Co-axial

Looking through a telescope; sending and receiving electromagnetic waves through this telescope; taking pictures through this same telescope. And all through the same line-of-sight: co-axial. I know what it is, I know what it does, but how does it work?

Since their invention in about the 16th century surveyors have been using telescopes, initially to get a magnified image and thus see distant objects more clearly, later as an angle-measuring device. For the latter purpose, two parts had to be added to the telescope: a levelling vial and a circle over which the telescope rotates and which is provided with a circular scale to measure the direction in which the telescope tube is pointing. Further, a crosshair had to be mounted in the tube to enable the sighted object to be centred within the field of view. For obtaining proper angle measurements an important requirement is that the line-of-sight defined by the optical centre of the objective and the crosshair must be perpendicular to the horizontal axis.

Parallel Lines-of-sight
The introduction of Electronic Distance Measurement (EDM) devices offered an opportunity to further extend the measuring capabilities of the theodolite from angles to angles and distances. Their combination introduced an additional EDM line-of-sight: it had to be ensured that the two lines-of-sight were parallel to each other. Initially, the EDM devices were mounted on top of the theodolite so that the two lines-of-sight were 10cm to 15cm apart. As a result, the surveyor may see the target through the telescope whilst obstructing objects such as foliage or scrub may be present in the EDM line-of-sight, making distance measurements impossible. Later, EDM devices were mounted directly on the telescope, which reduced the distance between the two lines-of-sight but increased the instability of the combination. To solve this problem the manufacturer Leica, for example, placed extra counterweights, whilst Kern and Geodimeter placed the EDM signal generator device on top of the telescope and the return signal receiver beneath the telescope.

Integrated Devices
Today the land surveyor is confronted with total stations consisting of several integrated devices, including:

- theodolite, which enables the land surveyor to observe the target by looking through the telescope and to measure the direction to that target using
  either prisms or by reflectorless means
- EDM devices for measuring the distances to targets using either prisms or by reflectorless means
- digital video camera.

The above devices are no longer mounted on top of each other but are completely integrated. Their line-of-sight are not placed at a certain distance from each other but are all co-axial; all signals pass through the line-of-sight of the telescope. A multitude of lenses, mirrors, prisms and filters ensure that the diverse internal signal paths finish up in one line-of-sight. The nesting of all these optical, mechanical and electronic components presents a special challenge in constructing modern total station s. These solutions are not trivial, and there is academic interest in further development. For example, last year (2004) Bernd Hans-peter Walser received a PhD degree from the Swiss Federal Institute of Technology (ETH) Zurich with a dissertation entitled *Development and calibration of an image assisted total station*.