NASA SP-198

ATLAS OF COMETARY FORMS

Structures Near the Nucleus

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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Structures Near the Nucleus

by
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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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FOREWORD

By providing a comprehensive collection of photographs and photo-reproductions of worldwide visual observations of comets from 1835 to 1962, this atlas makes available material on which to develop theories both as to the nature of comets and on the interactions of comets with the solar corona.

There are no comparable collections in the literature. Available data about comets and their various interactions are restricted to the few generally more spectacular reproductions in texts or journal articles. Visual observations of the 19th century are practically inaccessible, as they appear in journals now difficult to obtain; furthermore, these original publications are deteriorating. The availability for study of this more representative and comprehensive material is an important contribution to the field.

Comets are natural interplanetary probes. Many comet orbits have large inclinations with the ecliptic and they have been observed grazing the Sun and as far out as 11 A.U. Investigations of the interplanetary medium with man-made probes over such an extensive volume of space are not expected for several years.

Based on current cosmogony, it appears that most comets are residues of the principal solar nebula, and thus may provide clues to the early history of the solar system. But because of our incomplete understanding of them, comets are analogous to man-made probes whose telemetry codes are not at present adequately known. The National Aeronautics and Space Administration's objective of understanding the origins and evolution of the solar system and the universe can be advanced from the interpretation and understanding of these cometary observations.

It is hoped and expected that the atlas may also prove useful to other students of the solar system—amateur as well as professional astronomers—and that physicists and astrophysicists studying solar activity and the interplanetary medium may find it of value in their work.

Maurice Dubin
Physics and Astronomy Programs

ACKNOWLEDGMENTS

It is a pleasure to thank the persons and institutions who assisted us and made material available for this volume. For allowing us to make extensive use of a large collection of comet plates, we are particularly indebted to Drs. H. W. Babcock of Mt. Wilson and Palomar Observatories, J. Hall of Lowell Observatory, G. Mannino of Bologna University Observatory, L. Rosino of Asiago Observatory, A. H. M. Samaha of Helwan Observatory, K. A. Strand of the U. S. Naval Observatory, A. E. Whitford of Lick Observatory, and Sir R. Woolley of Greenwich Observatory.

Photographic reproductions were kindly prepared and sent to us by Drs. A. Bohrmann, P. Maffei, and H. Neckel. Valuable assistance with the use of plate material at their respective institutions was furnished by Dr. E. Roemer, H. L. Giclas, and Wm. C. Miller. C. W. McCracken was extremely helpful in the computation of ephemerides and phase angles for each drawing or photograph. Dr. V. Vanysek supplied additional material on comet luminosities and spectra. Several discussions with Drs. J. C. Brandt and V. Vanysek were held during the preparation of the manuscript.

The initial plans for the atlas were developed in collaboration with Dr. Roemer, and we had the benefit of her advice at several stages of preparation.

The collaboration on the *Atlas of Cometary Forms* was made possible by the awards to Karl Wurm and Jürgen Rahe of a Senior and a Regular National Academy of Sciences—National Research Council Postdoctoral Research Associateship, respectively.

J. R.
B. D.
K. W.

CONTENTS

I. INTRODUCTION

There is currently considerable renewed interest in comets. This interest is found not only among astronomers but particularly among physicists concerned with space science, and even among a growing number of chemists.

Because of the notable variety of coma and tail structures exhibited by comets, an atlas of representative appearances and features of particular significance has for some time been comtemplated as a needed and valuable contribution to the literature. The first examples of such material for a comet atlas were presented by Professor Karl Wurm in the Session of Commission 15 (Physics of Comets) at the meeting of the International Astronomical Union in Hamburg in 1964, where he showed pictures with different magnifications and exposure times. He also described and showed examples of an atlas of Comet Morehouse, including sequences of eight and nine pictures taken at about 20-minute intervals on each of two nights. The preparation of a comprehensive atlas was independently proposed to the I.A.U. at the same meeting by Drs. E. Roemer and B. Donn. Commission 15 (Physics of Comets) approved that venture as an I.A.U. endorsed project. As with many such programs, the intentions exceeded the resources, and little was accomplished for several years.

In 1966 Professor Wurm came to the Goddard Space Flight Center for a year as a National Academy of Sciences—National Research Council Senior Research Associate. One result of his participation in the NASA cometary research program was the inception of a comet atlas.

The original proposal was for a comprehensive atlas showing the variety of coma and tail phenomena and their changes with distance from the Sun and with time. The atlas would emphasize the fact that comets are individual objects and that a truly representative comet does not exist. When the work of assembling cometary photographs for such an atlas was begun, it soon became apparent that this task still exceeded the available resources and the completion date would have to be moved rather far into the future.

The solution to the problem was to divide the atlas into several parts of which the first would be devoted to structures near the nucleus. For the reasons given later, only a limited quantity of suitable material exists. A large amount of this material was already available in the collection of cometary photographs which had been assembled by Dr. Wurm. Further justification for this form of presentation is the current interest of astronomers and of physicists concerned with space science in the behavior of cometary ions. Since Biermann's suggestion in 1951 that the principal features of ion tails are the result of an interaction between cometary material and the solar wind, there has been a rather extensive study of this proposed interaction. Several theoretical analyses of the ionization of cometary molecules and the formation of tail rays have been published. A rather prompt publication of a large amount of observational material, much of it concerning the behavior of ions near the nucleus, appeared to be desirable. This then is the subject matter of this volume. Succeeding volumes of the *Atlas of Cometary Forms* will contain material completing the scope of the original proposal.

In studying the photographic material on structural features near the nucleus, Dr. Wurm and his associates emphasized the occurrence of ions and tail rays within 1000 km of the nucleus. This sometimes disputed feature of comets has been almost completely overlooked in theoretical discussions of solar wind interactions with comets. There is one aspect of the nuclear region of comets that has to be kept in mind, however: It is necessary to distinguish the brightest region of the coma, or "photometric nucleus," from the source of coma and tail material, or "physical nucleus." These may be displaced from each other by significant distances.*

This volume of the atlas contains four sections of pictorial material. In the first section, we reproduce drawings from visual telescopic observations of the central regions of comets made during the 19th and early 20th centuries. They are reproduced at about the same size as originally published. These drawings, which appear in publications that are not easily available now, show many interesting and significant details. Ironically, with the advent of photography—a most powerful tool in many areas of astronomical investigation, including cometary research—an almost complete halt came to the visual observation of the important central region of comets. This region is nearly always greatly overexposed on plates taken for structural and physical studies of comets. On the other hand, on plates taken for astrometric purposes, comets usually have a nearly stellar appearance, even the inner coma being greatly underexposed. Furthermore, photographic plates lack the contrast sensitivity of the eye and consequently show less detail than does a good drawing. However, the value of the greater detail obtained in a drawing is somewhat compromised by the subjective character of visual observation, whereby the observer may imagine he sees details that are not really present.

The second section is devoted to the two comets for which *both* visual and photographic observations are available. The coma is heavily overexposed in the photographs of Comet Daniel 1907 IV, and no structure is visible. However, in the photographs and drawings of Comet Halley 1910 II for May 21, 24, and 25, the similarity between the two types of reproduction can readily be seen. This comparison enables one to judge how objectively the drawings represent real structural details of the coma. In this and the following sections, because of the low contrast in the photographic material, special pains were taken with the prints and the printing process to reproduce structural details found in the inner coma. For Comet Halley on May 25, 1910, both positive and negative transparencies were combined to bring out faint details that could be seen on the original negative but were lost in a normal print.

The third pictorial section is the largest portion of this volume of the atlas. In it are displayed a number of photographs of three of the bright comets of this century, Comet Morehouse 1908 III, Comet Halley 1910 II, and Comet Humason 1962 VIII. In order to have the large scale to resolve the nuclear region, a bright comet is required. Only

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*This was pointed out by Hamid and Whipple (Astron. J. **58**, 100, 1953) and Roemer (Astron. J. **66**, 368, 1961), and discussed by Sekanina and Vanysek (Icarus **7**, 168, 1967) and Jackson and Donn (Icarus **8**, 270, 1968).

for these three could we find a large number of photographs revealing structure in the inner coma. Comets Morehouse and Humason are further exceptional in having very intense CO^+ emission and only weak emission from neutral molecules. Ion structures in the coma were not washed out by the usual intense emission from neutral species near the nucleus. Comet Halley 1910 II was also exceptional because of its close approach to the Earth, within 0.2 A.U.

For a number of these plates, in order to bring out details in the bright central region, several prints from each are included. By suitably varying the printing time, paper contrast, and enlargement, we obtained a sequence of photographs showing structure successively closer to the nucleus. However, some of the details visible on the original plates could not be preserved on prints. To show these details, an artist was employed to make a drawing with increased contrast. He was given the original plate and told to emphasize the structural features near the nucleus in a drawing, but he was not given detailed instructions on what it was to look like. These pictures are clearly identified, and appear together with a photographic print from the plate.

The fourth section includes photographs of six additional comets for which less extensive photographs of structure in the coma are visible. These, again, were bright comets. The main purpose of the section is to illustrate the effect of telescope exposure time and of plate and filter characteristics upon the appearance of a comet.

Throughout this volume, pertinent facts about each photograph or drawing are given to the extent that they are known. These data include the observatory, observer, telescope, plate, and filter; mid-exposure time in decimals of a day given in universal time, and duration of exposure; heliocentric distance r and geocentric distance Δ of the comet in astronomical units; phase angle α (Sun-comet-Earth; see Fig. A-2, Appendix A); and enlargement factor and scale of reproduction. In some cases, especially among older plates, there was difficulty in establishing the time of observation, since occasionally the times given in the record of observations and on the plate did not agree.

In order not to bias the viewer, no interpretation or explanation of any of the pictures has been presented. Our intention was to make available now as complete a collection of observational material as possible on the central region of the coma. Anyone seeking to interpret or explain cometary features can form his own opinion regarding the structure and behavior of material in the inner coma. The source of each picture is given so that the original material can be located and examined if desired.

The appendixes contain several types of information which should be useful in providing a better understanding of the phenomena depicted in this volume. Orbital and luminosity parameters are given for all of the comets represented. General physical characteristics of comets according to the most generally accepted current model, the icy conglomerate, are also given. Appendix D contains references to papers on characteristics of comets.

VISUAL OBSERVATIONS OF COMETS

COMET HALLEY 1835 III

Visual observations of Comet Halley 1835 III by W. Bessel (Astron. Nachrichten 13, p. 185, 1836)

Bessel remarked on the visual appearance of Comet Halley 1835 III that there seemed to be less "light material" on that side of the center which was away from the sun. He points out oscillations of the emitting light cone that were clearly observed (see the pictures of October 12 to October 25). In all pictures the sun is vertically over the comet nucleus.

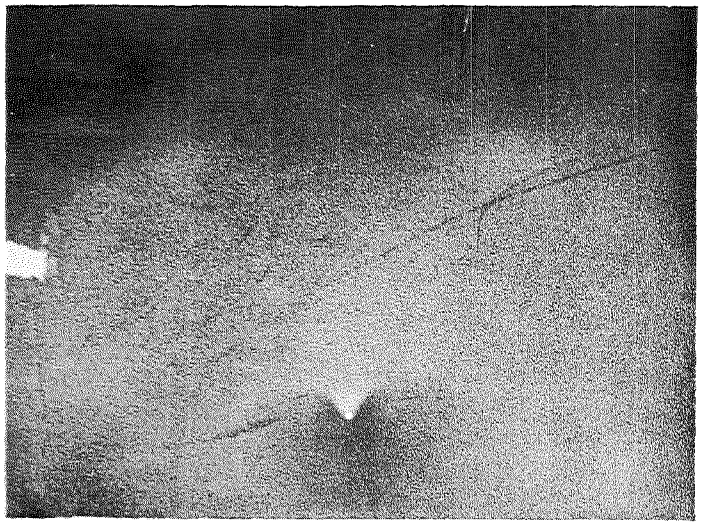

Fig. 1: Oct. 2.972

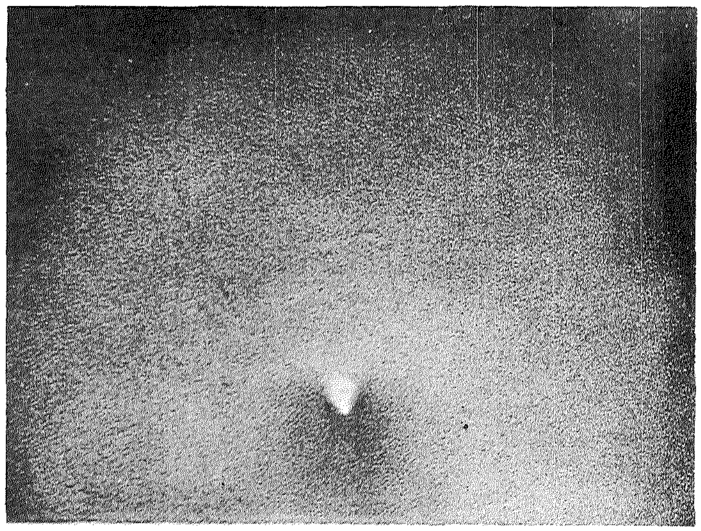

Fig. 2: Oct. 8.938

Figure	Date	r (A.U.)	Δ (A.U.)	a	km/mm
1	1835 Oct. 2.972	1.08	0.44	67°.3	1400
2	1835 Oct. 8.938	0.99	0.25	84.4	700

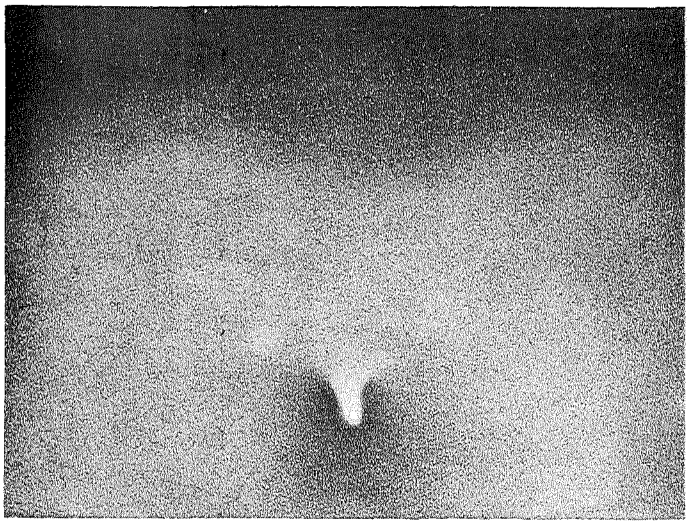

Fig. 3: Oct. 12.697

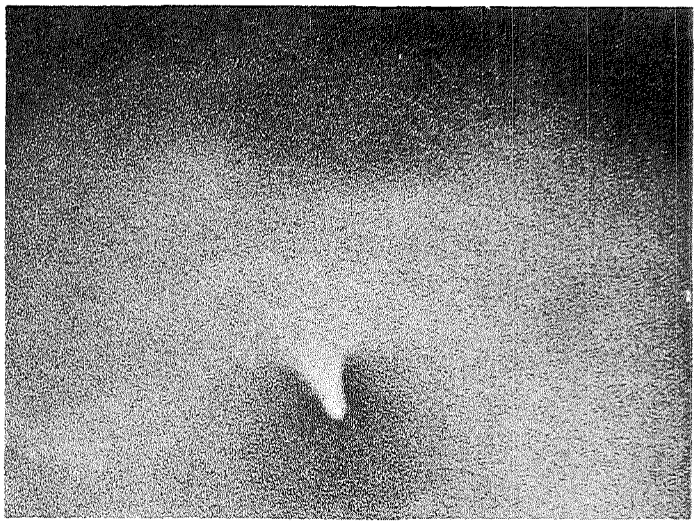

Fig. 4: Oct. 12.883

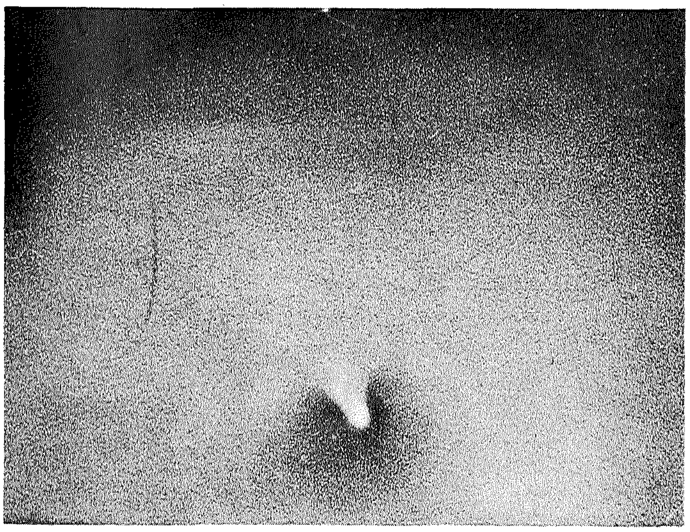

Fig. 5: Oct. 12.971

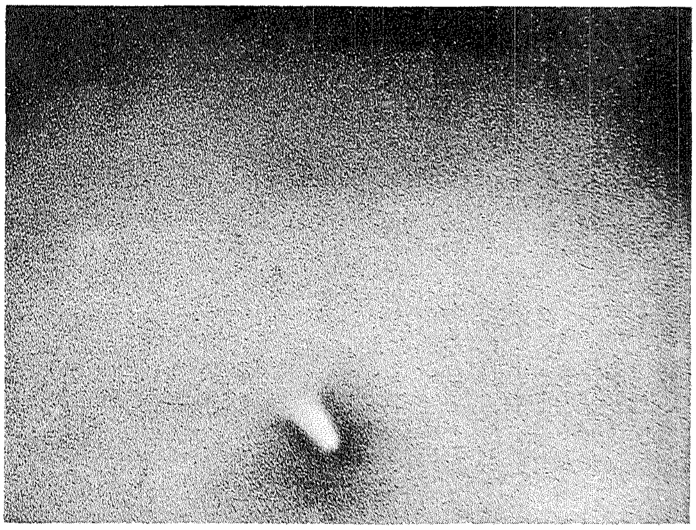

Fig. 6: Oct. 13.043

Figure	Date	r (A.U.)	Δ (A.U.)	α	km/mm
3	1835 Oct. 12.697	0.94	0.19	104°.1	600
4	1835 Oct. 12.883	0.93	0.19	105.1	600
5	1835 Oct. 12.971	0.93	0.19	105.6	600
6	1835 Oct. 13.043	0.93	0.19	105.9	600

COMET HALLEY
1835 III

Visual observations of Comet Halley 1835 III by W. Bessel (Astron. Nachrichten 13, p. 185, 1836)

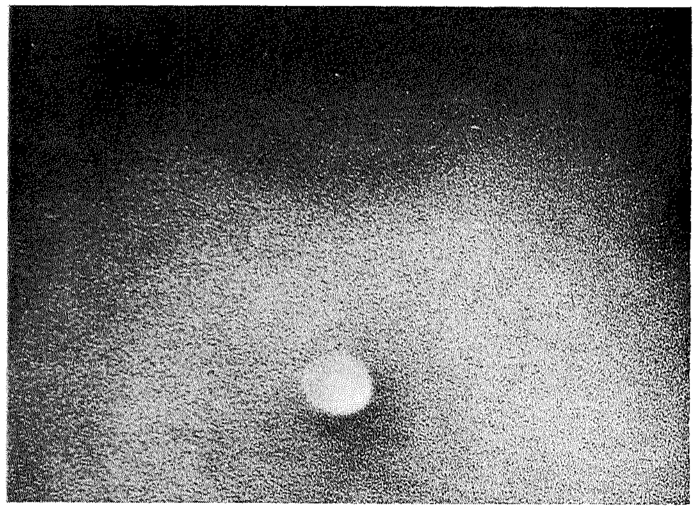

Fig. 7: Oct. 13.735

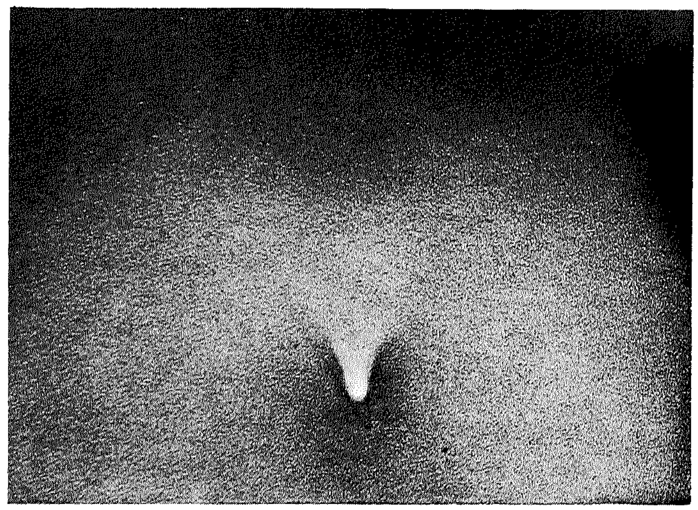

Fig. 8: Oct. 14.744

Figure	Date	r(A.U.)	Δ (A.U.)	α	km/mm
7	1835 Oct. 13.735	0.92	0.19	108$^\circ\!.$9	600
8	1835 Oct. 14.744	0.90	0.20	112.0	600

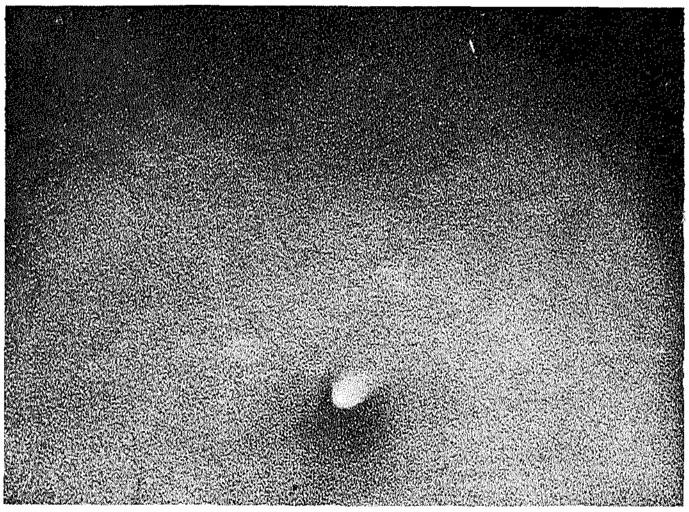

Fig. 9: Oct. 15.724

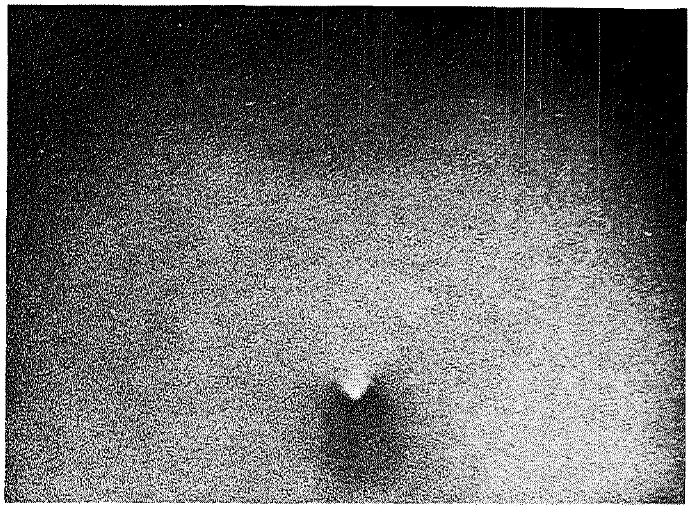

Fig. 10: Oct. 20.710

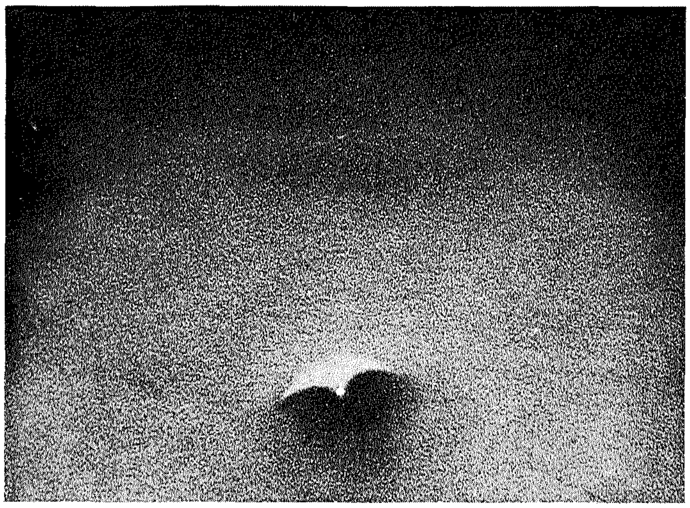

Fig. 11: Oct. 22.695

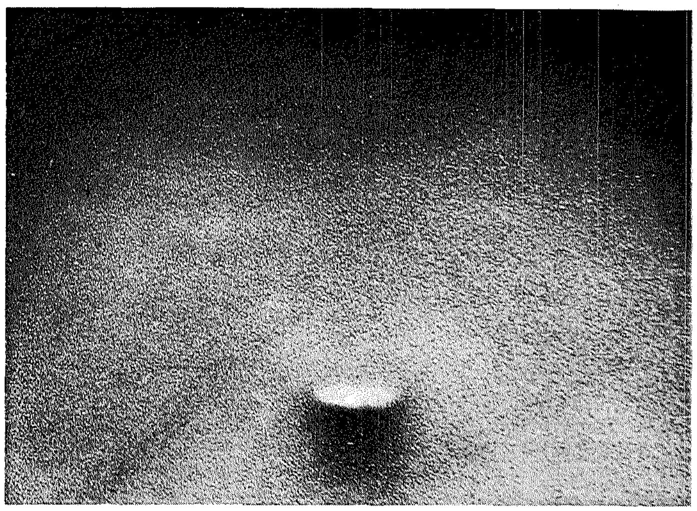

Fig. 12: Oct. 25.698

Figure	Date	r (A.U.)	Δ (A.U.)	α	km/mm
9	1835 Oct. 15.724	0.89	0.22	113.5°	700
10	1835 Oct. 20.710	0.82	0.36	108.8	1100
11	1835 Oct. 22.695	0.79	0.43	105.2	1300
12	1835 Oct. 25.698	0.75	0.54	99.3	1700

COMET HALLEY
1835 III

Visual observations of Comet Halley 1835 III by H. Schwabe with 4.6(?)-inch refractor, f = 166.8 inches. (Astron. Nachrichten 13, p. 145, 1835)

Schwabe remarked on the visual appearance of Comet Halley 1835 III that the nucleus seems to emit its light toward the sun. The sun pushes this light-emitting matter back in such a way that it separates into two parts which bend back in the form of an arc and form the tail. The dark spot (behind the nucleus) can be explained by noting that only the side of the nucleus which is directed toward the sun emits light.

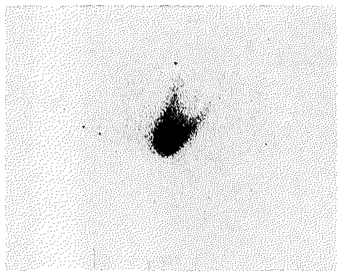

Fig. 13: Oct. 10

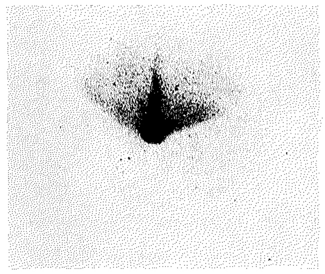

Fig. 14: Oct. 11

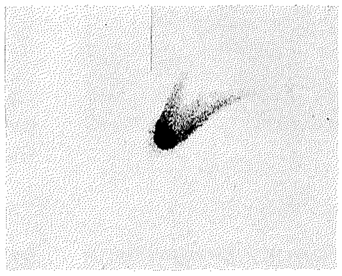

Fig. 15: Oct. 15*

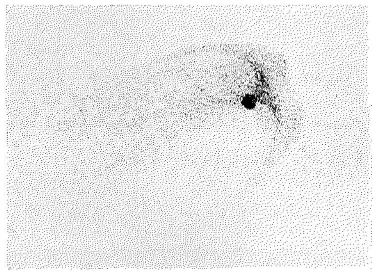

Fig. 16: Oct. 15*

Figure	Date	r (A.U.)	Δ (A.U.)	α
13	1835 Oct. 10	0.98	0.22	89°4
14	1835 Oct. 11	0.96	0.20	94.7
15	1835 Oct. 15	0.90	0.20	112.5

*See also Bessel's drawing for October 15 (page 5).

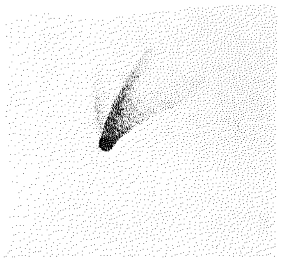
Fig. 17: Oct. 21

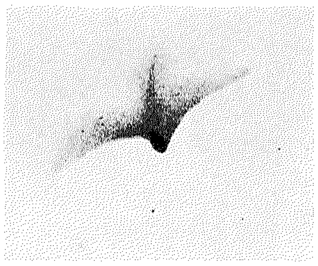
Fig. 18: Oct. 22, 5^h30^m p.m.*

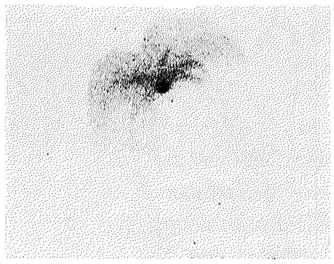
Fig. 19: Oct. 22, 6^h p.m.*

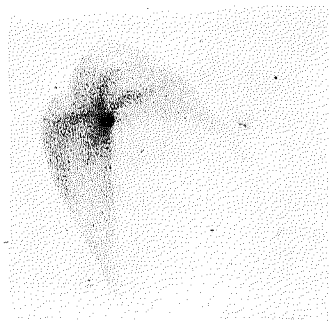
Fig. 20: Oct. 23

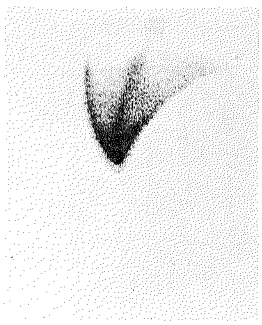
Fig. 21: Oct. 25

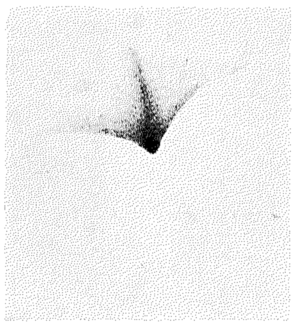
Fig. 22: Oct. 26, 5^h5^m p.m.

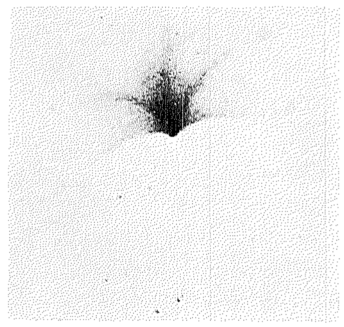
Fig. 23: Oct. 26, 5^h15^m p.m.


Fig. 24: Oct. 26, 5^h30^m p.m.

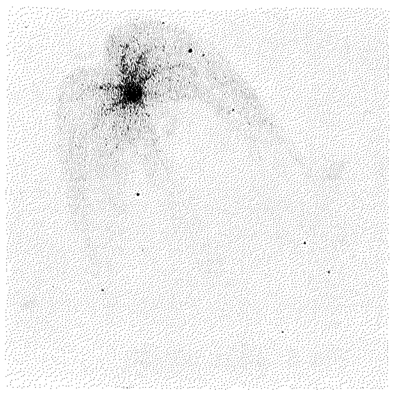
Fig. 25: Oct. 26, 6^h p.m.


Fig. 26: Oct. 30

Figure	Date	r (A.U.)	Δ (A.U.)	α
17	1835 Oct. 21	0.81	0.37	108°3
20	1835 Oct. 23	0.79	0.44	104.6
26	1835 Oct. 30	0.70	0.70	90.4

*See also Bessel's drawing for October 22 (page 5).

COMET DONATI 1858 VI

Visual observations of Comet Donati 1858 VI by J. F. Julius Schmidt, "Astronomische Beobachtungen über Kometen," Athens, 1863 (Publications de l'Observatoire d'Athènes, 1re series, tome 1)

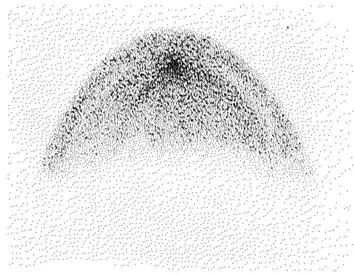

Fig. 1: Sept. 16

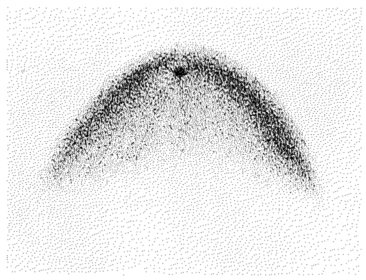

Fig. 2: Sept. 24

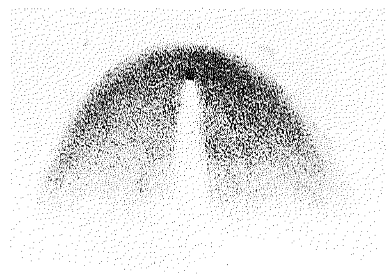

Fig. 3: Sept. 29

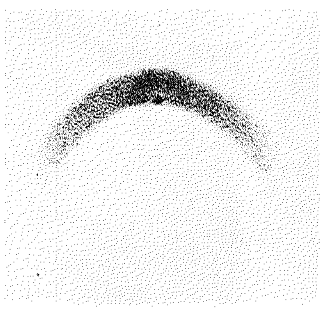

Fig. 4: Sept. 30.705

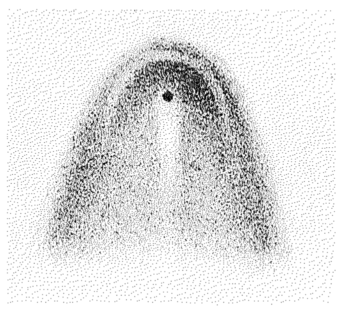

Fig. 5: Sept. 30.726

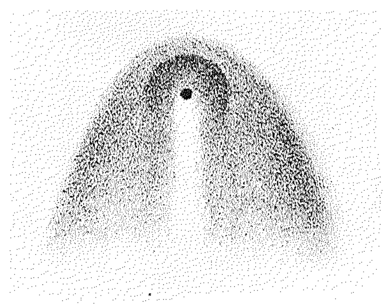

Fig. 6: Sept. 30.774

Figure	Date	r (A.U.)	Δ (A.U.)	α
1	1858 Sept. 16	0.66	1.20	57°.2
2	1858 Sept. 24	0.60	0.92	79.5
3	1858 Sept. 29	0.58	0.76	96.2
4	1858 Sept. 30.705	0.58	0.71	102.0

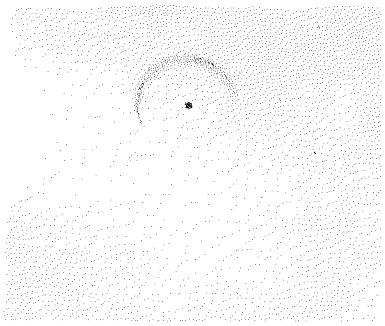

Fig. 7: Oct. 3.690

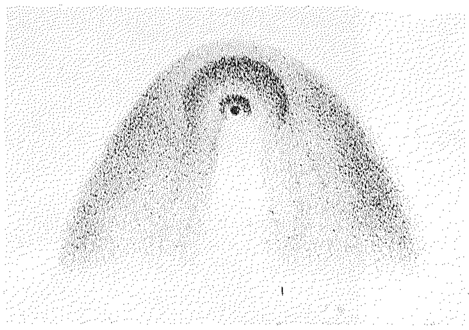

Fig. 8: Oct. 3.712

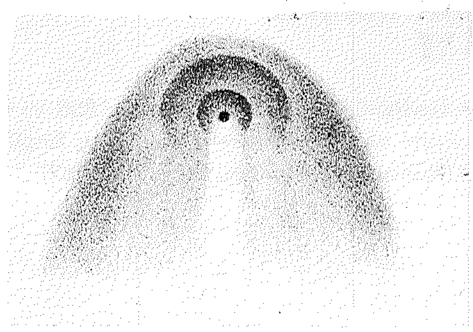

Fig. 9: Oct. 3.781

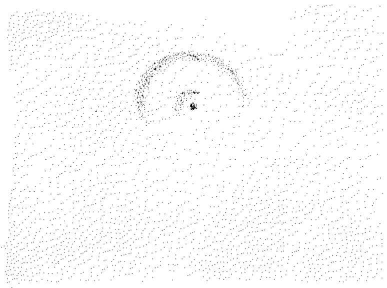

Fig. 10: Oct. 4.698

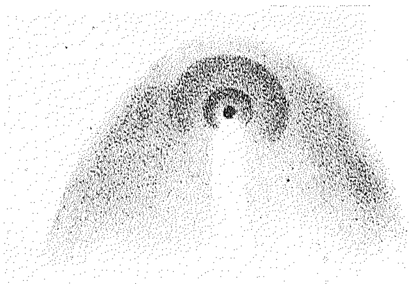

Fig. 11: Oct. 4.718

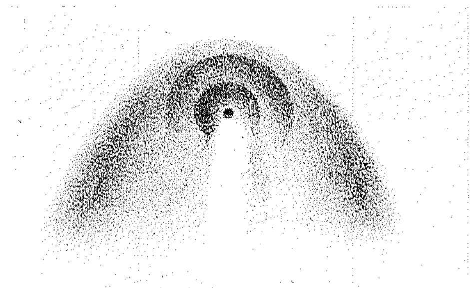

Fig. 12: Oct. 4.775

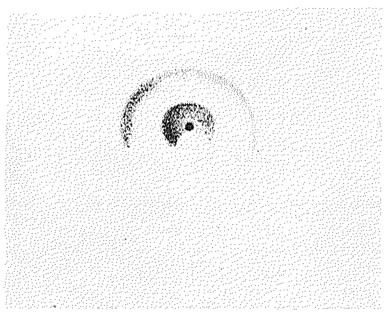

Fig. 13: Oct. 5.698

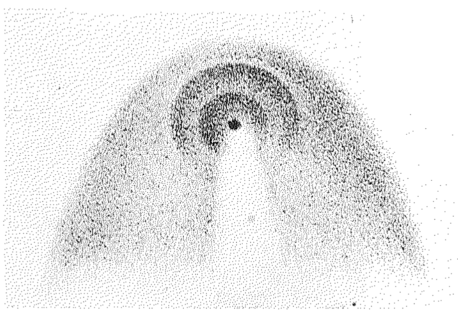

Fig. 14: Oct. 5.716

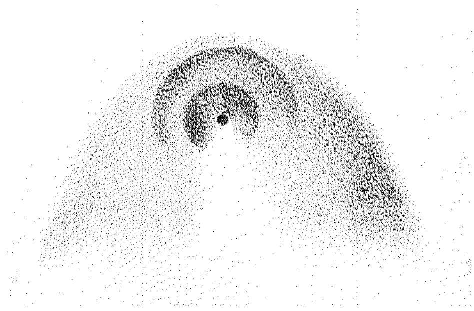

Fig. 15: Oct. 5.750

Figure	Date	r (A.U.)	Δ (A.U.)	α
7	1858 Oct. 3.690	0.58	0.63	111°4
10	1858 Oct. 4.698	0.59	0.61	114.1
13	1858 Oct. 5.698	0.59	0.59	116.4

COMET DONATI
1858 VI

Visual observations of Comet Donati 1858 VI by G. P. Bond with 15-inch refractor, focal length 270 inches (Harvard Astron. Obs. Annals 3, 1862)

Fig. 16: Sept. 30

Fig. 17: Oct. 2

Figure	Date	r(A.U.)	Δ(A.U.)	α
16	1858 Sept. 30	0.58	0.0.73	99°.6
17	1858 Oct. 2	0.58	0.67	106.3

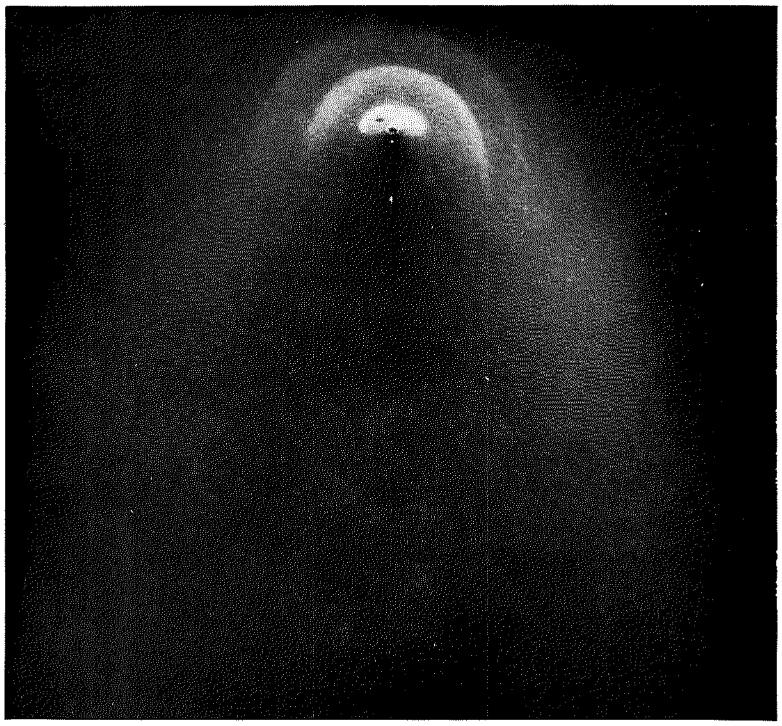

Fig. 18: Oct. 4

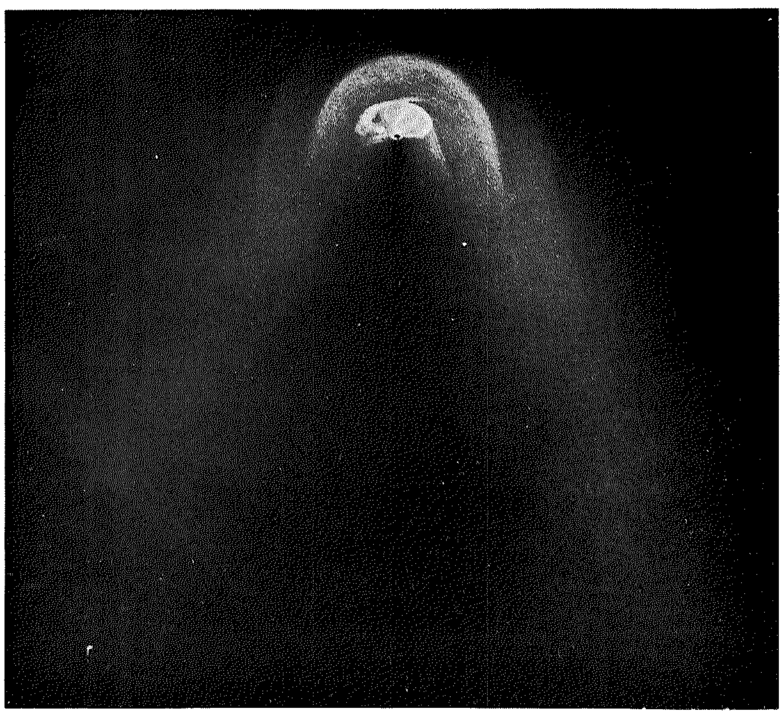

Fig. 19: Oct. 5

Figure	Date	r(A.U.)	Δ(A.U.)	α
18	1858 Oct. 4	0.58	0.62	$112^\circ.3$
19	1858 Oct. 5	0.59	0.60	114.8

COMET DONATI
1858 VI

Visual observations of Comet Donati 1858 VI by G. P. Bond with 15-inch refractor, focal length 270 inches (Harvard Astron. Obs. Annals 3, 1862)

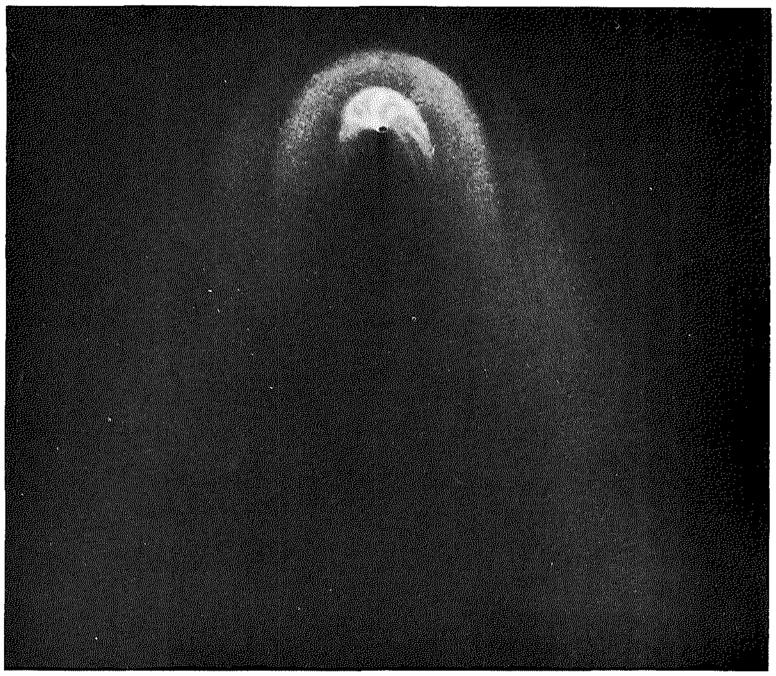

Fig. 20: Oct. 6

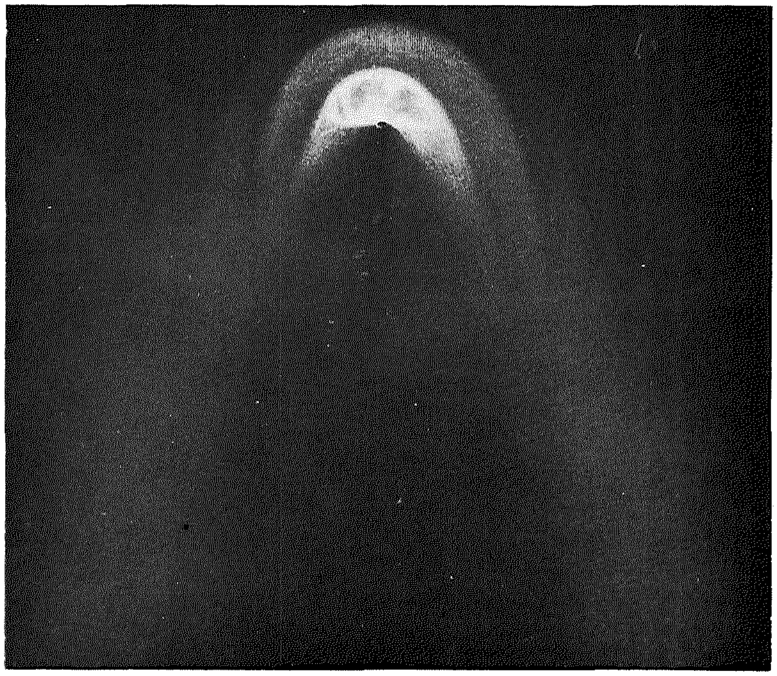

Fig. 21: Oct. 8

Figure	Date	r (A.U.)	Δ (A.U.)	α
20	1858 Oct. 6	0.59	0.58	117°.0
21	1858 Oct. 8	0.60	0.55	119.5

Fig. 22: Oct. 9

Fig. 23: Oct. 10

Figure	Date	r (A.U.)	Δ (A.U.)	α
22	1858 Oct. 9	0.61	0.54	119°.7
23	1858 Oct. 10	0.62	0.54	119.2

COMET TEBBUTT 1861 II

Visual observations of Comet Tebbutt 1861 II by J. F. Julius Schmidt, "Astronomische Beobachtungen über Kometen," Athens, 1863 (Publications de l'Observatoire d'Athènes, 1re série, tome 1)

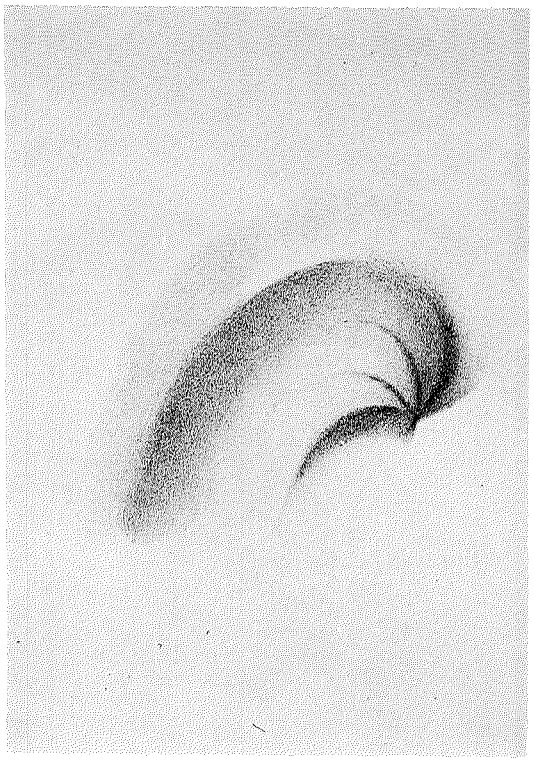

Fig. 1: July 1.884

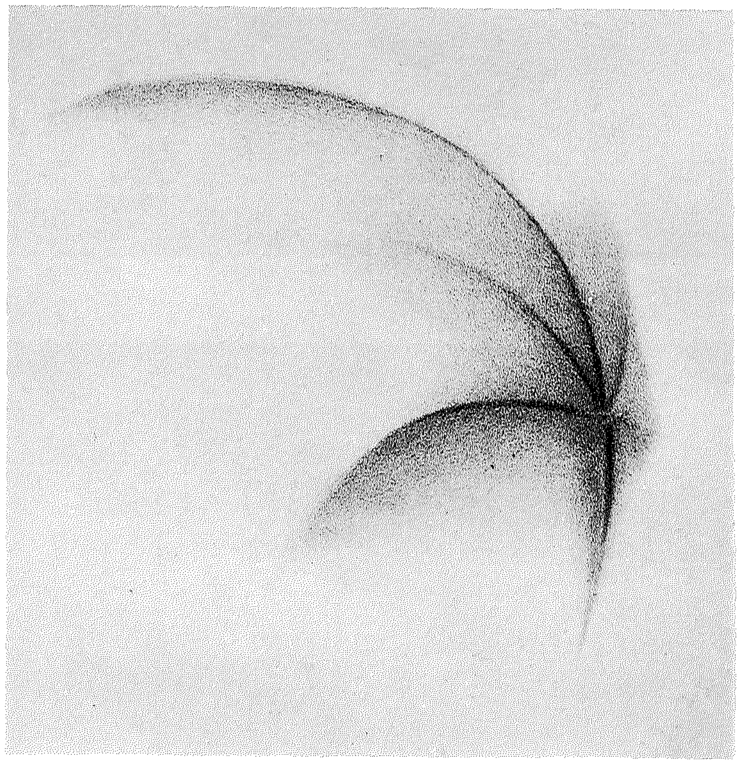

Fig. 2: July 2.119

Figure	Date	r (A.U.)	Δ (A.U.)	α	km/mm
1	1861 July 1.884	0.90	0.14	142.°1	400
2	1861 July 2.119	0.90	0.14	139.4	500

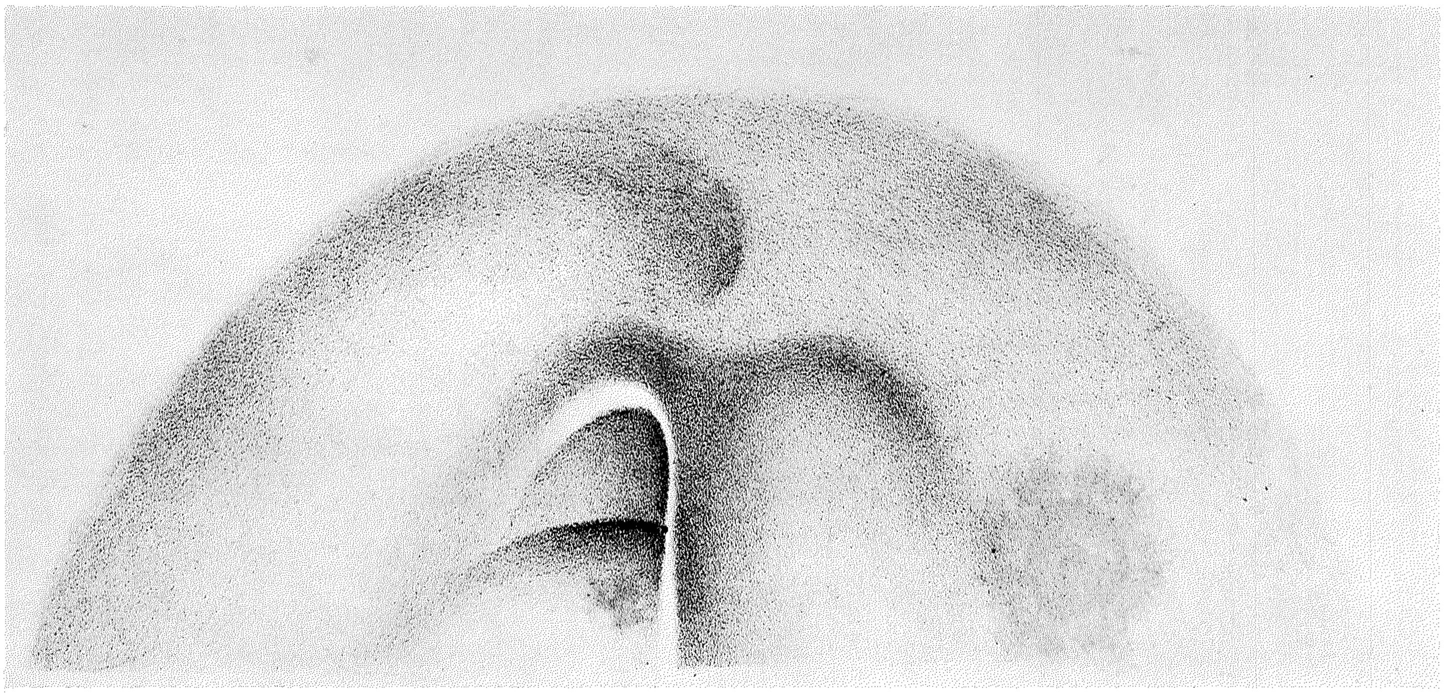

Fig. 3: July 2.8

Figure	Date	r (A.U.)	Δ (A.U.)	α	km/mm
3	1861 July 2.8	0.91	0.15	$131\overset{\circ}{.}9$	500

COMET TEBBUTT
1861 II

Visual observations of Comet Tebbutt 1861 II by J. F. Julius Schmidt, "Astronomische Beobachtungen über Kometen," Athens, 1863 (Publications de l'Observatoire d'Athènes, 1re series, tome 1)

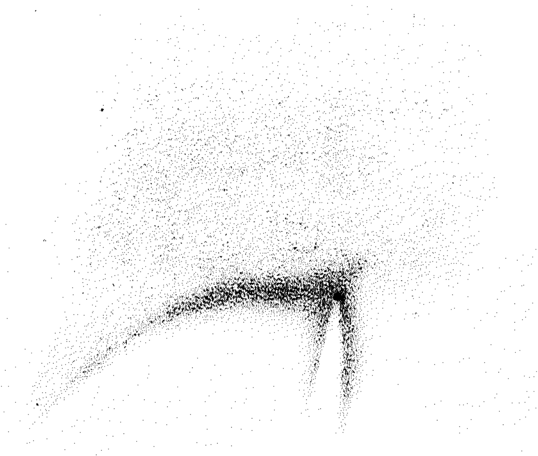

Fig. 4: July 2.922

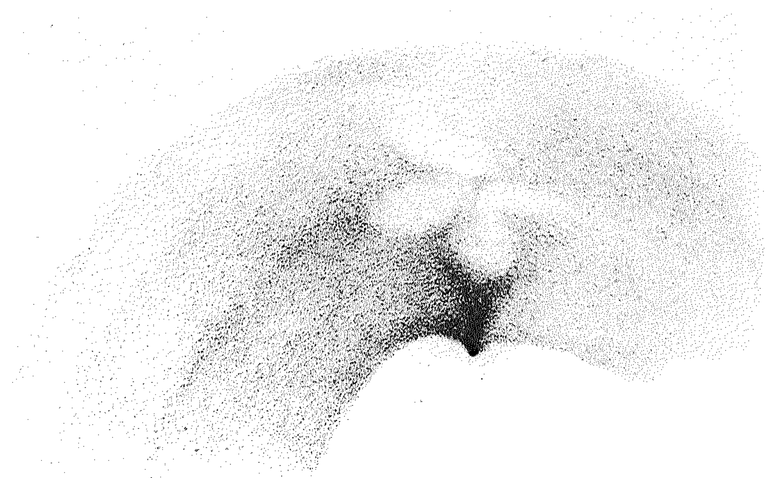

Fig. 5: July 3.822

Figure	Date	r (A.U.)	Δ (A.U.)	α	km/mm
4	1861 July 2.922	0.91	0.15	130°6	500
5	1861 July 3.822	0.92	0.17	122.0	600

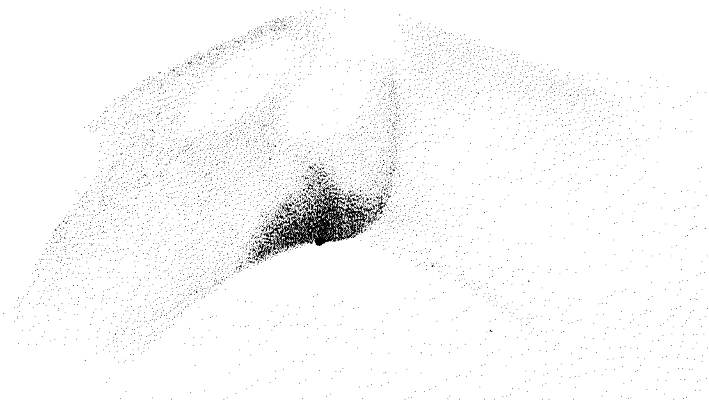

Fig. 6: July 3.936

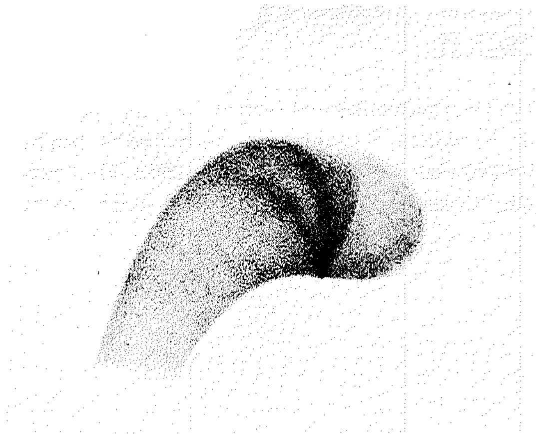

Fig. 7: July 4.068

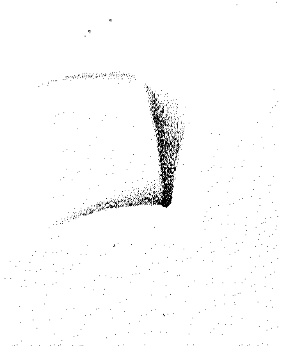

Fig. 8: July 4.797

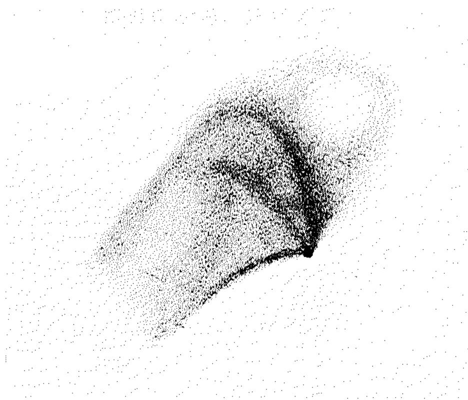

Fig. 9: July 4.805

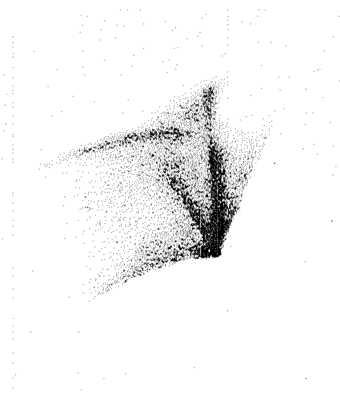

Fig. 10: July 4.822

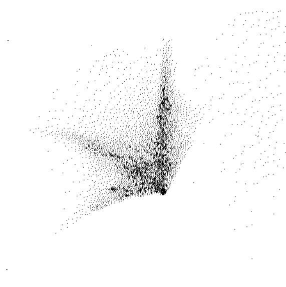

Fig. 11: July 4.906

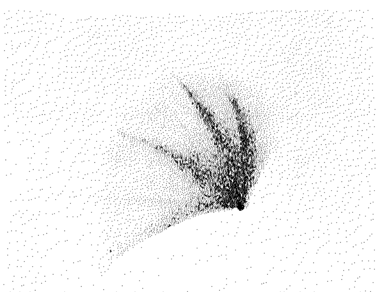

Fig. 12: July 4.920

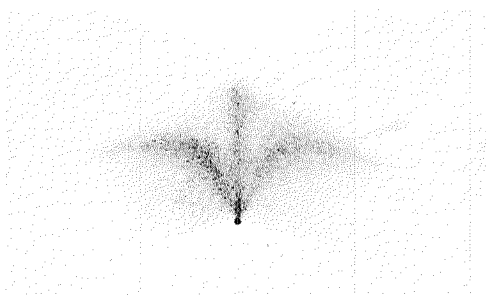

Fig. 13: July 5.092

Figure	Date	r (A.U.)	Δ (A.U.)	α	km/mm
6	1861 July 3.936	0.92	0.17	121°0	600
8	1861 July 4.797	0.93	0.19	114.2	600
11	1861 July 4.906	0.93	0.19	113.4	600
13	1861 July 5.092	0.93	0.19	112.1	600

COMET TEBBUTT
1861 II

Visual observations of Comet Tebbutt 1861 II by J. F. Julius Schmidt, "Astronomische Boebachtungen über Kometen," Athens, 1863 (Publications de l'Observatoire d'Athènes, 1[re] series, tome 1)

Fig. 14: July 5.805

Fig. 15: July 5.955

Figure	Date	r (A.U.)	Δ (A.U.)	a	km/mm
14	1861 July 5.805	0.93	0.21	107°.5	700
15	1861 July 5.955	0.94	0.21	106.6	700

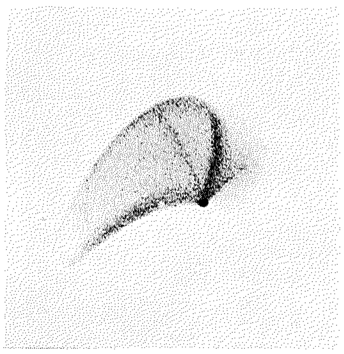

Fig. 16: July 6.818

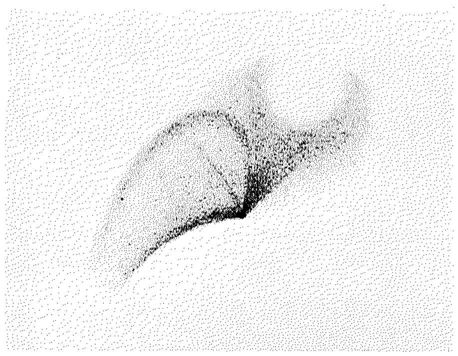

Fig. 17: July 6.840

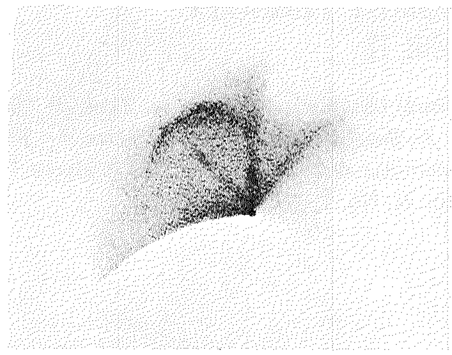

Fig. 18: July 6.888

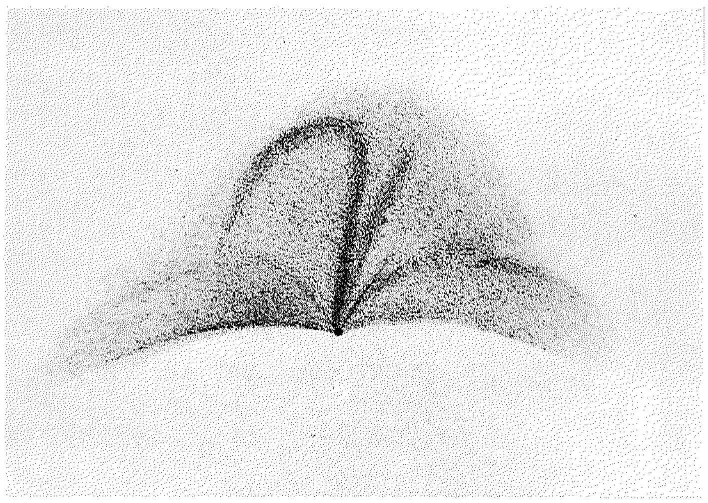

Fig. 19: July 7.021

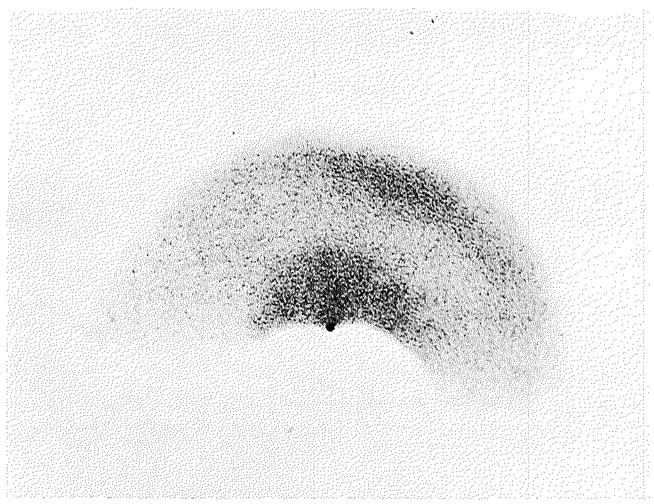

Fig. 20: July 7.795

Figure	Date	r (A.U.)	Δ (A.U.)	α	km/mm
16	1861 July 6.818	0.94	0.23	101°9	800
18	1861 July 6.888	0.94	0.24	101.5	800
20	1861 July 7.795	0.95	0.26	97.2	900

COMET TEBBUTT
1861 II

Visual observations of Comet Tebbutt 1861 II by P. A. Secchi with 9.6-inch refractor, f = 180 inches (Memorie dell'Osservatorio del Collegio Romano, Vol. II, No. 1, 1863)

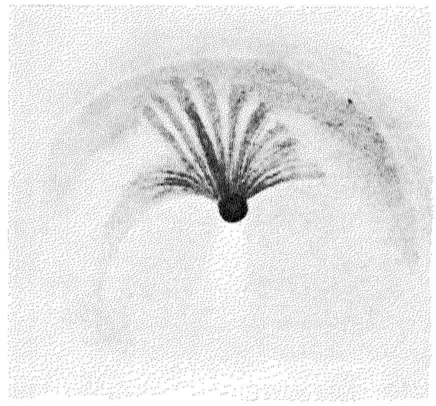

Fig. 21: July 1, 3^h a.m.

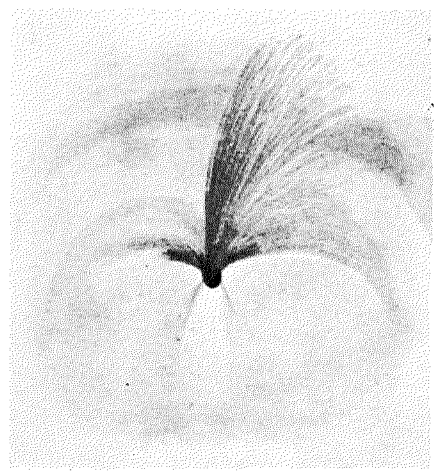

Fig. 22: July 1, 9.5^h p.m.

Figure	Date	r (A.U.)	Δ (A.U.)	α
21	1861 July 1.1	0.90	0.13	$152\overset{\circ}{.}7$
22	1861 July 1.9	0.90	0.14	141.9

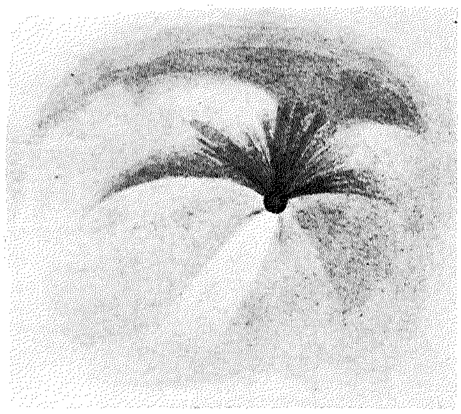

Fig. 23: July 2, 9^h p.m.

Fig. 24: July 3, 10^h p.m.

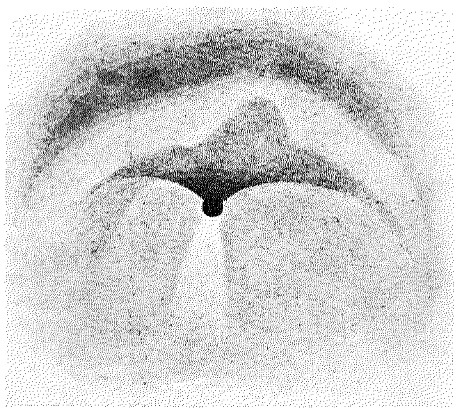

Fig. 25: July 5, 10^h p.m.

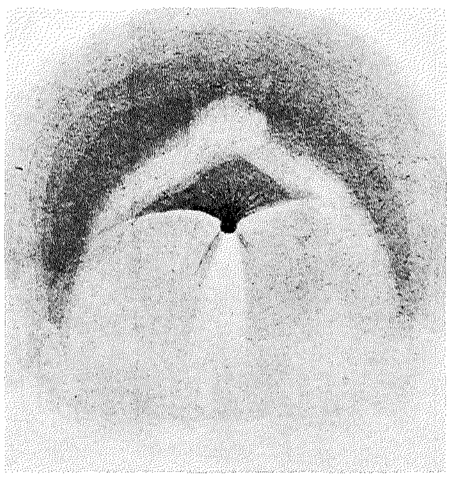

Fig. 26: July 6, 10^h p.m.

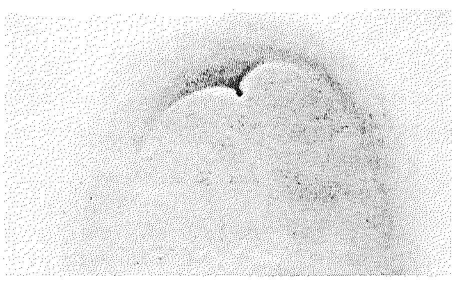

Fig. 27: July 13

Figure	Date	r (A.U.)	Δ (A.U.)	α
23	1861 July 2	0.90	0.14	140°7
25	1861 July 5	0.93	0.19	112.7
27	1861 July 13	1.00	0.39	80.8

COMET SWIFT-TUTTLE 1862 III

Visual observations of Comet Swift-Tuttle 1862 III by J. F. Julius Schmidt, "Astronomische Boebachtungen über Kometen," Athens, 1863 (Publications de l'Observatoire d'Athènes, 1re series, tome 1)

Fig. 1: Aug. 13

Fig. 2: Aug. 14

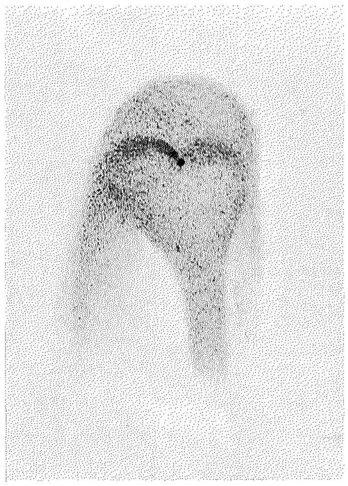

Fig. 3: Aug. 15

Fig. 4: Aug. 17

Figure	Date	r (A.U.)	Δ (A.U.)	α	km/mm
1	1862 Aug. 13	0.98	0.70	71°.9	1400
2	1862 Aug. 14	0.98	0.67	73.1	1400
3	1862 Aug. 15	0.97	0.65	74.4	1300
4	1862 Aug. 17	0.97	0.59	76.8	1200

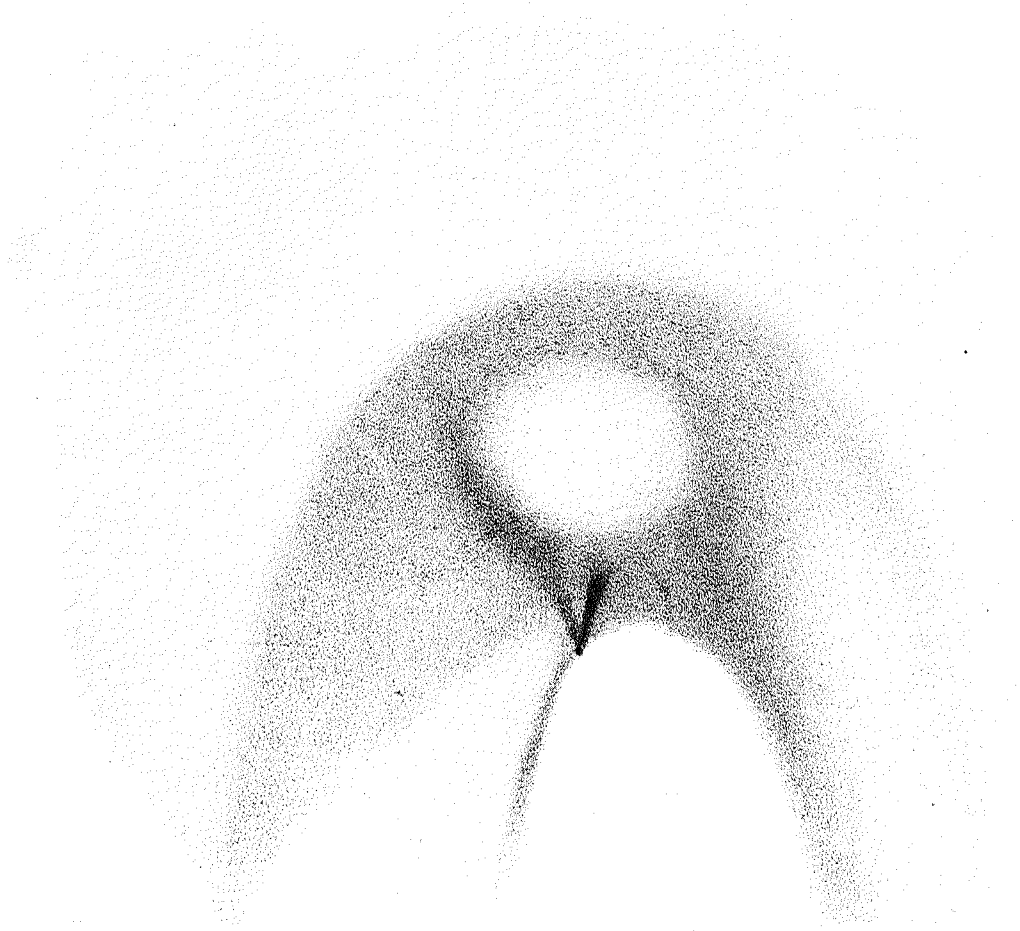

Fig. 5: Aug. 17 (drawing enlarged by Schmidt)

COMET SWIFT-TUTTLE
1862 III

Visual observations of Comet Swift-Tuttle 1862 III by J. F. Julius Schmidt, "Astronomische Beobachtungen über Kometen," Athens, 1863 (Publications de l'Observatoire d'Athenes, 1re series, tome 1)

Fig. 6: Aug. 19

Fig. 7: Aug. 20

Fig. 8: Aug. 21

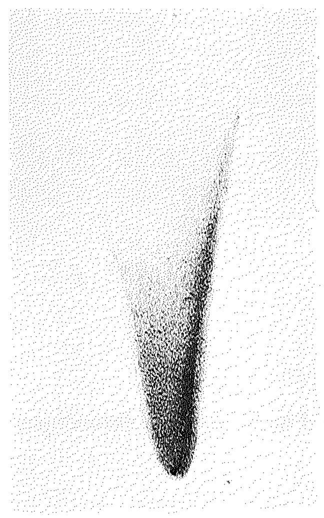

Fig. 9: Aug. 21 (drawing enlarged by Schmidt)

Figure	Date	r (A.U.)	Δ (A.U.)	α	km/mm
6	1862 Aug. 19	0.97	0.53	79°.2	1100
7	1862 Aug. 20	0.96	0.51	80.3	1100
8	1862 Aug. 21	0.96	0.48	81.5	1000
10	1862 Aug. 22	0.96	0.46	82.5	1000
13	1862 Aug. 25	0.96	0.40	85.3	800
16	1862 Aug. 28	0.97	0.35	86.7	700

Fig. 10: Aug. 22

Fig. 11: Aug. 23

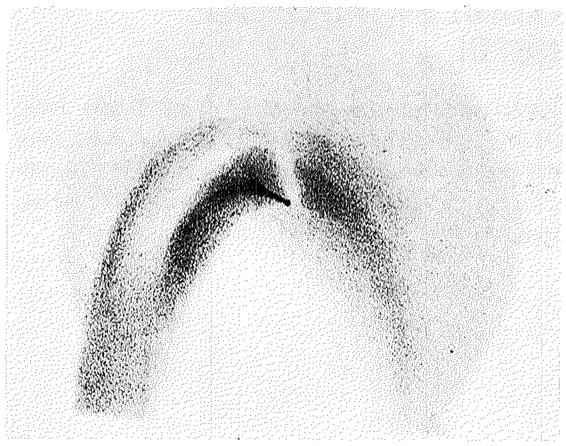

Fig. 12: Aug. 24

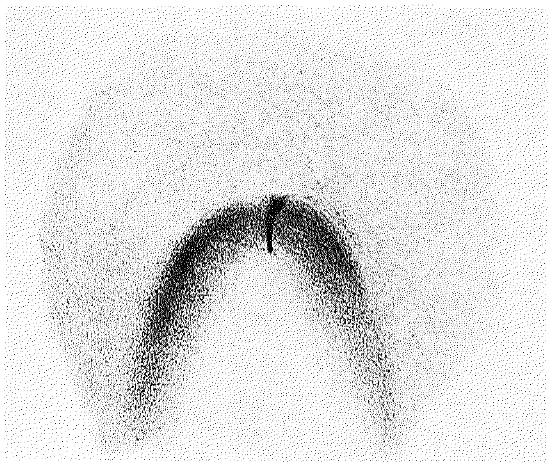

Fig. 13: Aug. 25

Fig. 14: Aug. 26

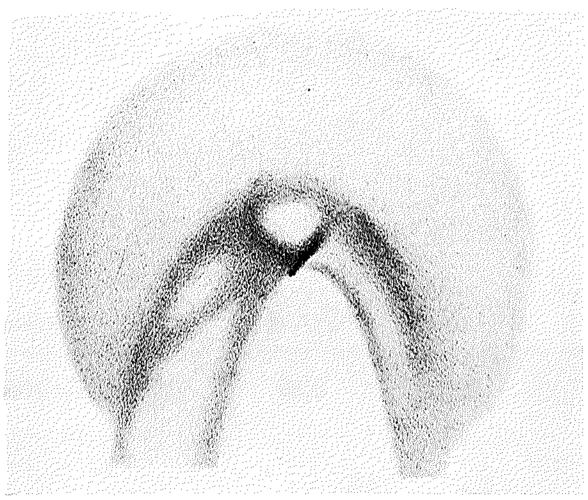

Fig. 15: Aug. 27

Fig. 16: Aug. 28

COMET SWIFT-TUTTLE 1862 III

Visual observations of Comet Swift-Tuttle 1862 III by J. F. Julius Schmidt, "Astronomische Beobachtungen über Kometen," Athens, 1863 (Publications de l'Observatoire d'Athènes, 1re series, tome 1)

Fig. 17: Aug. 29

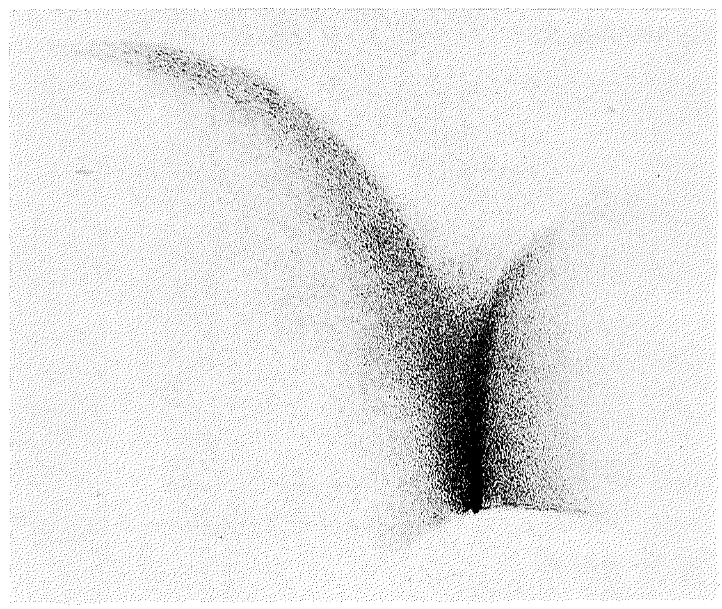

Fig. 18: Aug. 29 (drawing enlarged by Schmidt)

Figure	Date	r (A.U.)	Δ (A.U.)	α	km/mm
17	1862 Aug. 29	0.97	0.35	86°8	700

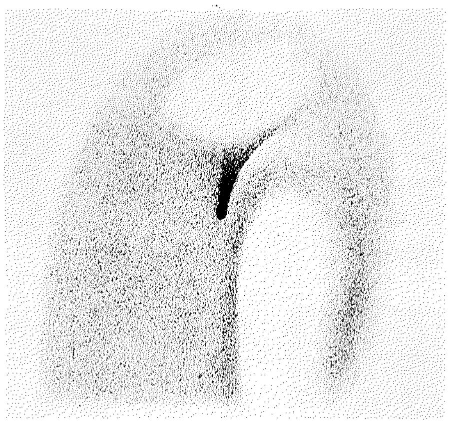

Fig. 19: Aug. 30

Fig. 20: Aug. 31

Fig. 21: Sept. 1

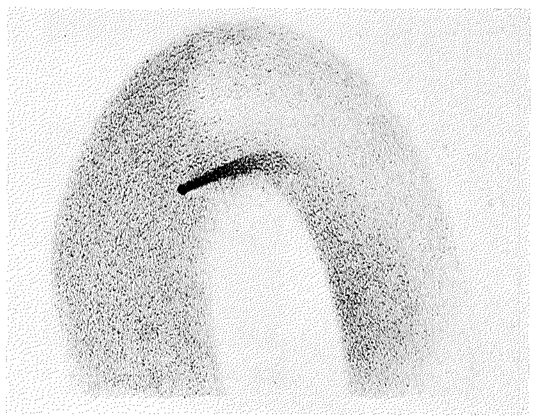

Fig. 22: Sept. 2

Fig. 23: Sept. 5

Fig. 24: Sept. 8

Figure	Date	r (A.U.)	Δ (A.U.)	a	km/mm
19	1862 Aug. 30	0.97	0.34	86°.7	1500
22	1862 Sept. 2	0.98	0.35	85.0	1500
24	1862 Sept. 8	1.00	0.45	78.0	2000

COMET SWIFT-TUTTLE
1862 III

Visual observations of Comet Swift-Tuttle 1862 III by P. A. Secchi with 9.6-inch refractor, f = 180 inches (Memorie dell'Osservatorio del Collegio Romano, Vol. II, No. 1, 1863)

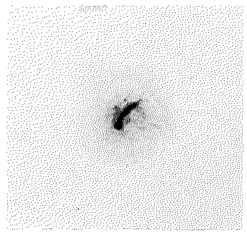
Fig. 25: July 26

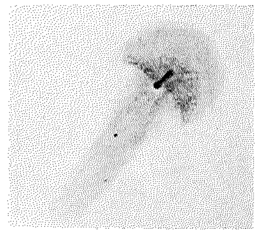
Fig. 26: July 28

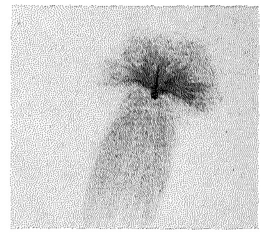
Fig. 27: Aug. 1

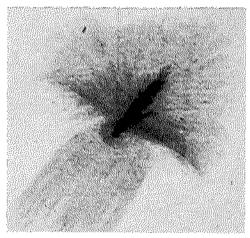
Fig. 28: Aug. 6

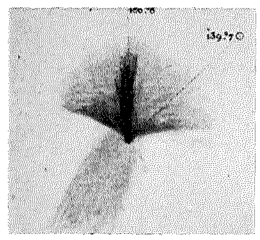
Fig. 29: Aug. 7

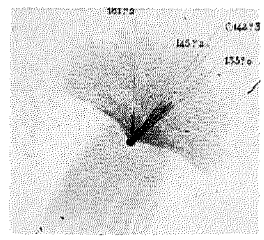
Fig. 30: Aug. 8

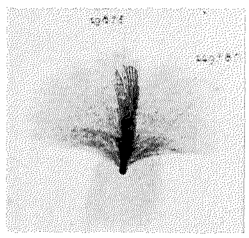
Fig. 31: Aug. 10

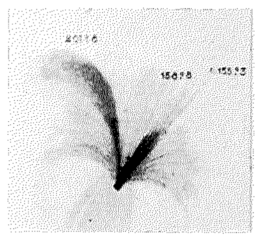
Fig. 32: Aug. 11

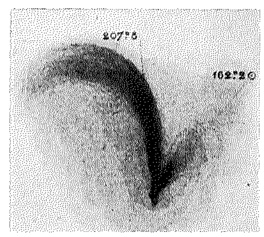
Fig. 33: Aug. 12

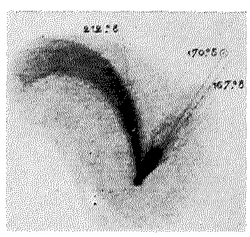
Fig. 34: Aug. 13

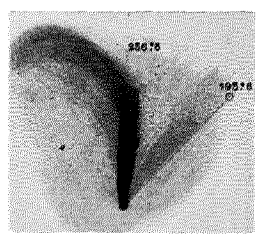
Fig. 35: Aug. 15

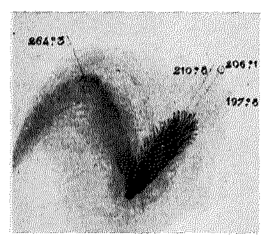
Fig. 36: Aug. 16

Figure	Date	r (A.U.)	Δ (A.U.)	α
25	1862 July 26	1.08	1.23	51°.6
28	1862 Aug. 6	1.01	0.91	63.5

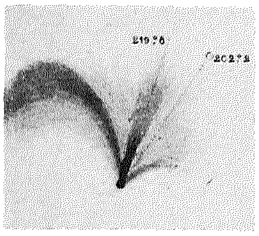
Fig. 37: Aug. 17

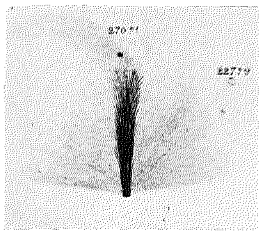
Fig. 38: Aug. 18

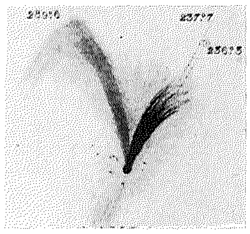
Fig. 39: Aug. 19

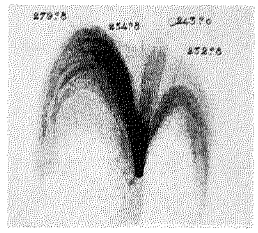
Fig. 40: Aug. 20

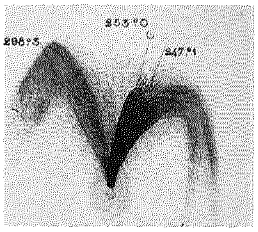
Fig. 41: Aug. 22


Fig. 42: Aug. 23

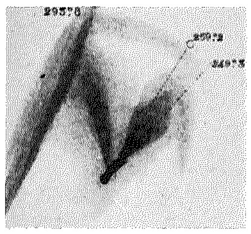
Fig. 43: Aug. 24

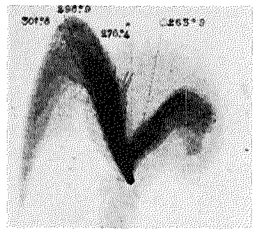
Fig. 44: Aug. 26

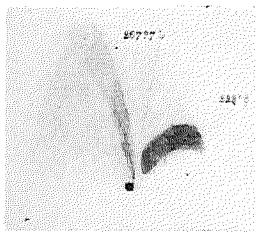
Fig. 45: Aug. 28.33

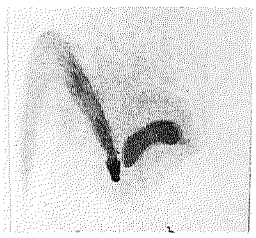
Fig. 46: Aug. 28.45


Fig. 47: Aug. 29

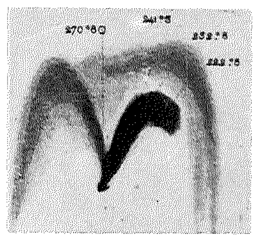
Fig. 48: Aug. 30

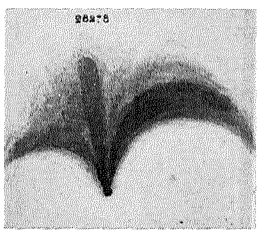
Fig. 49: Aug. 31

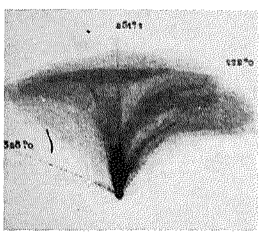
Fig. 50: Sept. 1

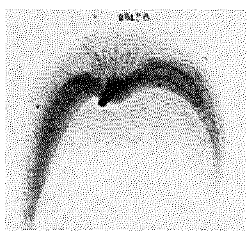
Fig. 51: Sept. 6


Fig. 52: Sept. 12

Figure	Date	r (A.U.)	Δ (A.U.)	α
37	1862 Aug. 17	0.97	0.59	76.°8
45	1862 Aug. 28	0.97	0.35	86.7
51	1862 Sept. 6	0.99	0.41	80.6
52	1862 Sept. 12	1.02	0.55	72.9

COMET WINNECKE 1868 II

Visual observation of Comet Winnecke 1868 II by C. Bruhns with 9.6-inch refractor, f = 166.8 inches (Astron. Nachrichten 72, p. 273, 1868)

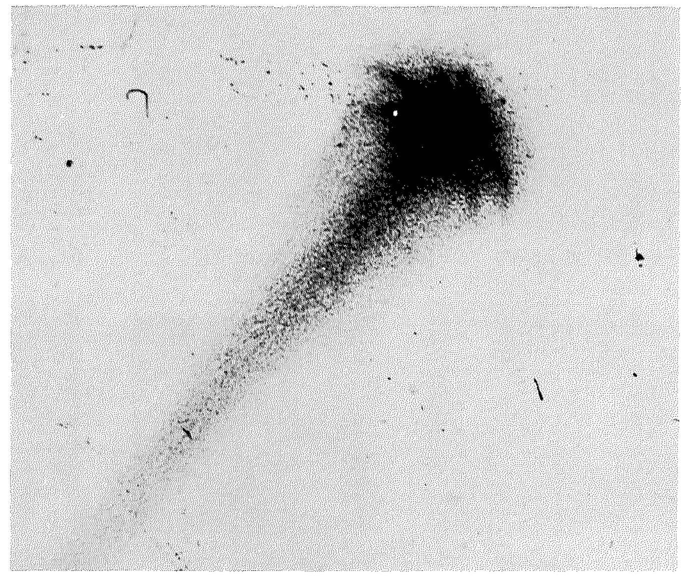

Fig. 1: 1868 June 19

r (A.U.)	Δ (A. U.)	a
0.61	0.85	86°8

COMET TEBBUTT 1881 III

Visual observation of Comet Tebbutt 1881 III by Tacchini (in R. Jaegermann, "Mechanische Untersuchungen über Kometenformen," St. Petersburg, 1903)

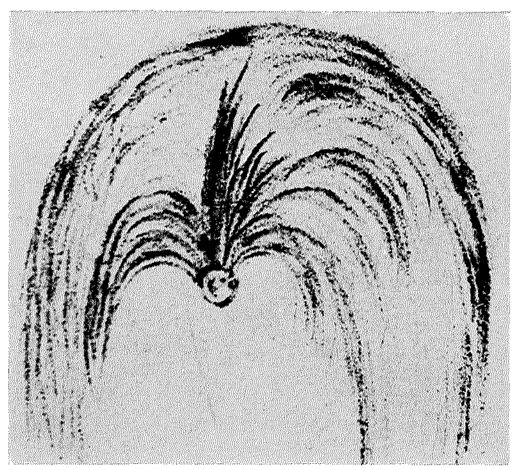

Fig. 1: 1881 June 27

r (A.U.)	Δ (A.U.)	a
0.76	0.34	131°2

COMET COGGIA 1874 III

Visual observations of Comet Coggia 1874 III by H. C. Vogel (Astron. Nachrichten 85, p. 17, 1874)

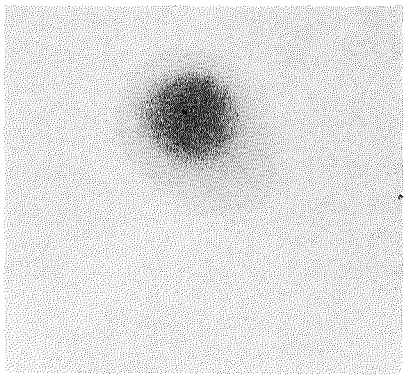

Fig. 1: May 6

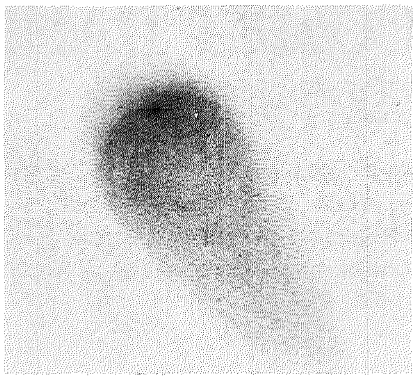

Fig. 2: May 18

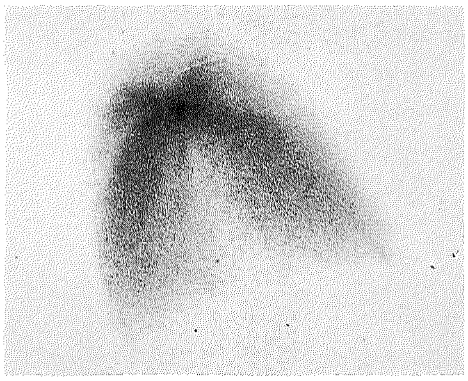

Fig. 3: June 14

Fig. 4: June 22

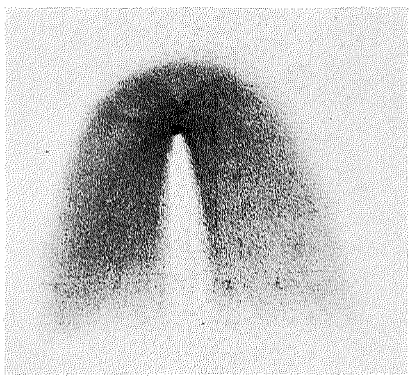

Fig. 5: July 8

Fig. 6: July 13

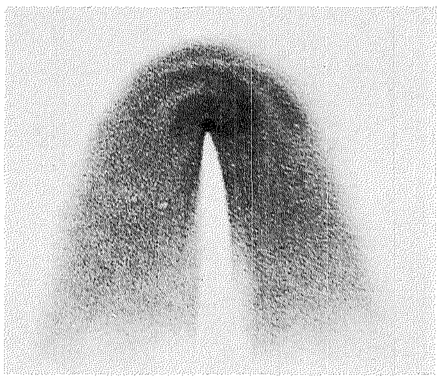

Fig. 7: July 14

Figure	Date	r (A.U.)	Δ (A.U.)	α
1	1874 May 6	1.40	1.56	39°.4
3	1874 June 14	0.85	1.07	62.5
4	1874 June 22	0.77	0.91	74.3
7	1874 July 14	0.68	0.40	139.3

COMET DANIEL 1907 IV

Visual observations of Comet Daniel 1907 IV by M. Wolf with 72-cm reflector, f = 282 cm, Kőnigstuhl Observatory, Heidelberg, Germany (Abhandlungen der Bayer. Akad. d. Wissenschaften 23, p. 439, 1909)

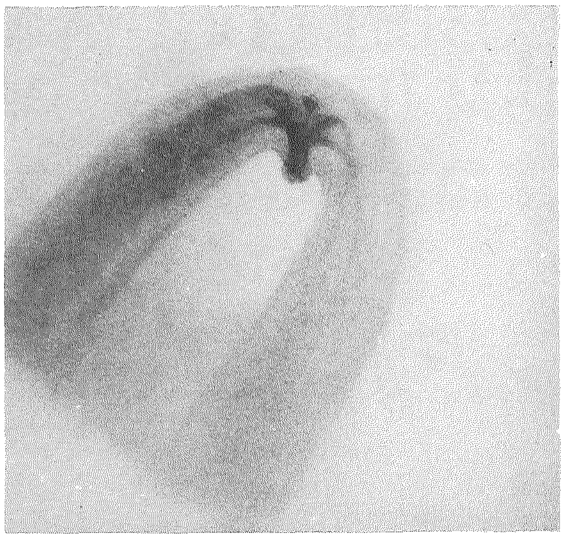

Fig. 1: Aug. 4

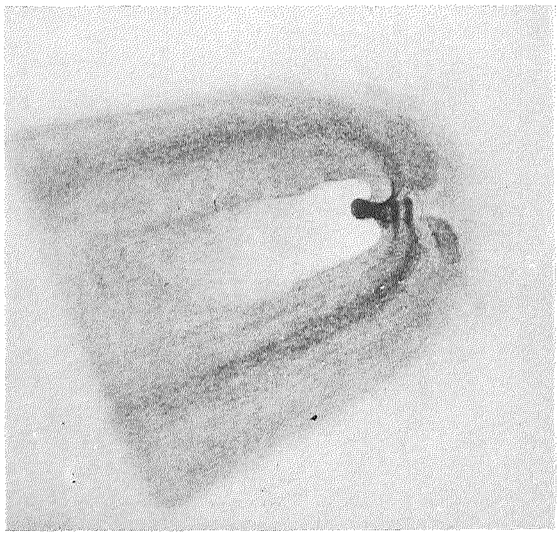

Fig. 2: Aug. 7

Figure	Date	r (A.U.)	Δ (A.U.)	α
1	1907 Aug. 4	0.88	0.76	76°4
2	1907 Aug. 7	0.83	0.77	79.0

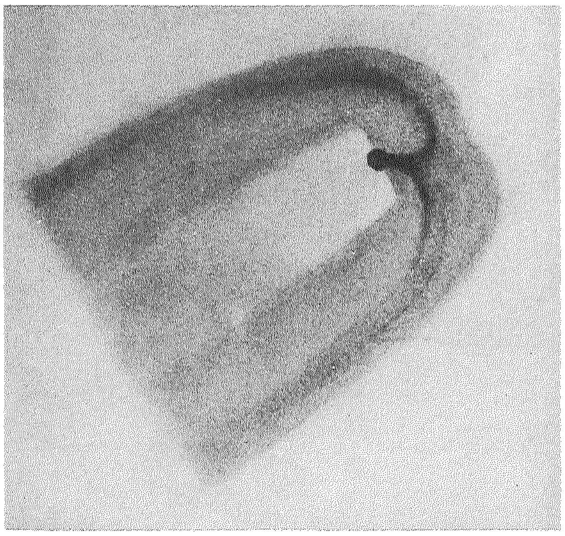
Fig. 3: Aug. 8

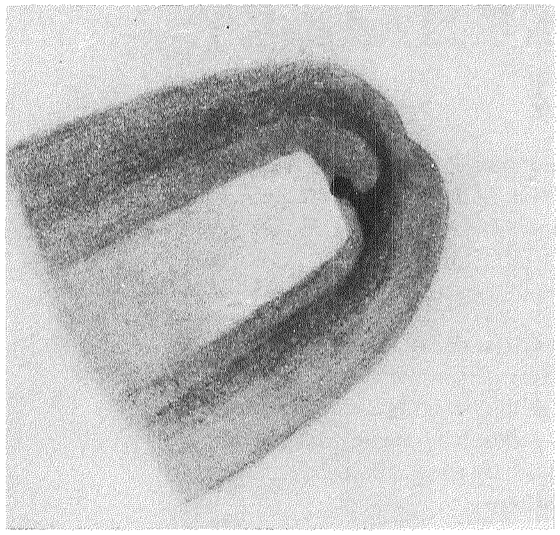
Fig. 4: Aug. 9


Fig. 5: Aug. 11

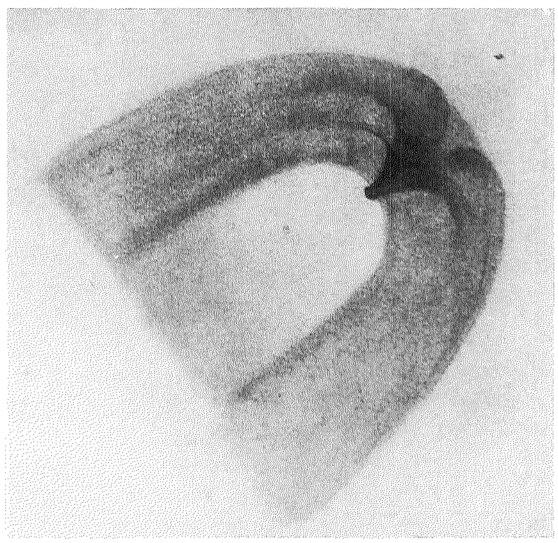
Fig. 6: Aug. 14

Figure	Date	r (A.U.)	Δ (A.U.)	α
3	1907 Aug. 8	0.81	0.77	79°.8
4	1907 Aug. 9	0.79	0.78	80.5
5	1907 Aug. 11	0.76	0.79	81.6
6	1907 Aug. 14	0.72	0.82	82.6

COMET HALLEY 1910 II

Visual observations of Comet Halley 1910 II by R. T. A. Innes and W. M. Worssell (Transvaal Observatory Circular No. 4, p. 23, 1910, Johannesburg)

Drawings marked I (R. T. A. Innes) were made at the 9-inch refractor; those marked W. (W. M. Worssell) were made at the 4-inch refractor—sometimes, however, supplemented by views with the 9-inch. Figure 16 (marked M) was made by R. J. Mitchell at the 9-inch refractor.

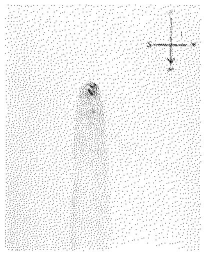
Fig. 1: Apr. 16 (I)

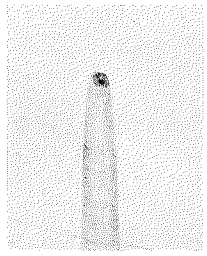
Fig. 2: Apr. 18 (I)

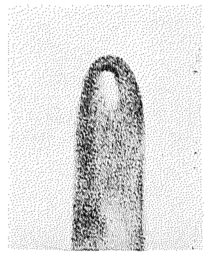
Fig. 3: Apr. 19 (I)

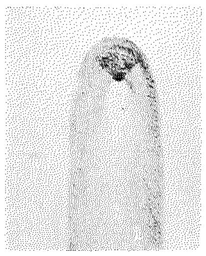
Fig. 4: Apr. 21 (I)

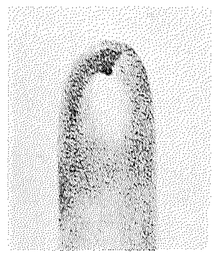
Fig. 5: Apr. 22 (I)

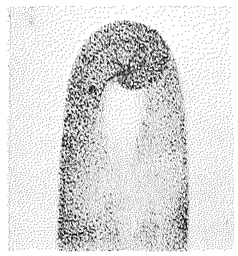
Fig. 6: Apr. 23 (I)

Figure	Date	r (A.U.)	Δ (A.U.)	α
1	1910 Apr. 16	0.59	1.34	$44\overset{\circ}{.}1$
3	1910 Apr. 19	0.59	1.25	52.5
6	1910 Apr. 23	0.59	1.11	64.2

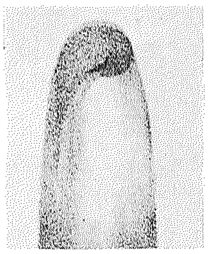
Fig. 7: Apr. 24 (I)

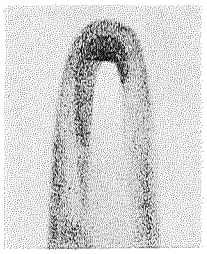
Fig. 8: Apr. 25 (I)

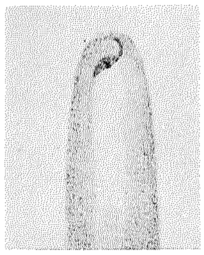
Fig. 9: Apr. 27 (I)

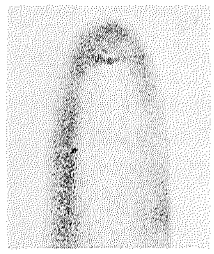
Fig. 10: Apr. 28 (I)

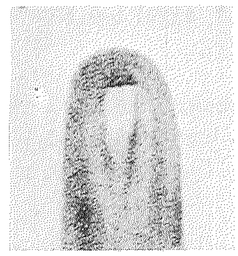
Fig. 11: Apr. 29 (I)

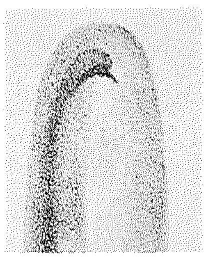
Fig. 12: Apr. 30 (I)

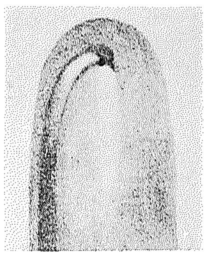
Fig. 13: May 1 (I)

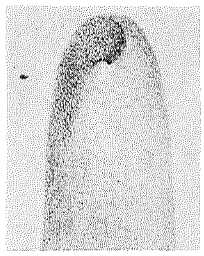
Fig. 14: May 2 (I)

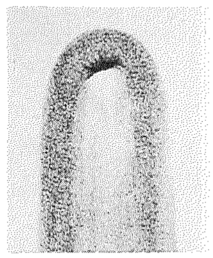
Fig. 15: May 3 (W)

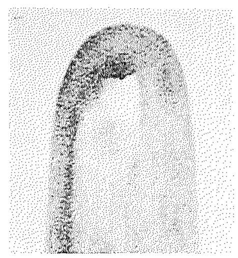
Fig. 16: May 3 (M)

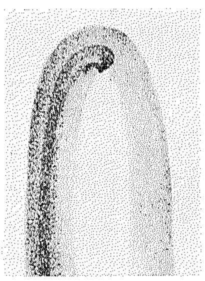
Fig. 17: May 4 (I)

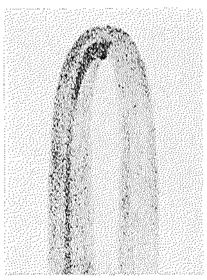
Fig. 18: May 4 (W)

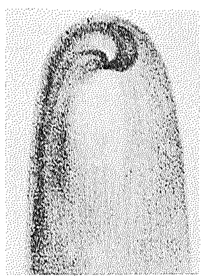
Fig. 19: May 5 (I)

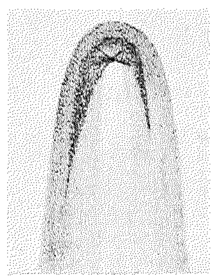
Fig. 20: May 5 (W)

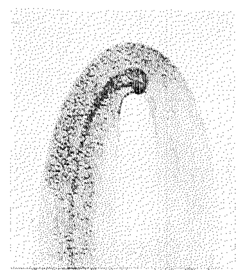
Fig. 21: May 6 (I)

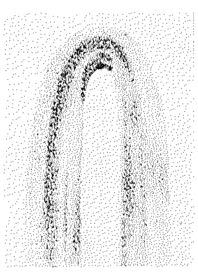
Fig. 22: May 6 (W)

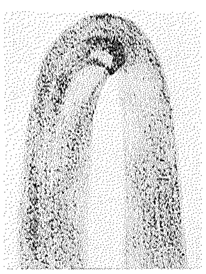
Fig. 23: May 8 (I)

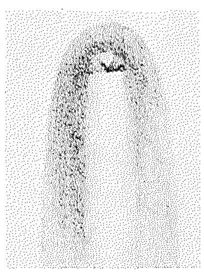
Fig. 24: May 8 (W)

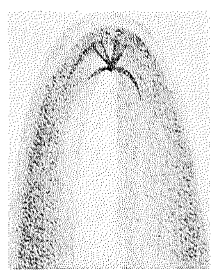
Fig. 25: May 9 (I)

Figure	Date	r (A.U.)	Δ (A.U.)	α
7	1910 Apr. 24	0.59	1.08	$67\overset{\circ}{.}1$
12	1910 Apr. 30	0.63	0.85	84.6
21	1910 May 6	0.68	0.62	102.1
25	1910 May 9	0.72	0.50	111.5

COMET HALLEY
1910 II

Visual observations of Comet Halley 1910 II by R. T. A. Innes and W. M. Worssell (Transvaal Observatory Circular No. 4, p. 23, 1910, Johannesburg)

Fig. 26: May 9 (W)

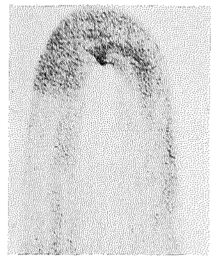

Fig. 27: May 10 (I)

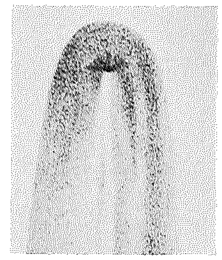

Fig. 28: May 10 (I)

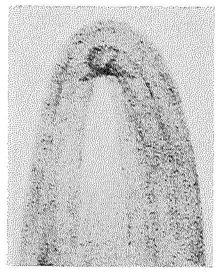

Fig. 29: May 11 (I)

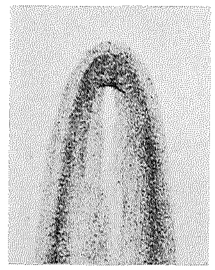

Fig. 30: May 11 (W)

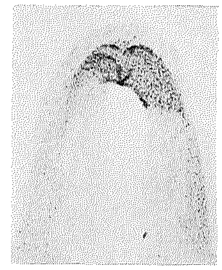

Fig. 31: May 12 (I)

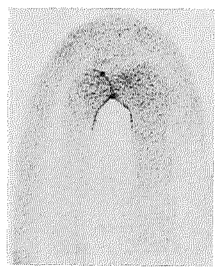

Fig. 32: May 12 (W)

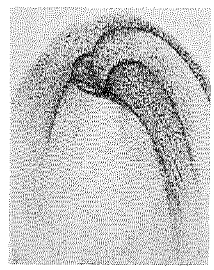

Fig. 33: May 13 (I)

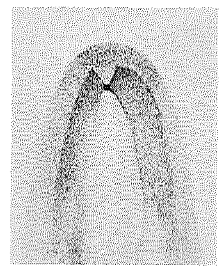

Fig. 34: May 13 (W)

Figure	Date	r (A.U.)	Δ (A.U.)	α
27	1910 May 10	0.73	0.46	114.°9
31	1910 May 12	0.75	0.38	122.5

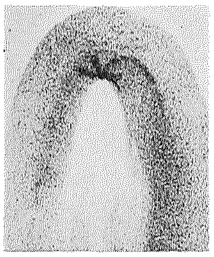
Fig. 35: May 14 (I)

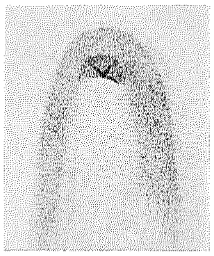
Fig. 36: May 14 (W)

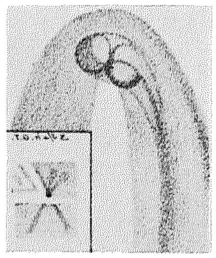
Fig. 37: May 15 (I)

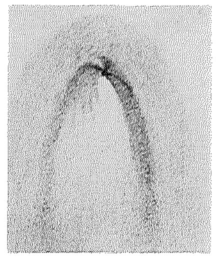
Fig. 38: May 15 (W)

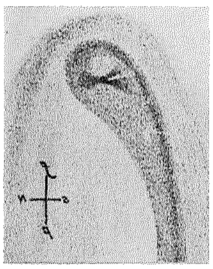
Fig. 39: May 16 (I)

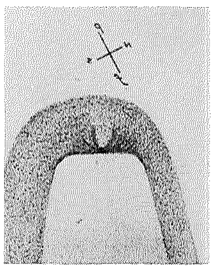
Fig. 40: May 20 (I)

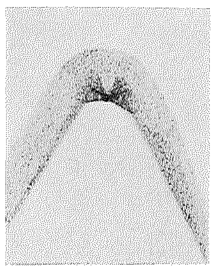
Fig. 41: May 20 (W)

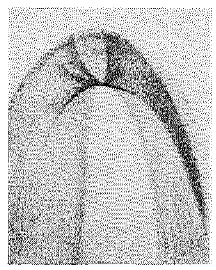
Fig. 42: May 21 (I)

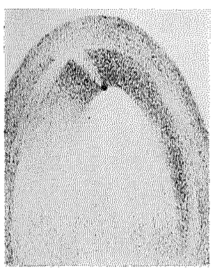
Fig. 43: May 21 (W)

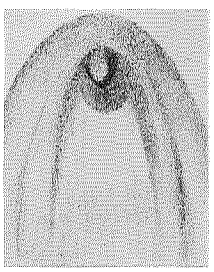
Fig. 44: May 22 (I)


Fig. 45: May 22 (W)

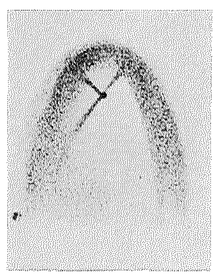
Fig. 46: May 23 (I)

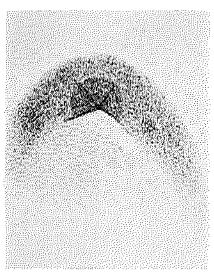
Fig. 47: May 23 (W)


Fig. 48: May 24 (I)

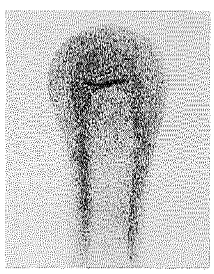
Fig. 49: May 27 (I)

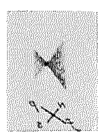
Fig. 50a: May 31 (I)

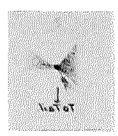
Fig. 50b: May 31 (W)

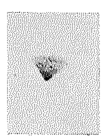
Fig. 50c: June 1 (I)

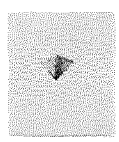
Fig. 50d: June 1 (W)

Figure	Date	r (A.U.)	Δ (A.U.)	α
35	1910 May 14	0.78	0.31	131°9
36	1910 May 14	0.78	0.31	131.9
40	1910 May 20	0.86	0.15	166.8
48	1910 May 24	0.91	0.18	121.1
50d	1910 June 1	1.04	0.49	73.0

COMPARISON OF VISUAL AND PHOTOGRAPHIC OBSERVATIONS OF COMETS

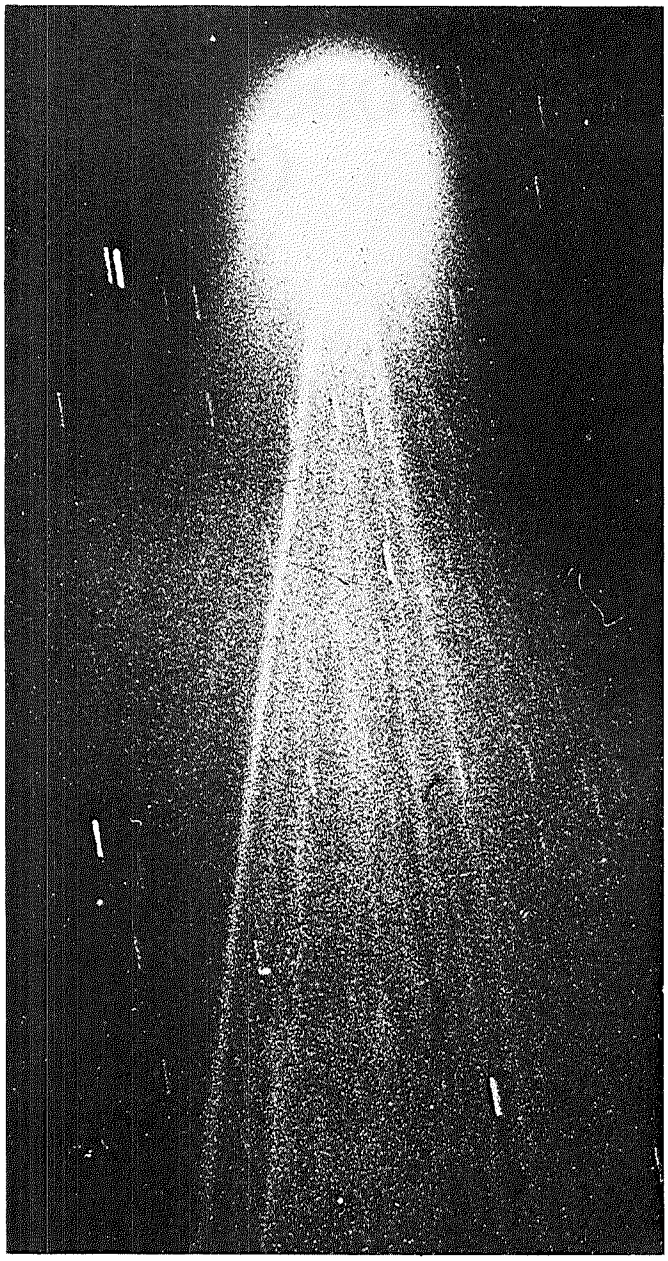

Fig. 1: Photograph of Comet Daniel 1907 IV taken by M. Wolf with 72-cm reflector, Königstuhl Observatory, Heidelberg, Germany, 1907 Aug. 5.083; exposure 15 minutes; r = 0.86, Δ = 0.76, α = 77°4; scale: 1.4×10^4 km/mm.

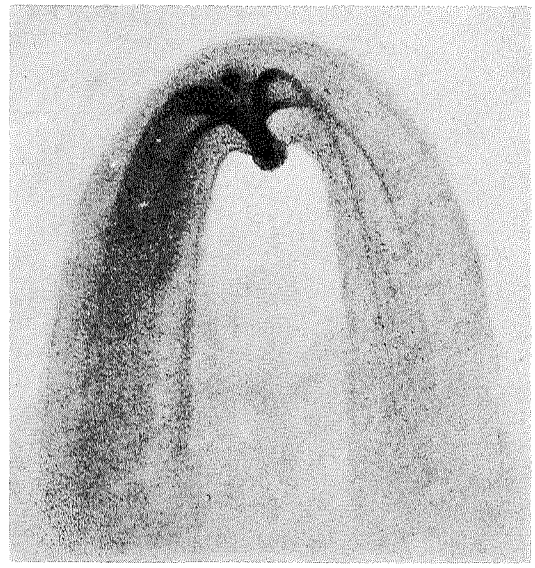

Fig. 2: Drawing of the visual appearance of Comet Daniel 1907 IV by M. Wolf. These photographs and drawings of Comet Daniel 1907 IV (Figs. 1 to 4) were obtained at about the same time using the same telescope (M. Wolf, Abhandlungen der Bayer. Akad. d. Wissenschaften 23, p. 439, 1909). Most striking feature in the drawings is the more or less separated streamers directed towards the sun. Because of overexposure, these streamers cannot be recognized in the photographs.

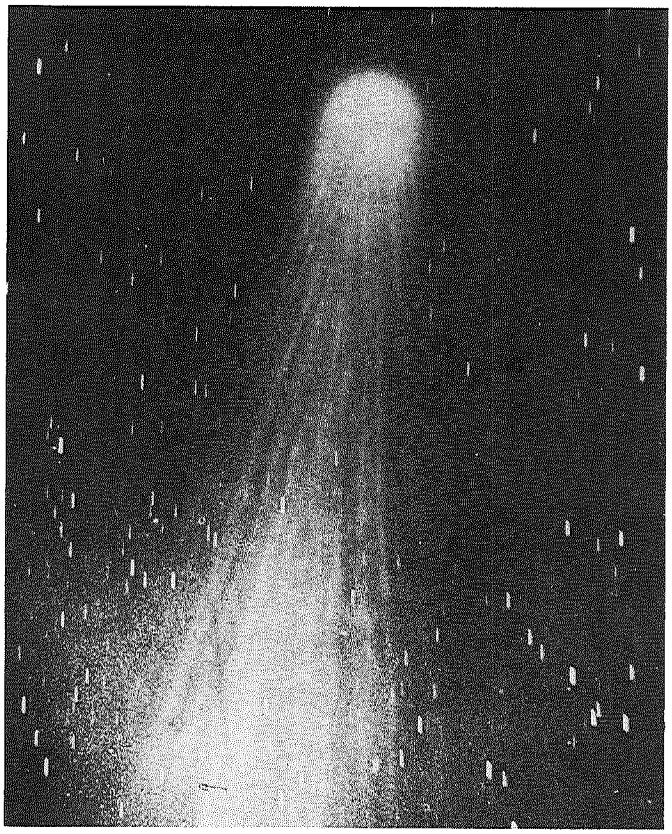

Fig. 3: Photograph of Comet Daniel 1907 IV taken by M. Wolf with 72-cm reflector, Königstuhl Observatory, Heidelberg, Germany, 1907 Aug. 15.106; exposure 12 minutes; r = 0.70, Δ = 0.83, α = 82°.7; scale: 2.5 × 10^4 km/mm.

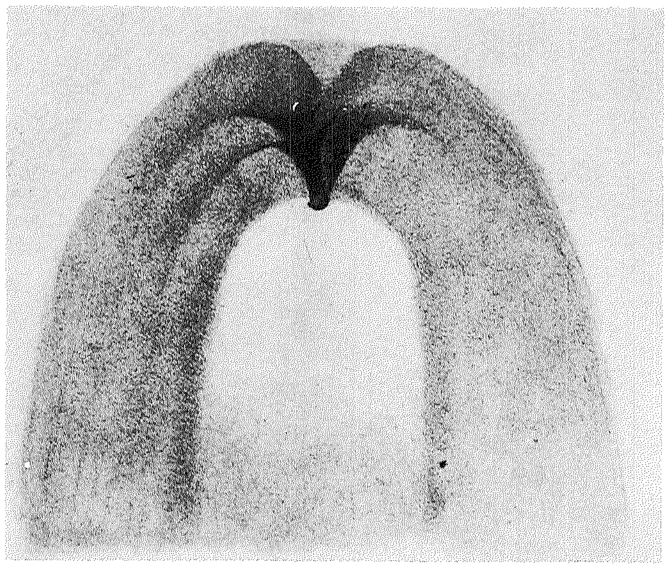

Fig. 4: Drawing of the visual appearance of Comet Daniel 1907 IV by M. Wolf.

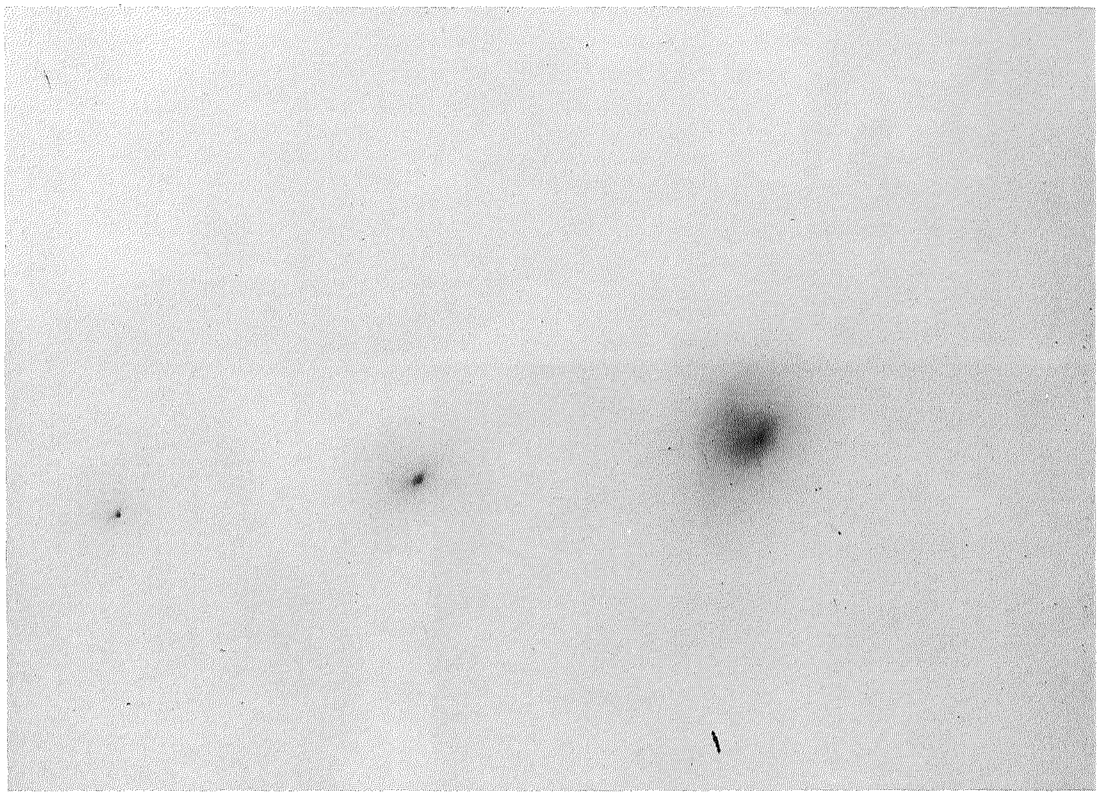

Fig. 5: Comet Halley 1910 II. Photographs taken by C. O. Lampland with 42-inch reflector, Lowell Observatory, Flagstaff, Arizona, U.S.A., 1910 May 22.153; exposures (left to right) 30, 60, 120 seconds; r = 0.89, Δ = 0.17, α =132°2; enlarged 1.4X; scale: 2.6 X 10^3 km/mm.

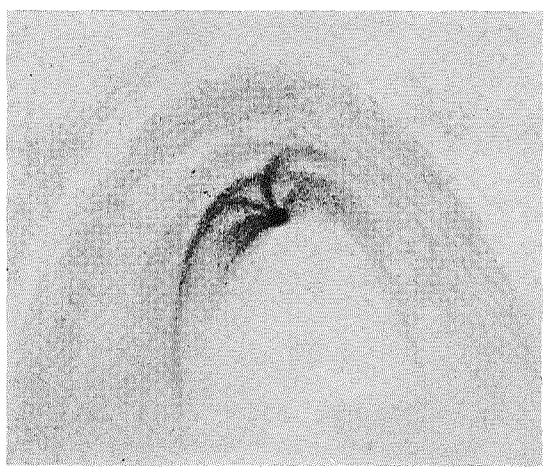

Fig. 6: Drawing of the appearance of Comet Halley 1910 II on May 21 (A. Ricco, "Mem. Soc. Spettroscopisti Ital." Ser. 2ª, Vol. 1, p. 97, 1912). Drawing made after visual inspection through a telescope. Note the similarity in the appearance of the structures near the nucleus in the drawing (Fig. 6) and in the short-exposed photographs (Fig. 5).

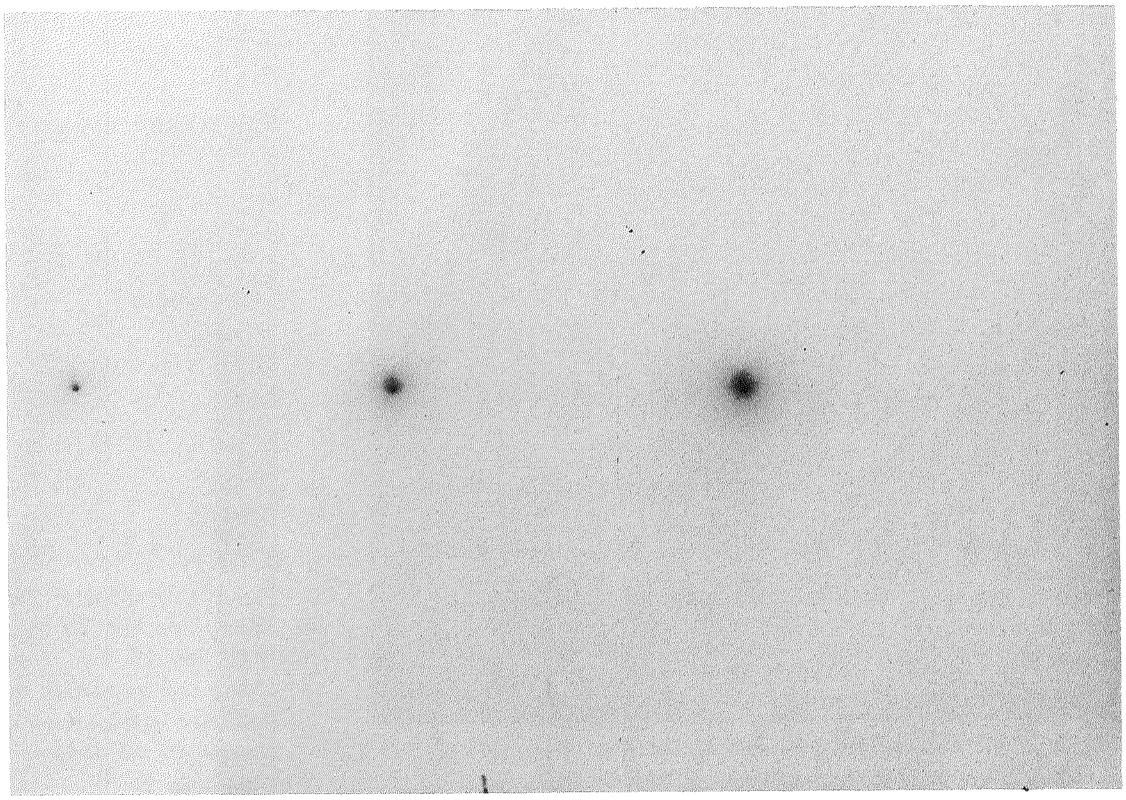

Fig. 7: Comet Halley 1910 II. Photographs taken by C. O. Lampland with 42-inch reflector, Lowell Observatory, Flagstaff, Arizona, U.S.A., 1910 May 23.174; exposures (left to right) 40, 80, 120 seconds; $r = 0.91$, $\Delta = 0.19$, $\alpha = 119^\circ.1$; enlarged 1.3X; scale: 3.2×10^3 km/mm.

Fig. 8: Drawing of the appearance of Comet Halley 1910 II on May 24 (A. Ricco, "Mem. Soc. Spettroscopisti Ital." Ser. 2ª, Vol. 1, p. 97, 1912). Drawing made after visual inspection through a telescope Note the similarity in the appearance of the structures near the nucleus in the drawing (Fig. 8) and in the short-exposed photographs (Fig. 7).

Fig. 9: Comet Halley 1910 II. Photograph taken by H. Knox Shaw with 30-inch reflector, Khedivial Observatory, Helwan, Egypt, 1910 May 25.769; exposure 5 minutes; r = 0.95; Δ = 0.26, α = 97$^\circ_.$0; enlarged 2.7X; scale: 4.1 $\times$ 10^3 km/mm (see also Figs. 10a, b on page 83).

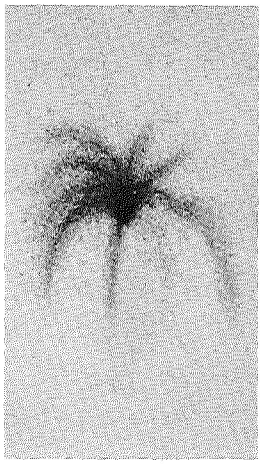

Fig. 10: Drawing of the appearance of Comet Halley 1910 II on May 25 (A. Ricco, "Mem. Soc. Spettros-Ital." Ser. 2^a, Vol. 1, p. 97, 1912). Drawing made after visual inspection through a telescope. Note the similarity in the appearance of the structures near the nucleus in the drawing (Fig. 10) and in the photograph (Fig. 9).

PHOTOGRAPHIC OBSERVATIONS OF COMETS

COMET MOREHOUSE 1908 III

The photographs of Comet Morehouse 1908 III in this section were taken by C. Davidson, D. Edney, and P. J. Melotte with the 30-inch reflector, Royal Greenwich Observatory, Herstmonceux, England.

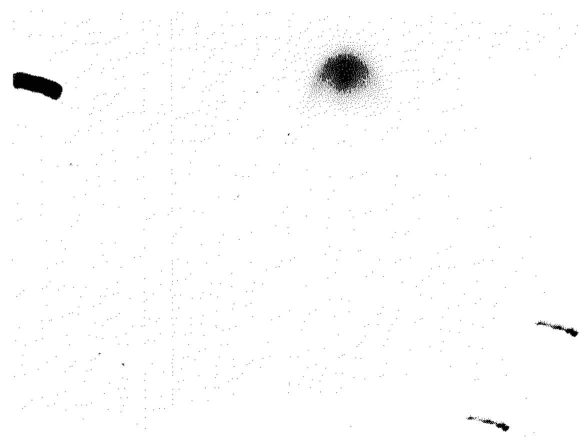

Fig. 1a: 1908 Sept. 7.093; exposure 30 minutes; r = 2.01, Δ = 1.67, α = $30^\circ.0$; enlarged 6.0X; scale: 1.2 X 10^4 km/mm.

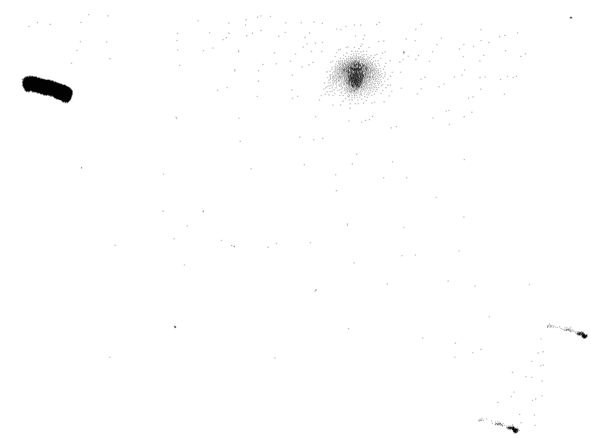

Fig. 1b: Same photograph as Fig. 1a, printed to bring out greater detail closer to the nucleus.

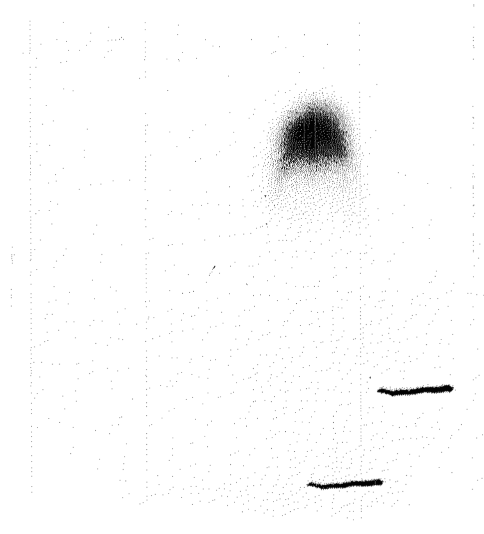

Fig. 2a: 1908 Sept. 7.147; exposure 47 minutes; r = 2.01, Δ = 1.67, α = $30^\circ.0$; enlarged 6.0X; scale: 1.2 X 10^4 km/mm.

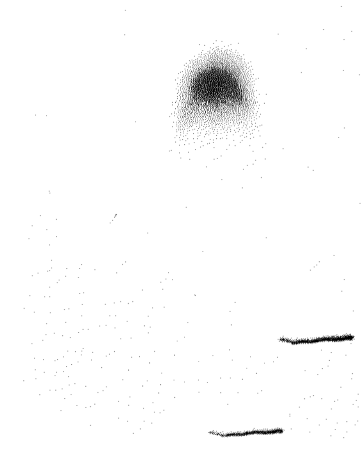

Fig. 2b.

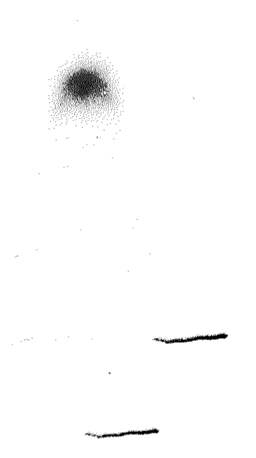

Fig. 2c.

Figs. 2b, 2c: Same photograph as Fig. 2a, printed to bring out greater detail closer to the nucleus.

Fig. 3a: 1908 Sept. 8.123; exposure 60 minutes; r = 2.00, Δ = 1.64, $\alpha = 30\overset{\circ}{.}2$; enlarged 6.0X; scale: 1.2 X 10^4 km/mm.

Fig. 3b.

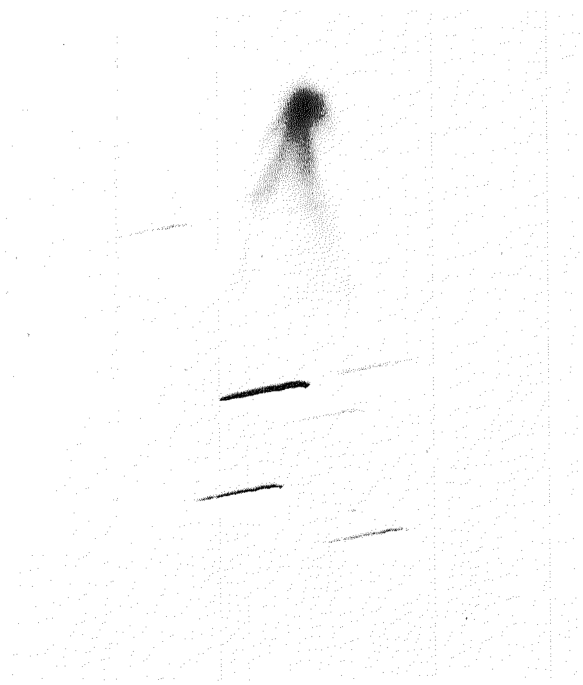

Fig. 3c.

Figs. 3b, 3c: Same photograph as Fig. 3a, printed to bring out greater detail closer to the nucleus.

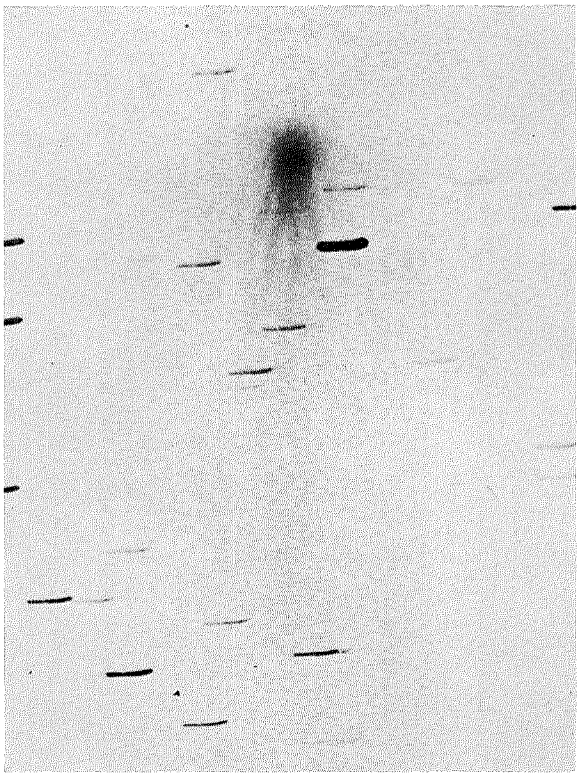

Fig. 4a: 1908 Sept. 26.890; exposure 18 minutes; $r = 1.76$, $\Delta = 1.22$, $\alpha = 33\overset{\circ}{.}4$; enlarged 6.0X; scale: 8.8×10^3 km/mm.

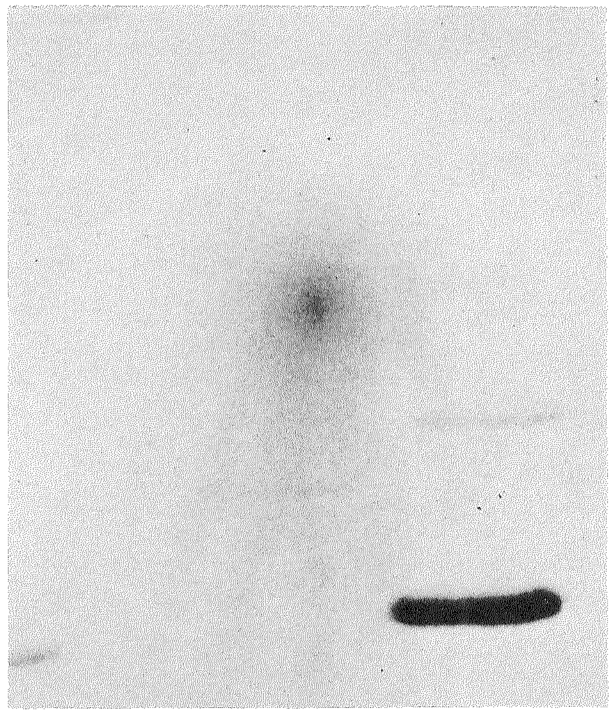

Fig. 4b: Detail of Fig. 4a; enlarged 20.4X; scale: 2.6×10^3 km/mm.

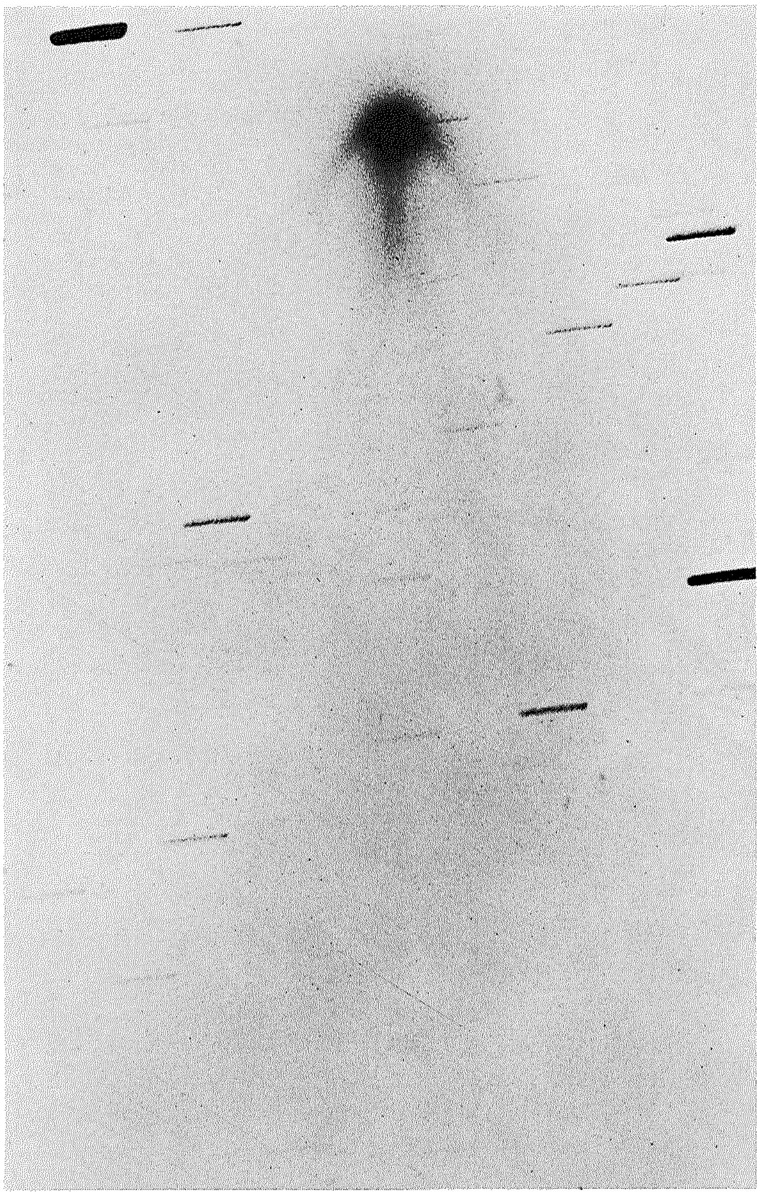

Fig. 5a: 1908 Oct. 2.852; exposure 20 minutes; r = 1.69, Δ = 1.13, α = $35\overset{\circ}{.}0$; enlarged 6.0X; scale: 8.2 X 10^3 km/mm.

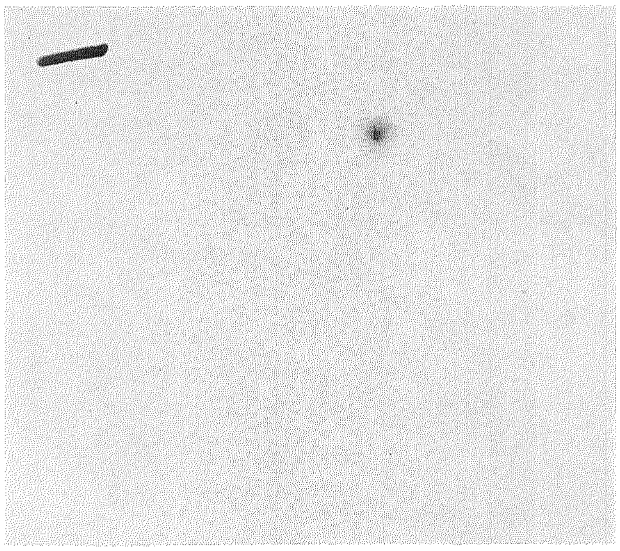

Fig. 5b: Same photograph as Fig. 5a, printed to bring out greater detail closer to the nucleus.

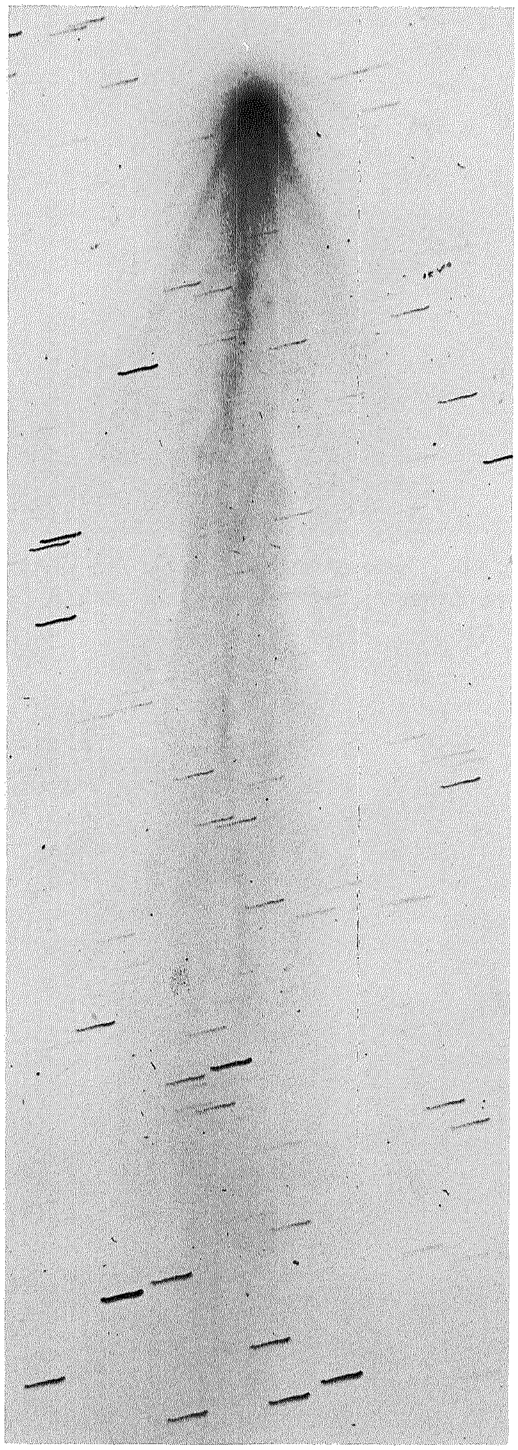

Fig. 6a: 1908 Sept. 30.177; exposure 25 minutes; $r = 1.72$, $\Delta = 1.16$, $\alpha = 34\overset{\circ}{.}2$; enlarged 3.3X; scale: 1.5×10^4 km/mm.

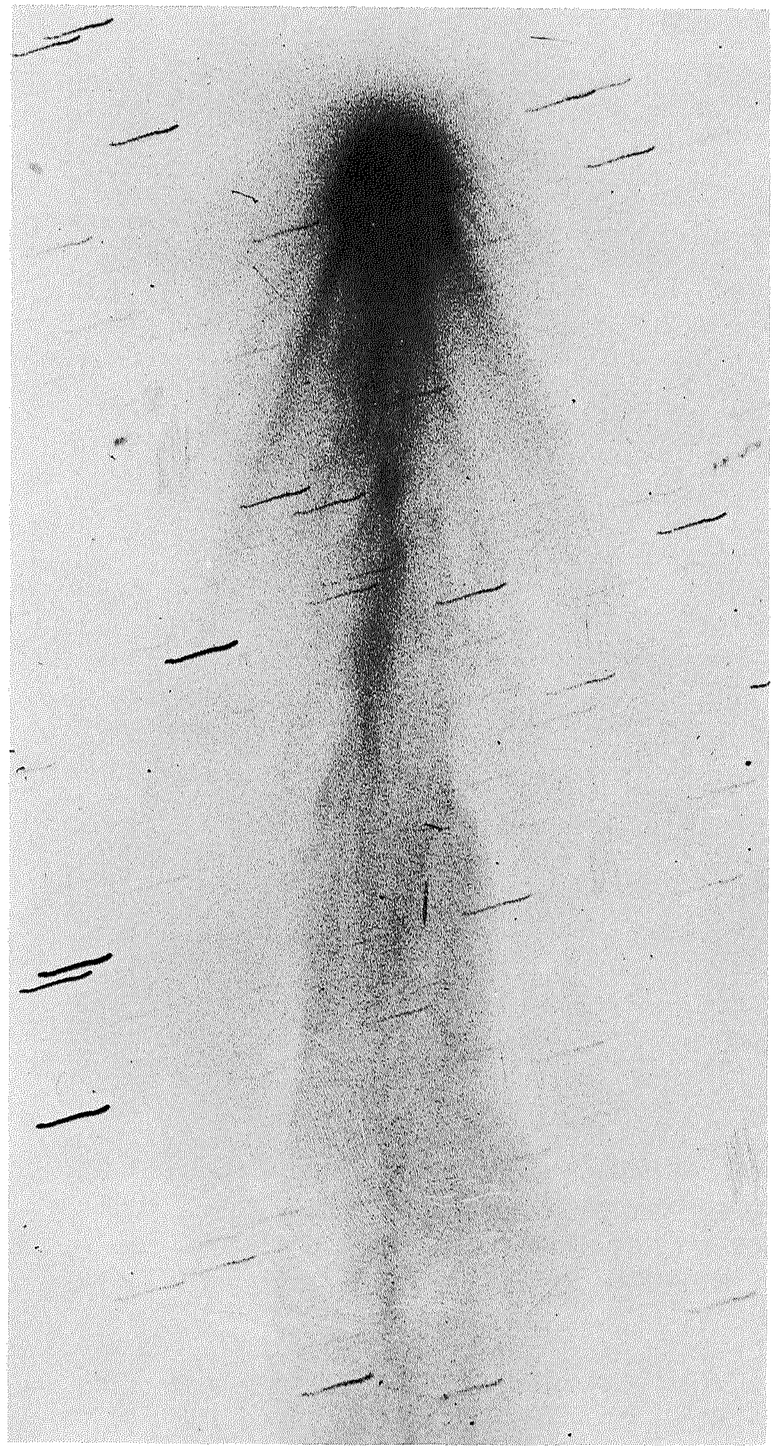

Fig. 6b: Detail of Fig. 6a; enlarged 6.0X; scale: 8.5×10^3 km/mm.

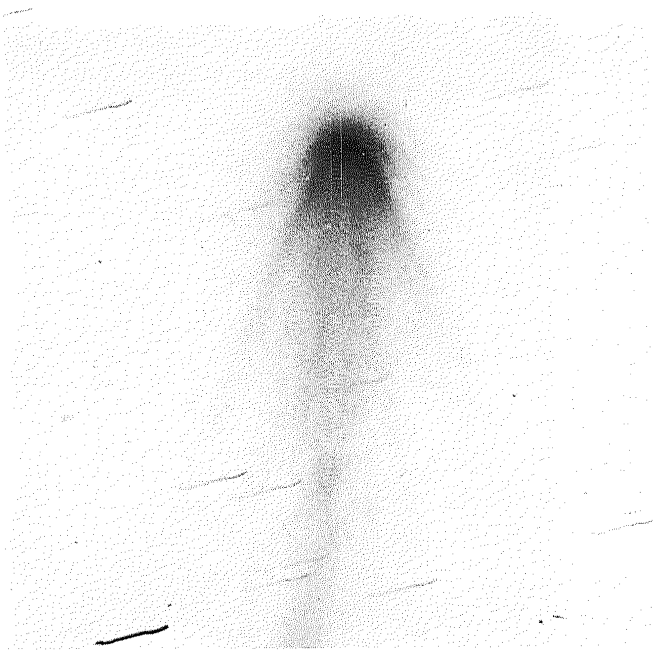

Fig. 6c.

Fig. 6d.

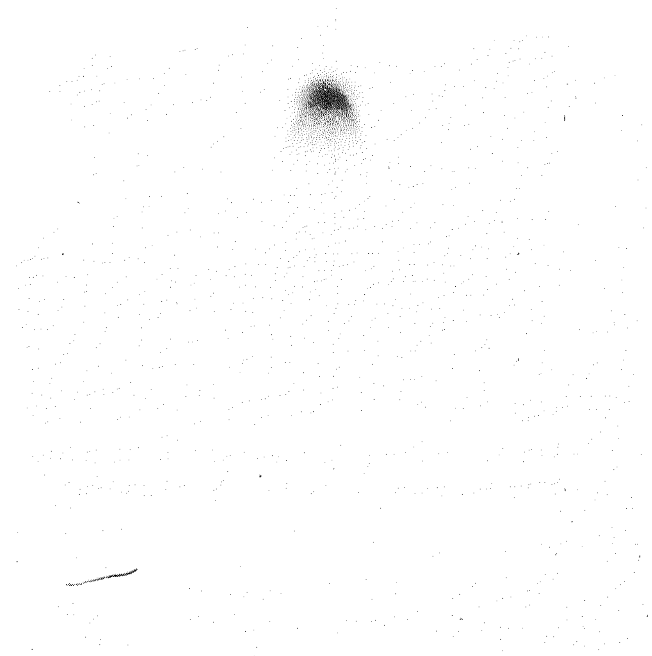

Fig. 6e.

Figs. 6c, 6d, 6e: Same photograph as Fig. 6b, printed to bring out greater detail closer to the nucleus.

Fig. 6f: Drawing based on Greenwich photograph of Sept. 30.177, enlarged about 18X; see Figs. 6a–6e.

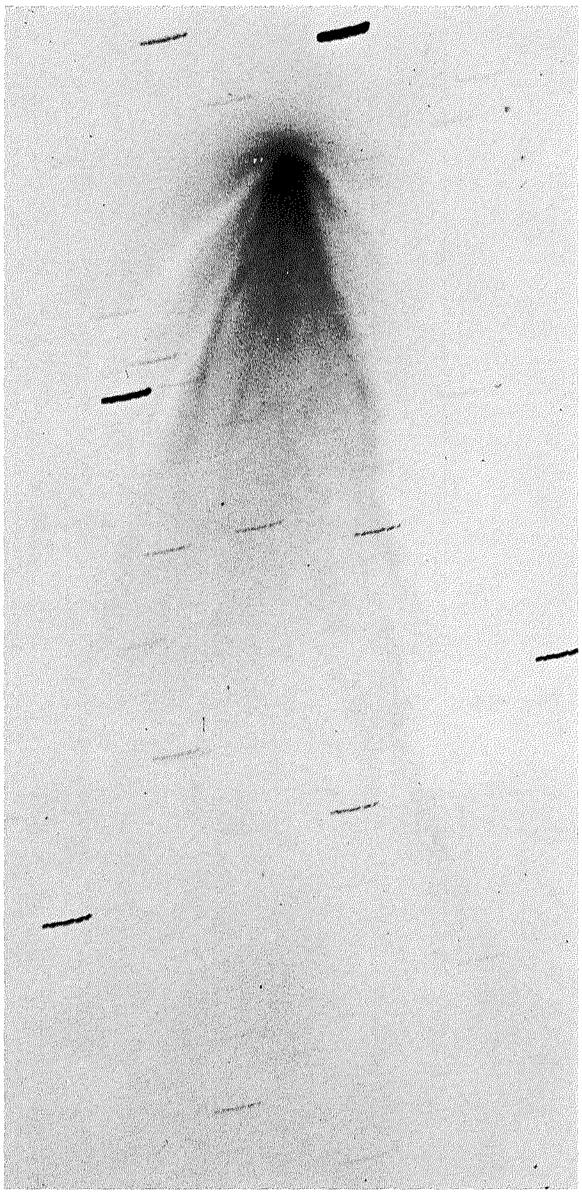

Fig. 7a: 1908 Sept. 30.877; exposure 15 minutes; r = 1.71, Δ = 1.15, α = 34°4; enlarged 6.0X; scale: 8.3×10^3 km/mm.

Fig. 7b: Same photograph as Fig. 7a, printed to bring out greater detail closer to the nucleus.

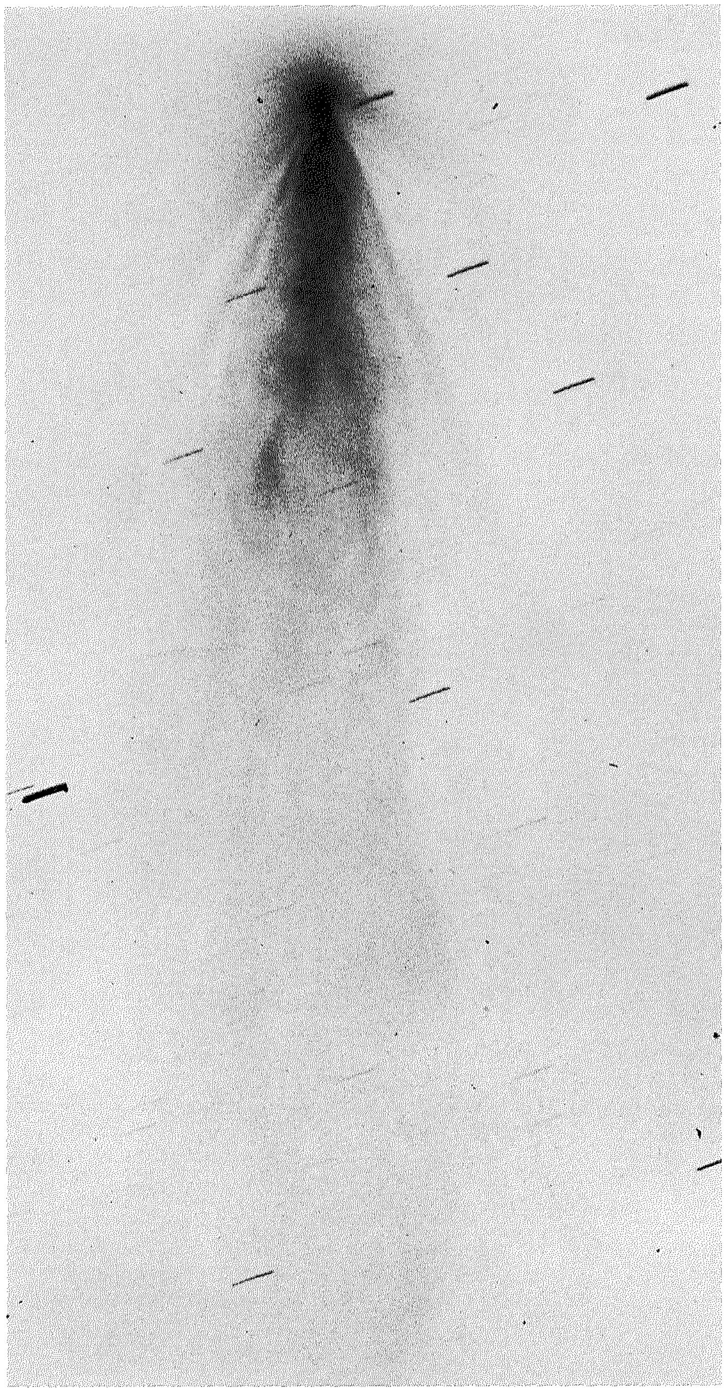

Fig. 8a: 1908 Oct. 1.074; exposure 16 minutes; r = 1.71, Δ = 1.15, α = 34°.5; enlarged 6.0X; scale: 8.3×10^3 km/mm.

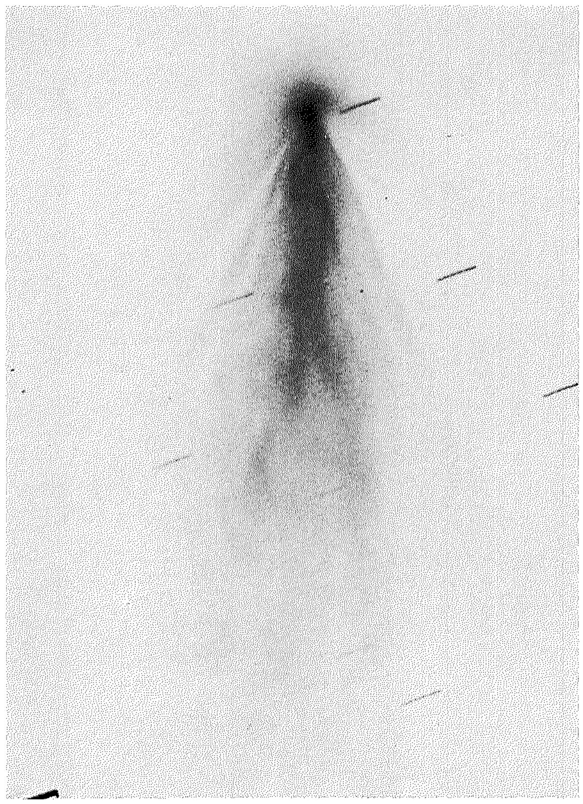

Fig. 8b.

Fig. 8c.

Figs. 8b, 8c: Same photograph as Fig. 8a, printed to bring out greater detail closer to the nucleus.

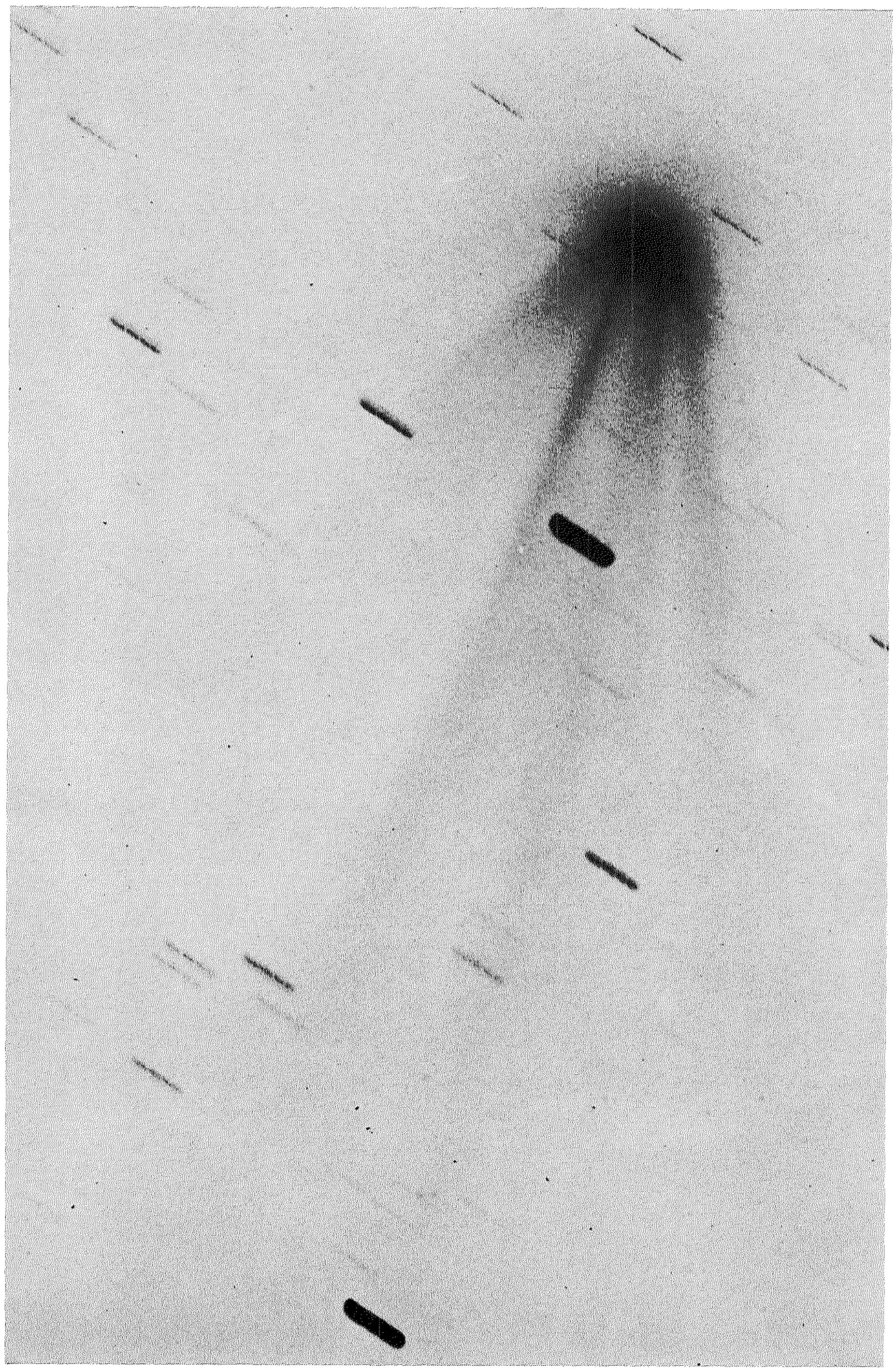

Fig. 9a: 1908 Oct. 3.804; exposure 15 minutes; $r = 1.68$, $\Delta = 1.11$, $\alpha = 35\overset{\circ}{.}3$; enlarged 8.0X; scale: 6.1×10^3 km/mm.

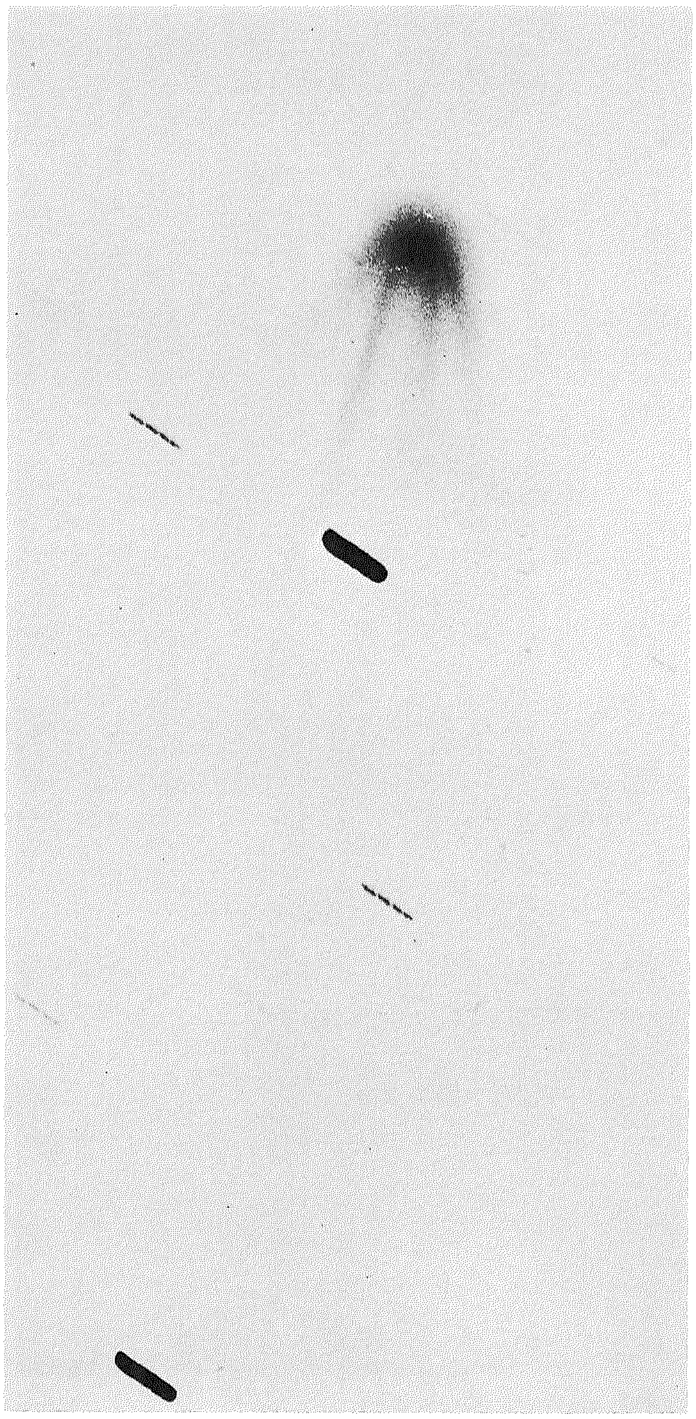

Fig. 9b.

Fig. 9c.

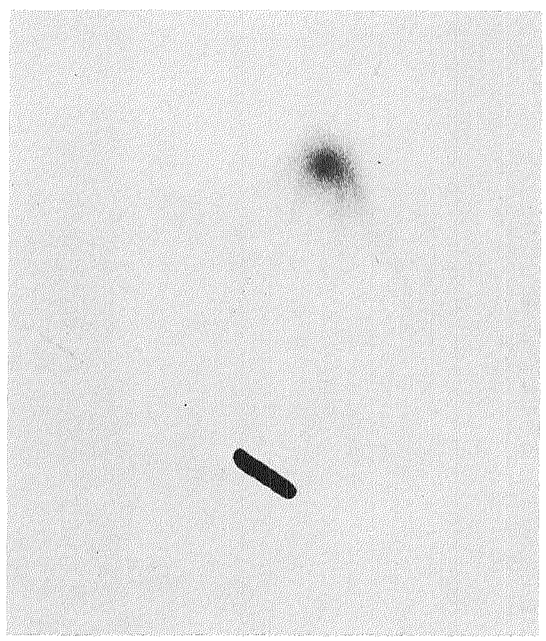

Fig. 9d.

Figs. 9b, 9c, 9d: Same photograph as Fig. 9a, printed to bring out greater detail closer to the nucleus.

Fig. 10a: 1908 Oct. 3.912; exposure 40 minutes; r = 1.67, Δ = 1.11, α = 35°.3; enlarged 8.0×; scale: 6.1 × 10^3 km/mm.

Fig. 10b.

Fig. 10c.

Figs. 10b, 10c: Same photograph as Fig. 10a, printed to bring out greater detail closer to the nucleus.

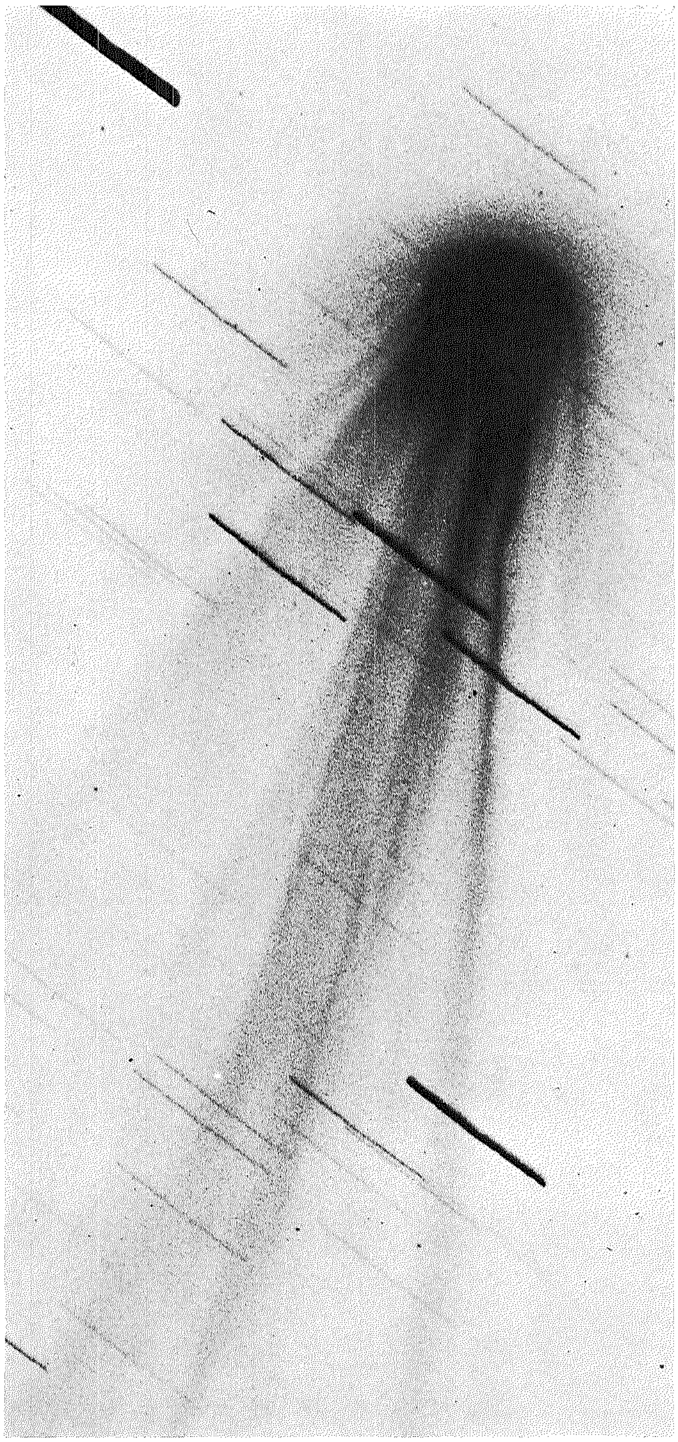

Fig. 11a: 1908 Oct. 3.980; exposure 40 minutes; $r = 1.67$, $\Delta = 1.11$, $\alpha = 35\overset{\circ}{.}3$; enlarged 8.0×; scale: 6.0×10^3 km/mm.

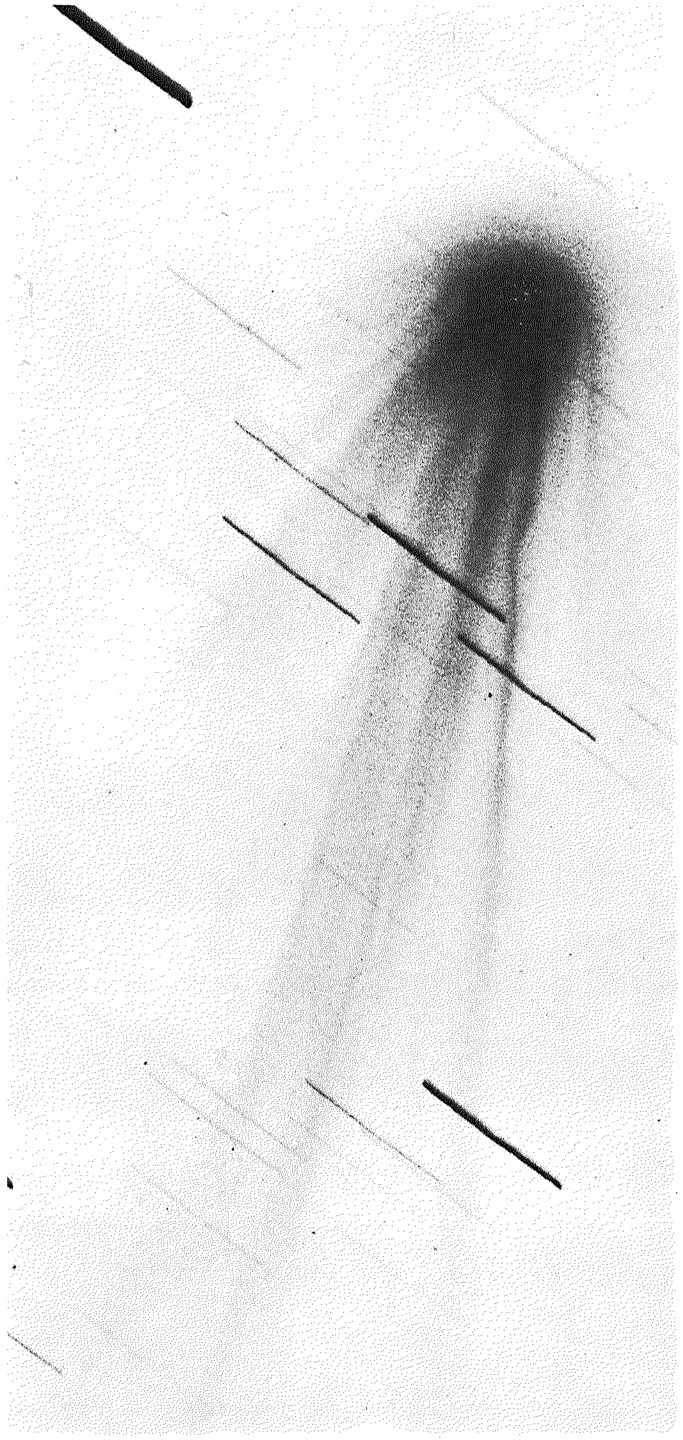

Fig. 11b: Same photograph as Fig. 11a, printed to bring out greater detail closer to the nucleus.

Fig. 11c.

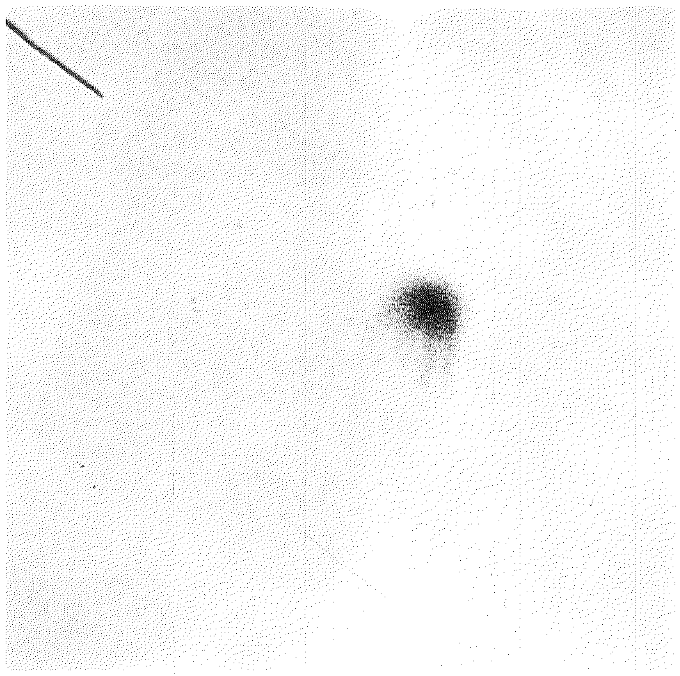

Fig. 11d.

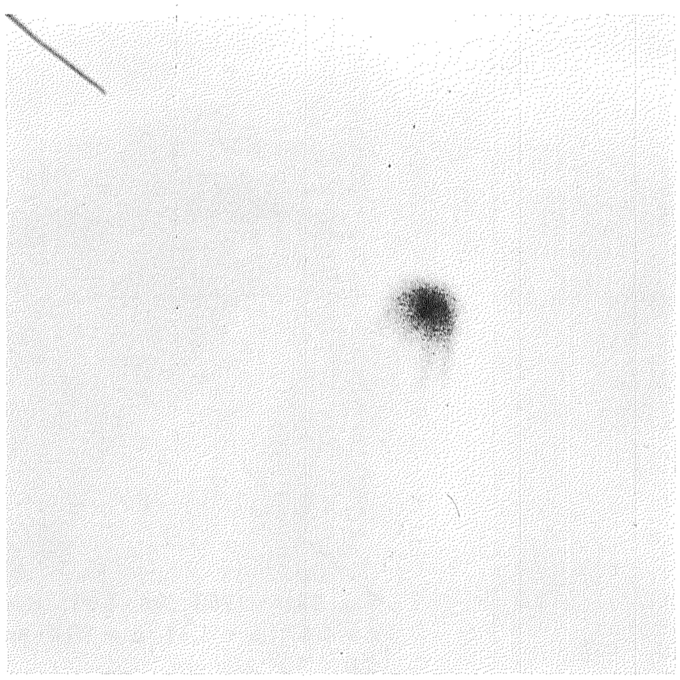

Fig. 11e.

Figs. 11c, 11d, 11e: Same photograph as Fig. 11a, printed to bring out greater detail closer to the nucleus.

Fig. 11f: Drawing based on Greenwich photograph of Oct. 3.980; enlarged about 24X; see Fig. 11a.

Fig. 12a: 1908 Oct. 4.051; exposure 38 minutes; r = 1.67, Δ = 1.11, α = 35$^\circ\!\!.$4; enlarged 8.0×; scale: 6.0 × 10^3 km/mm.

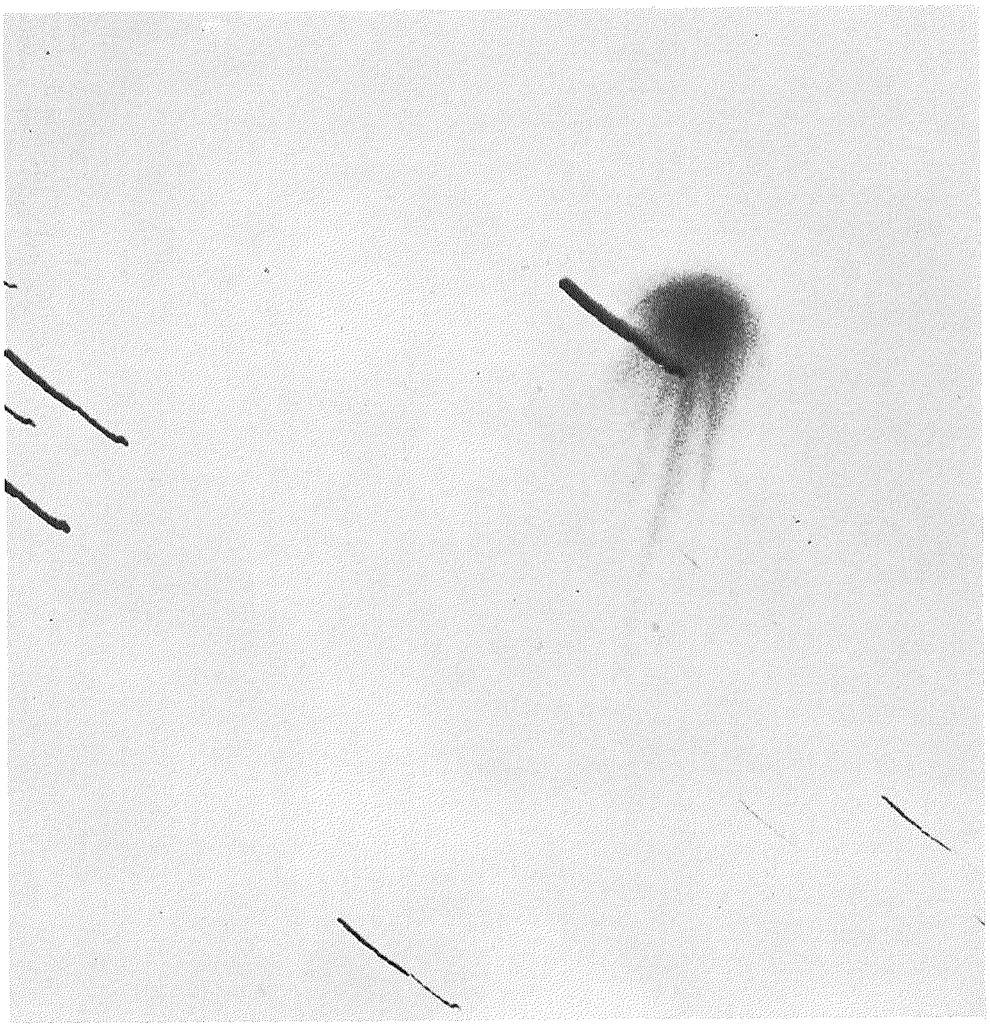

Fig. 12b.

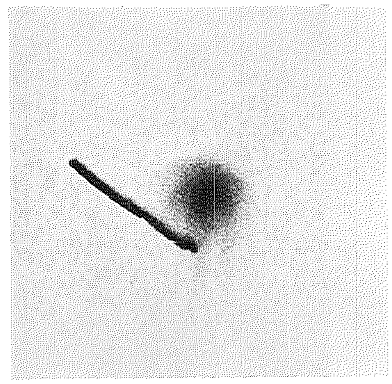

Fig. 12c.

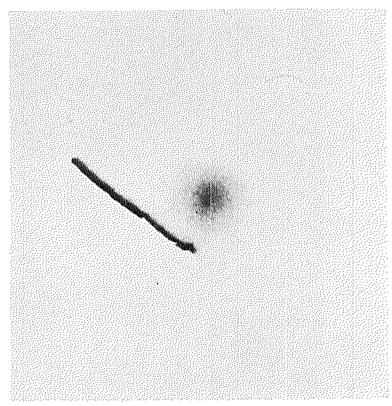

Fig. 12d.

Figs. 12b, 12c, 12d: Same photograph as Fig. 12a, printed to bring out greater detail closer to the nucleus.

Fig. 12e: Drawing based on Greenwich photograph of Oct. 4.051; enlarged about 24X; see Fig. 12a. Note the change in the initial direction of the tail particle outflow in less than two hours (Fig. 11f and Fig. 12e).

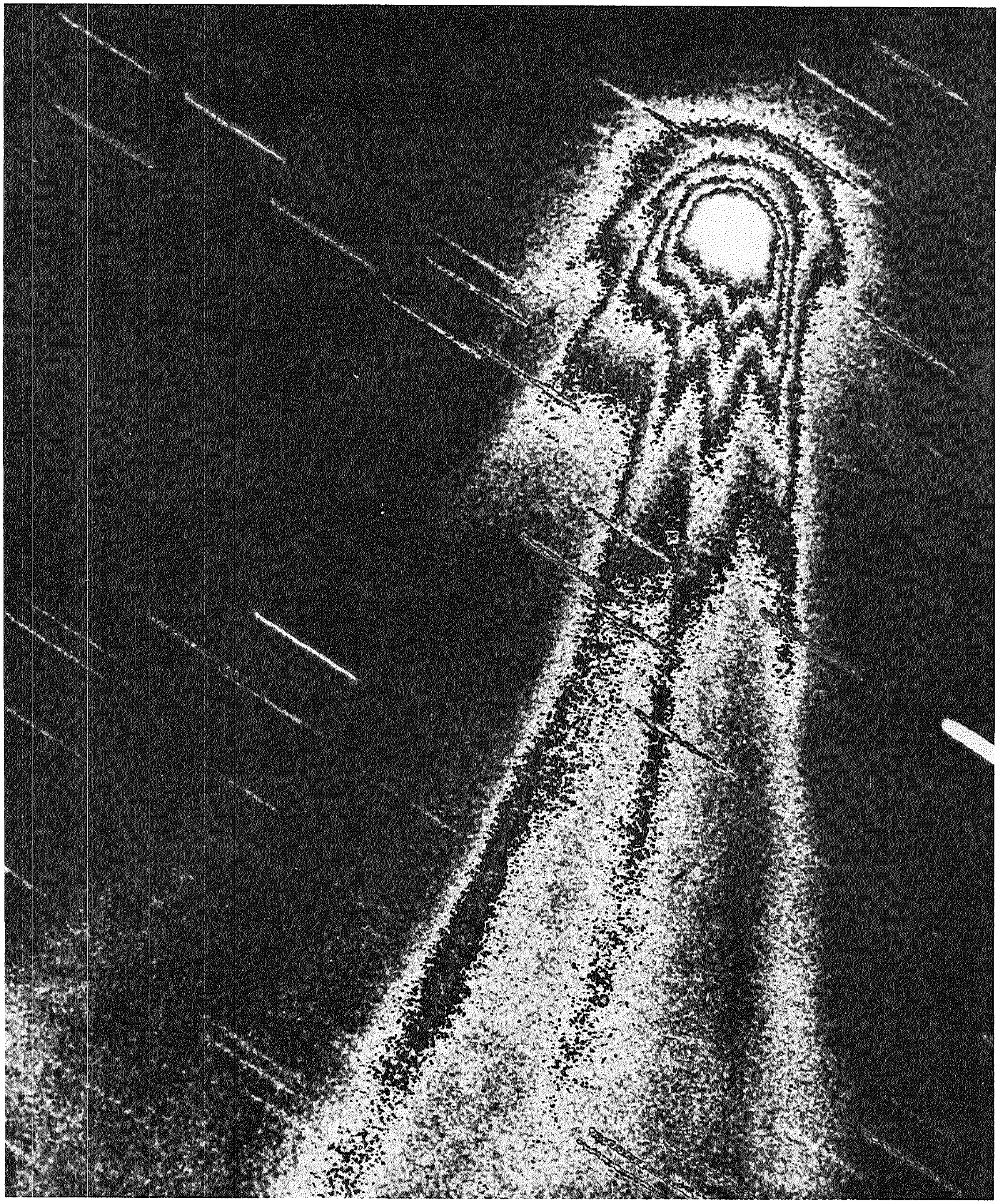

Fig. 13: Isodensitometer tracing of Greenwich photograph of 1908 Oct. 3.879; exposure of the original photograph, 30 minutes; r = 1.67, Δ = 1.11, α = 35°.3; enlarged 8.0×; scale: 6.1 × 10^3 km/mm.

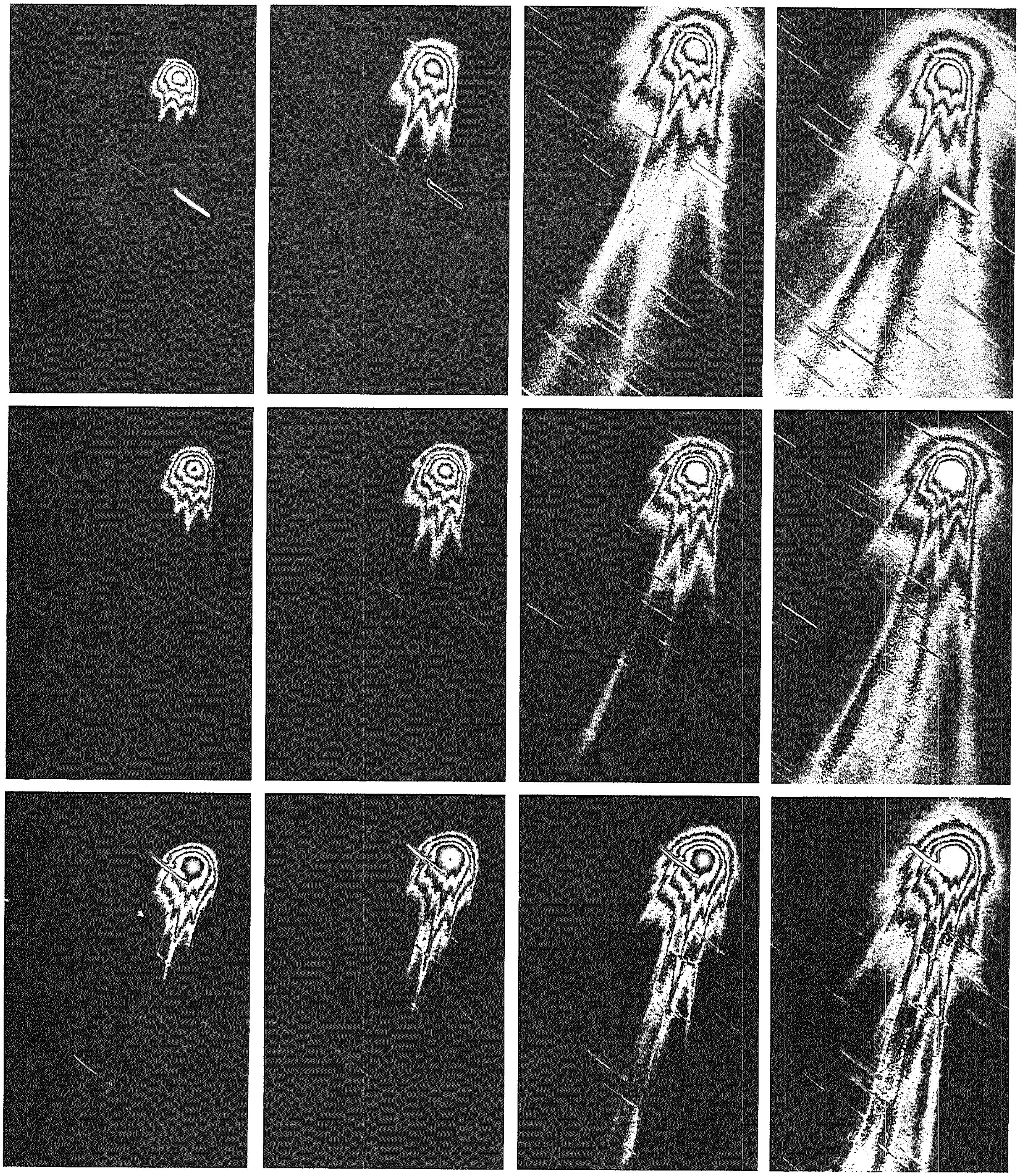

Fig. 14: Sequence of isodensitometer tracings of Greenwich photographs of Oct. 3.827 (top row), Oct. 3.879 (middle row; see also Fig. 13), and Oct. 4.051 (bottom row; see also Fig. 12a).

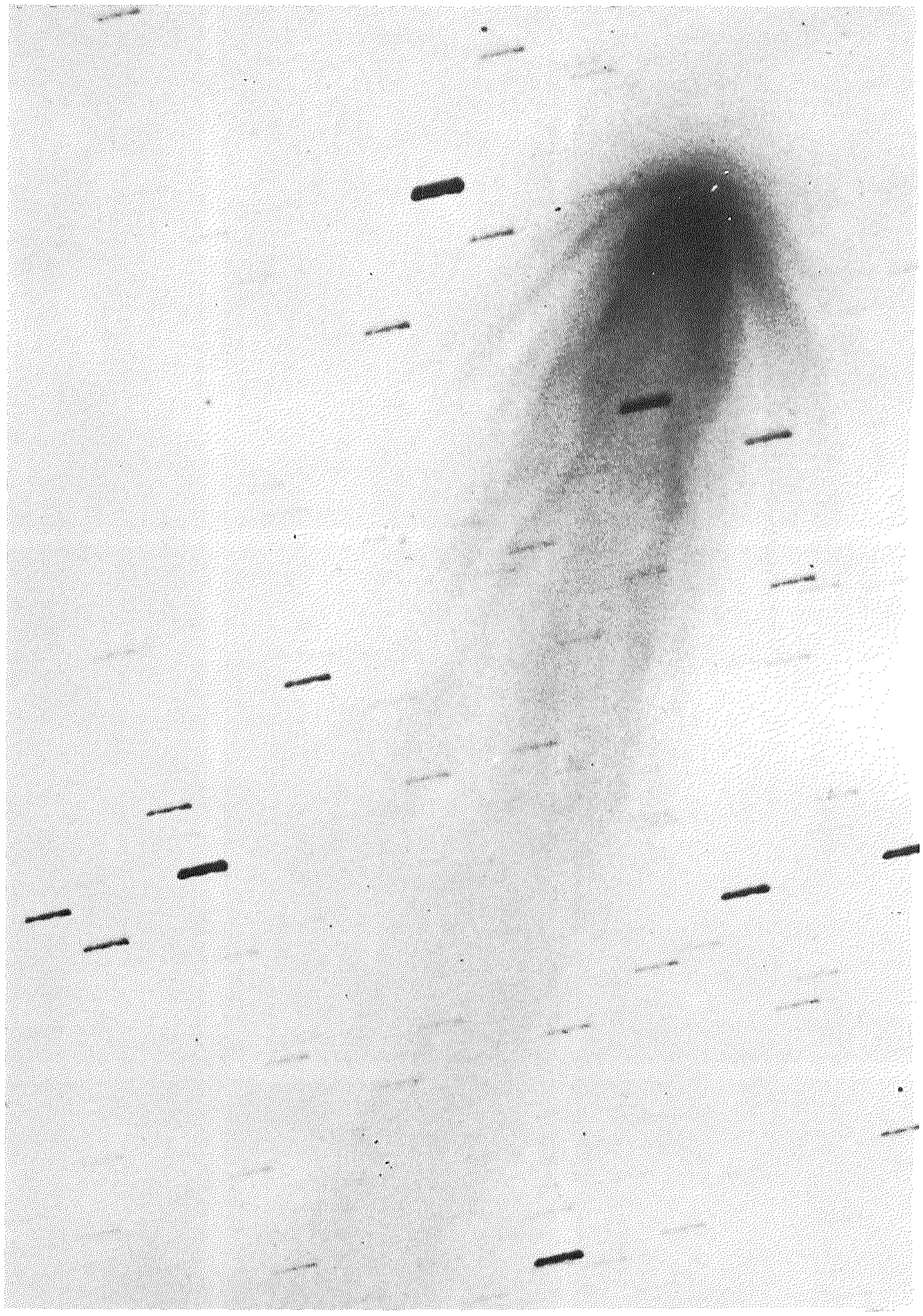

Fig. 15a: 1908 Oct. 21.847; exposure 11 minutes; r = 1.45, Δ = 1.05, α = 43°.2; enlarged 8.0×; scale: 5.7 × 10^3 km/mm.

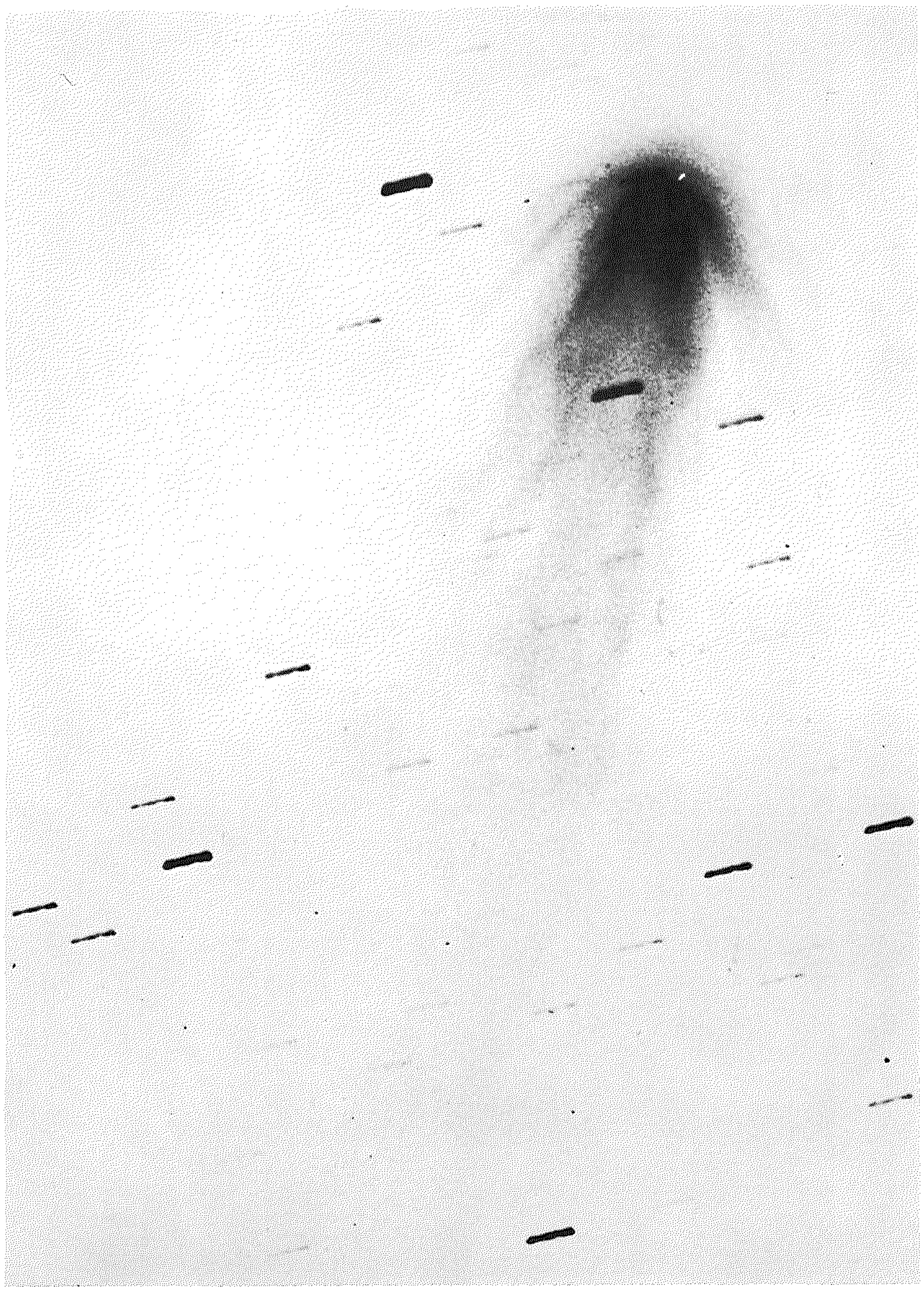

Fig. 15b: Same photograph as Fig. 15a, printed to bring out greater detail closer to the nucleus.

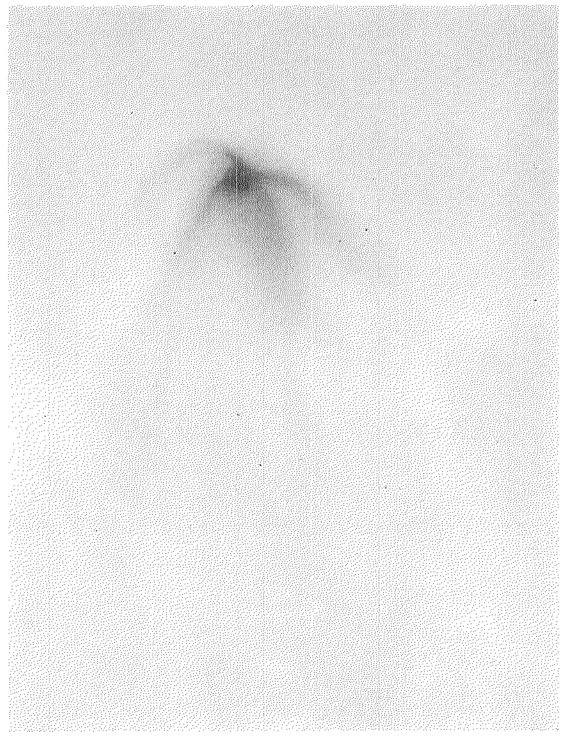

Fig. 15c: Drawing based on Greenwich photograph of Oct. 21.847; enlarged about 8X; see Fig. 15a.

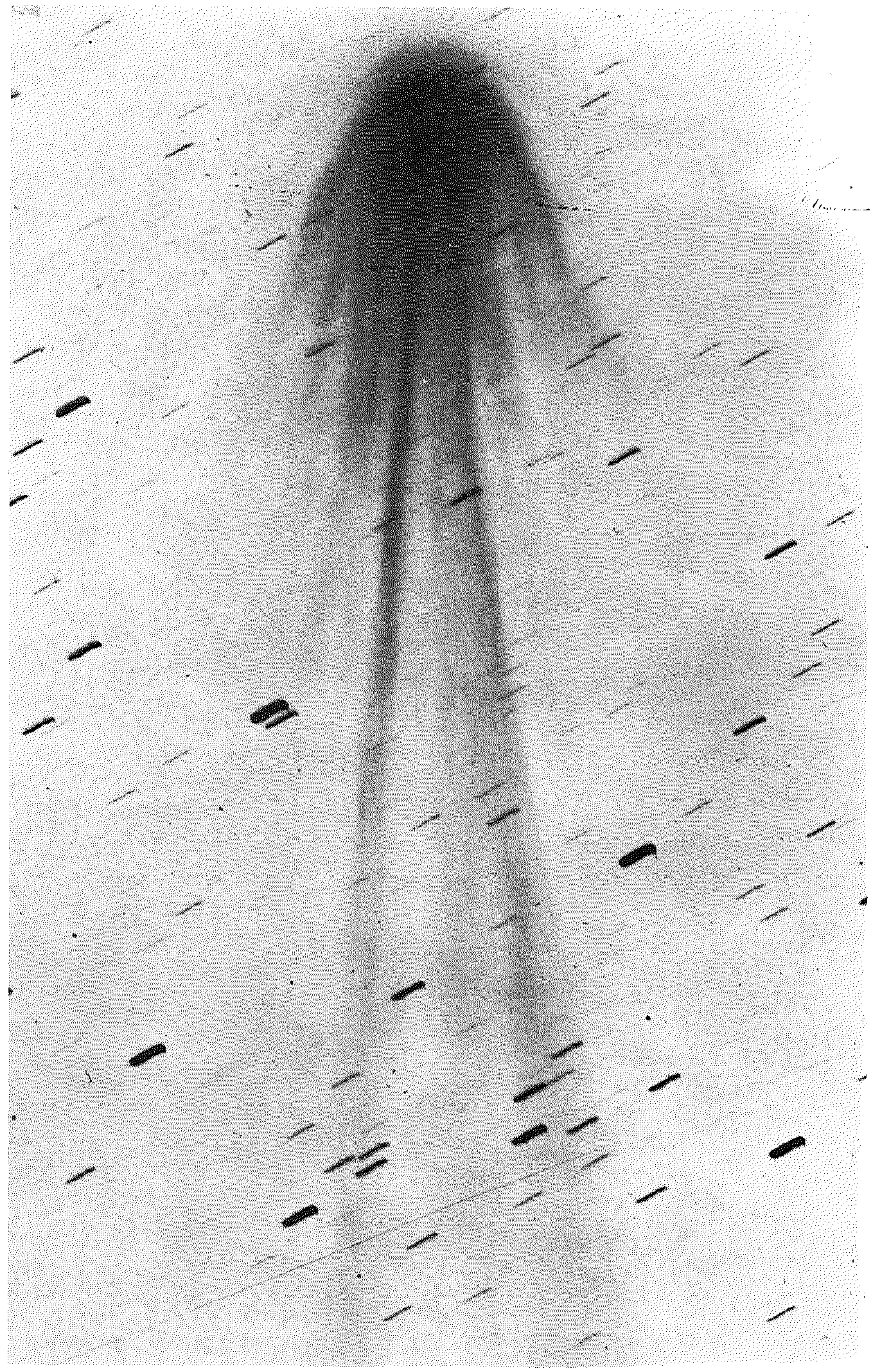

Fig. 16a: 1908 Oct. 23.798; exposure 10 minutes; r = 1.43, Δ = 1.06, α = 44°.0; enlarged 6.0×; scale: 7.7 × 10^3 km/mm.

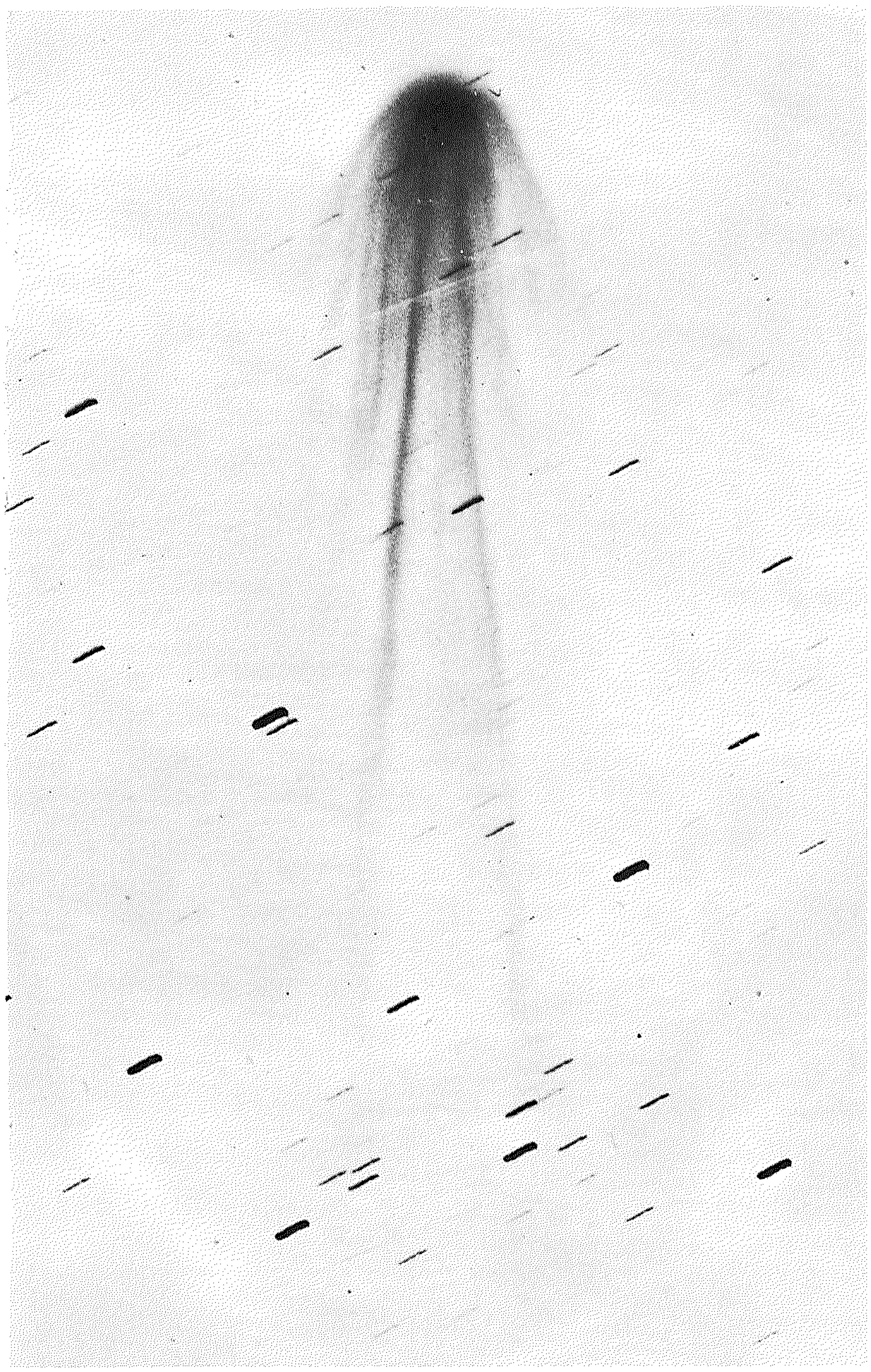

Fig. 16b.

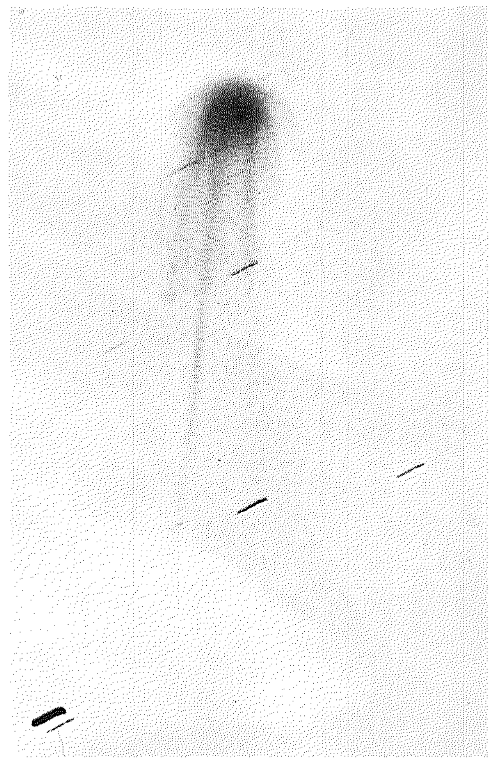

Fig. 16c.

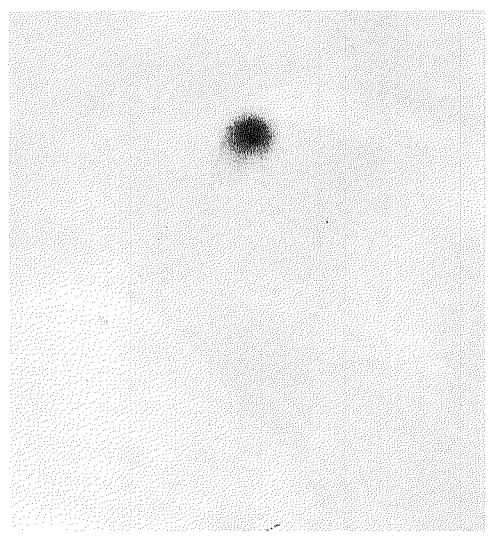

Fig. 16d.

Figs. 16b, 16c, 16d: Same photograph as Fig. 16a, printed to bring out greater detail closer to the nucleus.

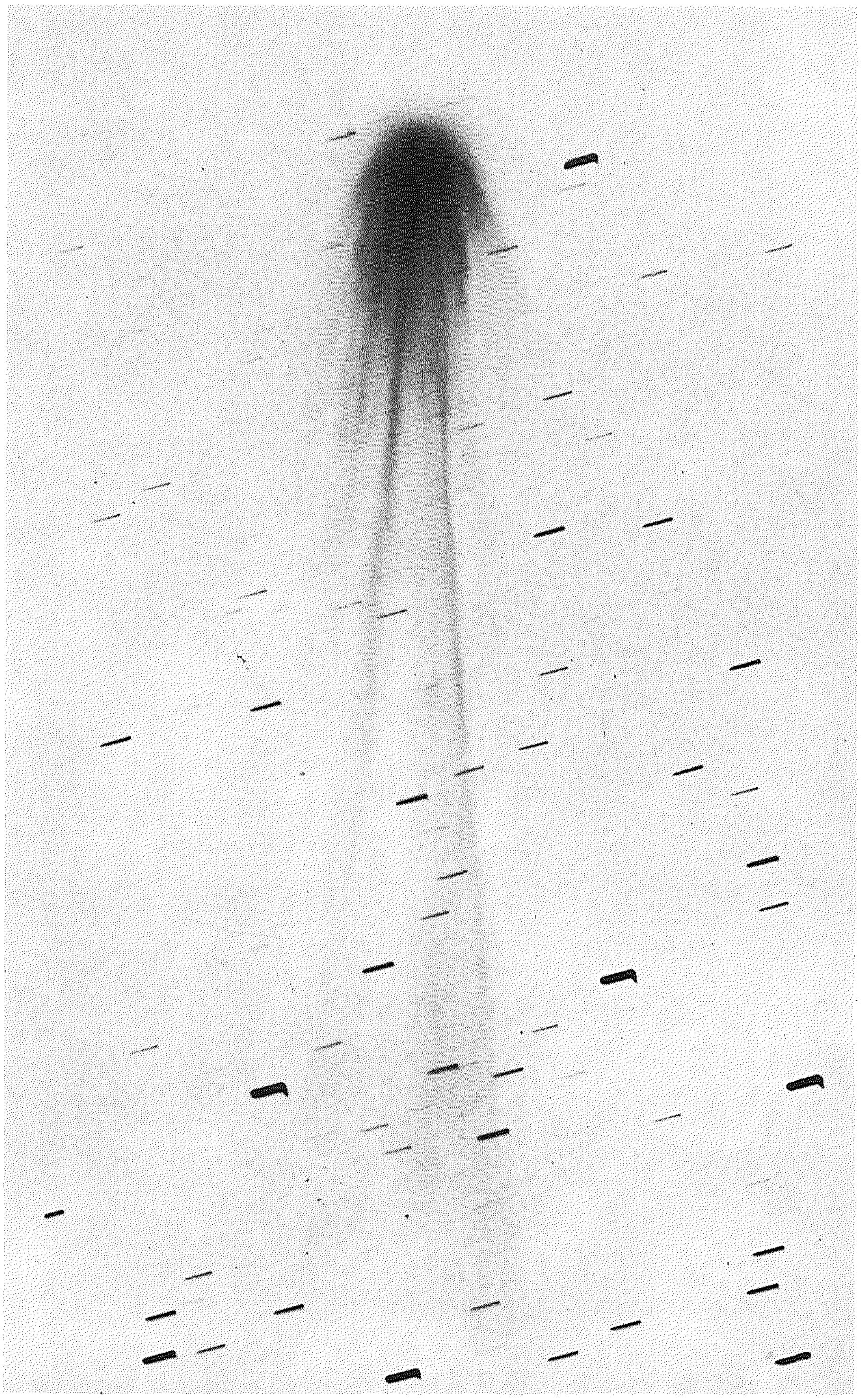

Fig. 17a: 1908 Oct. 23.883; exposure 10 minutes; r = 1.43, Δ = 1.06, α = 44°.0; enlarged 6.0X; scale: 7.7 X 10^3 km/mm.

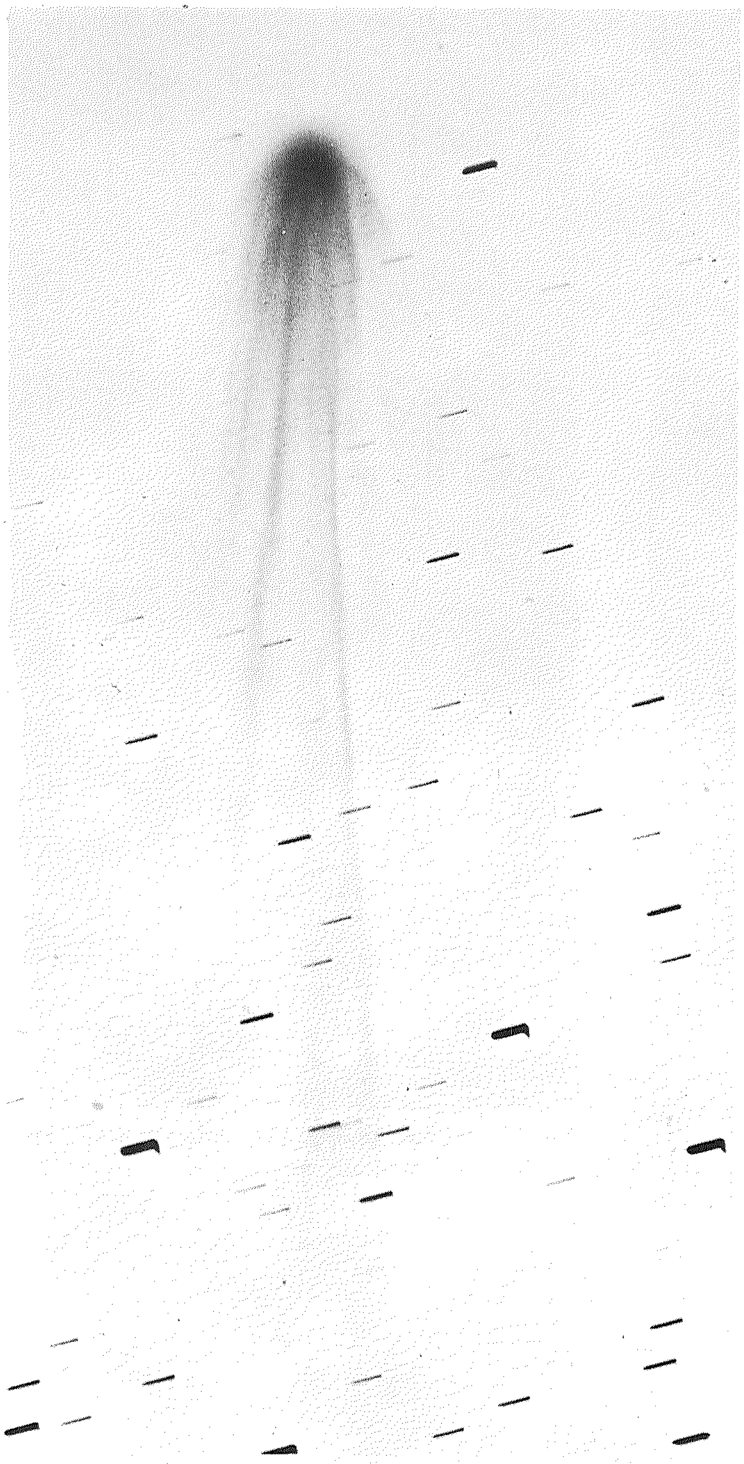

Fig. 17b.

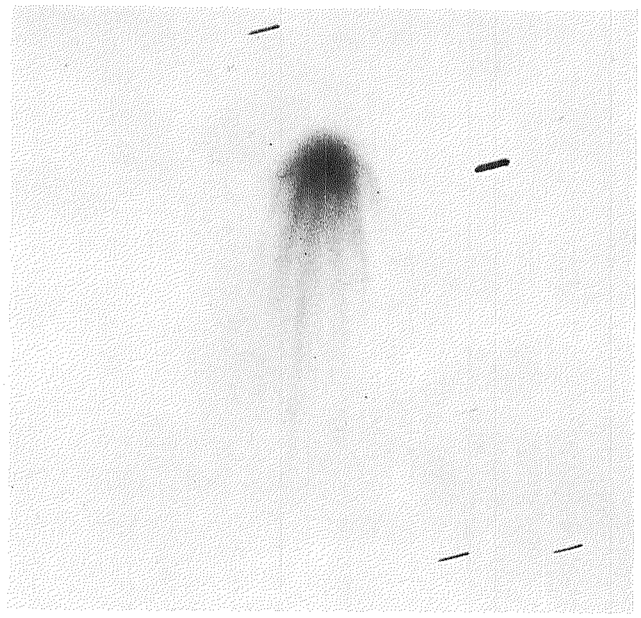

Fig. 17c.

Fig. 17d.

Figs. 17b, 17c, 17d: Same photograph as Fig. 17a, printed to bring out greater detail closer to the nucleus.

Fig. 18b: Detail of Fig. 18a; enlarged 4.4X; scale: 1.3×10^4 km/mm.

Fig. 18a: 1908 Nov. 12.777; exposure 14 minutes; $r = 1.21$, $\Delta = 1.32$, $\alpha = 45°8$; enlarged 2.1X; scale: 2.7×10^4 km/mm

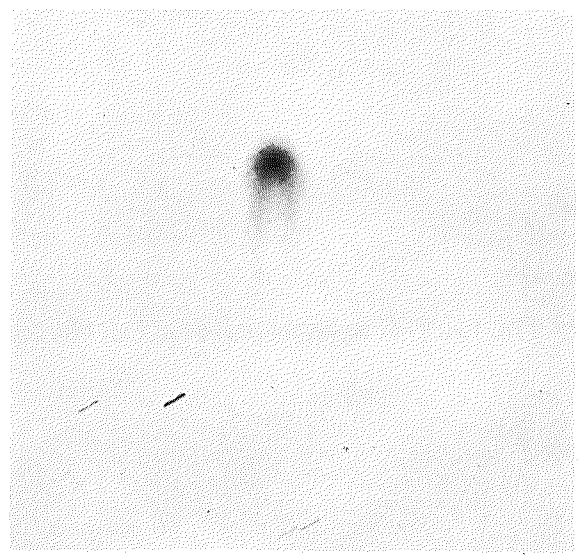

Fig. 18c: Detail of Fig. 18a; enlarged 4.4X; scale: 1.3×10^4 km/mm.

Fig. 19: 1908 Nov. 17.748; exposure 15 minutes; r = 1.16, Δ = 1.41, α = 44°.1; enlarged 6.0X; scale: 1.0×10^4 km/mm.

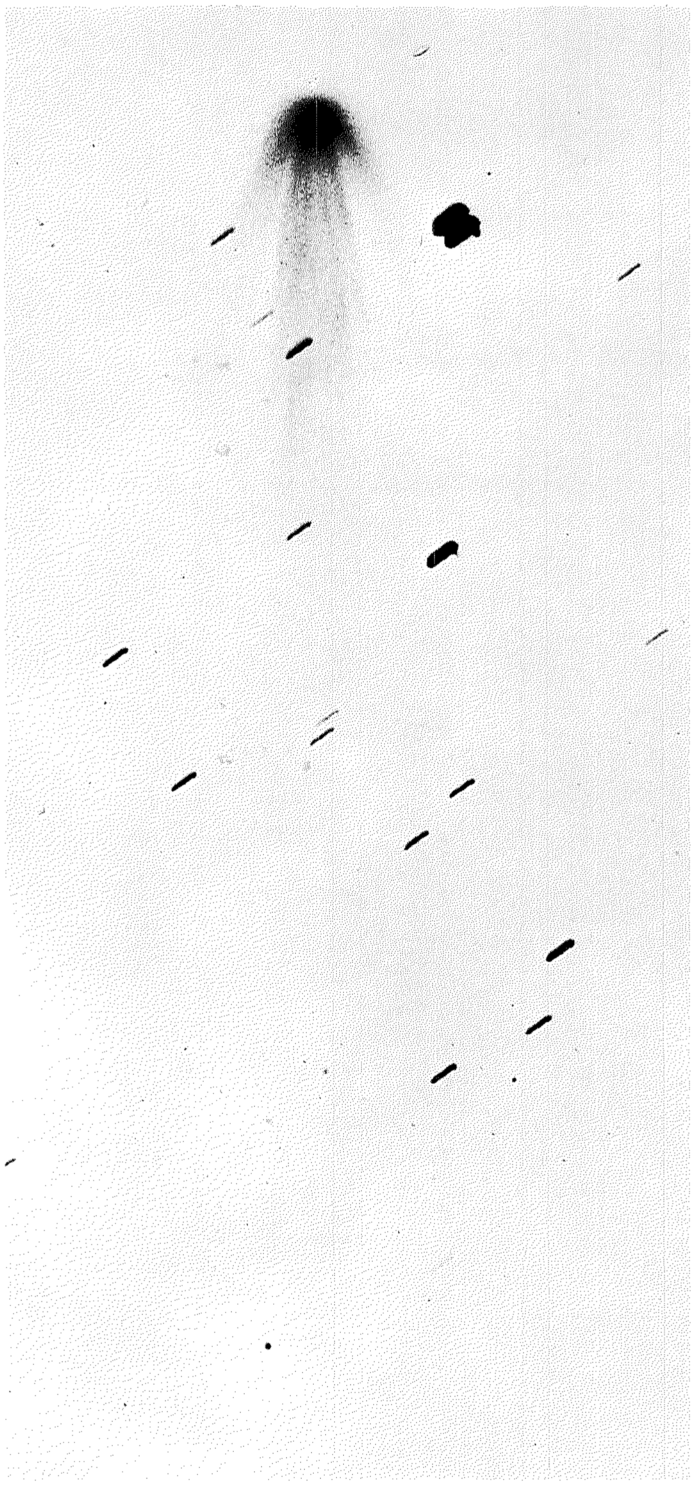

Fig. 20: 1908 Nov. 17.771; exposure 15 minutes; r = 1.16, Δ = 1.41, α = 44°.0; enlarged 6.0X; scale: 1.0×10^4 km/mm.

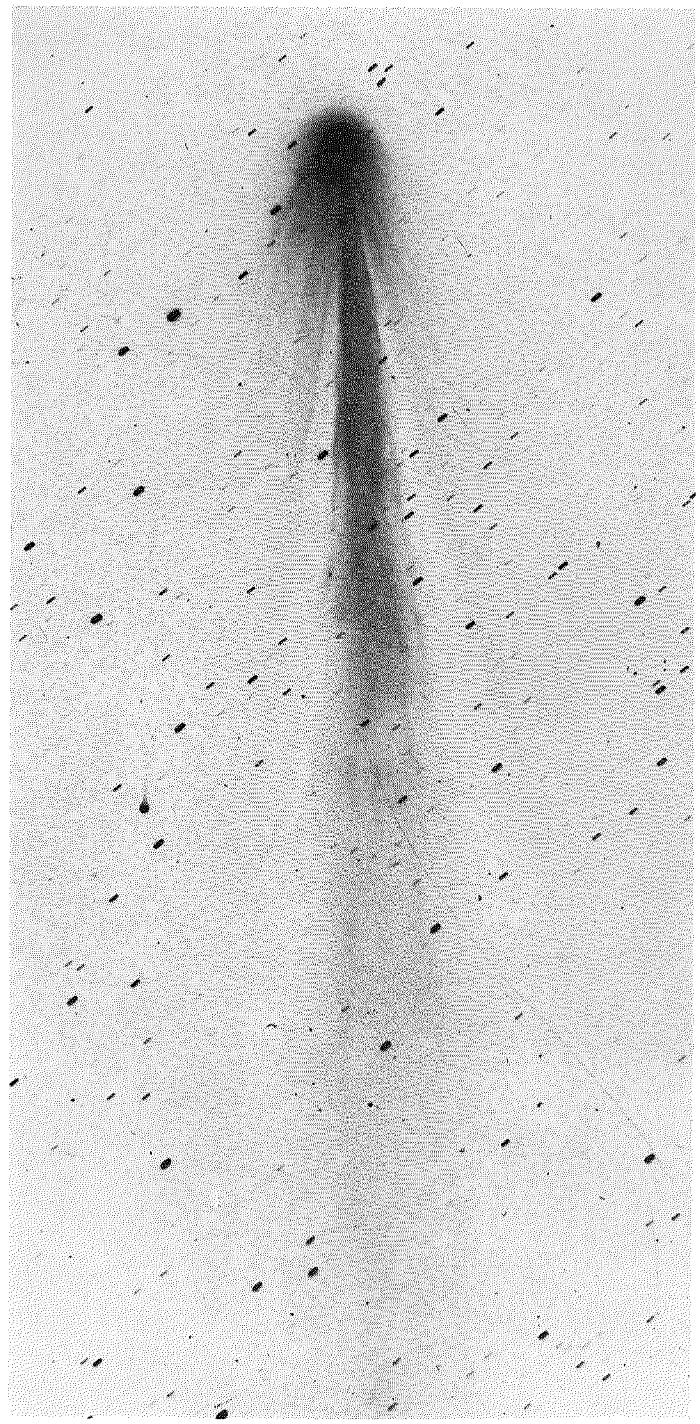

Fig. 21: 1908 Nov. 22.748; exposure 20 minutes; $r = 1.11$, $\Delta = 1.49$, $\alpha = 41^{\circ}.5$; enlarged 1.7×; scale: 3.8×10^4 km/mm.

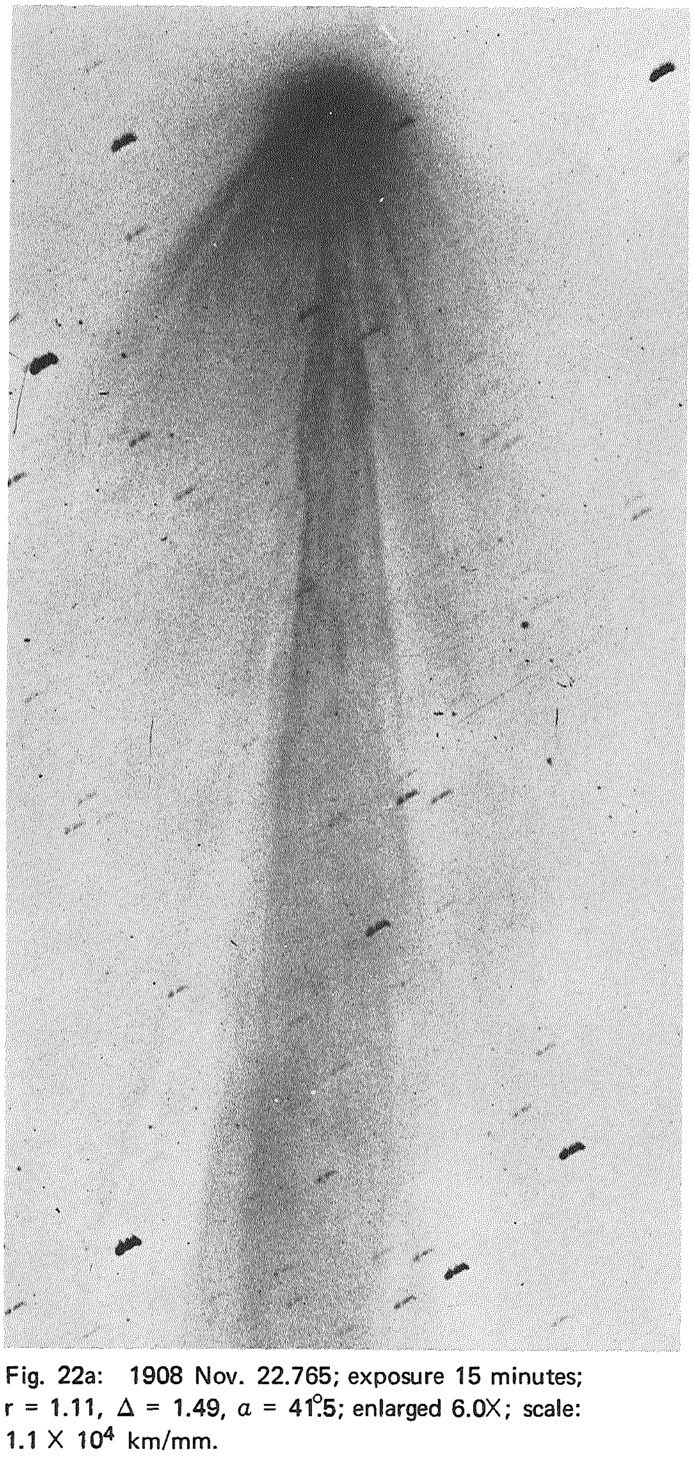

Fig. 22a: 1908 Nov. 22.765; exposure 15 minutes; r = 1.11, Δ = 1.49, α = 41°.5; enlarged 6.0X; scale: 1.1 X 10^4 km/mm.

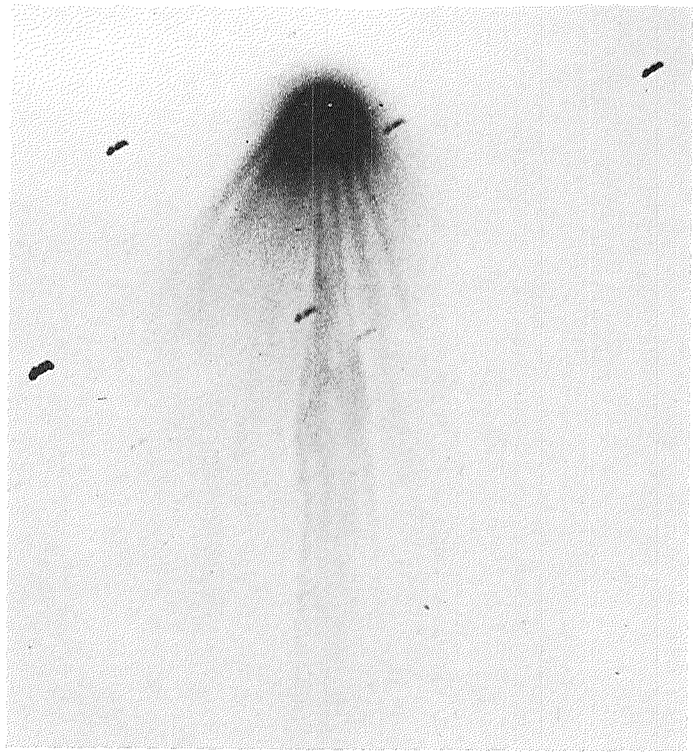

Fig. 22b.

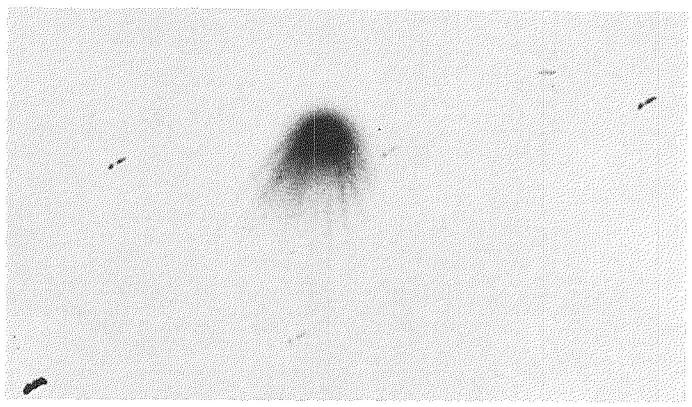

Fig. 22c.

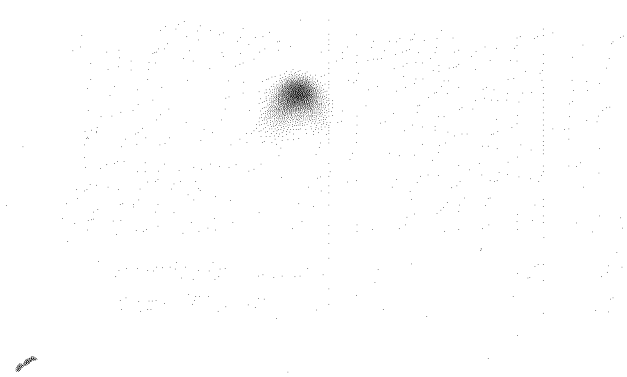

Fig. 22d.

Figs. 22b, 22c, 22d: Same photograph as Fig. 22a, printed to bring out greater detail closer to the nucleus.

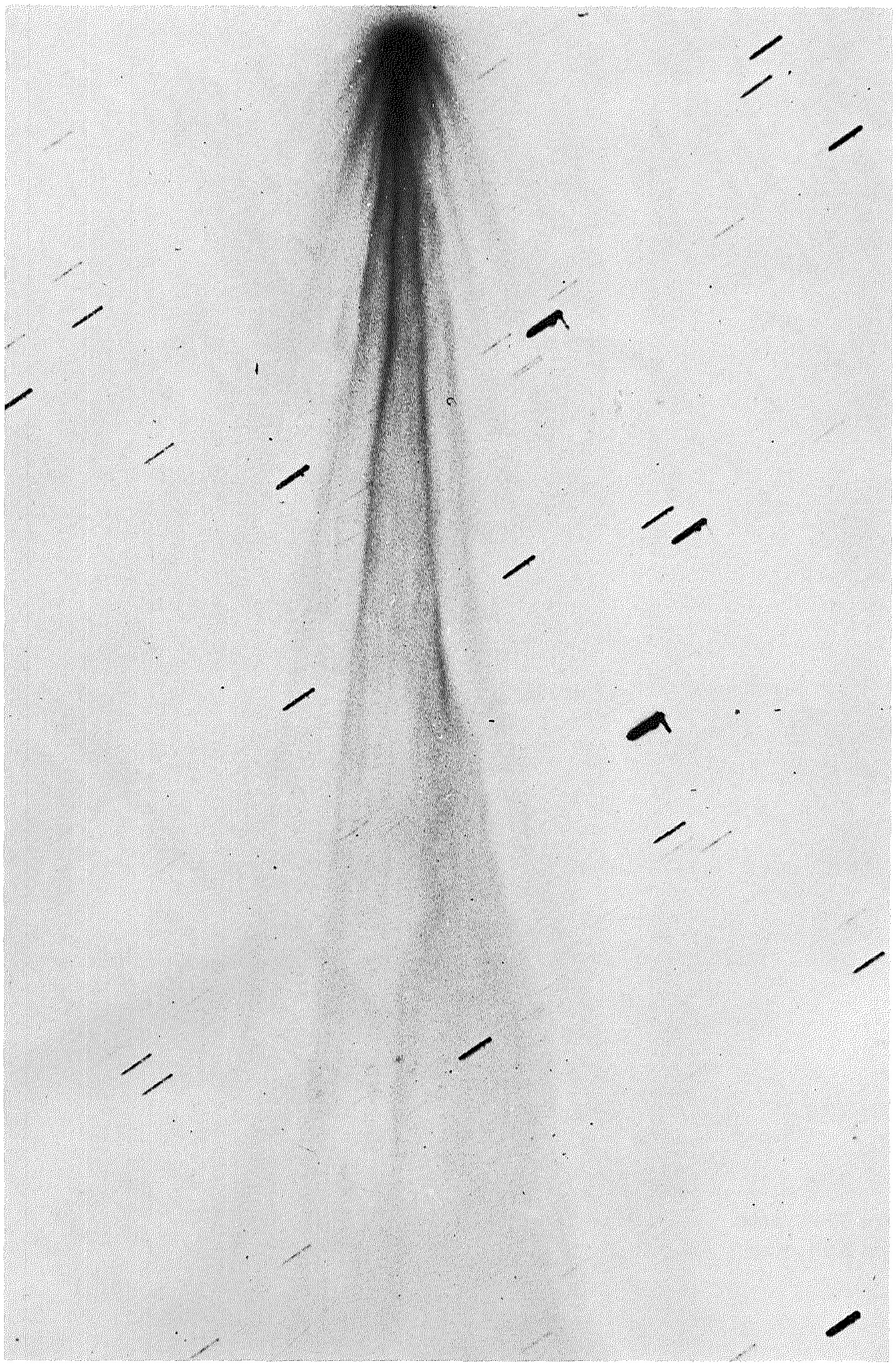

Fig. 23a: 1908 Nov. 19.754; exposure 30 minutes; r = 1.14, Δ = 1.44, α = 43°.1; enlarged 4.6X; scale: 1.4 X 10^4 km/mm.

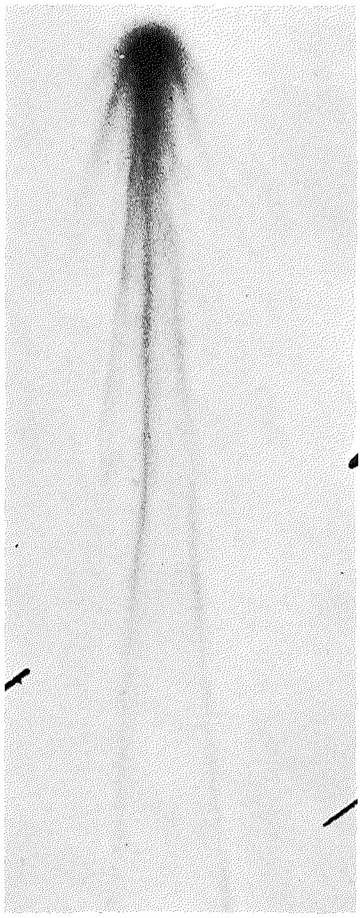

Fig. 23b: Detail of Fig. 23a; enlarged 6.0X; scale: 1.0 X 10^4 km/mm.

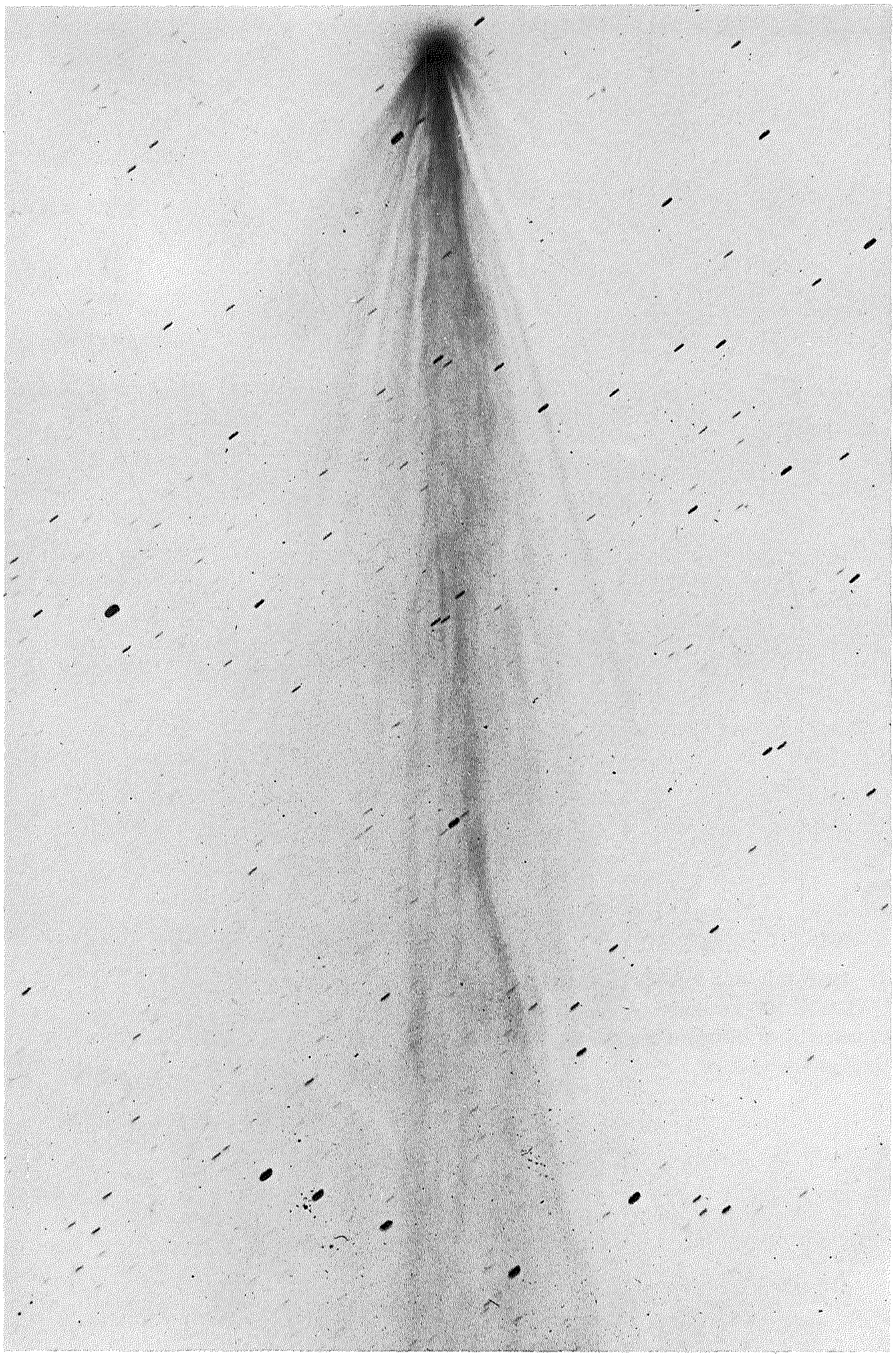

Fig. 24: 1908 Nov. 25.748; exposure 15 minutes; r = 1.09, Δ = 1.54, α = 39°.5; enlarged 2.5X; scale: 2.7 X 10^4 km/mm.

COMET HALLEY
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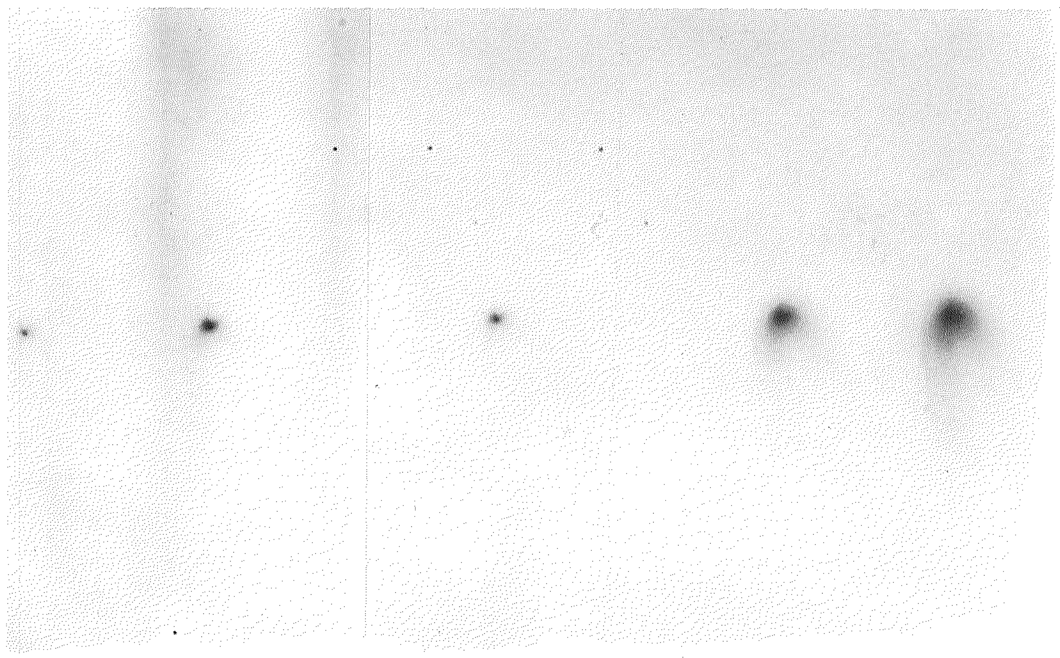


Fig. 1: 1910 May 8; r = 0.70, Δ = 0.54, α = 108°.2; scale: 1.1 × 10^4 km/mm. A sequence of photographs taken with different exposures. Duration of exposures unknown.

Photographs taken by C. O. Lampland with 42-inch reflector, Lowell Observatory, Flagstaff, Arizona, U.S.A.

Fig. 2: 1910 May 10.076; exposure 8 minutes; r = 0.73, Δ = 0.46, α = 115°.1; enlarged 1.5X; scale: 1.3 X 10^4 km/mm.

Fig. 3: 1910 May 11.077; exposure 7 minutes; r = 0.74, Δ = 0.42, α = 118°.8; enlarged 1.5X; scale: 1.2 X 10^4 km/mm.

Photographs taken by H. Knox Shaw with 30-inch reflector, Khedivial Observatory, Helwan, Egypt.

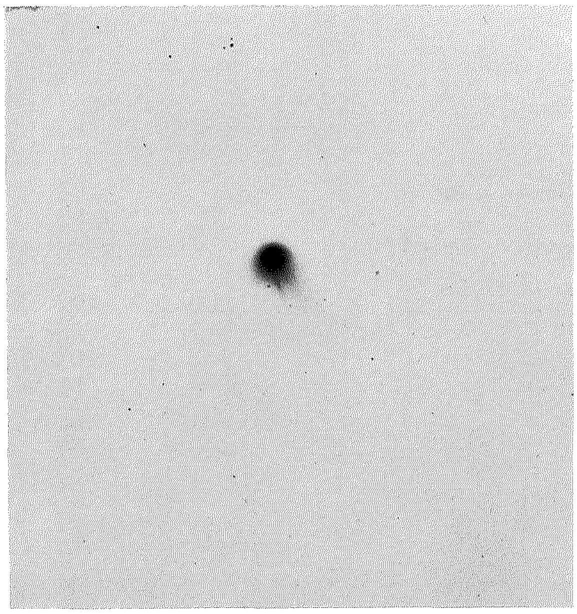


Fig. 4: 1910 May 15.074; exposure 6 minutes; r = 0.79, $\Delta = 0.27$, $\alpha = 138\overset{\circ}{.}3$; enlarged 1.5X; scale: 7.7 X 10^3 km/mm.

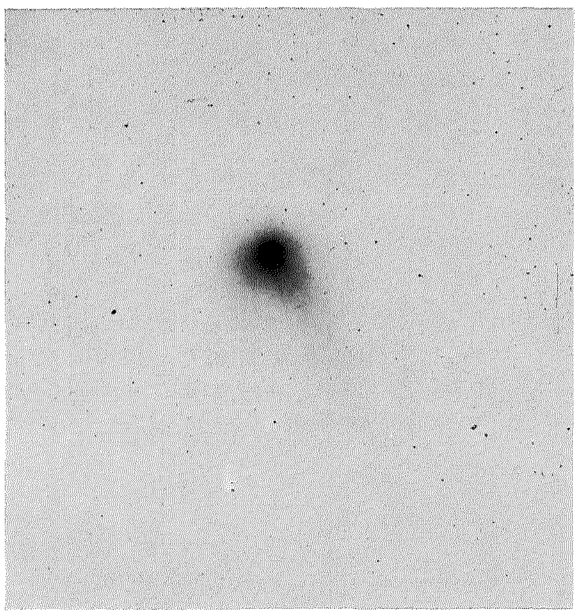


Fig. 5a: 1910 May 15.079; exposure 1 minute; r = 0.79, $\Delta = 0.27$, $\alpha = 138\overset{\circ}{.}3$; enlarged 1.5X; scale: 7.7 X 10^3 km/mm.

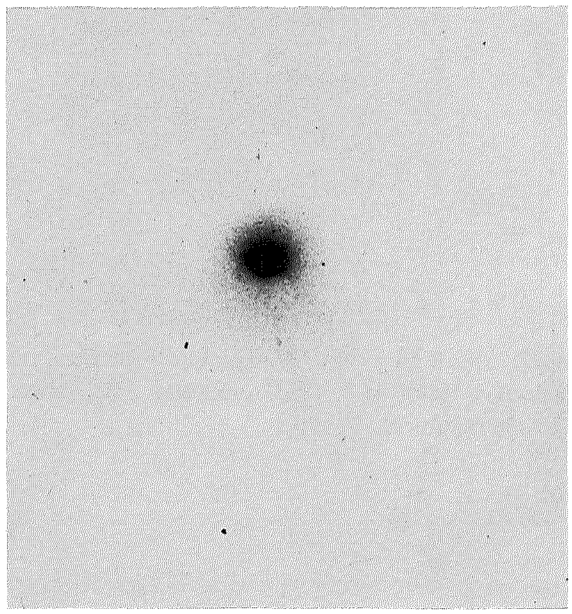


Fig. 5b: Detail of Fig. 5a; enlarged 6.3X; scale: 1.9 X 10^3 km/mm.

Photographs taken by H. Knox Shaw with 30-inch reflector, Khedivial Observatory, Helwan, Egypt

Fig. 5c: Drawing based on Helwan photograph of May 15.079; enlarged about 3X; see Fig. 5a.

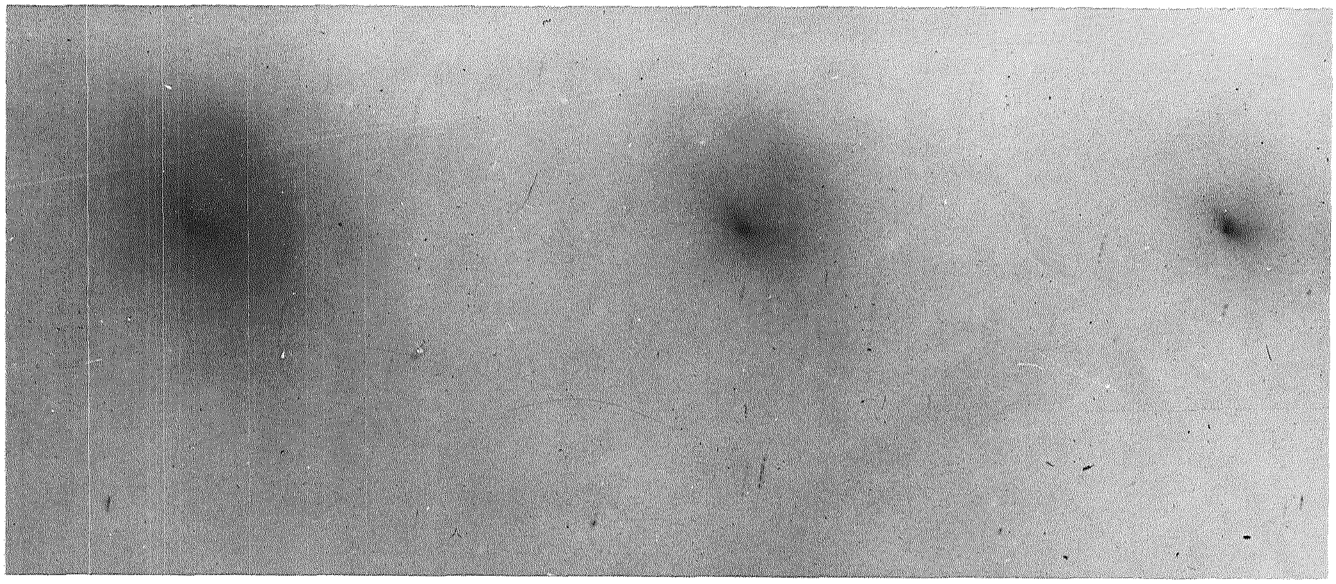


Fig. 6: 1910 May 22.153; exposures (left to right) 2, 1, 0.5 minutes; r = 0.89, Δ = 0.17, α = 132°.2; enlarged 2.2X; scale: 1.7×10^3 km/mm.

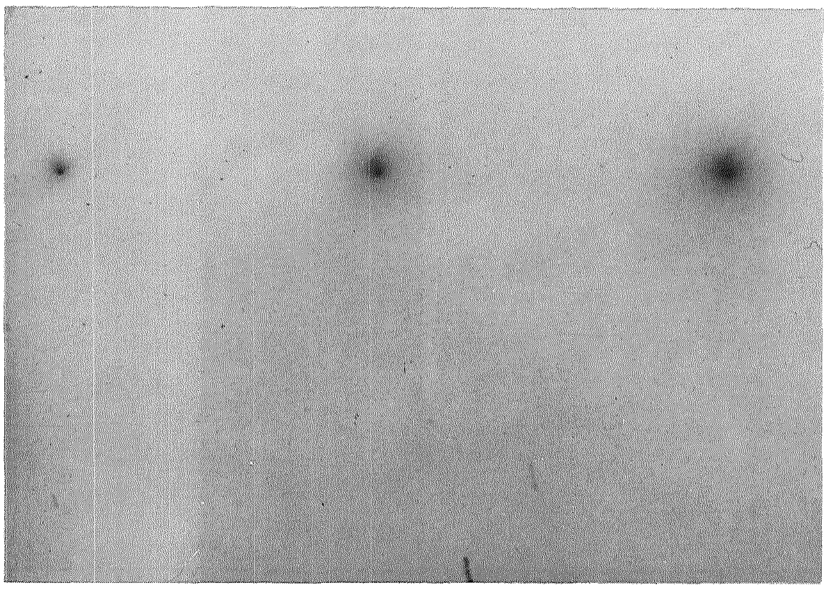


Fig. 7a: 1910 May 23.174; exposures (left to right) 40, 80, 120 seconds; r = 0.91, Δ = 0.19, α = 119°.1; enlarged 1.3X; scale: 3.2×10^3 km/mm.

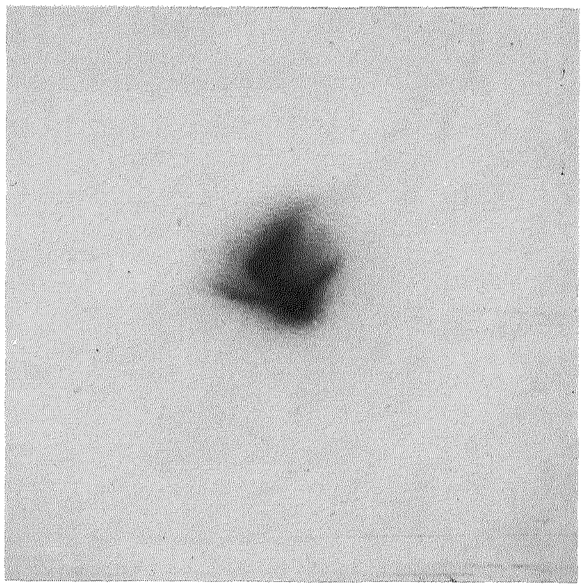


Fig. 7b: Drawing based on Lowell photograph of May 23.174; enlarged about 6X; see Fig. 7a.

Photographs taken by C. O. Lampland with 42-inch reflector, Lowell Observatory, Flagstaff, Arizona, U.S.A.

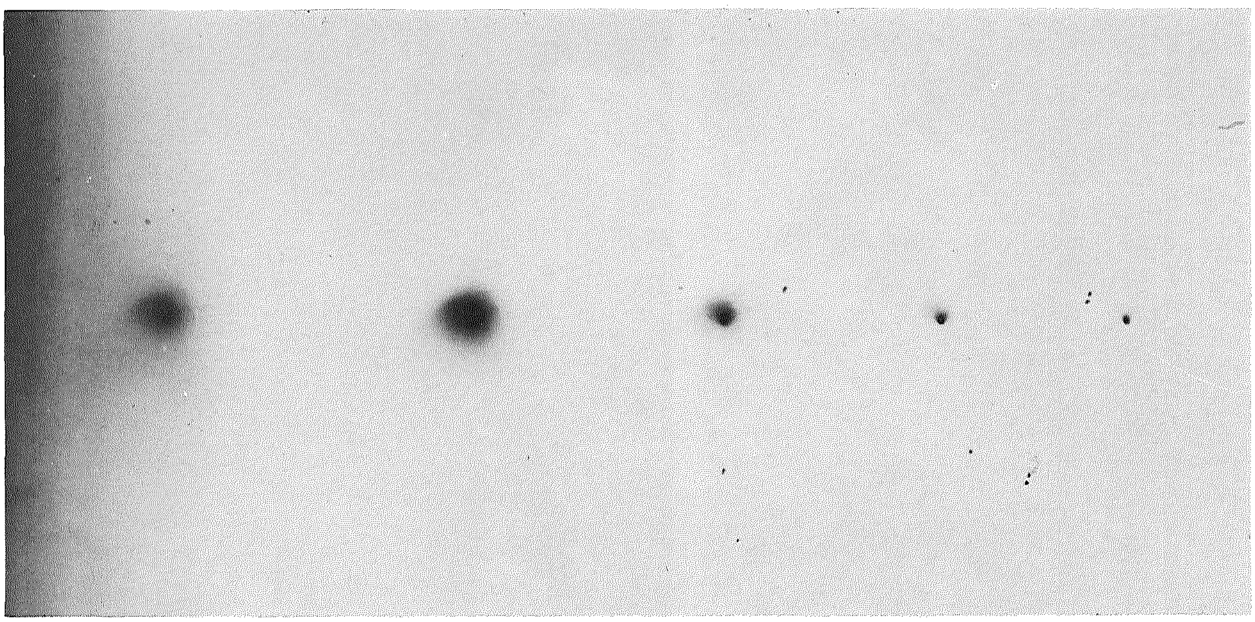


Fig. 8a: 1910 May 25.151; exposures (left to right) 2, 3, 1, 0.5, 0.25 minutes; r = 0.94, Δ = 0.24, α = 101°0; scale: 5.4 × 10^3 km/mm.

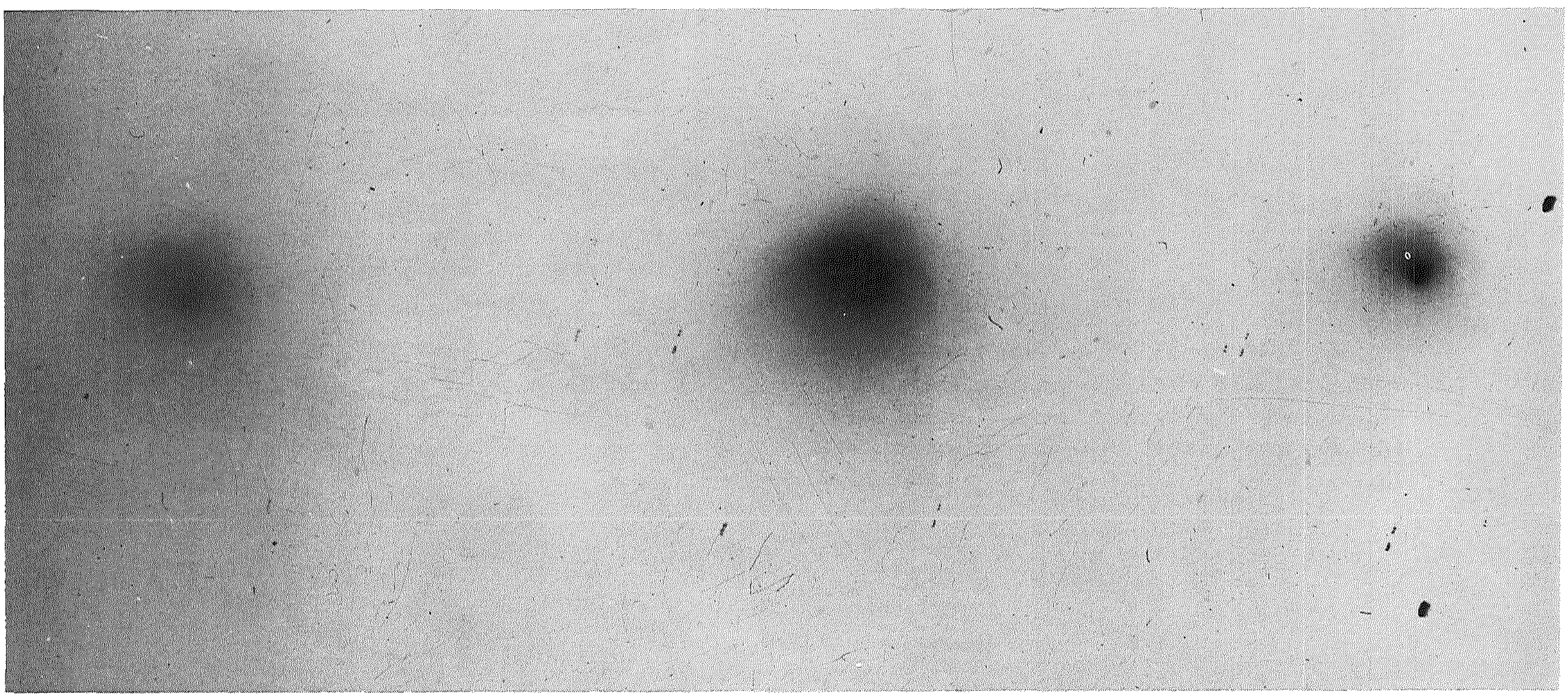


Fig. 8b: Detail of Fig. 8a; exposures (left to right) 2, 3, 1 minutes; enlarged 2.2×; scale: 2.4 × 10^3 km/mm.

Photographs taken by C. O. Lampland with 42-inch reflector, Lowell Observatory, Flagstaff, Arizona, U.S.A.

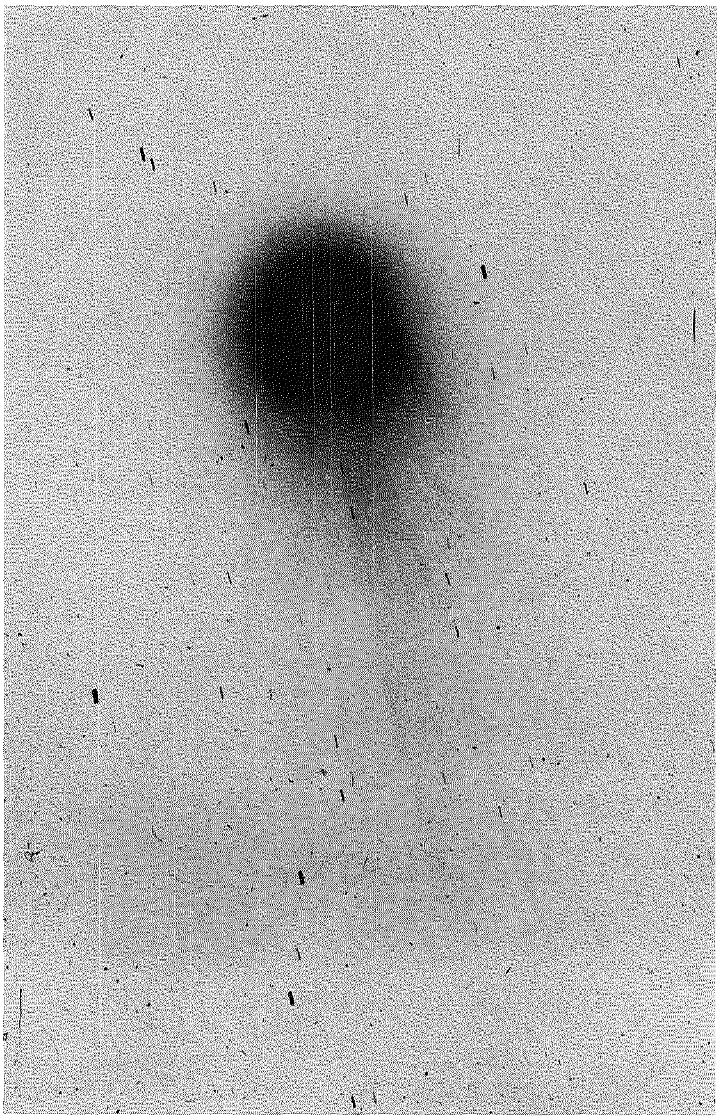


Fig. 9a: 1910 May 25.755; exposure 5 minutes; r = 0.95, Δ = 0.26, α = 97.°0; enlarged 1.5X; scale: 7.4 X 10^3 km/mm. Photograph taken by H. Knox Shaw with 30-inch reflector, Khedivial Observatory, Helwan, Egypt.

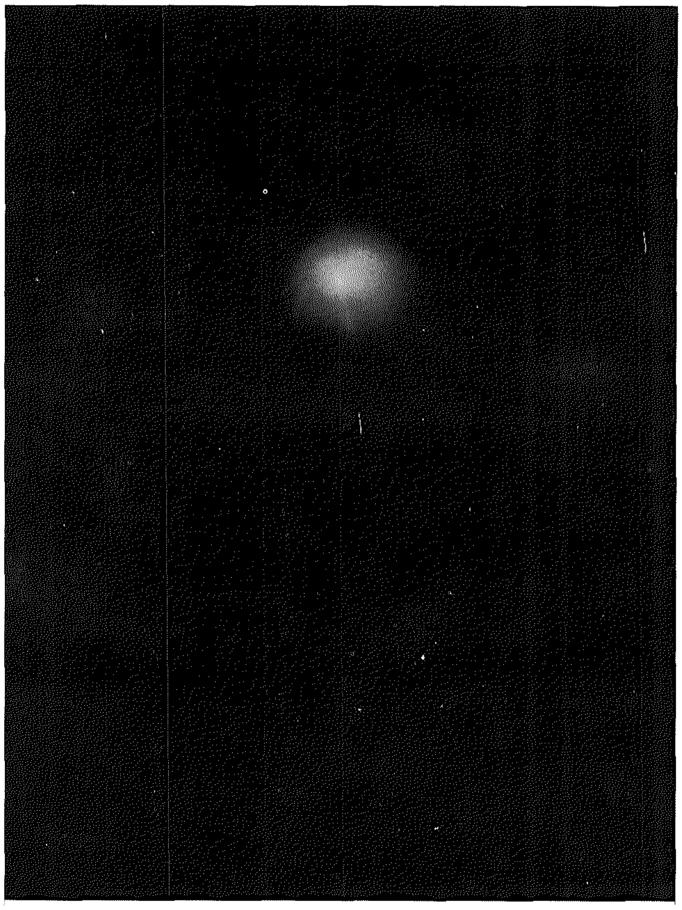


Fig. 9b: Detail of Fig. 9a; enlarged 2.7X; scale: 4.1 X 10^3 km/mm. A positive and a negative copy of the original photograph were superimposed to bring out faint details that can be seen in the original but are lost in a normal print.

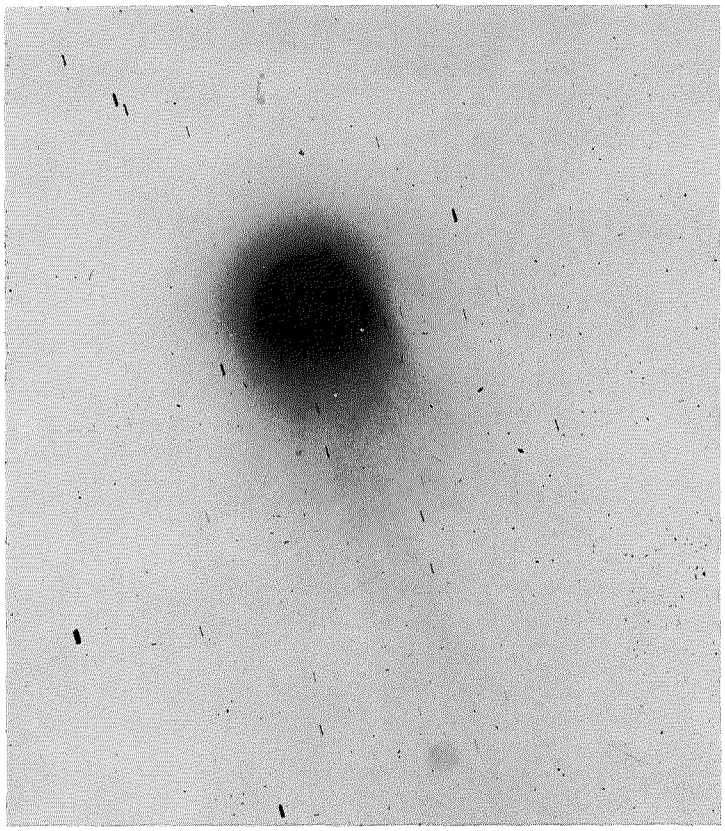


Fig. 10a: 1910 May 25.769; exposure 5 minutes; r = 0.95, Δ = 0.26, α = 97°0; enlarged 1.5X; scale: 7.4 X 10^3 km/mm. Photograph taken by H. Knox Shaw with 30-inch reflector, Khedivial Observatory, Helwan, Egypt.

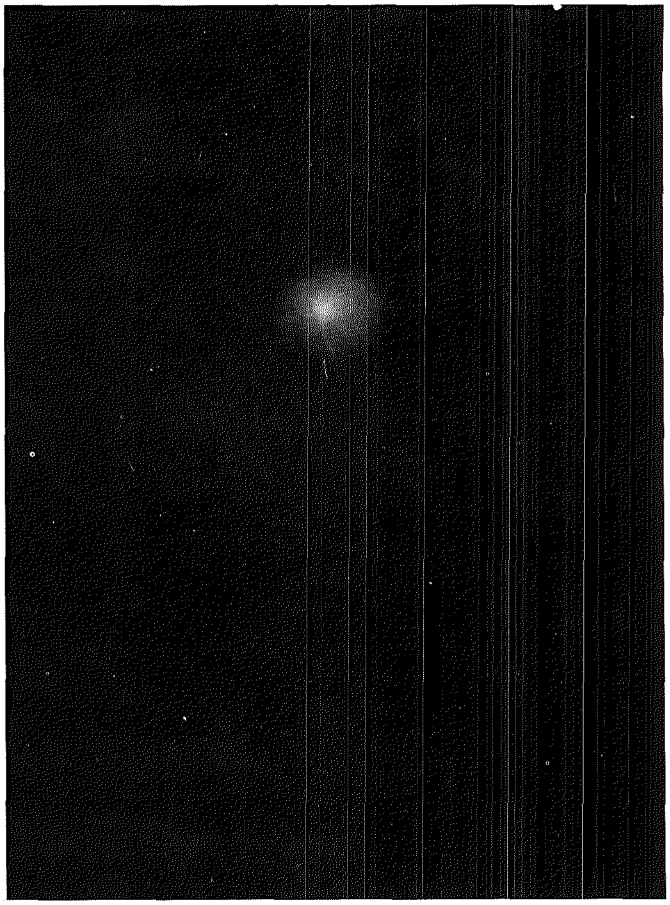
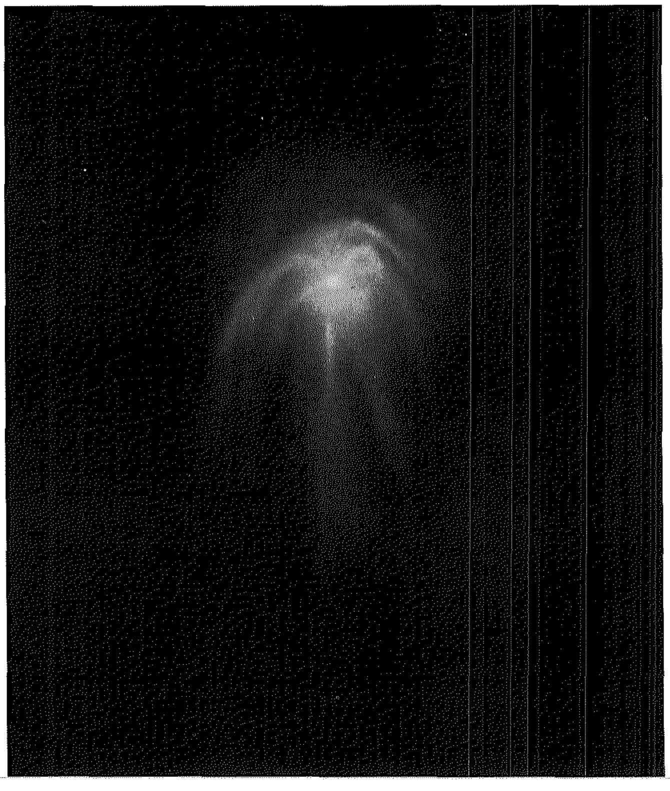


Fig. 10b: Detail of Fig. 10a; enlarged 2.7X; scale: 4.1 X 10^3 km/mm. A positive and a negative copy of the original photograph were superimposed to bring out faint details that can be seen in the original but are lost in a normal print.

Fig. 10c: Drawing based on Helwan photograph of May 25.769; enlarged about 3X; see Fig. 10a.



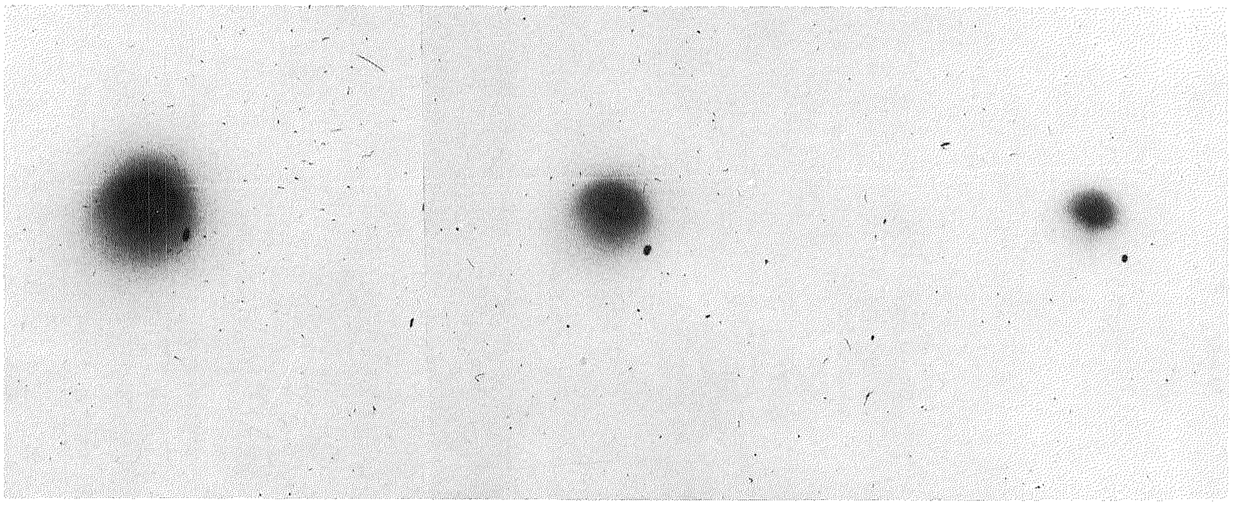


Fig. 11: 1910 May 27.162; r = 0.97, Δ = 0.31, α = $89\overset{\circ}{.}3$; enlarged 2.2X; scale: 3.1 X 10^3 km/mm. A sequence of photographs taken with different exposures. Duration of exposures unknown. Photographs taken by C. O. Lampland with 42-inch reflector, Lowell Observatory, Flagstaff, Arizona, U.S.A.

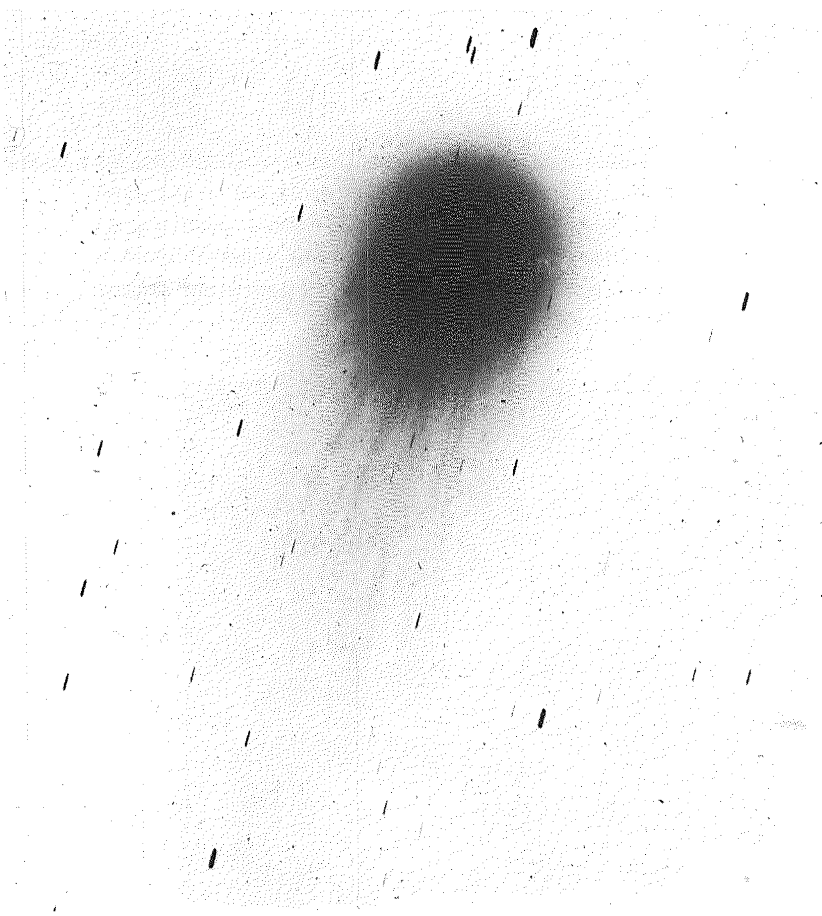


Fig. 12a: 1910 May 27.758; exposure 10 minutes; r = 0.98, Δ = 0.33, α = $86\overset{\circ}{.}6$; enlarged 1.5X; scale: 9.4 X 10^3 km/mm. Photograph taken by H. Knox Shaw with 30-inch reflector, Khedivial Observatory, Helwan, Egypt.

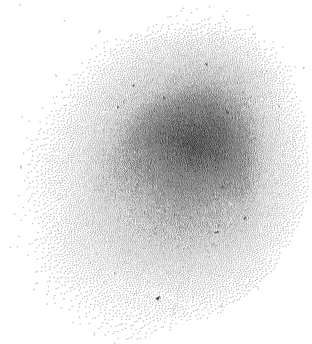


Fig. 12b: Detail of Fig. 12a; enlarged 3.4X; scale: 4.1 X 10^3 km/mm.

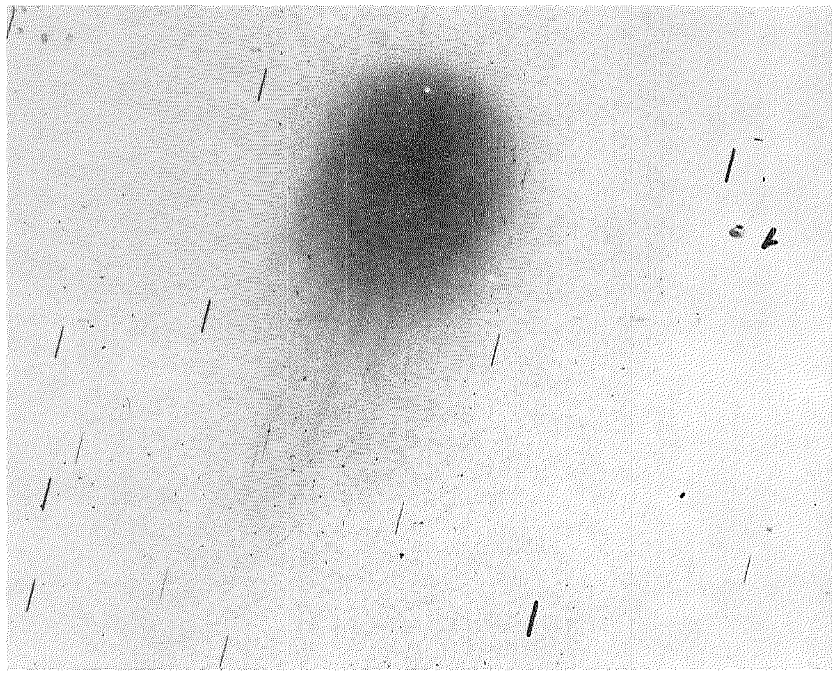


Fig. 13: 1910 May 27.778; exposure 20 minutes; r = 0.98, Δ = 0.33, α = 86°.5; enlarged 1.7X; scale: 8.3×10^3 km/mm.

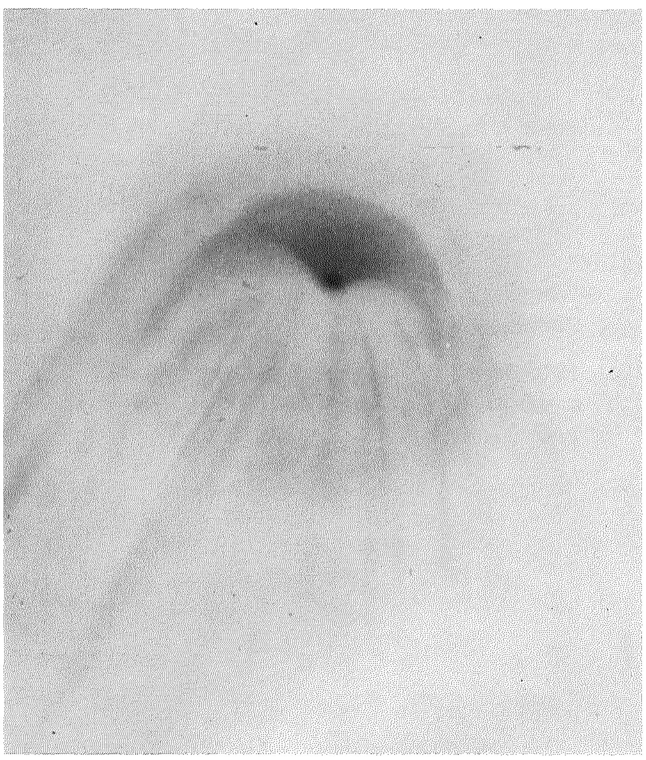


Fig. 12c: Drawing based on Helwan photograph of May 27.758; enlarged about 6X; see Fig. 12a.

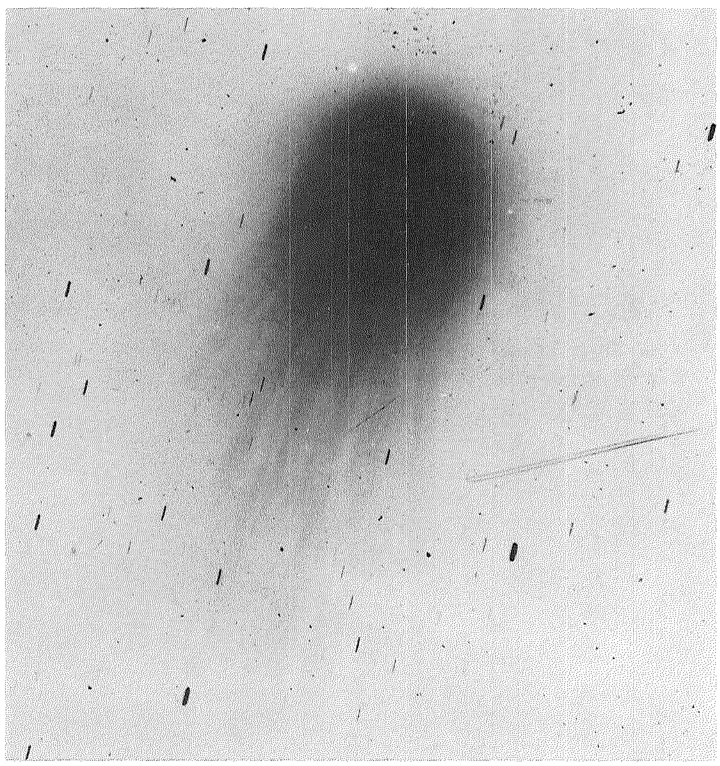


Fig. 14: 1910 May 27.805; exposure 10 minutes; r = 0.98, Δ = 0.33, α = 86°.4; enlarged 1.6X; scale: 8.9×10^3 km/mm.

Photographs taken by H. Knox Shaw with 30-inch reflector, Khedivial Observatory, Helwan, Egypt.

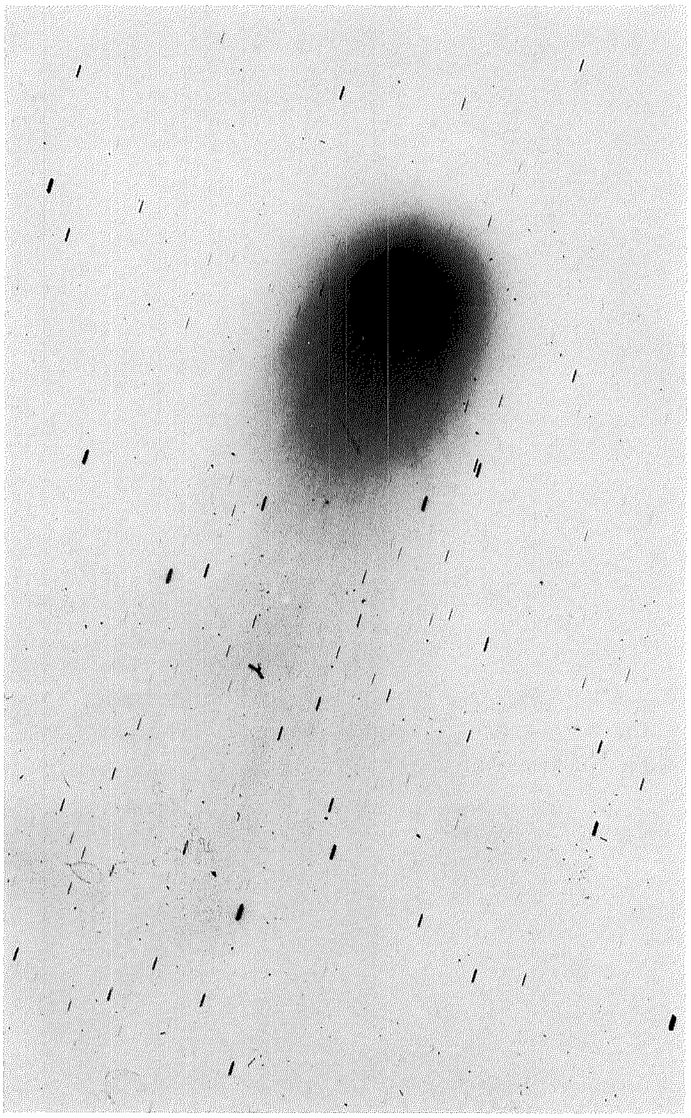


Fig. 15: 1910 May 28.761; exposure 10 minutes; r = 0.99, Δ = 0.37, α = 82°.6; enlarged 1.6X; scale: 9.8 $\times$ 10^3 km/mm.

Fig. 16: 1910 May 28.789; exposure 10 minutes; r = 0.99, Δ = 0.37, α = 82°.5; enlarged 1.6X; scale: 9.8 $\times$ 10^3 km/mm.

Photographs taken by H. Knox Shaw with 30-inch reflector, Khedivial Observatory, Helwan, Egypt.

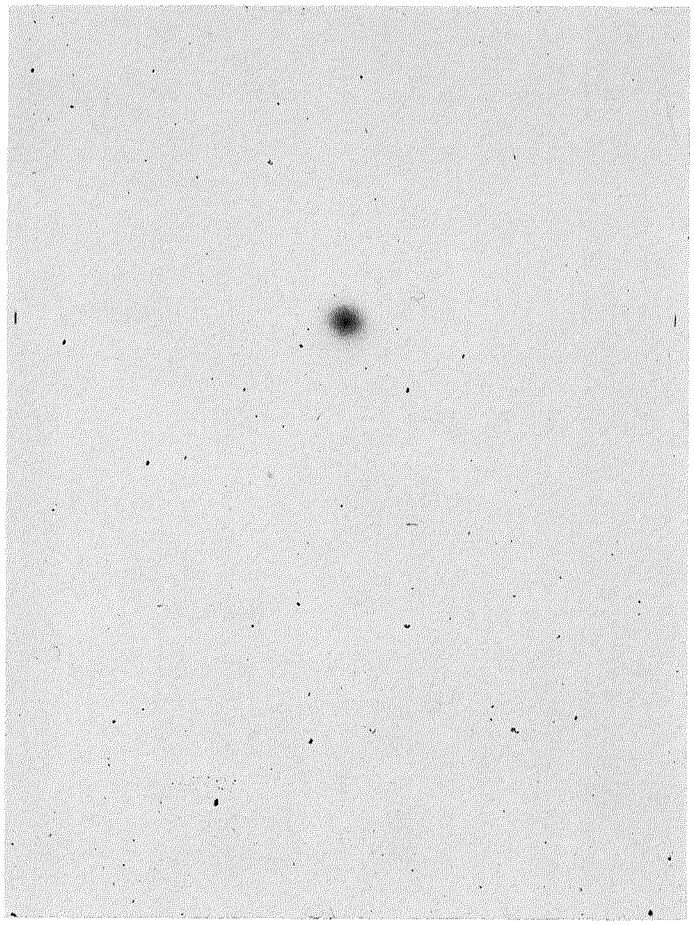


Fig. 17a: 1910 May 28.843; exposure 3 minutes; r = 1.00, Δ = 0.37, α = 82°.3; enlarged 1.5X; scale: 1.1 X 10^4 km/mm. Photograph taken by H. Knox Shaw with 30-inch reflector, Khedivial Observatory, Helwan, Egypt.

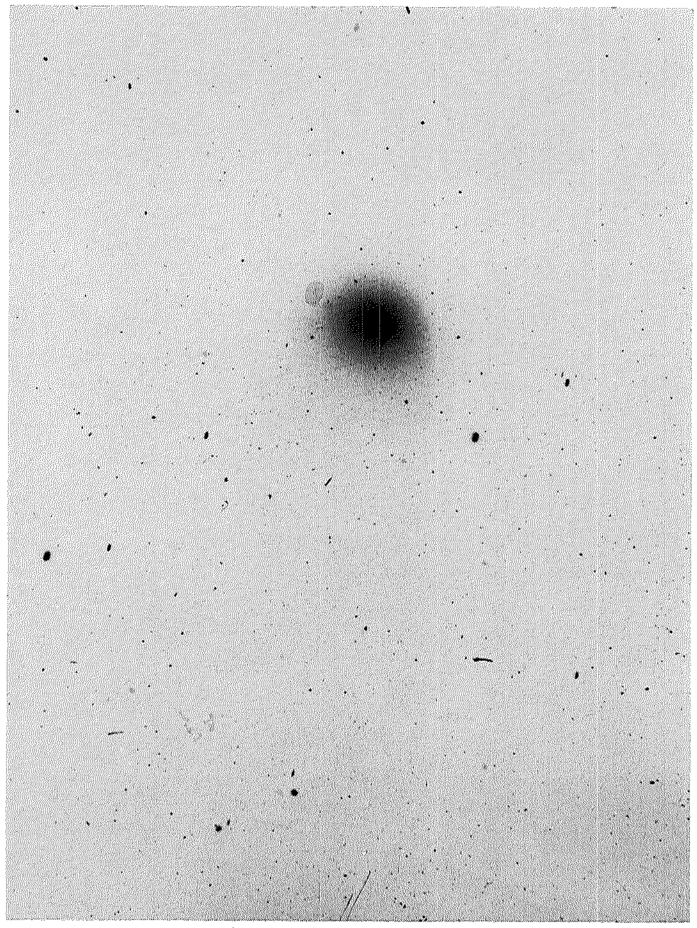


Fig. 17b: Detail of Fig. 17a; enlarged 2.6X; scale: 6.1 X 10^3 km/mm.

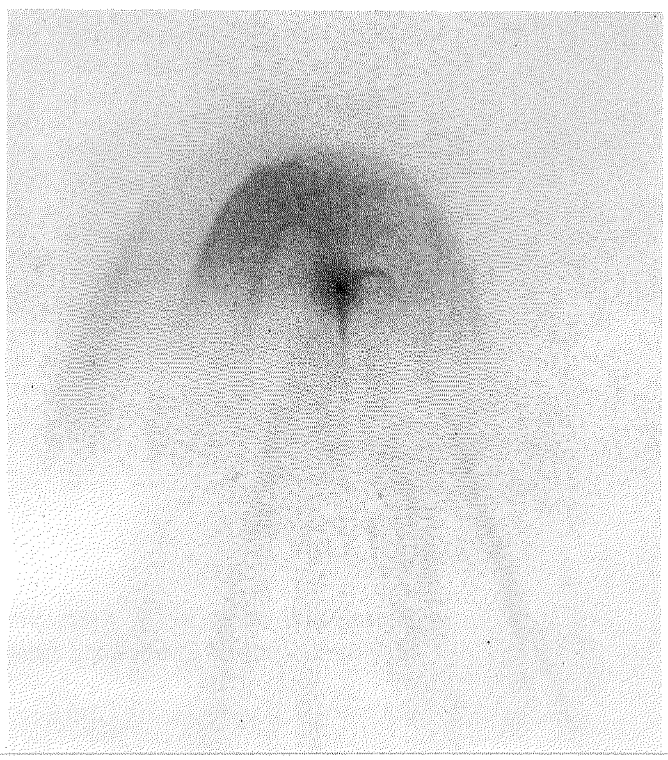


Fig. 17c: Drawing based on Helwan photograph of May 28.843; enlarged about 7X; see Fig. 17a.

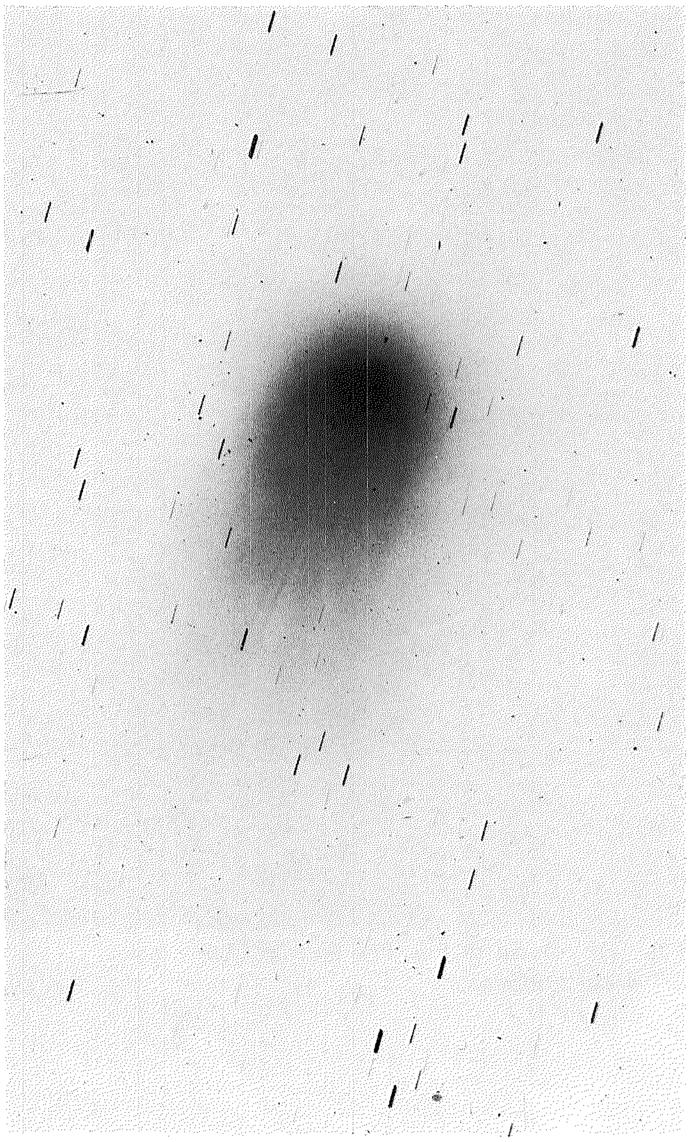


Fig. 18: 1910 May 29.790; exposure 20 minutes; r = 1.01, Δ = 0.40, α = 79°.1; enlarged 1.5X; scale: 1.2×10^4 km/mm.

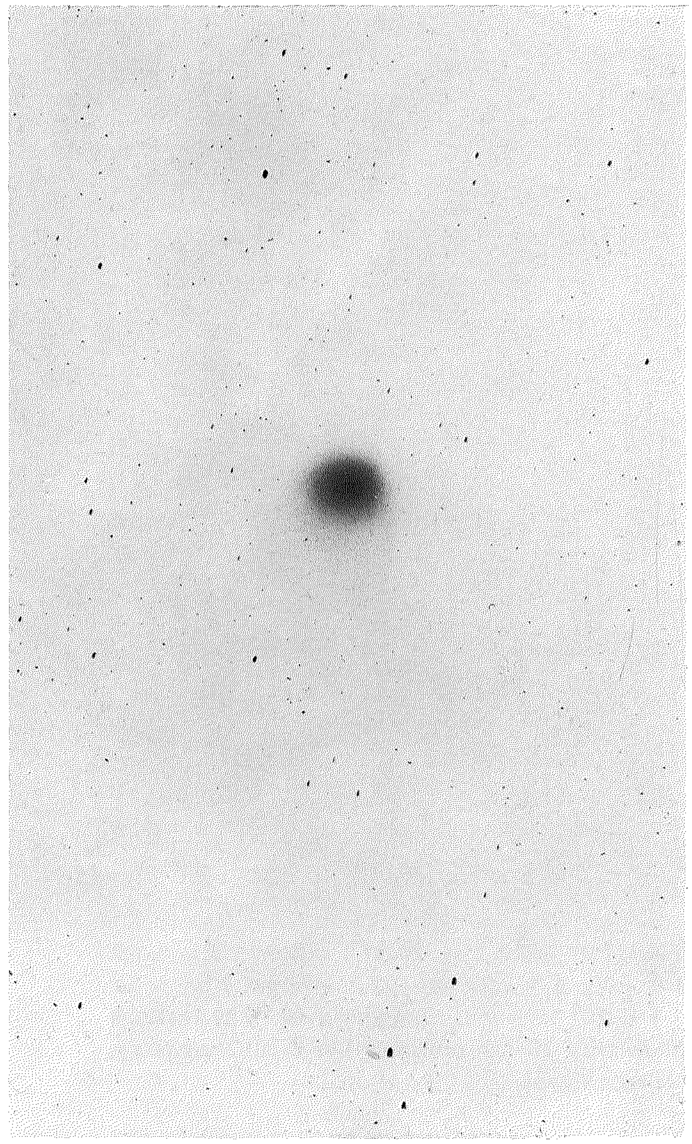


Fig. 19: 1910 May 29.843; exposure 5 minutes; r = 1.01, Δ = 0.41, α = 79°.0; enlarged 1.5X; scale: 1.2×10^4 km/mm.

Photographs taken by H. Knox Shaw with 30-inch reflector, Khedivial Observatory, Helwan, Egypt.

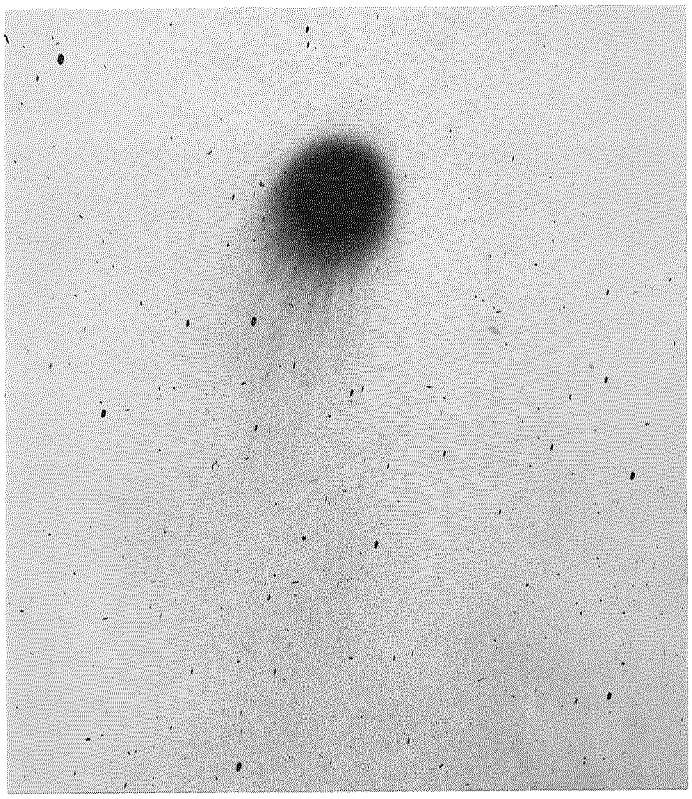


Fig. 20: 1910 May 30.753; exposure 5 minutes; r = 1.02, Δ = 0.44, α = 76°.3; enlarged 1.5×; scale: 1.3 × 10^4 km/mm.

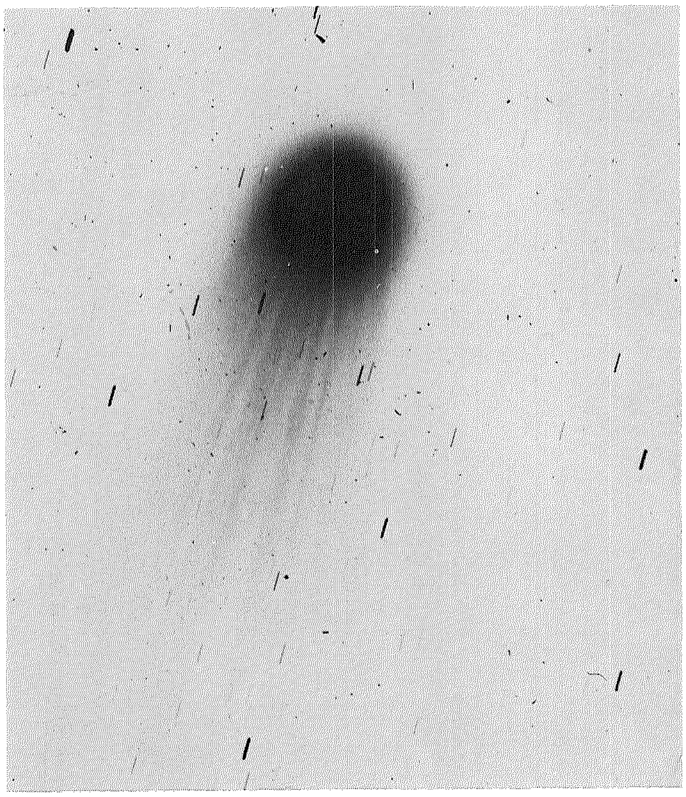


Fig. 21: 1910 May 30.768; exposure 20 minutes; r = 1.02, Δ = 0.44, α = 76°.2; enlarged 1.5×; scale: 1.3 × 10^4 km/mm.

Fig. 22: 1910 May 30.783; exposure 20 minutes; r = 1.02, Δ = 0.44, α = 76°.2; enlarged 1.6×; scale: 1.2 × 10^4 km/mm.

Photographs taken by H. Knox Shaw with 30-inch reflector, Khedivial Observatory, Helwan, Egypt.

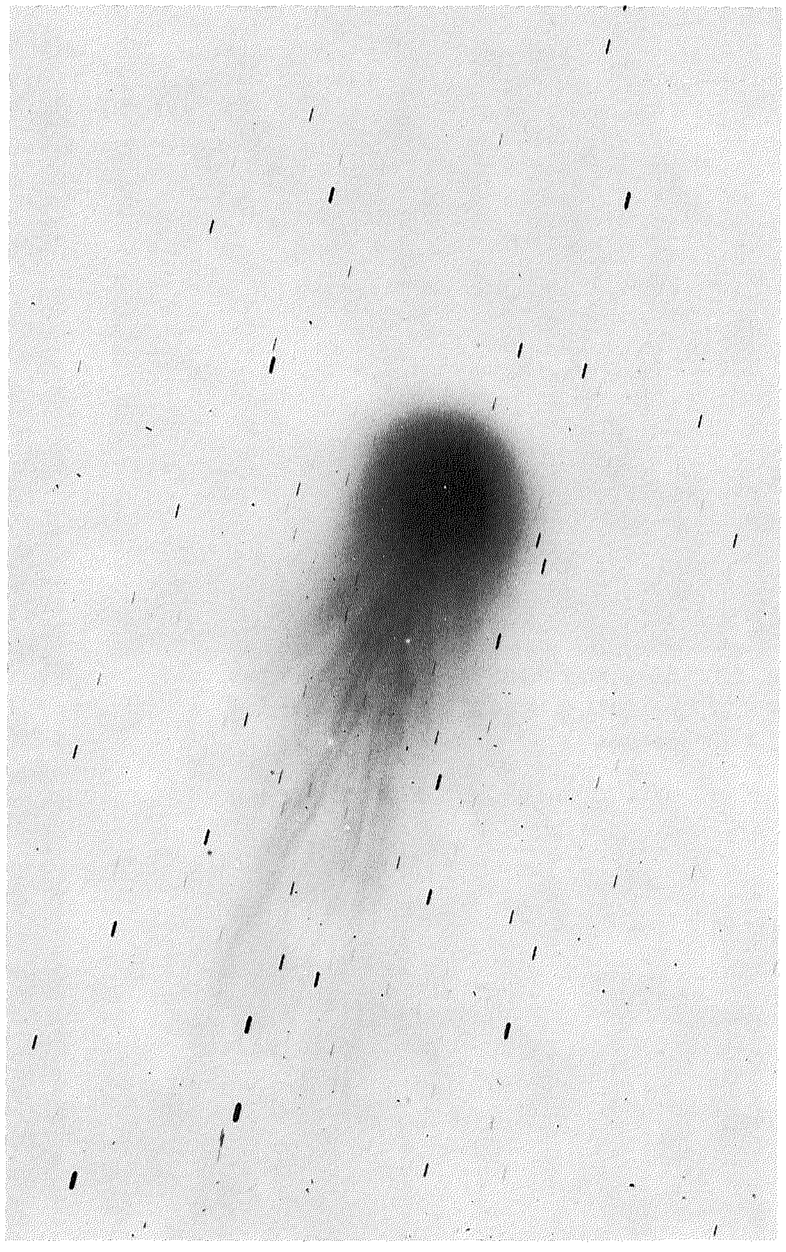


Fig. 23: 1910 June 2.776; exposure 20 minutes; r = 1.07, Δ = 0.55, α = 69°.1; enlarged 1.6×; scale: 1.5 × 10^4 km/mm. Photograph taken by H. Knox Shaw with 30-inch reflector, Khedivial Observatory, Helwan, Egypt.

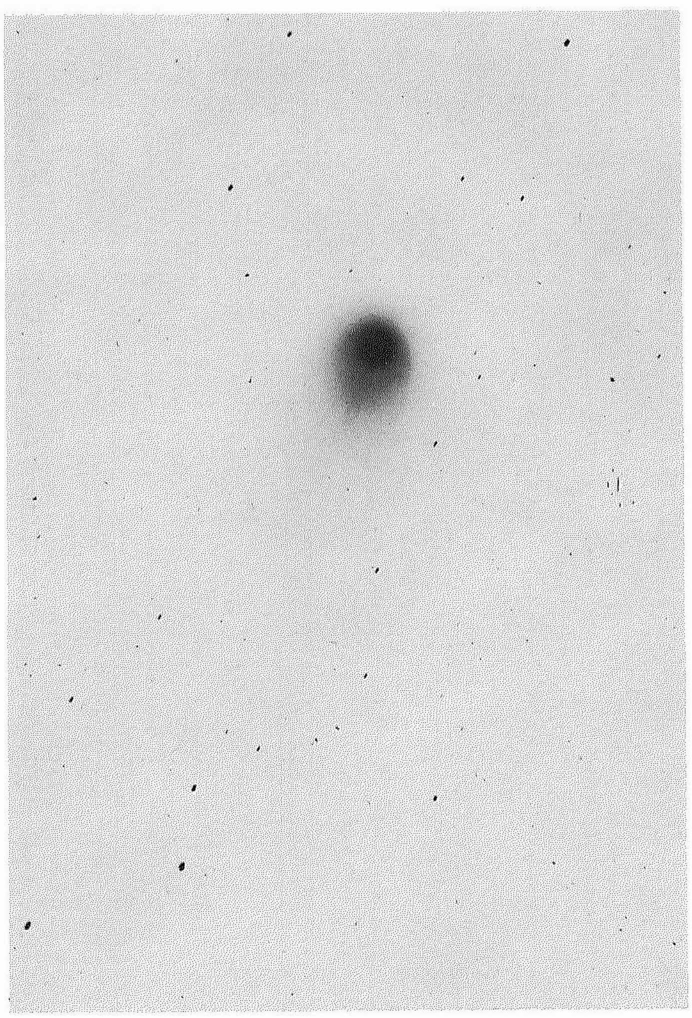


Fig. 24a: 1910 June 2.842; exposure 10 minutes; r = 1.07, Δ = 0.56, α = 68°9; enlarged 1.5X; scale: 1.6 X 10^4 km/mm. Photograph taken by H. Knox Shaw with 30-inch reflector, Khedivial Observatory, Helwan, Egypt.

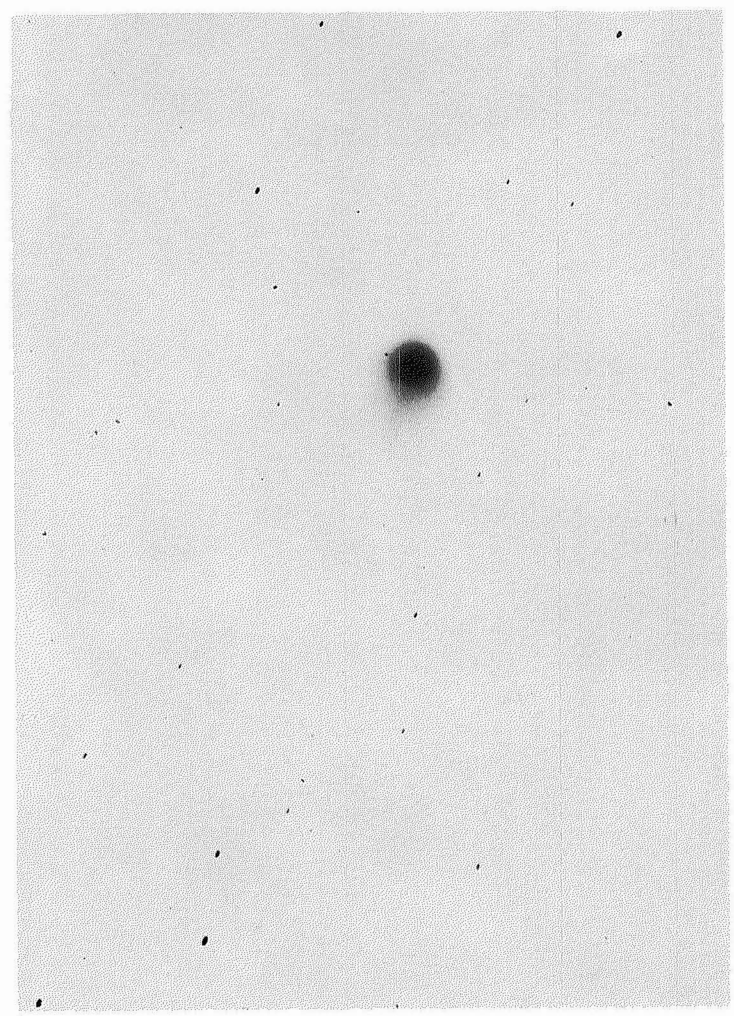


Fig. 24b: Detail of Fig. 24a; enlarged 1.7X; scale: 1.4 X 10^4 km/mm.

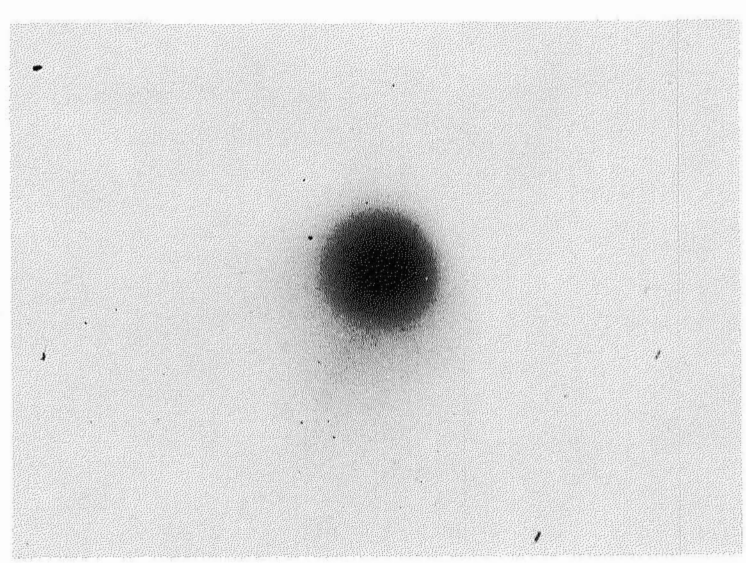


Fig. 24c: Detail of Fig. 24a; enlarged 4.1X; scale: 5.8 X 10^3 km/mm.

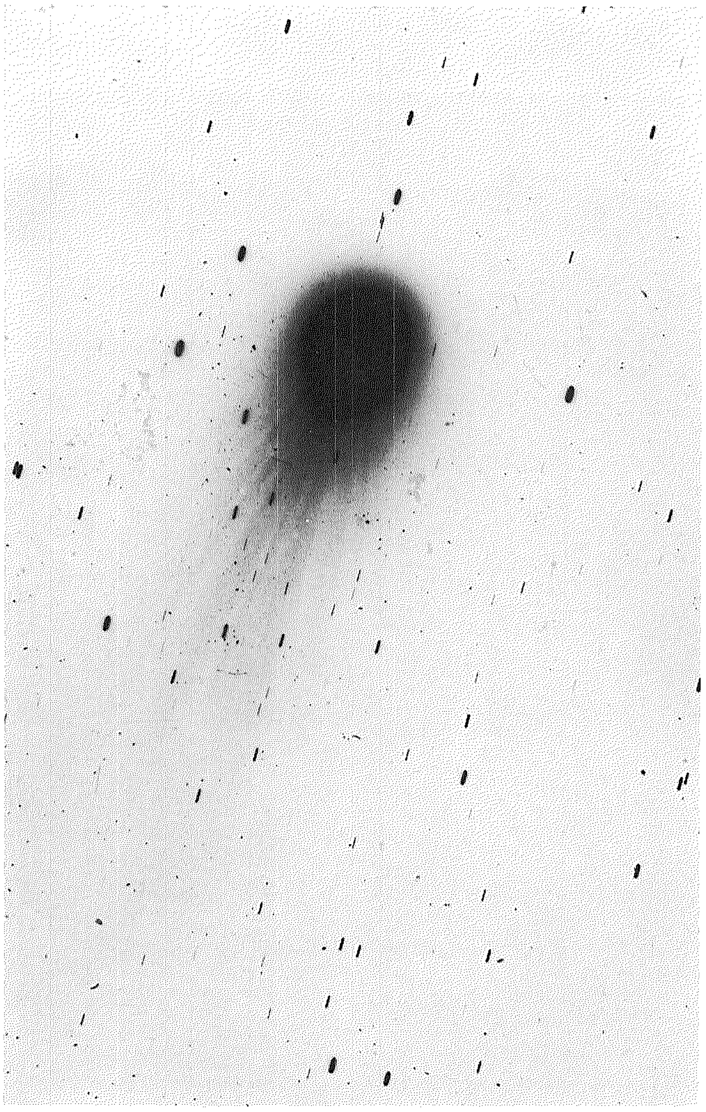


Fig. 25: 1910 June 3.774; exposure 20 minutes; r = 1.09, Δ = 0.59, α = 67°.1; enlarged 1.5X; scale: 1.7×10^4 km/mm.

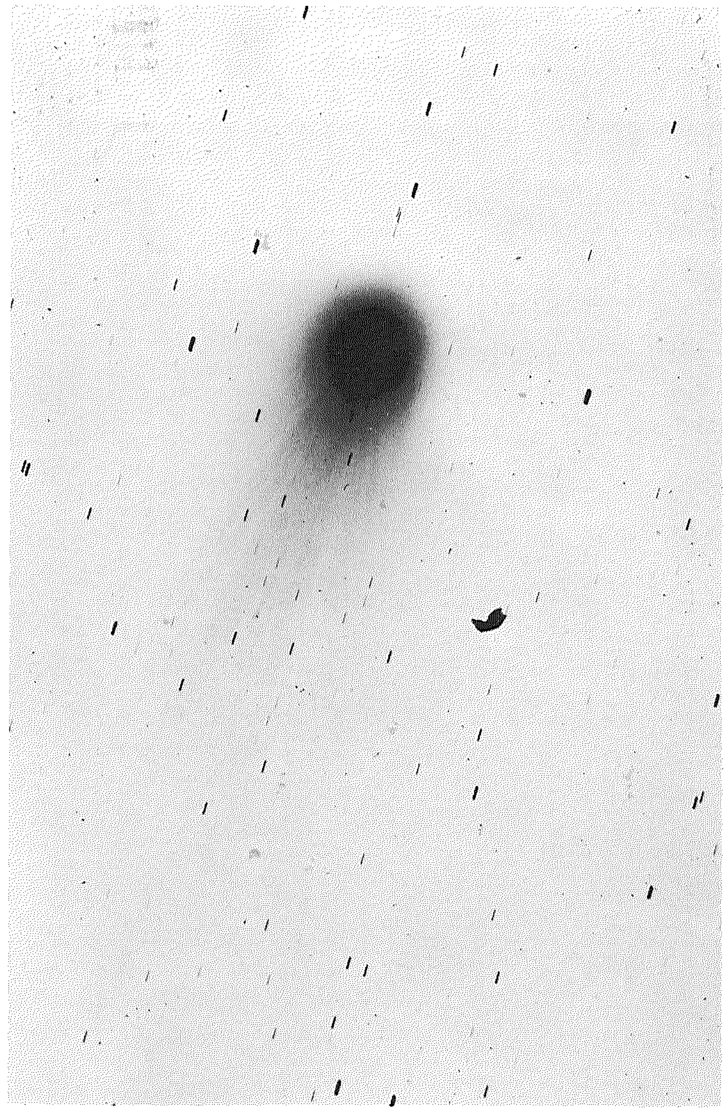


Fig. 26a: 1910 June 3.789; exposure 20 minutes; r = 1.09, Δ = 0.59, α = 67°.1; enlarged 1.5X; scale: 1.7×10^4 km/mm.

Photographs taken by H. Know Shaw with 30-inch reflector, Khedivial Observatory, Helwan, Egypt.

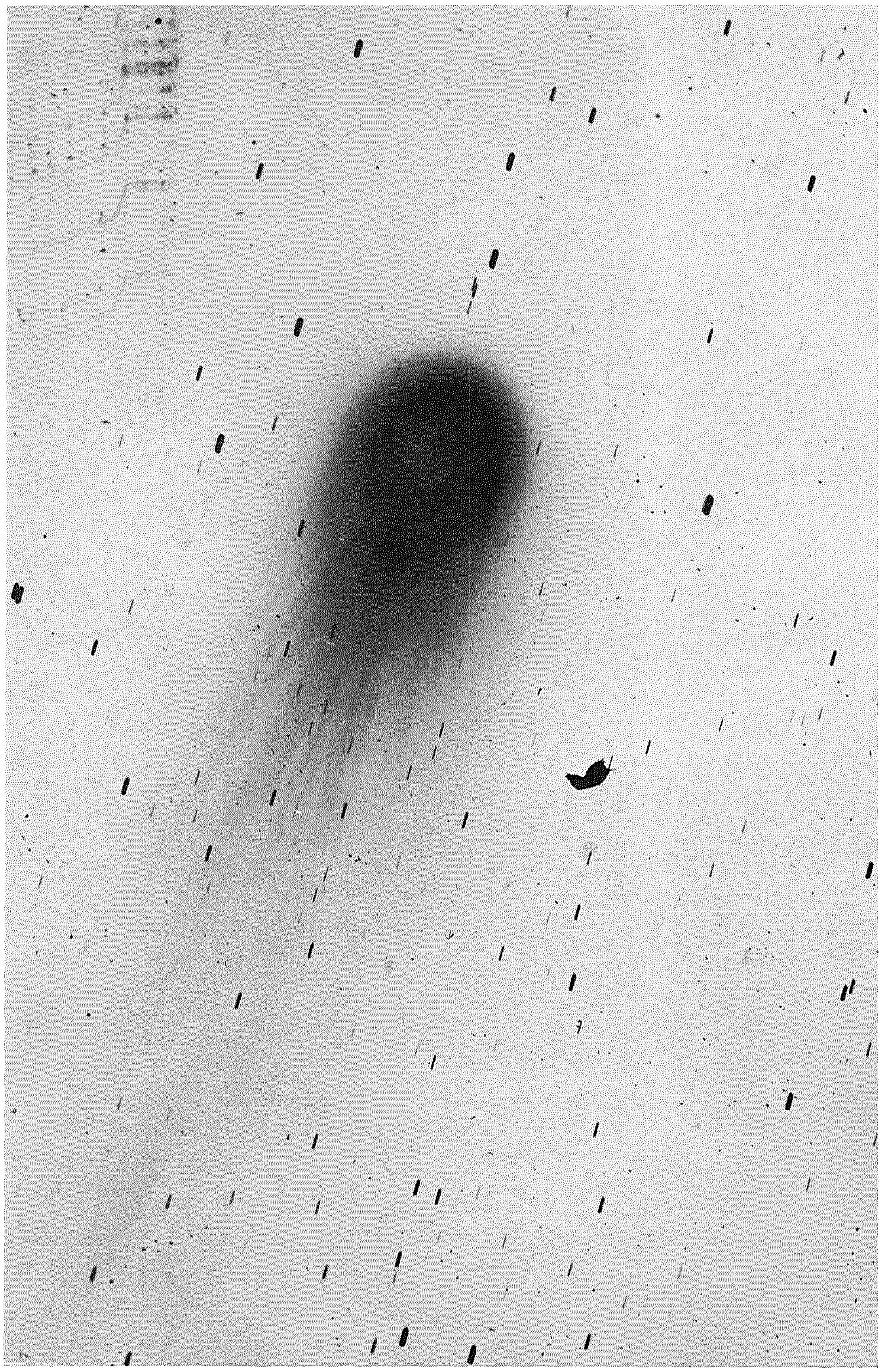


Fig. 26b: Detail of Fig. 26a; enlarged 2.1X; scale: 1.2×10^4 km/mm.

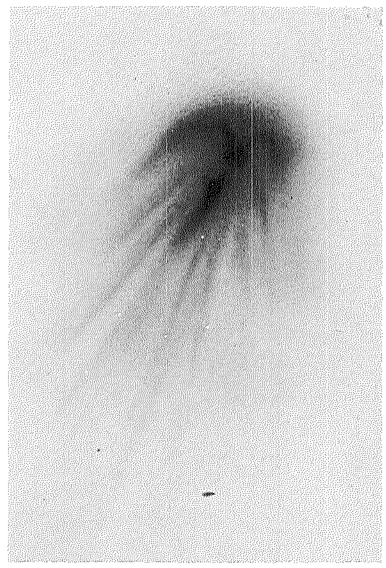


Fig. 26c: Drawing based on Helwan photograph of June 3.789; enlarged about 5X; see Fig. 26a.

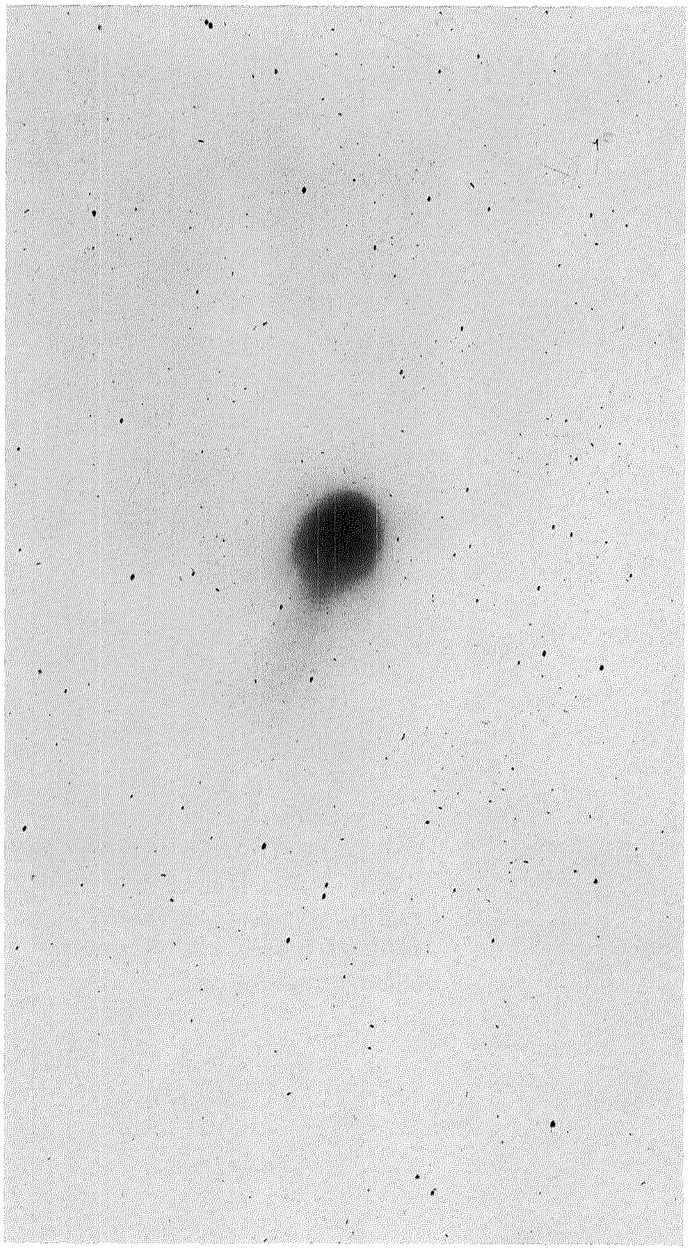


Fig. 27: 1910 June 4.757; exposure 5 minutes; r = 1.10, Δ = 0.63, α = 65°.3; enlarged 1.6X; scale: 1.7 X 10^4 km/mm.

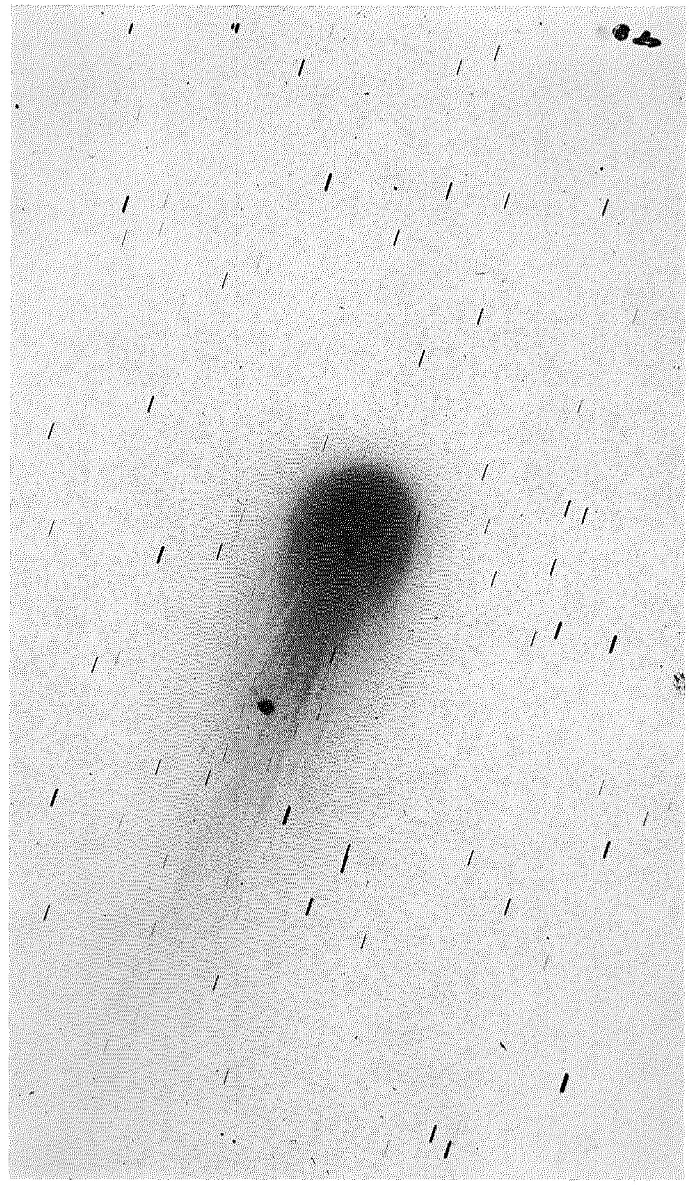


Fig. 28: 1910 June 4.774; exposure 30 minutes; r = 1.10, Δ = 0.63, α = 65°.3; enlarged 1.6X; scale: 1.7 X 10^4 km/mm.

Photographs taken by H. Knox Shaw with 30-inch reflector, Khedivial Observatory, Helwan, Egypt.

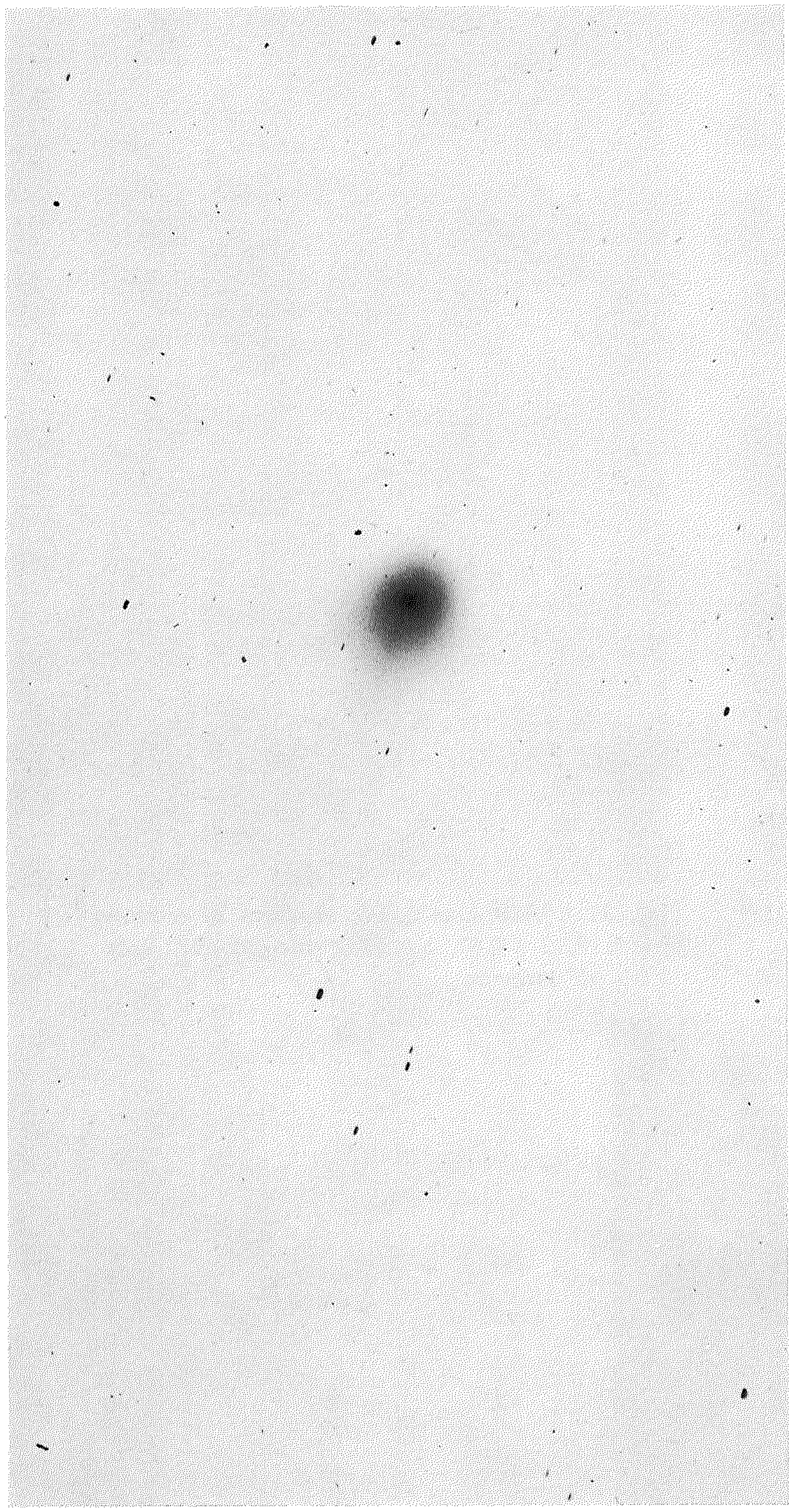


Fig. 29a: 1910 June 4.829; exposure 10 minutes; r = 1.10, Δ = 0.63, α = 65°.2; enlarged 2.4X; scale: 1 X 10^4 km/mm. Photograph taken by H. Knox Shaw with 30-inch reflector, Khedivial Observatory, Helwan, Egypt.

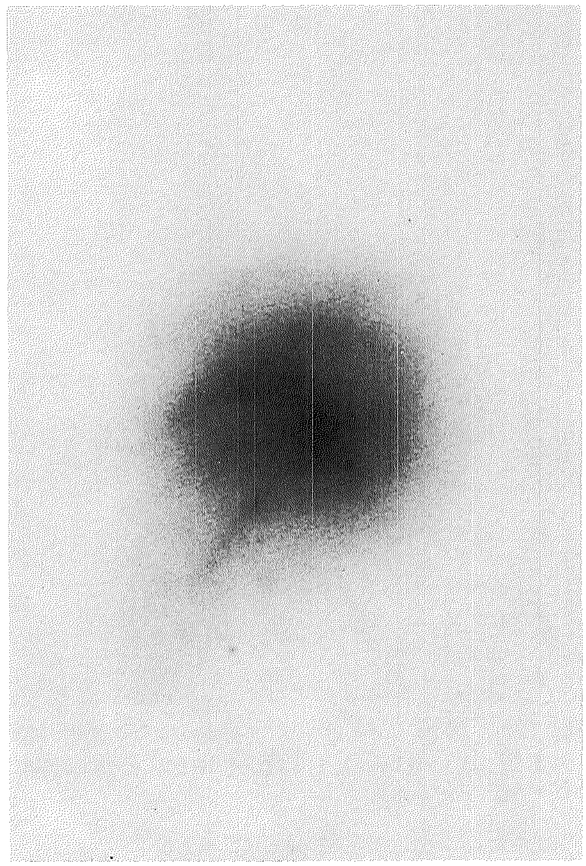


Fig. 29b: Drawing based on Helwan photograph of June 4.829; enlarged about 10X; see Fig. 29a.

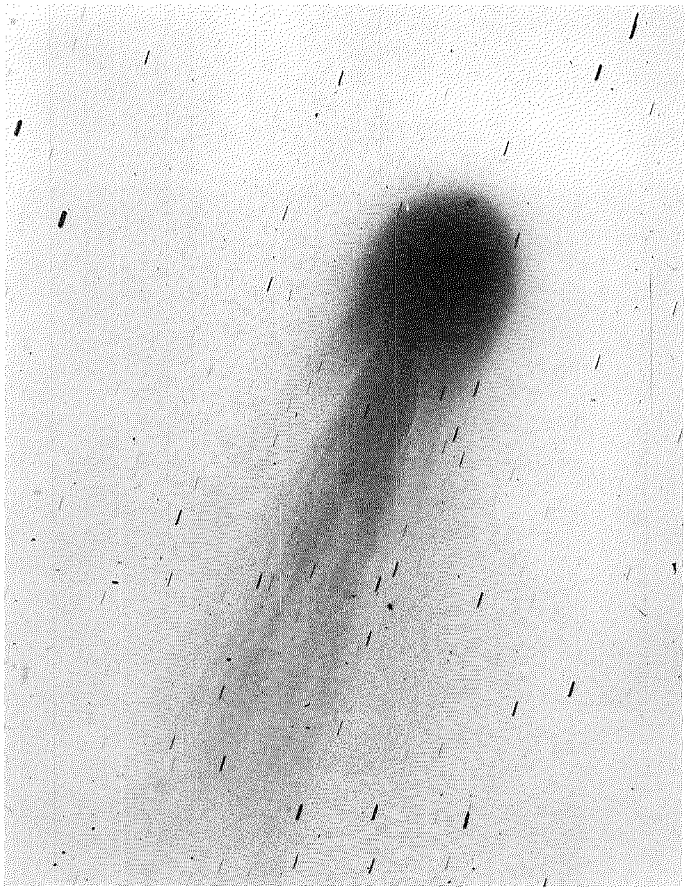


Fig. 30: 1910 June 5.782; exposure 30 minutes; r = 1.12, Δ = 0.67, α = 63.°6; enlarged 1.5X; scale: 1.9 X 10^4 km/mm.

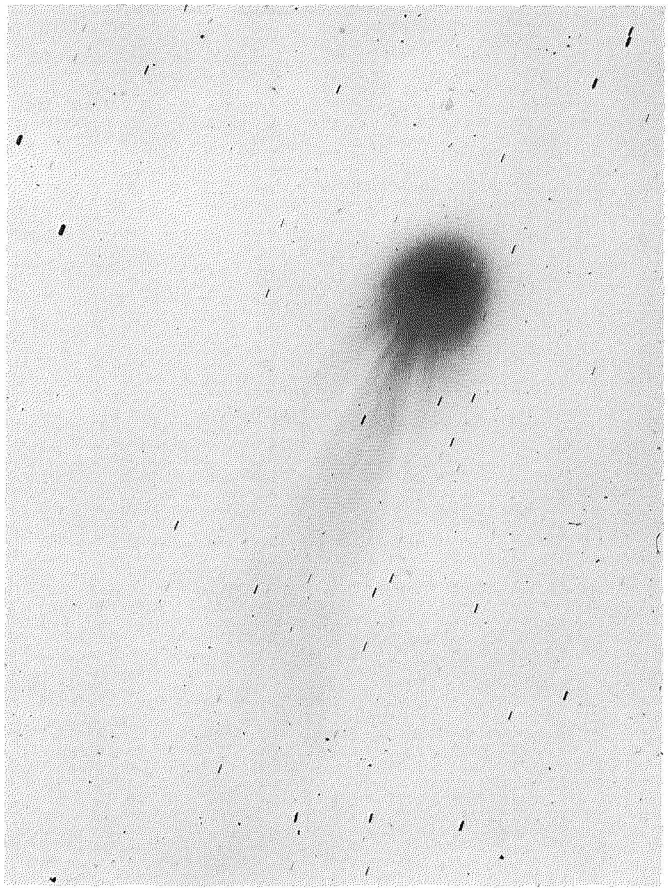


Fig. 31: 1910 June 5.806; exposure 20 minutes; r = 1.12, Δ = 0.67, α = 63.°6; enlarged 1.5X; scale: 1.9 X 10^4 km/mm.

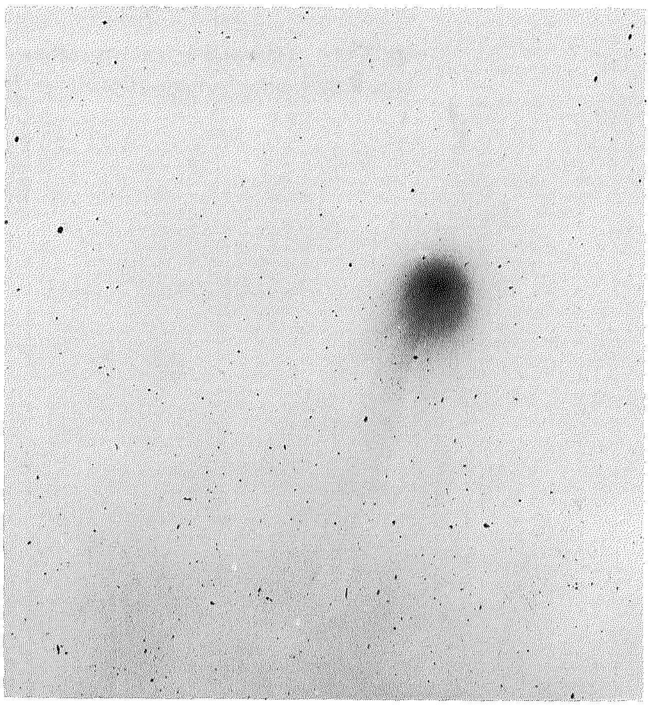


Fig. 32a: 1910 June 5.826; exposure 10 minutes; r = 1.12, Δ = 0.67, α = 63.°5; enlarged 1.5X; scale: 1.9 X 10^4 km/mm.

Photographs taken by H. Knox Shaw with 30-inch reflector, Khedivial Observatory, Helwan, Egypt.

Fig. 32b: Drawing based on Helwan photograph of June 5.826; enlarged about 10X; see Fig. 32a.

COMET HUMASON 1962 VIII

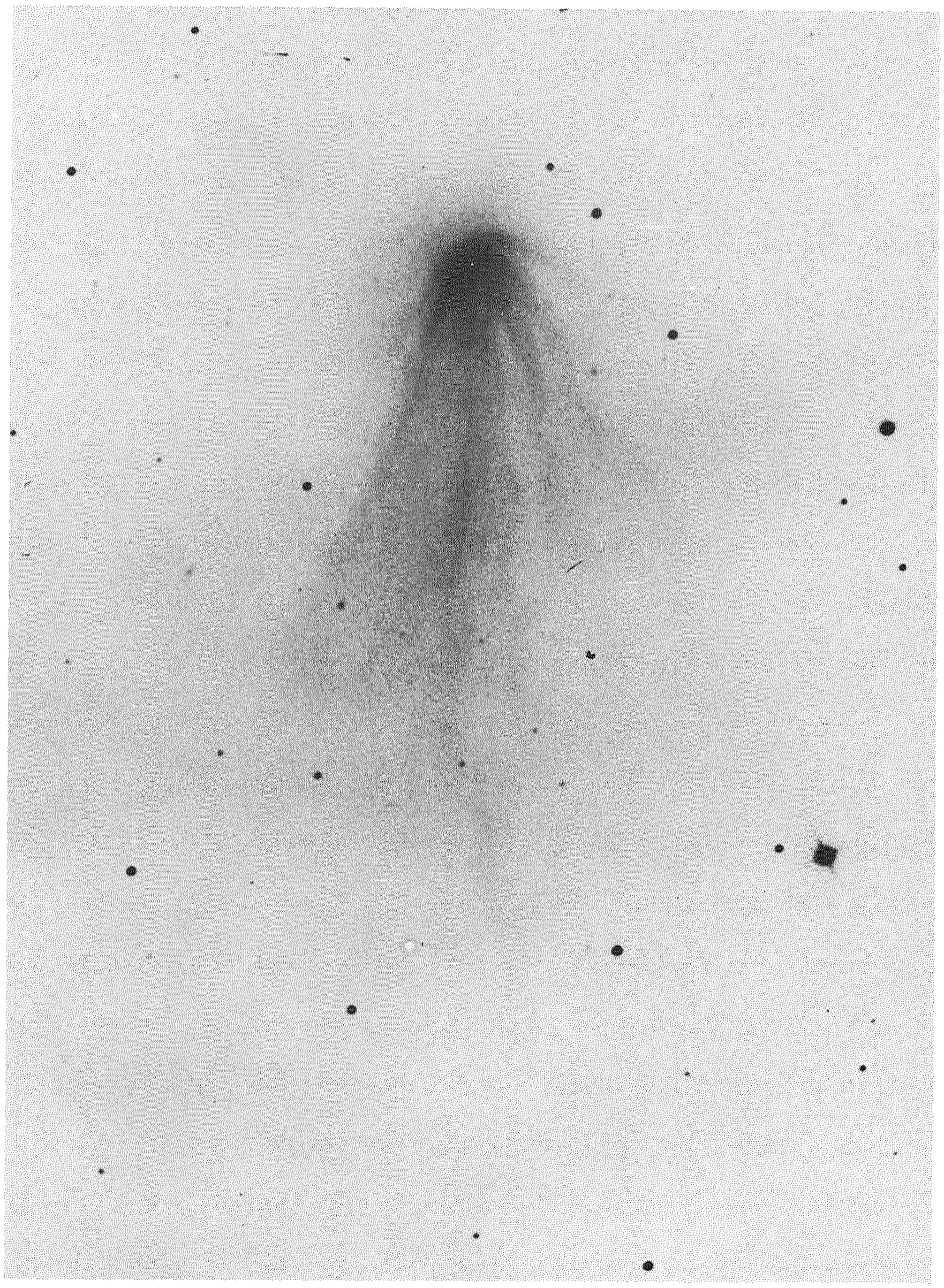


Fig. 1: 1962 May 29.446; exposure 20 minutes on Kodak 103a-O plate; r = 3.06, Δ = 3.38, α = 17°2; enlarged 4.1×; scale: 1.8 × 10^4 km/mm.

Photograph taken by E. Roemer with 40-inch reflector, U.S. Naval Observatory, Flagstaff Station, Arizona, U.S.A.

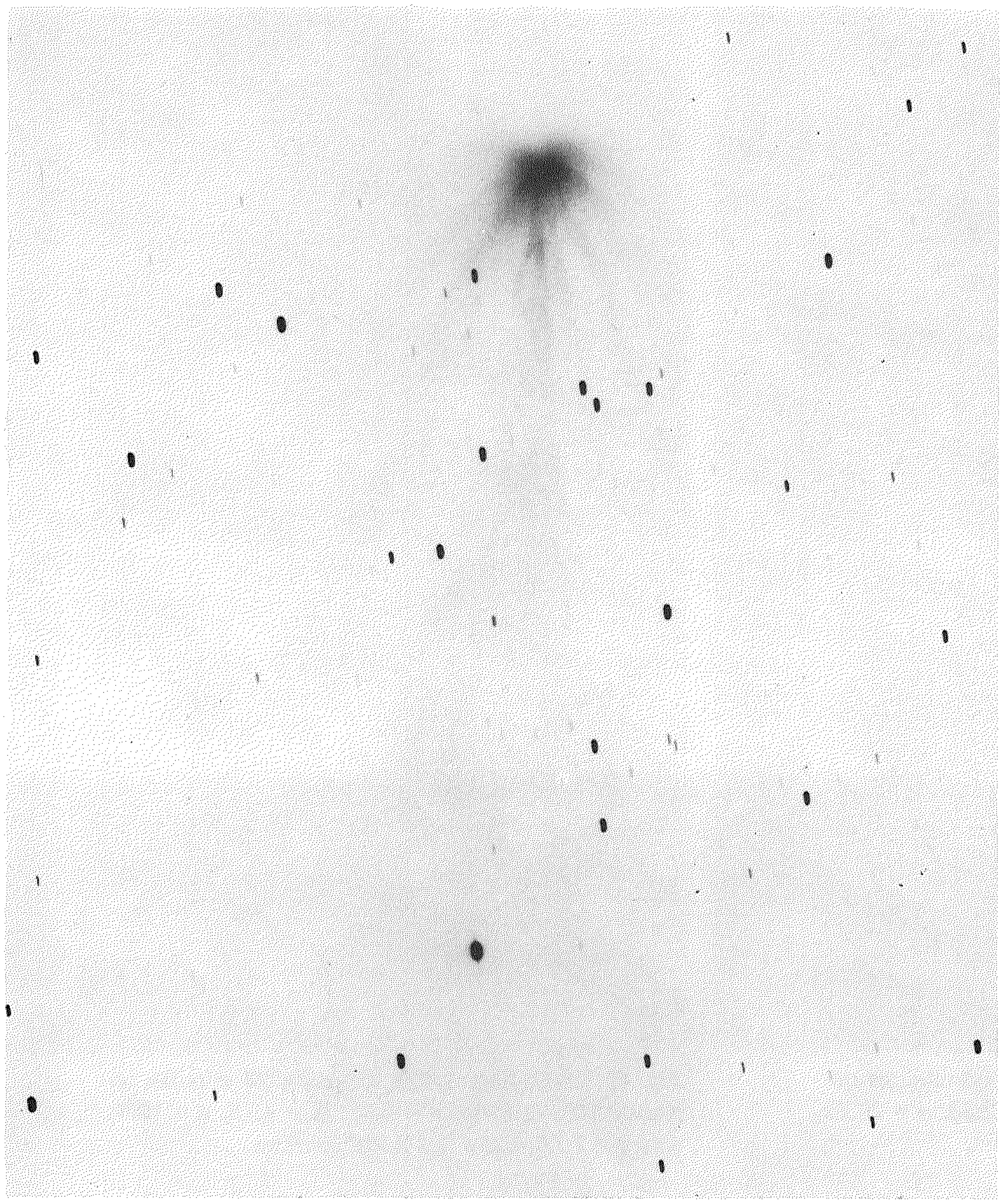


Fig. 2a: 1962 June 30.392; exposure 20.5 minutes on Kodak 103a-O plate; r = 2.83, Δ = 2.52, α = 20°9; enlarged 3.2×; scale: 1.7 × 10^4 km/mm.

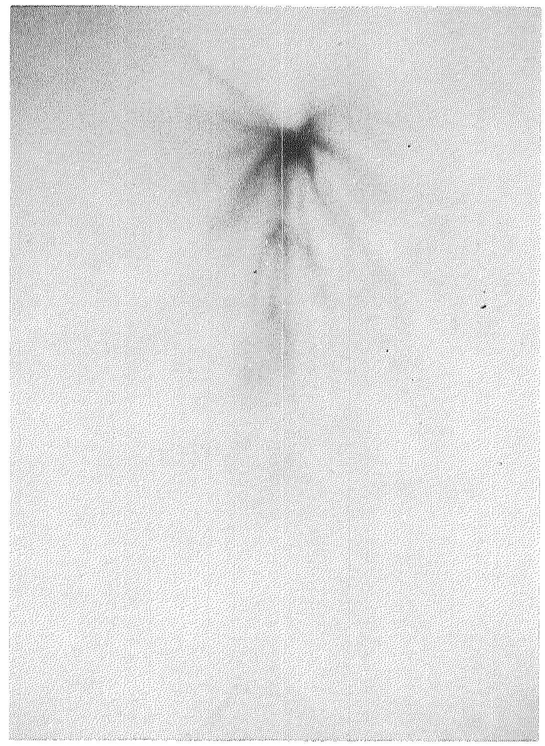


Fig. 2b: Drawing based on photograph of June 30.392; enlarged about 4×; see Fig. 2a.

Photograph taken by E. Roemer with 40-inch reflector, U.S. Naval Observatory, Flagstaff Station, Arizona, U.S.A.

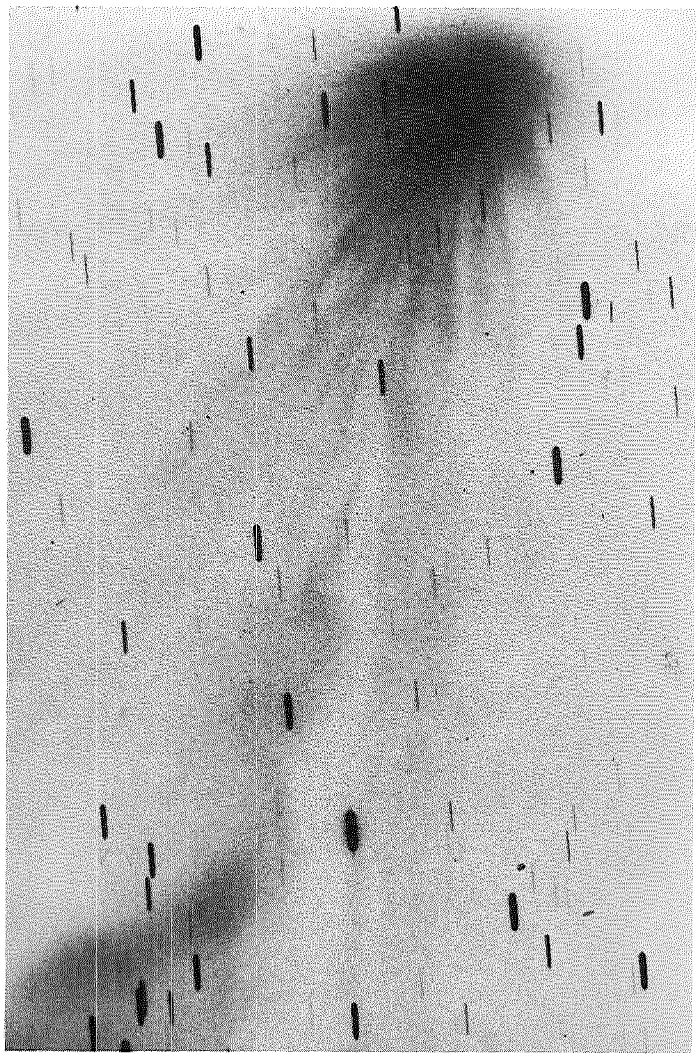


Fig. 3: 1962 July 7.400; exposure 60 minutes on Kodak 103a-O plate; r = 2.78, Δ = 2.33, $\alpha = 20\overset{\circ}{.}7$; enlarged 2.7X; scale: 1.9×10^4 km/mm.

Fig. 4: 1962 Aug. 1.459; exposure 23 minutes on Kodak 103a-O plate; r = 2.61, Δ = 1.73, $\alpha = 13\overset{\circ}{.}6$; enlarged 2.7X; scale: 1.4×10^4 km/mm.

Photographs taken by E. Roemer with 40-inch reflector, U.S. Naval Observatory, Flagstaff Station, Arizona, U.S.A.

Fig. 5a: 1962 July 10.374; exposure 60 minutes on Kodak 103a-O plate; r = 2.76, Δ = 2.25, α = 20°.4; enlarged 3.2X; scale: 1.5 X 10^4 km/mm.

Fig. 5b: Drawing based on photograph of July 10.374; enlarged about 4X; see Fig. 5a.

Photograph taken by E. Roemer with 40-inch reflector, U.S. Naval Observatory, Flagstaff Station, Arizona, U.S.A.

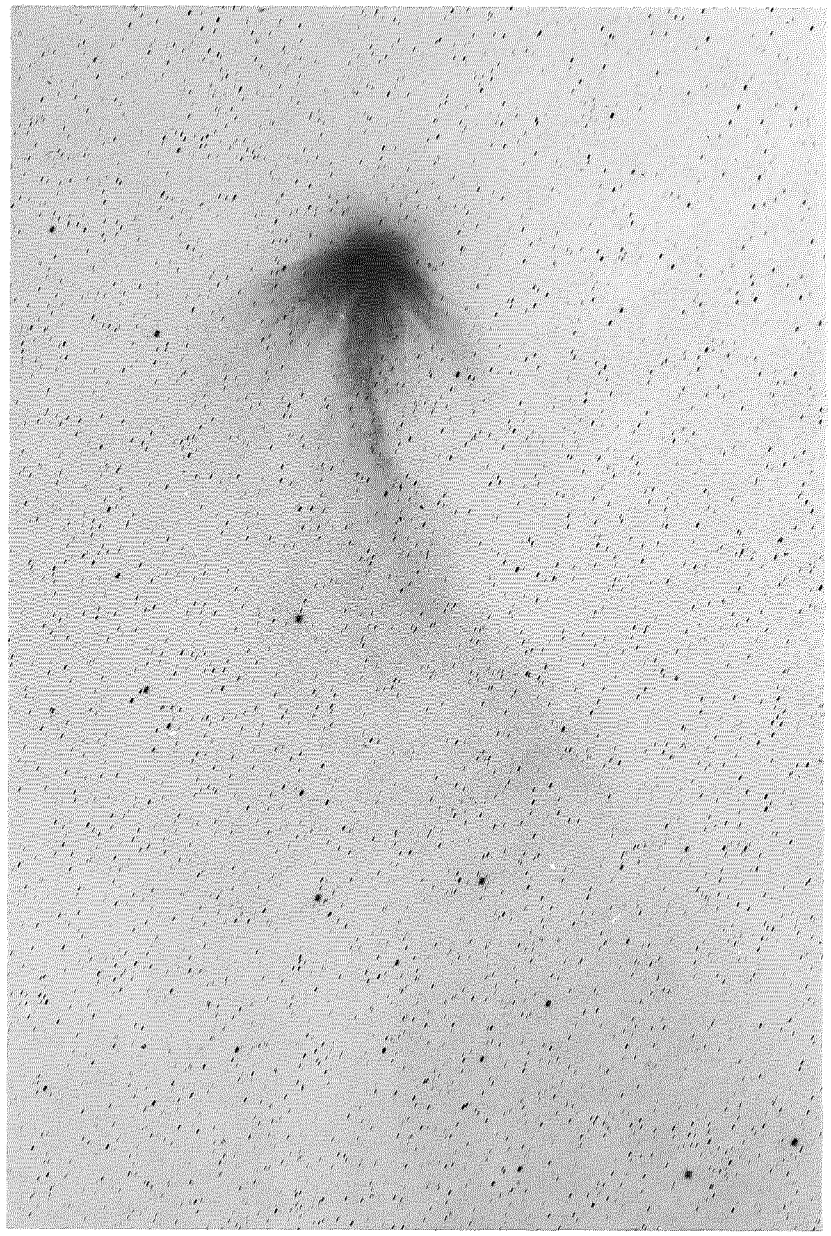


Fig. 6: 1962 Aug. 31.295; exposure 10 minutes on Kodak 103a-O plate; r = 2.43, Δ = 1.48, α = $10\overset{\circ}{.}0$; scale: 7.2×10^4 km/mm.

Photograph taken by C. E. Kearns and K. Rudnicki with 48-inch Schmidt telescope, Palomar Observatory, California, U.S.A.

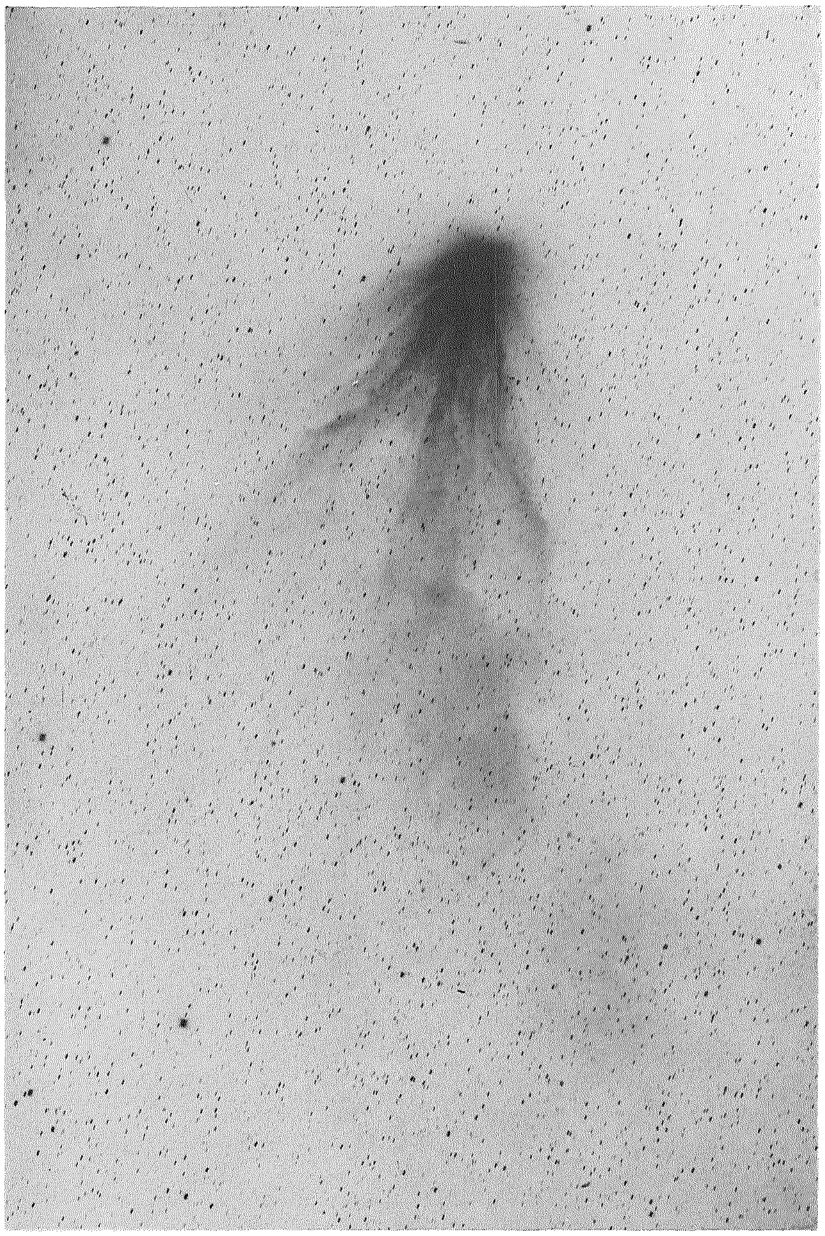


Fig. 7: 1962 Sept. 1.270; exposure 10 minutes on Kodak 103a-O plate; $r = 2.43$, $\Delta = 1.48$, $\alpha = 10^{\circ}.7$; scale: 7.2×10^4 km/mm.

Photograph taken by C. E. Kearns and K. Rudnicki with 48-inch Schmidt telescope, Palomar Observatory, California, U.S.A.

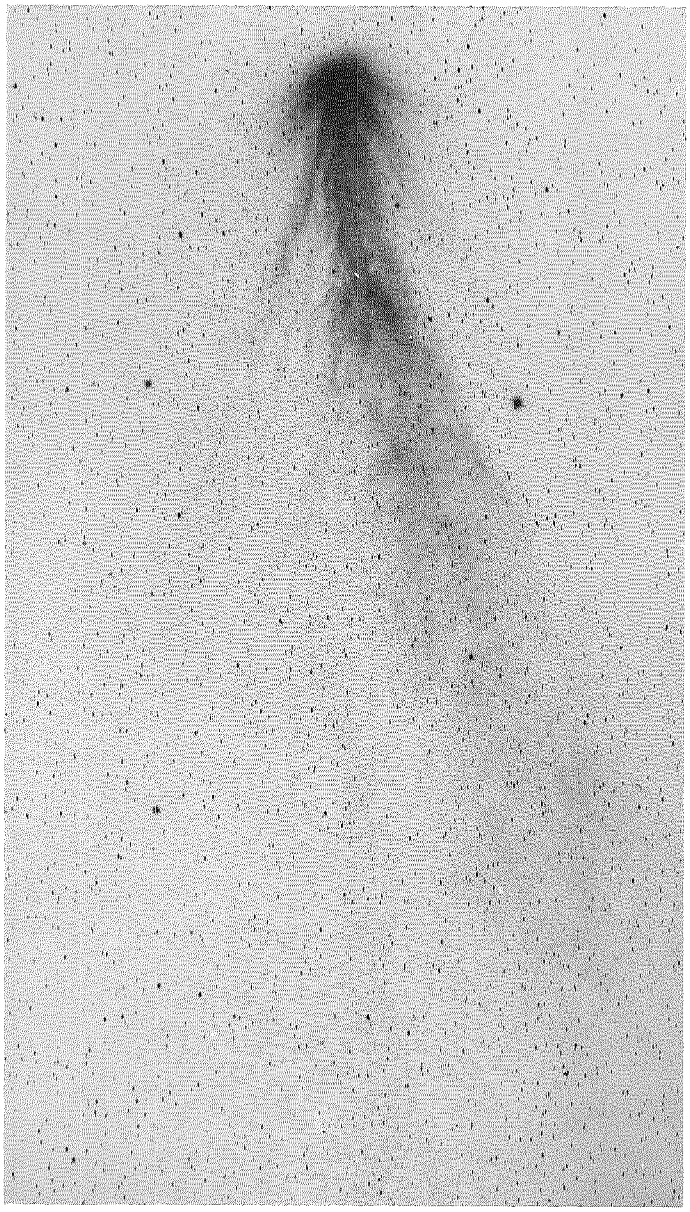


Fig. 8: 1962 Sept. 5.244; exposure 10 minutes on Kodak 103a-O plate; r = 2.41, Δ = 1.51, α = 13.°8; scale: 7.3×10^4 km/mm.

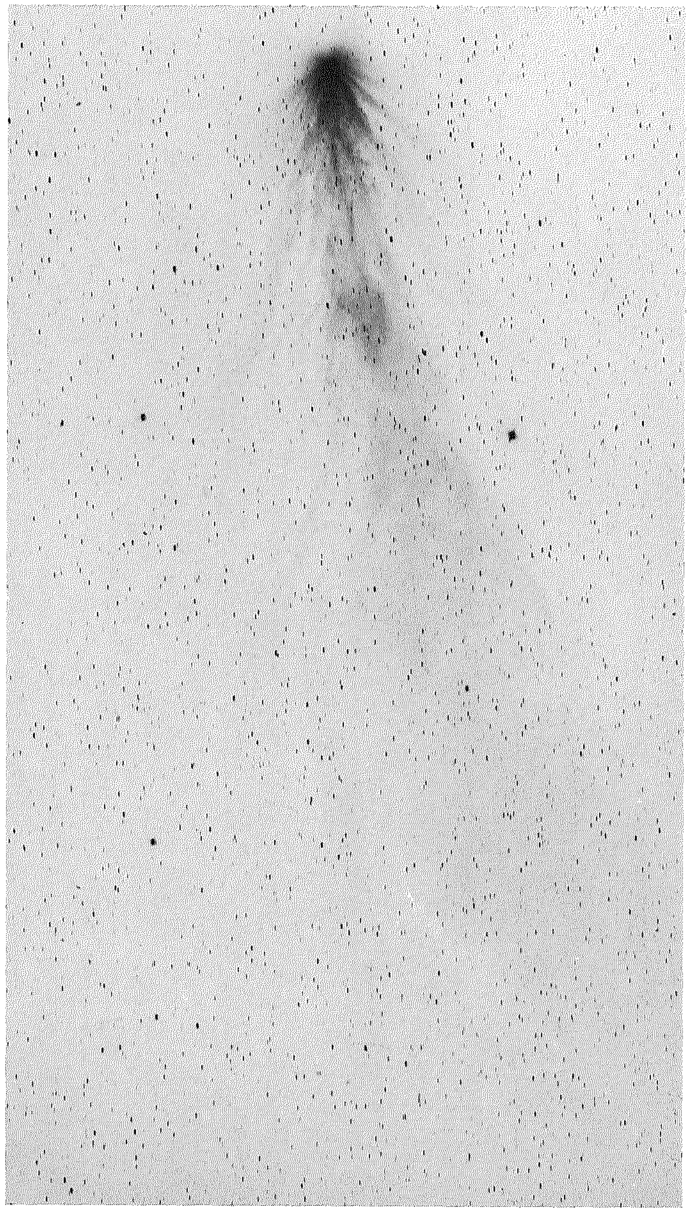


Fig. 9: 1962 Sept. 5.349; exposure 10 minutes on Kodak 103a-O plate; r = 2.41, Δ = 1.51, α = 13.°9; scale: 7.3×10^4 km/mm.

Photographs taken by C. E. Kearns and K. Rudnicki with 48-inch Schmidt telescope, Palomar Observatory, California, U.S.A.

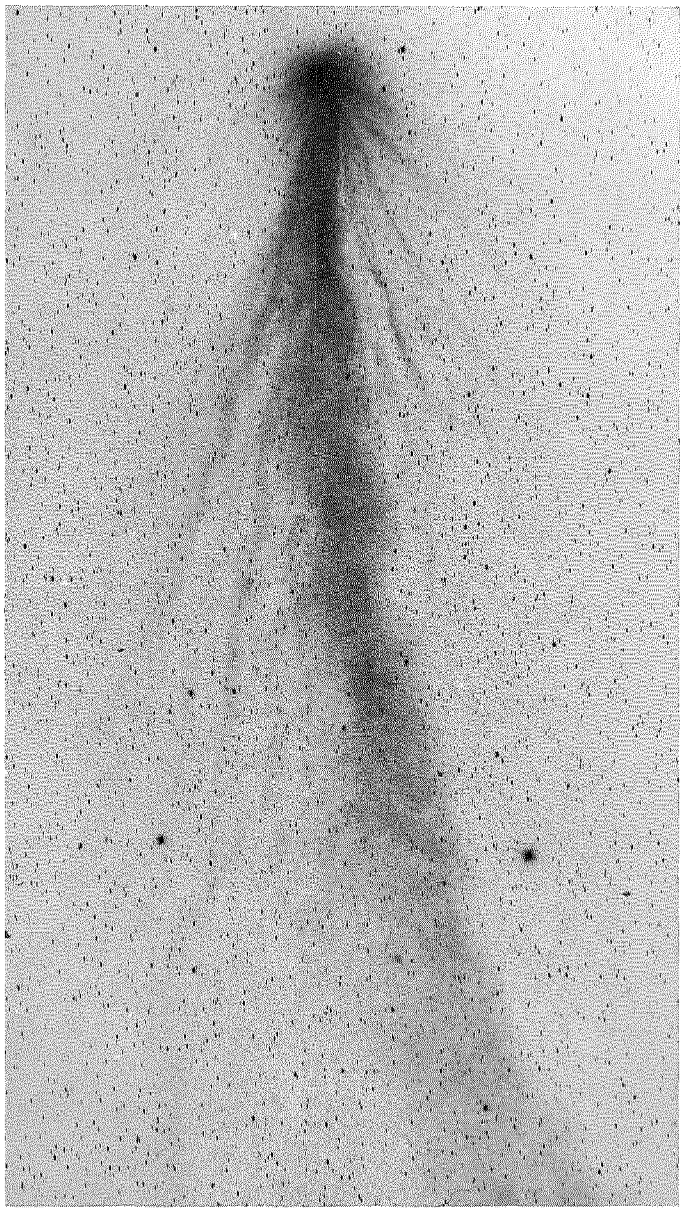


Fig. 10: 1962 Sept. 6.281; exposure 10 minutes on Kodak 103a-O plate; r = 2.40, Δ = 1.52, $\alpha = 14\overset{\circ}{.}6$; scale: 7.4×10^4 km/mm.

Photograph taken by C. E. Kearns and K. Rudnicki with 48-inch Schmidt telescope, Palomar Observatory, California, U.S.A.

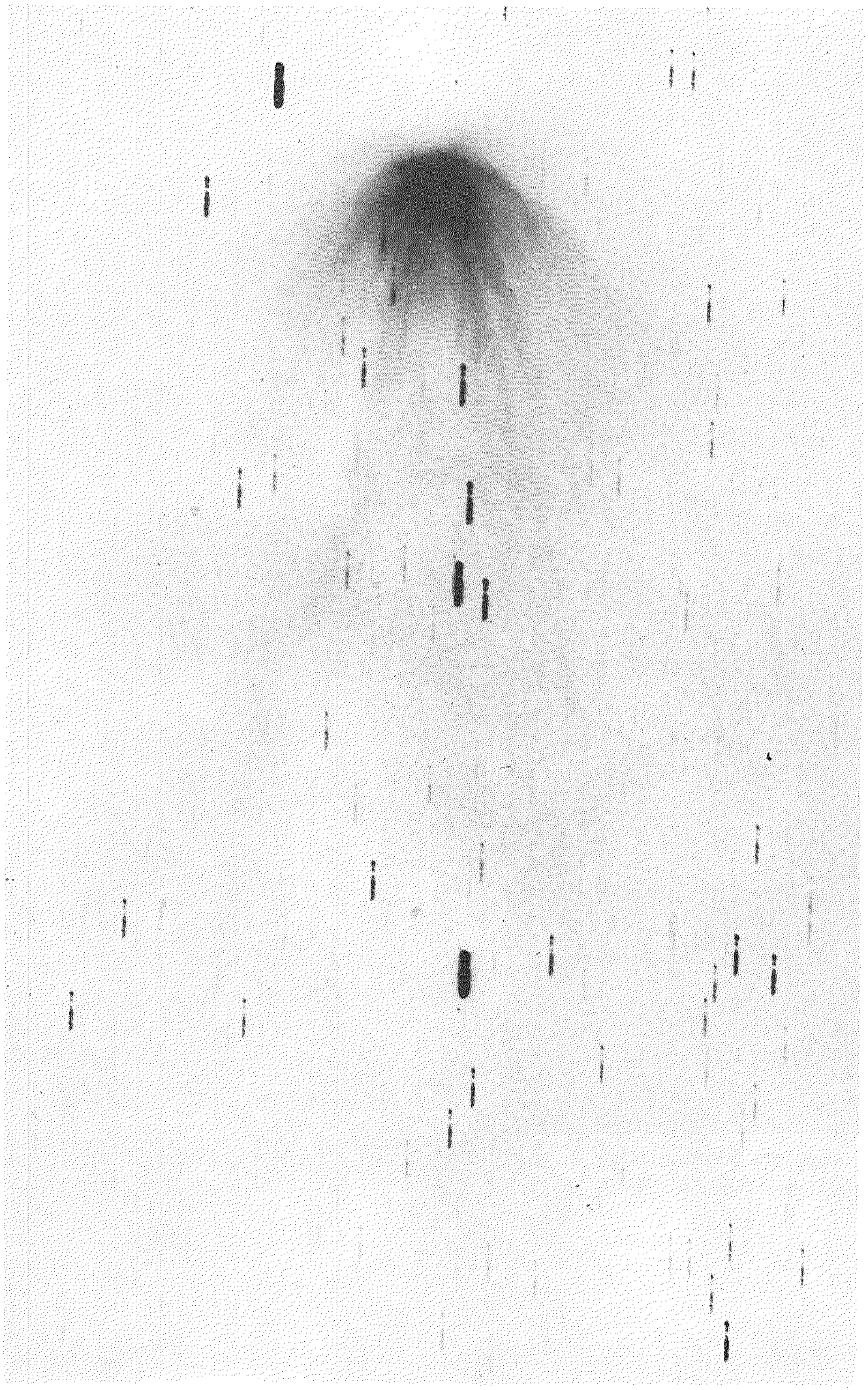


Fig. 11a: 1962 Sept. 19.170; exposure 30 minutes on Kodak 103a-O plate; r = 2.34, Δ = 1.68, $\alpha = 22\overset{\circ}{.}1$; enlarged 4.2X; scale: 8.6×10^3 km/mm.

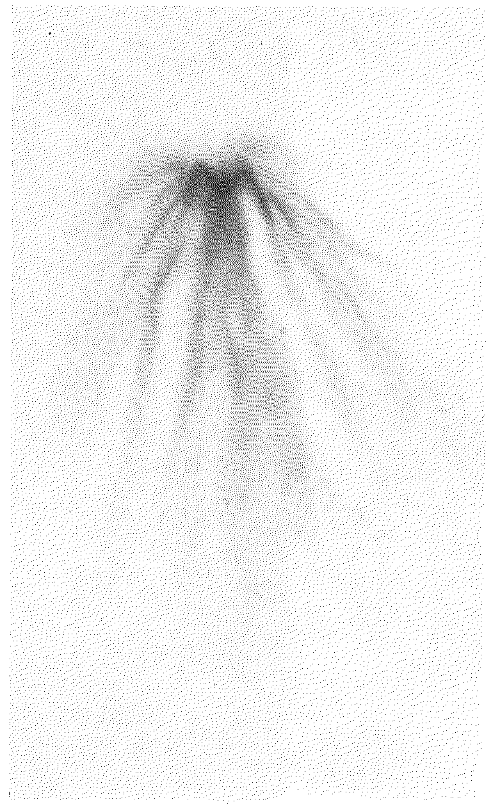


Fig. 11b: Drawing based on photograph of Sept. 19.170; enlarged about 5X; see Fig. 11a.

Photograph taken by E. Roemer with 40-inch reflector, U.S. Naval Observatory, Flagstaff Station, Arizona, U.S.A.

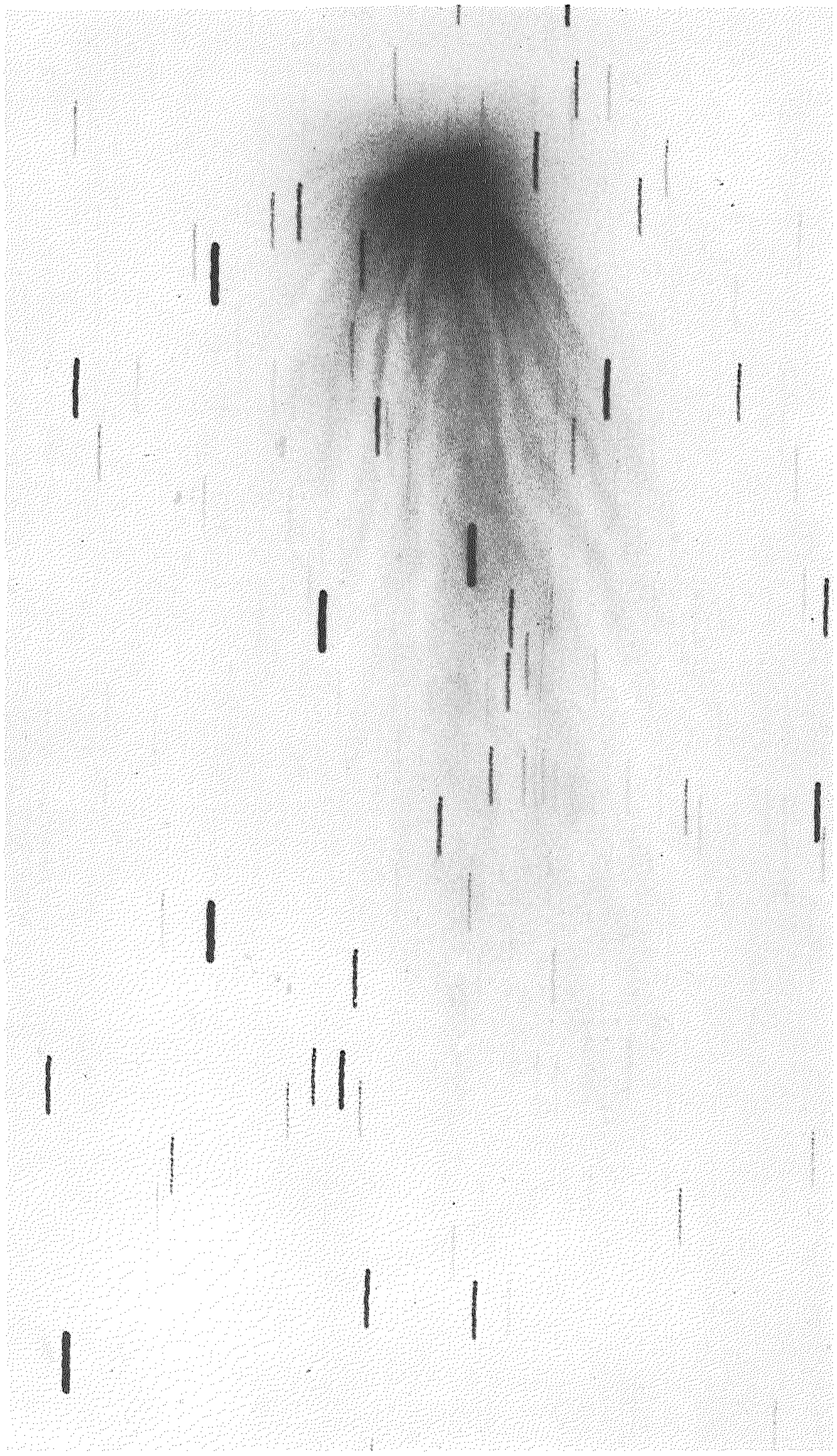


Fig. 12a: 1962 Sept. 26.131; exposure 10 minutes on Kodak 103a-O plate; r = 2.31, Δ = 1.80, $\alpha = 24\overset{\circ}{.}5$; enlarged 4.2X; scale: 9.2×10^3 km/mm.

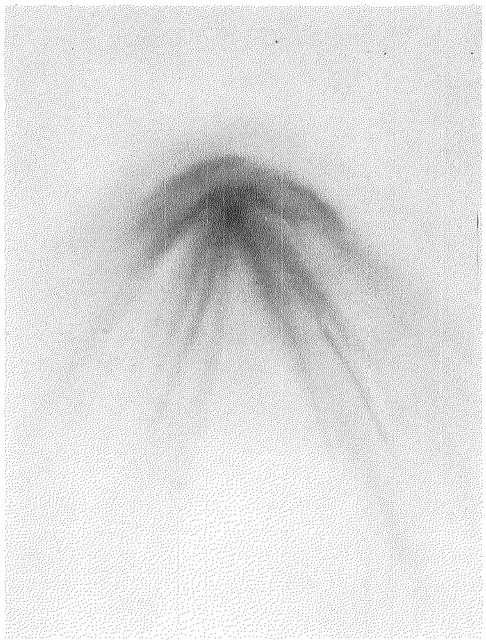


Fig. 12b: Drawing based on photograph of Sept. 26.131; enlarged about 5X; see Fig. 12a.

Photograph taken by E. Roemer with 40-inch reflector, U.S. Naval Observatory, Flagstaff Station, Arizona, U.S.A.

INFLUENCE OF INSTRUMENTAL FACTORS ON THE APPEARANCE OF A COMET

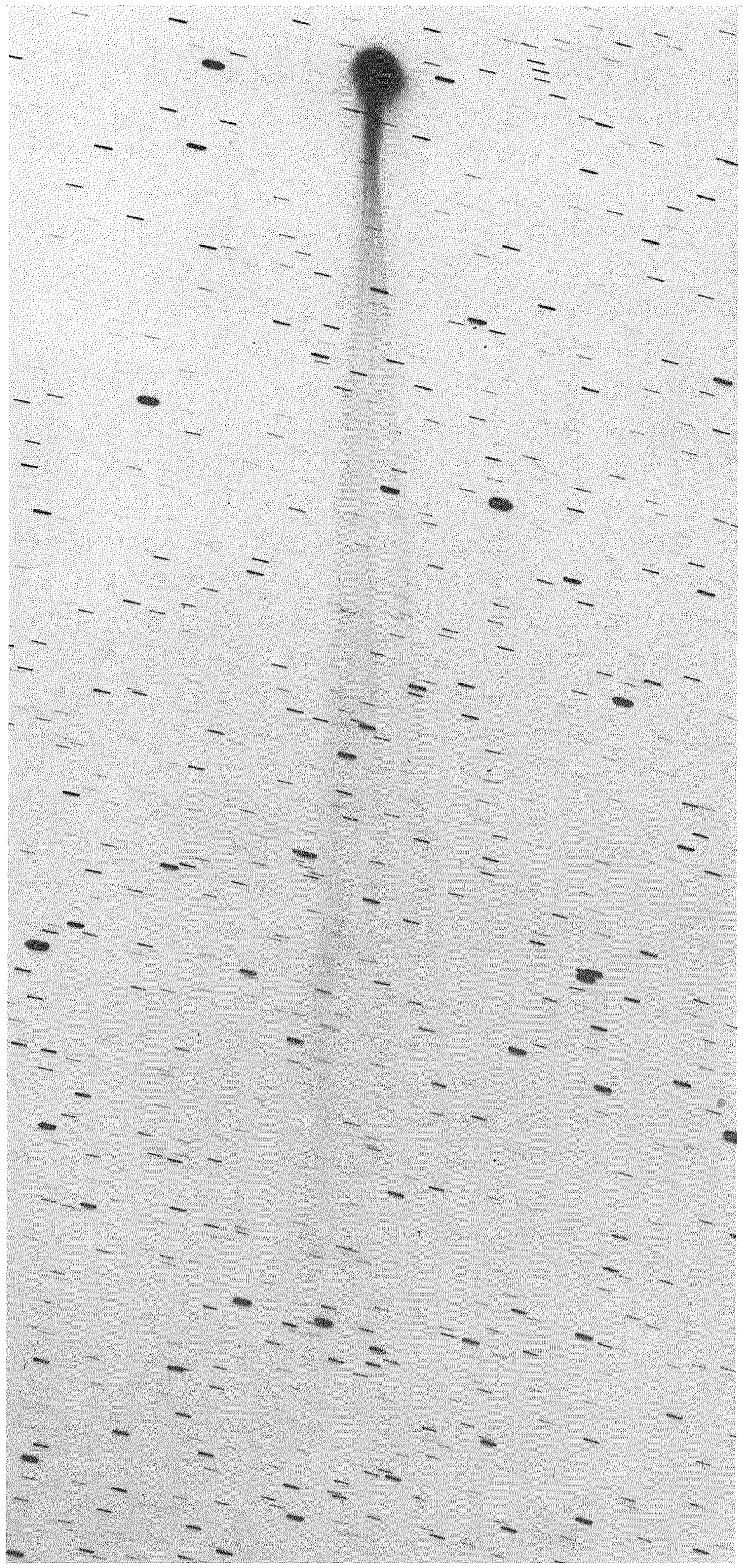


Fig. 1: Comet Finsler 1937 V. Photograph taken with 5-inch Cooke lens; f = 22.55 inches; scale of original photograph: 360″/mm; see Fig. 2.

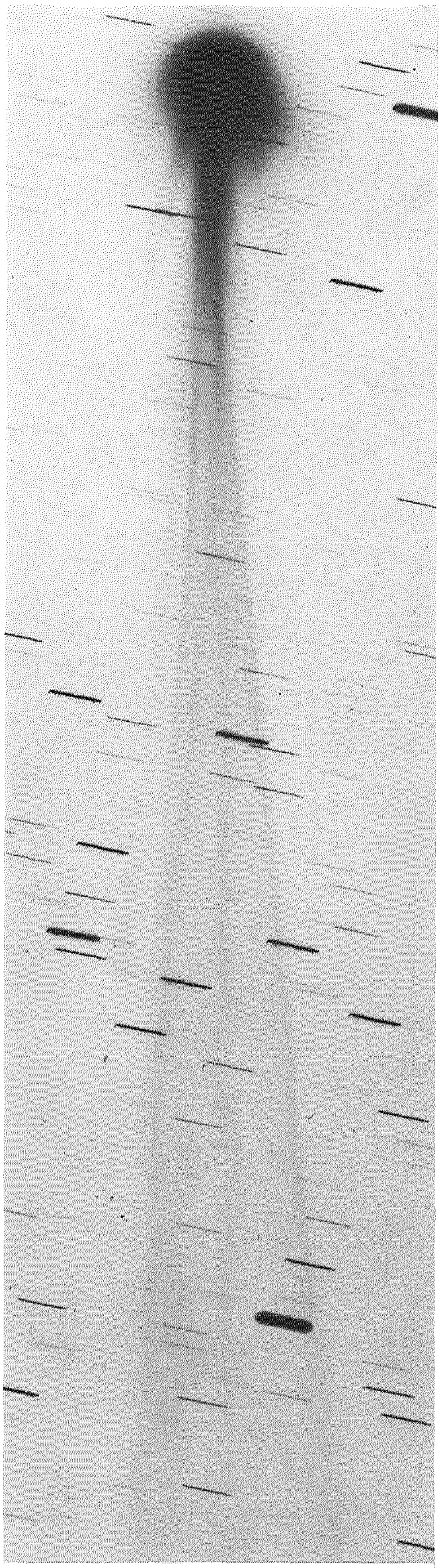


Fig. 2: Comet Finsler 1937 V. Photograph taken with 13-inch refractor; f = 66.47 inches; scale of original photograph: 122″/mm; see Fig. 1.

Photographs of the same comet, shown in Figs. 1 and 2, were taken by H. L. Giclas simultaneously with different instruments at Lowell Observatory, Flagstaff, Arizona, U.S.A., 1937 Aug. 9.247; exposure 31.1 minutes; $r = 0.87$, $\Delta = 0.55$, $\alpha = 88^\circ\!.1$; both enlarged 2.8×.

Fig. 3: Comet Halley 1910 II. Photograph taken with 210-mm Tessar lens, Lowell Observatory, Flagstaff, Arizona, U.S.A., 1910 May 8.446; exposure 40.5 minutes; r = 0.71, Δ = 0.52, α = 109$^{\circ}\!.$7.

Figs. 3, 4, and 5 show photographs of the same comet, taken at about the same time with different telescopes. In Figs. 3 and 4, identical stars are marked by an arrow. Because of short exposure in Fig. 5, stars cannot be recognized at all.

Fig. 4: Comet Halley 1910 II. Photograph taken with 35-inch Brashear lens, Lowell Observatory, Flagstaff, Arizona, U.S.A., 1910 May 8.464; exposure 24 minutes; r = 0.71, Δ = 0.52, α = 109°.7.

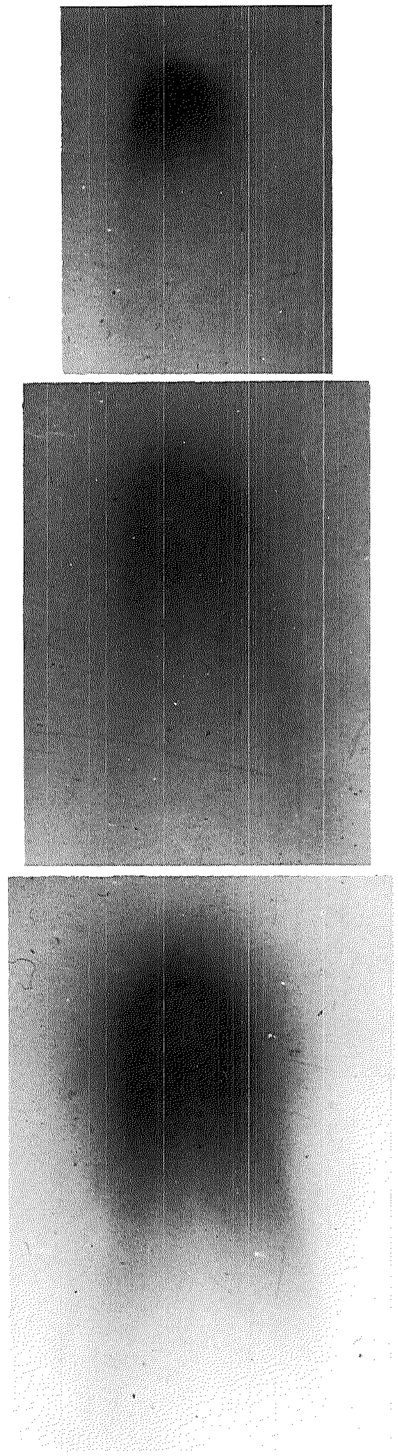


Fig. 5: Comet Halley 1910 II. Photographs taken with 42-inch reflector, Lowell Observatory, Flagstaff, Arizona, U.S.A., 1910 May 8.471. A sequence of different exposures. Duration of exposures unknown; r = 0.71, Δ = 0.51, α = 109°.7.

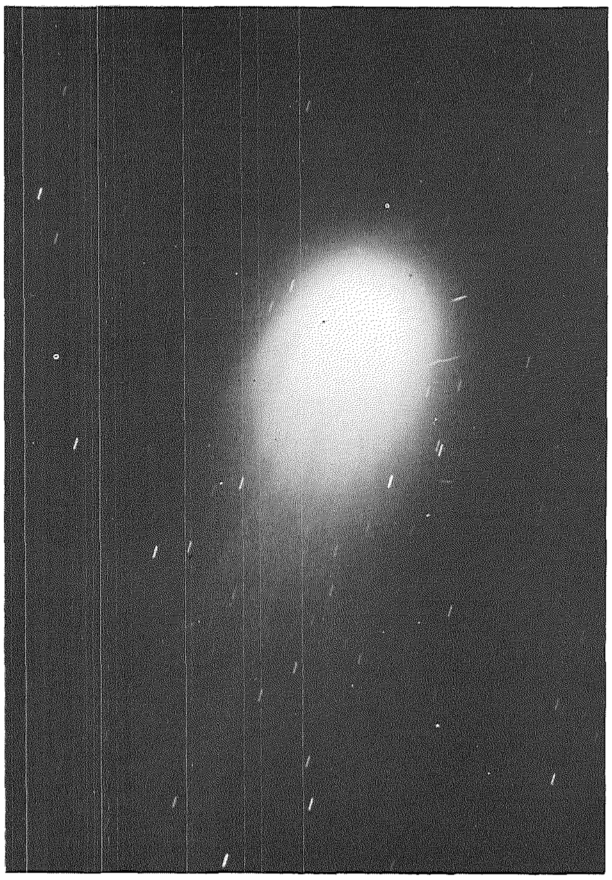


Fig. 6: Comet Halley 1910 II. Photograph taken 1910 May 28.789; exposure 10 minutes; r = 0.99, Δ = 0.37, α = 82°5; enlarged 1.4X; scale: 1.3×10^4 km/mm.

Fig. 7: Comet Halley 1910 II. Photograph taken 1910 May 28.843; exposure 3 minutes; r = 1.00, Δ = 0.37, α = 82°3; enlarged 1.4X; scale: 1.3×10^4 km/mm. More details can be recognized in the coma region (see Fig. 6).

The influence of different exposure times is illustrated in Figs. 6 through 9 of Comet Halley 1910 II. The photographs were taken by H. Knox Shaw with 30-inch reflector, Khedivial Observatory, Helwan, Egypt.

Fig. 8: Comet Halley 1910 II. Photograph taken 1910 June 2.776; exposure 20 minutes; r = 1.07, Δ = 0.55, α = 69°1; enlarged 1.4X; scale: 1.7 X 10^4 km/mm.

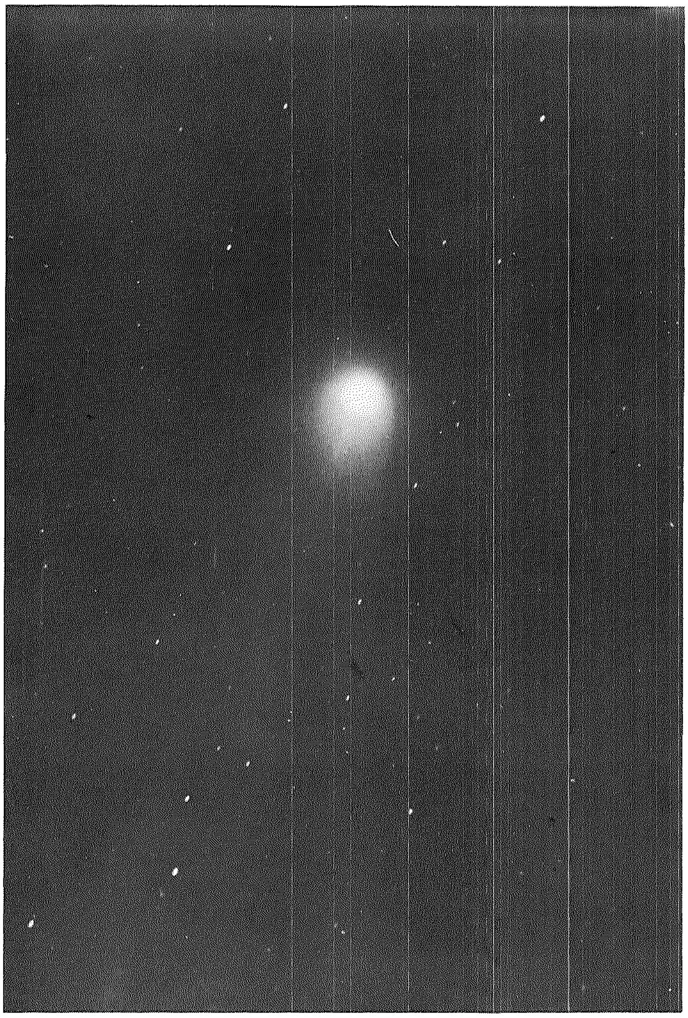


Fig. 9: Comet Halley 1910 II. Photograph taken 1910 June 2.842; exposure 10 minutes; r = 1.07, Δ = 0.56, α = 68°9; enlarged 1.4X; scale: 1.7 X 10^4 km/mm. The circular halos around the nucleus appear very clearly in this photograph (see also the photographs on page 91).

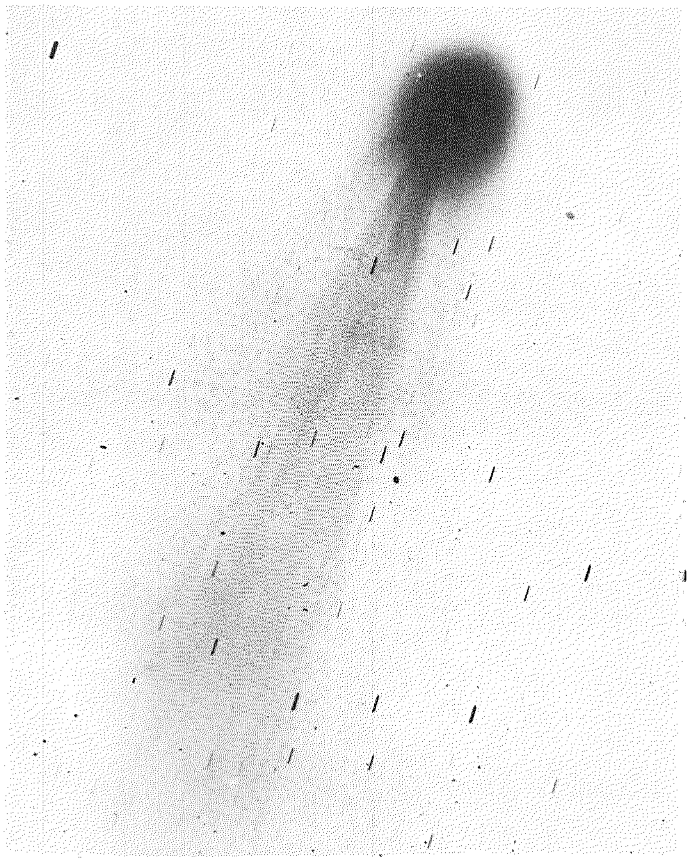


Fig. 10: Comet Halley 1910 II. Photograph taken by H. Knox Shaw with 30-inch reflector, Khedivial Observatory, Helwan, Egypt, 1910 May 30.783; exposure 20 minutes; $r = 1.02$, $\Delta = 0.44$, $\alpha = 76\overset{\circ}{.}2$; enlarged 1.6X; scale: 1.2×10^4 km/mm.

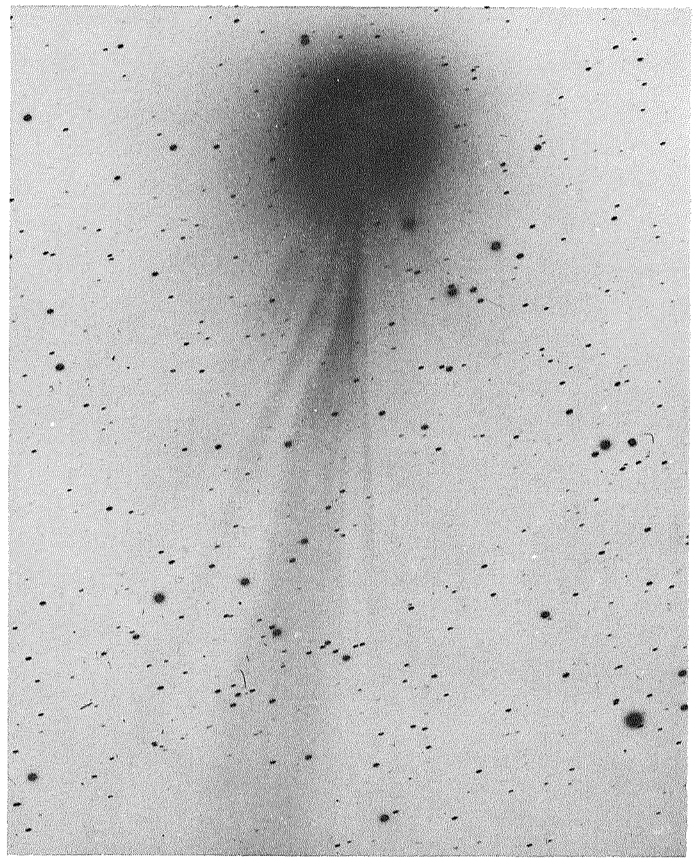


Fig. 11: Comet Whipple-Fedtke-Tevzadze 1943 I. Photograph taken by H. L. Giclas with 5-inch Cooke lens, Lowell Observatory, Flagstaff, Arizona, U.S.A., 1943 Feb. 28.249; exposure 30 minutes; $r = 1.39$, $\Delta = 0.53$, $\alpha = 33\overset{\circ}{.}0$; enlarged 2.2X; scale: 6.2×10^3 km/mm.

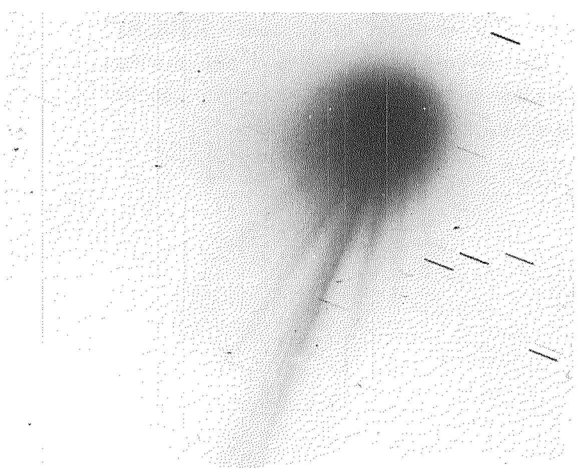


Fig. 12a: Comet Finsler 1937 V. Photograph taken by H. M. Jeffers with 36-inch Crossley reflector, Lick Observatory, Mt. Hamilton, California, U.S.A., 1937 Aug. 11; exposure 5 minutes; $r = 0.87$, $\Delta = 0.56$, $\alpha = 88\overset{\circ}{.}1$; enlarged 1.5X; scale: 1.0×10^4 km/mm.

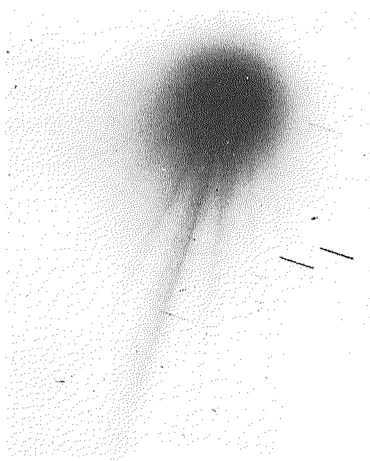


Fig. 12b: Detail of Fig. 12a; enlarged 1.8X; scale: 8.6×10^3 km/mm.

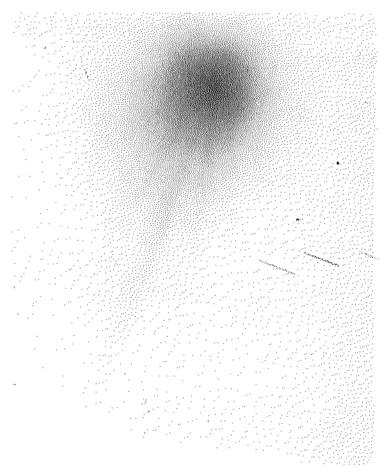


Fig. 12c: Detail of Fig. 12a; enlarged 1.8X; scale: 8.6×10^3 km/mm.

Figs. 12b and 12c are printed to bring out detail closer to nucleus.

Fig. 13: Comet Brooks 1911 V. Photograph taken by H. D. Curtis with 36-inch Crossley reflector, Lick Observatory, Mt. Hamilton, California, U.S.A., 1911 Oct. 22.035; exposure 40 minutes; $r = 0.51$, $\Delta = 0.74$, $\alpha = 104\overset{\circ}{.}3$; enlarged 1.5X; scale: 1.4×10^4 km/mm.

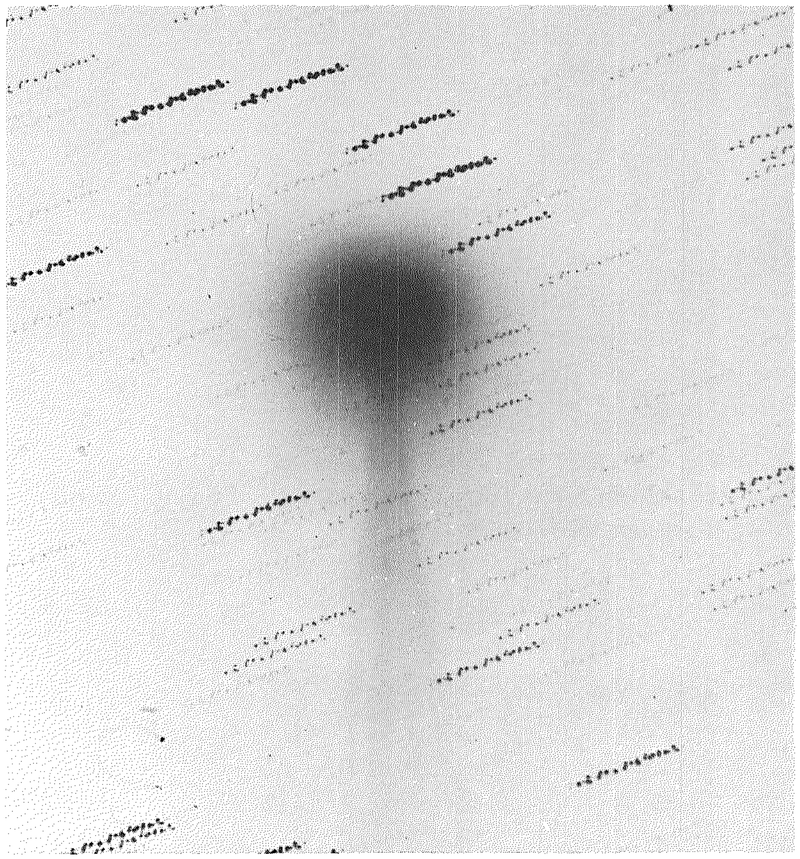


Fig. 14: Comet Burnham 1960 II. Photograph taken by P. Maffei and K. Wurm with 48-inch reflector, Astrophysical Observatory of Padua University, Asiago, Italy, 1960 April 26.085; exposure 15 minutes on Kodak 103a-O plate; $r = 0.95$, $\Delta = 0.21$, $\alpha = 98\overset{\circ}{.}3$; enlarged 1.3X; scale: 3.9×10^3 km/mm.

Usually tail structures in the coma region of comets are masked by the emission of coma molecules. Examples are given in Figs. 10 through 14.

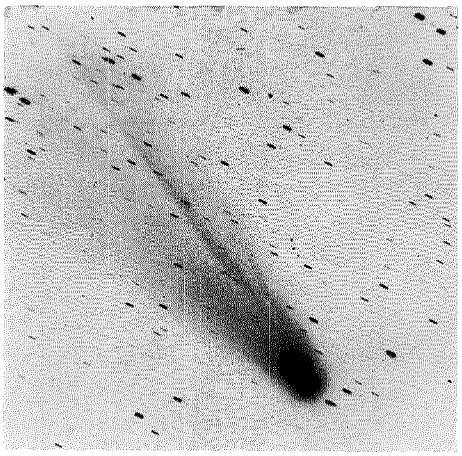


Fig. 15: 1957 May 4.901; exposure 15 minutes on Kodak 103a-O plate, covering the region 3500-5000 Å.

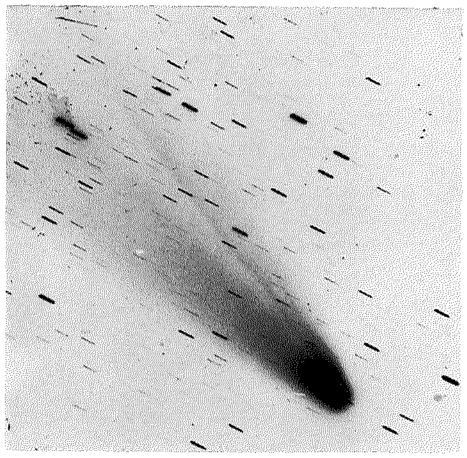


Fig. 16: 1957 May 4.942; exposure 30 minutes on Kodak 103a-O plate + Topas Agfa O filter, covering the region 4200-5000 Å.

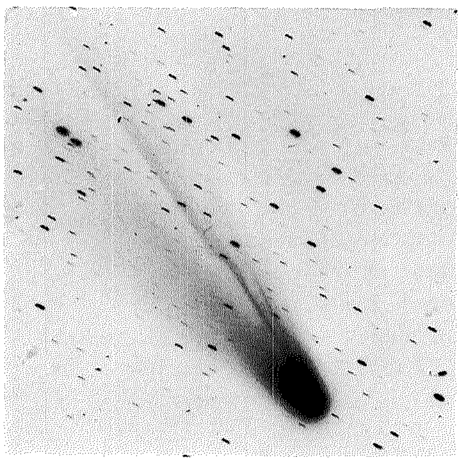


Fig. 17: 1957 May 4.967; exposure 16 minutes on Kodak 103a-O plate, covering the region 3500-5000 Å.

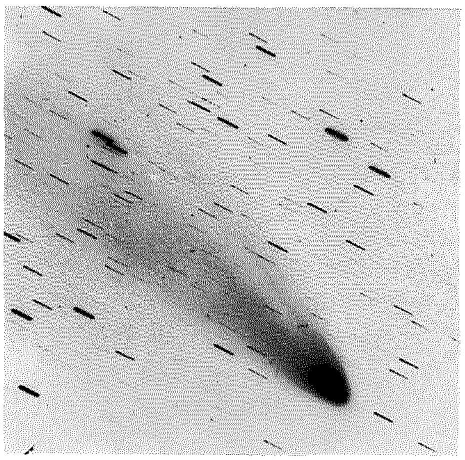


Fig. 18: 1957 May 5.000; exposure 40 minutes on Kodak 103a-E plate + RG1 filter, covering the region 6200-6900 Å.

Comet Arend-Roland 1957 III. Photographs taken by P. Maffei using different plate emulsions and filters with 24-inch Zeiss reflector, Bologna University Observatory, Loiano Station, Italy. For all figures, $r = 0.79$, $\Delta = 0.86$, $\alpha = 75\overset{\circ}{.}4$; enlargement 1.5X; scale: 4.1×10^4 km/mm.

For a detailed analysis of these and further photographs, see P. Maffei, "Osservazioni di Comete," Mem. della Soc. Astron. Ital. 32, pp. 1-32, 1961.

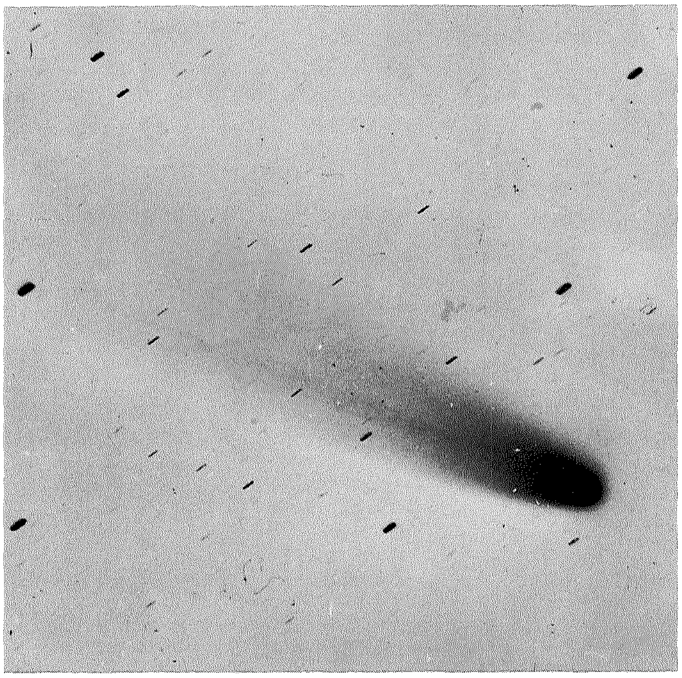


Fig. 19: 1957 Aug. 27.828; exposure 12 minutes on Kodak 103a-E plate + RG1 filter, covering the region 6200-6900 Å.

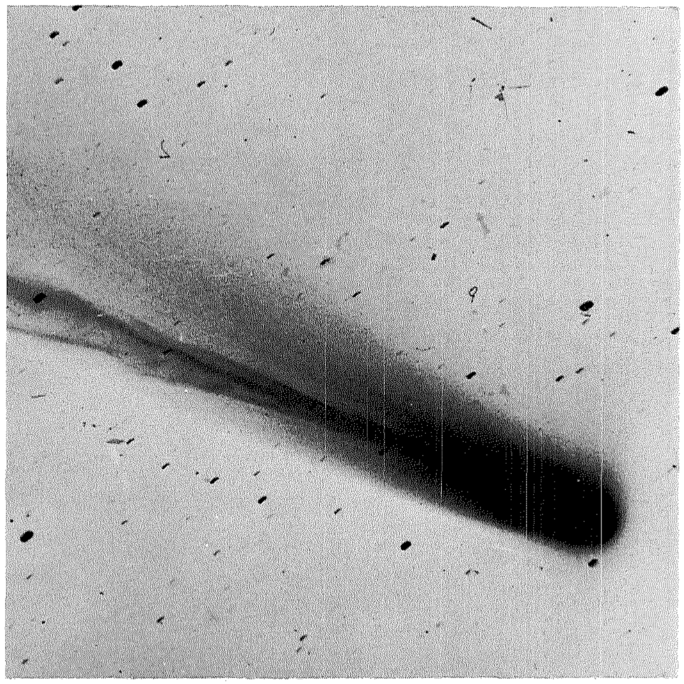


Fig. 20: 1957 Aug. 27.840; exposure 8 minutes on Kodak 103a-O plate, covering the region 3500-5000Å.

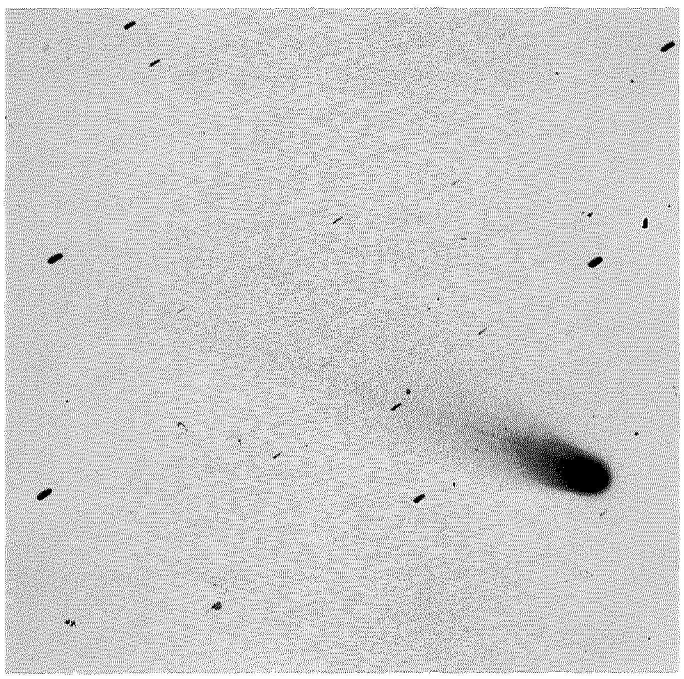


Fig. 21: 1957 Aug. 27.849; exposure 12 minutes on Kodak 103a-O plate + Topas Agfa O filter, covering the region 4200-5000 Å.

Comet Mrkos 1957 V. Photographs taken by P. Maffei using different plate emulsions and filters with 24-inch Zeiss reflector, Bologna University Observatory, Loiano Station, Italy. For all figures, $r = 0.78$, $\Delta = 1.22$, $\alpha = 55\overset{\circ}{.}8$, enlargement 2.5X; scale: 3.5×10^4 km/mm.

For a detailed analysis of these and further photographs, see P. Maffei, "Osservazioni di Comete," Mem. della Soc. Astron. Ital. 32, pp. 1-32, 1961.

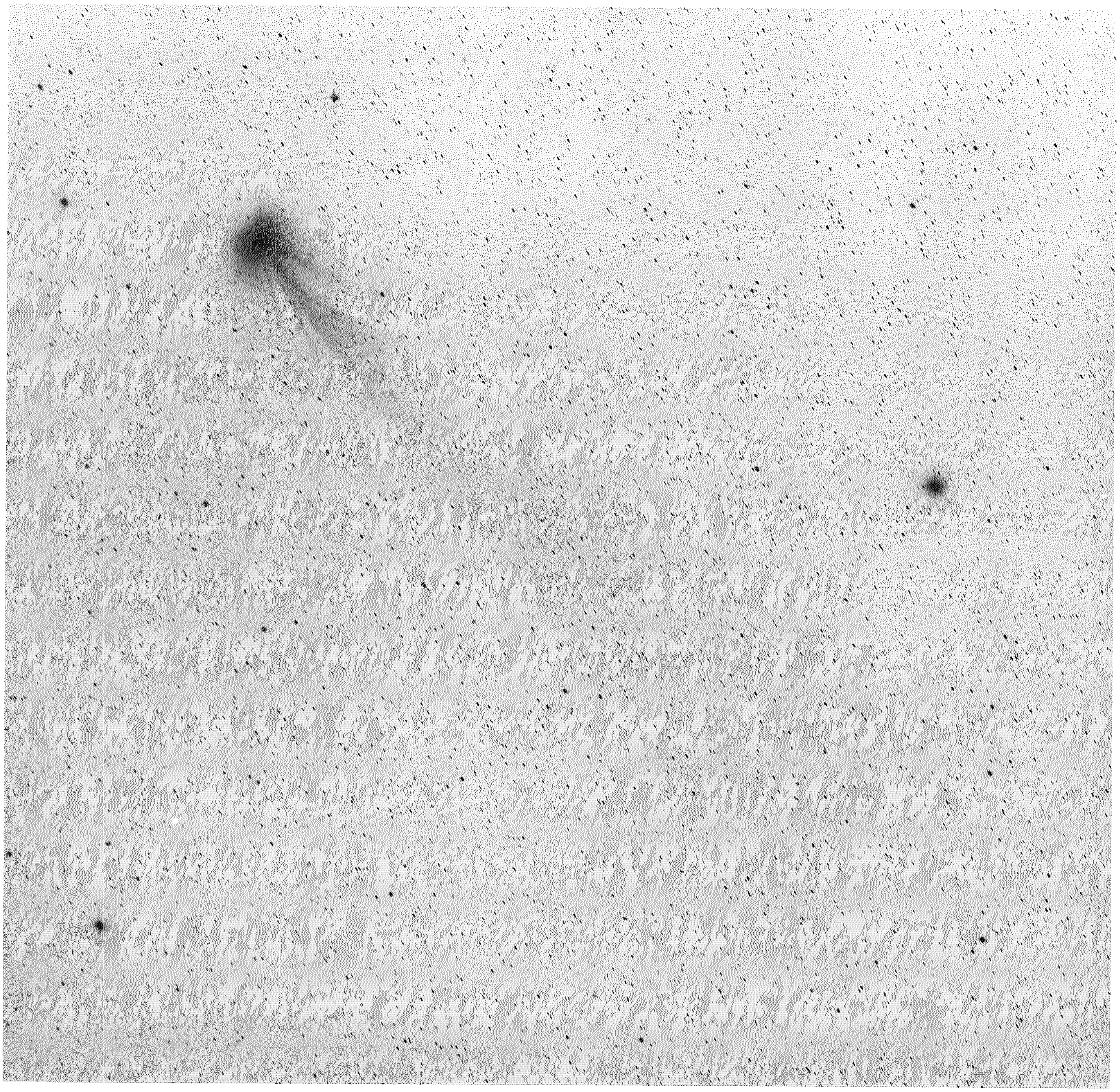


Fig. 22: Comet Humason 1962 VIII. Photograph taken by C. E. Kearns and K. Rudnicki with 48-inch Schmidt telescope, Palomar Observatory, California, U.S.A., 1962 Sept. 4.259; exposure 12 minutes on Kodak 103a-D plate + yellow filter; $r = 2.41$, $\Delta = 1.50$, $\alpha = 13\overset{\circ}{.}1$; scale: 7.3×10^4 km/mm; see Fig. 23.

Fig. 23: Comet Humason 1962 VIII. Photograph taken by C. E. Kearns and K. Rudnicki with 48-inch Schmidt telescope, Palomar Observatory, California, U.S.A., 1962 Sept. 4.269; exposure 10 minutes on Kodak 103a-O plate; r = 2.41, Δ = 1.50, $\alpha = 13\overset{\circ}{.}1$; scale: 7.3×10^4 km/mm; see Fig. 22.

APPENDIX A

DIAGRAM OF ORBITAL ELEMENTS AND PHASE ANGLE

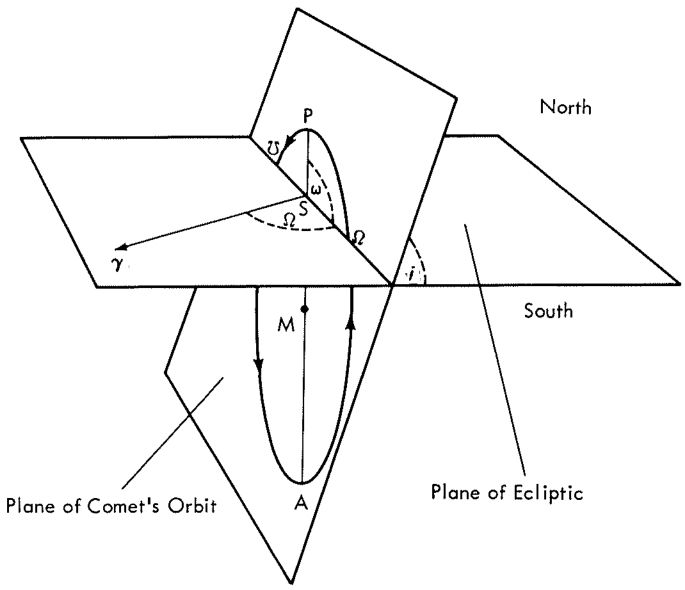


Fig. A-1. Orbital Elements of a Comet

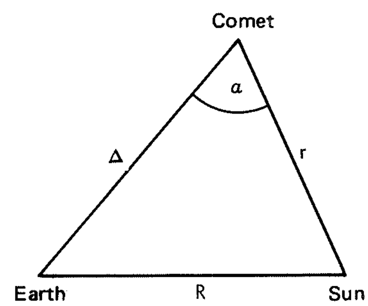


Fig. A-2. Definition of the Phase Angle α

Symbols and Definitions

S = Sun
M = Center of Comet's Orbit
P = Perihelion
A = Aphelion
γ = Vernal Equinox
Ω = Ascending Node
℧ = Descending Node
e = Eccentricity
q = Perihelion Distance
a = Semi-major Axis
ω = Angle between Ascending Node and Perihelion
Ω = Longitude of Ascending Node
i = Inclination of Orbital Plane to Ecliptic

R = Radius Vector of the Earth
r = Heliocentric Distance of the Comet
Δ = Geocentric Distance of the Comet
α = Phase Angle

$$\cos \alpha = \frac{r^2 + \Delta^2 - R^2}{2r\Delta}$$

APPENDIX B

ORBITAL ELEMENTS,* LUMINOSITY,** AND SPECTROSCOPIC DATA† FOR THE COMETS APPEARING IN PART I OF ATLAS

Comet No.	Definite Designation	Preliminary Designation	Name	T (U.T.)	q (A.U.)	ω	Ω	i
1	1835 III	1835c	P/Halley	Nov. 16.44	0.59	110°.7	56°.8	162°.3
2	1858 VI	1858e	Donati	Sept. 30.46	0.58	129.1	166.6	117.0
3	1861 II	1861b	Tebbutt	June 12.01	0.82	330.1	280.2	85.4
4	1862 III	1862b	P/Swift-Tuttle	Aug. 23.41	0.96	152.8	138.7	113.6
5	1868 II	1868b	Winnecke	June 26.98	0.58	126.6	53.4	131.6
6	1874 III	1874c	Coggia	July 9.36	0.68	152.4	119.8	66.3
7	1881 III	1881c	Tebbutt	June 16.94	0.73	354.2	271.9	63.4
8	1907 IV	1907d	Daniel	Sept. 4.46	0.51	294.4	143.6	9.0
9	1908 III	1908c	Morehouse	Dec. 26.26	0.95	171.6	103.8	140.2
10	1910 II	1909c	P/Halley	Apr. 20.18	0.59	111.7	57.8	162.2
11	1911 V	1911c	Brooks	Oct. 28.24	0.49	153.0	293.5	33.8
12	1937 V	1937f	Finsler	Aug. 15.66	0.86	114.8	58.7	146.4
13	1943 I	1942g	Whipple-Fedtke-Tevzadze	Feb. 6.72	1.35	39.8	100.1	19.7
14	1957 III	1956h	Arend-Roland	Apr. 8.03	0.32	308.8	215.2	119.9
15	1957 V	1957d	Mrkos	Aug. 1.44	0.35	40.3	67.6	93.9
16	1960 II	1959k	Burnham	Mar. 20.99	0.50	306.7	252.0	159.6
17	1962 VIII	1961e	Humason	Dec. 10.20	2.13	233.6	154.7	153.3

*The orbital elements for Comets 1835 III – 1960 II are taken from J. G. Porter, *Mem. Brit. Astron. Assoc. 39,* No. 3, 1961; for Comet 1962 VIII from B. G. Marsden, *I.A.U. Cir. 1848,* 1963.

**The photometric parameters for Comets 1835 III and 1868 II are taken from S. K. Vsekhsvyatskii, "Physical Characteristics of Comets," 1958; for Comets 1858 VI – 1943 I from A. Hruska and V. Vanysek, *Publ. Astron. Inst. Czech. Acad.,* p. 345, 1958; for Comets 1957 III – 1960 II from S. K. Vsekhsvyatskii, *Sov. Astron. – AJ 6,* p. 849, 1963; for Comet 1962 VIII from S. K. Vsekhsvyatskii, *Sov. Astron. – AJ 10,* p. 1034, 1967.

†According to A. Hruska and V. Vanysek, *Publ. Astron. Inst. Czech. Acad.,* p. 345, 1958, and P. Swings and L. Haser, "Atlas of Representative Cometary Spectra," 1956.

APPENDIX B (Continued)

Comet No.	e	P* (years)	1/a $(A.U.)^{-1}$	H_0†	n†	Relative Intensities of Spectral Components: Continuum	Neutral Emission	Ion Emission
1	0.9674	76	0.0064	5.2	5.0			**
2	0.9963		0.0064	3.7	3.8			**
3	0.9851		0.0181	5.1	0.5			**
4	0.9604	120		5.4	8.6			**
5	1.0000			7.6	4.0			**
6	0.9988		0.0017	6.3	5.0			**
7	0.9959		0.0055	5.6	2.6			**
8	0.9988		0.0024	4.4	3.6	Strong	Fair	Fair
9	1.0007		0.0007	3.9	5.1	Very weak	Very weak	Strong
10	0.9673	76	0.0064	5.6	4.0	Strong	Strong	Strong
11	0.9970		0.0060	5.6	3.6	Weak	Fair	Strong
12	0.9997		0.0003	6.2	0.6	Weak	Fair	Strong
13	0.9922		0.0058	5.2	2.9	Weak	Fair	Fair
14	1.0002		0.0007	5.2	4.4	Strong	Strong	Fair
15	0.9994		0.0018	3.5	2.4	Strong	Fair	Fair
16	1.0000			8.5	3.6	Very weak	Fair	Fair
17	0.9895		0.0049	1.5	4.0	Very weak	Weak	Strong

*P, which here denotes the orbital period, is given for comets with periods of less than 200 years.

†The brightness of a comet as it depends on the distance from the earth, Δ, and from the sun, r, is generally given by an expression of the form

$$J = \frac{J_0}{\Delta^2 r^n}$$

Expressed in magnitudes, the total brightness H is given by

$$H = H_0 + 5 \log \Delta + 2.5 n \log r,$$

where H_0 is the brightness of the comet reduced to a heliocentric and geocentric distance of 1 A.U.

**Type I tail observed visually.

APPENDIX C

GENERAL PHYSICAL CHARACTERISTICS OF COMETS

The composition, especially the gas/dust ratio, varies widely among comets.

Ion tails are present in about 30% of comets.

Identified molecular-emission bands are excited by resonance fluorescence. For a number of bands, the source is unknown and the excitation mechanism uncertain. The means of excitation producing the forbidden atomic oxygen lines is also uncertain.

Nucleus

- Diameter : 1 to 50 km
- Mass : 10^{15} to 10^{21} g
- Composition: Volatile molecules (parents of observed species), meteoric particles, micron grains

Coma

- Observed constituents: O, CN, C_2, C_3, CH, NH, NH_2, OH, CO^+, CO_2^+, N_2^+, CH^+, OH^+, dust
- Diameter : 10^4 to 10^6 km
- Gas density : 10^{14} molecules/cm^3 at nucleus for very bright comets; varies approximately as r^{-2}
- Velocities : Neutral species and dust—up to 1 km/sec expansion

Tail

- Observed constituents: Ions (CO^+, CO_2^+, N_2^+, CH^+, OH^+), dust
- Length : Up to 10^8 km
- Width : Up to 10^6 km
- Gas density : 0.1 to 10^2 molecules/cm^3
- Velocities : 10 to 10^3 km/sec

APPENDIX D

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