

The US Naval Observatory Double Star CD, 2006.5

Brian D. Mason and William I. Hartkopf

United States Naval Observatory
3450 Massachusetts Avenue, NW
Washington, D.C. 20392

Abstract: The United States Naval Observatory has recently released its second CDROM of double star catalogs. This article describes the contents of the CD and how to obtain a copy.

The U.S. Naval Observatory has produced its second CDROM of double star catalogs. This successor to the 2001.0 CDROM will include the latest versions (30 June 2006) of four major double star catalogs maintained at the USNO:

- Washington Double Star Catalog (WDS),
- Second Photometric Magnitude Difference Catalog,
- Fourth Catalog of Interferometric Measurements of Binary Stars, and
- Sixth Catalog of Orbits of Visual Binary Stars.

Each of these catalogs had seen significant changes during the past six years; for example, the WDS has grown by over 150,000 measures and the number of systems in the Interferometric Catalog has nearly doubled. Other improvements include precise coordinates for the vast majority of systems, as well as new observing lists for tens of thousands of "neglected" doubles.

Also included on this CDROM is a Catalog of Linear Elements for several hundred optical pairs. These elements should prove useful for improving the components' proper motions, as well as providing scale calibration out to several tens of arcseconds. Another item included on the CD is a history of double star work at the US Naval Observatory.

Each of these is described in some detail below.

Washington Double Star Catalog, 2006.5

The WDS summary catalog is a listing of 102,387 systems based on 727,726 mean positions. In addition to the summary data we also provide precise positions, proper motions, as well as cross reference identifications. We also provide more detailed notes as

well as indicating when systems are also in other datasets. The WDS is the successor to Index Catalog of Double Stars (IDS) and has gone through three major releases (1984, 1996, 2001), is under continual growth (Figure 1) and is updated nightly.

The WDS has been matched with astrometric catalogs, primarily those used for the determination of proper motion for Tycho-2. These catalogs have significantly improved the identification of pairs with their precise position such that 97% of them have at least arcsecond-precise positions. Also the proper motion of the secondary is now provided for 38% of all

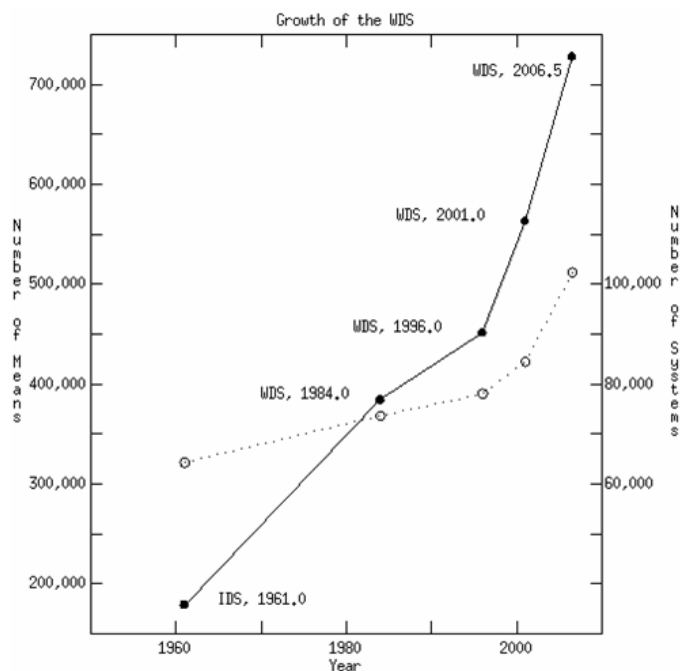


Figure 1: Growth of Washington Double Star Catalog

The US Naval Observatory Double Star CD, 2006.5

pairs, aiding in the identification of common proper motion binaries and optical doubles. Pairs having common or mutually exclusive parallaxes are also indicated.

As well as providing a DM cross-reference, the WDS also provides cross-references to Hipparcos, Tycho-2, and historical double star catalogs (ADS & BDS). New lists of "Neglected Doubles" are provided. Pairs are classified as neglected if they are unconfirmed or infrequently observed. Observation of these pairs by amateurs has significantly improved the database. Amateurs have also provided arcsecond-precise coordinates for pairs too faint, or unmatched, with astrometric catalogs. Unpublished measures of doubles from various sources are included, as well as lists of verified single stars.

While the mean number of measures per system is 7.1, the median is only 3. (Figure 2) Some 1522 have orbits of varying quality, 354 have common parallax, and an unknown number have common proper motion. Others are certainly optical: 1163 have published rectilinear solutions and 174 show mutually exclusive parallax. With only a few percent even approximately described kinematically, there still remains much work to be done.

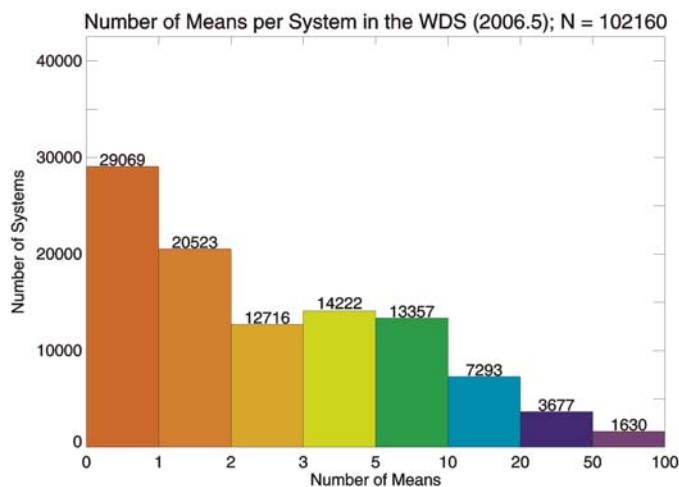


Figure 2: Distribution of mean number of measures per system.

Sixth Catalog of Orbits of Visual Binary Stars

The Sixth Catalog of Orbits of Visual Binary Stars continues the series of compilations of visual binary star orbits published by William Finsen, Charles Worley, and Wulff Heintz from the 1930's to the 1980's. As of 30 June 2006, the new catalog included 2,024 orbits of 1,888 systems. All orbits have been graded as in earlier catalogs, although the grading scheme was modified as of the Fifth Catalog to be more objective.

Nominally a single "best" orbit is given for each system; however, a second solution is occasionally given in cases of two very different orbits of similar quality or instances of quadrant ambiguity. Ephemerides are given for all orbits with complete elements, as are plots including all associated data in the Washington Double Star (WDS) database. Examples of these figures are shown below. Notes are given for many systems, and a subset of orbits potentially useful for scale calibration is also presented.

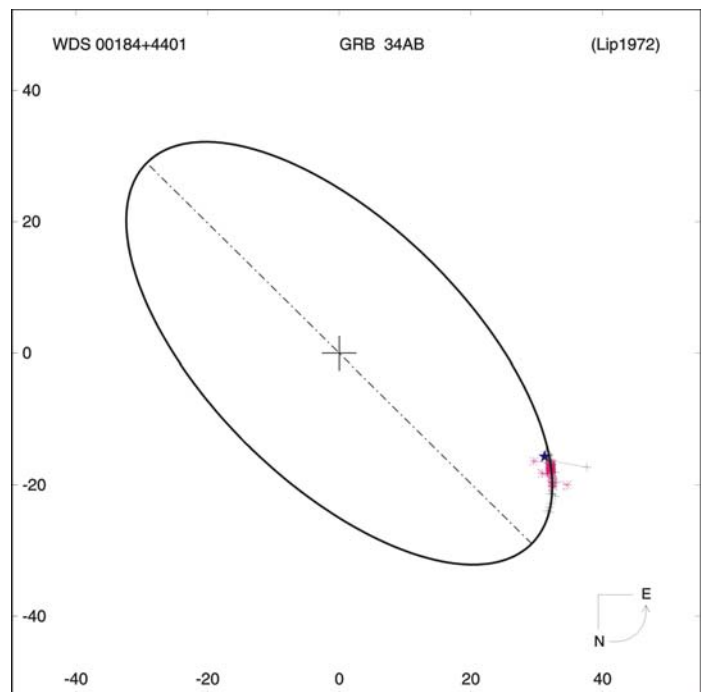


Figure 3: The "Grade 5" indeterminate orbit for GRB 34. While residuals are small, and the ephemeris quite accurate for many years to come, the orbital coverage is slight and calculated astrophysical parameters would have large errors.

The US Naval Observatory Double Star CD, 2006.5

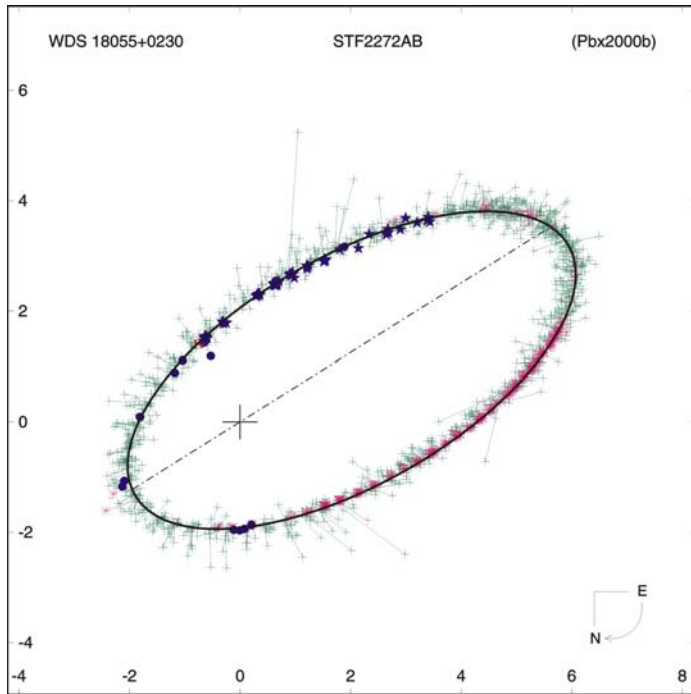


Figure 4: The "Grade 1" (definitive) orbit for STF2272AB. Small residuals and excellent orbital coverage makes this among the best. The submotion seen in STF2272AS (see Figure 8) is due to the approximate 88 year orbit of this pair.

Fourth Catalog of Interferometric Measurements of Binary Stars

The Fourth Catalog of Interferometric Measurements of Binary Stars includes 104,618 published measures of binary and multiple star systems obtained by high-resolution techniques (speckle interferometry, photoelectric occultation timings, etc.), as well

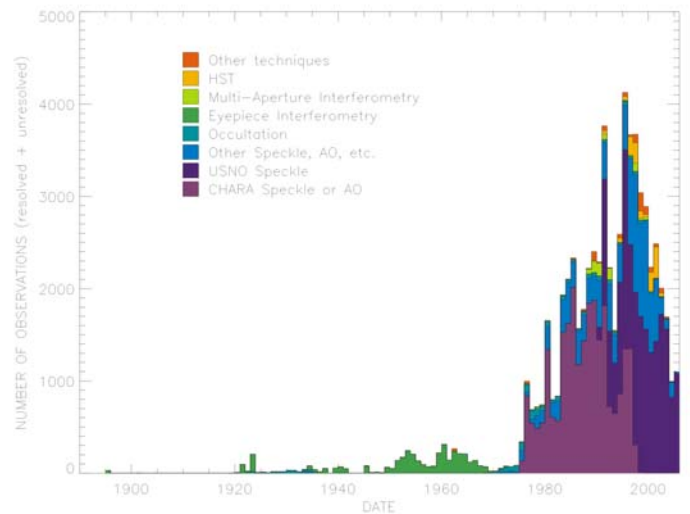


Figure 5: Distribution of measures with time. Barely visible are the 1895 observations of Schwarzschild & Villiger, followed two decades later by the 1919-1921 data obtained using the famous 20-foot beam interferometer with the Mount Wilson 100-inch Hooker Telescope by Anderson and Merrill.

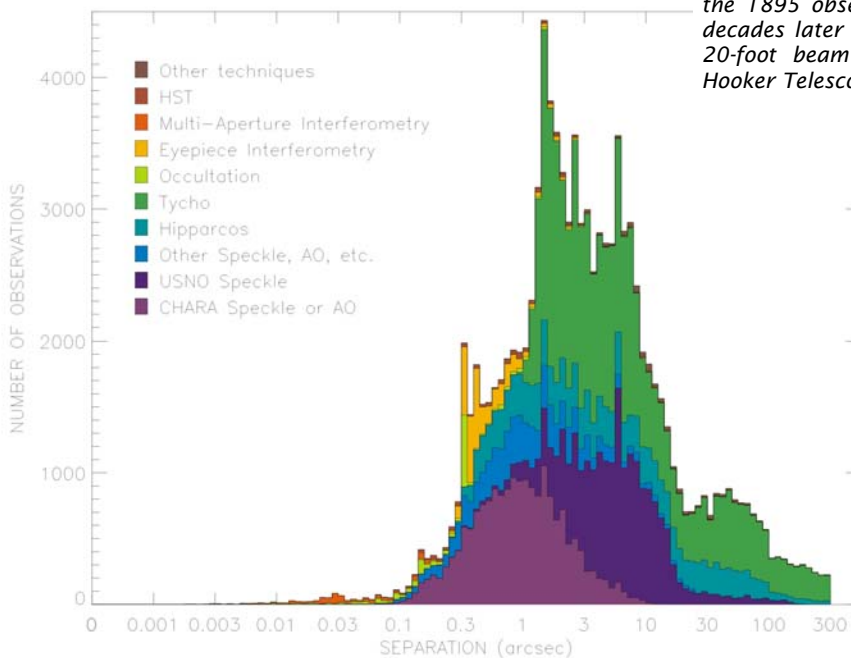


Figure 6: Distribution of measures with separation, from the closest measures by long-baseline interferometry to the widest Tycho pairs..

The US Naval Observatory Double Star CD, 2006.5

as 30,956 negative examinations for duplicity.

Second Photometric Magnitude Difference Catalog

The Second Photometric Magnitude Difference Catalog is a collection of magnitude difference measures for double stars and serves as a repository for double star observations where no astrometry is given. It is ten times larger than the First Catalog and consists of 209,365 measures of 63,643 systems with a mean Δm of 1.49. The most significant addition since the last version of this catalog is due to matching the WDS with the 2MASS catalog. Δm determinations in J, H, and K bands are now listed for the 42,009 systems matched with WDS pairs. A brief summary and statistical analysis of the contents of the catalog are presented.

Catalog of Rectilinear Elements of Visual Double Stars

This is new on the Second Double Star CD. Many systems in the Washington Double Star Catalog have shown significant relative motion since their discovery. The Catalog of Rectilinear Elements provides linear fits for those systems whose motion does not appear to be Keplerian. While a few of these may in fact be very long-period physical pairs whose orbital motion is not yet apparent, most are probably optical pairs (i.e., chance alignments of unrelated stars). These linear fits, then, just describe the relative proper motions between these pairs of stars.

The purposes of this catalog are threefold. First, the very well-defined motions of some of these systems means they may prove useful for scale calibration for imaging systems such as CCDs or photographic cameras. Also, these differential proper motions may allow us to improve upon proper motions of individual

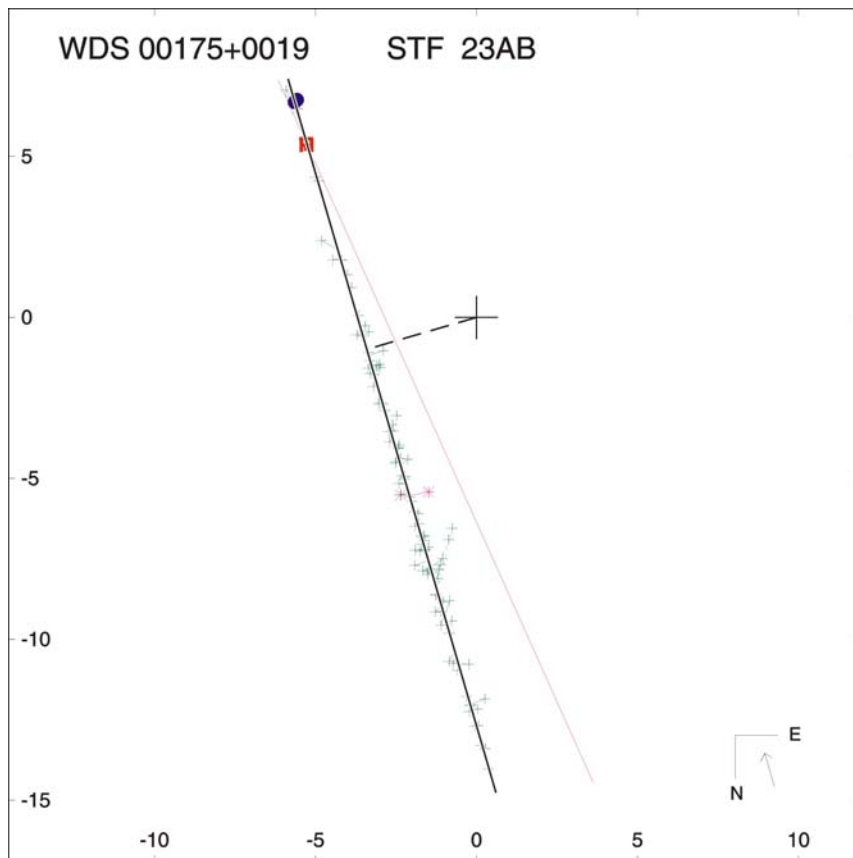


Figure 7: STF 23, whose 170+ years' worth of data illustrate a clear deviation from the published relative proper motion (red line). For this class of objects, the long timebase of double star measures may yield better proper motions than traditional techniques.

The US Naval Observatory Double Star CD, 2006.5

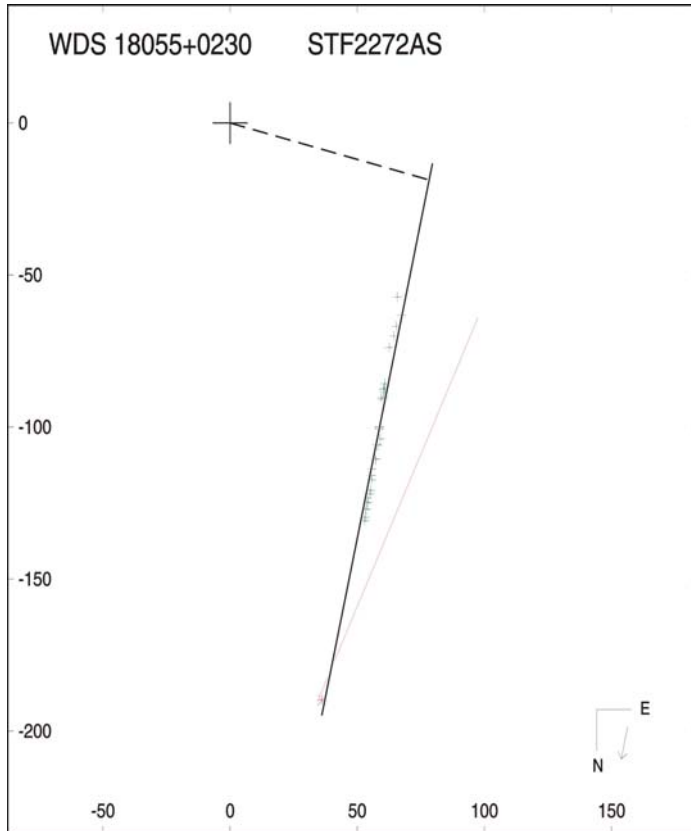


Figure 8: *STF2272AS, a distant pair exhibiting a "wobble" in its motion due to the orbit of a closer pair.*

components. Finally, these linear fits, especially in comparison with Hipparcos proper motions, may be useful in searches for submotions due to closer components. These investigations are underway.

As shown in Figure 8, Fourier analysis of residuals to linear fits may indicate the presence of unseen companions as well.

Double Star Astronomy at the US Naval Observatory

The U.S. Naval Observatory has, for well over a hundred years, been involved in various programs related to the observation of double stars. Highlights of these efforts, using the three observing techniques of visual filar micrometry, photography, and speckle interferometry, are given, along with many historic photographs, some of which are shown below.

How do I get one?

Copies of the US Naval Observatory Double Star CD, 2006.5 are available. Simply fill out the web form at http://ad.usno.navy.mil/wds/cd_request.html.



Figure 9: *The 26" in 1911.*

The US Naval Observatory Double Star CD, 2006.5

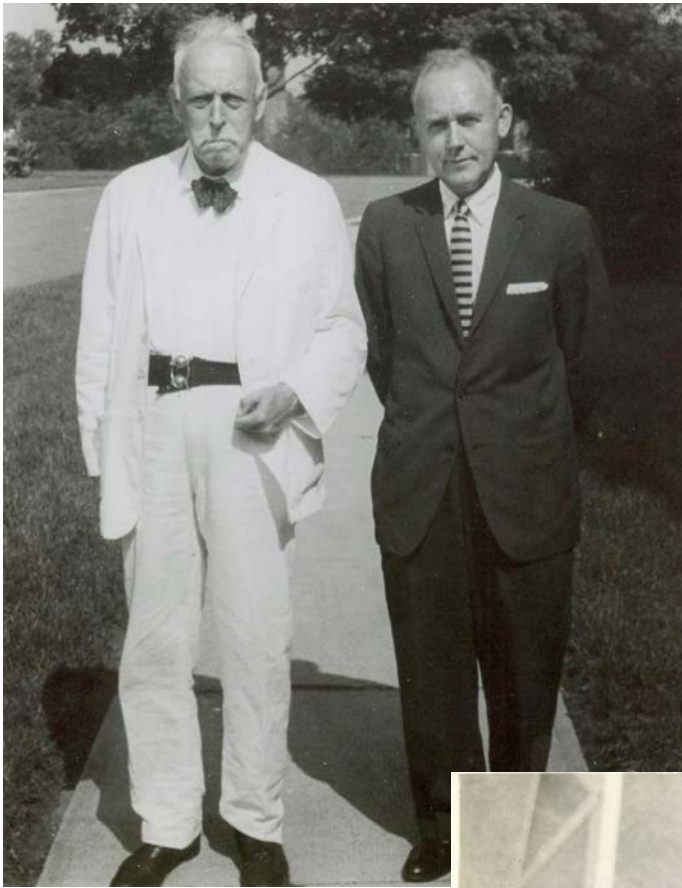


Figure 10: Ejnar Hertzsprung visiting the USNO, seen with Scientific Director, Kaj Strand.

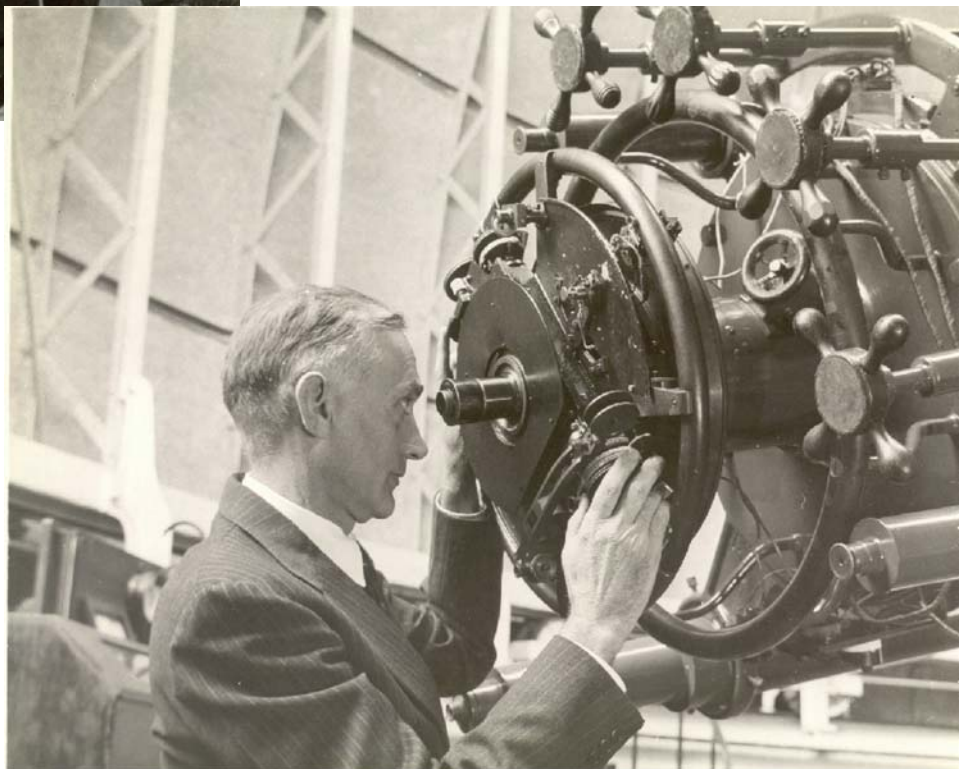


Figure 11: U.S. Lyons with a micrometer on the 26".