Stockholm Natural Radiocarbon Measurements I

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After almost a year of construction and trouble, radiocarbon dating work in Stockholm began early in 1955 with the black-carbon method, using the double screen-wall counter of the type developed in Copenhagen (*1*). However, after only a few months, it was evident that the measuring techniques had to be changed because of several disturbances from airborne radioactive contamination. In the autumn of 1955, construction was started of the present carbon dioxide proportional-counting apparatus. This apparatus came into routine operation early in 1956. Tables 1 and 2 give the results obtained using the black-carbon method (indicated by an asterisk) and the new method up to 12 May 1957 (*2*), when the apparatus was demounted for transportation from the temporary localities in the Royal Institute of Technology to the Swedish Geological Survey.

Techniques

The preparation and measuring methods now used are similar to those used by the Groningen (*3*), New Zealand (*4*), and Lamont (*5*) laboratories. A few facts only are given here (*6*).

The sample is converted to extremely pure carbon dioxide, taking care to exclude the carbon dioxide of the air. The proportional-counting tube has a net volume of 1.00 liter and a working pressure of 3 bar. Each sample is counted at least two times, for 20 hours each time, and with 14 days between the two periods. Before every counting period, the purity of the gas is carefully controlled by checking the gas amplification by means of an external source of radioactivity.

Oak tree rings grown about A.D. 1850 are used as a standard. Thereby we avoid the isotopic dilution effect on modern plant carbon caused by the industrial burning of coal and oil. This effect has been observed by Suess (*7*). The variation of the isotopic composition of the carbon of living plants and animals (*8*), together with possible isotopic fractionation in the preparation of the sample, has an influence on the activity of the sample. Therefore, all purified carbon dioxide samples for gas counting, except those with zero activity, have been mass-spectrometrically analyzed for their C^{13}/C^{12} ratio (*6, 9*).

Our counter characteristics follow: modern carbon, 18.5 C^{14} counts per minute over the background of 3.78 counts per minute, the former figure having been calculated from measurements of our standard wood. The background figure has a distinct dependence on atmospheric pressure, as is shown in Fig. 1. The solar flare on 23 February 1956 caused a small effect on the counting rate; the result obtained that day was rejected. With the exception of the effect mentioned, no sample has ever shown other uncontrolled fluctuations than those expected from purely statistical reasons.

Calculations

The ages given in Tables 1 and 2 were calculated by using the adopted value of a half-life of 5568 ± 30 years for C^{14}, assuming sufficient long-time constancy of the natural radiocarbon production, and trusting the physical correctness and freedom from organic materials of wrong age of the samples when submitted to the laboratory.

For calculation of the age, the net count rate of the sample, as obtained from the actual measurings of the sample itself, and the background figure taken from a curve consistent with Fig. 1, and corrected according to the C^{13} analysis are used. The net count for modern carbon is obtained as the average calculated from several measurements in the same manner.

The errors σ_A in the ages are obtained from the equation

$$\sigma_A = \frac{t_{\frac{1}{2}}}{\ln 2}[E_R{}^2 + (E_{\frac{1}{2}} \cdot \ln R)_2 + (2E_{13})^2]^{\frac{1}{2}}$$

where E_R is the relative error in the ratio R between numbers of C^{14} counts per minute in the standard and in the sample; $E_{\frac{1}{2}}$ is the relative error in the half-life, and E_{13} the relative error in the measurement of the C^{13}/C^{12} ratio (± 0.1 percent). Of these three parts, E_R gives by far the greatest contribution. E_R is calculated from the relative errors of the sample and modern carbon net count

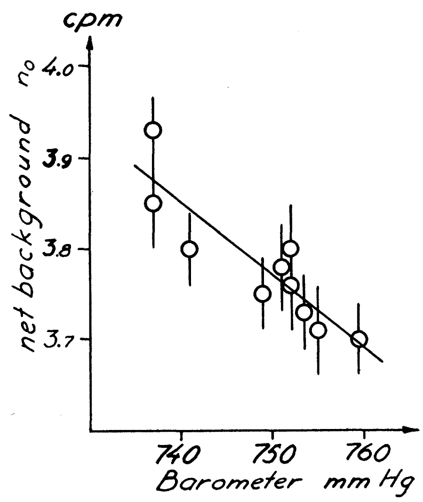

Fig. 1. Influence of the atmospheric pressure on the net background counting rate during September, October, and November 1956.

Table 1. Radiocarbon measurements of industrial samples.

Description	Sample No.	Isotopic composition correspondence
Korsnäs Ltd., Gävle, Sweden. Organic incrust inside a boiler tube in the Korsnäs cellulose works. The object was to determine the origin of the incrust, whether from petroleum or cellulose. Submitted by W. Rosén.	St-16*	47.5 ± 1.6% recent carbon
Ostrand Manufacturing Co., Timrå, Sweden. Barium carbonate made from highly chlorinated organic compounds in the chlorine plant. The purpose was to determine whether the compounds were formed from the action of chlorine on ebonite or on graphite. Submitted and described by G. Wranglén (*10*, p. 401).	St-141	30 ± 1% recent carbon

* Measurement made by the black-carbon method.

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rates, the errors in these rates being calculated according to the afore-mentioned method. Lower values of σ than ± 0.03 count per minute for background and ± 0.06 count per minute for modern carbon rates have not been used, even when lower figures were formally defensible, owing to the great number of measurements.

When a minimum age is given, it corresponds to 3σ in the net count of the very old sample, added to the actual net count rate, negative rate taken as zero. This calculation thus gives 99.86 percent or better certainty in the statement (*3*).

Table 2. Radiocarbon datings. All ages are given in years before the present. All samples, except when it is otherwise stated, were collected in Sweden. Determinations made by the black-carbon method are marked by an asterisk (*) after the sample number.

Description	Sample No.	Age
I. *Cross-check samples and samples of known age*		
Angelsta, Småland. Hewed stub of fir, found at a depth of 3.5 m in Rya Moor, Angelsta, together with a fragment of diorite, possibly a part of a stone axe. Several kilograms of the wood are at our disposal, and the material is in an excellent state of preservation. Submitted by the Museum of National Antiquities, Stockholm.		
Tree rings No. 1 to 50 from the core, dated by the black-carbon method.	St-13*	2560 ± 190
Tree rings No. 101 to 150 from the core, dated by the carbon dioxide method. The same rings were dated at the Lamont laboratory (sample L-296), and an age of 2600 ± 80 yr was obtained (*11*).	St-156	2470 ± 65
Lake Nemi, Italy. Wood from one of Caligula's ships. Historically dated to about A.D. 50. The sample was taken from the innermost tree rings. The total number of rings to the bark is not known. Submitted by C. Cortesi and M. Beneventano, C^{14} laboratory, Rome.	St-103A St-103B	1940 ± 70 2090 ± 75 Average 2010 ± 65
Ruds Vedby, Zealand, Denmark. Small pieces of wood from the zone boundary between the Alleröd and younger Dryas periods. The sample was submitted by H. Tauber, and has been dated by the Copenhagen laboratory (sample K-101) to 10,890 ± 240 yr (*1*).	St-18*	10,200 ± 370
Sequoia tree rings. This series of samples has been dated to check the reliability of the C^{14} method, since a recent paper (*12*) suggests that one would obtain results which are 200 yr too high for an age of 2000 yr. The samples were submitted by R. Sievert at the Radiophysical Institute, Stockholm. No one but he himself knew anything about the ring age of the samples we received. We were told the exact age when a signed certificate with our values was given to him.		
Sequoia 1. Ring age, 2390 yr.	St-193A St-193B	2400 ± 75 2330 ± 65 Average 2360 ± 60
Sequioa 2. Ring age, 2000 yr.	St-213A St-213B	1845 ± 60 1910 ± 60 Average 1875 ± 55
Sequioa 3. Ring age, 2180 yr.	St-214A St-214B	2170 ± 65 2120 ± 65 Average 2145 ± 60
II. *Geologic, submorainic samples*		
Boliden, Västerbotten. Small pieces of wood from submorainic deposits found at Bjurliden, near Boliden. Submitted and described by Jan Lundqvist, Swedish Geological Survey (*13*).	St-19*	> 24,000
Bollnäs, Hälsingland. Pieces of wood in submorainic position. Described by B. E:son Halden (*14*). Submitted by C. Lundqvist, Swedish Geological Survey.	St-105	> 30,000
Kil, Värmland. Spruce wood (*Picea*) found at a depth of 30 m in the glaciofluvial deposits at Fryksta, north of Kil, in 1918. Described as Finiglacial by L. von Post (*15*). Submitted by G. Lundqvist.	St-113	> 30,000
Lund. Relics of tree roots (*Alnus*), found 200 m southwest of Råbyholm, in a vertical position in glacial sand underlain by northeastern moraine and partly covered by Baltic moraine. No roots were found at a higher level than 2 m below the surface. In spite of this, the sample evidently represents tree roots that grew down in post glacial time. In the superficial layers, the roots may have been destroyed by weathering without leaving any traces. Submitted by H. Möller, department of geology, University of Lund.	St-158	3930 ± 80
Lund. Relics of tree roots (*Alnus* or *Betula*), found at Måsvägen 18, in glacial sand covered by 1.3 m of Baltic moraine and underlain by northeastern moraine. The sample was taken 1.5 m below the surface. No traces of similar roots were seen in the covering Baltic moraine. In spite of this, the sample evidently represents post glacial tree roots. Submitted by H. Möller.	St-159	4060 ± 80
Oje Kapell, Kopparberg, Dalarna. Wooden log found under moraine at Oje Kapell. Submitted by G. Lundqvist, who has also described it (*16*).	St-11* St-181	> 24,000 > 40,000
Pilgrimsstad, Jämtland. Several relics of a mammoth in primary position were discovered in sand (*17*).		
A felty, 1-cm-thick bed of *Drepanocladus* sp. in a lacustrine sequence of strata under the thin ground moraine. Collected and submitted by O. Kulling, Swedish Geological Survey.	St-211	> 39,000
Plant sediments in connection with the mammoth find. Submitted by A. Martinsson, department of paleontology, University of Uppsala.	St-205	> 35,000
Sjöbo, Skåne. Peat on the Baltic moraine at Robertsdal, 20 km southeast of Sjöbo. The find was described as interstadial by H. Munthe (*18*), but is evidently post glacial. Submitted by G. Lundqvist.	St-212	10,980 ± 140
Vålbacken, Lake Storsjön, Jämtland. Plant remains at a depth of 16 m in ice lake sediments, between two moraines. Submitted and described by P. Torslund, Swedish Geological Survey (*19*).	St-206	> 37,000
III. *Prehistory of the Baltic Sea*		
Baltic Sea. Stump of fir found on the bottom of the sea at a depth of 43 m of water in the Baltic Sea south of Karlskrona, at lat. 56°00′N, long. 15°28′E. Submitted by B. Kullenberg, Oceanographic Institute, Gothenburg.	St-120	9100 ± 120
Baltic Sea. Stump of fir from the sea bed between Kåseberga and Bornholm at a depth of 35 to 37 m. The sample was submitted by Tage Nilsson, department of geology, University of Lund.	St-179	9330 ± 120

Description	Sample No.	Age
Fröjel, Gotland. Sample of the peat under the Ancylus beach at Gåistes (Göstas) in Fröjel. The sample was collected by H. Munthe in 1890. Submitted by G. Lundqvist.	St-174	9190 ± 130
Mölner, Klinte, Gotland. Peat below the Litorina beach. Collected by H. Munthe and submitted by G. Lundqvist.	St-185	9510 ± 140
Ramsås, Mönsterås, Småland. Peat sample below the Litorina beach. Collected by H. Munthe in 1901 and submitted by G. Lundqvist.	St-191	7030 ± 110
Stigstäde, Havdhem, Gotland. Oak wood found under Litorina sand by the late R. Sernander. From the Museum of the Swedish Geological Survey.	St-190	4355 ± 90
IV. *Geologic samples from peat bogs*		
A. *Datings of recurrence surfaces.* [A recurrence surface has been defined by Granlund (*20*) as a boundary between highly humified peat under less humified material, indicating a climatic change to a colder and wetter weather type.]		
Åstorp Moor, Nyed, Värmland. Peat samples submitted by Jan Lundqvist.		
A very thin recurrence surface 115 cm below the surface.	St-180	1225 ± 65
A recurrence surface 130 cm below the surface.	St-184	1225 ± 70
Blomskog, Värmland. Peat from a recurrence surface 295 to 300 cm below the surface in Blomma Mossen (Blomma Moor), Töcksmark. Submitted by G. Lundqvist.	St-167	2165 ± 65
Bråtenmossen, Gräsmark, Värmland. Peat from a recurrence surface 225 to 230 cm below the surface, found to be near the beginning of the *Picea* curve by pollen analysis. Submitted by G. Lundqvist.	St-178	2435 ± 70
Kindsjö, Bograngen, Värmland. Peat at a depth of 150 to 155 cm below the surface, at a recurrence surface about 35 cm below the level of the rational limit of the *Picea* curve. Submitted by G. Lundqvist.	St-176	2780 ± 70
Mosstakan, Arvika, Värmland. Peat sample collected at a recurrence surface 370 to 375 cm below the surface. Submitted by G. Lundqvist.	St-177	3010 ± 70
B. *Samples of special palynologic interest*		
Adak Mire, Malå, Västerbotten. Profile of peat at the open cut of the mine. The samples are intended to show the correlation between the pollen diagram and the C^{14} dates (*21*). Submitted by G. Lundqvist.		
Taken 5 cm below surface.	St-138	650 ± 70
Taken 35 cm below surface.	St-139	3000 ± 75
Taken 80 cm below surface.	St-140	5360 ± 80
Taken 130 cm below surface.	St-143	6940 ± 105
Taken 175 cm below surface.	St-144	8575 ± 120
Samples St-217, St-172, and St-173 were taken from peat bogs in the levels where the curve of *Alnus* starts in the pollen diagrams. The date for this point in the diagram from different parts of Sweden has great importance for reference. The samples were submitted by G. Wenner, department of geology, University of Stockholm.		
Degerfors, Närke. Gyttja 19 cm above the limit between clay and gyttja at the southern end of Lake Grytsjön. The actual level is 3.05 m below the present water level of the lake.	St-217	8880 ± 120
Hällesjö, Jämtland. The peat bog of Hällesjömyren, not far from the Ångerman River. Amblystogium peat collected 5 cm above the limit between gyttja and peat, which in the middle of the bog is situated 3.70 m below surface.	St-172	9100 ± 120
Långared, Västergötland. Peat collected 1.85 m below the bottom of a peat pit in the southern part of Långaredmossen Bog.	St-173	8500 ± 110
V. *Archeological samples from Lappland and neighboring provinces*		
Gäddede, Frostviken, Jämtland. Charcoal from the hearth of the Stone Age settlement T 61. No reliable archeological dating. Submitted by H. Hvarfner, Royal Office of National Antiquities, Stockholm,	St-187	3115 ± 75
Gällivare, Lappland. Charcoal from the bottom of a hunting pit filled with stones at Saivorova. No archeological dating. Submitted by H. Hvarfner.	St-152	1150 ± 65
Hotingsjön, Tåsjö, Ångermanland. A very interesting system of dwelling places. The samples were submitted by H. Hvarfner.		
Charcoal from a Stone Age settlement from which the oldest archeological find was dated to the Middle Neolithic.	St-188	5470 ± 100
Charcoal from another point, situated 100 m south of the former. The very great age is a little confusing at this locality, and a new sample will be collected as soon as possible.	St-198	7600 ± 110
Lake Storuman, Stensele, Lappland. Wooden remnants from the covering of a ritually buried bear. Submitted by H. Hvarfner.	St-207	215 ± 60
Lake Storuman, Stensele, Lappland. Charcoal from the hearth of a camp at the same place as sample St-207. Archeological finds of scanty fragments of bronze kettles make it reasonable to date this part of the camp to the end of the Viking period or the early (Scandinavian) Medieval. Submitted by H. Hvarfner.	St-208	1010 ± 60
Tärna, Västerbotten. Peat with sand lenses near Solberget. The sand was thrown up when a hunting pit was being dug. Submitted by G. Lundqvist.	St-110 St-131	1070 ± 80 1165 ± 85 Average 1115 ± 60
Tåsjö, Ångermanland. Wood from the bottom of a hunting pit at Lake Rörström, Tåsjö. The pit is a part of a system of hunting pits, the existence of which has been historically fixed to about A.D. 1273 and also to the beginning of the 17th century. Submitted by H. Hvarfner.	St-170	450 ± 55
Trehörningsjö, Ångermanland. Ancient ski found in 1907 at a depth of 60 cm in a peat bog in the parish of Trehörningsjö. The ski is of the Bothnian type, which, according to pollen analysis, together with several other finds, dates from the period 1500 B.C. to A.D. 1000. Submitted by E. Manker, Nordiska Museet, Stockholm.	St-161	2870 ± 70
VI. *Various Swedish archeological samples*		
Alvastra, Östergötland. The Neolithic dwelling place in the former swamp at Dags Moor, Alvastra. Archeological dating, 2000 to 3000 B.C. Submitted by L. Kaelas, Museum of National Antiquities, Stockholm.		
Wooden pile from the pilework.	St-9*	4210 ± 150
Peat from the corresponding culture layer.	St-15	4090 ± 230 Average 4180 ± 130
Angelsta, Småland. Flax found in a moor at Hedenstorp, together with several wooden artifacts. No archeological dating.	St-128	435 ± 85

Description	Sample No.	Age
Submitted by A. Oldeberg, Museum of National Antiquities.		
Badelunda, Västerås. Wood from a grave with rich gold findings in Badelunda, city of Västerås. Archeologically dated to the beginning of the 4th century A.D. Submitted by D. Selling, Museum of National Antiquities.	St-148	1805 ± 70
Badelunda, Västerås. Wood from ship grave 75 in Badelunda. Archeological dating, latter part of 9th century A.D. Submitted by B. Schönbeck, Museum of National Antiquities.	St-150	1225 ± 65
Kattegat. Wood from a ship, found by trawling at 75-m depth in the Kattegat, 40 nautical miles northeast of Christiansö. No archeological dating. Submitted by Trelleborg's Museum.	St-27	650 ± 150
Falsterbo, Skåne. Cattle hair oakum from a ship found in 1932 in the southern Baltic Sea outside Falsterbo. Palynologically and archeologically suggested to come from early Medieval. Submitted by J. Tandberg, Swedish C^{14} Board.	St-137	850 ± 70
Falun. Three samples in a series that will be used to date the beginning of mining at Falun Copper Mines. Submitted by Stora Kopparbergs Bergslag, Ltd.		
Uppermost peat layer below the mineral waste northwest of the opening.	St-163	1105 ± 60
Piece of wood in the mineral waste 10 cm above the peat layer.	St-165	690 ± 55
Wooden branches on the surface of the peat under the mineral waste.	St-166	875 ± 60
Galtabäck, near Varberg, Halland. Cattle hair oakum from a ship, excavated in 1928. Previous geologic and archeological datings are controversial, both 5th to 7th centuries and 12th to 13th centuries A.D. having been proposed. Submitted by C.-A. Moberg, Gothenburg Archaeological Museum.	St-204	880 ± 65
Hasslöv, Halland. Resin packing from a hexagonal stone cist containing bronze finds. Museum of National Antiquities. No. 3987 : 5, c. Archeologically dated to the later part of the IV period of the Bronze Age (about 800 B.C.). Submitted by A. Oldeberg.	St-201	2810 ± 75
Högom, Selånger, Medelpad. Charred wood from a tumulus containing a richly furnished warrior's grave. Archeologically dated to about A.D. 500. Submitted by D. Selling, Museum of National Antiquities.	St-186	1570 ± 70
Hylletofta, Småland. Wooden log with runic carvings found in the floor at the altar in the Roman church of Hylletofta. Archeological dating uncertain. Submitted by P.-O. Westlund, Museum of National Antiquities.	St-168	585 ± 60
Ljungsbro, Östergötland. Gyttja from the "Hell Marsh" (Helveteskärr) at 0.9-m depth where a primitive-looking male human skull was found, showing a cut from a stone axe. Pollen analysis places the sample just above Granlund's recurrence surface V, about 2000 B.C. (*20*). Submitted by N.-G. Gejvall, Museum of National Antiquities.	St-109	3750 ± 100

Description	Sample No.	Age
Stenåsa, Öland. Part of a wooden log (oak?) found under the floor of the apse in the Roman church of Stenåsa. Submitted by Iwar Andersson, Museum of National Antiquities. The sample was in a rather poor condition, and it was not possible to determine how far from the bark the actual rings had been located.	St-135	675 ± 75
Tingstäde Träsk, Gotland. The swamp of Tingstäde contains the remnants of a large wooden fortification called Bulverket. It consisted of a central part of heavier piles and a palisade of thinner ones. The pile-work fortifications are architecturally and archeologically dated to about A.D. 1000, but have been the subject of many discussions.		
Outer tree rings of a log from a raft. Submitted by G. Lundqvist from the collections of the Swedish Geological Survey.	St-10	790 ± 120
Plank from the palisade, tree rings near the bark. Submitted by G. Arwidsson, department of archeology, University of Stockholm.	St-125	960 ± 60
Central tree rings of a wooden prop about 35 rings thick, from the central part. Collected in the autumn 1955 and sent in by G. Arwidsson.	St-118	850 ± 70
Valö, Uppland. Heavy deal plank carved in the shape of a dragon's head. The find is stylistically dated to the end of the 8th or the 9th century A.D. by W. Holmquist (*22*), who also submitted the sample.	St-122	1140 ± 65
VII. *Archeological samples from other countries*		
Erimi, Cyprus. Charcoal from the Erimi culture containing artifacts, approximately dating between 3400 and 3000 yr B.C. (*23*). Submitted by P. Dikaios, Cypus Museum, Nicosia.		
Layer No. 2.	St-202	4630 ± 80
Layer No. 3.	St-203	4540 ± 80
Beaumont, Cotentin, France. Charcoal from large wall constructions of uncertain age at Le Hague-Dike. Described and submitted by H. Arbman (*24*), University of Lund Historical Museum.		
Cut I 1951 from the second layer of the uppermost section.	St-153	2855 ± 75
Cut I 1951 from the second layer of deepest section.	St-146	2710 ± 65
Rang Mahal, Rajputana, India. Charcoal from a pit in the uppermost layers of a mound. Archeologically and geologically dated to about 500 A.D. Submitted by H. Arbman.	St-192	1525 ± 70
Teotihuacán, Mexico valley. Charcoal from a cremation under large ruin complex Tlamimilolpan, Teotihuacán. Excavated in 1935 under the nethermost of three concretelike, intact floors. Artifacts from Maya culture under the same floor point to a date A.D. 278 to 593 (Goodman-Martínez-Thompson correlation) or A.D. 18 to 333 (Spinden's correlation). Submitted by S. Linné, Ethnographical Museum, Stockholm.	St-162	1720 ± 65

References and Notes

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2. The economic possibility of starting this work was made by the King Gustaf VI Adolf Foundation for Swedish Culture, which has also, together with the Humanistic Fund and the Scientific Research Council, supported the routine work. The laboratory is under the supervision of the Swedish C^{14} Board. For the very first experiments during 1954, I am indebted to G. Widmark ad C. Mileikowsky. Without the skilled work of L. Engstrand, making the rapid change to the new method would not have been so relatively easy. Engstrand and L. Lundgren also made excellently all the routine experimental work.

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H. R. Morgan, Astronomer

The death of Herbert Rollo Morgan at his home in Washington, D.C., 11 June 1957, brought to a close a life of sincere devotion to his family and to astronomy. His last illness extended over a period of 2 months; however, he had suffered considerably, prior to this, from frequent spells of bad health during the last few years.

He was the son of Henry D. and Olive Smith Morgan and was born on 21 March 1875, near Medford, Minnesota. By the time he was 9, the rigors of the Minnesota winters proved to be so trying to his health, which was somewhat impaired by an asthmatic condition, that his mother sought relief for him in the milder climate of Tennessee, where he grew up and received his early education.

He received his A.B. and Ph.D. degrees from the University of Virginia in 1899 and 1901, respectively. While a student at the university, he held one of the prized Vanderbilt fellowships at the Leander McCormick Observatory. During the last year of his graduate work he commenced teaching mathematics at the Pantops Academy and continued there until he received an appointment to the U.S. Naval Observatory as a computer, in 1901. Four years later he decided to try teaching again and accepted a professorship in astronomy and mathematics at Pritchett College, where he also served as director of the Morrison Observatory.

In 1907 he returned to the Naval Observatory as assistant astronomer on the staff of the 9-inch transit circle. In 1913 he was placed in charge of the instrument and at once began a series of fundamental observations which lasted until 1926. The catalog of final results for this program is a typical example of the thoroughness and painstaking care which he devoted not only to the major problems arising in his work but to those small details as well, which, if not properly attended to, sometimes ruin an otherwise excellently planned project. This program was followed by two others—the first, a differential determination of the positions of the reference stars for the Yale zone $-10°$ to $-20°$, and the second, another fundamental program which was not entirely completed at the time of his retirement in 1944.

Retirement to Morgan merely meant more time for his researches. These he carried on privately for a while and later, from 1947 to 1950, as research associate of Yale University. Even up to the time of his last illness he was busily engaged in computing the proper motions of a group of O and B spectral type stars.

Morgan's principal contributions were in the field of fundamental astronomy. His philosophy that good observations should be put to use, combined with a thorough knowledge of how to use them, brought forth during his life many papers and publications of the first order of importance. His earliest papers were concerned mainly with the orbits of comets and asteroids. These were followed by a number of articles in which he ably treated problems and questions that come up during a transit circle program. By the time he reached his middle years his attention began to focus on the fundamental quantities upon which astronomy is built. He analyzed hundreds of thousands of observations for the purpose of obtaining a better knowledge of the position of the equator, the motion of the equinox, the constants of aberration and nutation, the motion of the perihelion and corrections to the orbital elements of the planets. In his late years he compiled his N30 catalog, in which are given the definitive positions and motions of 5268 stars. The fundamental coordinate system established by the N30 and the proper motions based on it have formed the starting point for several recent investigations, among which may be mentioned a correction to the precession, the luminosities of the nearest Cepheids, and other researches related to the structure of the galaxy. Without doubt, the N30 and its associated papers represent the greatest achievement of his career.

Morgan's capacity in his field of specialization won him many recognitions. In 1952 the National Academy of Sciences awarded him the Watson medal for his contribution to fundamental astronomy and, by invitation, he presented a report on the astronomical constants at the Paris conference in 1950. He also presented a discussion of the basis on which the reference system of stellar positions rests at the symposium on the Fundamental Properties of the Galactic System conducted by the New York Academy of Sciences in 1941.

He was a member of the National Research Council, the Washington Academy of Sciences, and the Geophysical Union. He served as vice president of the American Astronomical Society from 1940 to 1942 and as chairman of Section D of the American Association for the Advancement of Science in 1936. He attended his first meeting of the International Astronomical Union in 1928 and served as president of the commission on meridian astronomy of that organization from 1938 to 1948. He was an associate editor of the *Astronomical Journal* from 1942 to 1948.

A humble man, Morgan conducted his life in a very unpretentious manner. His high sense of honor made personal dealings with him a pleasure. His associates at the Naval Observatory and his colleagues in the astronomical world respected him, and will remember him, as a valued friend and faithful worker.

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