Sept. 6, 1966 M. G. LEONARD 3,271,710

COOLING SYSTEMS FOR UNDERGROUND TRANSFORMERS

Filed March 6, 1964 2 Sheets-Sheet 1

Fig. 2.

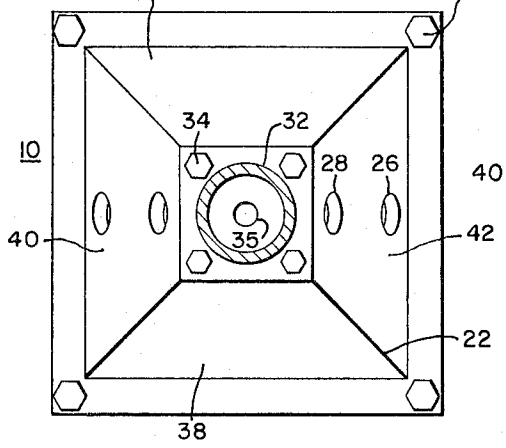
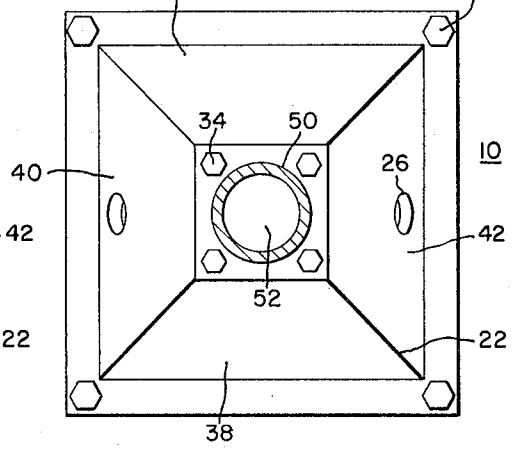


Fig. 4.



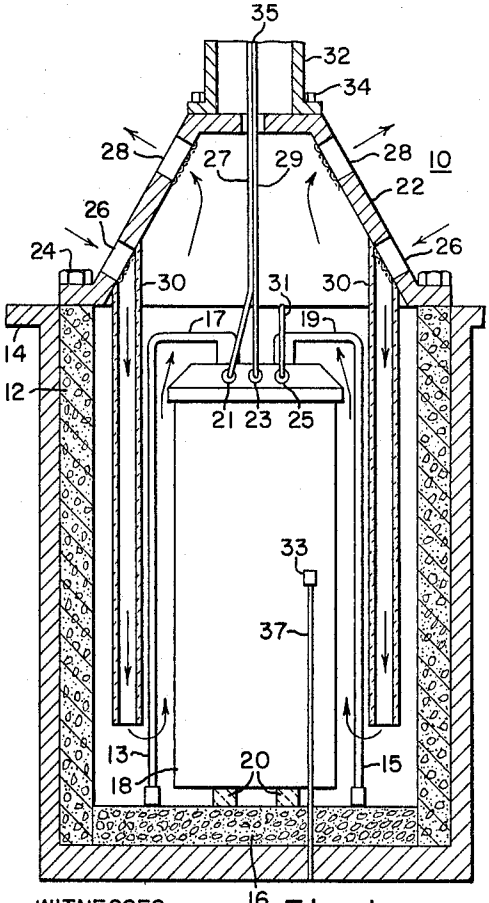


Fig. 1.

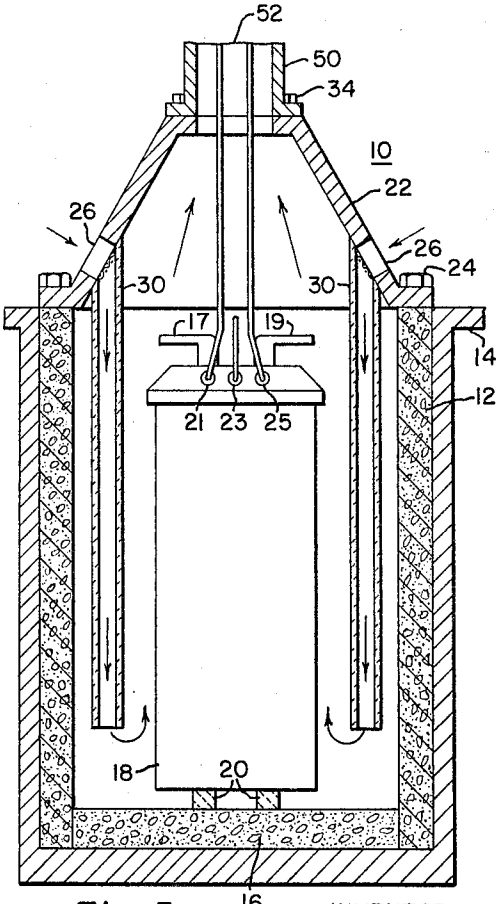


Fig. 3.

WITNESSES:

John L. Chapp

James F. Young

INVENTOR

Merrill G. Leonard

BY

Donald R. Lackey

ATTORNEY

Sept. 6, 1966 M. G. LEONARD 3,271,710

COOLING SYSTEMS FOR UNDERGROUND TRANSFORMERS

Filed March 6, 1964 2 Sheets-Sheet 2

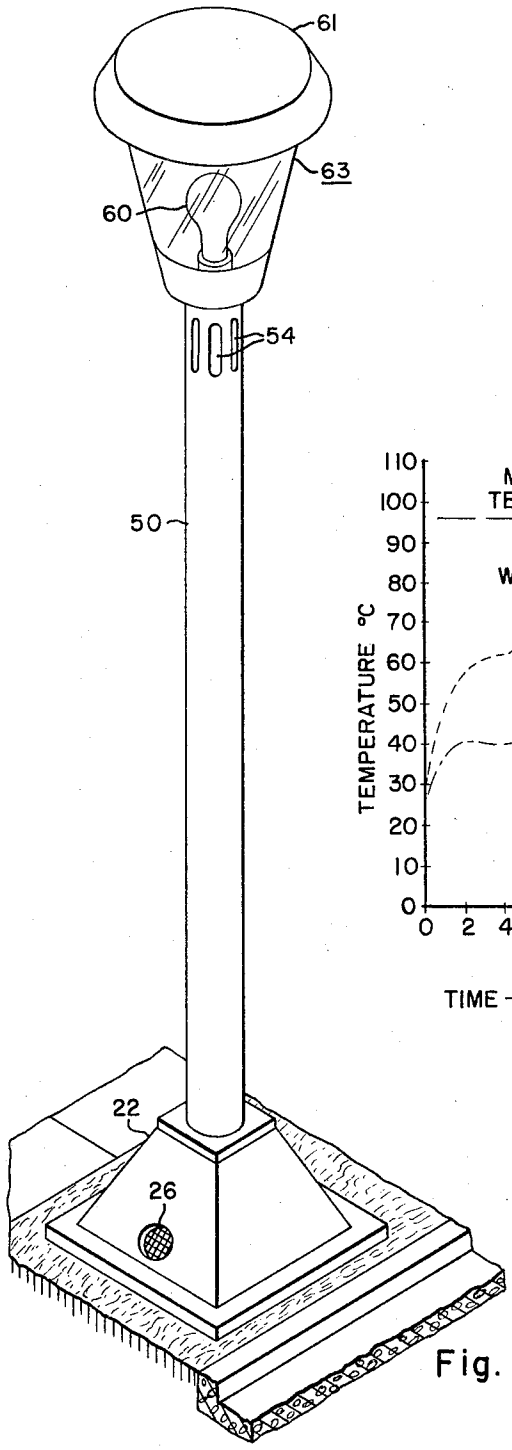
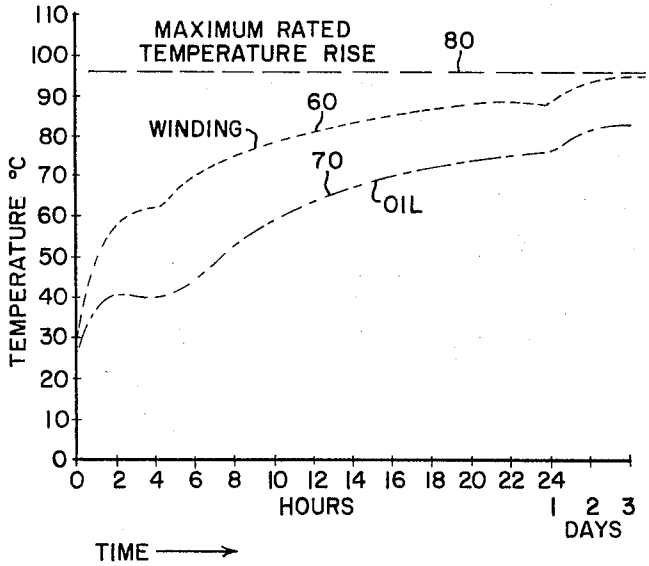


Fig. 5.

Fig. 6.



United States Patent Office

3,271,710

Patented Sept. 6, 1966

3,271,710

COOLING SYSTEMS FOR UNDERGROUND TRANSFORMERS

Merrill G. Leonard, Brookfield Township, Ohio, assignor to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

Filed Mar. 6, 1964, Ser. No. 349,895
6 Claims. (Cl. 336—55)

This invention relates in general to improvements in the ventilation and safety of electrical inductive apparatus, and more particularly to improvements in ventilation and safety relative to transformers mounted partially or wholly below ground level.

Some underground enclosures or vaults for housing transformers may have solid covers for safety purposes, with the transformers being substantially derated because of the lack of ventilation. Other underground vaults may have flat expanded metal covers, with some of the openings in the expanded grill work being utilized for intake air and other openings being utilized to discharge heated air. The opposite air flow pattern set up by the expanded metal type cover results in considerable recirculation of the air, with the heated air immediately re-entering the transformer enclosure, with a resultant loss of cooling efficiency. Further, the openings in the expanded metal cover are hazardous from a safety standpoint as it is easy for children to push sticks and other foreign objects through the openings.

Accordingly, it is an object of this invention to provide a safe and efficient cooling system for inductive apparatus.

Another object of this invention is to provide a cooling system for underground vault-mounted transformers that will allow the transformers to be operated without reduction in rating.

A further object of the invention is to provide a cooling system for underground vault-mounted transformers that substantially eliminates recirculation of the cooling air.

Another object of the invention is to provide a strong chimney effect which increases circulation of air around vault-mounted transformers.

A further object of this invention is to provide a transformer-electric light pole combination which is safe, highly efficient, and which protects the transformer from damage when vehicles accidentally strike the light pole.

Briefly, the present invention accomplishes the above-cited objects by providing an enclosure disposed below ground level in which a transformer is mounted; said enclosure being provided with a substantially dome-shaped top having a flat horizontal upper portion. The inlet air enters near the bottom of the dome through long, thermally insulated ducts which discharge air near the bottom of the vault. The lighter, heated air is discharged near the top of the dome. Thus, the intake and outlet air currents are separated not only by distance, but also by height, substantially eliminating recirculation with its resulting loss in cooling efficiency. The air inlet ducts prevent sticks and other foreign objects from being inserted into dangerous areas, and the outlet ducts may be suitably baffled to prevent children from inserting foreign articles into dangerous areas.

Another embodiment of the invention is to mount a hollow pole or tube over the top of the dome-shaped cover, such as an electric light pole. The hollow pole produces a strong chimney effect, greatly increasing air circulation, and at the same time eliminating the necessity of air outlets on the dome cover. Thus, there is absolutely no way for articles to be inserted into the vault, except through the long intake ducts, which safely divert the articles away from any dangerous electrical potentials.

Further objects and advantages of the invention will become apparent as the following description proceeds and features of novelty which characterize the invention will be pointed out in particularity in the claims annexed to and forming a part of this specification.

For a better understanding of the invention, reference may be had to the accompanying drawings, in which:

FIGURE 1 is a side elevation, partially in section, of an underground enclosure and transformer, illustrating one embodiment of the invention;

FIG. 2 is a top view of the apparatus shown in FIG. 1;

FIG. 3 is a side elevation, partially in section, of an underground vault and transformer combination illustrating another embodiment of the invention;

FIG. 4 is a top view of the apparatus shown in FIG. 3;

FIG. 5 is a perspective view illustrating how the invention may be combined with electric street lighting apparatus to form a safe, efficient, esthetically pleasing installation; and

FIG. 6 is a graph illustrating the winding and oil temperatures of a vault-mounted transformer utilizing the teachings of this invention.

Referring now to the drawings, and FIG. 1 in particular, there is shown a side elevation, partially in section, of a transformer-vault installation **10**, illustrating one embodiment of the invention. In particular, the transformer-vault installation **10** comprises an enclosure or vault **12**, which may be constructed of concrete or other suitable material, and disposed below the ground level **14**. The bottom **16** of the enclosure **12** may consist of gravel to facilitate drainage, with a transformer **18** being disposed within the enclosure **12**. Supports **20** may be provided between the transformer **18** and the bottom **16**, to insure adequate ventilation under the transformer. High voltage leads **13** and **15** may enter the enclosure **12** from underground, and are connected to high voltage bushings **17** and **19**. Low voltage bushings **21**, **23** and **25** have leads **27**, **29** and **31** connected respectively thereto, and may go out the sides of the enclosure **12** to serve connected loads, and may also extend vertically, as will hereinafter be explained, to serve lighting loads. The transformer ground connection may be made through conductor **37** to terminal **33** on the transformer **18**.

In order to prevent recirculation of cooling air which is caused by the presence of adjacent opposite air flow patterns, a dome-like cover or top **22** is provided and suitably attached to the enclosure **12** by nut and bolt combination **24**, or other suitable fastening means. The cover **22** may be constructed of steel, or other structurally strong materials. The dome-shaped cover **22** allows a circulation of cooling air to be set up around transformer **18**, which takes full advantage of the natural laws of cool and warm air flow, and prevents recirculation of the air which lowers cooling efficiency. This is accomplished by providing one or more openings **26** around the bottom portion of cover **22**, and one or more openings **28** around the upper or top portion of cover **22**. The openings **26** are for inlet air, and they are connected to ducts **30** which direct the inlet air towards the bottom of the enclosure **12**. The ducts **30** should be formed of a material having good thermal insulating properties, such as the asbestos base materials, to prevent thermal blocks from being set up in the ducts which would prevent the desired air circulation. The openings **26** may be covered with a metallic grill work to prevent large foreign objects from being placed in the ducts **30**. Any objects, however, that are inserted into ducts **30**, would be diverted from the transformer, and thus the ducts **30** provide an additional safety factor.

As the incoming air, as shown by the arrows, is heated, it rises toward the top of the dome cover **22**. Air outlets **28** are provided to allow the heated air to readily escape the enclosure **22**. The air discharge level, being substantially higher than the air intake level, prevents adjacent contra air currents from setting up recirculation of the heated air back into the enclosure **12**. Further, a chimney effect is set up after a few hours operation of the transformer **18**, which provides a natural circulation, drawing fresh cooler air into the enclosure **12** through inlet openings **26** and ducts **30**, passing the air under, over and around the transformer **18** and up to the air discharge outlets **28**. The air discharge outlets **28** may also have a metallic grid work covering them to prevent the entry of large foreign objects. The height of the discharge outlets **28** above the transformer adds to the safety of the installation; however, baffles may be strategically disposed in the dome to prevent sticks and other foreign objects that may be inserted through the grill work from coming into contact with dangerous potentials. Or, as an alternative, the grid work may be protected by a baffle. If the transformer-vault installation **10** is also associated with street lighting, an electric light pole **32** may be attached, by nut and bolt means **34**, or any other fastening means, to the top of the dome cover **22**. Electrical leads **27** and **29** may gain access to the electric light through a suitable opening **35** through the pole **32**.

FIG. 2 shows a top view of the transformer-vault combination **10**, shown in FIG. 1. The air openings **26** and **28** may be disposed as shown, or the openings **28** may be located on sides **36** and **38** of the dome cover **22** instead of sides **40** and **42**. Further, more or less air outlets **26** and **28** may be utilized, depending upon the desired quantity of air flow.

The arrangement shown in FIGS. 1 and 2 also protects the transformer **18** from possible damage when vehicles accidentally strike the dome cover **22**.

When the transformer-vault combination **10** is to be associated with street lighting, it is possible to make use of the electrical light pole in a manner that provides very efficient air circulation and added safety from foreign objects being inserted into the enclosure **12**. This embodiment of the invention is illustrated in FIGS. 3 and 4, with like reference numerals indicating like components.

More specifically, by utilizing an electric light pole **50** having a large longitudinal opening **52** therein, a very strong chimney effect is produced which eliminates the necessity of the air discharge openings **28** shown in FIGS. 1 and 2. The heated air will rise through the longitudinal opening **52** in the electric light pole **50**, and may be discharged through suitable openings near the top of the pole. FIG. 5 shows a perspective view of this type of installation, with air discharge openings being shown at **54**, just below an electric light **60** and enclosure **63**. The upper surface **61** of electric light enclosure **63** may be reflectorized in order to distribute the light to the street below. The sides of enclosure **63** may also be strategically reflectorized to produce different light intensities on the street side as compared to the curb side.

Thus, the air inlet ducts **30** safely divert foreign objects placed through openings **26** from coming into contact with the transformer **18** and its associated leads and bushings, and the air discharge openings are high enough above ground level to be completely safe from foreign objects.

To illustrate the effectiveness of the cooling, tests were made using a 75 kva. transformer disposed in a subway type enclosure or vault. The maximum rated winding temperature, ambient plus temperature rise of the transformer windings was 95° C., and the transformer loads which would produce a maximum winding temperature of 95° C. for different types of ventilation were noted. With a completely closed cover, the 75 kva. transformer had to be derated 18% in order to not exceed the 95° C.

maximum winding temperature. With a flat, expanded metal cover, which is the conventional method of ventilating subway type transformer installations, the transformer had to be derated 2% in order to prevent the winding temperature from exceeding 95° C. The expanded metal top also is hazardous from a safety viewpoint, because of the ease with which foreign objects may be placed into the transformer enclosure **12**. Utilizing the teachings of this invention, two five-inch diameter thermally insulated ducts were connected to inlet openings, with the air being discharged through a hollow electric light pole. The 75 kva. transformer operated without any derating and without exceeding the 95° C. maximum winding temperature.

FIG. 6 is a graph, with time in hours and days being plotted on the abscissa, and temperature in degrees C. being plotted on the ordinate, showing curves of how the transfarmer winding temperature and transformer oil temperature varied over a three-day period. The transformer was ventilated in accordance with the principles disclosed herein. Dotted curve **60** is the winding temperature, and the dot-dash curve **70** is the transformer oil temperature. It can be seen from the graph in FIG. 6, that with the transformer at 100% load, the winding temperature **60** did not exceed the maximum temperature rise line **80** located at 95° C.

In summary, a new and improved ventilating system for subway or vault mounted transformers has been disclosed which not only improves the air circulation efficiency, but provides a safer, less hazardous installation. Transformers may be disposed in underground enclosures, utilizing the teachings of this invention, without derating the transformers, and when the transformer-vault combination is associated with electric street lighting, an efficient, safe, esthetically pleasing installation can be provided.

Since numerous changes may be made in the above-described apparatus and different embodiments of the invention may be made without departing from the spirit thereof, it is intended that all matter contained in the foregoing description or shown in the accompanying drawings shall be interpreted as illustrative, and not in a limiting sense.

I claim as my invention:

1. In combination, an enclosure; electrical inductive apparatus disposed within said enclosure; a cover having a sloping side portion forming a substantially dome shape, with its side portion sloping inwardly from the bottom portion of said cover to its top portion; said cover being disposed over said enclosure; said cover having at least one opening disposed near its top portion, and at least one opening disposed near its bottom portion, with said at least one opening disposed near its bottom portion being disposed in the side portion of said cover; and duct means extending downwardly from said at least one opening near the bottom portion of said cover to the lower portion of said enclosure; said electrical inductive apparatus heating the surrounding air when energized and starting air circulation, with the air heated by said inductive apparatus rising and being discharged through said at least one opening near the top portion of said cover and air being drawn into the enclosure through said at least one opening near the bottom portion of said cover through said duct means to the lower portion of said enclosure.

2. The combination of claim **1** wherein said an enclosure is disposed at least partially below ground level; and including a pole having a longitudinal opening therein; said pole being disposed on the top of said cover.

3. The combination of claim **1** including an electric light pole and associated electric light; said electric light pole having a longitudinal opening therein and being disposed upon the top of said cover; the electrical connection between said electrical inductive apparatus and said elec-

tric light being through the opening in said electric light pole.

4. In combination, an enclosure; an electrical transformer disposed within said enclosure; a cover having a sloping side portion forming a substantially dome shape with a substantially flat top portion; the sides of said cover sloping inwardly from the bottom portion of said cover to its top portion; said cover being disposed over said enclosure; said cover having an opening in its top portion; said cover having at least one opening disposed in said side portion near its bottom portion; duct means extending downwardly from said at least one opening in the side portion of said cover to the lower portion of said enclosure; a pole having a longitudinal opening therein and being disposed on said cover with the opening in the top of said cover coinciding with the opening in said pole; the heating of said transformer when energized starting air circulation, with the air in the enclosure heated by said transformer rising up through the opening in said pole, and air being drawn in through the bottom openings of said cover through said duct means to the lower portion of said enclosure.

5. The combination of claim 4 including an electric light disposed on said pole; the electrical connections between said transformer and said electric light being completed through the longitudinal opening in said pole.

6. The combination of claim 5 wherein said enclosure is disposed at least partially below ground level.

References Cited by the Examiner

UNITED STATES PATENTS

322,018	7/1885	Smith et al.	174—16
342,552	5/1886	Westinghouse	336—90 X
387,123	7/1888	Thomson	336—59
415,110	11/1889	Johnson	174—16 X
424,778	4/1890	Gee	98—49
3,202,815	8/1965	Moore	240-47 X
3,225,224	12/1965	Rydbeck	317—103 X

FOREIGN PATENTS

701,486	1/1931	France.
1,165,708	3/1964	Germany.
3,220	2/1903	Great Britain.

LEWIS H. MYERS, *Primary Examiner.*

ROBERT K. SCHAEFER, *Examiner.*

T. J. KOZMA, *Assistant Examiner.*