Jan. 1, 1935. D. K. BLAKE 1,986,619

ELECTRICAL SUBSTATION

Original Filed March 16, 1931

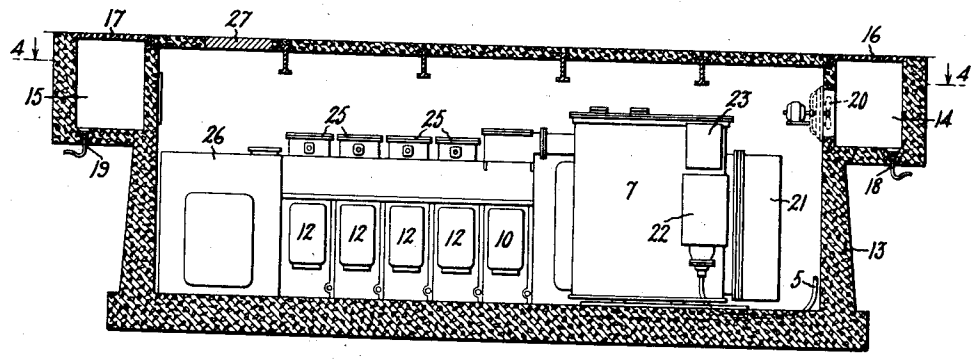


Fig. 2.

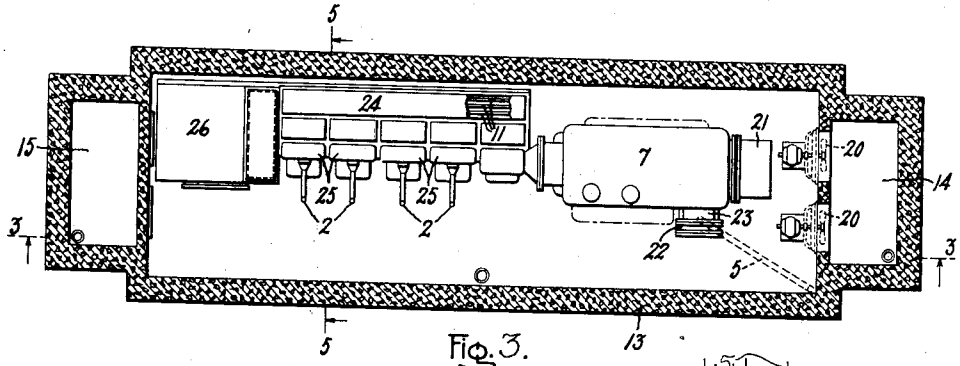
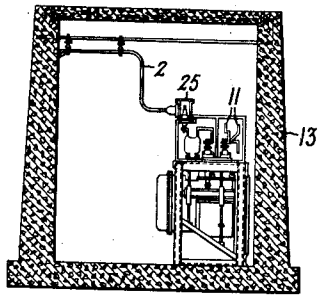


Fig. 3.

Fig. 4.



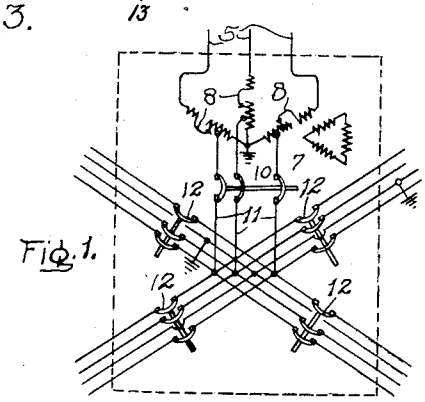


Fig. 1.

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UNITED STATES PATENT OFFICE

1,986,619

ELECTRICAL SUBSTATION

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Original application March 16, 1931, Serial No. 523,140. Divided and this application February 7, 1933, Serial No. 655,601

5 Claims. (Cl. 175—298)

My invention relates to apparatus of electrical distribution systems and particularly to an electrical substation for alternating current network systems of distribution.

This application is a division of my application Serial No. 523,140, filed March 16, 1931 and assigned to the assignee of the present application.

It is a matter of common knowledge that the voltage of the electrical energy which operates the lights, radio sets, toasters, fans and all the numerous other appliances which play such a large part in the daily life of most persons is practically standardized throughout the country. It is this standardization which in turn permits the standardization of these various appliances with the result that the full benefits of low individual cost mass production can be realized. This standard voltage is relatively low, it usually being very close to 115 volts. One reason that the standard voltage is relatively low is that the danger of accidental injury or electrocution is much less at low voltage than at high voltage.

It is also a well known fact that up to certain maximum values it becomes more economical to transmit and distribute electrical energy the higher the transmission or distribution voltage. This is because a given amount of electrical power at relatively high voltage represents a relatively small current flow and consequently a relatively small resistance loss in the conductors of the circuit. A given amount of power can therefore be transmitted with less copper at high voltage than at low voltage for the same loss.

The problem in electrical distribution is therefore to provide a system which will best and most reliably and economically distribute electrical energy throughout large load areas, such as towns and cities and their suburbs, and which at the same time will make the energy available at a standard low voltage.

A further factor which complicates the matter is the fact that in any large load area the load density varies greatly from the very high density downtown business sections to the low density outlying residential sections.

Still another difficulty results from the fact that the load density of various sections is continually changing. Thus the load density is usually growing radially outward as the city or town expands.

In the past the usual distribution system has been what may conveniently be called the radial system. In this system the generated electrical energy is stepped up to high voltage and transmitted to relatively large substations from which the energy is distributed at a medium voltage by radially extending feeders. Each of these feeders supplies a separate load area through the usual distribution transformers which step the voltage down to the standardized low voltage. The low voltage circuits may or may not be interconnected to form a low voltage network. Usually in high load density load areas such a network can most easily be formed and it is in such areas that the advantages of continuity of service which results in the interconnection is most desirable.

The radial system has many disadvantages, almost all of which can be attributed to the large "custom made" substations. Thus the large concentrations of power necessitate elaborate and expensive protective equipment. The necessarily unequal lengths of the feeders require individual voltage regulators in each feeder. The nature of the system requires difficult and expensive long range load forecasting, the difficulty and expense of obtaining satisfactory sites for substations, usually resulting in compromise locations, and the growing pressure of public opinion requiring expensive landscaping and architectural beautification of the substation sites. Furthermore, the engineering design of each substation presents individual problems and difficulties depending upon the nature of its location, the anticipated load growth and many other factors.

The radial system has the added disadvantage that it requires a relatively large amount of copper in that many of the radial feeders are necessarily parallel to each other for portions of their length.

As distinguished from the radial system my invention has to do with a medium voltage system network of distribution involving one or more of my novel standardized unit substations which are connected in the network at points where the load density is less than a predetermined amount, said medium voltage network serving to supply the low load density portions of a low voltage network whose high load density portions are supplied directly through transformers from high voltage transmission circuits, said substations being capable of removal as units as the load density of the areas they serve exceeds a predetermined amount and being capable of reinsertion in said network at points where the load density has not yet reached said predetermined value.

The above system, however, is not limited to cases where the low voltage distribution conductors are interconnected to form a network at

times when the load density is less than a predetermined value and it includes cases where these conductors are not so interconnected at these times, they being only interconnected to form a low voltage network at the time they are to be fed directly from the high voltage feeder circuits through step down power transformers instead of from the unit substations through the medium voltage network.

An object of my invention is to provide a novel standardized unit substation for use in my system of distribution.

My invention will be better understood from the following description taken in connection with the accompanying drawing and its scope will be pointed out in the appended claims.

In the drawing Fig. 1 is a diagrammatic showing of the main circuits of the standardized unit substation embodying my invention, Figs. 2, 3 and 4 are respectively elevation, plan and end views of my unit substation.

In Fig. 1, wherein is illustrated diagrammatically the main circuits of my substation, together with the main electrical elements thereof, 5 is a three-phase high voltage transmission circuit which upon entering the substation is connected to the primary winding of a three-phase step-down transformer 7. Although it is obviously not necessary, I prefer to employ an auto-transformer, as shown, because such a transformer has about 25 per cent lower losses than the ordinary transformer, while it also has considerably smaller physical dimensions for equal power rating. The particular voltage regulating means which I prefer to employ, is the transformer tap-changing type or load ratio control type voltage regulating means illustrated diagrammatically at 8 in the drawing. This tap-changing means may be controlled in any well known manner responsive to voltage. As most of the already installed medium voltage feeders are four-wire, three-phase circuits, it is necessary to ground the neutral points of the transformer as shown so that it may be connected to the fourth or ground wire of the feeder circuit. In order to suppress harmonics which are likely to cause telephone interference, I preferably provide the transformer with a delta connected winding 9.

For preventing a reverse power flow through the transformer from the network in case of a fault on the transmission circuit 5, I provide a transformer circuit breaker 10. Connected to this circuit breaker 10 is a substation bus 11 to which are connected four medium voltage network circuit breakers 12, whose function it is to sectionalize that portion of the network on which a fault occurs.

The individual substations, which are in themselves standardized units, are made up of standardized component elements. The result is that these units may be manufactured on a production basis which will greatly reduce their cost per k. v. a. These unit substations are preferably made small enough so that they may be factory assembled and shipped direct on flat cars as units to the place where they are to be installed. A specific example of such a unit would be a unit of about 1500 k. v. a. capacity, which, when assembled, would be about 27 feet long by 5 feet wide by about 8½ feet high, the entire unit weighing less than 25 tons. Such a unit would readily fit into a vault built beneath the surface of a street. Furthermore, such a vault need not be more than about 8 or 9 feet wide, so that its construction necessitates tearing up but half of the street and consequently the entire street need not be blocked to traffic while one of these units is being installed.

Referring now to Figs. 2, 3, and 4 which illustrate views of a physical embodiment of a preferred form of standard unit substation which is enclosed in a concrete vault 13. As shown, this vault is provided with end ventilating compartments 14 and 15, which are open to the atmosphere through gratings 16 and 17. Suitable drains 18 and 19 are provided for removing rainwater, etc. Blowers or fans 20 are provided for securing the necessary ventilating air flow through the vault.

The arrangement of the main electrical elements is such that the incoming power through transmission circuit 5 enters transformer 7, passes therethrough and to circuit breaker 10 from which it flows through the enclosed substation bus 11 to the feeder circuit breakers 12. The main elements are thus arranged in a straight line in the order of power flow therethrough. The load ratio control voltage regulating means for the transformer is enclosed in an end-housing 21 on the transformer. The disconnecting and grounding switch for the transformer is located in a housing 22 thereon, while the terminals of the tertiary winding of the transformer are enclosed in a housing 23 on the transformer. Bus 11 is enclosed in a metal casing 24 which is filled with an insulating compound thereby rendering the bus virtually short circuit proof. Above this housing are mounted a plurality of small housings 25 which enclose the connections of the medium voltage network feeders to the bus and which also enclose the usual current transformers for controlling the relays which trip the circuit breakers. All of the relays and recording instruments of the substation are mounted in a substantially constructed metal compartment 26. This has the advantage of centralizing all of this equipment in a waterproof compartment which is at the low voltage end of the substation. Through this arrangement the parts which will need most constant inspection are all mounted as remotely as possible from the high voltage transformer end of the substation.

For gaining access to the vault enclosing the substation I provide a door, which in the illustrated embodiment is shown as a manhole 27 in the top of the vault. As shown, this manhole is nearest the instrument and relay compartment of the substation so that an attendant entering the substation will enter it at its low voltage end and nearest to those elements which will require most frequent inspection.

No medium voltage network disconnecting devices independent of the oil circuit breakers 12 are employed. These circuit breakers which are of the well known metal clad type are so arranged in connection with the bus 11 that they may be connected or disconnected thereto by raising or lowering through the use of the conventional rod and socket connections.

Such a standardized unit substation as has been described, with all its internal connections completed, greatly simplifies the layout of a distribution system so the substation may be transported directly from a flat car to the vault. The high voltage input line connected to the transformer and the network feeders connected to the oil circuit breakers, and the substation is practically ready to be put into operation. The tertiary winding on the transformer is preferably used as a convenient source of power supply for reclosing

the oil circuit breakers and also for operating the motors of the blowers 20.

While I have shown and described a particular embodiment of my invention, it will be obvious to those skilled in the art that changes and modifications may be made without departing from my invention, and I therefore aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States, is,—

1. In combination, a standardized transformer, a standardized transformer circuit breaker, and a standardized feeder circuit breaker, said standardized devices being physically arranged to form a unit substation whose overall width is substantially equal to the width of the widest of said devices.

2. A standardized unit electrical distribution substation having, in combination, an elongated enclosure, high voltage apparatus at one end of said enclosure, low voltage apparatus at the other end thereof, and a normally closed entrance in said closure adjacent said low voltage apparatus and remote from said high voltage apparatus.

3. An enclosed standardized unit electrical distribution substation including high voltage apparatus which requires relatively infrequent inspection, low voltage apparatus which requires relatively frequent inspection, and an entrance in the enclosure of said unit adjacent said low voltage apparatus and remote from said high voltage apparatus whereby a person entering said substation will encounter the low voltage apparatus before encountering the high voltage apparatus.

4. In combination, an enclosed unit substation including in sequential arrangement a high voltage intake circuit, a step down transformer, oil circuit breakers, a compartment for housing the protective relays and instruments of the station, and a normally covered entrance in the enclosure of said unit for allowing access thereto for inspection and repair, said entrance being adjacent said relay and instrument compartment whereby an attendant entering said compartment through said entrance enters at the low voltage end of said station.

5. A standardized medium voltage network electrical distribution substation including, in combination, a standardized voltage step-down power transformer, a standardized feeder circuit breaker, a standardized network circuit breaker, said devices being arranged in a row in the order of power flow through said station and with the lengths of said devices substantially in a line so that the width of said station is substantially the width of the widest of said devices.

DAVID K. BLAKE.