ing given to the development of processes for the manufacture of alcohol from cheap raw materials which are generally available, and it seems reasonable to expect that the price of denatured alcohol will eventually become as low as or lower than the price of gasoline, especially if the price of gasoline advances. It also seems reasonable to expect a greater general improvement in alcohol engines than in gasoline engines.

When used as a fuel, denatured alcohol is not always so classed as to be exempt from restrictions placed on the use of gasoline by the rules of insurance and transportation companies or city ordinances. The restrictions that are placed on the use of denatured alcohol are, however, never greater than those placed on the use of gasoline. In some places they are such that the use of an alcohol engine is permitted where the

use of a gasoline engine is prohibited. For instance, alcohol motor trucks and automobiles are admitted to many of the steamer piers in New York that are not open to gasoline machines.

Where the restrictions placed on the use of denatured alcohol are less than those placed on the use of gasoline or where safety and cleanliness are important requisites, the advantages to be gained by the use of alcohol engines in place of gasoline engines may be such as to overbalance a considerable increase in the fuel expense, especially if the cost of fuel is but a small portion of the total expense involved, as is often the case. Denatured alcohol, will, however, probably not be used for power purposes to any great extent until its price and the price of gasoline become equal and the equality of gasoline and alcohol engines in respect to adaptability to service required and quan-

tity of fuel consumed per brake horse-power, which has been demonstrated to be possible, becomes more generally realized.

A further general development in the design and construction of engines that use kerosene, or cheaper distillates, and the crude petroleum may be reasonably expected and may delay the extensive use of denatured alcohol for some time to come, but as yet comparatively few data pertaining to this phase of the general investigation are available. Some investigations relating specifically to the extent and economy with which these cheaper oils can be used as fuels for internal-combustion engines of the types suited to various classes of service are, however, in progress at the testing station of the United States Geological Survey, where a Hornsby-Akroyd and a Mietz & Weiss oil engine have been installed.

CAPTURED COMETS.*

THE FAMILIES OF SATURN, URANUS, AND NEPTUNE.

BY H. C. WILSON.

In vol. vi. of Popular Astronomy Plate I is a diagram of the comet families of the planets Saturn, Uranus, and Neptune, drawn by Dr. A. G. Sivaslian, of Anatolia College, Marsovan, Turkey. One of our readers has recently called attention to a technical error in this plate and suggested that the diagram be revised and brought up to date. This we have attempted to do and the results are herewith presented.

The error referred to is a technical one resulting from neglecting the inclinations of all the comet orbits to the plane of the ecliptic and drawing, not their projections upon that plane, but their true forms as if they all lay in that plane, indicating by dotted lines the portions of the curves which lie below the ecliptic. In the case of the Jupiter family of comets the inclinations are in general so small that the diagram constructed in this way gives very nearly the true projection of the family of orbits. In the case of these outer families the inclinations average much higher, so that a true projection would not give at all the true forms of their orbits. For example, the orbit of the Pons-Brooks comet is inclined 74 deg. to the plane of the ecliptic. The line of nodes or intersection of the plane of the orbit with the plane of the ecliptic makes an angle of 254 deg. with the line from the sun to the vernal equinox. In order to get the true perspective of the orbit one must imagine the right side of the ellipse to be lifted up from the paper and tipped over toward the left, the dotted portion being tipped downward and to the right, so that the projection will appear much narrower than the true orbit and will lie almost wholly within the projection of the orbit of Brorsen's comet. The orbit of DeVico's comet likewise must be tipped over through an angle of 85 deg. so that it will be almost perpendicular to the plane of the ecliptic, and will also lie almost wholly within the projection of the orbit of Brorsen's comet.

The orbit of Halley's comet has an inclination of 162 deg. and the longitude of the ascending node is 57 deg. The inclination is so great that the orbit must be tipped clear over to within 18 deg. of the ecliptic on the other side, so that as projected its motion is backward (retrograde) and the aphelion point is in longitude 125 deg. approximately, instead of 345 deg., as shown on Plate I, vol. vi., where the effect of the inclination was neglected.

* Popular Astronomy.

COMET FAMILIES OF SATURN, URANUS, AND NEPTUNE.

Tempel's comet (1866 I) also has an inclination of more than 90 deg. so that its motion is retrograde. Its line of nodes lies more nearly lengthwise of the orbit than does that of Halley's comet, so that the change of position of the orbit when correctly projected is not so marked as in the case of the latter comet.

In the diagram Plate X we have given the true forms of all the orbits neglecting the inclinations except that in the case of Halley's and Temple's comets the orbits have been plotted to correspond to retrograde motion.

In the diagram, Fig. 1, the true projections of all the orbits have been drawn to the same scale as on Plate X. A glance at these diagrams shows at once the very marked change in position of the orbits of the Olbers, Pons-Brooks, DeVico, and Westphal comets when they are correctly projected. The paths of the Olbers and Westphal comets no longer reach out to the orbit of Neptune, and they should probably not be classified as belonging to the Neptune family. The fact that their descending nodes are near the orbit of Jupiter would rather point to their being members of the Jupiter family.

If, however, we take the position of the nodes as a criterion none of the six comets which have been reckoned in the Neptune group really belong there. Halley's and Brorsen's have their nodes near the paths of earth and Mars; DeVico's and Pons-Brooks's belong to the Uranus group with Tempel's and Coggia's. None of these comets in their present orbits can approach near enough to Neptune to have their orbits very seriously disturbed by that planet.

Of the two comets in the Saturn group, Peters's has its descending node near the path of Saturn, but the nearer node of Tuttle's comet is farther from Saturn's than it is from Jupiter's orbit, and it may be questionable to which planet the latter comet belongs.

The elements which were employed in making the diagrams are given in Table I, together with a refer-

TABLE I.

ELEMENTS OF THE SATURN, URANUS AND NEPTUNE FAMILIES OF PERIODIC COMETS.

Name	Period in Years	Time of Perihelion Passage Greenwich M. T.	Perihelion Distance	Aphelion Distance	<i>e</i>	<i>ω</i>	<i>Ω</i>	<i>i</i>	Mean Equinox	Calculator and Reference
1846 VI (Peters)	13.376	1846 June 1.134	1.52928	9.7404	0.728605	339 37 44	260 23 53	30 40 10	1846.0	Reberich, A. N. CXVII, 251
Tuttle	13.667	1899 May 4.515	1.01913	10.4133	0.821712	206 39 09	289 49 54	54 29 16	1900.0	Rahts, A. N. CXLIX, 42
1866 I (Tempel)	33.2	1866 Jan. 11.134	0.97652	19.6747	0.905421	170 57 13	231 52 59	162 41 57	1899.0	Bidschof, A. N. CXIV, 299
1867 I (Coggia)	40.1	1867 Jan. 20.207	1.57723	21.8502	0.865352	357 31 15	78 27 35	18 12 33	1867.0	Becker, M. N. LI, 489
1852 IV (Westphal)	60.66	1852 Oct. 12.751	1.24996	29.6262	0.919034	57 03 42	346 10 00	40 53 00	1852.0	Westphal, A. N. L, 49
Pons-Brooks	71.56	1884 Jan. 25.717	0.77573	33.6980	0.954996	199 11 33	254 05 42	74 02 36	1880.0	Schulhof-Bussert, A. N. CVIII, 16
Olbers	72.65	1887 Oct. 8.479	1.19912	33.6234	0.931130	65 20 11	84 32 20	44 34 16	1890.0	Ginzel, Rechen-Inst-Publ. 3, p. 33
1846 IV (DeVico)	75.71	1846 Mar. 5.546	0.66380	35.1301	0.962910	12 53 26	77 33 16	85 06 27	1846.0	Heppberger, A. N. CXVII, 245
Halley	76.0	1910 Apr. 19.65	0.58715	35.3034	0.967281	111 42 16	57 16 12	162 12 42	1910.0	Cowell and Crommelin, M. N. LXVIII, 393. The Observatory Oct. and Nov., 1909
1847 V (Brorsen)	81	1847 Sept. 9.516	0.48827	36.9700	0.973930	128 18 05	309 50 23	19 09 00	1847.0	Gould, A. J. I, 143

ence giving the authority for each. In every case we have selected what seemed to us to be the most reliable elements which have been published. Those of Halley's comet are being revised by the aid of recent observations and so will be subject to slight changes, but the time of perihelion passage is now known within a small fraction of a day and the other elements cannot change very much.

Of the ten comets four only have been observed at more than one apparition; Tuttle's has been seen at five apparitions, Pons-Brooks's and Olbers's each at two, and Halley's at no less than twelve successive apparitions. Peters's 1846 VI. must be considered as a lost comet since it has not been detected at any of its four returns since 1846. If its period is unchanged, it is due again in 1913. Tuttle's and Westphal's com-

ets are also due in 1913, DeVico's should return about 1921, Brorsen's about 1928, Tempel's in 1932, Olbers's about 1960. Coggia's was due somewhere from 1905 to 1909, but has not been detected, the period being uncertain by two or more years. Halley's has recently come into sight on its return for 1910 but will not be visible to the naked eye until some time in next April or May.

ACHIEVEMENT IN POLAR EXPLORATION.*

THE EXHIBIT OF THE PEARY ARCTIC CLUB.

For several years a record of polar exploration has been on exhibition at the Museum of Natural History in the east corridor immediately off the main foyer.

farthest north, 86 deg. 14 min., reached in 1895, the Duke of the Abruzzi's (Cagni's) record, 86 deg. 33 min., made in 1900, and the northernmost point of all,

the red cord marking Peary's latest expedition spanned this remaining distance, and a small flag floated at the center of the Arctic map to bear record to the larger

THE PEARY ARCTIC CLUB EXHIBIT.

A great map painted on the floor shows Peary's route to the North Pole.

PRESSURE RIDGE IN NORTH POLAR ICE, SHOWING ONE OF THE DIFFICULTIES OF ARCTIC TRAVEL.

Greely Expedition, June, 1881.

ACHIEVEMENT IN POLAR EXPLORATION.

Here, on two fifteen-foot maps painted on segments of a globe fastened to the wall have been indicated the routes of Arctic and Antarctic expeditions.

On September 6th the Arctic map showed Nansen's

* Reprinted from the American Museum Journal.

87 deg. 6 min., gained by Peary on April 26th, 1906, but the routes went no nearer the Pole than these points, and from them stretched untraversed a region known to be more than two hundred miles wide on all sides of the Pole. On September 7th, 1909, however,

American flag that was left on April 6th, 1909, waving over the drifting ice where half the year is day and half is night.

This achievement, striven for by many men of many nations, marks an event in history. It closes a cen-