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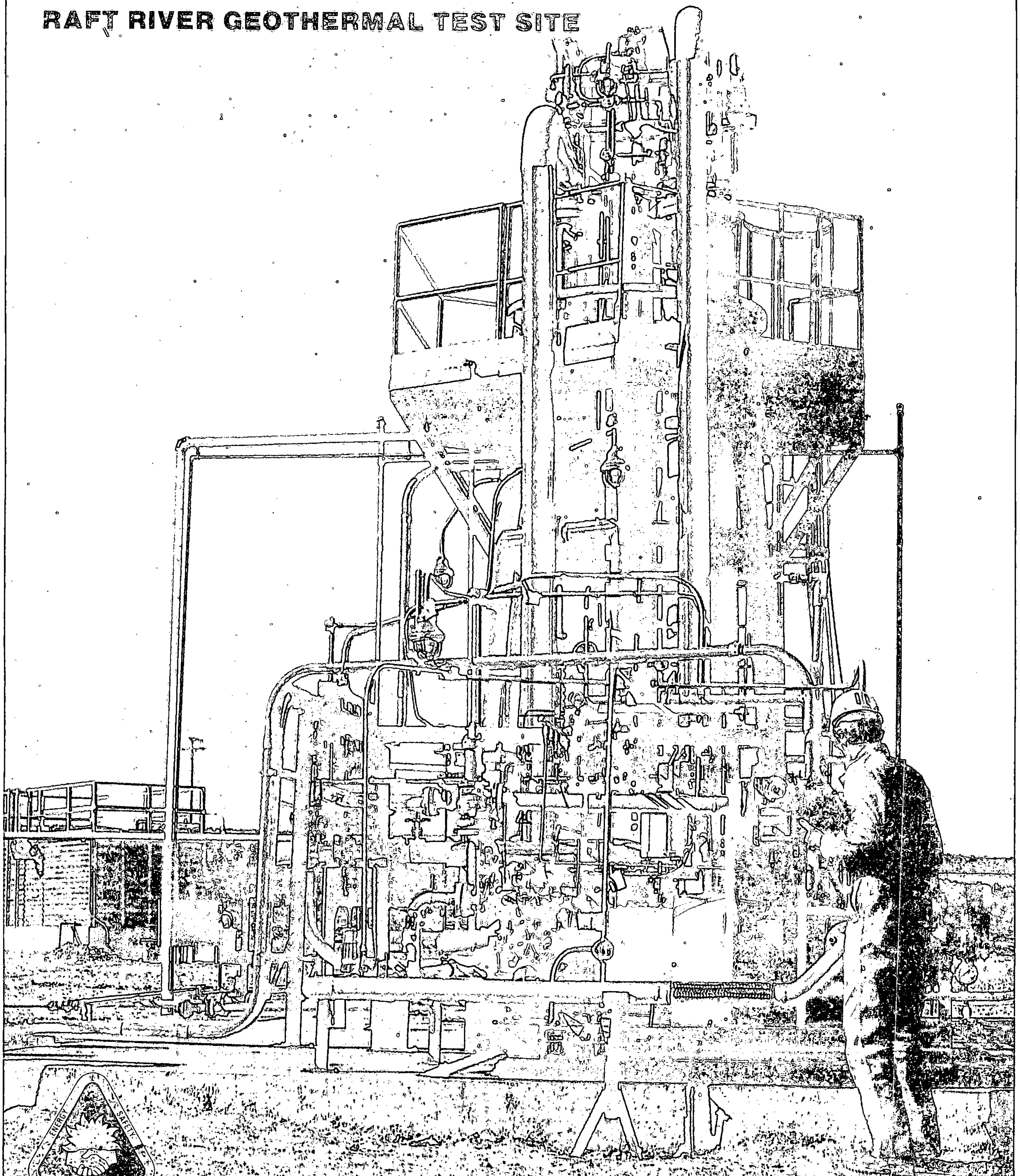
PROTOTYPE POWER PLANT

RAFT RIVER GEOTHERMAL TEST SITE



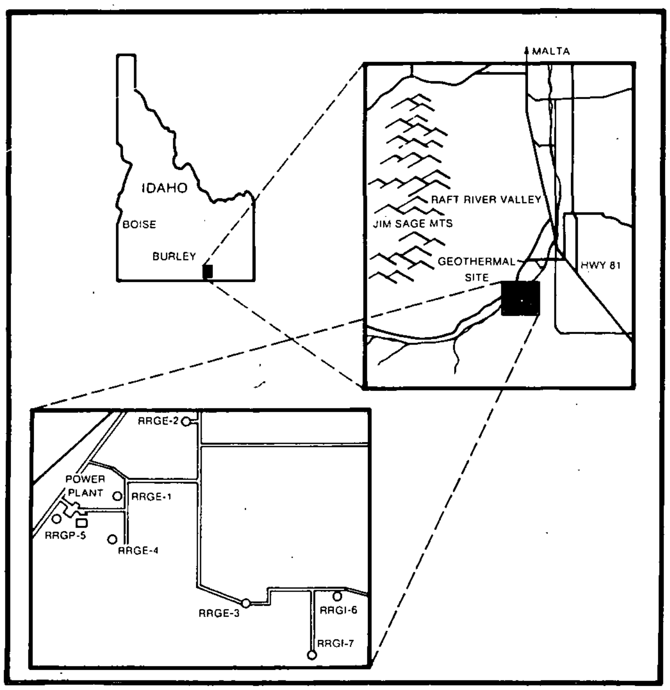
ENERGY · SAFETY · ENVIRONMENT

IDAHO NATIONAL ENGINEERING LABORATORY

DEPARTMENT OF ENERGY · IDAHO OPERATIONS OFFICE

RAFT RIVER TEST SITE

At a test site in south-central Idaho's Raft River Valley, the Idaho National Engineering Laboratory (INEL) is investigating practical uses for moderate-temperature geothermal fluid. This research is sponsored by the Department of Energy (DOE), and the prime contractor is EG&G Idaho, Inc. Among the facilities is a prototype electrical power plant which will not only generate power, but will be used as a test bed to study improved equipment designs and provide information for the design of larger pilot plants to be built in the 1980's.

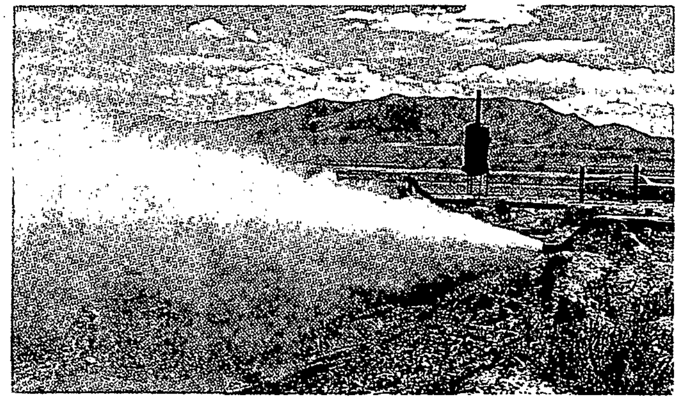


Raft River geothermal site and location of wells

BACKGROUND

Geothermal energy is considered to be that energy which is stored in liquid, vapor, or solid form and located under the earth's surface. The largest source, but also the most difficult to recover, is magma, the molten material which appears during a typical volcanic eruption. A second source of energy is dry steam, which is produced by water coming in contact with hot rock formations. These sources are usually at a temperature in excess of 204° C (400° F) but are rare. However, where these resources have been found, they have usually been harnessed and used to generate power or provide heat. The first known use of geothermal steam to generate electrical power occurred in Larderello, Italy, in 1904. Because this resource is in vapor form, and at high temperature and pressure, standard turbo-generator machinery can be used to provide power.

Another source of geothermal energy is hot water which ranges from 38 to 260° C (100 to 500° F). The lower temperature fluid can be used for power plant cooling and is also used for other purposes. In fact, Boise, Idaho has used it since 1892 to heat buildings. The very hot resources, like steam, are used or are planned for use in power production. However, the most abundant fluid occurs in the moderate temperature range of 90 to 150° C (194 to 300° F) and is prevalent in the Intermountain West. This superheated fluid can be used either in direct applications or for power production. Because of its moderate temperature the fluid can not be used for power generation by flashing, because the resultant steam pressure is low. This low steam pressure would require large plant equipment which is economically impractical. For these reasons dual-boiling cycle systems are being investigated at Raft River for power production using this energy source.


Steam produced from flashing geothermal fluid

GEOTHERMAL WELL

The well, which supplies fluid to the prototype plant, was drilled to a depth of 1521 m (4989 ft) using a conventional rotary bit rig, that was modified to prevent the fluid from flashing to steam. During the drilling operation, water was used as the drilling fluid rather than the conventional mud. The well, designated RRGP-1, supplies fluid at 50.5 l/sec (800 gpm) and 147° C (297° F).

This well was the first completed at the test site and was drilled into a geological fault to ensure its productivity. Geologists are not certain how the fluid is heated, but speculate that heat is provided by either a near-surface igneous source or by the fluid flowing to great depths and being heated by the earth's normal temperature gradient, 1.8° C/100 m (1° F/100 ft). A submersible pump located 213 m (700 ft) below ground level moves the fluid.

The well's production was initially used to evaluate materials and components which were eventually incorporated into the prototype plant. The "used" fluid was also employed in other geothermal research projects, such as crop irrigation and fish farming. The conservatively estimated well life is at least 10 years.

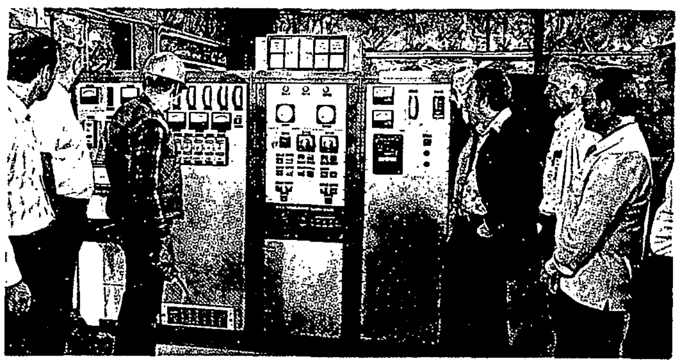
The estimated amount of fluid at the test site is 5×10^5 hectare-m (4×10^6 acre-feet), which is enough to run a 5-$MW_{(e)}$ plant for over 1000 years.

POWER CYCLE

Since it is impractical to generate power with steam flashed from moderate-temperature geothermal fluid, engineers have been testing a binary cycle system. By using the geothermal fluid to heat a second fluid which has a low boiling point (and consequently a high vapor pressure) a power generation system can be constructed using conventional components. In the prototype plant, the secondary fluid is isobutane. Another advantage in using the dual-boiling cycle system is that the somewhat corrosive geothermal fluid does not make contact with the turbo-generator machinery and thereby reduces maintenance costs.

PROTOTYPE POWER PLANT

The prototype plant, which is a joint DOE/industry project, is the first attempt to produce electricity for a commercial power grid by using moderate-temperature geothermal fluid in a dual-boiling cycle. The basic plant operation is as follows. Geothermal (primary) fluid enters the boiler at 5.05 l/sec (80 gpm) and 135° C (275° F) and flows out to a cooling pond at 116° C (240° F). From the cooling pond the "used" geothermal fluid is either pumped back into the ground or diverted to areas where other geothermal research projects are conducted. While in the boiler, enough heat is transferred from the geothermal fluid to the secondary fluid (isobutane) to cause boiling. The vaporized isobutane drives the single-stage, axial flow turbine which turns the electrical generator. The 1.6 kg/sec (13,000 lbs/hr), 49° C (120° F) isobutane passes into the condenser where it is cooled and liquidized. The fluid is cooled by regular well water which is pumped into the condenser at 12.7 l/sec (200 gpm) and 24° C (75° F). The cooling water is heated in the condenser to 35° C (95° F) and then circulated through a standard wet cooling tower where the temperature is reduced to 24° C (75° F). The liquid isobutane is pumped back to the boiler where it is available to start the cycle again.



Initial startup tests of the prototype power plant

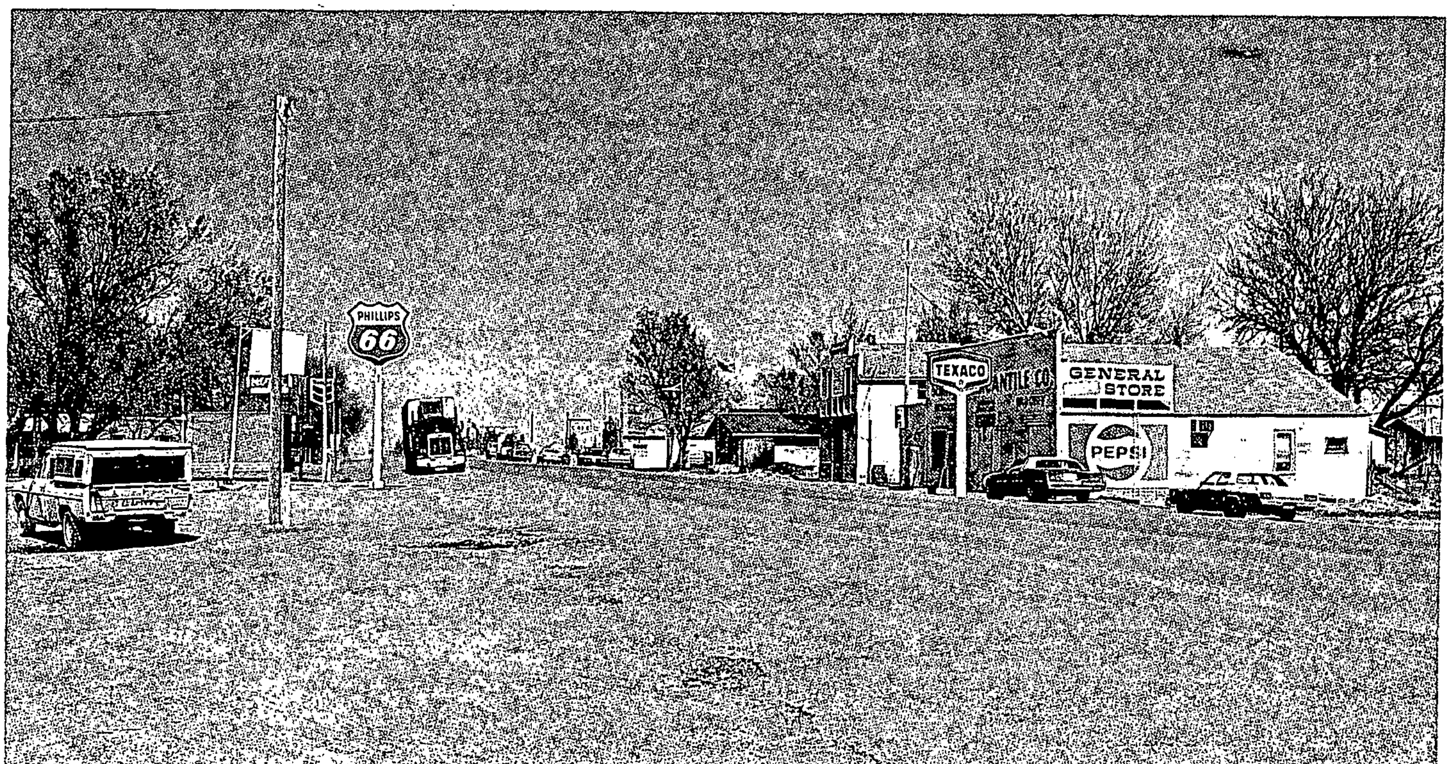
The plant has an automatic control system, much like those used in commercial power generation plants, which regulates most plant conditions such as flows, temperatures, and pressures. The plant also has an emergency shutdown system which will stop plant operation if an out-of-specification condition is experienced, such as turbine overspeed, overpressurization and power loss.

Besides providing enough electrical power to meet the lighting requirements for the town of Malta, Idaho, the plant will be primarily used as a test bed to: (a) develop an understanding of the isobutane dual-boiling cycle; (b) accumulate data on power plant operation; (c) determine if it is feasible to use fluidized bed heat exchangers; and (d) test advanced condenser designs. The system is designed so that test components can be easily removed and replaced as dictated by experiment requirements. This, in turn, results in minimum downtime.

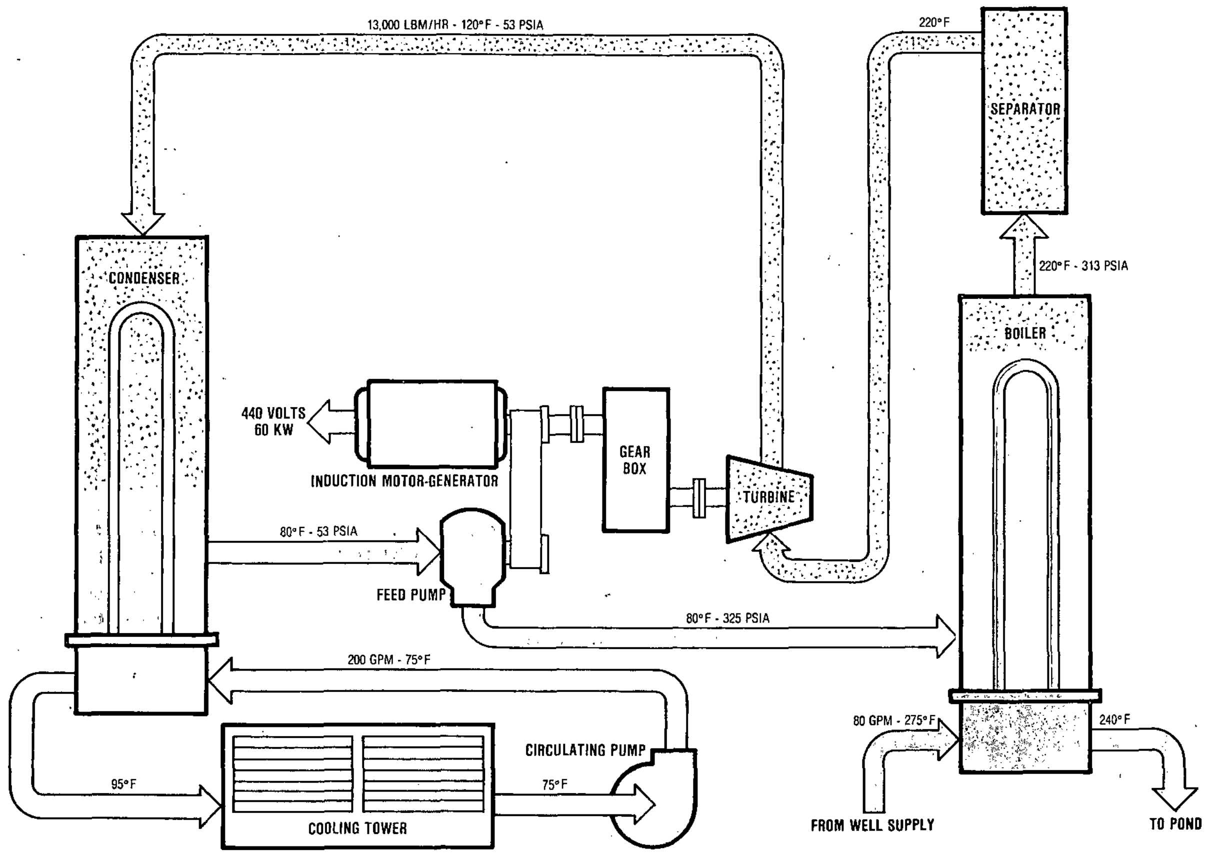
THE FUTURE

The next generation of geothermal power production plants is already on the drawing board. Preconceptual design of a second 5-$MW_{(e)}$ plant, also scheduled for construction at the Raft River Geothermal Test Site, has started, and the plant is expected to be "on stream" during 1983. Construction of a 50-$MW_{(e)}$ plant is envisioned with a completion date in the late 1980's.

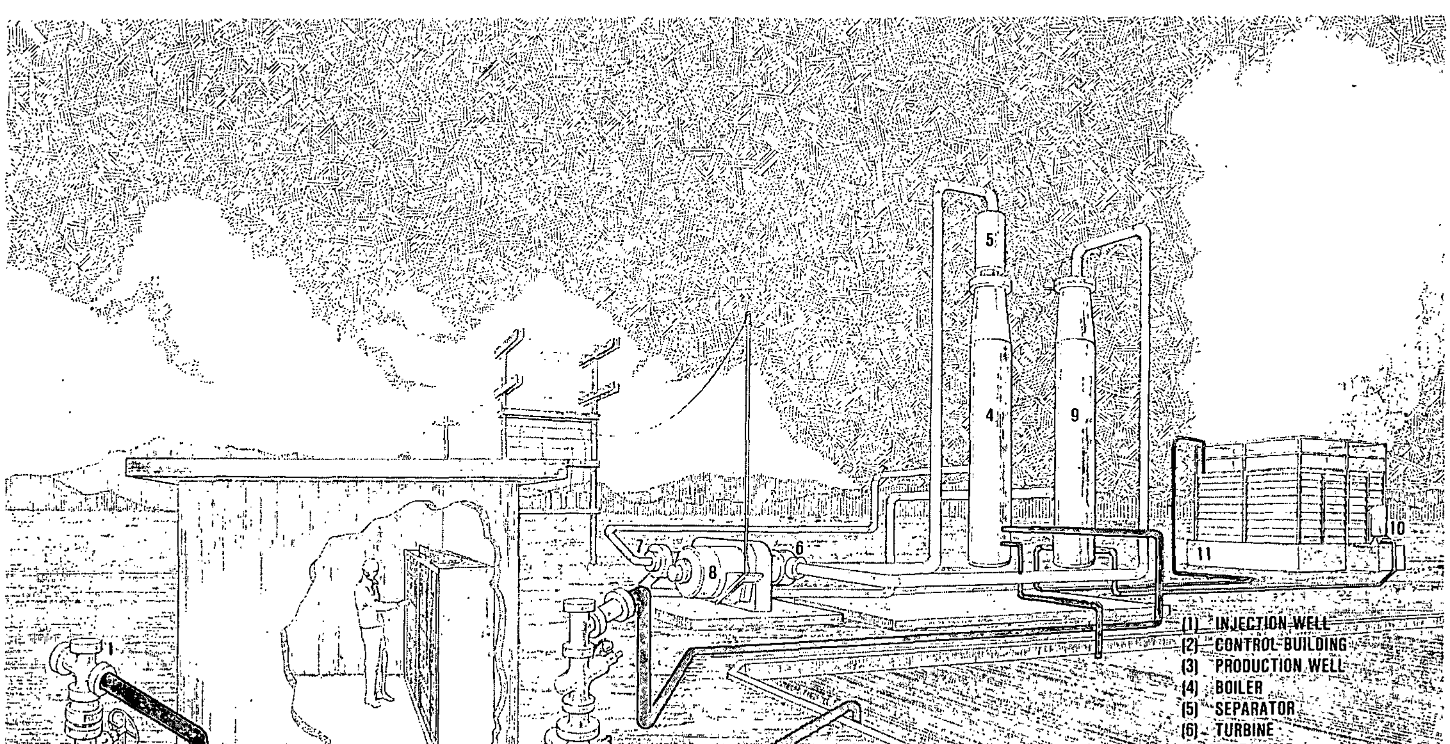
Proposals have been developed for the construction of power plant/industrial complexes. In these complexes the geothermal fluid is first used to generate power in the 25 to 50 $MW_{(e)}$ range and then is put to one or more industrial/agricultural uses before being injected back into the ground. Secondary uses include greenhouse heating, feedlot operation, manure processing, fish farming, and food processing.



Sufficient power is generated by the prototype power plant to light the town of Malta, Idaho



PROTOTYPE GEOTHERMAL GENERATOR



Artist's concept of Prototype Power Plant

EG&G Idaho, Inc.