The **contactless convergence measurement** method, which is based on the optical trigonometric measurement of target markers such as luminous diodes or reflecting signals, is performed with an electronic tachymeter equipped with an integrated co-axial distance measuring device. The displacements measured with the help of the tachymeter are saved on a data carrier inside the tachymeter and can be transferred to a PC when the measurements are completed. To achieve tunnel convergence measurements with an accuracy of ± 1 mm, the tachymeter must enable direction measurements with an accuracy of at least ± 0.3 mgon and distance measurements with an accuracy of at least ± 0.5 mm.

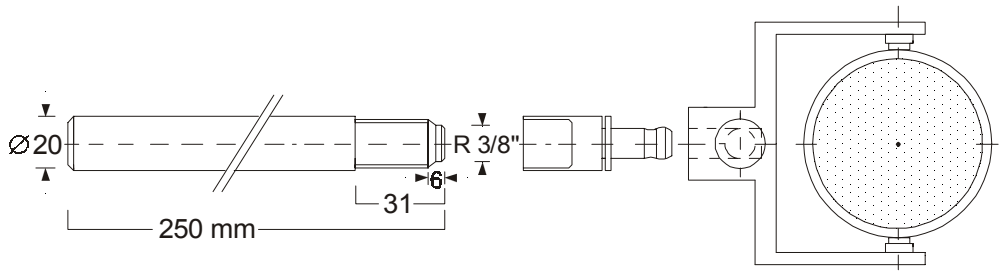

Fig. 1 Contactless convergence measurement signal, consisting of a convergence bolt, rupture joint adapter and bireflex target

To generate signals for the measuring points, a convergence bolt is set in concrete in the tunnel support and a bireflex target is fastened to it by means of a PVC rupture joint adapter that enables the target to rotate (see Fig. 1). This type of signal is used for all measurements taken at a distance of between approximately 15 and 50 m. It is very easy to home in on the target with the tachymeter when a light beam is directed at the reflector. If the measuring point happens to be touched by machinery during tunnelling work, the bireflex target will break off at the rupture joint but normally the convergence bolt will not be bent. The target can be returned to its former position (as it was before the damage occurred) after screwing on a new rupture joint adapter.

Signals for measuring points at a distance of less than 15 m and signals for fixed points are created by triple prisms instead of bireflex targets.

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