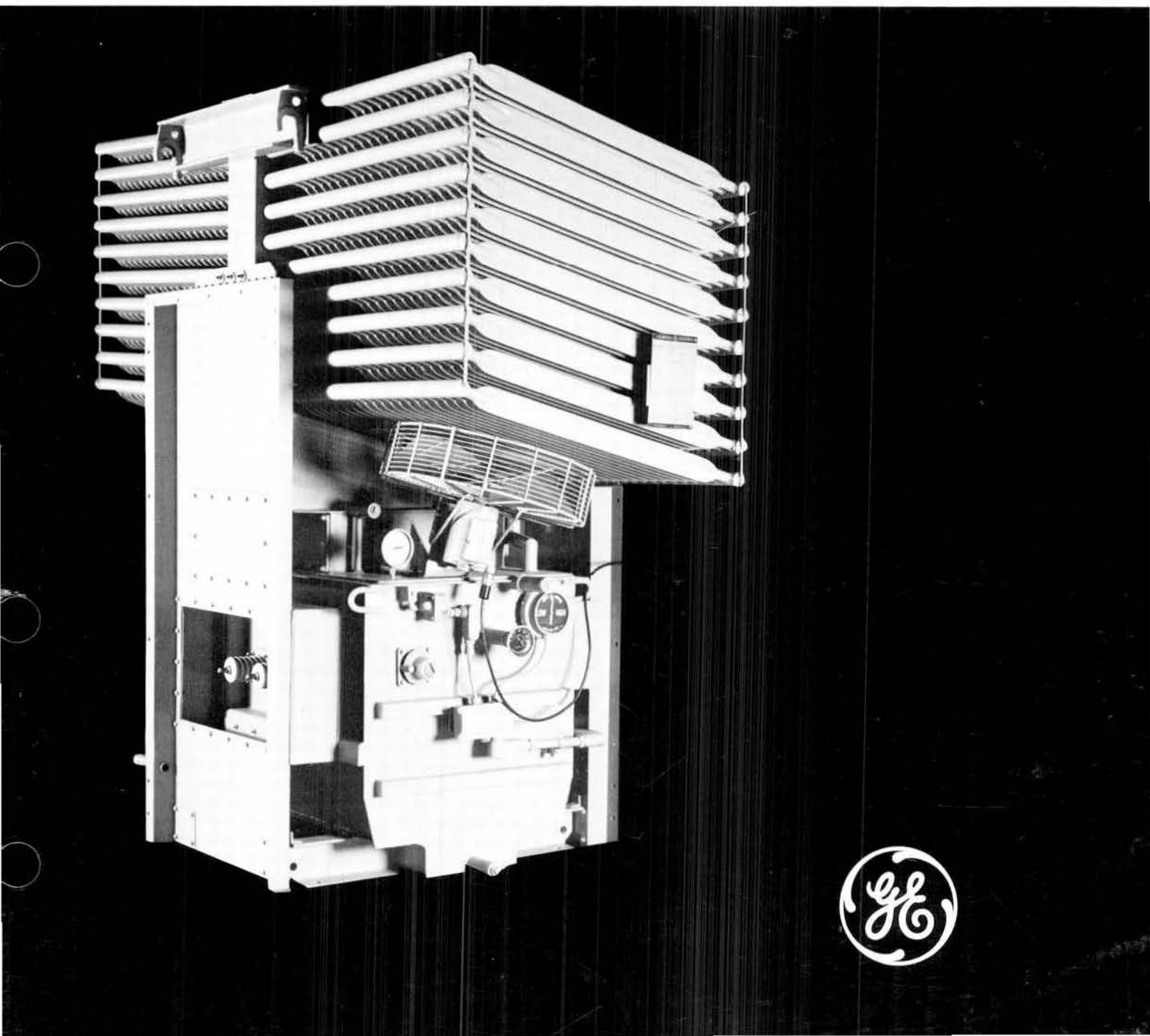
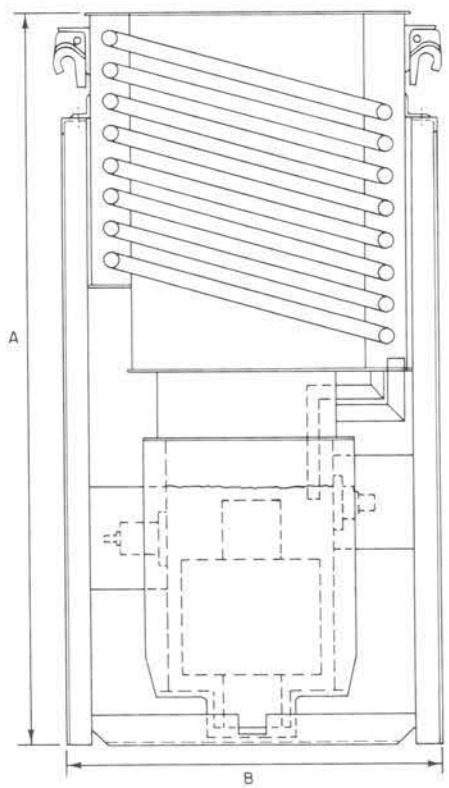
GEA-10495E

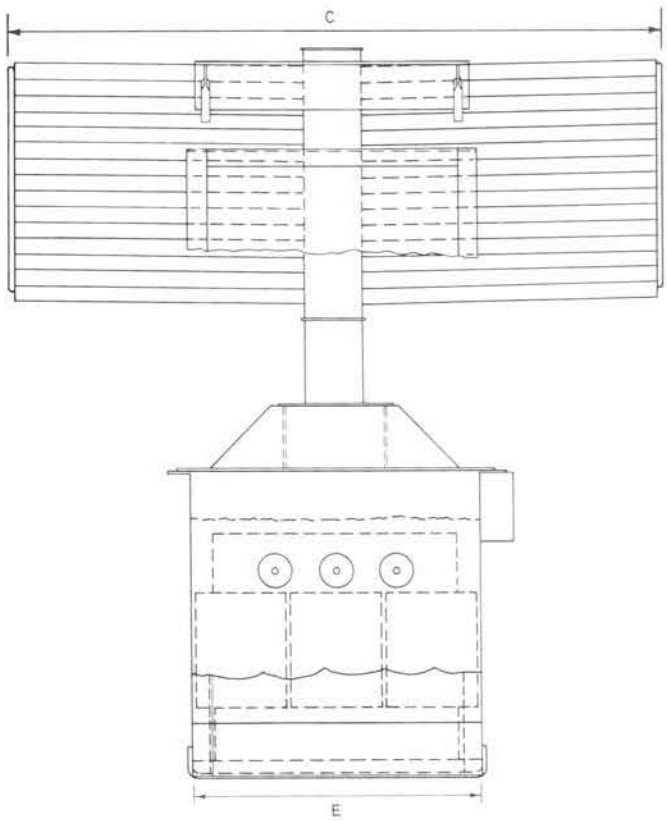
VaporTran®

Secondary Substation Transformers



Dimensions and Weights





Dimensions and Weights—15 kV to 480 Volts

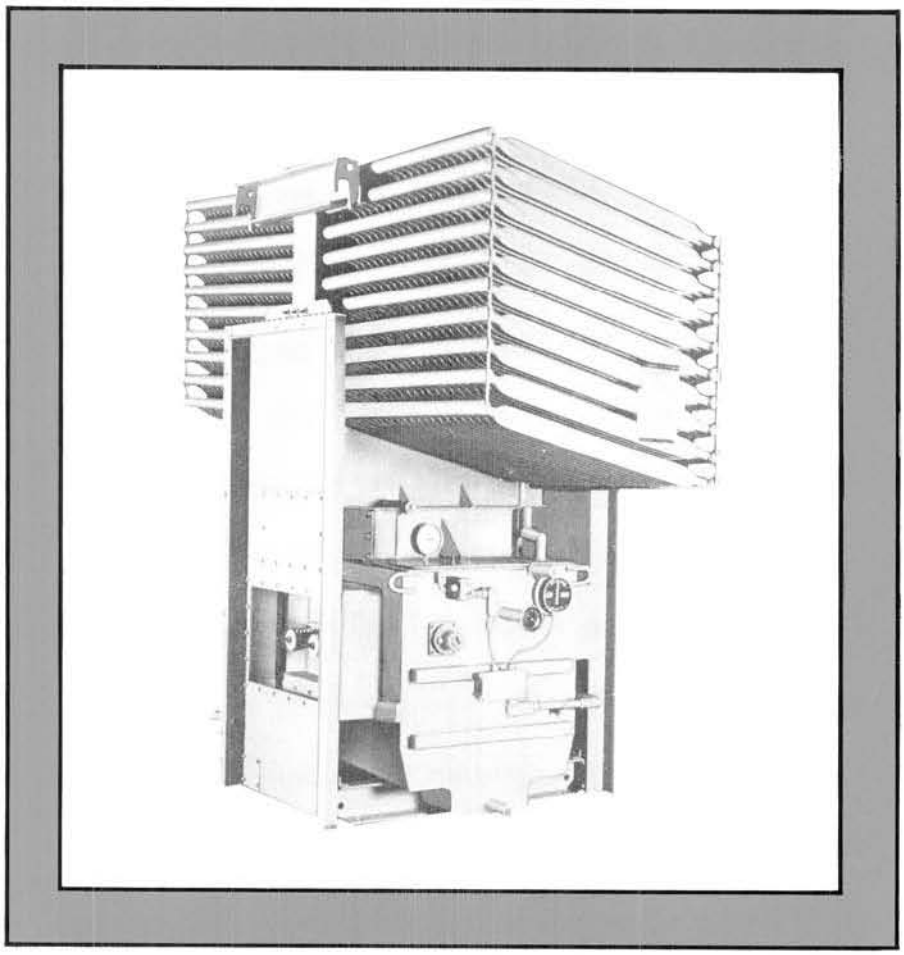
kVA	Dimensions in Inches				Total Weight in Pounds
	"A"	"B"	"C"	"E"	
500	89	49	81	42	5880
750	89	55	88	42	6790
1000	97	66	88	45	7530
1500	117	61	84	47	9320
2000	124	60	96	48	10770
2500	123	66	96	52	12300

Standard Ratings and Characteristics

TRANSFORMER RATINGS

The available incoming power supply determines the primary voltage and the frequency of the transformer. The voltage that is required by the load determines the secondary voltage. Present load, plus allowance for growth, determines the kVA rating of the transformer. Transformers with specific combinations of voltages and kVA ratings are available as standard units.

All standard secondary substation transformers are three-phase, 60 Hz with high-voltage windings, delta-connected.



STANDARD kVA RATINGS

500 kVA
750 kVA
1000 kVA
1500 kVA
2000 kVA
2500 kVA

STANDARD HIGH-VOLTAGE RATINGS

All Delta:

2400 Volts*	12000 Volts
4160 Volts	12470 Volts
4800 Volts	13200 Volts
6900 Volts	13800 Volts
7200 Volts	

Primary voltage ratings are supplemented with four approximately 2½-percent full-capacity taps, two above and two below normal. This combination allows compensating for either a higher or a lower than normal sustained primary voltage.

* Not standard above 1500 kVA.

STANDARD LOW-VOLTAGE RATINGS

208Y/120† 480Y/277
480

† Not standard above 1000 kVA.

Secondary voltage ratings are approximately 4.2 percent above the new standard motor voltages (460 and 230 volts), allowing for voltage drop in the line between the substation and the motor terminals without operating the motor at subnormal voltage. Motors and control operate satisfactorily on voltages 10 percent above or below rating.

Secondary lighting voltages are standardized at the voltage rating of the lamps (120 volt). Lamp operating performance is fairly critical to voltage. Overvoltage causes overheating and subsequent short life of lighting equipment, while undervoltage reduces illumination output and may have adverse effects on the operation of fluorescent lamps. The 120-volt rating for lighting transformers normally gives the best results. If the regulation is then too great, it is the usual practice to correct it with a small voltage regulator installed on each feeder.

RATED FULL-LOAD CURRENTS OF TRANSFORMING SECTIONS

kVA	Primary Line-to-line Volts									Secondary Line-to-line Volts			
	2400	4160	4800	6900	7200	12,000	12,470	13,200	13,800	208	240	480	600
500	120	69.4	60.1	41.8	40.1	24.1	23.1	21.9	20.9	1388	1203	601	481
750	180	104	90.2	62.8	60.1	36.1	34.7	32.8	31.4	2082	1804	902	722
1000	241	139	120	83.7	80.2	48.1	46.3	43.7	41.8	2776	2406	1203	962
1500	361	208	180	126	120	72.2	69.6	65.6	62.8	....	....	1804	1443
2000		278	241	167	160	96.2	92.5	87.5	83.7	....	....	2406	1925
2500		347	301	209	200	120	115.5	109	105	....	....	3007	2405

Standard Ratings and Characteristics

STANDARD IMPEDANCES

kVA	Percentage Impedance
500	4.5
750-2500	5.75§

§ 1000-kVA units with 480 V (delta or wye) low voltage are available with optional 8-percent impedance.

AUDIO SOUND LEVELS

All transformers have an inherent sound caused by the alternating magnetic flux in the core. The sound level is proportional to the kVA size of the transformer. When, due to special application requirements, standard sound levels are objectionable, take the following steps:

1. Install the transformer where sound will be least objectionable.

2. Use flexible conduit connections to prevent sound from being transmitted to other locations where it may be objectionable. Use auxiliary vibration dampers if needed.

3. Design transformer rooms of such a size and shape that they will minimize sound.

4. Install the transformer away from smooth surfaces, hallways, stairways, and enclosures which may reflect, resonate, or echo the sound.

STANDARD SOUND LEVELS

Self-cooled Rating kVA	Sound Levels, Decibels	
	Without Fans	With Fans Running
500	56	67
750	58	67
1000	58	67
1500	60	67
2000	61	67
2500	62	67

PROVISION FOR FAN COOLING

Cooling fans for VaporTran® transformers will increase the transformers capacity 50 percent at 30 C ambient. Provision for adding fans is inherent in all units rated 500-kVA and above.

It includes:

1. Capacity in all current-carrying parts for fan-cooled rating.
2. Provision for thermometer relay to control fan from liquid temperature.

LOADABILITY FOR AMBIENT TEMPERATURES

The VaporTran transformer is responsive to lower ambient temperatures. Loadability increases significantly in ambients, below 30 C.

Ambient Temperature Degrees Centigrade	Per Unit Load, Self Cooled	Per Unit Load, Fan Cooled
0	1.42	1.60
5	1.38	1.60
10	1.34	1.60
15	1.27	1.60
20	1.18	1.60
25	1.09	1.56
30	1.00	1.50
35	.90	1.44
40	.80	1.33

DIELECTRIC TESTS OF WINDING INSULATION

Nominal System Voltage	BIL	Insulation Class	Low Frequency Test	Impulse Tests		
				Chopped Wave		Full Wave
kV	kV	kV	kV	kV Crest	Min. Time to Flashover, Microseconds	kV Crest
1.2	30	1.2	10	36	1.0	30
2.4	45	2.5	15	54	1.25	45
4.8	60	5	19	69	1.5	60
8.32	75	8.7	26	88	1.6	75
14.4	95	15	34	110	1.8	95

Standard Features

HISTORY

The history of the vaporization-cooled transformer dates all the way back to 1894, when the first patent was issued to H. A. Rowland. Work continued and other patents were issued in the early 1900's. GE started its experimentation on the concept in the 1950's and out of this activity other patents were issued in the early 1960's.

In 1962, the Medium Transformer Department in Rome, Georgia tested various methods of applying vaporization cooling to transformers, including the use of an encapsulated core and coil. From 1970 to 1974, GE's Corporate Research and Development Operation refined the "change of state" technology used in vaporization cooling. This test encompassed the changing of liquid dielectric fluids into vapors and the effectiveness of the process.

In 1975 GE developed a vaporization-cooling technique that sprayed a liquid onto the core and coil. The next year several full-sized transformers were built and operated using the spray-cooled technique. Further testing demonstrated the feasibility of a more efficient and economical means of vaporization cooling for transformers — pool boiling. A variety of electrical and insulation tests were performed and several prototypes were built using the pool-boiling technique.

After stringent testing, GE became satisfied that all the strict design criteria had been met. The VaporTran® transformer is the answer to the need for a truly non-flammable, yet economical transformer. These features and the ones that follow make VaporTran the trend in transformers of the future.

NON-FLAMMABLE INSULATING FLUID

The insulating fluid is a fully halogenated halocarbon with the chemical name, trichlorotrifluoroethane, familiarly known as R-113. It is currently used industrially in a variety of applications — most notably as a cleaning agent and refrigerant.

R-113 is non-flammable, therefore meeting the fire safety requirements in paragraph 450-24 of the National Electrical Code and OSHA Directive 100-54. It is considered superior to the liquids currently offered for non-flammable transformer applications because those liquids all have definite fire and flash points, usually in excess of 300 C.

R-113 is processed to meet GE's dielectric specifications after it arrives at the plant in Rome. It has been thoroughly tested and has proven compatibility with standard insulation materials. The VaporTran transformer uses the pool-boiling technique which allows the core and coil to always be totally immersed in dielectric fluid similar to a conventional liquid unit. This compatibility enables the VaporTran transformer to incorporate GE's proven core and coil technology.

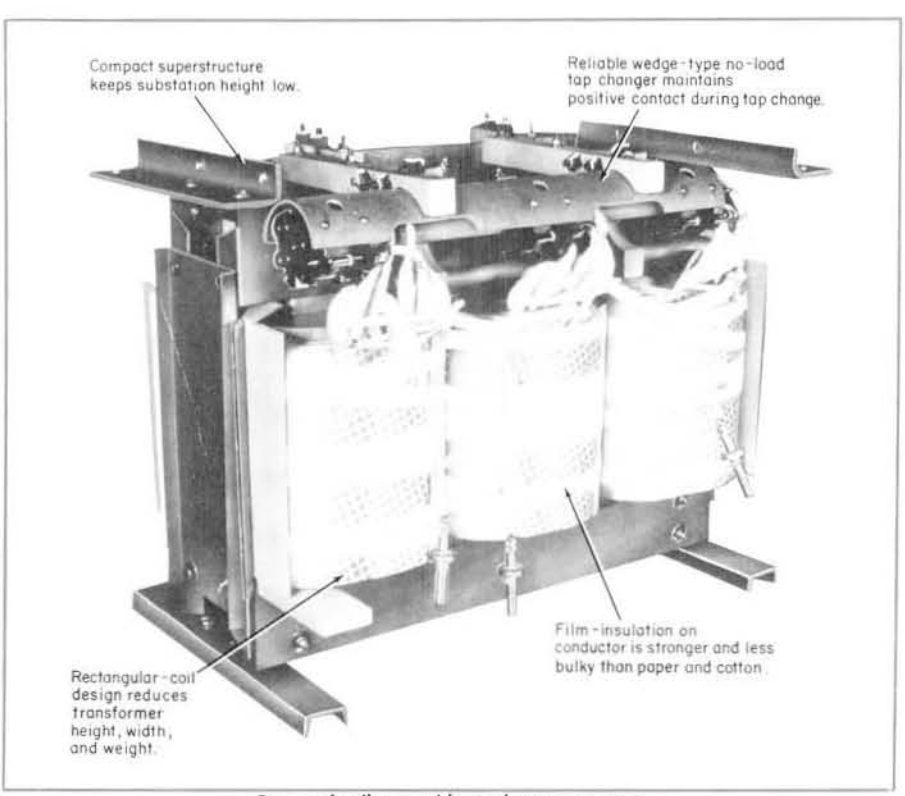
CORE-AND-COIL CONSTRUCTION FEATURES

All GE VaporTran transformers are built with rectangular windings and core. The rectangular core-and-coil construction reduces the size of the tank which results in savings in weight and floor space.

First, the low-voltage coils are wound on a rectangular form which simulates the rectangular core leg and serves as the main support for all the windings. These coils are of sheet winding construction using strip conductors. An adhesive-coated electrical-grade paper is used as the insulation between each low-voltage turn.

The high-voltage coils are wound, under tension, over the low-voltage coils and are of layer-wound construction using film-insulated wire. Film-insulated wire is used because it is less bulky than paper, has higher dielectric strength on a volts-per-mil basis, and does not tend to split or crack when small radius bends are made. To provide insulation between each layer in the high-voltage windings, an electrical-grade adhesive-coated paper is used.

After completing the winding process the high- and low-voltage coils are clamped to the desired dimensions. They are then oven baked at a temperature which causes the adhesive coating on the paper to bond the adjacent conductors and wires together. The result is a winding structure which



Core-and-coil assembly and superstructure

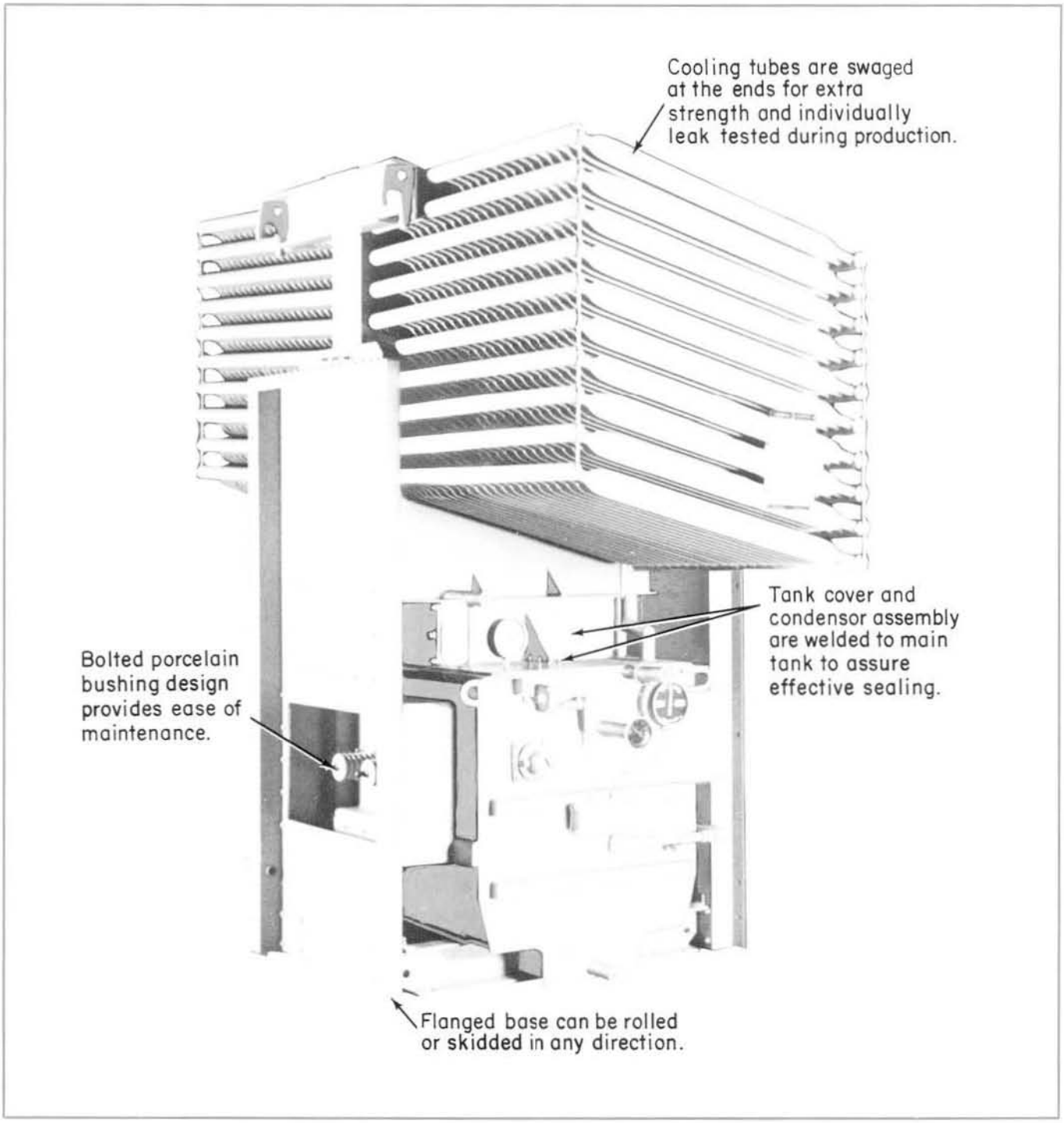
CORE-AND-COIL CONSTRUCTION FEATURES (Cont'd)

has high short-circuit strength and high electrical stress withstand capability.

The core has a rectangular cross section in both leg and yoke. It is constructed of silicone grain-oriented steel laminations which reduce size, sound and losses in the finished core.

The rectangular core legs serve as the main support for the coils and are clamped with structural members at the top and bottom yokes. The top and bottom structural members are bolted together with end channels after assembly of the coils on the legs. This forms a compact structure of core and coil which restrains both axial and radial movement, essential to superior short-circuit strength.

In addition to the structure required to restrain the movement of the coils on the core, a compact super-structure supports the leads and wedge-type, no-load tap changer which is designed to withstand the full short-circuit current of the transformer.



Standard Features

LEAK-RESISTANT WELDED TRANSFORMER TANK CONSTRUCTION

The tank of the VaporTran® transformer provides a secure enclosure for the core-and-coil assembly, as well as connecting to and supporting the condenser assembly. The separate components—main tank and condenser—are subjected to strenuous leak tests before being welded together and the complete unit is further tested after being filled with fluid.

The base of the unit is designed to allow for rolling or skidding in two directions to facilitate installation. The tank walls and cover locate the high-voltage and low-voltage bushings and accessories in the most convenient locations for assembly of primary and secondary connections and for observation and operation of accessories as needed during operation.

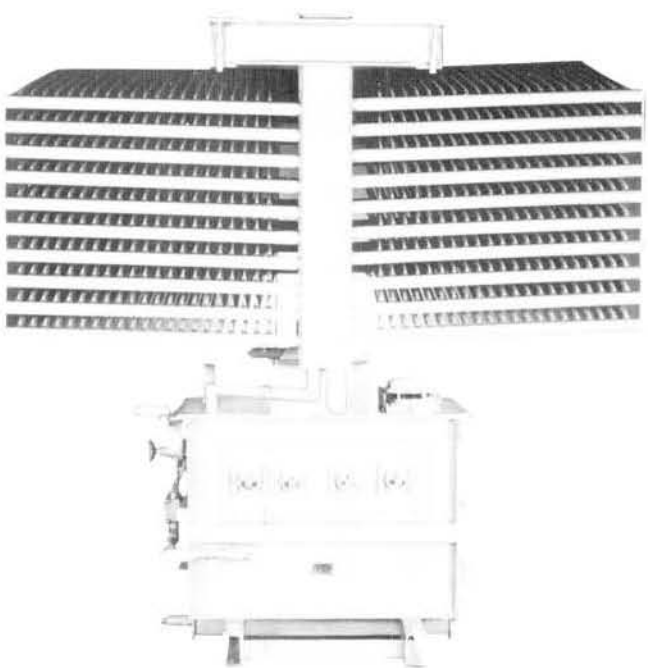
The tank cover and condenser assembly is welded to the main tank to assure effective sealing of the unit. Cooling tube ends are swaged and submerged arc-welded to tube headers and individually leak tested during their production process.

BUSHING DESIGN

The bushing design utilizes bolted construction with proven gasketing techniques and materials compatible with the liquid dielectric. Both high-and low-voltage bushings are externally removable without the necessity of removing the tank cover. This enables easy bushing replacement should accidental damage ever make such replacement necessary.

The porcelain bushings provide good mechanical and electrical strength, dimension stability, and thermal and chemical resistance—making them ideal for an application demanding high reliability.

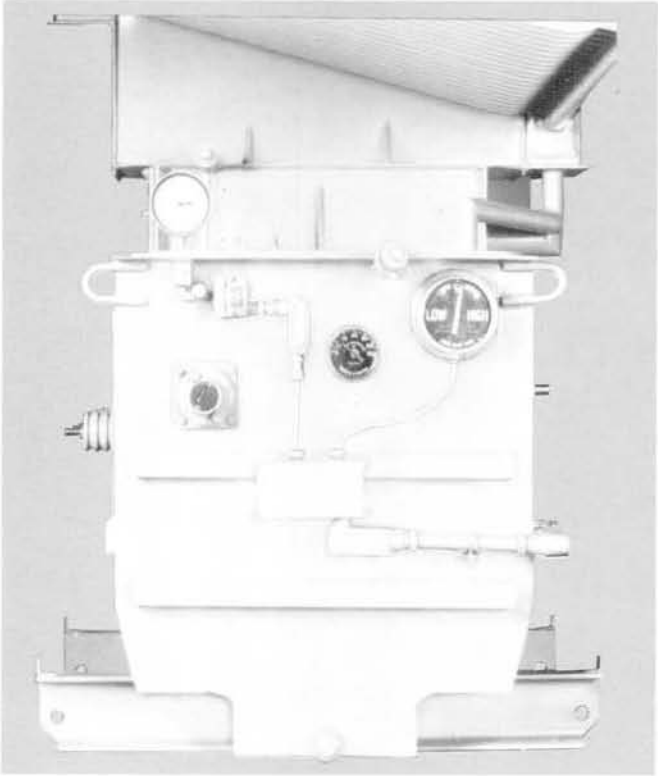
High-voltage bushings



Low-voltage bushings

Standard Features and Accessories

STANDARD FEATURES



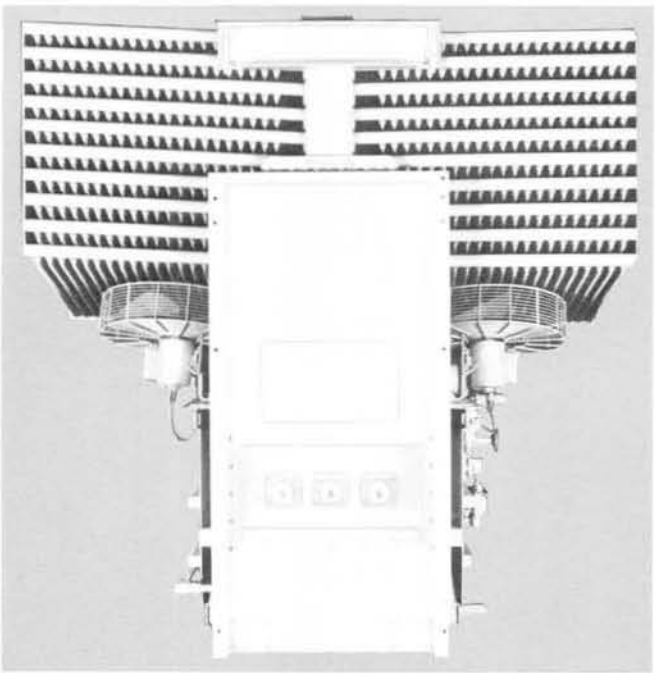
- Filling valve
- Drain valve
- Pressure relief device
- Dial Type liquid thermometer
- Magnetic dial-type liquid level gage
- Pressure—vacuum gage
- Pressure switch
- Lifting lugs
- Grounding pads
- Stainless-steel diagrammatic nameplate
- Tap changer for changing deenergized taps

The instrumentation and operating mechanisms are grouped together for ease of observation and operation. The liquid level gage, dial-type thermometer and pressure-vacuum gage are located together on the tank for easy readability. The operating mechanism for the no-load tap changer is located on the tank wall for ease of operation, and is equipped with a cover that also serves as a tap position indicator.

For ease of handling and installation, sturdy lifting lugs are welded into place on top condensor unit for lifting by crane.

The base is designed with bolt holes for easy tie down. It is constructed for rolling, skidding or sliding in any direction.

OPTIONAL ACCESSORIES



The VaporTran transformer design offers optional fan capability never thought possible with a liquid-filled transformer. The high cooling efficiency of the dielectric fluid means that the addition of fans can greatly increase the loadability of the transformer up to 50%. Fan cooling on oil units will only add from 15 to 25%, and on open dry only 33-1/3%. See page 4 for loadability at different ambient temperatures.

Finishing and Testing

PAINT FINISH

Prior to painting, the tanks, and cooling tube units are shot blasted to white metal. They are flow coated with one coat of primer and baked.

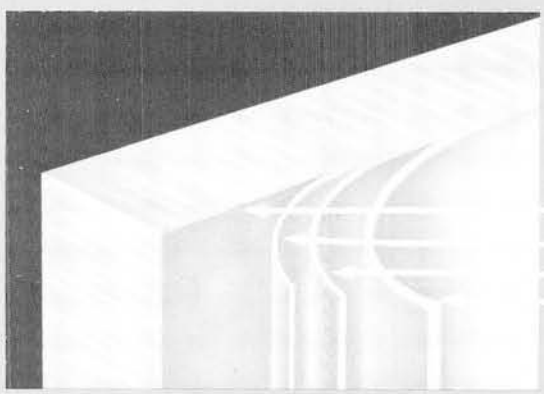
An intermediate flow coat of enamel is then applied and baked. If the unit is for **outdoor application** a third flow coat is applied and baked to give a minimum film thickness of two mils.

Final finishes use an air dry enamel which is applied by either the hot air spray or conventional cold spray methods.

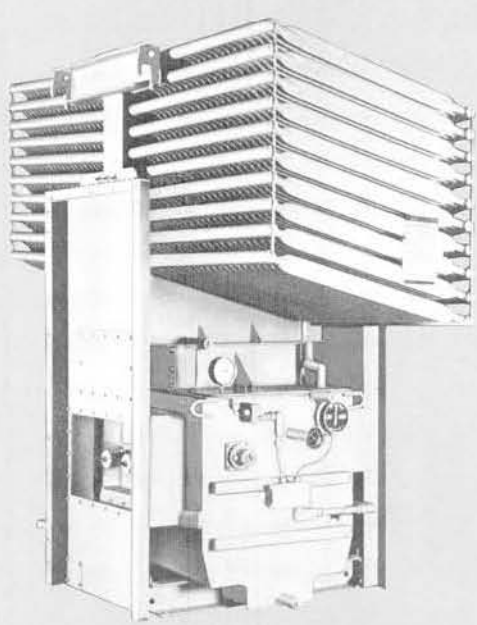
The standard paint finish color is ANSI Number 61, Light Gray, Munsell Notation 8.3G 6.10/0.54.

Optional colors available are:

Color	ANSI #	Munsell Notation
Light Gray	70	5.0 BG 7.0/4.0
Dark Gray	24	10 B 2.4/1.18



FOR OUTDOOR UNITS



Standard paint finish color is ANSI Number 61, Light Gray, Munsell Notation 8.3G 6.10/0.54

STANDARD TESTS

The following tests will be made on all transformers but not necessarily in the sequence listed. All tests are performed in accordance with the latest revision of ANSI Standard Test Code for Transformers, C57.12.90—1980.

1. Resistance measurements of all windings.
2. Ratio tests on the rated voltage connection and on all tap connections.
3. Polarity and phase-relation tests on the rated voltage connection.
4. No-load loss at rated voltage on the rated voltage connection.
5. Exciting current at rated voltage on the rated voltage connection.
6. Impedance and load loss.
7. Applied potential tests.
8. Induced potential tests.

Incoming Termination Equipments

FOR VAPORTRAN® SECONDARY SUBSTATION TRANSFORMERS

AIR-FILLED TERMINAL COMPARTMENT

This is a simple metal enclosure to safeguard personnel when the substation is connected directly to the incoming high-voltage line. It can be supplied with either clamp-type terminals or potheads to terminate the incoming-line cables. The low cost of this section makes it ideal when over-current protection is provided elsewhere.

The compartment is suitable for single or loop feed and for either top or bottom cable entrance. A bolted-on end panel gives easy access to the cable fittings.

Potheads can be supplied with special fittings such as wiping sleeves, stuffing boxes, armor clamps, or conduit couplings for any of the common types of cable.

OIL CUTOUTS

If fuses are required, oil cutouts are the most economical interrupter switches available. The three-pole, two position, (OPEN/CLOSED) cutouts are operated simultaneously by a handle accessible through a hinged door on the end of the compartment for 5 kV and on the side for 15 kV. Cables and other live parts are completely metal enclosed. They are not accessible through the operating door, so operators are protected.

Either clamp-type terminals or potheads can be used to terminate cables. The compartment can be specified by the customer for single or loop feed, top or bottom cable entrance, indoor or outdoor installation.

Switch contacts of the cutouts are completely metal enclosed. The contacts operate under oil, completely submerging the arc flame during circuit interruption. The cutout can be supplied with fuses which will clear fault currents up to 11,000 amperes at 4160 volts and 7000 amperes at 13,800 volts.

VERSATILE AND RELIABLE AIR-INTERRUPTER SWITCHES

Switches are rated for use with VaporTran transformers rated 500 through 2500 kVA, 2400 through 13,800 volts.

The basic switch, incorporating a stored-energy operating mechanism, has an interrupting rating of 600 amperes at all voltages. The stored-energy mechanism provides a positive, controlled closing and opening stroke independent of the operator.

All air switches meet NEMA Standard SG-5 for power switching equipment and ANSI Standard C37.30.

Incoming-line cables can enter the top or bottom of the compartment and can be connected for either single or loop feed. Cables can be terminated with clamp-type terminals or potheads. The terminals are easily accessible to apply test voltage or check the phasing of the unit.

Two observation windows of shatterproof safety glass are provided in the sheet-steel door. The windows are sized and located to give an adequate view of the switch contacts, but are small enough to provide maximum personnel protection during inspection.

Current-limiting fuses can be included in the compartment under the interrupter switch. They can provide interrupting capacity sufficient to clear a fault at the low-voltage terminals. When fuses are furnished, the fuse compartment door is mechanically interlocked with the switch so the fuse door cannot be opened unless the interrupter switch is in the OPEN position. Likewise, the interrupter switch cannot be closed unless the fuse door is also closed. Key interlocking with low-voltage circuit-interrupting devices can also be furnished.

Lightning arresters can be supplied in the switch compartment for added protection against voltage surges.

Incoming Termination Equipments

FOR VAPORTRAN® SECONDARY SUBSTATION TRANSFORMERS

AIR-INTERRUPTER SWITCHES (Cont'd)

Two-position Air-interrupter Switch

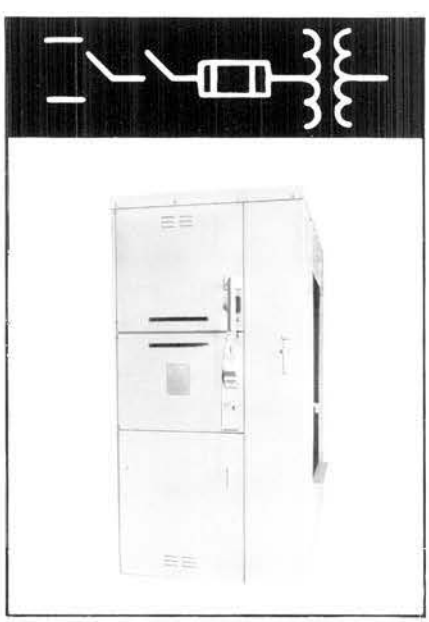
This switch consists of a two-position (OPEN/CLOSED), three-pole mechanism. All three poles are operated simultaneously by a non-removable handle on the front of the switch compartment. A mechanical position indicator is included.

Two-position Air-interrupter Switch

Air-interrupter Selector Switch

Where there are two separate incoming lines, the interrupter selector switch gives three positions (LINE 1/OPEN/LINE 2). This gives continuity of service by allowing the operator to switch from one incoming line to the other in case primary feed fails, or to the OPEN position for planned maintenance.

The unit consists of a two-position (OPEN/CLOSED) air-interrupter switch in series with a two-position (LINE 1/LINE 2) selector switch. The selector switch is a dead-break device and is mechanically interlocked so it cannot be operated unless the interrupter switch is open.



Air-interrupter Selector Switch

Double Air-interrupter Switch

This three-position (LINE 1/OPEN/LINE 2) switch is also used where there are two separate incoming lines, and allows the operator to switch from one line to the other, or to OPEN for planned maintenance.

The double switch has the advantage of isolating the two lines, permitting maintenance of one line while the other line is energized and reducing the probability of fault transfer from one cable to the other. This is accomplished by using two two-position (OPEN / CLOSED) air-interrupter switches, key-interlocked so both incoming line switches cannot be closed at the same time.

Double Air-interrupter Switch

AIR SWITCH CONTINUOUS AND SHORT-CIRCUIT CURRENT RATINGS

kV	BIL	Continuous Current Rating and Load Break	Momentary and Close and Latch Assembly (KA without fuses)
5	60	600	40
5	60	1200	61
15	95	600	40
15	95	1200	61
15	95	1200	80

Application Information

SURGE PROTECTION

There are three classes of valve-type lightning arresters available; Distribution, Intermediate and Station Class. Intermediate and Station Class arresters generally provide greater protective margin for the equipment than Distribution Type.

The selection of arrester rating and class require reference to the following bulletins:

Arrester Class	Descriptive Bulletin
Distribution	GER-3341
Intermediate	GEA-11096
Station	GET-6951

INTERLOCKING

To safeguard personnel and reduce switch contact maintenance, the high-voltage switch should be operated while de-energized or while carrying only the magnetizing current of the transformer.

Key interlocking the high-voltage switch with the low-voltage main circuit breaker makes it necessary to remove the low-voltage load before opening the high-voltage switch. When required, this feature is included on GE Substations.

APPLICATION OF UNFUSED INTERRUPTER SWITCHES

High Voltage	2400–48000V		6900–7200V		12000–13800V
Transformer kVA	500–750	1000–2500	500–1500	2000–2500	500–2500
Air Switch	X	X	X	X	X
Oil Cutouts	X	—	X	—	X

FUSING

Fuses, while available for air switches and cutouts, are not generally required on Integral Distribution Centers. A plain interrupter switch does not involve the expense and coordination problems of fuses and it is adequate for all units that can be protected by remote overcurrent relays.

Sometimes, though, other loads on the circuit are great enough that the National Electrical Code requires fuses on the incoming side of the substation. For example, if the kVA size of the substation is less than about 1/4 to 1/6 of the total load on the feeder, an interrupter switch and fuse combination should be used to protect the unit against short circuits.

Minimum suggested primary fuses are listed in the table on page 13 for the self-cooled rating.

It is essential that the coordination of fuses with other primary and secondary devices be checked before selecting the fuse rating.

For further information on GE current-limiting fuses, refer to GET-6779. For information on oil cutouts and fuse links, refer to GEA-7191.

FUSE INTERRUPTING RATING, RMS AMPERES

Operating Voltage	Oil Cutouts With Fuse Link (Asymmetrical)	Air Switch With EJ Fuse (Symmetrical)	Air Switch With Type SM-4S S&C Fuses (Asymmetrical)
2400	11000	50,000	27,500
4160	11000	50,000	27,500
4800	10000	50,000	25,000
6900	5000	50,000	25,000
7200	5000	50,000	20,000
12470	7000	50,000	20,000
13200	7000	50,000	20,000
13800	7000	50,000	20,000