Retrofit Implementation of Medium Voltage Contactors at Abou Quir Power Station in Egypt

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***Abstract*— A new generation of medium voltage vacuum circuit breakers were used to retrofit sealed Sf6 contactors which experienced difficulty in disconnecting the loads safely after 15 years of service. The new breakers which replaced the contactors and the associated fuses were mounted on the same panel truck preserving all original interlocks. Mechanical and electrical modifications were implemented to match the new breakers to the existing panel. Retrofitted breakers are in good service successfully for 5 years now.**

***Index Terms*—Retrofit of medium voltage switchgear, Magnetic actuator circuit breakers.**

I. INTRODUCTION

Vaccum circuit breakers became dominant in medium voltage switchgear in the past decade. This is due to high reliability, less maintenance cost, and ecological purity. Development of vacuum interrupters, the heart of vacuum circuit breaker has reached near saturation and a mean time between failures of 2000 years has been accomplished by Major manufacturers [1]. This has directed the research efforts to develop the drive mechanism of the vacuum circuit breakers. The first major step was the introduction of the magnetic drive breakers, instead of the charged spring drives, by Tavrida Electric in 1984. This was used for military purposes until the technology release in 1991 [2]. The main idea was based on the use of an armature under the influence of a magnetic field excited by two coils. The opening position is maintained by the action of opening spring. In the closed position the armature is not held mechanically but rather by the action of residual magnetic induction. In 1994, newer design was introduced in the market by Tavrida Electric. This design differs from other designs by the complete alignment of solenoid armature and vacuum interrupter. This configuration allowed designers to simplify mechanical structure of the circuit breaker, do not use hinged joins or any sort of loaded shafts carried by bearings, which in turn, made possible to reduce the breaker size and claim maintenance free breakers for 25 years and mechanical life of 150000 close open operations [3]. Magnetic actuators circuit breakers were first introduced in Europe by ABB in late 1990's. The design allowed reducing the number of the moving parts of standard spring-charged drive gears by 60% which simplified the mechanical design and increased the reliability of the drive [4]. Nowadays, virtually all reclosers use magnetic drive technology due to its reliability, small size and light weight.

The well known Tavrida Electric circuit breaker consists of two modules, switching module (ISM) and control module (CM). The switching module carries the vacuum interrupter and the magnetic latch drive mechanism to perform the switching operations. The control module is an intelligent microprocessor module that controls the switching module, signaling, and monitoring, it is normally mounted in the low voltage compartment. Circuit breaker modules are shown in Fig. 1. The small size, reliability, and modularity made these breakers very suitable for medium voltage retrofitting solutions.

Fig. 1. Circuit Breaker Modules

II. CIRCUIT BREAKER OPERATION [5], [6]

Fig. 2 shows the arrangement of Tavrida Electric Circuit Breaker. To close the vacuum interrupter contacts, a current pulse derived from the closing capacitor in the control modules is injected into the actuator coil. The current in the coil produces a magnetic flux in the gap between the upper yoke and the actuator armature. Under electromagnetic attraction, the armature, drive insulator and moving contact begin to move towards the upper yoke and compress the opening spring. At contact, the moving contact stops while the armature travel continues for 2 mm compressing the contact pressure spring. At the limit of its travel, the armature latches magnetically to the upper yoke. The coil current saturates the ring magnet to increase its power to a level that generates flux

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to hold the armature in the closed position after the coil current has been cut off. To open the interrupter, a current of opposite polarity, derived from the opening capacitor in the control module, is passed through the coil and demagnetizes the ring magnet. Opposing forces from the charged springs cause the armature to release and accelerate rapidly, ensuring a high interrupting capacity. At full travel, the armature moving contact assembly is held open by the opening spring force. The synchronizing shaft is also rotated during these operations and provides position indication, auxiliary switch operation and mechanical interlocking actions. The module may be manually opened by rotating the synchronizing shaft. The control module needs to be reset after each manual triping by momentary connecting the open dry contacts.

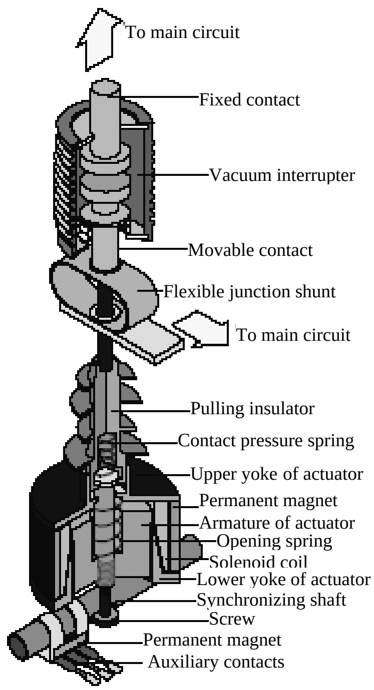

Fig. 2. Arrangement of Tavrida Electric Circuit Breaker

III. Scope of Work

Abou Quir power station is a 900 MW thermal plant consists of 4 units, 150 MW each which were commissioned in 1984, plus additional 300 MW unit (unit 5) which was commissioned in 1991. Unit 5 has several 6.6 kV distribution panels that serves many medium voltage motors feeding air compressors and pumps, 295 kW each, and few service transformers 6.6 kV/380V. These loads are fed from 6.6 kV, 250 A, SF6 contactors that lack the presence of gas level indicators or gas level switches. Short circuit protection was acheived by series fuses rated 31.5 kA on the same truck. After 15 years of service, the gas level in these contactors began to be so critical that the plant experienced two explosions when the plant engineers tried to switch off the loads. So, the urgent need of replacing these distributor panels arised, but with the plant in continuous service, the solution was to retrofit the contactors on the same panel trucks keeping the same interlocking system.

IV. Retrofit Process

Magnetic actuator circuit breaker rated 11 kV, 1000 A, 31.5 kA, was chosen to replace the contactor and the fuse in each truck. The small size of the breaker (56x65 cm) was a key issue for this retrofit. Electrical diagram for breaker wiring is shown in Fig. 3.

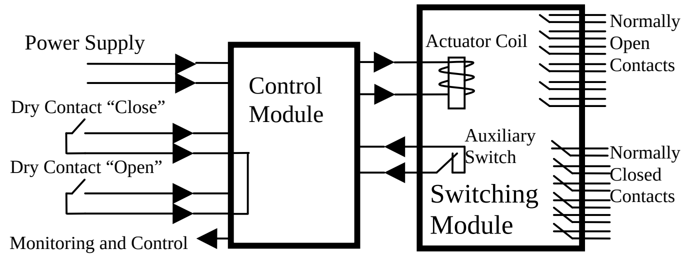

Fig. 3. Wiring of Control and Switching Modules

The SF6 contactors needed to be retrofitted were mounted on a movable truck in series with high rupture capacity fuses for short circuit protection; this is shown in Fig. 8a. Control of these contactors was via the control room. Withdrawing the truck involved rotating a handle anti-clockwise to release the interlocking system. This interlock system involved limit switch, MC1 in Fig. 4, 5, 6, and 7, that acted to prevent the contactor from connection if the truck was not engaged in its right position and also gives a signal to the control room. Moreover, if the breaker was in On position and the handle was rotated as the first step to move the truck, the limit switch disconnects the contactor immediately preventing any faulty dangerous truck withdrawal. Fig. 4 and 6 show the original electrical circuit diagram for the transformer and motor cells.

The retrofit process involved the following:

a. The proper selection of a typical Retrofit set developed by the design bureau
b. The dismantling of the old circuit breakers.
c. Mechanical and electrical integration of the vacuum circuit breakers into the cubicle
d. Connection to and co-ordination with the relay protection system after its replacement with digital one.

Mechanical design of fitting the breaker on the truck was provided from the breaker manufacturing company. It was necessary to modify the original electrical circuit to adapt the new breaker control. The limit switch, which prevented closing the breaker in middle positions and trips it before moving the truck outwards, was also used to reset the control module in case of manual trip, otherwise, this has to be done from the control room. The modified wiring diagram for the transformer cell and the motor cell are shown in Fig. 5 and 7. During commissioning, a dummy box was made representing the panel wiring in order to test the breaker before putting it into service. New digital protection relays replaced the old electromechanical ones. The new relays were coordinated with the system and the time lag due to the fitted signal relay, MM, was taken into consideration. Fig. 8 shows the retrofit project stages. The retrofitted 16 breakers are now in service for 5 years without a single concern.

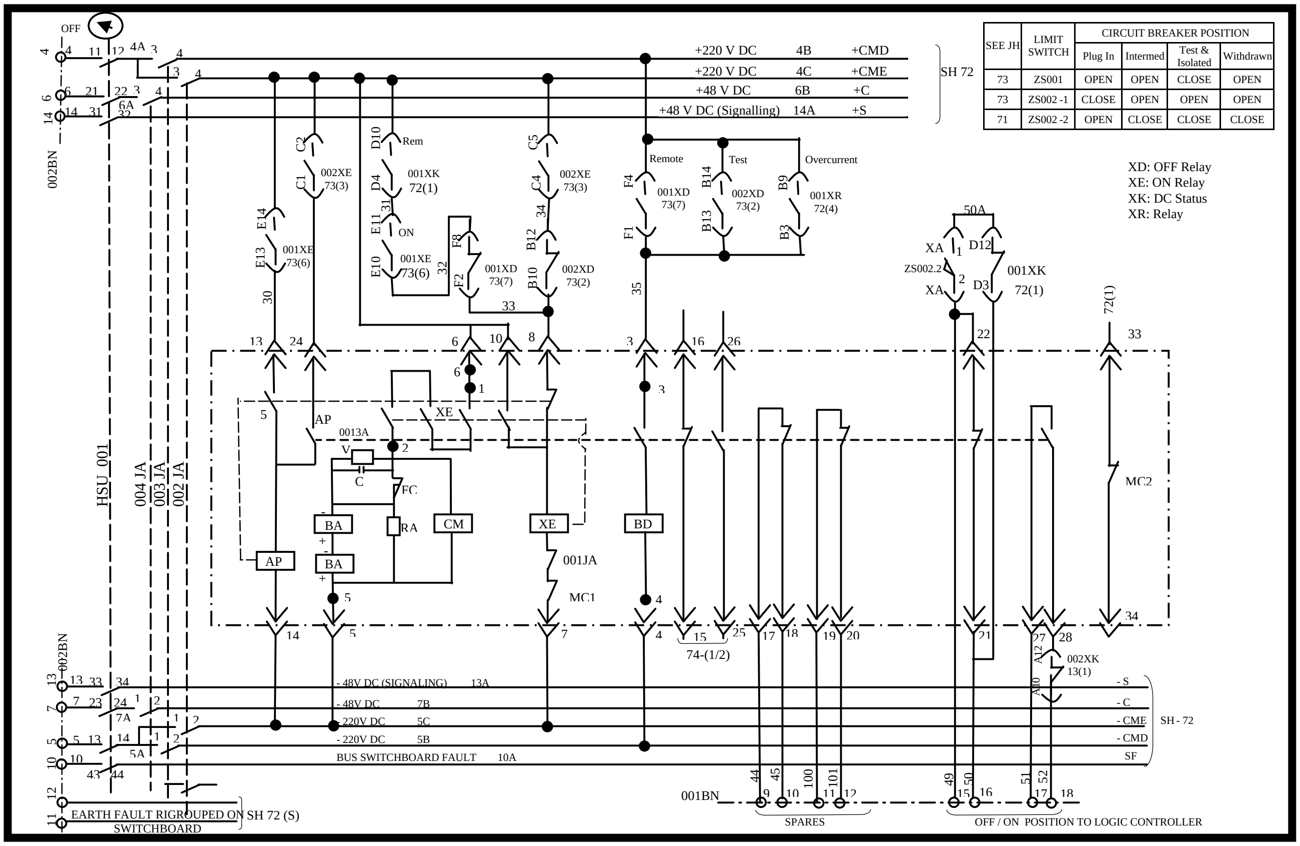

Fig. 4. Original Wiring Diagram for Transformer Feeder Contactor Cell

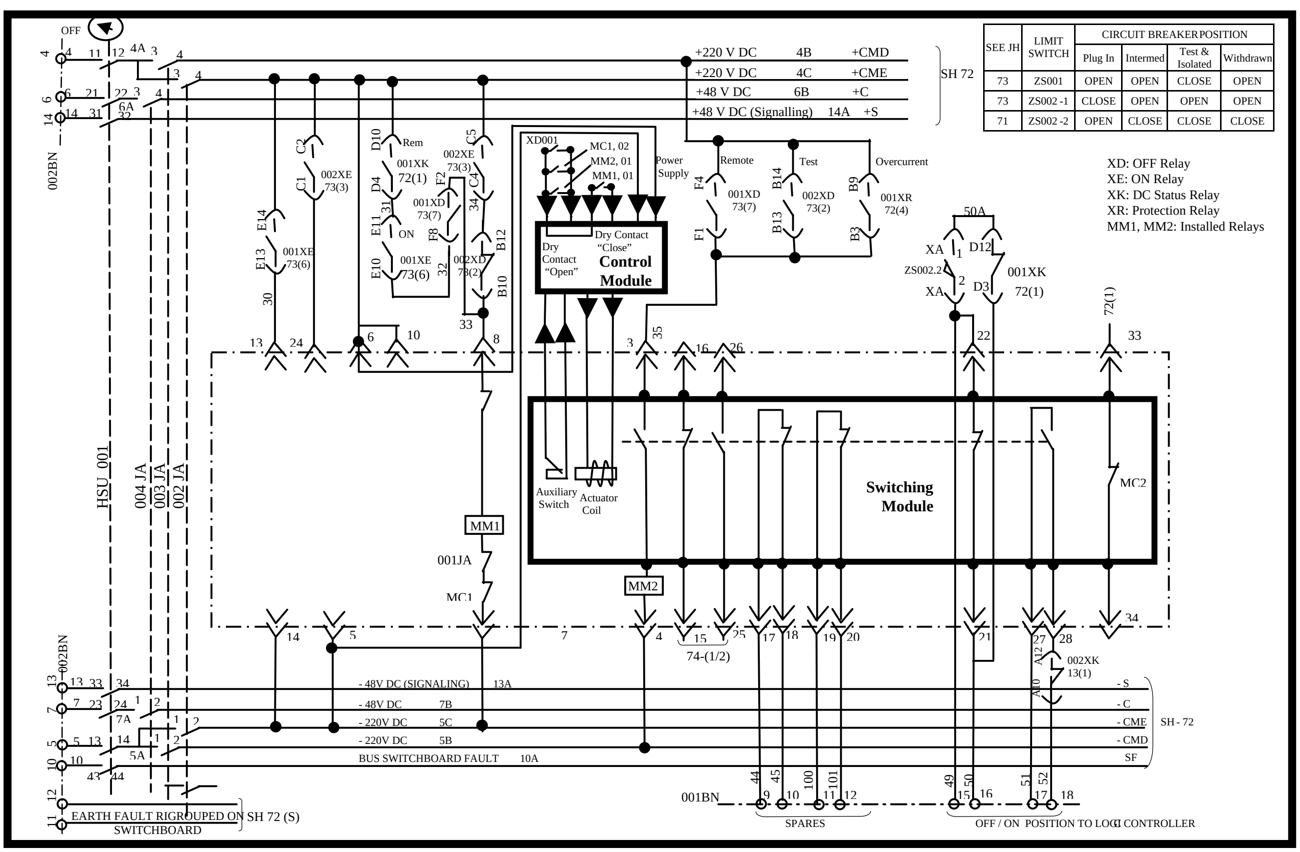

Fig. 5. Wiring Diagram for Transformer Feeder Contactor Cell after Retrofit

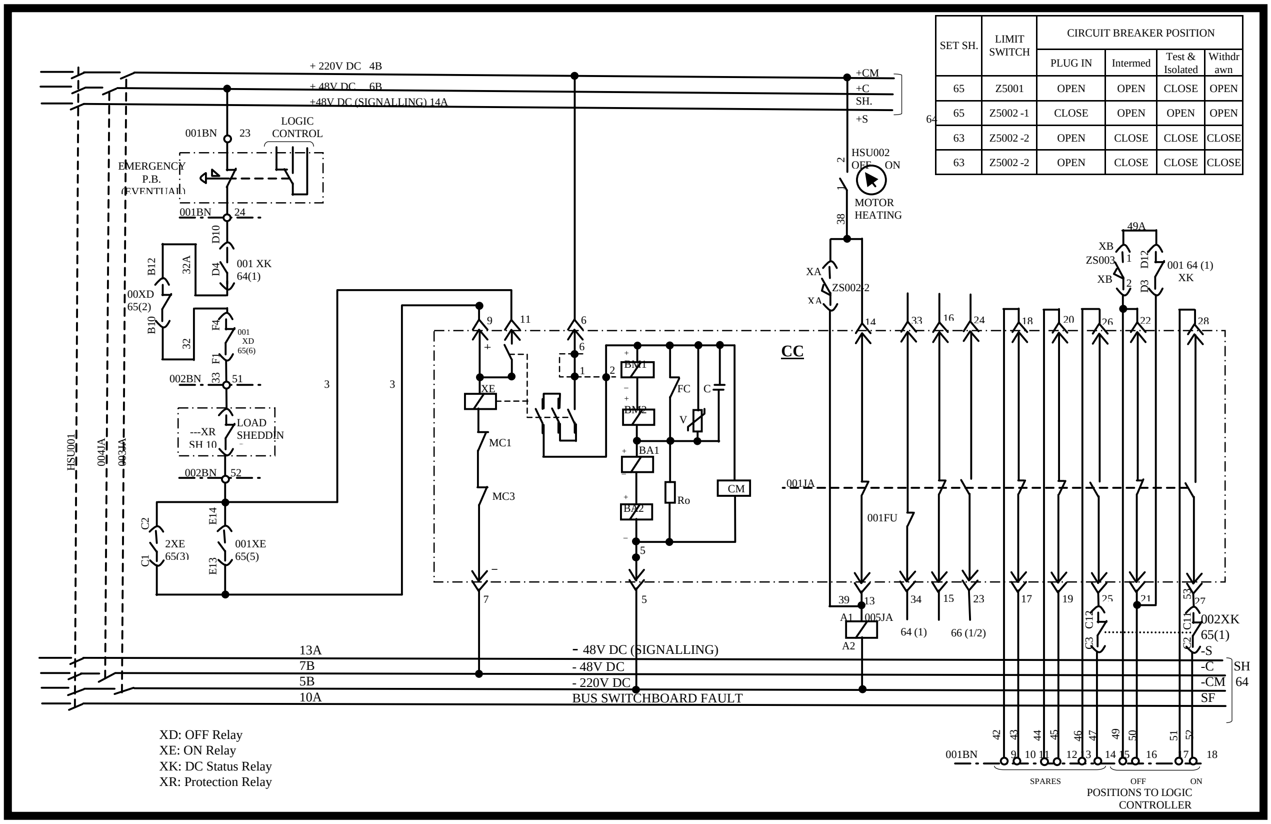

Fig. 6. Original Wiring Diagram for Motor One Speed Feeder Cell

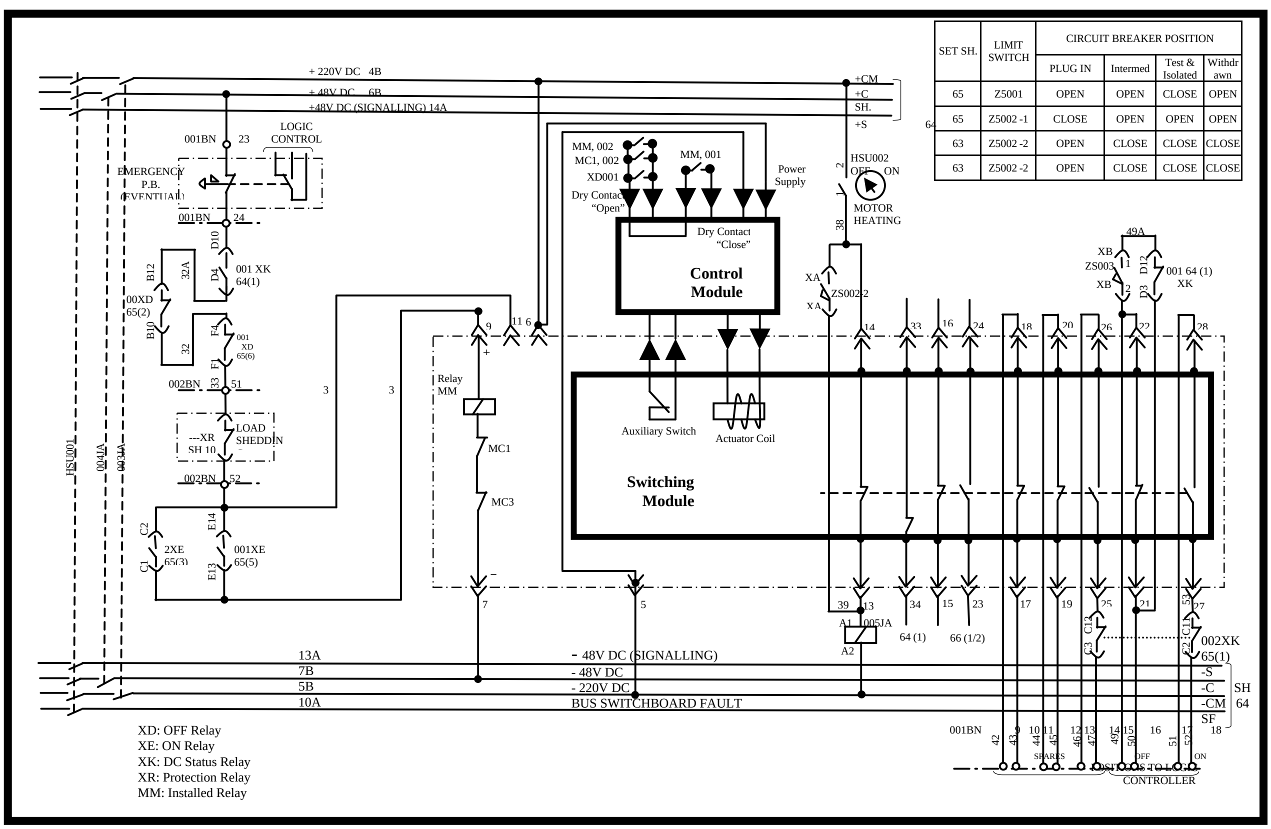

Fig. 7. Wiring Diagram for Motor One Speed Feeder Cell after Retrofit

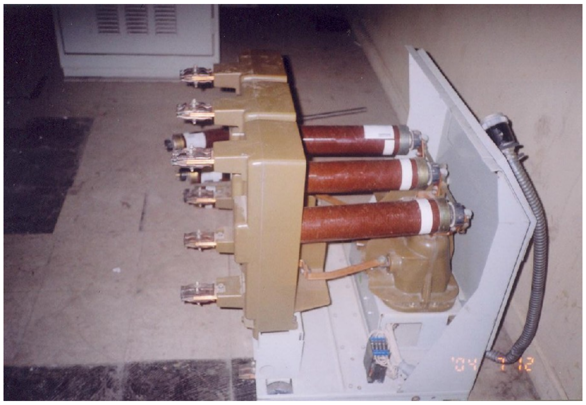

Fig. 8a

Fig. 8b

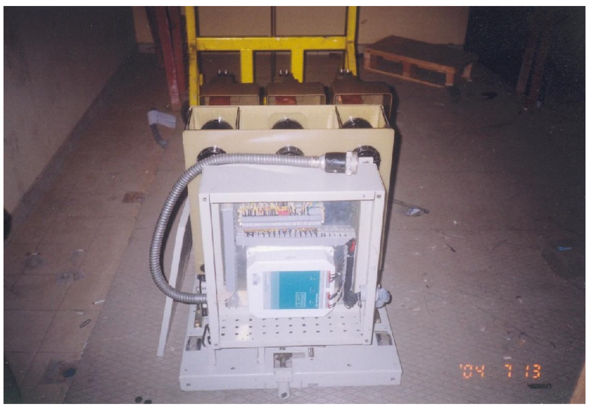

Fig. 8c

Fig. 8d

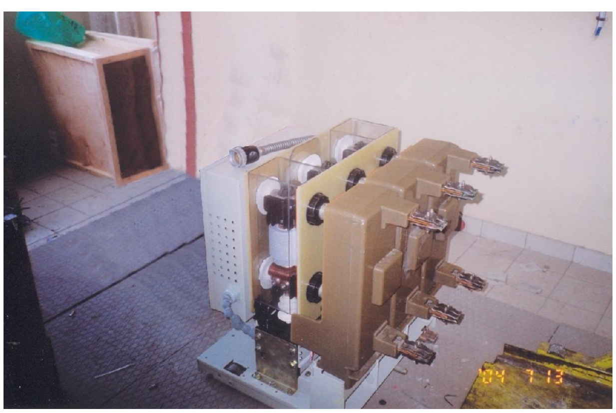

Fig. 8e

Fig. 8f

Fig. 8. Stages of Retrofit from Original Contactor to the Retrofitted Installed Breaker

V. Conclusions

Magnetic drive vacuum circuit breakers are mature technology by now, and will very soon dominate the old charged spring types. This type of drive is very suitable for retrofitting solutions due to its reliability, modularity, no maintenance required, and the small size. The retrofit process requires mechanical and electrical modification for the original switchgear and coordination with the relay protection system as well. The modularity of the breaker and the intelligent micro processor control module made most circuit breakers currently in service adaptable.

Acknowledgment

A. Ghazala thanks Tavrida Electric Export and Abou Quir power station engineers for their technical support, cooperation, and valuable experience. This project made it easier for many other industrial plants and utilities to take the decision for similar retrofits.

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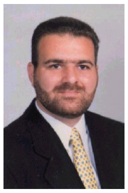

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