TABLE I—PHYSICAL CHARACTERISTICS OF TYPICAL 2500-KW STEEL-MILL GAS ENGINE

ENGINE END	
Floor space occupied by one unit	2400 sq ft
Height above floor (over flywheel)	18 ft, 4½ in.
Number of cylinders	4
Cylinder size	47-in. dia x 60 in.
Crankpin	23-in. dia x 16 in.
Crosshead pins	13-in. dia x 17 in.
Main bearings	30-in. dia x 54 in.
Shaft dia at center	36 in.
Flywheel dia	28 ft
Cooling water	18,500 gph
Gas consumption (normal load)	435,000 cfh
Thermal efficiency (less waste-heat boiler)	26.0%
Complete engine, wt (including flywheel)	1,500,000 lb
Frame, wt	167,000 lb
Cylinder, wt (without valves or gears)	35,000 lb
Connecting rod, wt	14,000 lb
Shaft, wt	72,000 lb
Shaft, wt (with cranks and wheel hub)	196,000 lb
Main crosshead, wt	11,000 lb
Piston, wt	3600 lb
Piston rod, wt	7400 lb
Flywheel, wt	260,000 lb
GENERATOR END	
Field poles, number	34
Rating at 0.8 pf, continuous	2500 kw
Current	25 cycles, 3 phase, 6600 v
Efficiency (full load)	95%
Rotor, wt	65,000 lb
Complete generator, wt	134,000 lb

TABLE II—HEAT BALANCE Typical Gas Engine and Boiler

	M Btu	Percent
Net power generation	12,683	27.16
Steam generation	13,983	29.94
Loss to cooling water	12,040	25.78
Loss to boiler blowdown	913	1.95
Loss to sensible heat in stack gas	4,691	10.04
Loss to CO in stack gas	——	0.00
Radiation and unaccounted for	2,398	5.13
	46,708	100.00
Boiler Heat Balance		
Steam generation	13,983	70.51
Loss to blowdown	913	4.60
Loss to sensible heat in stack gas	4,691	23.66
Radiation and unaccounted for	243	1.23
	19,830	100.00
Engine Heat Balance		
Net power generation	12,683	47.18
Loss to cooling water	12,040	44.80
Radiation, mechanical and electrical losses	2,153	8.02
	26,878	100.00

ard procedure. Time required to bring an engine up to load hinges on the length of time it has been off the line as well as number and type of repairs made while it was out of service. As an example, some repairs require "running-in" time and an engine may be run for as much as 20 to 30 min for this operation before having any load put on it. Again, if an engine has been down some time and all parts are cold, allowance must be made for heating it up so difficulties from uneven expansion can be avoided. Cast-iron liners covered with a layer of insulation and housed in steel shells act as the exit channel for exhaust gas from the engines. They undergo considerable expansion and growth in starting up so allowance must be made for this action.

Normally, starting up with a warm engine takes less than 5 min. Compressed air at 250 psi admitted through cam-operated air-starter valves turns the engine over. During this turning-over period gas is gradually introduced until a combustible mixture is available. After it is in the cylinders, the compressed-air supply goes off and engine is brought up to speed under manual control with visual guidance from a synchroscope. Once it indicates the engine is up to *exact speed* the *generator* is put on the line.

Load scheduling for these engines is made on their duty as base-load units. They can carry reduced loads but within definite limits. With steam turbines also delivering energy the usual practice is to take advantage of the turbine's better ability to follow any load variation.

Engine exhaust passes through cast-iron liners, and enters waste-heat boilers. Exhaust-gas temperature entering the boilers runs about 1200 F. These are vertical watertube units equipped with economizers and superheaters, capable of reducing engine exhaust from 1200 to 350 F. Some deliver steam at 165 psi, others at 275 psi, with capacities from 2 to 4 lb per kwhr.

Feedwater for the boilers acts first as a cooling agent for pistons, cylinder jackets, cylinder heads and exhaust valves. About 18,500 gal per hr pass through the engine to experience a temperature rise of about 60 F. This heat pickup is credited to the engine in computing its thermal efficiency. Table II gives a typical heat balance from a paper by T A Lewis, superintendent, service div, Bethlehem plant, Bethlehem Steel, presented before the Association of Iron and Steel Engineers.

A definitely scheduled maintenance program is carried out for all gas-electric engines. It consists of a shutdown about every 600 hr to check bearings, piston-rod alignment, cylinder lubrication, generator clearance, etc, and to flush cooling-water jackets. . .

VERTICAL TURBINE PUMPS Q&A

W C Mumford, application engineer, vertical turbine-pump division, Worthington, gives practical information on construction, operation, characteristics, troubles, remedies

1—Service, Drives, Construction

Q 1—What is a vertical-turbine centrifugal pump?

A—It is a vertical-shaft, diffuser, single- or multi-stage centrifugal pump with the pumping element suspended from the discharge piping, Fig. 1 and 2. Needs of a given installation determine length of discharge piping. Pumping bowl, *B*, may connect directly to the discharge head, as in close-coupled pumps for shallow pits or sump service. Under such conditions there may be no discharge piping.

These pumps, originally designed for raising water from wells, have been variously known as deepwell, turbine-well or borehole pumps. Vertical-turbine pump is now the accepted term.

Q 2—What is the difference between a vertical-turbine pump and vertical wet-pit propeller pump?

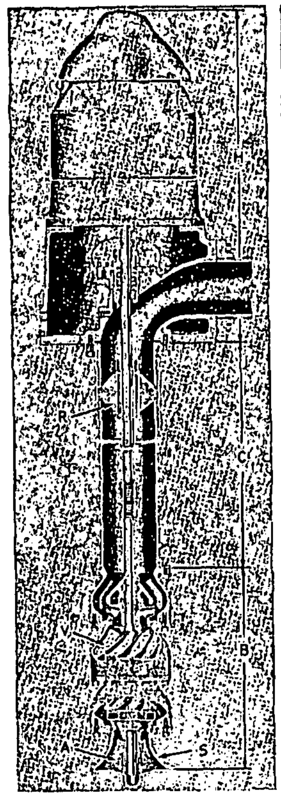
A—The basic difference between these units is specific speed. Although there are generally no limitations, vertical-turbine pumps are of medium specific speed and wet-pit propeller pumps of high specific-speed design.

Vertical-turbine pumps are suitable for installation in cased wells; by multi-staging, heads as high as 1000 ft can be obtained.

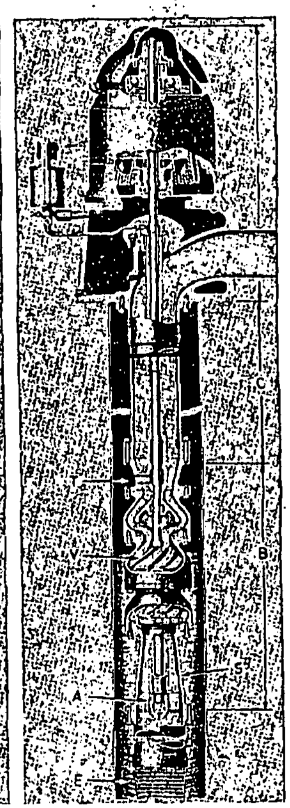
Vertical wet-pit propeller pumps are used for open-pit or sump service. For the same capacity and operating speed their head per stage is lower than that of a comparable vertical-turbine pump. Although single-stage pumps predominate, two stages are often used and sometimes three stages are required to meet heads below the range of a vertical-turbine pump. They are usually called wet-pit propeller pumps and have either axial-flow or mixed-flow impellers.

Q 3—In what services are vertical-turbine pumps used?

A—Pumping from wells constitutes their largest field of applications, but



1 Motor-driven, vertical-shaft, diffuser, multistage, deepwell centrifugal pump has pumping element suspended from the discharge piping



2 Vertical-shaft turbine deepwell pump has discharge opening above the foundation and driving shaft enclosed in a tube and oil lubricated