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Switching station scheme with triple bus-bar system is shown in Fig. 2.8.

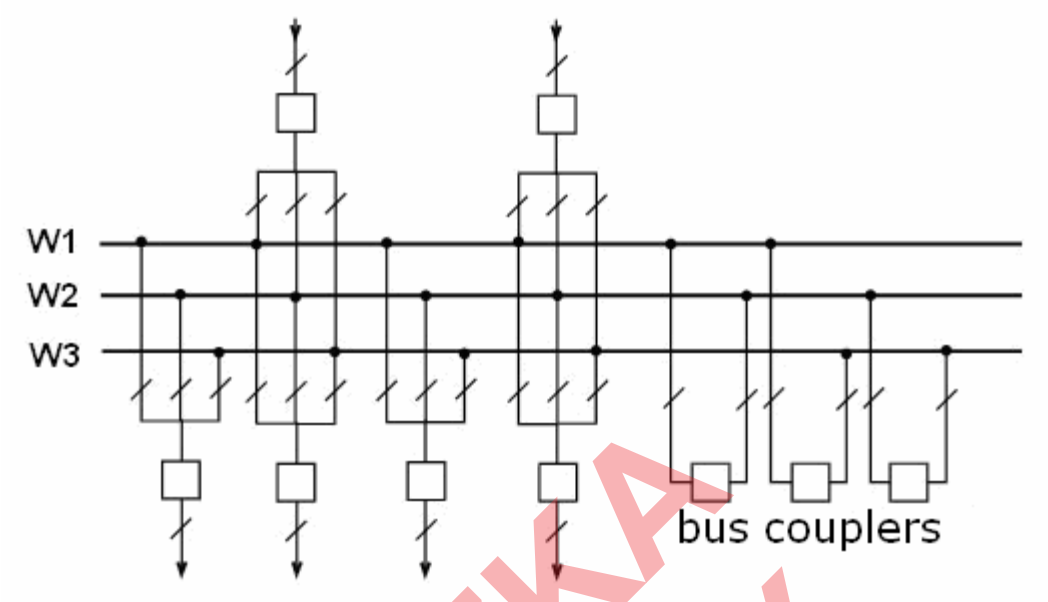

Fig. 2.8: Triple bus-bar system

If the simultaneous operation of the bus-bars is not possible, bus coupler circuit-breakers can be combined in one bus coupler with one breaker. Combined bus coupler scheme is shown in Fig. 2.9.

In distribution facilities with high number of branches, bus-bar systems are sectionalized similarly as in double bus-bar systems. Simple equipment with insulators between individual sections is usual.

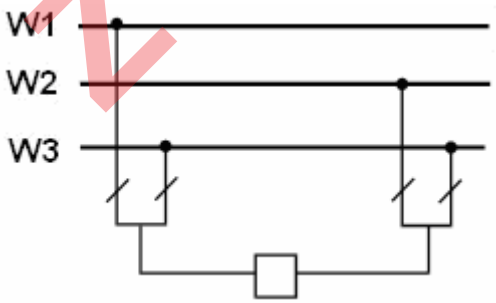

Fig. 2.9: Combined bus coupler

Auxiliary bus-bar system

If is not admissible to shutdown the branch for entire maintenance period of a breaker or related equipment (e.g. electrical protections, measuring transformers, control signalling and measuring circuits), connection with the transfer bus-bar system is often used for backup power supply of particular branch. Disconnections, protections, signalling and measurements in the branch with an auxiliary bus-bar switch are provided by spare equipment. In this branch, bus-bar insulators enable

the connection type selection to the main bus-bar systems according to the original branch connection.

Operation of branch 3 using an auxiliary bus-bar, while its circuit-breaker are under inspection, is presented in Fig. 2.10. Bus coupler may be combined with the auxiliary switch as shown in Fig. 2.11.

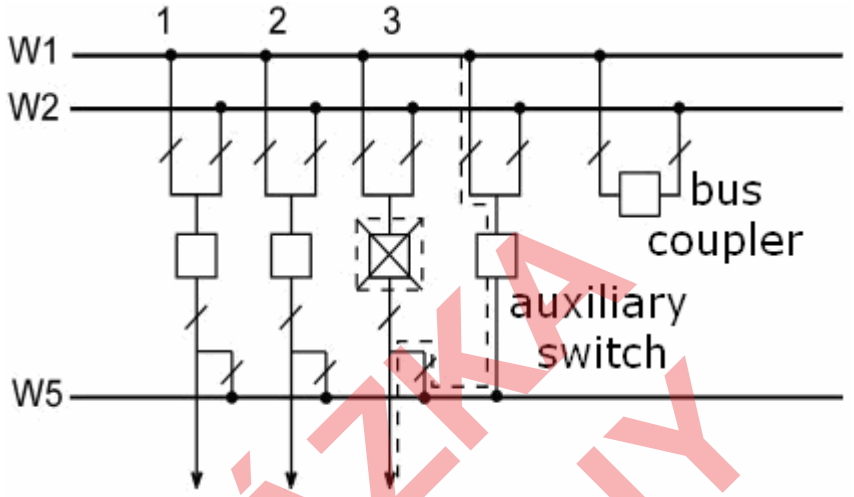

Fig. 2.10: Auxiliary bus-bar system

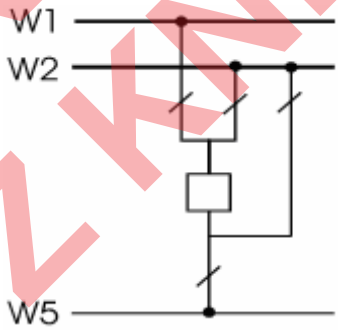

Fig. 2.11: Auxiliary switch combined with bus coupler

The operation, where a branch is connected via an auxiliary bus-bar, is called ***alternate operation***. Since it is necessary to ensure this operation during both normal and failure states, one branch only may be connected to the auxiliary bus-bar system.

Sizing of auxiliary bus-bar system and branch equipment with an auxiliary switch is identical with the most heavy-loaded branch. If the simultaneous operation of main bus-bars are not assumed, it is admissible to use one of the main bus-bar systems in the mode of an auxiliary system for a low number of branches. The breaker is by-passed with an insulator and the bus coupler is used as an auxiliary switch.

Substation scheme with double bus-bar system and by-passed breaker is shown in Fig. 2.12. This line scheme represents power supply route of the branch under inspection. One branch only is operated via a by-pass similarly as via an auxiliary bus-bar.

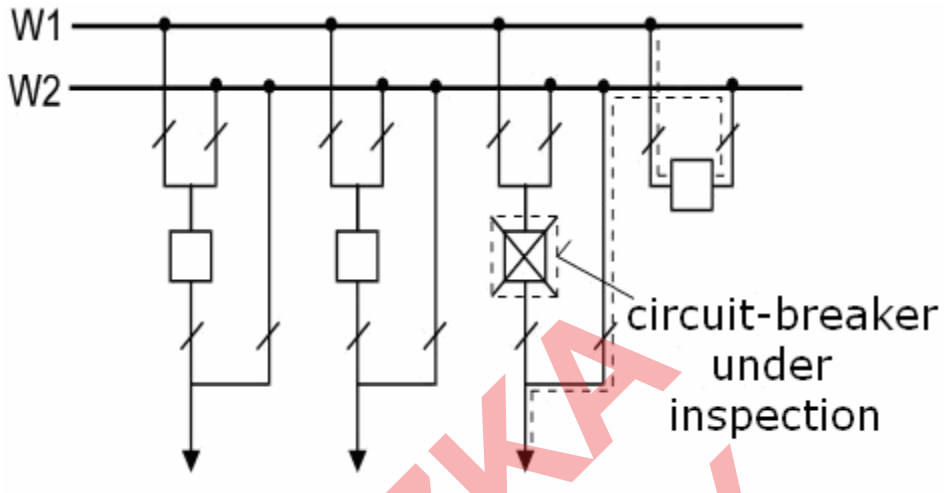

Fig. 2.12: Scheme with a by-passed breaker

Auxiliary bus-bar system can be used for distribution facilities with one, two or three bus-bar systems.

Polygonal connection

In switching stations with polygonal connection, bus-bar sections are wired in polygons (e.g. triangles, tetragons up to octagons). These schemes are required for the reduction of short-circuit effects in the switching station to a minimum number of branches. Although these schemes show the highest reliability indicators, they are used only exceptionally due to their complex design and subsequent extensions. Setting of electrical protections is also more difficult compared to substations with double or triple bus-bar systems.

Polygonal connection is operated:

- **without a backup breaker** - distribution schemes with bus-bar sections connected in polygons without a backup breaker are shown in Fig. 2.13.

- **with a backup breaker** - breaker is common for all the branches and its use is analogical with an auxiliary bus-bar.

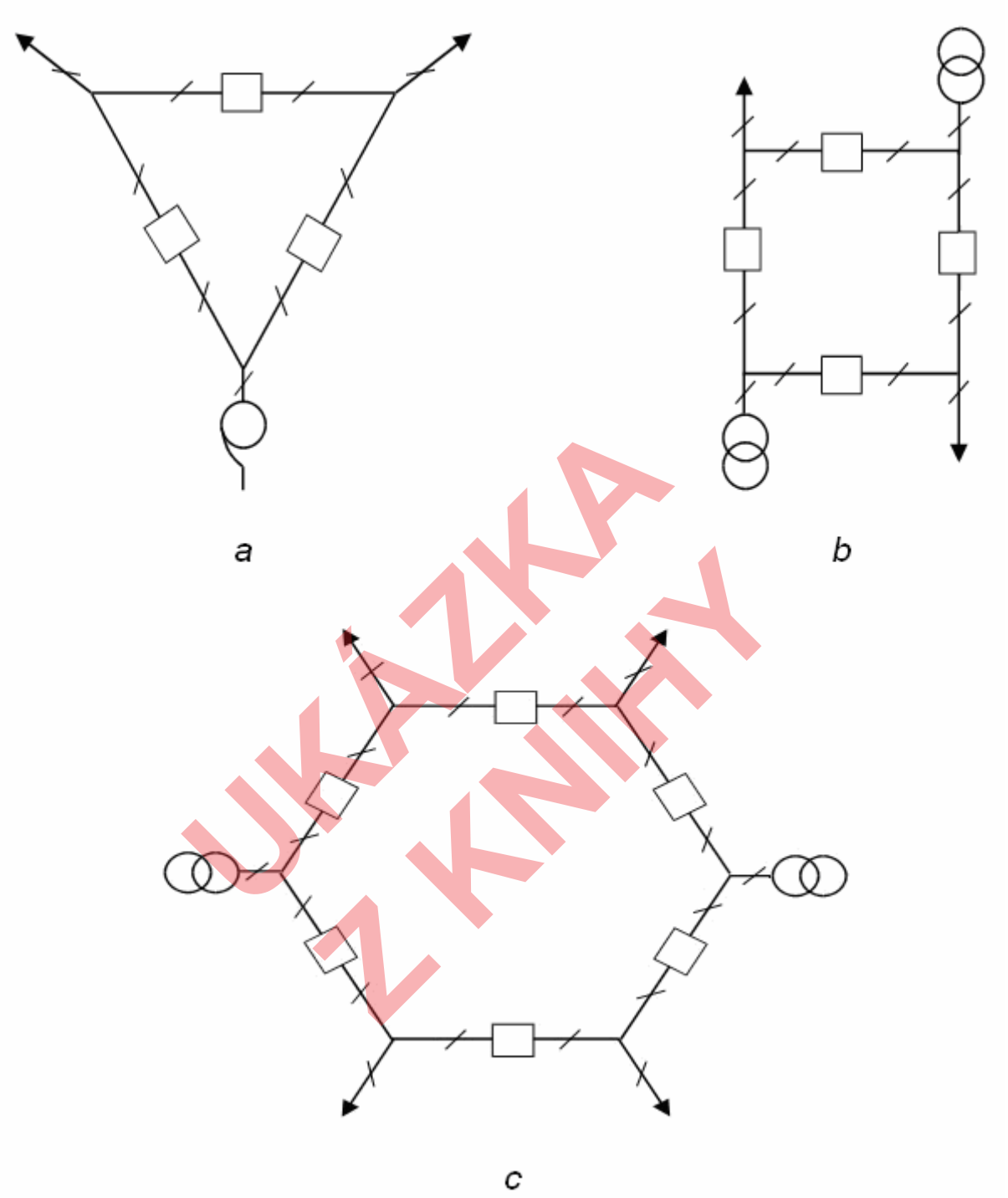

Fig. 2.13: Polygonal connections without a backup breaker

Substation schemes containing the polygonally connected bus-bar sections with a common backup breaker are shown in Fig. 2.14 *a* and *b*.

These schemes illustrate the power supply route during the failure or inspection on one of the operating breakers.

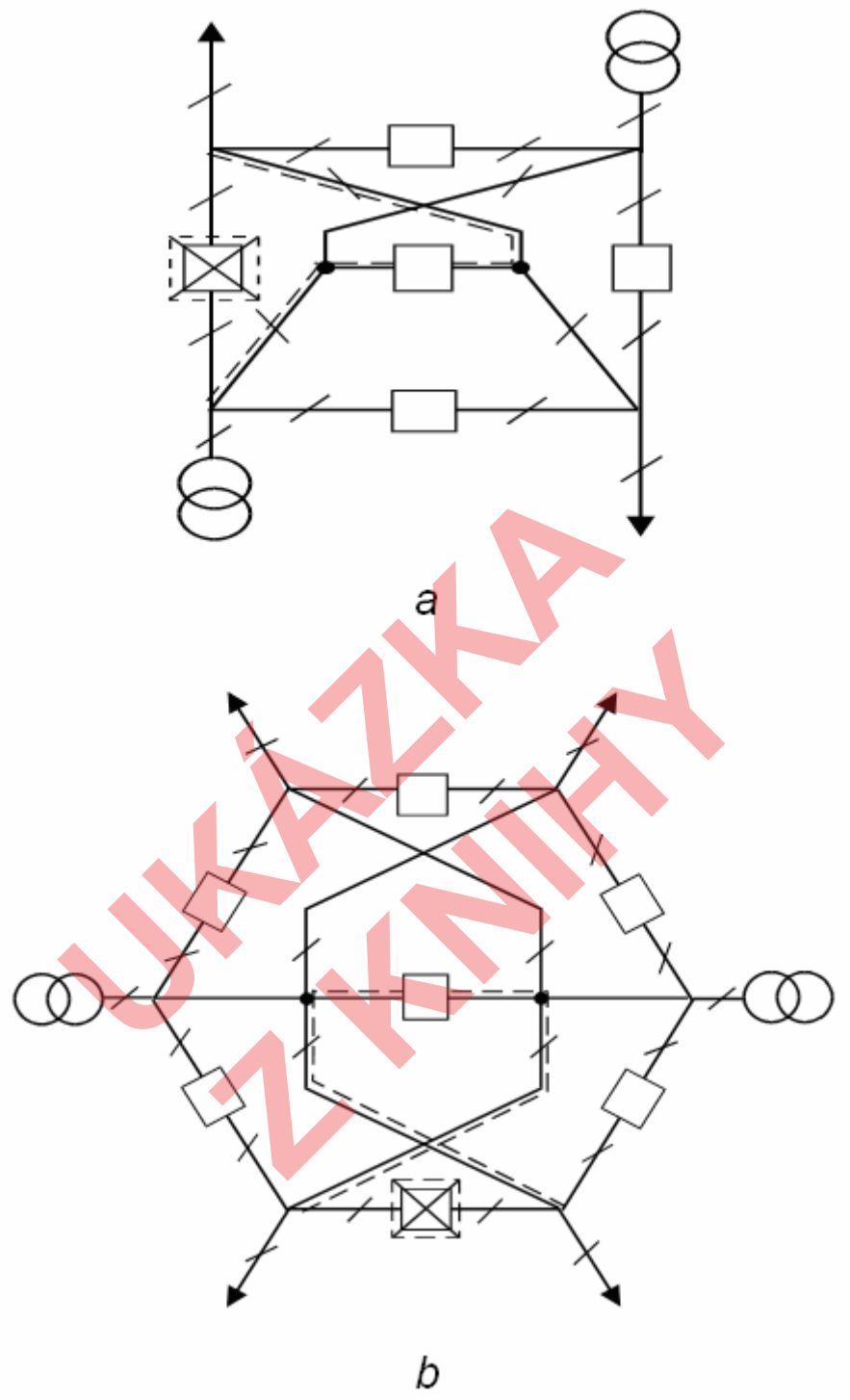

Fig. 2.14: Polygonal connections with a backup breaker

2.2.1.3 Switching Stations without Bus-Bars

These HV distribution facilities contain a small number of branches (≤ 6). Such a scheme is a special example of connection with ring bus-bars, where one or two bus-bar sections are designed as transverse links between the branches. The

H-type connection is a typical scheme frequently used in HV/MV substations see Fig. 2.15.

Scheme *a* is used for terminal electrical substations in distribution networks, while scheme *b* is applied in cases with continuous lines. Scheme *c* is a simplified form of an electrical distribution substation connected to a continuous line. Scheme *d* includes the instrumentation and protection commonly employed for this substation type.

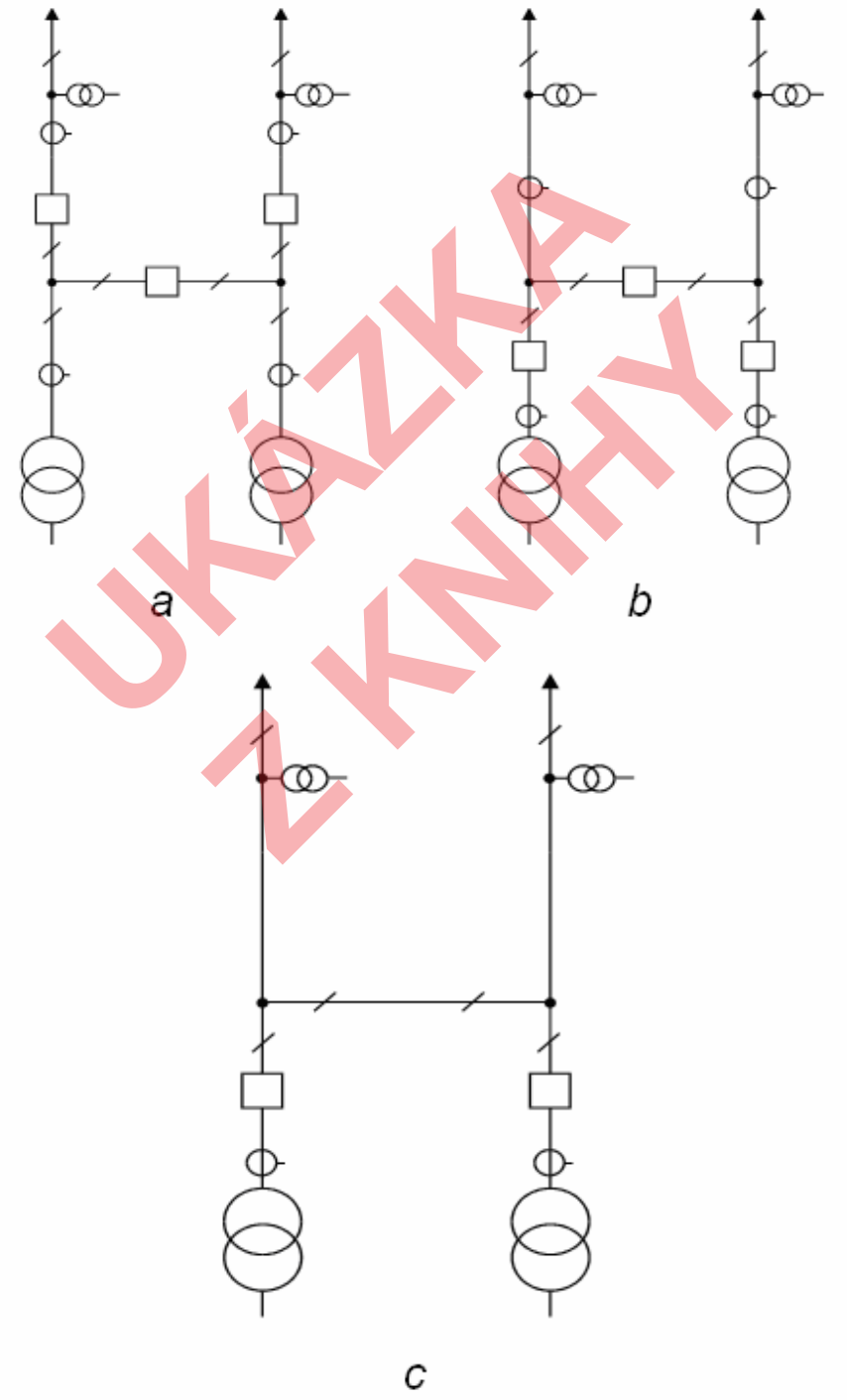

Fig. 2.15 a), b), c): The H-type connection scheme

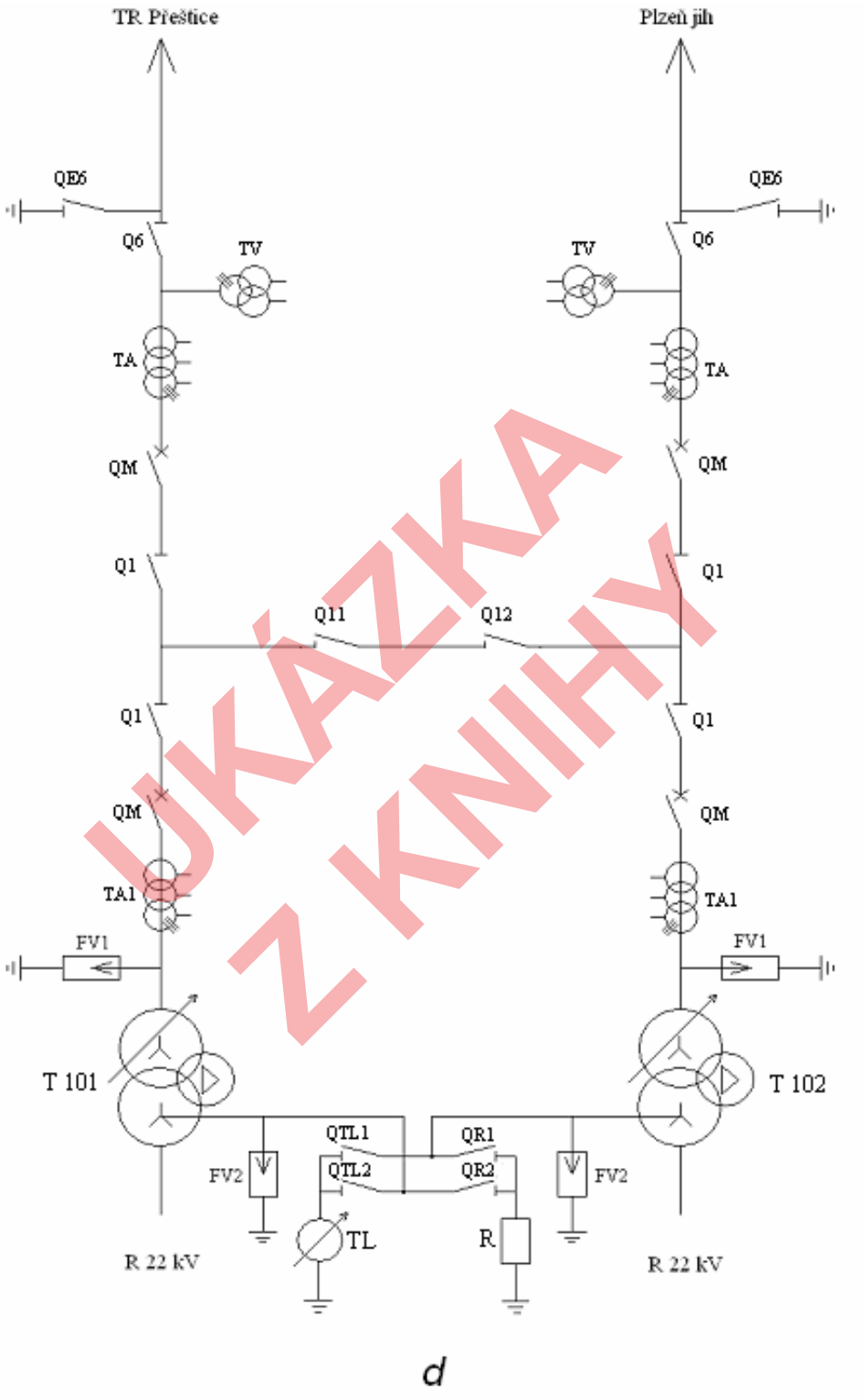

Fig. 2.15 d): The H-type connection scheme

As already mentioned above, the scheme with four breakers shown in Fig. 2.4 and included to the schemes with single sectionalized bus-bar systems is similar to the design of H-type connection scheme.

2.2.1.4 Substations with more Breakers per Branch

The layout with more breakers per branch is designed for substations with more branches which are required to operate when the breaker fails.

- Substations with **n+1** breakers per **n** branches – the scheme with three breakers for two branches is shown in Fig. 2.16. and with four breakers for three branches in Fig. 2.17. Central breaker with insulators forms the backup for two adjacent branches.
- Substations with two breakers per branch – feature relatively high operating reliability, but also high acquisition costs. Therefore, they are justifiable only in cases of exceptional importance levels. The scheme is shown in Fig. 2.18.

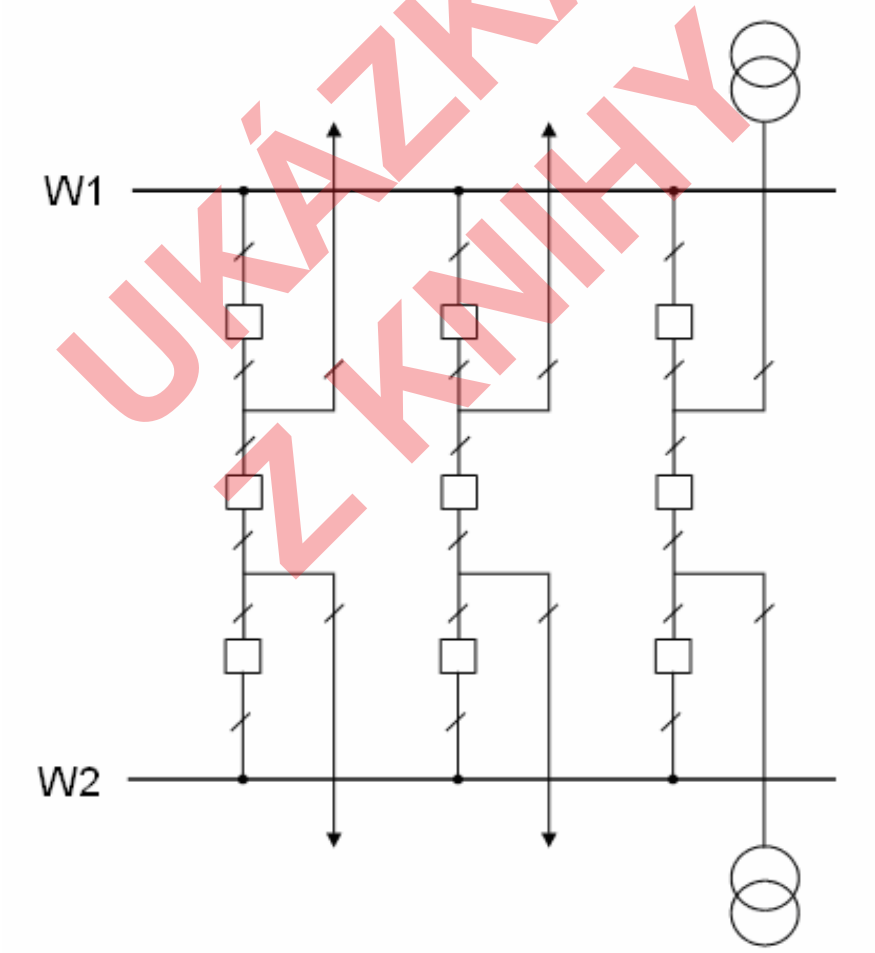

Fig. 2.16: Substation with three breakers per two branches