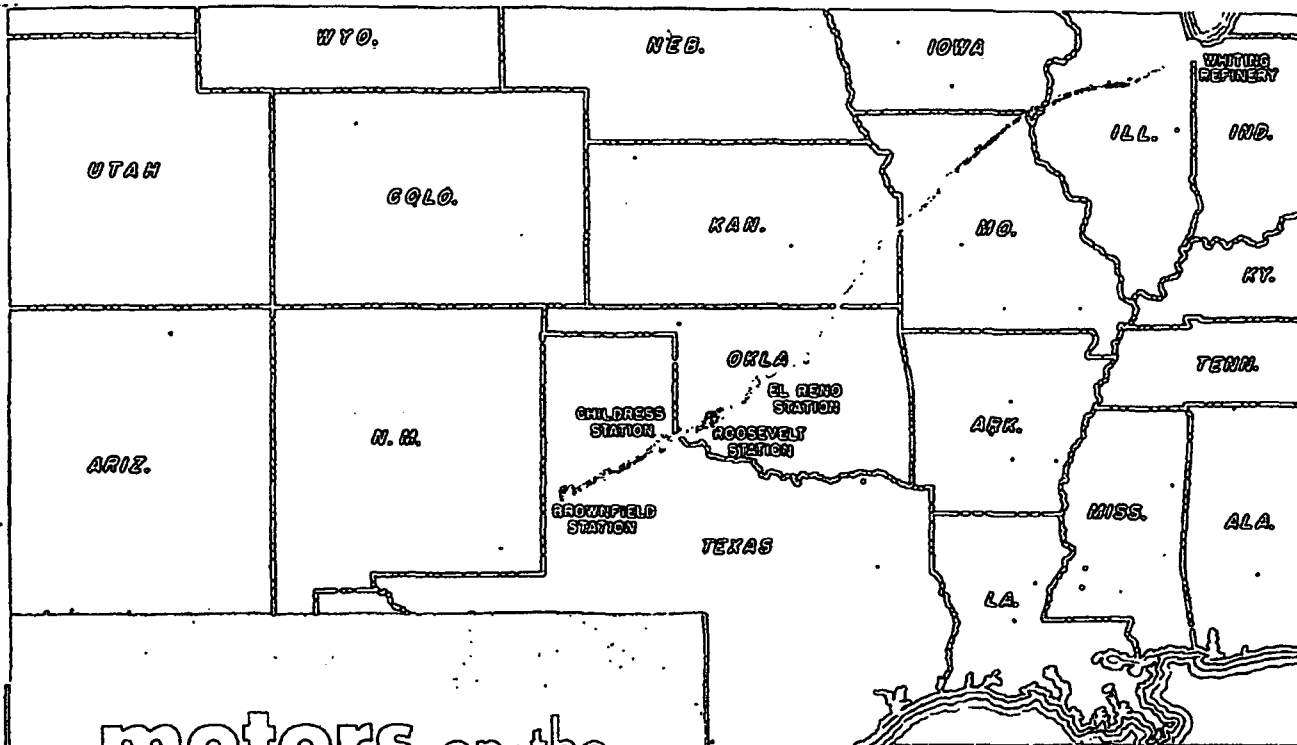
being 145 days, the next 415.8 days, followed by this recent record run of 610.5 days' continuous operation. During the 3½ years that this Fluid Unit has been in operation, over 21,000,000 barrels of heavy waxy vacuum flashed distillates have been converted into high octane motor gasoline fractions and other products.

Since a chain is no stronger than its weakest link, all rotating equipment in connection with a refinery unit must be of utmost reliability. For instance, the big Elliott turbine-driven multi-stage blower, illustrated here, was turning at 4000 rpm—24 hours a day—all through the year and three-quarters of this record run. In addition to the turbo-blower, numerous Elliott mechanical drive turbines operate in connection with this unit. Just one failure on the

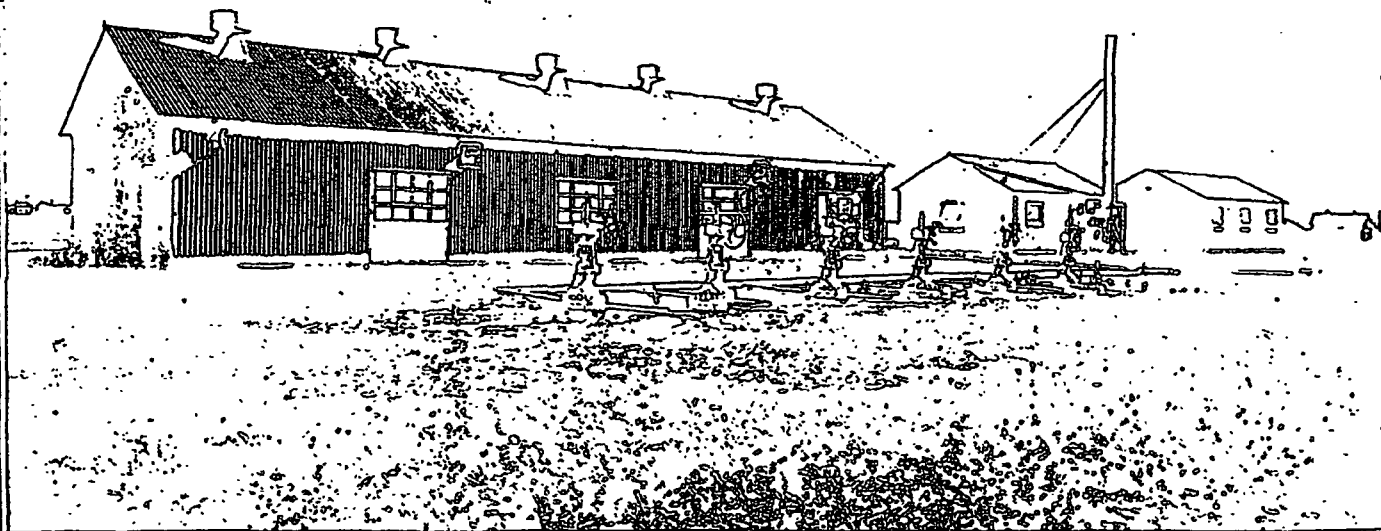
part of any of these could have ruined this record. But the Elliott equipment came through—as it is doing in many plants throughout the country.

The operation of the modern facilities at Avon has contributed greatly to the meeting of the demand for increasingly large quantities of high-quality petroleum products.

The Avon Fluid Unit was returned to service after normal maintenance and repairs. These were quite moderate considering the large volumes of oil and catalyst continuously circulated during the record-breaking run. The operation of the unit is expected to be further improved during the next run through the installation of a new cellular stripping section which will further prolong Filtrol natural catalyst activity and increase gasoline yields.



motors on the Stanolind Pipe Line



● The photographs show three Elliott 1000-hp two-pole induction motors in the El Reno, Okla., station of the Stanolind Pipe Line Co., and a view of the station. These motors drive centrifugal pumps on the crude oil pipe line extending from Brownfield in West Texas to Whiting, Ind. There are four stations similar to this one, the other three being at Brownfield and Childress, Texas, and at Roosevelt, Okla.

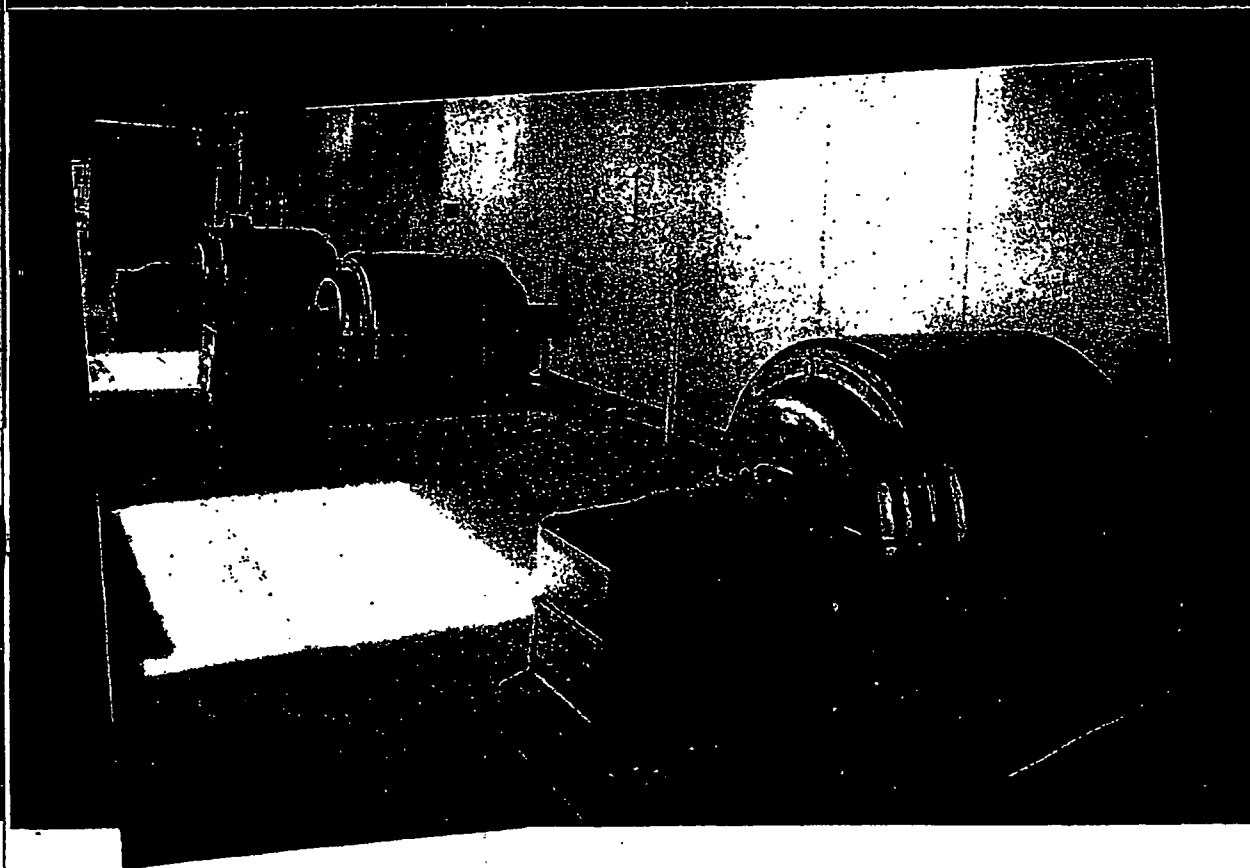
Originally there were only two stations, at Brownfield, Texas, and Roosevelt, Okla., with three pumps driven by 500-hp motors in each station. Early in 1947, in order to increase the capacity of the line, the pumps were modified and the 500-hp motors were replaced with 1000-hp motors. Two additional stations were built. Five more pumps and 1000-hp motors are on order. One more unit will be installed in each of the four stations, with a fifth available as a spare.

Two of the motors in each station operate continuously, while the third serves as standby. In the summertime, the 4000 cfm of air required to ventilate each motor is exhausted through the bottom, under the floor and out of the building; in the wintertime, the side plates are removed from the motors and the warm air is exhausted into the motor room.

The motors are force-lubricated, and arranged so that either dangerously high oil temperature or low oil pressure operates a signal and shuts off power to the motor.

From Cushing, Oklahoma to Whiting, Indiana, oil is pumped through this pipe line by Diesel-engine-driven reciprocating pumps. All of these Diesel engines are equipped with Elliott-Buchi turbochargers. An article telling how turbochargers boosted the horsepower of existing Diesels on this line was printed in the Winter 1944 issue of *Powerfax*.

This installation at the El Reno Station shows three of the twelve Elliott 1000-hp, two-pole induction motors on the Stanolind Pipe Line.





JOHN P. GALLAGHER, who wrote this article, has been director of utilities in Piqua for six years. But he had known the Piqua Plant intimately since 1936, while he was with the Traveler's Insurance Company of Hartford, Connecticut. A native New Englander, Mr. Gallagher was with Associated Gas and Electric Company at Cambridge, Mass., 1926 to 1929. Then, for seven years, he was with New York Power and Light Company. When he left he was electrical engineer for steam generating stations.

● Successful power plants are born of long range planning. They do not survive long unless the engineering, operation, and management are sound and healthy. Adherence to this basic philosophy accounts for the present status of Piqua's Power Plant System.

The original power plant building, one-third of the present structure, was erected in 1933. It contained two steam generating units and two Elliott 4000-kw turbine-generators designed for 375 psig inlet pressure (750 F). Maximum demand in 1936 was 3200 kw. Three years later demand had increased to 4650 kw, indicating the need for another unit. In 1939, the first addition to the plant included an additional 50,000-lb-per-hr steam generating unit and another 4000-kw turbine-generator. During 1947, peak demand was 9700 kw, and 41,000,000 kwh were produced.

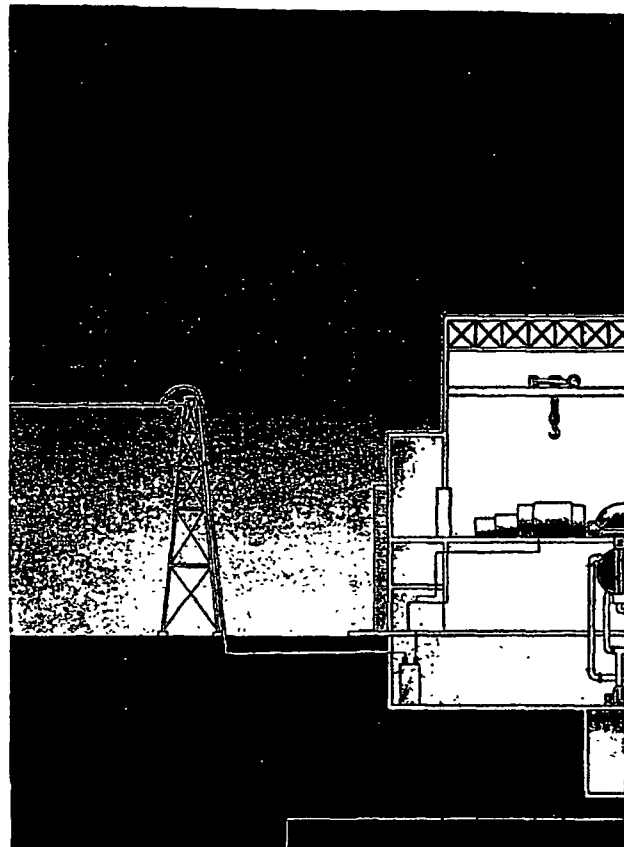
The present utilities director assumed charge in October, 1942, at which time the maximum demand was 5300 kw and the monthly gross production slightly less than 2,200,000 kwh. Within three months, because of the war, the demand had increased to 6000 kw and monthly production to 2,500,000 kwh.

To condition the power plant and distribution system for the expected load increases and to assure continuity of operation, a complete survey and rehabilitation program was initiated late in 1942.

The distribution system was expanded and improved. Two new feeder circuits were installed, as well as equipment for the improvement of system power factor and voltage.

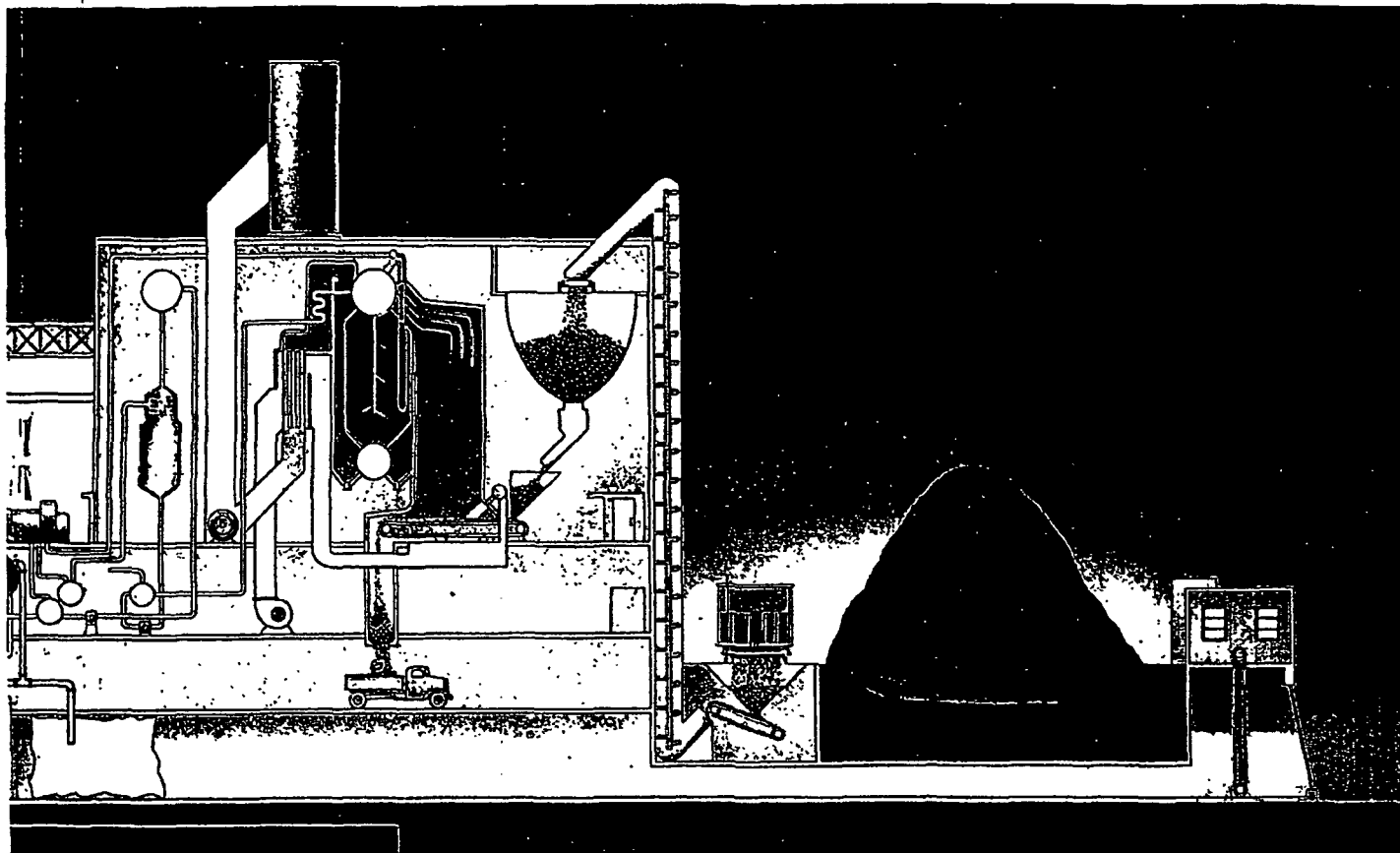
Remote controls and alarms for all essential auxiliary equipment within the plant and in the river screen and pump house were installed.

Boiler-feed pump control and regulating equipment was installed so that all four boiler-feed pumps which had different head characteristic curves could be operated in parallel. Also remote control for these units and automatic start-up of one turbine-driven pump in the event of low feedwater header pressure, was provided.



Piqua e
includes Back





Expansion Pressure Turbine



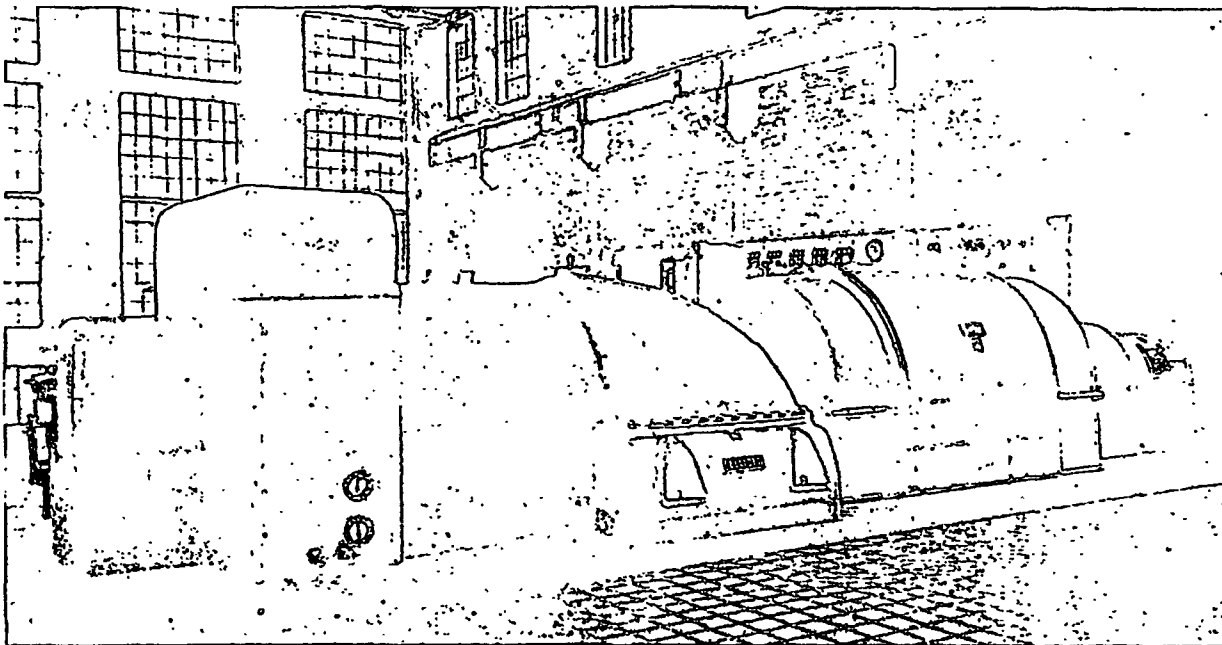
A Fullers earth filter system for the oil used on all turbine units was put in.

Feedwater heater capacity was increased in one heater from 65,000 to 130,000 lb per hr.

An analysis of steam generating equipment revealed several conditions which it seemed desirable to change. Steam flow-air flow meters and new draft gages were installed on the two original units to provide more definite operating data.

The redesign and installation of new baffles in the two original boilers resulted in a $1\frac{1}{2}$ per cent improvement in steam generating unit efficiency. The installation of 15 air zones under the stoker with orifice plates for the better distribution and control of forced draft under-fire air resulted in a 1 to 2 per cent improvement in overall efficiency in No. 3 boiler, with less burning of stoker iron.

Two 6500-gpm horizontal motor-driven river pumps and one 400-gpm vertical motor-driven pump were originally provided to supply condenser circulating water, as well as water for oil and air coolers, etc. A turbine drive was installed on the vertical pump to increase its capacity to 7000 gpm, so that it could replace one of the other pumps in the event of breakdown. The turbine-driven pump can be started by remote control.



Close-up of the new Elliott 7500-kw turbine-generator unit. The turbine, designed for 400 psi, 750 F inlet steam, is equipped with three extraction openings, only one now used. Below right, another view of this unit.

The coal storage area and equipment, including a Caterpillar bulldozer, was increased so as to provide more adequate storage facilities.

In March, 1944, a survey of adjacent industries was begun to determine the feasibility of supplying steam to the major local industries located within a half mile radius of the power plant. It had become evident by this time that as the profit margin per unit sold decreased, due to fixed sale prices and rising costs, sales would have to be increased in order to maintain a safe operational margin.

The steam survey indicated that the power plant could sell industrial steam in a limited area in order to increase plant load factor and efficiency, and to reduce the unit labor cost per kilowatt. This business, which now has a gross revenue of over \$114,000 per year is mutually profitable to the Power Plant and the local industries. Steam distribution provides a service at reasonable cost, with man-power savings; and abatement of a local smoke nuisance.

Since 1946 the Piqua Plant had supplied approximately 60 per cent of the energy requirements of the Pioneer Rural Electric Co-operative, Inc., which organization supplies rural areas in three adjacent counties. Now all their requirements are supplied, Pioneer having just constructed a 33-kv transmission system which made distribution of the energy economically feasible.

The acquisition of the Pioneer contract and the sale of industrial steam on a long-term contractual

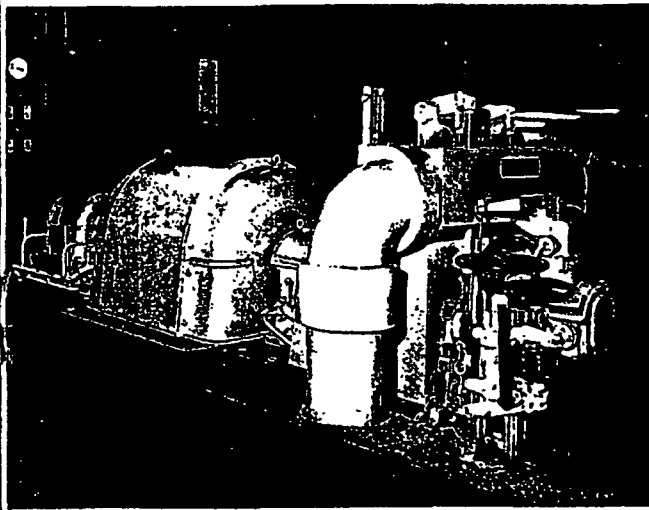


The new 7500-kw turbine-generator unit with its Elliott surface condenser visible immediately below it.

basis provided the foundation for the long range expansion program.

In 1943 a study of street lighting conditions was begun, although new fixtures and luminaries were not available at that time. To date every street has been mapped and the engineering completed. Over 600 new street lights have been installed and 1000 more will be placed in service during the next three years to give the City better lighting service.

Engineering on a new plant addition was officially begun in July, 1944. The general program was



Close-up of the new Elliott 1000-kw noncondensing turbine-generator unit. Turbine takes steam 400 psi, 750 F, exhausting at 175 psi. Exhaust steam goes to the distribution system or it may be used to drive boiler-feed pumps, turbines driving forced-and induced-draft fans, or to supply closed type feedwater heaters.

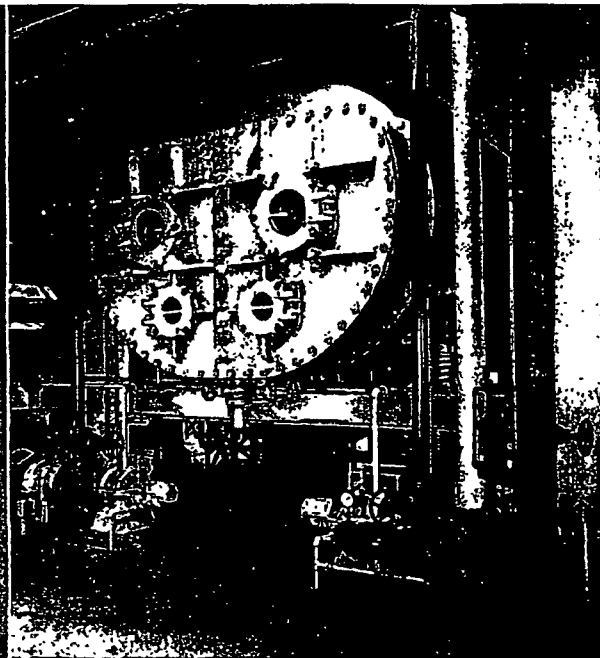
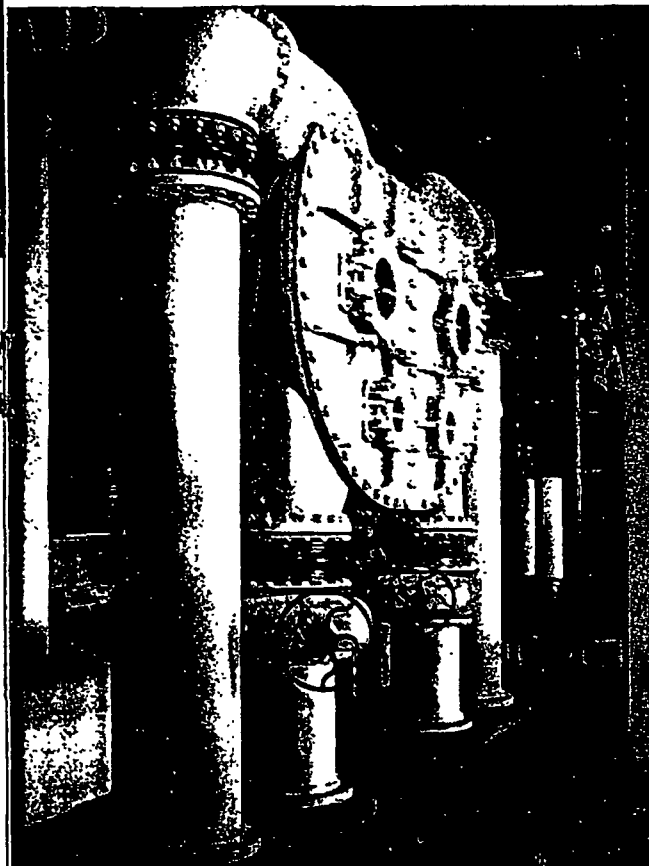
in mind prior to the time steam distribution was begun, as is evidenced by the fact that the steam distribution system was so arranged that it fitted into a scheme of plant operation for a back-

pressure turbine which would act as a reducing valve for the steam system. The building of load and the expansion of plant facilities were closely interwoven throughout the entire program.

The steam customers require steam at 125 psig, dry and saturated. Before the steam goes into the underground system it is reduced in pressure to 170 psi and desuperheated to less than 50 F above saturation. On each customer's premises a reducing station with down-stream pressure control was established so as to reduce the metered pressure to 125 psig. Approximately 7 F of superheat is held at all times at the premises of the most remote customer so as to assure a dry steam condition. These conditions are worthy of mention primarily because they placed certain definite requirements on the proposed station expansion and also imposed certain restrictions.

The results of load and equipment studies resulted in a decision to erect a building addition sufficiently large to house two new main steam generating units, two main turbine-generator units and, in lieu of extraction for the steam distribution system, a 1000-kw, 175-psi back-pressure turbine. One steam generating unit, one 7500-kw turbine-generator, and the 1000-kw back-pressure turbine were to be installed at the earliest possible moment.

The new steam generating unit is rated at 450



Reversing chamber end of the Elliott surface condenser showing the two condensate pumps—one motor-driven and one turbine-driven. Close-up of latter pump on next page.



The 13,000-gpm circulating pump is dual driven. It is connected to its driving units by Rawson couplings. It may also be used as an emergency supply for other condensers in the plant. This view shows the Elliott 175-hp geared turbine. Remote control for both turbine and motor (shown in photo at right) is provided on the turbine control panel.



Elliott 200-hp, 585-rpm Fabri-steel induction motor direct-connected to dual-driven circulating pump. In the foreground may be seen an Elliott 10-in. twin strainer which serves in a general service water line supplying circulating water to the generator air cooler, oil cooler, etc. There are two other Elliott twin strainers in the plant.

psi, 750 F, 125,000 lb per hr, continuous, with a 4-hour rating of 150,000 lb per hr. The boiler has 16,490 sq ft of heating surface in addition to 2725 sq ft of water-wall surface. The furnace volume is 7200 cu ft. Stoker equipment consists of a Lloyd traveling grate stoker with 460 sq ft of grate surface divided into seven air zones. Two clinker chill tubes are provided along the stoker sides. Supplementary oil firing is also provided up to 75,000 lb per hr steam output. The stoker is normally motor-driven, but an auxiliary turbine drive is provided. Induced- and forced-draft fans have dual drives.

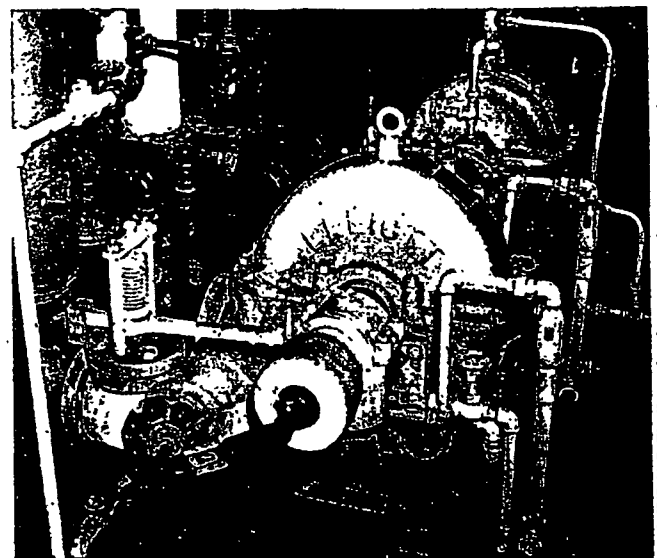
An air heater and economizer are incorporated in the steam generating unit. A closed heater is used to raise the feedwater temperature from 220-225 F to 265-270 F before it enters the economizer in order to eliminate corrosion, the water temperature being controlled by a temperature controller and diaphragm valve in the steam line to the heater. A new four-stage, 1300-ft-head, turbine-driven, boiler-feed pump was installed.

The main purpose of the Elliott 1000-kw turbine-generator unit (400 psig, 750 F at inlet with a back-pressure of 175 psig) is to supply steam to the distribution system in parallel with a reducing valve. The unit, however, may be used as a house turbine and on 200-psi inlet steam, exhausting to atmosphere, it will produce 500 kw. Exhaust steam from this back-pressure unit may be used to drive the boiler-feed pump, and induced- and forced-draft fan turbines, or to supply the closed feedwater

heater on the new steam generating unit. In this way it is possible to operate the back-pressure unit advantageously the year round. The exhaust of the mechanical drive turbine units is used to heat feedwater in the two open deaerating heaters; consequently a very satisfactory plant heat balance can be attained.

The Elliott 7500-kw turbine-generator is designed for 400 psi, 750 F, inlet steam. This unit has three extraction openings, only the eleventh stage being used for extraction heating, with the first and third stage extraction openings blanked off as it was considered unnecessary to use these points in view of the 175-psi steam available and the extraction

Close-up of the turbine-driven condensate pump shown in position with the condenser on the previous page. The cooling water piping to the turbine bearings is well arranged.



openings that are provided on the older machines.

With the Elliott 12,000-sq ft surface condenser provided for this unit, a 28-in. vacuum can be obtained with 85 F circulating water. Photographs show this condenser, its dual-driven circulating pumps, dual condensate pumps and ejector. A steam-operated priming ejector with remote control is installed on the circulating pump. In order to assure an adequate cooling water supply for the new 7500-kw unit, as well as for a future unit, a circulating water aqueduct approximately 200 ft long and 20 ft deep was built under the power plant. This aqueduct has an intake chamber 5 ft wide and a discharge chamber of the same width. The new circulating water pump was therefore located directly under the condenser. At the mouth of this aqueduct an additional traveling screen 102 in. wide, with a capacity of 17,500 gpm, with a 2-ft-per-sec velocity, was installed.

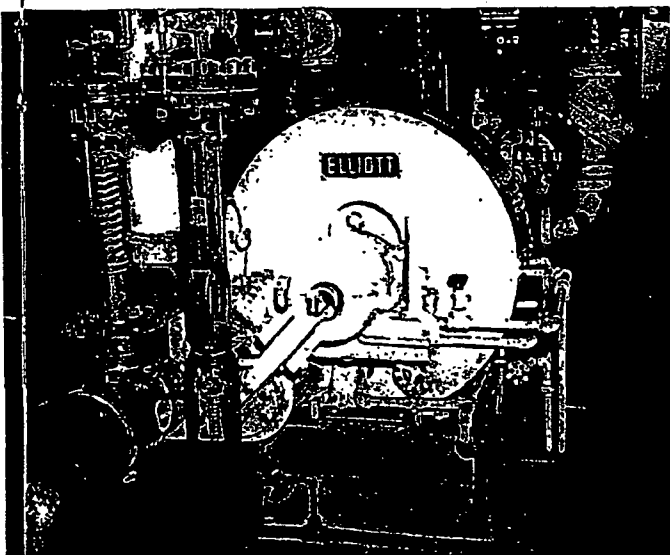
New switchgear was installed, not only for the new units, but for the entire plant and all distribution feeders.

One of the problems commonly encountered in plants of this size and type is that of arranging equipment and control, so that a so-called skeleton crew may provide satisfactory operation. It is not only necessary that the plant be reasonably efficient, but that labor costs per kilowatt-hour be kept at a minimum. With this thought in mind, three control panels located on the turbine floor were set up as a master control point for all station equipment, exclusive of coal handling equipment. These three panels, namely, the boiler control panel, turbine panel, and main switchboard, not only control all equipment but carry a complete visual and audible alarm system for essential equipment.

Coal-handling equipment in the new plant addition consists of one 75-ton bucket elevator and one emergency 25-ton bulk flow elevator, each of which has its own track hopper pit. Coal can be routed through the crusher or by-passed around it. Either or both of these elevators can dump on to a horizontal flight conveyor at the top of the 423-ton bunker. Near the bottom of the bunker is located a continuous flow conveyor so arranged that it will supply the old one-ton weigh-larry, which in turn can feed the original boilers. In the new building, coal is taken from the bottom of the bunker by a five-ton weigh-larry to supply the new boiler and a future boiler. A control unit, with interlocks, is located on the ground floor near the track hopper pits.

Needless to say the 1947 Piqua power plant addition is only another step in the expansion program and not the final story. The firm capacity, that is, the capacity prior to the 1947 edition, with one large unit out of service, is now only 150,000 lb of steam per hr or, on the generating end, 12,000 kw. This compares to 100,000 lb of steam per hr or 8000 kw. However, with the addition of another 150,000-lb-per-hr steam generating unit, foundations for which are already installed, and with the installation of an additional turbine-generator unit, the firm capacity of the Piqua plant will then be 300,000 lb of steam per hr and 20,000 kw. Considerable preliminary work has already been undertaken towards the installation of this future equipment, and to safeguard the present loads and those forecast for the next year, auxiliary oil-burning equipment is to be installed on the two original steam generating units. The capacity of this oil-burning equipment per unit will be approximately 20,000 lb of steam per hr.

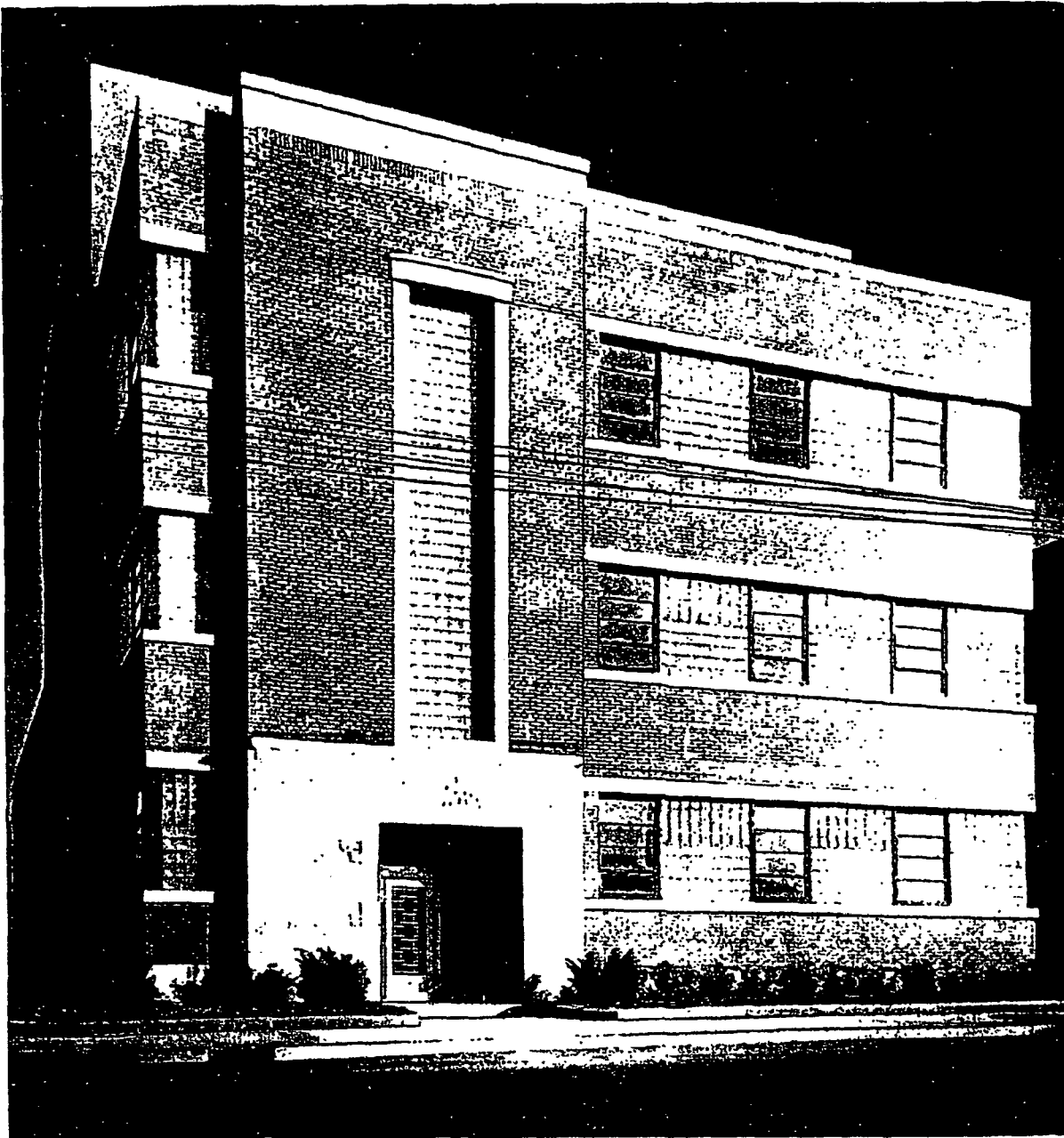
The Elliott 207-hp steam turbine driving a four-stage, 400-gpm boiler-feed pump is fitted with a differential pressure regulator and equipment for remote control.



The Sursumat induced-draft fan is also dual-driven. This photograph shows the Elliott motor which is a two-speed, two-winding motor, 900/1800 rpm synchronous speed, with a rating of 100/50 hp. An Elliott geared turbine is on the other end. The forced-draft fan is also dual-driven. Raxson couplings are used on both fans.

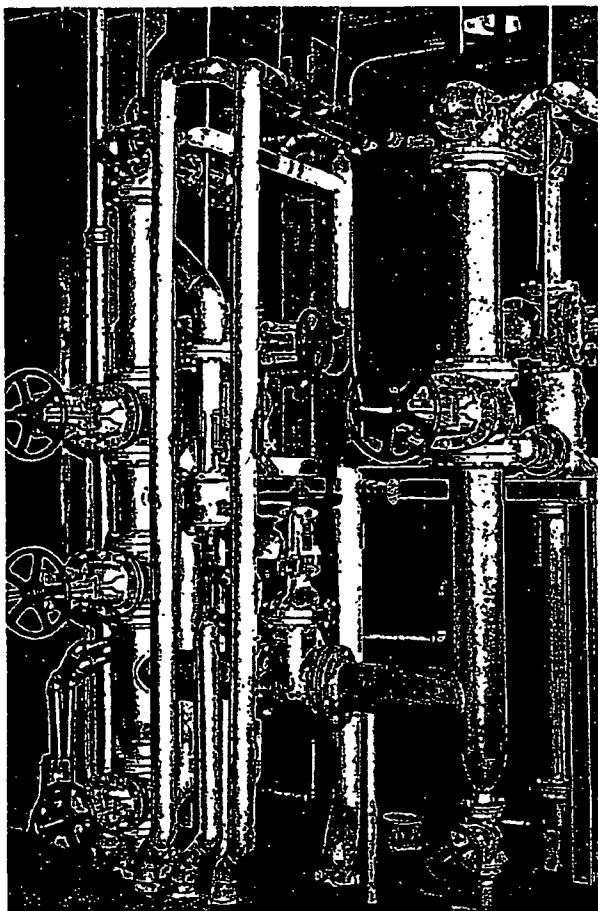


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● In manufacturing ethical pharmaceuticals and biologicals, Eli Lilly and Company, of Indianapolis, use Elliott ejectors of various sizes and types for maintaining vacuum for distillation, evaporation, and drying processes. When the pilot plant pictured here was erected recently, Elliott ejectors were installed to maintain the necessary vacuum required for the plant's operations.

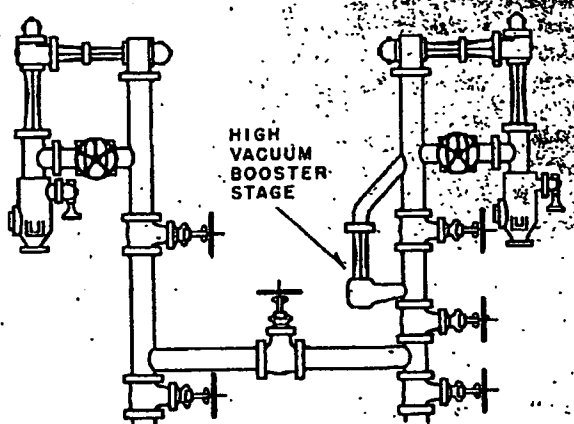
One of the ejector installations for the pilot plant is particularly interesting be-



cause it is piped up with a full complement of tees and valves in order to make it suitable for handling all kinds of material at different vacuums.

The photograph shows how the installation was arranged in order to obtain the maximum amount of flexibility from a multi-stage ejector system. In order to illustrate clearly the manner in which the ejector was hooked up and to show ejector stages not visible in the photograph, a line sketch of the arrangement is included. Two three-stage ejectors and an extra booster stage are connected so that by manipulation of various shutoff valves, all of the stages of both ejector units can be used at once, each three-stage ejector can be used separately, various combinations can be made, or the smallest

maximum flexibility
 features ejector hook up
 for pilot plant

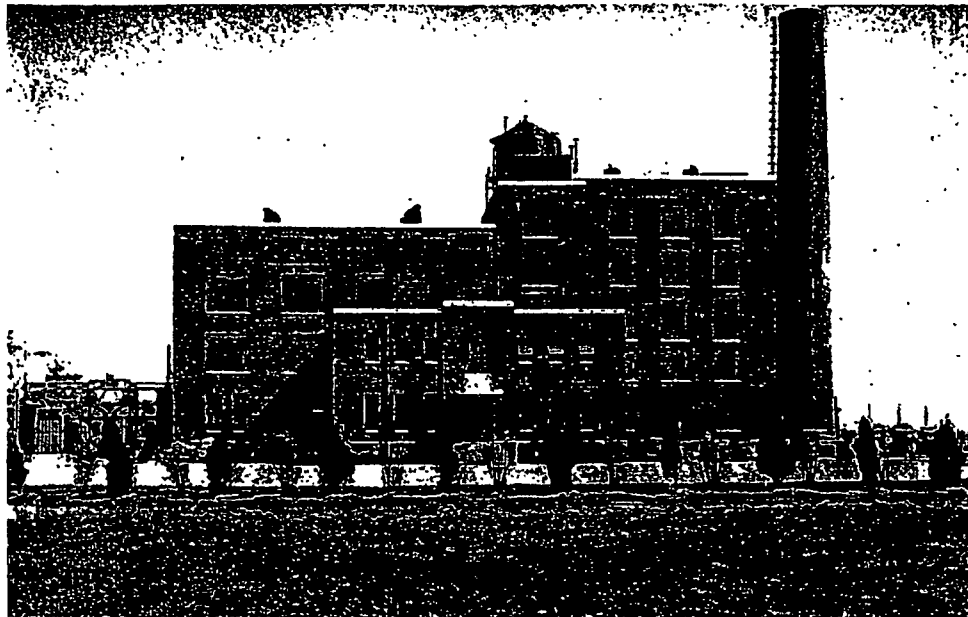
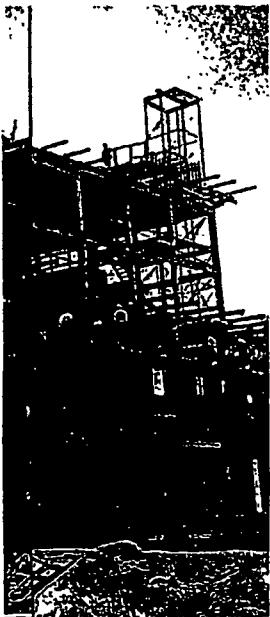


unit, a single-stage ejector with its barometric condenser, can be utilized by itself.

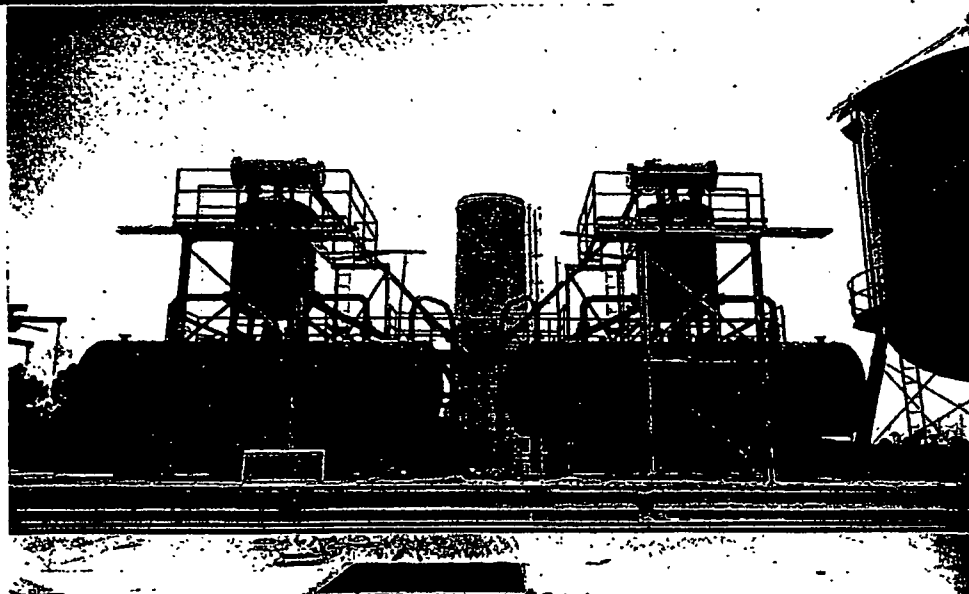
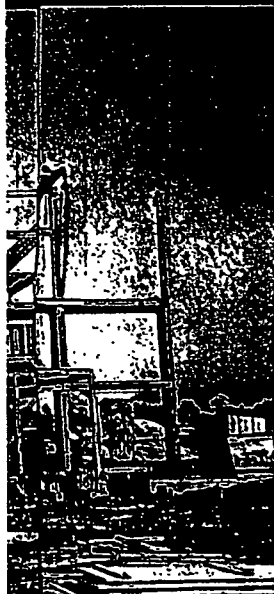
For lower vacuum requirements in the new building, other Elliott ejectors, including single-stage and two-stage noncondensing units, are located near the equipment which they serve.

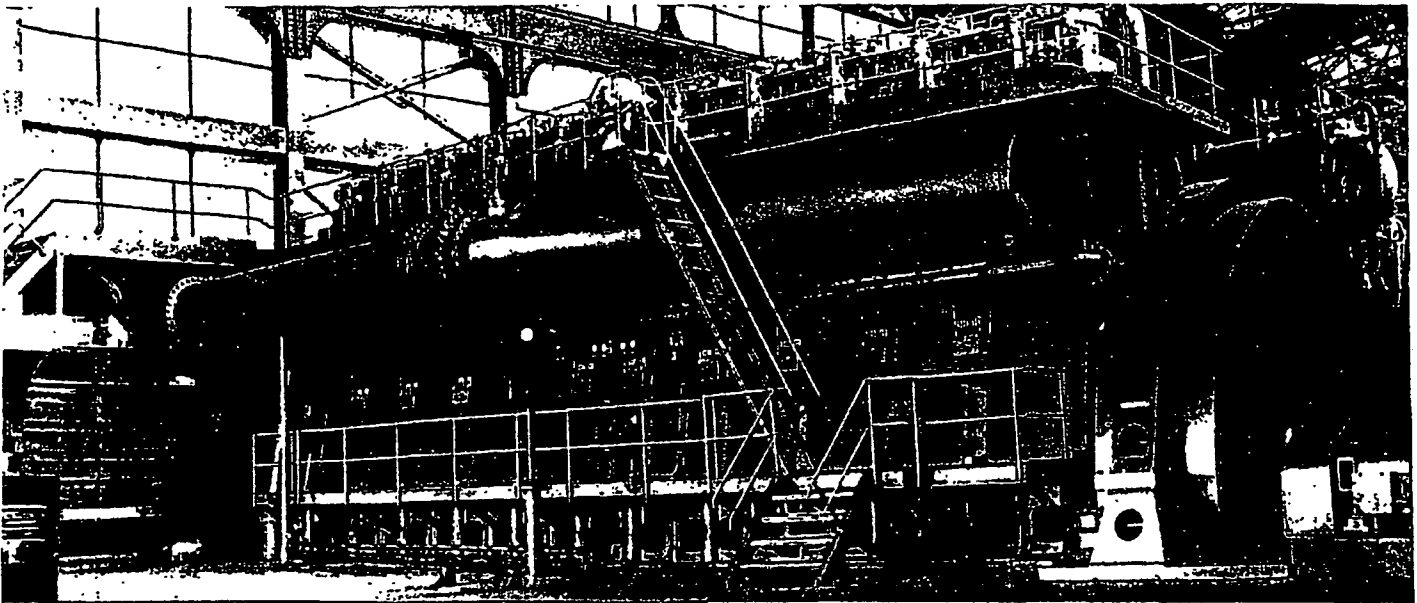
The story of the pilot plant itself is very interestingly told in a recent issue of the *Lilly Review*. From this article we quote as follows:

"After a new drug has been discovered and it is known that it will be useful in medicine, it must be produced in quantities large enough to supply all doctors. That is where the pilot plant enters. A pilot plant is used to translate the development laboratories' small-scale production of a new product into large-scale factory production. Whereas the development laboratories use 12- and 22-liter flasks to make small quantities of a new product, the pilot plant utilizes equipment from 30 to 75



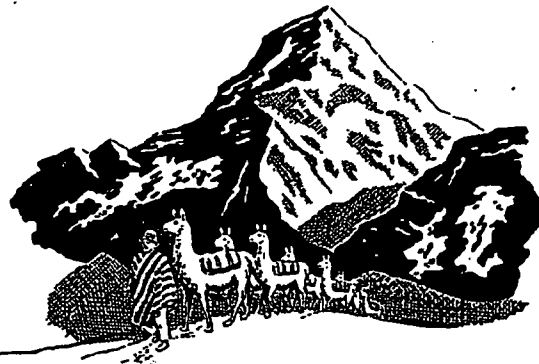
● Deaerating feedwater heaters have to be on the job very early in the construction of a new power plant. The pictures on these pages show why. The heaters are installed high up in the air and often remain on the roof of the building after the plant is finished. Two new plants in the South illustrate this point very well. Pictures show early construction views and finished jobs.





This 10-cylinder, 7100-hp Nordberg Diesel was installed last year at plant in Pedro de Valdivia, Chile.

big diesel serves Chilean Nitrate Industry



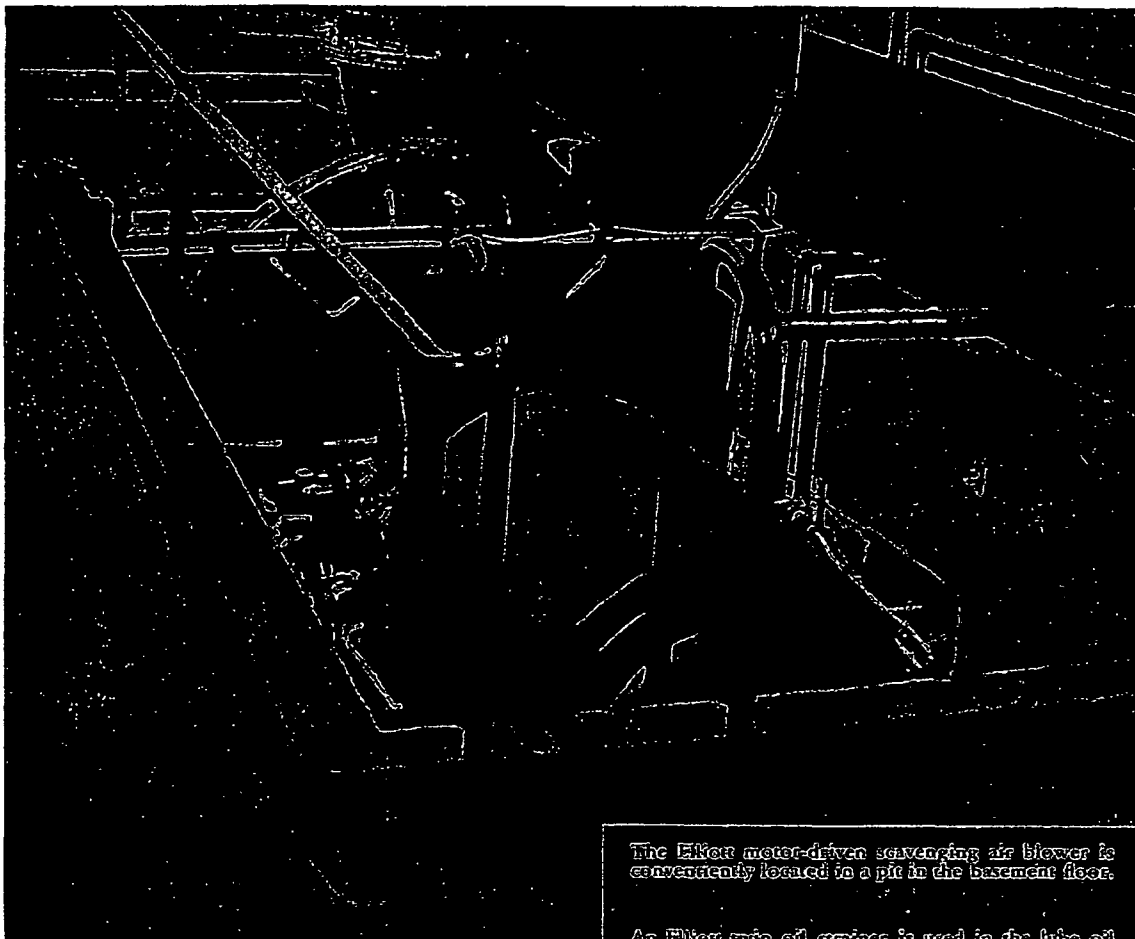
● The 7100-hp Diesel engine-generator unit illustrated was installed last year in Pedro de Valdivia, a large sodium nitrate plant in Northern Chile, owned and operated by the Lautaro Nitrate Company, Ltd. Already operating, since 1932, in the plant were five 4700-hp Diesels. And the plant is interconnected with another power plant of the company about 20 miles away having a capacity of 24,000 hp. The two plants represent the largest Diesel power block in South America.

Nitrate-bearing rock is mined in the vicinity, the ore hauled to the plant by electric railroad, where an average of 30,000 tons per day goes through the crushing plant. From there conveyors carry the product to large concrete vats where nitrate salts are leached out and the residue hauled away, again by electric locomotive. The sodium nitrate is recovered by means of refrigeration and centrifuging.

The final product amounts to some 2000 tons daily. Considerable electric power is required for such an operation, which also includes the pumping of 10,000 tons of water per day.

Increased mechanization at the plant and world demand for Chilean nitrates called for a substantial addition to the Pedro de Valdivia power plant. The new engine-generator unit consists of a Nordberg 10-cylinder, 2-cycle, single-acting Diesel with a sea level rating of 7100 bhp at 164 rpm, direct-connected to a 6600-volt alternator. At the altitude of 5000 ft, the engine develops 6400 bhp.

The Elliott motor-driven scavenging blower which was selected for this engine, was located 8 ft below the basement floor level and the distributing header for scavenging air was placed underneath the floor, where the fresh air duct was already located. The single-stage blower, rated 34,500 cfm,

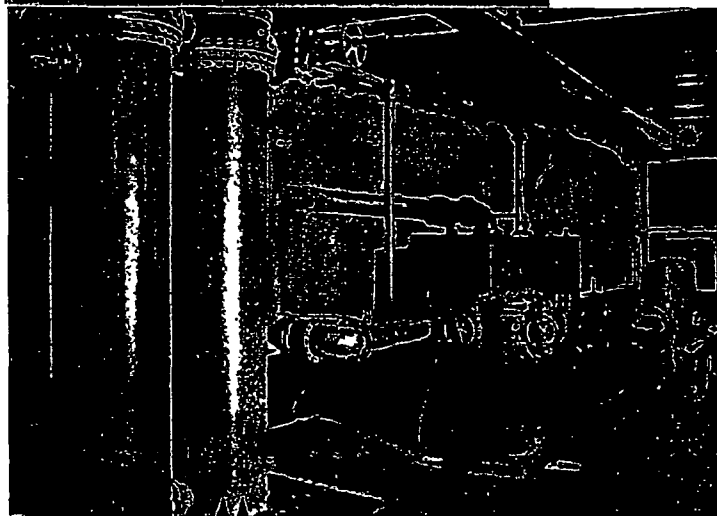


The Elliott meter-driven scavenging air blower is conveniently located in a pit in the basement floor.

An Elliott twin oil strainer is used in the lube oil system. The photograph shows the sump tank, gear pumps, purifiers, and oil coolers.

with a pressure differential of 3.25 psi at 3450 rpm, is driven by an Elliott 700-hp, 6600-volt, squirrel-cage induction motor which receives power direct from the station bus. A gage board incorporating the electrical controls for the Elliott blower is installed alongside the instrument panel for the engine. (The article beginning on the next page discusses the application of motor-driven scavenging blowers.)

An Elliott twin oil strainer is used in the lube oil system. Two 500-gpm pumps are required to pump the necessary amount of lube oil through the Elliott strainer and the coolers back to the pressure oil header inside the engine. A third pump acts as a standby. A relief valve set for 60 psi maximum pressure is installed ahead of the strainer thereby limiting the delivery pressure of the positive displacement pumps. The total amount of lube oil in circulation within the system is 2900 gal.



● The use of the motor-driven centrifugal blower as the source of scavenging air for a two-cycle Diesel engine has provided one solution to the problem of installing maximum additional horsepower into restricted space. When the blower is properly proportioned and its peculiarities are understood, it is a very satisfactory source of air. That the motor-driven blower is economically justified is proven by the fact that the author's company has installed, or has under construction, since the end of World War II, Diesel engine installations in excess of 170,000 hp employing motor-driven blowers.

When an additional engine is installed in an existing power house either in place of an older engine

scavenging air distribution to the cylinders becomes quite unbalanced if air is supplied through one end of the scavenging header. The arrangement shown provides even distribution and uniform scavenging for all cylinders.

For an engine of the magnitude just mentioned, which requires 45,000 cfm at a pressure rise of 3.6 psi, there are no commercially available positive displacement type blowers which are suitable. Even if developed they would be extremely large and require either a large slow-speed motor or a reduction gear. A reciprocating pump would be much too large and cumbersome.

In ships where the machinery space is very crowded it has been found practical to locate the centrifugal blowers at almost any reasonable place and pipe the air to the engine.

In studying the interrelation of centrifugal blower and Diesel engine, it is important to realize that both speed and conditions at blower inlet are variable as volume and density change. Characteristic curves must be constructed for the unit as installed, allowing for increasing resistance in the intake system with increasing volume, and also decreasing motor speed with increasing horsepower. Both of these factors increase the droop of the blower characteristic curves. Fouling of the engine and of the blower impeller blades by dust and oil must also be taken into account.

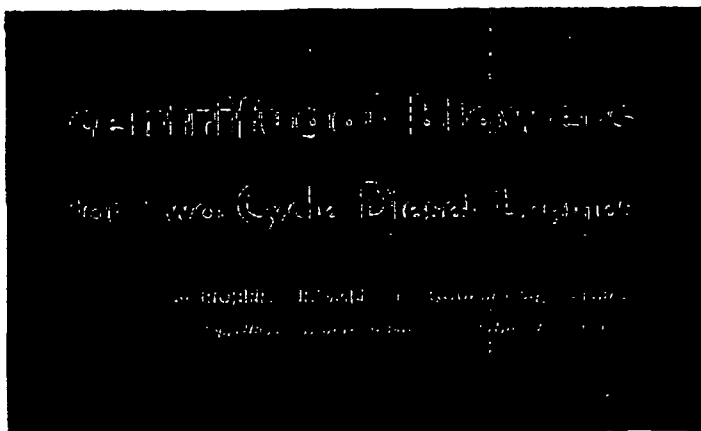
The blower discharge pressure curves shown are actual curves, the pressure droop being increased due to motor speed droop as volume, and consequently power, increase. Also they have been constructed by using the total pressure rise developed in the blower and subtracting the loss in inlet piping and filter, which increases almost as the square of the volume.

There is a small pressure loss in the blower discharge piping which has here been included with the engine resistance.

For most efficient operation, the air volume of a two-cycle engine could decrease as the load decreases, but no available air source has this characteristic, with the possible exception of an exhaust driven supercharger. The characteristic of positive displacement blowers and pumps is very steep, i.e., the volume delivered is almost independent of changes in engine resistance or atmospheric conditions. The power required is affected only by atmospheric density variations.

The characteristics of the centrifugal blower are less favorable and because it is necessary to select the blower for maximum ambient temperature,

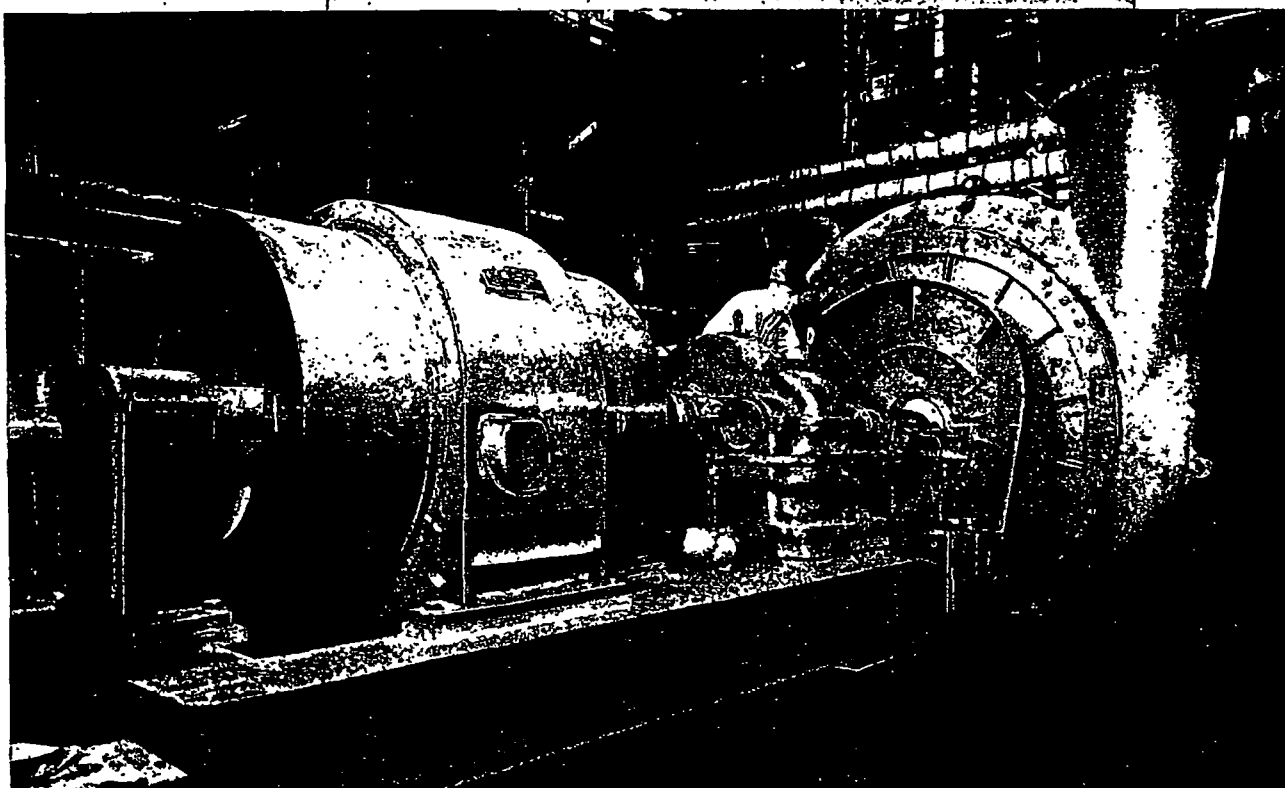
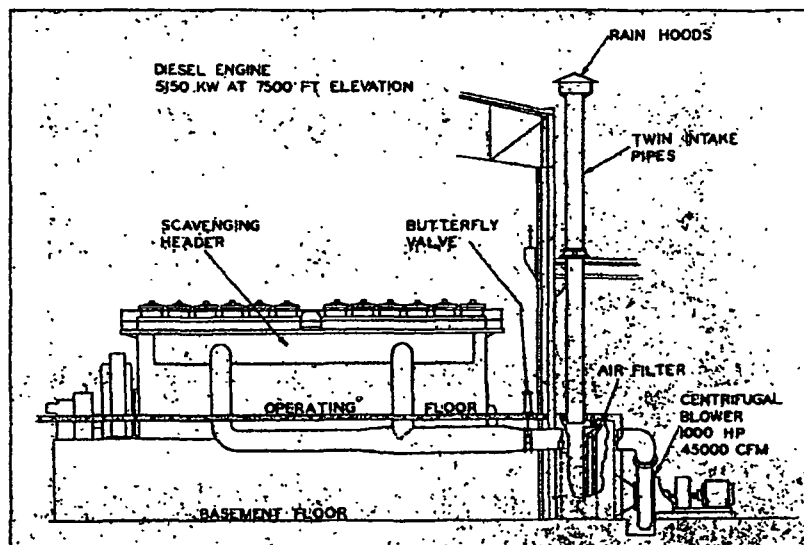
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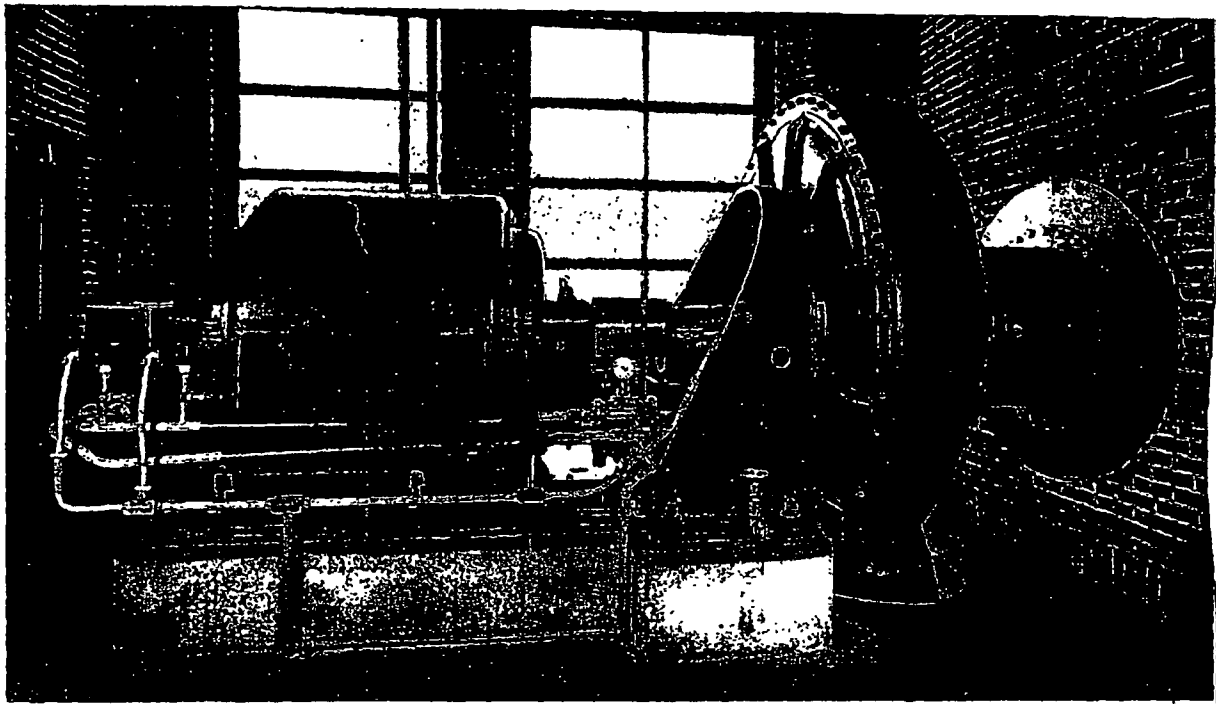
or in other available but restricted space, it has been found possible to include one or two additional cylinders in the space which would be occupied by the scavenging pump or gear-driven blower. The centrifugal blower may be located in a smaller structure outside the main power house, in a separate available room as in the installation pictured on the opposite page, or perhaps placed in a pit as shown on the preceding page.

For very large engines, especially with large numbers of cylinders, a much better distribution of scavenging air is possible than with an engine-driven blower or pump located on one end of the crankshaft. A line drawing is reproduced showing the arrangement of the scavenging air system for a large power plant currently being built in Mexico City. The engine is one of six 12-cylinder, 29 in. x 40 in. machines, the crankshaft being 57 ft long. It has been found that for engines of this length,

Showing the arrangement of the scavenging air system for the 29 in. x 40 in., 12-cylinder Diesel engine at Mexico City.



Shop view of one of six Elliott motor-driven scavenging blowers serving Nordberg 7300-hp Diesel engines for Commission de Federal Electricidade, Mexico City, D. F. This single-stage blower is rated at 45,000 inlet cfm at a pressure rise of 3.62 psi. The blower is driven through gears by an Elliott 1000-hp, 3-phase, 50-cycle, 6300-volt, squirrel-cage induction motor. The motor operates at 1460 rpm and the blower at 4360 rpm. The line drawing above shows how this blower is used in the scavenging air system of this big Diesel engine, the blower being conveniently located outside the building which houses the engine.



Elliott motor-driven scavenging blower serving a Nordberg 7100 hp Diesel Engine at Iowa Electric Light & Power Company, Marshalltown, Iowa. Blower is rated 34,000 cfm, at a pressure rise of 2.6 psi. It is driven by a 600-hp, 3550-rpm squirrel-cage induction motor. Blower takes air from outside and discharges to the engine on the floor below. The use of a separately driven centrifugal scavenging blower, together with the use of a belted exciter-pilot exciter combination instead of the direct-connected exciters of the older engines in the station, made it possible to install a 29-in. engine of 7100 hp rating in the same overall length as either of the 3600-hp units.

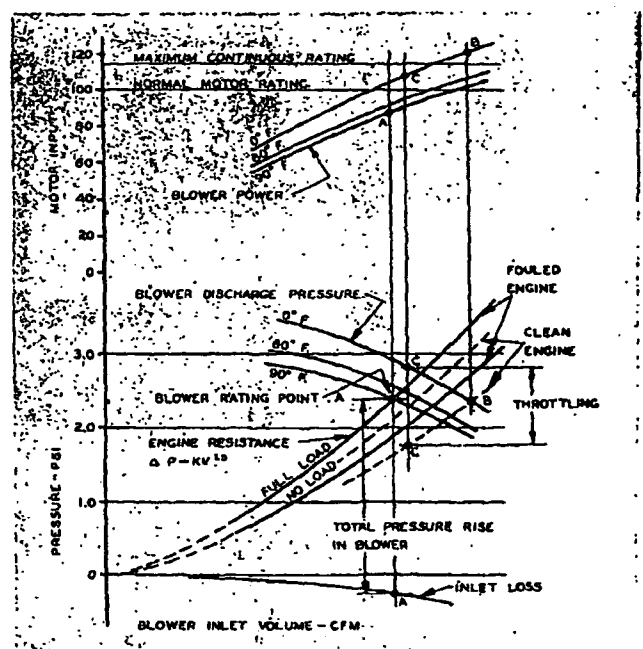
minimum barometer, maximum load condition, plus allowance for engine and blower fouling, it is also necessary to limit the blower power at high density (cold air) and minimum load conditions to maintain reasonable fuel consumption and to avoid overloading the motor. This is most conveniently done by throttling with a butterfly valve. Again referring to the curves, the rating point (90 F, full load) is shown at "A." If with no other changes the load drops to zero and the temperature decreases to 0 F, the volume will increase about 20 per cent and the power about 45 per cent to the point "B." Accepting the premise that weight flow is the necessary criterion for proper engine performance it will be seen that any point to the right of "A" and above the 90 F characteristic will give better than minimum scavenging, and any throttling which does not reduce the volume below point "A" is not detrimental. Hence by throttling to some point such as "C," the blower power may be reasonably limited.

The throttling valve may be located in either blower suction or blower discharge. It is usually located in the discharge because it is more readily accessible to the engine operator. Automatic control has not been found necessary. Generally, the

Characteristics of 2 1/2 in. x 29 in. Diesel engine at 225 rpm with centrifugal blower.

adjustment is mainly to compensate for atmospheric temperature variation and a conveniently located ammeter to show motor current is a rough but reliable guide to throttle setting.

When centrifugal blowers are driven by DC motors, as in marine installations, some compensation for atmospheric variation may be accomplished by variable speed control.



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"You've read that sentence wrong, Miss Adams—it's 'all men are created equal'—not 'all men are made the same way'!"

Look out for the friendly gal
Who loves her beer and rye;
You may not know it, pal,
But she'll make you buy and buy.

Chief: "How come you're late this morning, Joe?"
Fireman: "I overslept."
Chief: "What! Do you sleep at home, too?"

Then there was the bitter golf match between two Scots under a broiling sun, in which one of them had a stroke—and the other made him count it.

A salesman became tired of his job and joined the police force. Later, when asked how he liked his new job, he replied:
"Swell: the pay is good, the hours O. K., and the customer is always wrong."

The best way to get a person's head out of the clouds and his feet on the ground is to place some heavy responsibility upon his shoulders.

Shot—that which, if some people have more than one, they're half.

Before signing a receipt for his pay check, the young man was handed a company form slip with the wording: "Your salary is your personal business—a confidential matter—and not to be disclosed to anybody else."

He read it carefully, then, shielding the paper with his hand, he wrote:
"I won't mention it to anybody. I'm just as much ashamed of it as you are."

He: "Now that we are married, perhaps I can point out a few of your defects."
She: "Don't bother, dear. I know all about them. It's those defects that kept me from getting a better man than you."



"My you're handsome! You're brave! You got everything! Now you run right in and ask her to sharpen this pencil for you."



"Now Gus, that's what I call a real—well, that's just what I call a real GURL!"

Girl needs a job. Is willing to struggle if given opportunity.

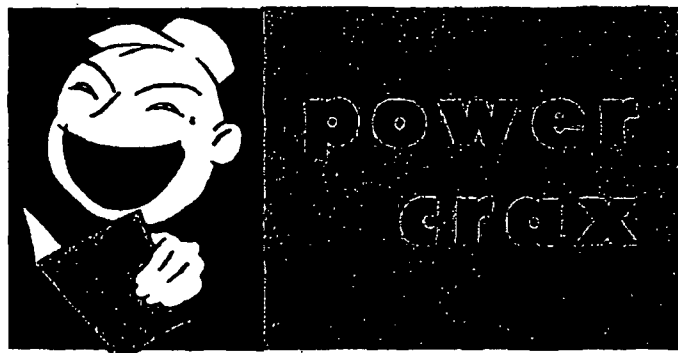
Up to the age of sixteen a boy may be a boy scout. But from that time on he's a girl scout.

Nothing robs a man of his good looks like a hurriedly-drawn shade.

Some doctor says that kissing shortens life. Sure it does—single.

House Dick (on phone): Are you entertaining a man in your room?
Tootsie: Just a minute—I'll ask him!

The reason a dog has so many friends is that his tail wags instead of his tongue.



Woman Customer (in bank): "I would like to make a loan."
Bank Official: "You'll have to see the loan arranger."
Woman: "Who?"
Official: "The loan arranger. The loan arranger!"
Woman: "Oh, you mean the one who says, 'Hi-Ho Silver?'"

The family had overslept and the lady of the house woke with a start to the clanking of cans down the street. She remembered that the garbage had not been put out, and raced down to the front door, struggling into a robe, with her hair in curlers, and looking sleepy-eyed.
"Yoo hoo," she called. "Am I too late for the garbage?"
"No," shouted the collector. "Jump right in."

An elderly gentleman saw a young boy sitting on the curb crying and sobbing. "Why are you crying, little boy?" the oldster asked.
"Because I can't do what the big boys do," he sobbed.
So the oldtimer sat down on the curb and cried too!

Then there is a nurse who is so conceited that when she takes her patient's pulse, she subtracts ten beats for her personality.



"Ten mistakes in this one letter—Miss Lovelace you're 6—you're fire—oh, er—ah, that's a lovely dress, Miss Lovelace!"

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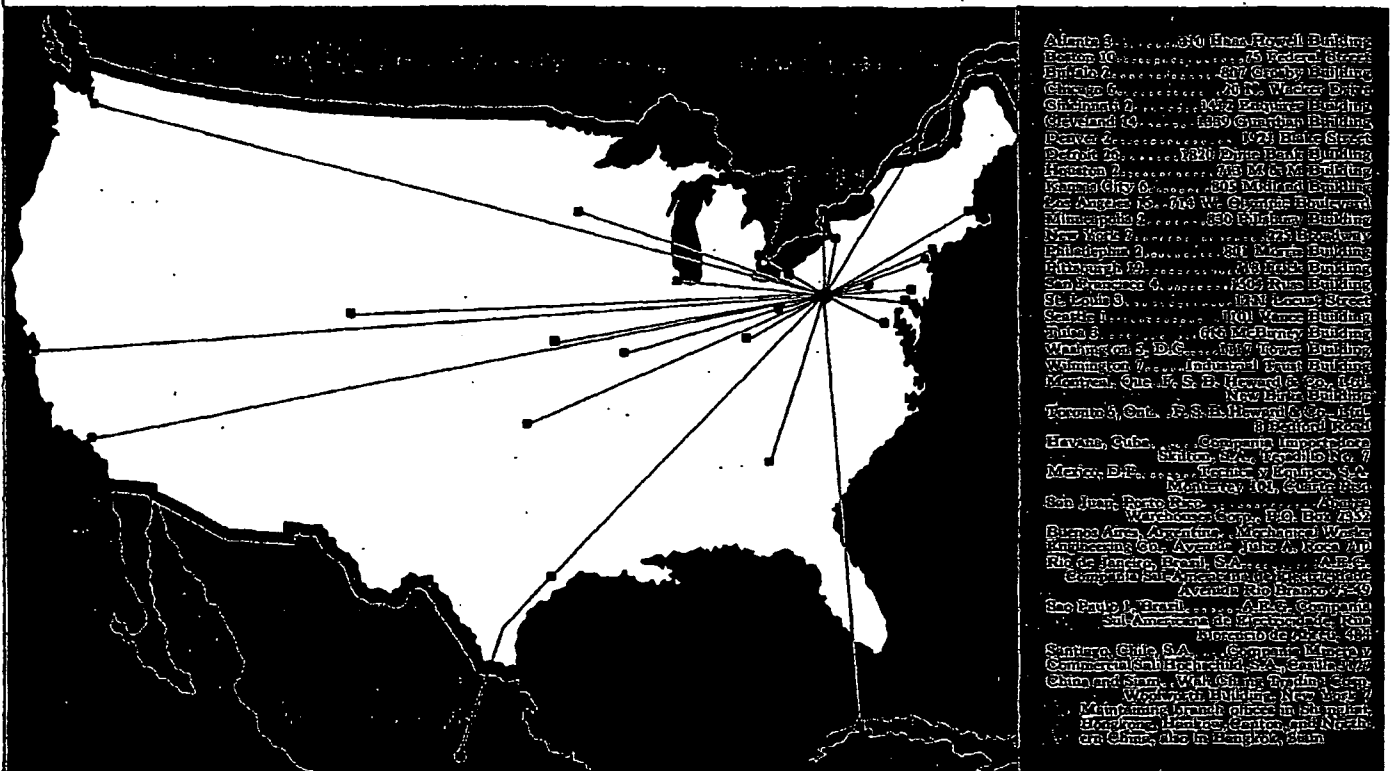
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