CHEMICAL HERITAGE FOUNDATION

JOHN L. HOLMES

American Society for Mass Spectrometry

Transcript of an Interview
Conducted by

Michael A. Grayson

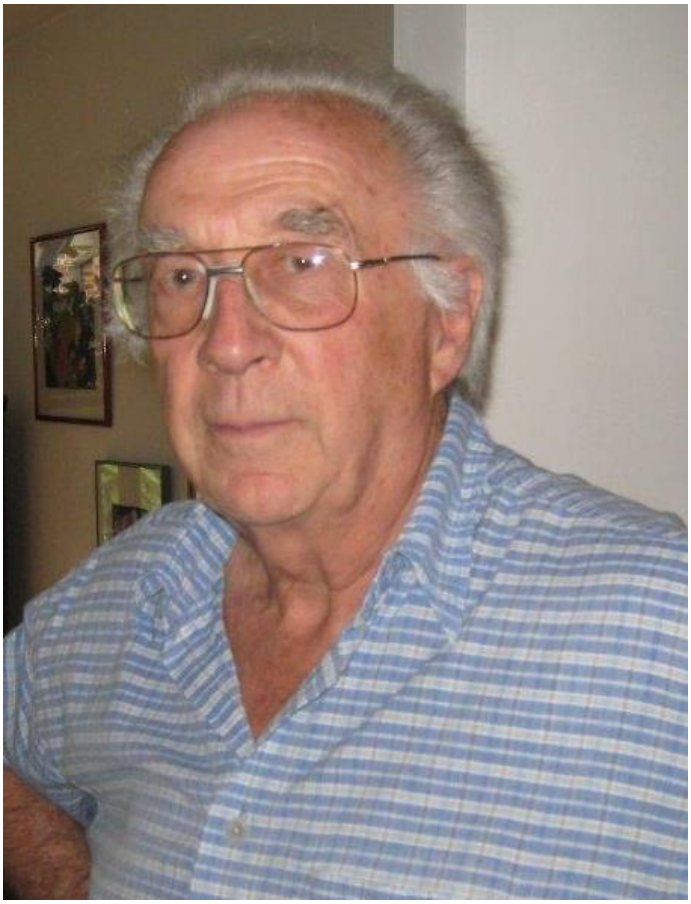
at

University of Ottawa
Ottawa, Canada

on

12 December 2013

(With Subsequent Corrections and Additions)



John L. Holmes

ACKNOWLEDGMENT

This oral history is one in a series initiated by the Chemical Heritage Foundation on behalf of the American Society for Mass Spectrometry. The series documents the personal perspectives of individuals related to the advancement of mass spectrometric instrumentation, and records the human dimensions of the growth of mass spectrometry in academic, industrial, and governmental laboratories during the twentieth century.

This project is made possible through the generous support of the

American Society for Mass Spectrometry.

CHEMICAL HERITAGE FOUNDATION
Center for Oral History
FINAL RELEASE FORM

This document contains my understanding and agreement with the Chemical Heritage Foundation with respect to my participation in the audio- and/or video-recorded interview conducted by Michael Grayson on December 12, 2013. I have read the transcript supplied by the Chemical Heritage Foundation.

1. The recordings, transcripts, photographs, research materials, and memorabilia (collectively called the "Work") will be maintained by the Chemical Heritage Foundation and made available in accordance with general policies for research and other scholarly purposes.

2. I hereby grant, assign, and transfer to the Chemical Heritage Foundation all right, title, and interest in the Work, including the literary rights and the copyright, except that I shall retain the right to copy, use, and publish the Work in part or in full until my death.

3. The manuscript may be read and the recording(s) heard/viewed by scholars approved by the Chemical Heritage Foundation unless restrictions are placed on the transcript as listed below.

This constitutes my entire and complete understanding.

(Signature) John L Holmes
John L. Holmes

(Date) 29 NOV. 2015

OPTIONAL: I wish to place the following restrictions on the use of this interview:

_____

_____

I understand that regardless of any restrictions that may be placed on the transcript of the interview, the Chemical Heritage Foundation retains the rights to all materials generated about my oral history interview and will make the title page, abstract, table of contents, chronology, index, et cetera (collectively called the "Front Matter and Index") available on the Chemical Heritage Foundation's website. Should the Chemical Heritage Foundation wish to post to the Internet the content of the oral history interview, that is, direct quotations, audio clips, video clips, or other material from the oral history recordings or the transcription of the recordings, the Chemical Heritage Foundation will be bound by the restrictions for use placed on the Work as detailed above. Should the Chemical Heritage Foundation wish to post to the Internet the entire oral history interview during my lifetime, I will have the opportunity to permit or deny this posting.

I understand that the Chemical Heritage Foundation will enforce my wishes until the time of my death, when any restrictions will be removed.

This oral history is designated **Free Access**.

***Please note*:** Users citing this interview for purposes of publication are obliged under the terms of the Chemical Heritage Foundation (CHF) Center for Oral History to credit CHF using the format below:

> John L. Holmes, interview by Michael A. Grayson at University of Ottawa, Ottawa, Canada, 12 December 2013 (Philadelphia: Chemical Heritage Foundation, Oral History Transcript # 0906).

Chemical Heritage Foundation
Center for Oral History
315 Chestnut Street
Philadelphia, Pennsylvania 19106

The Chemical Heritage Foundation (CHF) serves the community of the chemical and molecular sciences, and the wider public, by treasuring the past, educating the present, and inspiring the future. CHF maintains a world-class collection of materials that document the history and heritage of the chemical and molecular sciences, technologies, and industries; encourages research in CHF collections; and carries out a program of outreach and interpretation in order to advance an understanding of the role of the chemical and molecular sciences, technologies, and industries in shaping society.

JOHN L. HOLMES

1931 Born in Cricklewood (London), United Kingdom, on 29 November

Education

1954 BSc, University of London, Chemistry
1957 PhD, University of London, Chemistry
1983 DSc, London University

Professional Experience

National Research Council
1958-1960 Postdoctoral fellow

Edinburgh University, Chemistry Department
1960-1961 I.C.I. Fellow
1961-1962 Lecturer

University of Ottawa, Chemistry Department
1962-1965 Assistant Professor
1965-1973 Associate Professor
1973-1997 Full Professor
1997-present Emeritus Professor

University of Ghana
1971 Nuffield Visiting Professor

University College London
1973-1974 Sabbatical Leave

University of Utrecht
1979 Overbeek Visiting Professor
1988 Visiting Professor

University of Adelaide
1984 Distinguished Visiting Scholar

Australian National University
1984 Visiting Research Fellow
1993 Visiting Professor

2000 Visiting Professor

University of Bern

1993 International Exchange Fellow

Honors

1970 Fellow, Chemical Institute of Canada
1980 Barringer Research Award, Spectroscopy Society of Canada
1986 Fellow, Royal Society of Canada
1988 Award for Excellence in Research, University of Ottawa
1989 Chemical Institute of Canada Medal
1990 Herzberg Award, Spectroscopy Society of Canada
1998 Life Member, British Mass Spectrometry Society
2000 F.P. Lossing Award, Canadian Society for Mass Spectrometry
2008 Fellow and Life Member, Royal Society of Chemistry

Festschrifts

1993 *Organic Mass Spectrometry* 28, no. 10
2004 *European Journal of Mass Spectrometry* 10, no. 6

ABSTRACT

John L. Holmes was born in North London, United Kingdom, the son of a civil servant and a stay-at-home mother. From an early age, Holmes was encouraged to read, write and experiment. World War II disrupted his education, when the pupils of the Westcroft School were evacuated from London to the West Country, but by Christmas 1939 Holmes had returned to London to be with his parents. He remained in London for the duration of the war, and vividly recalls the London Blitz.

A mere 'pass' in chemistry on his Higher School examination meant that Holmes was bound for employment, rather than university. He accepted a position as a trainee analytical chemist at Glaxo Laboratories, where he learned to assay penicillin samples and to devise new analytical methods for novel synthetic products. While working at Glaxo, he pursued his education one day and three evenings per week at Acton Technical College, eventually passing the London External BSc examination in chemistry. His score earned him admission to graduate studies at University College London. There he studied thermal decomposition of alkyl iodides under the mentorship of Allan Maccoll.

After earning his PhD, Holmes fulfilled his National Service requirement at the National Coal Board then took up a postdoc in Ottawa at the National Research Council (NRC) of Canada, doing photochemistry of trifluoromethyl radicals with aromatic substrates. It was at NRC that he met Fred Lossing and got his introduction to mass spectrometry. After a frustrating two-year interlude at the University of Edinburgh, Holmes returned to Ottawa, accepting a position as assistant professor in the Chemistry Department at the University of Ottawa, where (with the exception of sabbaticals and visiting professorships abroad) he spent the remainder of his career. He began his work at Ottawa on the kinetics of hydrogen atom reactions, but soon found himself volunteering to take on a leadership role in the department's nascent center for mass spectrometry. Throughout the interview, Holmes recounts his evolving research interests, his collaborations with Fred Lossing, Hans Terlouw and others, his teaching and mentoring work, as well as the changing funding climate in Canada, the growth of the University of Ottawa, his experiences at international scientific meetings, and his work as editor of *Organic Mass Spectrometry*. Holmes concludes the interview with a discussion of his passion for sailing.

INTERVIEWER

Michael A. Grayson is a member of the Mass Spectrometry Research Resource at Washington University in St. Louis. He received his BS degree in physics from St. Louis University in 1963 and his MS in physics from the University of Missouri at Rolla in 1965. He is the author of over 45 papers in the scientific literature. Before joining the Research Resource, he was a staff scientist at McDonnell Douglas Research Laboratory. While completing his undergraduate and graduate education, he worked at Monsanto Company in St. Louis, where he learned the art and science of mass spectrometry. Grayson is a member of the American Society for Mass Spectrometry (ASMS), and has served many different positions within that organization. He has served on the Board of Trustees of CHF and is currently a member of CHF's Heritage Council. He currently pursues his interest in the history of mass spectrometry by recording oral histories, assisting in the collection of papers, and researching the early history of the field.

TABLE OF CONTENTS

INTERVIEWEE: **John L. Holmes**

INTERVIEWER: **Michael A. Grayson**

LOCATION: **University of Ottawa**
Ottawa, Canada

DATE: **12 December 2013**

GRAYSON: [. . .] This is the twelfth of December, [2013], and I'm on the campus of University of Ottawa, and interviewing Professor John Holmes, who is Emeritus here. [. . .] And who has an illustrious career in thermochemistry and mass spectrometry, and so I think that's enough to get us started. And what I like to do, particularly for people who have these very scientific careers, is to find out information about their early childhood, and the attitude of their parents toward education, and how—if this encouraged them in their education, or what influences led to their becoming a well-educated person. So you were born in the UK [United Kingdom], I believe.

HOLMES: I was born in Cricklewood, which is [in] North London, [United Kingdom]. [. . .] It's about four miles north of Marble Arch, so it's not far from Central London by present day standards. But when the house was built [. . .], [in about 1900, the district was a new] suburb. [. . .] And so Cricklewood was getting on [towards "the sticks" back] then.

GRAYSON: Now it's in the middle of the city, probably.

HOLMES: Yes. There's another fifteen miles to go [before you see much in the way of countryside].

GRAYSON: And you were born in 1930?

HOLMES: [. . .] Thirty-one.

GRAYSON: Thirty-one. Okay. And your parents, [what were] their names?

HOLMES: My mother is Jessie Ethel [Holmes], and my father is Leonard Thomas [Holmes] [. . .]. [Mother's] maiden name was Doble.

GRAYSON: [. . .] And what were their professions?

HOLMES: My father worked in local government [in] the Department of Health [. . .] for the [London] district [then] known as Willesden. [. . .] When Mother and Father [. . .] married, my mother had to give up work, because married women were not [permitted] to work [in the 1920s.] Sometime after the war, I remember my mother was very keen that Dad should quit his job and [that] they should start a [small] business. I think they would have been a great success, largely because of Mother's drive, but Father was fiscally very conservative, and he was not prepared to take the risk. And so, life continued as usual, and he retired at sixty-five from local government. But I think they would have made a very good commercial team.

GRAYSON: Did your mother have a job prior to getting married?

HOLMES: Yes. She worked in a variety of secretarial posts. One was with the Canadian YMCA [Young Men's Christian Association], by a strange coincidence, during the First World War, when there were a lot of Canadian troops [who] had quite a big organization in London.

GRAYSON: So what about her education?

HOLMES: She went to a very good North London high school called Paddington and Maida Vale High School for Girls. [. . .] That's a district of North London as well. It's a very good girls' school. I visited it from my own school [in about 1948], when they first introduced interschool dances for the sixth formers.

GRAYSON: There you go.

HOLMES: One of these [unexpected and unpredictable] school interactions. But I've still got the [1915] postcards which were made of all the facilities at **<T: 05 min>** my mother's school, and it was, for its time, astonishingly well equipped with art classrooms, a chemical laboratory, physics [lab], the whole bit. So she went through [school] as far as matriculation. Which would be [equivalent to] high school graduation in those days, I guess [that would have been] about 1914, [or] '15.

GRAYSON: And your father's education would have been more formal?

HOLMES: My father's father, [Robert Thomas Holmes], ran away from home when [Dad]—and I can't say that I'm surprised, because my paternal grandmother, [Alice née Launder], was a lady of whom I was [quite] frightened as a little boy. So [my] Dad was sent out to work as an office boy as soon as he was old enough [fourteen]. They had rather straitened family [circumstances].

GRAYSON: Yes. So now let me get this straight. It was your grandfather that ran away from home?

HOLMES: That's right. My grandfather on my father's side. My grandfather on my mother's side, [Edward John Doble], was a [. . .] successful businessman. He was a director of a company in the West End [of London], which still exists. It is called the Pall Mall Safety Deposit and Forwarding Company, and their business was in looking after the effects of wealthy people in the Empire and businessmen [and assisting in all their travel arrangements]. So if a family was suddenly sent off to do its empire duty in India, they would deposit their valuables with this firm. [. . .] It was a travel agency [too], so [personal] travel could [also] be arranged [. . .]. [Indeed, they booked my Liverpool to Montreal passage by Cunard, when I first came to Canada in 1958. They were also responsible for the shipping of all the goods of the Bolshoi Ballet when they started touring, around in I would guess in the fifties or maybe late forties].

GRAYSON: You say this company still exists?

HOLMES: [. . .] Yes, it does. But in a [somewhat] reduced form; I think you can understand, there wasn't a great deal of use for this kind of company during the war years and so their capital decreased very greatly [throughout the hostilities, and so they had to build] up again after the war. But there wasn't [much of] an Empire then [either], and so there weren't [large numbers] of people who wanted to leave all their jewelry and furs and precious belongings in a [secure place while they were on Imperial duty].

GRAYSON: So education was—well, let's finish with your father's education. He went to college, or—

HOLMES: No.

GRAYSON: He did not?

HOLMES: No. He would have finished middle school, I guess, [. . .] and was [then] sent out to work. [He began work when he was twelve, the normal school leaving age in 1916].

GRAYSON: So let's see. Your grandfather ran away from home, and he sent his son out to work at a young age.

HOLMES: No, that would have been [after] he had already left, and so [it was] my grandmother [who] would have sent him out to work at the earliest opportunity. His older sisters [Irene, Alice and Sybil] were also sent out to work [as typists and milliners] at the earliest opportunity.

GRAYSON: So this was a necessity for the family?

HOLMES: [Indeed] it was a necessity for the family, because Grandmother Holmes had to bring up a family with no father present.

GRAYSON: And so she was a little bit imperious—

HOLMES: She was a tough lady. She was [indeed].

GRAYSON: Well, she had a tough problem to deal with, and reacted toughly.

HOLMES: Yes, [certainly].

GRAYSON: So the education then was primarily [that] your mother had more formal education than your father?

HOLMES: Yes.

GRAYSON: And there was obviously an attitude towards education in your family growing up that I would assume encouraged you to do something [. . .] to develop your intellectual interests?

HOLMES: Yes.

GRAYSON: And your mother, father—

HOLMES: Yes. Oh, both of them were educationally enthusiastic. [laughter]

GRAYSON: So they encouraged your reading and provided material for you?

HOLMES: Yes. I had a lot of books as a kid. [The house that we lived at in Cricklewood was shared with my—Doble—grandparents, we living downstairs. My grandfather had a fine stock of books, history, art, novels etc. and from quite an early age—eight or nine—I was given the free run of his library].

GRAYSON: This was probably in the late thirties, early forties, then, when you were **<T: 10 min>** getting a lot of this influence from your parents.

HOLMES: I started reading very early, because my parents sent me [at age four] to a convent school first of all. They were not Catholic, but they knew of this convent school, where everybody who came out, after a fairly short period, [was very well schooled in the basics—reading, writing, and arithmetic, and that was certainly so]. Absolutely right; I came away from that school after [less than] a year, and I could write reasonably [well—proper cursive script—] I could read, and I could do my sums.

GRAYSON: Very good.

HOLMES: But the nuns were very kind, but very firm—but I'm afraid the religion that they imparted to me took a very long time to get out from under.

GRAYSON: Did they rap any knuckles with rulers?

HOLMES: Yes, they did. They had a short ruler, and they would whack you on the back of the knuckles if your writing [was not up to standard], "That's dreadful, John." *Whack*. [laughter]

GRAYSON: It's interesting, the difference in talking to different people from this era and how corporal punishment was dealt with or. . . performed, and today, you know, people would be put into jail [for] it.

HOLMES: Well, at the schools that came after [the convent, the slipper—a gym shoe—or] the cane was a normal formal punishment. [But not used] very often. You had to do something pretty bad to get caned. I think [that] a great deal of discipline was verbal, by carefully contrived [and cutting] putdowns, which [could certainly] reduce a stroppy small boy to silence. [laughter]

GRAYSON: Old psychology as well.

HOLMES: Yes.

GRAYSON: But you just went to this school for one year. To get your [basic] skill set—

HOLMES: Then I went to a prep school. It was [. . .] called Westcroft [Preparatory School for Boys].

GRAYSON: So that would have been [in about 1938]. . . when you say a prep school, what does that mean to Americans?

HOLMES: To Americans?

In the 1930s, there had not been the 1944 Education Act, and so one's way through the [middle to higher] education system [. . .] had to be paid for [or achieved by scholarships]. So I was sent to [Westcroft], which [was intended to be] a preschool for a [nearby] public school, [Haberdashers Aske's Hampstead School for Boys]. The prep school was very good—a small school, run by three maiden ladies. I suspect they were [unmarried] because their [fiancés]—or boyfriends—had been killed in World War I. But they were very good, and they taught a wide range of subjects. So [one] went there from the ages of about six to nine or ten. [It was a small school indeed, perhaps no more than sixty pupils].

GRAYSON: So in America today, a prep school is considered to be a high school that prepares kids for college, but in this case it was preparing kids for—

HOLMES: [No]. It's [to prepare] kids for secondary education, not higher.

GRAYSON: So these three women basically covered the turf for [all subjects]—

HOLMES: That's right. [The older two had in the 1920s worked as teachers with Haberdashers' Aske's Boys' School], [. . .] and they set up the [prep] school as their own [venture]—and they made a very good job of it.

GRAYSON: This was private, so—

HOLMES: This was private school.

GRAYSON: —it had to be paid for, and there was a fairly small class size, I would assume?

HOLMES: That's right. We were probably—I don't know, maybe not more than fifteen [to twenty] in a class.

GRAYSON: So [. . .] what were the other options for your education if your parents hadn't sent you to the prep school? [. . .]

HOLMES: [I would have gone to a state or council] school. [. . .] Of which there were quite a few in the neighborhood.

GRAYSON: But for some reason or other, your parents wanted you to go to this prep school, which was probably better, you would say?

HOLMES: Yes. Undoubtedly, because [. . .] the class sizes were [so] small, and the [particular] aim of the whole exercise was to **<T: 15 min>** get these [boys] into the nearby public school, Haberdashers', which, [by the way, still is a very] good school—except [that] now it is [extremely] expensive. I [have] visited [them] from time to time to see what's happened [over the years since I left].

GRAYSON: Is that a—the Haberdashers', is it another private school?

HOLMES: Yes. It was founded maybe in the seventeen hundreds. It was called Haberdashers' Aske's Hampstead School, and it was founded by a [man] called Robert Aske, who was a haberdasher. Haberdashers had a Guild, [. . .] and so it was [. . .] a Guild school. [I sat their entrance scholarship exam in 1940 and was fortunate to gain one, relieving my parents of the fees. I believe that in 1939 the fees were twenty-five pounds per term. For 2015 costs, a factor of about one hundred fifty to two hundred should be applied.]

GRAYSON: Very interesting. And something with a very long history as well.

HOLMES: Yes.

GRAYSON: Did you get exposed to that history as a student?

HOLMES: No, not at all. Oddly enough, [a—first—complete] history of the school has only recently been written by a [teacher thereat] called John Wigley.[1] [I met him on several occasions] and I asked him what the boys called him, but he wouldn't tell me. [I mean, with a name like Wigley]. [laughter] Anyway, [over the past ten years or so] he wrote the school history. [I was permitted to read the drafts and filled in some gaps for him—just as an aside—I suggested that he include that the headmaster, in June 1948, and so just before the London Olympics, showed to the senior classes the Leni Riefenstahl film "Olympiad." As boys, we were extremely impressed by this masterly propaganda, and could readily visualize why Hitler's regime had been so attractive to German youth. Mr. Wigley refused to include this item in his history; a pity, I think].

GRAYSON: Interesting. Do you remember the name of any of those ladies that taught you in your prep school?

HOLMES: Yes. The senior lady was a Miss Challen. [. . .] The second in command was a Miss Biggs, [. . .] and the third was a Miss Alderton, much younger than the other two [. . .]. [I don't think that I ever knew their first names]. Miss Alderton was, from this distant vantage point, probably quite an attractive woman. But the other two, [probably in their forties or fifties], dressed in [heavy] tweeds and [had] very severe [hairdos].

GRAYSON: And you suspect that [the older two] were basically widows from World War I?

---

[1] John Wigley, *Serve and Obey: The Story of The Haberdashers' Aske's Boys' School* (Costa Mesa: James and James, 2007).

HOLMES: Well, not widows, [because] neither of them had been married, but [it is quite likely] that their fiancés had been killed.

GRAYSON: So somewhere along the way, your interest began to become developed in science, chemistry, physics, mathematics?

HOLMES: [I am going to add a little bit here about education and World War II. Then]—in 1939, the hostilities began, and [Westcroft School was] evacuated from [London]. We were evacuated to the West Country, to Somerset, [United Kingdom], to [a big] old country house [called Brympton d'Evercy] which had belonged to [the Ponsonby-Vane family since 1731, but also had connections] with Clive of India.[2] Anyway, it was—[still is—in fine repair], a large old country house near Yeovil, United Kingdom]. [. . .] We were all evacuated there as [an entire] school. The whole lot of us got on a coach, and on the day [before] war was declared [2 September 1939], we were off down into Somerset. [Some mothers and aunts came too, to help out].

GRAYSON: So this was to get away from the big city?

HOLMES: Well, yes, [. . .] millions of children were moved [out of London late] in 1939. But because nothing [much] happened in 1939—[the war was not] "all over by Christmas" [as predicted]—in fact, [nothing much at] all happened before Christmas, and so [many] of these evacuation schemes appeared to be unnecessary. I remember [that] parents would come down to see how we were living. [The conditions were], let's say, rather primitive. [Some parents] moved their [boys] back to London, [and] so by [Christmas 1939] I was back in London with my parents, and [meanwhile], the school struggled on down in the country. Thus my schooling was haphazard for the rest of 1940. [Finally, that] evacuation was [deemed] a failure, and the school [returned] to Cricklewood. So I [thus] had about another six months of Westcroft before I moved on to Haberdashers'.

GRAYSON: I see. So the first impact of [. . .] **<T: 20 min>** World War II was this '39 evacuation—

HOLMES: That's right.

GRAYSON: —to get kids out of the big city.

[2] Robert Clive, a soldier and administrator who helped establish the power of Great Britain's empire in India.

HOLMES: That's right. [Yes].

GRAYSON: And you say there was some sense that everything would be over by Christmas—

HOLMES: Oh, [there] was the popular [notion that the] war would be over by Christmas. Nobody took it very seriously in terms of [it] being a long war. But then of course [came] 1940, [when] everything went to hell in a handcart. France fell [quickly to Guderian's blitzkrieg, and then] the Low Countries, Norway, and Denmark, [to be followed by the Dunkirk evacuation and] the Battle of Britain in September, '40, and [very soon thereafter the London] Blitz started. [. . .]

GRAYSON: So you were—you had to live through that.

HOLMES: [Yes]. I spent the war in London.

GRAYSON: So there was no more evacuation—

HOLMES: No more evacuation.

GRAYSON: So what other experiences from the war do you recall?

HOLMES: My grandfather paid to have a [small] brick and concrete air raid shelter built in the back garden, and we spent a lot of uncomfortable nights sitting in there, listening to [aircraft engines]—you could tell if it was "ours" or "theirs" by the beat of the engine. The German aircraft engines were slightly detuned to give them a beat, because that [apparently] interfered with audio direction and distance finding. [Thus] you knew it was one of theirs [whenever] the engine had a beat. If it was one of ours, it was a continuous, unbroken whine.

GRAYSON: Very interesting. These are the little strange things that you [recall]—

HOLMES: That's right, yes. And of course, at the beginning of the Blitz, there was not much of an antiaircraft barrage, which—although it was [almost wholly] ineffectual—was very good for morale. But by the time the Blitz [really] got going towards the end of October, there were

[anti-aircraft] guns everywhere, in the park down the road, and where you had a big intersection of roads with [a large] clear space in the middle, they would often bring a mobile antiaircraft gun—**[**a Bofors]—and establish it [there] in the middle [of the junction]. And so the Blitz was very noisy, but you felt that something was being done to protect you, even though we now know that it was not a [great deal] of use.

GRAYSON: Well, you know, maybe it had an effect on the German aviators. Who knows?

HOLMES: It might have done, but I'm not sure they needed to take it very seriously.

GRAYSON: So how frequently did you have to undergo this Blitz attack?

HOLMES: Oh, we had. . . I think at ninety days on the trot, or ninety nights [rather]. About three months, every night.

GRAYSON: Oh, God.

HOLMES: I remember in the early days of the Blitz, one [September] night we came out of the shelter because the "all clear" had sounded, and my father said, "Look, we can read a newspaper in the garden." And that was quite true; we could. Those were the fires in [the London Docklands, more than twenty miles away] making sufficient reflected light that you could [just] read [at 3 a.m.] out of doors.

GRAYSON: All that destruction. Was your property, the property of your parents, affected at all by [bombing?]

HOLMES: Luckily, no. Luckily, nothing worse than the occasional tiles dislodged from the roof by shrapnel, [and a deluge of oil from an oil bomb that fell on a neighbor's pear tree and failed to ignite. Very messy stuff—like a light machine oil].

GRAYSON: Oh, no.

HOLMES: Well, shrapnel was something [that] as a schoolboy, you went out looking for every morning [after a raid]. There would be these gleaming pieces of metal [to be found] in the road, [very collectable].

GRAYSON: Yes. Was your schooling—did the school routine change significantly because of the Blitz?

HOLMES: No, because it was [then] nearly all night bombing. [The school itself was hit but the damage was to the oldest of the buildings], and [so] the school routine was only [seriously] disturbed when the [V1's] started [later in the war]. When the Doodlebugs [V1's] started, [. . .] they were [usually] daytime events. And so we spent a lot of time [in 1944 and '45], sitting on cement blocks in the miserable air raid shelters at school.

GRAYSON: That must have been a pretty depressing thing to have to go through.

HOLMES: No, it wasn't depressing. It was interesting and I don't think [that] anybody was afraid. Anxious, yes, because when you sat in the air raid shelter at school, **<T: 25 min>** and you listened, you could hear, "There's one of those—there's a Doodlebug coming," and you would hear the [rough] note [of the ramjet engine] rising. You'd think, yes, it's getting nearer, it's getting nearer, it's getting nearer—I don't want it to cut out while the sound is still [rising]. I want the Doppler effect to tell me [that] it's passed. And so you'd sit there listening carefully, and when the beat [frequency] went through its maximum, you thought, "Okay, it can cut out now. It won't be falling on us." And—

GRAYSON: Fall on somebody else.

HOLMES: [Yes], that's right. So [. . .] the engine note would just suddenly cease, then you'd wait about ten seconds, and then *boom*.

GRAYSON: Well, I mean, people were killed during these—

HOLMES: [Yes], a very large number.

GRAYSON: Large number killed, and a lot of destruction of property.

HOLMES: You'd see that every day. When I went to school by train—[my Grandfather died in 1943 and then we moved to Kenton, about seven miles to the northwest of Cricklewood]—

you could see property damage from the train. On an elevated section, you [noted], "Oh, there's a big gap— there used to be two houses there."

GRAYSON: Would they—do you know if there was any targeted approach to industrial parts of the city, or just—

HOLMES: Well, I'm sure there [might have been], but you probably know that [with] aerial bombing then, you were [very] lucky if you got a bomb within a mile of your intended target.

GRAYSON: [Yes].

HOLMES: And that cut both ways.

GRAYSON: Well, the story I got is that radar is what actually was the savior—

HOLMES: In the Battle of Britain, [it certainly was, but remember, those were daylight raids]. It picked up the [enemy aircraft far away enough to give adequate] time. They had those [for the fighters to scramble. There were big radar towers all] along the south coast.

GRAYSON: Well, that must have been—so this lasted ninety days, and ended, or did it continue at a lesser pace?

HOLMES: No. [It didn't end, but rather petered out]. Why did Hitler discontinue the Blitz? I think really because he was [more interested in] the assault on Russia. The invasion of the UK [United Kingdom] went onto [his] backburner, and the planned [invasion of] Russia was the [main event in] 1941. [. . .] The air raids diminished greatly, until the V weapons, [which were in] '44 and '45. The rockets [V2], were an absolute pain, because you couldn't hear them coming. [Indeed], you heard them coming afterwards, because they came at supersonic speeds. So you heard a hell of a bang, and then the noise of [the missile's arrival] would come afterwards.

GRAYSON: Bad stuff.

HOLMES: [Yes]. And very arbitrary. They were not aimed at anything in particular, just the general London area. And so they fell anywhere. [I recall the arrival of one at breakfast time, a quarter of a mile away. Two houses obliterated].

GRAYSON: So I think there was an attempt to demoralize the English citizens on the part of Germany—

HOLMES: [But the "V" weapons were] too little and too late. [We now know that even massive bombing is a poor method for demoralizing a nation].

GRAYSON: [Yes]. That was I think the idea. [. . .] So during this period [at Haberdashers], you're developing an interest in science?

HOLMES: Yes.

GRAYSON: I'm just curious if you recall or have any idea what your parents were paying for this private education you were—

HOLMES: I got a scholarship [. . .]. [I believe that the fees were about twenty-five pounds each term].

GRAYSON: Very good. [laughter]

HOLMES: [A few years ago, my daughter Susan asked if I might write a life history for the granddaughters. This I began and so I found that I remembered many odd things that filled in all the details, adding extra snippets as they came along]. So that's probably why I [recall] quite a lot about the Blitz, and also the beginnings of [my] interest in science.

I can remember the first [solo] practical experiment [that] I ever did, which was separating a [homogeneous] mixture of salt and sand. You dissolved the salt in water, filtered off and dried the sand, weighed it, and [then] evaporated the liquid, [to produce] your sample of salt, [also weighed and so the analysis was complete]. I suppose I was, what, maybe ten at that [time]?

GRAYSON: Was this something that you did as a personal experiment—

HOLMES: Yes. All the [boys] in the class did it. We had a science teacher called Mr. Henwood, who was known as **<T: 30 min>** "Chickweed." Most [of the] masters collected nicknames in school.

GRAYSON: But you definitely didn't call him Chickweed?

HOLMES: No, no. That was amongst ourselves. He was a good science teacher; [. . .] you got a little bit of general physics and general chemistry and [related matters] from him [in Form one]. Chemistry didn't begin [seriously] until the third form, when I would have been about twelve. Then we started doing real hands-on chemistry. It seemed fantastic. All those colors, colored flames, colored precipitates—which did or did not dissolve—we did traditional analytical chemistry, with the Kipp's generator of H_2S in the [nearby] fume hood. [We also made interesting compounds] ourselves. I [recall making] pyrophoric iron by reducing Fe_3O_4 in a stream of coal gas. We had little boats [of the powdered oxide, placed] in a hard glass tube, and coal gas was streamed over them and ignited at the [exit]—of course. The little boats in the hard glass tube were heated to [dull] red heat, and the ferric oxide was reduced to iron. Afterwards, we took a glassblowing torch and sealed off one [dish] for keeps, and the other one we were allowed to take out into the air. [As] you shook the little dish, of course, [the finely divided pyrophoric iron] spontaneously ignited in [the] air. [. . .] Great. [laughter]

GRAYSON: So this was fine iron filings, then—

HOLMES: No, [it was] Fe_3O_4, ferric oxide as a powder, reduced to pyrophoric iron metal. It spontaneously ignited, all right.

GRAYSON: So these types of things captured your interest?

HOLMES: Oh, yes. It was marvelous.

GRAYSON: Sounds like you're a true alchemist at heart.

HOLMES: That's right. Yes.

GRAYSON: You weren't one of these individuals of this era that had their own chemistry set that—

HOLMES: Yes, I had a chemistry set at home.

GRAYSON: You had a chemistry set?

HOLMES: I had a chemistry set at home. No strong acids or bases, but [elemental sulfur and] a lot of salts, and because it was wartime, the home manufacture of gunpowder was something that everybody did.

GRAYSON: I think every chemistry set has been used somehow or another to manufacture something that goes *bang* by everyone who's ever had one.

HOLMES: Yes.

GRAYSON: There is a collection of chemistry sets at the Chemical Heritage Foundation.

HOLMES: Is there now? [I must certainly visit one day].

GRAYSON: If you ever get the chance to go to Philadelphia, [Pennsylvania]—

HOLMES: Yes. Oh, that would be wonderful. Yes.

GRAYSON: Of course, now they have been so emasculated that no one—

HOLMES: It's not really a chemistry set at all. No. In those days, you could go into a—I should call it a pharmacist—a chemist's shop, and you could buy sodium metal. It was stored in the [. . .] shop under toluene. You could [. . .] ask for a gram [or so, even] as a [schoolboy]. They would sell you a gram in a little [stoppered] hard glass tube with [some] toluene [and thus] you could take it away. [One thing] which caused punishments in the classroom was [when] one [boy] brought in a small sample of sodium, which he cut up on his desk, and we all had ink wells which contained [water-based black] ink. He dropped the pieces of sodium in the ink [wells], and *boom*. This [took place] in the little in-between [time] before [the next class. When the] teacher arrived there were still two desks with sodium flames [coming from the inkwells—and so] the culprit had to go and see the headmaster.

GRAYSON: I bet.

HOLMES: But it was the ease of getting chemicals then that was so extraordinary. God knows what you'd have to do now.

GRAYSON: It would certainly have to be reported to some authority, if you could even get the stuff.

HOLMES: Yes. [. . .]

GRAYSON: This is a sampling of how times have **<T: 35 min>** changed, [. . .] so many things you cannot do today that—

HOLMES: Yes. I know.

GRAYSON: I think Frank [H.] Field had the same experience, that he would supplement his chemistry set by going to a chemical supply house and buy whatever he wanted.[3] [. . .] Did you ever have a disastrous experiment personally, where something went wrong and you got more than you bargained for?

HOLMES: No. [But just as] a complete side issue, I was asked [some] years ago as a result of something that happened here, to make a little compendium of [all significant] chemical accidents that I had known or experienced. And when I [finished], my opinion was that [almost] all of them were true accidents. They were not a result of foolishness, carelessness, or larking about. They were things that happened [by chance]. Well, it was an accident. It would not have [readily] been foreseen. [Indeed] most of them fell in that category. [Hindsight is a wonderful thing].

GRAYSON: And you didn't happen to experience any of those personally in your early chemistry experiments?

HOLMES: No. I [did know] later in life [one fellow] who [had] lost his left hand, through a gunpowder [accident]. . . a schoolboy experience.

---

[3] Frank H. Field, interview by Michael A. Grayson in Durham, North Carolina, 9 and 10 December 2009 (Philadelphia: Chemical Heritage Foundation, Oral History Transcript # 0636).

GRAYSON: Well, that's not good. So you really have, it seems, an enthusiasm for chemistry by now.

HOLMES: Yes.

GRAYSON: And this would have been around your early teens?

HOLMES: Yes.

GRAYSON: And so you're really kind of committed at this point, to pursue chemistry, or—

HOLMES: Yes. I think so. [. . .]

GRAYSON: And did you have any friends who were likewise committed, or were you just—

HOLMES: Yes, I had a close friend who I still see. He became a chemical engineer. [We sometimes] did experiments together [at school], and we often did experiments in physics. I won't bother with the details, [but] there was a [device that] you could make called a filings coherer. A filings coherer was [an old method] of picking up electromagnetic radiation. So it [could be] a communication device. It was a curiosity of, I [think, the twentieth] century—you could read about it [in old magazines]. So I [recall] Ken [suggesting], "Let's see if we can make a pair of filings coherers," so [that] we could communicate between our houses. [However], we couldn't get the damned things to operate over more than about two hundred yards.

GRAYSON: That's a pretty good distance.

HOLMES: But it was [intended for about five miles]. [laughter]

GRAYSON: This is Ken—what was his name?

HOLMES: Ken Pearce is his name. He lives in Northern England now.

GRAYSON: But you still communicate?

HOLMES: We still travel together [to distant places].

GRAYSON: That's good. Well, your scholarship paid for your early education, and you're still in essentially what we would call in America as a high school.

HOLMES: Yes.

GRAYSON: So that was paid for through scholarship up until you were able to go on to college?

HOLMES: No, I didn't go on to [University from Haberdashers']. I should explain. There were two levels of exams in the UK [then]. There was [the] General School Certificate [GSC], which you took when you were about fifteen. If you did well [enough] in it, you could go on to the sixth form and study for the Higher School Certificate [HSC], which was essentially [for] university entry, or you could take your General School's results, [which] if they were good, would get you a good job in industry, government, wherever. Anyway, I [did very well in the GSC and so] went into the [science] sixth form, and I'm afraid [there], I messed about for two years. I didn't work very hard at all. And so I ended up with just a pass in chemistry at [the Higher Schools' level. And so it was a case of, "Alas]— but you're going to have to get a job."

[At that time] I knew a [young man] down our road—**[**now in Kenton, still in Middlesex]— that quite a good job was [to be] a trainee analytical chemist at Glaxo [Laboratories], the <**T: 40 min**> [then quite small] pharmaceutical company. [. . .] In 1948, Glaxo was [. . .] just beginning to make their name with [the production of] penicillin and streptomycin, which then were [both] new and exciting.

GRAYSON: Sure. [Yes].

HOLMES: And so I went to become a trainee analytical chemist at Glaxo at Greenford, [Middlesex, United Kingdom about four miles from home]. That was their main research and development and production facility in the London area.

GRAYSON: Greenford?

HOLMES: Greenford, exactly the way it sounds. I [went there, at a salary of about three pounds per week]. In those enlightened days, industry, by [post-war] law, had to allow [eligible] trainees one day a week off for study, [in order] to pursue their education, [without loss of salary]. So I took my day release, [and] had one day and [. . .] three evenings [per] week at Acton Technical College. [Now, in retrospect, Acton] was extremely good, even though it was only a [small] tech. [Acton is in west London, about six or seven miles from Glaxo].

GRAYSON: You were what age by this? Eighteen?

HOLMES: Nineteen forty-eight, so I was seventeen.

GRAYSON: Seventeen.

HOLMES: Seventeen. So I started at Glaxo, took the day release and went to Acton Tech one day and three evenings [a week, and passed my intermediate BSc the following year equivalent to the HSC exam mentioned above]. Then there was another hurdle—a maths hurdle—to jump. Intermediate mathematics on the way to the [London University External] BSc degree. After four years at Glaxo, I decided I would leave [Glaxo] and spend the whole year at Acton Tech [to study] for finals. Now Glaxo had a [very] good bonus scheme then. You got a quarterly bonus, which could be as much as 30 percent of what you'd earned in that quarter. [Mine] all went into a savings account.

GRAYSON: So the bonus was based on the performance of the—

HOLMES: Of the company. Yes.

GRAYSON: As a whole?

HOLMES: As a whole. Yes. Every employee got the bonus. Anyway, I [had] stashed all this in a post office savings account, [I] quit Glaxo, got another studentship [from Middlesex County Council—how generous they were then]—and with my bonus money, and obviously help from my parents, I [managed] a year's full-time study at Acton Tech, and then took the London External [Chemistry BSc].

In those days, London University ran an external BSc program, and [to] put it in perspective for you, [. . .] —anybody in any of the technical colleges in the UK [who had

qualified], could sit the London External BSc in chemistry, and in physics, [or] maths, and so on. [In] the year I sat, seven hundred-fifty people [from all over the UK] took the [Chemistry BSc] finals exam. There were five firsts, and there were fifty-two seconds, and one hundred eighty or so passes. [The firsts were all from Hull Technical College which became one of the earliest new Universities]. I got a second, [which] was good enough to get me [admission to postgraduate studies] at University College London.

That was a very good decision.

GRAYSON: [Yes]. So when you say BSc—

HOLMES: [. . .] Bachelor of Science [degree]. Yes. It's a first degree.

GRAYSON: So you [had] got a little more serious about your study?

HOLMES: [Yes], [certainly]. I [had] enjoyed my time at Glaxo, because after quite a long period doing routine analytical chemistry, from which you learned a huge amount, they moved me into the analytical research lab, where their responsibility was to devise [original] analytical methods for their new products, and for anything else which [required a new method]. That was astonishingly interesting. There were only three of us in the lab, and we **<T: 45 min>** [were prepared to try] just about anything.

GRAYSON: So most of your experience initially was wet chemical [methods]?

HOLMES: [It was mostly] wet chemistry. Yes.

GRAYSON: And do you recall much about the kinds of things that you were analyzing for?

HOLMES: Yes. Vitamin [products—there was an interesting problem with Vitamin D—] all synthetic intermediates from the pilot plant, [and] final products of [pharmaceutical syntheses]. There was [also the] biological assay of penicillin, which was a [very] boring thing to do [—that was a six month period. The biological assay of penicillin—sometimes] samples would come [direct] from the [local] hospital. You would [sometimes] get nasty-looking samples of sputum from [the nearby] Harrow Hospital for penicillin assay analysis. [. . .] You gloved up appropriately and prepared the sample for assay.

GRAYSON: And if the penicillin worked against that particular thing, it would [. . .] kill it?

HOLMES: Well, it would [. . .] tell the medical practitioner whether there was any penicillin left in the fluids of the [patient]. It was fairly crude then. You know that ordinary penicillin, penicillin G [Benzylpenicillin], is a sodium salt; [it] hydrolyzes very quickly [and so its] life in [aqueous] solution is [poor. Glaxo prepared] derivatives of penicillin which would be longer lasting, more stable. [A good idea of theirs was procaine penicillin. Of course, procaine is also an anesthetic, resulting in less painful injections].

GRAYSON: Yes.

HOLMES: [So the idea behind] procaine penicillin, [. . .] was [that it] could be [injected] into [patients] in large quantities, [which normally would be extremely painful], but as the procaine hydrolyzed off, the pain was greatly diminished. [Quite] nasty [. . .]. Procaine penicillin was used pharmaceutically as a suspension in arachis oil.

GRAYSON: What?

HOLMES: Arachis oil. It's [also] a cooking oil. [. . .] Anyway, the suspension of this white solid in [the] oil was what was [injected] into a muscle; since the quantities [required] were several [milliliters], the procaine was really needed. The idea was [also] that it was slowly dissipated, of course, from the muscle, from [the] oil suspension. [. . .]

GRAYSON: When you went into this elite kind of research group, what kind of instrumentation were you using? Were you using instrumentation then, or was it—

HOLMES: The only instrumentation we had [were] spectrophotometers and a polarimeter. Infrared was [then] a research-only machine [and had no analytical role]. That was [housed] in another building. Of course mass spectrometry [as a routine analytical technique also] didn't exist [. . .]. NMR [nuclear magnetic resonance] had not been heard of. Thus a great deal was UV [ultraviolet] and visible spectrophotometric analyses. Making colored derivatives for analytical purposes. A great way to go, if [you have only] got UV and visible spectrophotometers.

GRAYSON: So you actually just worked four days a week and then had a weekday—

HOLMES: And had a day off to go to Acton Tech.

GRAYSON: Now was this…you mentioned at one point this Education Act of 1944. It sounds like this—

HOLMES: That was a big move, because it [raised] the school leaving age to fifteen.

GRAYSON: Instead of before—

HOLMES: Instead of fourteen. And every child who [qualified was] guaranteed secondary education at no cost. So there was a huge expansion in education. And [perhaps] unlike today, education was regarded as a good thing. In the UK, the working class [seems to have lost motivation towards the education of its children] anymore. But then it was [a great leap forward], and so there was a [. . .] surge of [young] people [into advanced] education.

GRAYSON: And so you definitely qualified to continue your education. Now were you paying for the technical education?

HOLMES: At Acton Tech? No. [. . .] **<T: 50 min> [**Glaxo paid all those fees. If you failed exams more than once they could] withdraw the privilege.

GRAYSON: But once you quit Glaxo, then you had to pay your way, and then you had prepared for that by getting together [sufficient savings]—

HOLMES: For the year at Acton Tech, yes. [I used my Glaxo bonuses and also obtained a grant from Middlesex County Council].

GRAYSON: So you then decided to pursue chemistry there exclusively, [. . .] the educational system you [. . .] tend to focus a little bit more on a specialty, don't you?

HOLMES: Well, it was an Honors Chemistry degree then, [consisting of] chemistry, chemistry, chemistry, and with ancillary mathematics. You took quite a lot of calculus. But physics had dropped from the curriculum [for the last three years].

GRAYSON: And there were no, quote, humanities, liberal arts, or any of those kind of things?

HOLMES: [No, none]**.**

GRAYSON: So coming in with a second [class degree] gave you the opportunity to move on to graduate school.

HOLMES: [Yes].

GRAYSON: And you had a choice of schools, or—

HOLMES: You could apply anywhere [in the UK. Remember that there were only about twenty-five Universities in the entire country].

GRAYSON: Did you explore—

HOLMES: But yes, I [personally] visited King's College London, University College, and Queen Mary College [University of London]. I'm not sure if I went to Imperial [College London] or not? I don't [remember]. But anyway, it was obvious [then] that University College was where [most significant chemistry research was being done]. Christopher [K.] Ingold was the chair—he became Sir Christopher Ingold [a few years later]. His son [Keith, also a scientist by the way], lives in Ottawa.

Anyway, Ingold ran a department which was really second to none. It was probably the best department in the country, [and possibly still is]. I didn't know that [then], but the impression it made on me was striking. I went there for an interview, and [met] a very nice Welshman, [Professor Edward D.] Hughes, and Ingold were names that you coupled together, like Marks and Spencer. Ted Hughes interviewed me—he had a nice singsong Welsh [accent]—and he said, "I think we should be able to accommodate you, if you get a good degree." [So on receiving my degree result] I went [quickly] up [to UCL] and said, in effect, "Here I am. I'd like to do [graduate] studies here [. . .]." [Ted Hughes interviewed me all over again and placed me there and then] with Allan Maccoll.

GRAYSON: Wow. That's interesting. An old relationship that goes for years.

HOLMES: [Yes], that's right [. . .].

[The second interview with Prof. Hughes was more like] a jolly chat, and he [asked], "What [research] would you like to do?" And [so] we talked chemistry. "Okay." he said, "You're accepted. I will write [to] you shortly and name your supervisor." I [had never met Maccoll, but so it was a surprise when] a letter duly came [stating that your supervisor will be Allan Maccoll and so of course I immediately hurried] to University College [to] introduce myself to Allan.

GRAYSON: Very good. The beginning of a long, long, long relationship. So how long did it take for you to complete your studies there?

HOLMES: I did three years [at UCL. A three year] PhD [was then] the norm.

GRAYSON: And obviously, you've got to pick a topic to burrow in on and specialize on for that work.

HOLMES: Allan's main interest then was [the] thermal decomposition [of organic halides, for which] he had [already] done the foundation studies [. . .]. [One] point of the exercise in doing these kinetic studies was to **<T: 55 min>** try to find a correlation between a physical property of a series of [related] molecules and their rates of thermal decomposition [. . .]. For example, all the alkyl halides dissociate by loss of HX, the halogen acid, and in the case of the chlorides, it's a molecular [elimination] reaction. In the case of the bromides, [it has] free radical [plus a] molecular [component]. In the case of iodides, which [was my problem], they lose HI [hydrogen iodide] first, and then the hydrogen iodide reacts very smartly with the iodide to produce iodine, so you get an alkane, an alkene, and iodine from the thermal decomposition. So that was my project, to do [the alkyl iodides' pyrolyses. The end result was to correlate the activation energies of these molecular elimination processes with a physical property of the compounds—that turned out—a bit later—to be the heterolytic C-halogen bond strength].

GRAYSON: Well, these halogenated compounds; they're not a lot of fun to work with. I mean, they can be quite nasty, can't they?

HOLMES: Oh, I [don't think they are all that bad]—

GRAYSON: I mean, HF [hydrogen fluoride] is well known to be—

HOLMES: Well, [yes], HF is extremely nasty. [In those days] we made all our own compounds. [I also] did experiments with nitric oxide, and making pure nitric oxide [was] quite

a challenge. [. . .] That was a great prep. [. . .] You knew [if the NO] was pure when it was a white [crystalline material] at liquid nitrogen temperatures. If it had any NO_2 in it, it was blue, a pale blue, [due to N_2O_3]. So [some cold] trap-to-trap distillations [from liquid oxygen temperature to that of solid N_2] were required to get [the] pure [compound]—

GRAYSON: So this was really a wet chemical process that you were work was really synthetic and wet chemistry and pyrolysis?

HOLMES: A lot of making-of-compounds, yes, but the [pyrolysis] reactions were all gas phase thermal decompositions [in a static—glass—system].

GRAYSON: Were you using any analytical equipment in a modern sense in this exercise?

HOLMES: [Only] conventional analytical chemistry, the mass balance had to be found by titrating the halogen acid [with standard base, and] correlating that with the pressure change. [Yes], it was [quite] conventional chemistry. [The pressure change was monitored by means of a spoon gauge attached to a lamp and scale outfit].

GRAYSON: Quite challenging.

HOLMES: Well, it wasn't really [so difficult], because [. . .] certainly with the background [training from] Glaxo, I regarded [. . .] conventional analytical chemistry as a very powerful [and well-known] tool. Even though it was time consuming and full of technical difficulties.

GRAYSON: Yes. [. . .] Were people specializing in analytical chemistry during this period as a—

HOLMES: As a research topic? No. [Analytical chemistry] was [chiefly] developed in industry. [. . .] Certainly the pharmaceutical industries [strongly] needed analytical chemistry, because it was their only way to [test their products].

GRAYSON: But for instance, in these syntheses and study, you also had to be your own analytical chemist?

HOLMES: Yes.

GRAYSON: […] So it was a skill that just about every…or? A synthetic chemist had to really have some mastery or a friend who would be willing to do this dirty work for him.

HOLMES: Yes.

GRAYSON: Because how else could you prove what you had done?

HOLMES: Well, [one thing that I found, not entirely to my surprise], was that the students who had gone through the in-house degree system at University College did not have [many of] the practical skills that I had. So although they had had a better theoretical foundation, in practical terms, no, they weren't very experienced. So my time at Glaxo [had] served me well.

GRAYSON: Well, I mean, that's good. And the idea that they furthered your education as you worked there, also it paid off.

HOLMES: Yes.

GRAYSON: It's a, what would you say, a governmental mandate that came to fruition—

HOLMES: [Yes].

GRAYSON: How many other people probably benefited from that? I mean, it must have been many, many people who benefited by that enlightened attitude, I would think. I would hope. You know, because **<T: 60 min>** free education every—

HOLMES: Well, [. . .] in that particular year, [1954,] seven-hundred fifty people in the UK took the [London University External BSc Chemistry] degree exams. That's quite a lot of [young] people. Aged about twenty, twenty-two, [the great majority of whom] had been supported one way or another through [an industrial] release scheme.

GRAYSON: So you actually now have a degree, a PhD degree, and you are getting ready to look for a job?

HOLMES: [Yes. But] there were two problems. One was where to go, of course, and the [second] was how not to have to do National Service. Because two years of National Service, [likely in the army, were theoretically still] awaiting [me]. Before [reaching the age of] twenty-six, you [were expected] to do two years of National Service.

GRAYSON: And when you graduated with your [PhD] degree, you were—

HOLMES: I was twenty-four. [. . .]

GRAYSON: So these two problems had to be dealt with. How did you do that?

HOLMES: The normal way to avoid [. . .] spending two [rather] useless years in the Army, was to get a [. . .] reserved occupation job, which [for example] meant working for the Atomic Energy Authority, any of their multiple branches, [in] munitions, or weaponry, rocket research, and [the] research institutes of nationalized [industries. Thus] I went to the Radiochemical Centre [Ltd], which was in [Amersham North London], to [consider] a job there, and I [also] interviewed for the National Coal Board to do research on coal. To cut a long story short, and because of happenstance, I went to the Coal Board [to work] out my time, which in this instance was [a little over] one year, at the National Coal Board research establishment, which was way out in the countryside [at Stoke Orchard], near Cheltenham, [United Kingdom], in Gloucestershire.

GRAYSON: So this was not your really first choice?

HOLMES: Well, my first choice was to take a postdoc in North America. [laughter] But I had to do something about National Service [. . .], because I was not yet twenty-six. So I [spent the] year at the Coal Board, and then took a [post-doctoral] fellowship in Canada. [The latter] was thanks to Allan Maccoll, of course.

GRAYSON: So the year [at the Coal Board] satisfied your two year requirement, or you were twenty-six—

HOLMES: [. . .] You had to have done something of equivalence, but before [your] twenty-[sixth birthday]. I was twenty-six after just over a year at Stoke Orchard, [United Kingdom].

GRAYSON: [. . .] So what did you do at the Coal Board?

HOLMES: Do you remember a man called Jacob Bronowski? Well, he was a television scientist.

GRAYSON: Television scientist?

HOLMES: Yes. He produced a [very fine TV science] series which is still available [on DVD], and [also] in book form, called *The Ascent of Man*.[4]

GRAYSON: I've heard of that.

HOLMES: Well that was Jacob Bronowski. [He] was a man of many parts, and he was also director of the National Coal Board Coal Research Establishment. [Coal was a subject] about which he [appeared to know] remarkably little, [he having trained as a mathematician, I believe]. He was [. . .], a playwright as well, and he was. . . I think he was in a poetry writing stint at the time. He lived in a house way up in the [Cotswold] Hills, and every now and again he'd come down to Stoke Orchard. [He would] sit in on scientific meetings. There was no doubt he had a [wide] knowledge, but not necessarily organized the right way. I can see him sitting at one of the little scientific group meetings where we discussed what was going on in the thermal decomposition of coal, and somebody, **<T: 65 min>** not me, [. . .] was rattling on about free radical chemistry. "Oh, yes," said Bronowski, "free radicals. Those are molecules that have lost electrons." And nobody batted an eyelid. We let it go.

GRAYSON: Just let it go [. . .].

HOLMES: [Indeed]. There was a wonderful occasion when the Duke of Edinburgh [Prince Philip] came to Stoke Orchard on an inspection tour. [At that time] there was a process for turning [poor quality] coal into valuable coal.

GRAYSON: Useless coal being?

HOLMES: Useless coal, one of its [colloquial] names was [. . .] "nutty slack." It was high in sulfur and solids and it was pretty [poor stuff to burn, but there was a lot of it. The chemical engineers had] worked out a method of heating this [as a powder] in a [fluidized] bed, driving off the nasty volatiles, and the residual charcoal-rich material could [then] be compressed into

[4] Jacob Bronowski, *The Ascent of Man* (London: BBC Books, 2013).

briquettes, and [these] briquettes burned quite [cleanly]. The only trouble was they didn't stick together very well, but that was a secondary issue. Anyway, the Duke of Edinburgh came, and one of the things he was going to be shown was the wonders of the briquetting process. [There was an official domestic-type] fire with all these briquettes blazing away; [wonderful. However], I learned afterwards that [these] briquettes had been made out of pure anthracite. It was of course a fudge. It appeared in the newspapers with the Duke and Bronowski smiling at this fireplace, [warming their hands before the glow]. I'm afraid the process never [quite] made industrial grade. But it was [in principle] a good idea. It was the right idea, to get rid of the volatiles and produce a [carbon-rich] char which [could be compressed] into briquettes. But unfortunately they didn't [adhere well, even with an original briquetting process developed at Stoke Orchard].

GRAYSON: So your specific activities there were—

HOLMES: My [first] specific activity was [associated with] the briquettes—the fluid bed heating process gave rise, of course, to nasty vapors, and the [condensate was an intractable but homogeneous tar, which contained much water in emulsion. The engineers] said, "Well, we've no idea what to do with this stuff. Obviously, if [the technique] goes on to be an industrial process, there's going to be thousands of gallons of this. What can you do with it? [. . .] Think about it and see what you can [come up with]."

Well, the first thing was to break the emulsion, and they had failed conspicuously by blowing steam through [it] and [. . .] other [approaches]. I [suggested that perhaps it could be salted] out. You know how you salt out an emulsion? They said, "Well, you'd better [go ahead and] demonstrate it," [they challenged]. So I got the welder to build me a [large] steel can [with a stirrer and steam pipes for heating] the whole lot up, poured rock salt in, and lo and behold, the oil floated, and the aqueous salt solution came out the bottom [. . .]. ["So far, so good, but what about] the physical [and chemical] properties of the tar that remains?" Well, that was the next problem, as to what the [heck] to do with that [. . .]. It was [much] too viscous to put on the roads [. . .]. So I [began] a project which involved, first of all, a very controlled thermal decomposition of the tar, [with—and without—organic additives], to see if useful compounds could be dragged out of it. [But] by then, I had served my time.

GRAYSON: You got to escape?

HOLMES: I got to escape. Yes.

GRAYSON: And your friend Allan arranged for you to get a postdoc—

HOLMES: Well, yes. E. W. R. Steacie, who was President of the [National] Research Council [of Canada (NRC)] here in Ottawa, [Ontario], had visited University College [while] I was a student, [and] he and Allan [had become] quite good friends. So when I spoke to Allan [about] postdoc positions he asked], "Where would you like to go—[to] the States or Canada?" I [replied that I quite fancied Canada—not least because I [understood that there were excellent local winter sports in the Ottawa area. So Allan suggested that] he could probably fix [me] up with [Ed Steacie]. So I [applied and soon] got an offer from [the NRC], and I came to Ottawa in 1958.

GRAYSON: So you were then twenty-seven? **<T: 70 min>** Late twenties?

HOLMES: [Yes], in '58, I was [nearly] twenty-seven when I came here.

GRAYSON: And this was an academic appointment?

HOLMES: [No, no]. It was a postdoc [. . .]; a [postdoctoral fellowship at the NRC] Sussex Drive [laboratories], just up the road from where you are now. It [then] was a fantastic, wonderful place.

GRAYSON: Who did you work for [there]?

HOLMES: I was nominally working for Steacie, but he was [also the President of the NRC], and so obviously he had lieutenants who looked after [day to day] things. [The scientist to whom] I was assigned was [. . .] Ken Kutschke [. . .]. [Thus] I did photochemistry. [. . .] When chatting [with Steacie about it, he] said, "Well, we haven't [done] any [research] on free radical reactions involving aromatics, so why don't you have a go?" [Thus I studied] the reactions of [photochemically generated] trifluoromethyl radicals with aromatic substrates. [It was then that [I first I met Fred Lossing, because Fred [provided a small] analytical mass spectrometry [service], as well as [pursuing] his [ion energetics research].

GRAYSON: Now was he at the National Research Council?

HOLMES: [Yes], his lab was just down the corridor from me.

GRAYSON: But he wasn't at the university, was he?

HOLMES: [. . .] No, he was at NRC then. He'd been at the Research Council for quite a long time.

GRAYSON: So you developed a relationship with Lossing at that time.

HOLMES: [Not really], because, in fact, I thought mass spectrometry was a broken tool. The reason was this. He had [a home-made] analytical mass spectrometer [of very simple design. For example] the intensity of [each mass] peak was measured by the deflection of an ammeter [needle. The facility was operated by Bernice Thornton. Mostly], Fred was busy working up new ways of [accurately] determining ionization energies and appearance energies.

[. . .] You took your [gaseous] samples along to Bernice [in] an all-glass system [with] a magnetic break seal, and you would [return] in a day or two to see what the results were. [. . .] I strongly believed [that my samples were a mixture of, admittedly very dilute] aromatic compounds in [perhaps a trace of some] residual air and whatever else you could pump away from a liquid nitrogen cooled sample. Almost every time [the results] came back [as] CO_2 and water, but [she] couldn't find any organic compounds [. . .]. [Very frustrating. With hindsight, the samples may well have been much too small, but] I used to get [very] frustrated [. . .]. So I regarded mass spectrometry as a pretty flawed subject, and so I didn't really get to know Fred then.

GRAYSON: It didn't give me the answer you wanted?

HOLMES: That's right. Well, it didn't give me any answer at all [and] so I thought, "This is a waste of time." So it was quite funny, looking back at it, because we were all in the same boat [. . .], [taking our photochemical trace products down] to Bernice—and the chances were that she'd say, "Yes, [this one has a trace of C_2F_6, I think, and CO_2 and water."]

GRAYSON: So this was part of the routine arrangement that you were to take. . . [and other] people who were doing this work for the university [at NRC] would take samples over to Bernice to have them analyzed? That was a kind of a—

HOLMES: Well, the people in the photochemistry division [had] a standing arrangement, that if [we] had something which possibly could be analyzed by mass spectrometry, we had [a] free run. We could take [any] sample down and say, <**T: 75 min**> "Could you please tell us if we've got any whatever in this?"

GRAYSON: Do you recall what the vapor pressure might have been in this compound that you were trying to get her to find?

HOLMES: Well, I was hoping [I had some] trifluorotoluene, and that would have been a liquid [at RTP]. But the quantities, by the way, of course would have been very small. They would have been [in] micromoles. So it was not exactly a [visible] sample. [. . .]

GRAYSON: A wisp.

HOLMES: Yes.

GRAYSON: So the fact that, I mean, in retrospect, the fact that she didn't see much probably is not surprising.

HOLMES: [. . .] No, it's not surprising. [. . .] The [MS] apparatus [simply] wasn't sensitive enough, and we hadn't developed a [. . .] better technique for introducing [our gaseous] samples [. . .].

GRAYSON: [. . .] Now, you're doing your postdoc here.

HOLMES: [I was two years at NRC.]

GRAYSON: [So] NRC [fellowships were well] paid [at that time? What were] University of Ottawa [salaries like then]?

HOLMES. [. . .] I didn't know anything about the University of Ottawa then. The NRC [. . .] postdoctoral fellowship, which in those [. . .] days was [about three thousand five hundred dollars per annum and were] tax free—incredible.

So [un-]governmental, isn't it [. . .]? They were tax free [. . .]. [Soon after my time there, the Canadian Government decided that it was] not right. "We can't have people coming here and getting fellowships which are tax free. Raise the fellowships [by] the [amount of tax that they should pay and then make them taxable." Moreover the Fellows then would have to complete an Income Tax Form each year].

That happened [soon] after I left, and I thought, "Oh, God, government." [. . .]

GRAYSON: They gave you the money to give—

HOLMES: To give it back to them. That's right.

GRAYSON: I love it. That's good.

HOLMES: [. . .] Why did I come back [to the UK]? I quite wanted to stay in North America, but I thought I should give academic life in the UK a shot, so I went to the University of Edinburgh.

GRAYSON: So the idea that you were going to do academic [science] was pretty much cut and dried? You'd had enough experience in the—

HOLMES: [Yes], It was. . . because chemistry [was] such fun. [Most of all], I didn't want to be told what [research] to do. I wanted to do my own thing.

GRAYSON: So academic is the way to go.

HOLMES: Yes. So I got [an ICI-Imperial Chemical Industries] Fellowship and then a Lectureship at the University of Edinburgh. [That experience was something of a UK] cure.

GRAYSON: A cure?

HOLMES: It was very frustrating at Edinburgh. It really was.

GRAYSON: So while you're low man on the pole in the system—

HOLMES: Yes, it certainly worked like that [. . .]. I remember the second summer I was there, I had a really nice [research] project going. There were [then very small] grants that you could get [to enable] you [to] support a summer student. I [had a fine young student prospect and I thought that my project was just right] for a summer student. It was only a small sum of money, forty pounds or [less. When I didn't get it I decided that I should do better elsewhere].

GRAYSON: Do you have any idea why it wasn't funded, or—

HOLMES: Knowing Edinburgh, I'm quite sure there was a pecking order. The chair of the department was Sir Edmund Hirst, who [was not very approachable for a lowly beginner. In order] to see Sir Edmund, you had to jump a number of hurdles, especially his secretary, a formidable Scottish lady, [Miss Inch], who guarded everything, and made sure you didn't see [anyone easily].

Anyway, about this time, they [established] a new Chair of Physical Chemistry. You probably never came across a book [from] the [late] 1950s, I guess, or around 1960, *The Strengths of Chemical Bonds*.[5] It was a very good book, written by a man called Tom Cottrell [while he] had been working for ICI [Imperial Chemical Industries] **<T: 80 min>** [. . .] Explosives Division on the west coast of Scotland. And the story went—told by Tom, at any rate—that he had been sitting on a tram in London one day, and he saw [in the *Times* that] the Chair of Physical Chemistry in his old alma mater was up for grabs, so he applied for it and got it.

[Thus] I came to know Tom Cottrell quite well. He was an interesting man. He [later] became—this is parenthetic— [. . .] Principal at the University of Stirling, which was a new university in the west [. . .] of Scotland. Tom [appeared to be very placid, but was someone] who kept his emotions totally bottled. [However], once in a blue moon there would be a terrible explosion of [wrath]. I knew that Tom was internally like this, and while he was at Stirling it was a troubled time student-wise. [Stirling U] had a visit from the Queen [Elizabeth II] and some students threw eggs at [her]. Tom was Principal, and he took this [incident], as you might expect, extremely badly. He had a heart attack [soon after] and died. But he was a nice guy, Tom Cottrell. I sailed with him. He raced a [Dragon Class sailboat] on the Firth of Forth.

GRAYSON: So the chair position that he took was at the University of Stirling, or—

HOLMES: No, at the University of Edinburgh, [Stirling came later]. He came to Edinburgh, and he was my one [friendly] support, if you like, amongst the hierarchy.

GRAYSON: So of all the people there, he was kindly disposed towards you?

HOLMES: [Yes]. But what can I say? The pecking order at Edinburgh was clearly defined, and Edinburgh in those days was rife with class. It's something [that you as an American would be unfamiliar] with, but everybody [there] had their place. As an example, if you were an academic in Edinburgh, and you had a child, one of the [very first] things you did was to put his

[5] Tom Cottrell, *The Strengths of Chemical Bonds* (London: Butterworths Scientific Publications, 1958).

or her name down, at birth, in one of the public schools in Edinburgh, fee-paying, expensive, but status-[worthy]. And so the whole atmosphere of the place was like this.

GRAYSON: This was in the fifties?

HOLMES: In the early sixties. [. . .] If there's anything I did not like in the UK, it was the class system, and it was emphasized in Edinburgh.

GRAYSON: I was wondering too if you coming from a postdoctoral appointment in Canada, might have been an extra black mark against—you know, someone who left the UK and—

HOLMES: No, I [don't think so. The postdoc in North America] was regarded] as valuable experience in another country. [Although at that time] the "brain drain" business was in full swing, it certainly wasn't held against you. And there was no doubt that I got experience at NRC that I [could] not have got in the UK.

GRAYSON: And this Edinburgh position, you were to teach?

HOLMES: To teach and do research. [Yes].

GRAYSON: And what teaching assignment did you get?

HOLMES: The teaching. Every new [chemistry] lecturer, as [one of] their first [teaching assignments], was given "Chemistry for Engineers"—and the engineers being bloody engineers, didn't give a toss about chemistry. It was a hurdle [the new staff lecturer] had to jump. I have to [explain that] if you did not have a sense of humor, [the engineers] would destroy you. [The unfortunate] guy who came after me had to be relieved of the course at Christmas, because they [ran him ragged. They knew that they had] to pass this course, but they may as well get as much entertainment out of it as possible.

I'll give you two quick examples. [. . .] One morning, a [student] leaps up—it's a big class, about fifty or sixty students. A guy leaps up, blows a whistle in the middle of the lecture. Actually, it was exactly halfway through the lecture. He blew the whistle [and] the entire class on the right moved to the left [of the center], and all the class on the **<T: 85 min>** left moved to the right—because it was halftime. [They then] produced oranges and started to suck the oranges. Well, you had to laugh. I mean, come on, that was quite a good wheeze.

There was another [student] who was always late, and in those strange days, when you went to a lecture, there were gentlemen called servitors, dressed in [a University uniform], who stood outside [in] the corridors and took the names of the students as they came in, so they [kept the] class [attendance] record. Anyway, there was one student who was always late, and so I used to try and think up something new, some new little sarcasm for his late arrival, and it became a little interplay [between us]. One morning, I noticed [that he was absent and so] he's probably going to come late. And about a quarter of an hour into the lecture, there was a huge thumping on the door. "Oh, [Lord], who is this?" So [. . .] one of the students got up and opened the door. In comes this guy. He's in his pajamas with a dressing gown, a nightcap, [well-worn slippers] and a candle [on] a stick, and he shuffles in. [laughter]. It went on like that. Anyway, I told them what would happen if they didn't pass the bloody course at Christmas, and at the end of the academic year. But on the whole, a reasonable liaison existed between us. But if you took it to heart, it would be an awful ordeal. [. . .]

GRAYSON: Oh, [yes]. It sounds like a parody of—[. . .], but, I mean, these were engineers who weren't going to be chemical engineers?

HOLMES: That's right. [. . .] They were going to be mechanical or electrical or whatever [. . .] and chemistry was [viewed only as a minor] hurdle [that] they had to jump.

GRAYSON: [. . .] But, I mean, you actually. . . you held the power of the grade over their head, right?

HOLMES: [No, the marks did not relate to pranks played].

GRAYSON: On the other hand, I guess they were clever enough, most of them, they could probably pass the—

HOLMES: Yes. It wasn't a demanding course. It was a great deal of inorganic chemistry, the kind of chemistry that you expect an engineer to have some kind of knowledge of [and some of which they would have had at high school].

GRAYSON: So this was more for entertainment than—

HOLMES: Well, it didn't [always] feel entertaining at the time. At the time, I used to think, "Oh, [. . .], it's [the] engineers this morning"

GRAYSON: So did you have other teaching assignments besides—

HOLMES: [Yes], physical chemistry, thermodynamics, and that's another hurdle for you to jump, to be asked to do thermodynamics. [. . .] I quickly discovered [that] I'd pretty well forgotten what little thermodynamics I knew, and so I had to really work [very hard]. I [soon] discovered that the [best] way to teach thermodynamics is to state many of the [fundamental] ideas in as many possible equivalent ways as you can think of, because one of them will stick with the students. It's a [difficult] subject to teach.

GRAYSON: [Yes], it is, indeed. That is probably also one of the most feared things—

HOLMES: [Yes]. There's an American, [Henry Bent], who wrote a book called *The Second Law* [. . .].[6] It's a book which I have kept, it's [all] about thermodynamics of course, but it's a completely unconventional way of teaching [the subject. A] brilliant book; Henry Bent [has] saved my bacon on many an occasion.

GRAYSON: John [B.] Fenn had the same experience, of having to teach thermodynamics.[7] And he came about it in a non-conventional way and ended up writing a book on thermodynamics. So it's an interesting challenge, intellectually, to teach and to learn—

HOLMES: Yes, it [certainly] is. [. . .]

GRAYSON: I like the idea that you posed, of thinking about as many examples as possible to comprehend or understand it.

HOLMES: Yes. If you can explain entropy in six or seven different ways, you're halfway to getting [across] some kind of idea. And of course, [Ludwig E.] Boltzmann always saves the day. [laughter]

GRAYSON: Yes. So was this the extent of your teaching, then, those two courses? Or did you have more?

---

[6] Henry A. Bent, *The Second Law: An Introduction to Classical and Statistical Thermodynamics* (Oxford: Oxford University Press, 1965).
[7] John B. Fenn, *Engines, Energy and Entropy: A Thermodynamics Primer* (San Francisco: W.H. Freeman, 1982).

HOLMES: No, [. . .] I taught two [lecture] courses, [a typical teaching load. That involved about] six hours a week. Oh, and a laboratory course. We always had [one] lab course to do, one afternoon, **<T: 90 min>** usually.

GRAYSON: You hopefully had no untoward experiences in that lab course.

HOLMES: [No].

GRAYSON: So it took you, what, two years to figure out that this was—

HOLMES: That this was not [very satisfying].

GRAYSON: That it wasn't going to work?

HOLMES: This really wasn't going to work. [However], I knew of Keith J. Laidler from his work on [the kinetics of] thermal decompositions, and [. . .] that he was [Chair] at the University of Ottawa.[8] I also knew that he was going to be at a [chemical kinetics] conference in Cambridge, [United Kingdom], that I was [also] going to [attend].

GRAYSON: There you go.

HOLMES: So I buttonholed him after breakfast one morning, introduced myself, and said, "Might there be any possibility of a position at the University of Ottawa?" I don't suppose you ever met Keith Laidler?

GRAYSON: No.

HOLMES: Oh, [he was a very] nice [man], rather austere, but very friendly [. . .]. [He told me], "Send us your CV, John [. . .], and [. . .] I'll [soon] get back to you." About a month later, I got [the] offer of a job. So that was it. [The] emigration [formalities] took [—a mere—] three weeks. You went to Glasgow, [Scotland for] the medical and the interview all rolled into one

[8] Keith J. Laidler, interview by M. Christine King at the University of Ottawa, Ottawa, Ontario, Canada, 13, 14, and 18 October 1983 (Philadelphia: Chemical Heritage Foundation, Oral History Transcript # 0002).

[day]. Paperwork was completed [in days]. It was ridiculously easy [. . .]. [It takes at least a year now].

GRAYSON: Really?

HOLMES: [Also], you didn't have to produce a police chit then to show you hadn't [a criminal record]—from the local constabulary. So that was [all] really quick and easy. So back to Ottawa [I came].

GRAYSON: So now you're really basically coming back to where you had been before.

HOLMES: [Yes].

GRAYSON: And then you [. . .] had had enough experience with this part of the country that you felt this was a good place, you knew some people here [at NRC and so it would be easy] to come here and [quickly] get back into the swing of things.

HOLMES: [There's] a lot of outdoors here. There was outdoors like you wouldn't believe—[compared with the limitations of the UK].

GRAYSON: A lot of cold outdoors.

HOLMES: [Yes]. Well, that was fine, but it was outdoors with skiing and skating and sailing and canoeing and hiking, and it was all on your doorstep. Skiing in Scotland was really a hell of a business. The chances [there were] it'd be raining when you got [to the hills], anyway.

GRAYSON: So let's back up a little bit. When did your interest in all of this outdoors activity start? [. . .] When you were a wee tyke?

HOLMES: Oh, from childhood, I suppose. I was enchanted by my first bicycle [ca 1943]. I suddenly realized that I could [now independently] go [almost] anywhere. And the same friend that I still see, Ken [Pearce, he] and I used to take our bicycles on the continent every summer, until the money ran out.

GRAYSON: This was in your youth?

HOLMES: This is when we were just out of school. He was [at University] College. I was [working] at Glaxo, and then I was at University College, and so on. He did his PhD [. . .] in chemical engineering. So we [took our bicycles] on the continent for six years in a row, [1952-1957. We rode just about] everywhere west of the Iron Curtain, the lot, from the very top of Norway to Central Spain and to Italy, Switzerland, Germany, Denmark, the whole—

GRAYSON: Austria?

HOLMES: [. . .] Yes, [there too].

GRAYSON: All bicycling?

HOLMES: All by bicycle. [Ken and I] went back this year [2013], to the North Cape [of Norway by camper van from Stockholm, Sweden],—right at the very top of Norway, which then [in 1956] was only accessible by boat. Now they've built [an eight kilometers] tunnel under the fjord, [so] you can get there by road. The change [of course], is huge. It is now a tourist trap. [laughter]

[In 1956] you had to climb a one thousand foot cliff from a little jetty at the [water's edge, having been landed there from the coastal steamer]; but now, there's a huge parking lot, cafeteria, cinema, [restaurant, gift shop etc.].

GRAYSON: [. . .] So this was really like in your early teens, mid-teens, late teens?

HOLMES: No, it was in my [. . .] late teens and [early] twenties [that] all [this bicycle] travel [took place].

GRAYSON: And basically so you'd just go until the money ran out? You just—

HOLMES: Yes. We'd save up [carefully throughout the year] for **<T: 95 min>** our summer excursion in Europe, and we'd have an emergency return arranged.

GRAYSON: Emergency return? [. . .]

HOLMES: [That] was a provisional booking on a boat or a plane. We would work it out [such that] if all went according to plan, we would manage about six weeks on the residuum from our research grants, and then come home again. [. . .]

The other thing which we did [as students was that] we sailed together as well. We started sailing [at school and] while I was at University College. [Nineteen fifty-seven was] the very first time I ever went [out] to sea in a small boat. I've sailed the rest of my life.

GRAYSON: So Ottawa was attractive because of—

HOLMES: Because of the outdoors, the huge outdoors, and all the activities. [. . .] And [at] the University then, the chemistry department was small. Almost everybody was intensely interested in what they did. It was a very strong department with some extremely good people. So you [very quickly] felt at home. [. . .] The other wonderful thing was [that] Keith had worked out an arrangement with NRC, whereby NRC would build stuff for you [—for free]. So you could toddle up to NRC and go down to the engineering shops, and they'd say, "Hi, how are you?] And you'd say, "Well, I've got a little sketch here. I wonder if you could make one of these for me?" "Ooh, yeah, what's it for?" "Well, it's to do this research related to photochemical experiments." So, "We'll give you a call when we've made it." It was [a super arrangement.]

GRAYSON: There's nothing like having shops that—

HOLMES: Needless to say— [laughter]

GRAYSON: It doesn't work today.

HOLMES: It doesn't remotely work [like that] today.

GRAYSON: You probably couldn't walk into the shop because of—

HOLMES: Oh, [there would be] security [for starters]. . . you'd have to show a pass to get past the front door.

GRAYSON: So the university is situated right next to NRC, but—

HOLMES: No, [no]. Well, [. . .] NRC is [about] a mile and a half away.

GRAYSON: So it's easy enough to—

HOLMES: So it was easy to drop in to see the glassblower or [whoever]. [Ottawa] University then was still a Catholic institution, so there were crucifixes [in] all [. . .] the classrooms and so on.

GRAYSON: It started out as a Catholic school?

HOLMES: Started out as a Catholic university.

GRAYSON: Oh, that's interesting. I had no idea.

HOLMES: [. . .] It was run by the Oblate Order of Catholic Fathers, and in '64, it became a provincial university. The Oblates really couldn't afford it any longer, and so they backed out. [But] they've got a theological college [St. Paul's University] still [. . .] in town. But I liked the Fathers. They were great. [If] you had a problem, you picked up the phone, [and] said, "[Hi Father X]" and you'd have a chat about the state of the local [Canadian] football team, or the Montreal Canadians, and [then after some such chat], he'd say, "What can I do for you?" I can remember phoning [once], saying, "Listen, I'm planning to go to England for about a month in the summer next year, my entire vacation. Do you think I could have a month's salary in advance?"

[. . .] "Yes. No problem at all. Send me a little note." And sure enough, your salary would have been paid in advance, just by word of mouth and a little piece of paper. They were very, very flexible.

GRAYSON: So were there very many of them actually teaching, or—

HOLMES: [They taught] only in the humanities, and every now and again, [. . .] in my second year phys chem class, there would be a couple of young trainee priests [who] were [there] to learn about wicked old science, and they were usually very, very serious people. It was very difficult to raise a smile out of them. So [in '64] it became a provincial university, and—

GRAYSON: So in Canada that'd be sort of a state university?

HOLMES: That's equivalent [to] a state university. Yes. [Also] our research funding was [then] quite easy [to obtain].

GRAYSON: Being close to NRC helped?

HOLMES: Yes, **<T: 100 min>** [not least] because NRC [was then] the funding agency [. . .], it wasn't a separate branch of government. It was NRC's scientists who made the decisions. I think [that] they were very fair, but I have to say [that] being in town rather helped. [So from the very beginning] I always had by present day standards a small operating grant, but it was never in peril. Besides, there was too much going on, [so] much fun [in research]. I had some very good first [graduate] students, extraordinary, good, young people.

GRAYSON: So speaking of your career up to this point, you had. . . is there any one or two individuals that you considered to be, you know, what I would call mentors, or someone who—

HOLMES: Oh, Allan Maccoll. Allan was—

GRAYSON: He was your primary mentor?

HOLMES: Yes. You could always go to Allan for advice about anything, scientific or professional. He [was] a great friend. Otherwise, no, I don't think so. [. . .] I made some quite good friends at Edinburgh, but I was impermanent, and did I learn very much at Edinburgh? No. There was another photochemist there, [John Knox, but] we really never quite gelled.

[. . .] Sorry to go off at a tangent. I [did have great fun with one series of experiments] in Edinburgh. In studying [organic] pyrolyses, one of the key questions is whether it's a molecular reaction or a free radical reaction, and [there were] tests [that] would you apply to see if it was [either or both]. One of the tests was either to add an olefin, [such as] propene, which is not a very good free radical trap but never mind, or better still, nitric oxide [. . .]. [NO] is a great free radical trap, as you might guess, and so it will cut [short] a chain reaction. [Any residual process was likely to be molecular, not free radical].

Well, out of sheer curiosity at University College, I was [pyrolysing] sec-propyl iodide, which I was confident [involved an initial] molecular process, [the] elimination of HI, [followed by a fast] reaction of HI with the iodide [—involving I atoms—so that the products were] propane, propene, and iodine [. . .]. Just because it was the one thing, I added nitric oxide, and it didn't seem to do much to the overall kinetics [as expected]. The only problem was that in the trap that I used to condense out the products, [. . .] a white solid appeared. Now this [seemed]

silly. It must be a one-off [. . .]. [However the experiment was repeatable. What can it be]? It was ammonium iodide.

So I figured that nitric oxide [must have] reacted very rapidly with [the] hydrogen iodide and been reduced all the way down to ammonia, and then of course it would [condense] out on any [cooled] surface [as NH_4I]. So I promised that when I got the time and opportunity, I'd [look at] the kinetics of NO plus HI. [This] I did that at Edinburgh, and it was wow [. . .] a pure, second order reaction. NO + HI = HNO + I. The HNO then was reduced very rapidly by hydrogen iodide all the way down to ammonia. So the [activation energy of the rate determining] first reaction gave you the bond strength of HNO. So it was [. . .]. [That's what makes science such] a [joy]—you [have] these little observations, and you [promise yourself that] one day I'll follow it up and see what happens.[9]

GRAYSON: Well, that was. . . I put that in the category with the serendipity kind of thing, you know.

HOLMES: [Yes], that's right. Yes.

GRAYSON: You find something out that you never expected [. . .] because **<T: 105 min>** this white stuff is there.

HOLMES: [Yes]. What the hell is it?

GRAYSON: And then you pursue it, and that's a serendipitous result.

HOLMES: That's right. I would [strongly] argue that the difference between a good scientist and a better scientist is [that] the better scientist recognizes the luck when it happens. [. . .] All the exciting things [tend to be] luck, [. . .] have been [—involving] some [unexpected observation. Perhaps] many people would say [these stray observations don't deserve a follow up].

GRAYSON: [Yes]. I can't bring to mind right now the situation, but there's two or three different things that occurred that people, like you say, pushed aside, and someone else looked at a little bit more intently and says, whoa, you know.

---

[9] J.L. Holmes, "The Kinetics of the Reaction between Nitric Oxide and Hydrogen Iodide and the Dissociation Energy D(H-NO)," *Proceedings of the Chemical Society* (1962): 75.

HOLMES: Yes.

GRAYSON: Science isn't this linear thing that gets taught in textbooks.

HOLMES: Well, it's what granting agencies [tend to] want, [nicely] linear [proposals].

GRAYSON: Yes, indeed. Indeed.

HOLMES: When I was in East Germany at the [Leipzig University], I got talking to graduate students. Their English was great, and they told me what they were doing, and I said, "Oh, yeah, it sounds as if you're making good progress. What are you going to do next?" And to a man, they would say, "Ah, we have the plan." [. . .] "Well, what do you mean, the plan?" And [they would reply], "Well, in year one, I will do this, and I am nearly complete. In year two, I will do this. In year three, I will do that." So I [pointed out that] science doesn't [or shouldn't] work like that.

"What do you mean it doesn't work like that? This is the plan. This is the way our supervisor tells us we are going to do our research." But, I said, "Supposing an exciting result occurs here [or there]?" "No, no, no, no, no. We must stick to the plan." [. . .] East Germany was East Germany then, and I thought, "Yes, this is a very totalitarian view [as to] how science should [not] be pursued." [laughter]

GRAYSON: Very well-organized [. . .] it doesn't work that way.

HOLMES: No. It never has.

GRAYSON: Well, do you want to take a break now, or—

HOLMES: Oh, would you like a cup of coffee?

GRAYSON: That would be good.

HOLMES: We can go in search of a cup of coffee. [I'm sorry. I do rabbit on].

GRAYSON: Oh, no, no, no. This is good. [. . .]

HOLMES: [Just a few words about UK National Service**.** Each year at] University College, [the joint Universities' recruiting board would visit with] a representative of the [Royal] Air Force and the [British] Army. [Not] the [Royal] Navy, of course, you couldn't do your National Service in the Navy. You could only join the Navy. Anyway, these [military men] would come [to an open meeting in a very large lecture theatre]. The Air Force fellows [. . .] usually had a slight [but necessary] sense of humor, or could take a bit of [student] banter, [but] the Army people [tended to be] silly stuffed shirts. [. . .] Anyway, on this particular occasion, we were all duly assembled, and the military had taken up their positions, [with] all their bits of paper, on the platform, and there was a *rat-a-tat* at the door, and in came the engineers. They all had big T-squares at the slope, and they [. . .] came in and did a little drill with much stamping and shouting in front of the assembled military. [. . .] The Army fellow was [clearly] horrified, [but] the Air Force chap laughed [. . .].

[. . .] The whole proceedings went that way. The students didn't give a monkey's about messing about in the Forces for a couple of years, and wanted a way out of it. [In the event], the military people made quite reasonable presentations, but not holding out any brilliant prospects for the students. At the [very] end, the Air Force chap stood up, and he looked around, and he said, "Well, any questions?" And so of course the primed person at the back leapt up and said, "Yes. How can we get out of [doing] it?" [laughter]

GRAYSON: I'd like for you to repeat, if you would, briefly, that little anecdote that you told about when you were in Edinburgh, talking to this prim and proper woman.

HOLMES: Oh, the <**T: 110 min**> Scottish historian?

GRAYSON: [Yes]. Right.

HOLMES: The Scottish [lady] historian. [. . .] It was [at] one of those little parties for new members of staff where you drink sherry and eat little things on sticks, and are expected to mingle with the permanent staff. I found myself talking to a little tweedy Scottish lady, who told me [that] she was a [Reader in History], and we chatted about this and that, and I told her about [my time in] Canada. And she looked at me and said, very cannily, [. . .] "You'll have private means, of course," The understanding being, that as a poorly paid academic, I could not lead a proper life unless I had private means, which I [suppose] she probably had. [laughter]. I certainly did not.

GRAYSON: And was implying that by her—

HOLMES: It was implied that. . . it was assumed that any aspiring academic [in Edinburgh should] have private means. Tom Cottrell [certainly] had private means. [. . .] Tom had married an admiral's daughter, and they were [very] well-heeled. And it wasn't because Tom had had a super job with ICI, either.

GRAYSON: So it's a little bit. . . you know, there's this semi-soap opera we talked about, *Downton Abbey*, that—

HOLMES: [. . .] The specter of class raised its heads on so many occasions. When we first went to Edinburgh, I had to find somewhere to live, and [there] used to be a big general store, mostly expensive clothing and furniture, [. . .] on Princes Street called Jenners. They had a housing unit. [And so I went to that department seeking] a flat to rent at a fairly reasonable rate. [. . .]

[We were] given a list of addresses and [so off we went—most of them] were absolutely awful; dingy, gloomy places. The best of the bad lot was in a building made entirely of stone, [with] a series of flats on different floors. This was a ground floor flat, and it is no exaggeration to say that the sun could not possibly shine in any of its windows. The coal was kept in a cupboard in the kitchen. You brought the coal in through the front door [in sacks,] it was coal heating. It was as cold as charity, but it was the best of a bad lot.

We [returned] to Jenners and said [that] with reluctance, we're going to take this one in Comiston Gardens, [but we] really don't think very much of it." [The agent] leaned across the desk and said, "[But] it's a very good address. It's a very good address," because it was in the area called Morningside. And somehow that rather typified the way things were. [laughter]

GRAYSON: But in real estate it's location, location, location.

HOLMES: [Yes].

GRAYSON: [. . .] Now you said we.

HOLMES: Yes.

GRAYSON: Were you married?

HOLMES: I was married. Yes. That was my first wife [Una].

GRAYSON: Oh, okay. So you were married somewhere in that period before you [. . .] came to Ottawa [University]?

HOLMES: Yes. Before coming to Ottawa.

GRAYSON: [. . .] You started at the university [in 1962]?

HOLMES: Yes. [And] we had all that [scientific] help from NRC.

GRAYSON: Now here again, you were obliged to teach courses.

HOLMES: [Yes].

GRAYSON: So what did you start with here?

HOLMES: Physical chemistry. General physical chemistry, and of course, the dreaded thermodynamics, and [easier descriptive] things like electrochemistry. Anyway, general physical chemistry, and a course on [chemical] kinetics, because Keith Laidler's claim to fame was his knowledge and expertise in thermal decompositions, the kinetics and mechanisms of chain reactions and [much more besides]. He had done [much of] the fundamental work on small hydrocarbons, aldehydes, ketones, and so on, and so the [pyrolysis] mechanisms were known [. . .]. He had a very [fine and] wide reputation [and] wrote several books on chemical kinetics, [and] also wrote a **<T: 115 min>** history of physical chemistry.[10]

GRAYSON: Oh, really?

HOLMES: Which is an excellent book; [an] excellent book.

GRAYSON: I'll have to add it to my library.

[10] Keith Laidler and H. Gerischer, *The World of Physical Chemistry* (Oxford: Oxford University Press, 1995).

HOLMES: [Yes]. It's the only history of physical chemistry that I know of, and he covers all [. . .] the classical periods of [its development]—

GRAYSON: Did you get saddled with one of these huge sections of organic chemistry that usually—

HOLMES: [No]. Well, you have to remember, it was really rather a new university then, particularly in terms of [the] sciences, and so the undergraduate intake at first year was maybe between one hundred and about one fifty students. And so at the [. . .] top of the [student] pyramid, the number of fourth year honors chemistry students was perhaps ten, [or as few as] eight. All the others [that were in the] first year [class], had gone off into biology, [chemical engineering] or whatever other sub-discipline.

GRAYSON: So it was a fairly small school, well, a pretty small school.

HOLMES: Yes. The second year of Phys. Chem. was a class of between twenty and thirty [students]. So you knew the class [well]. You [very quickly] got to know the beards and the girls by name [. . .].

GRAYSON: And then the relationship with NRC probably was really good for the university, because it [provided so much free help]—

HOLMES: Oh, it was excellent, [for example] they gave us free liquid nitrogen. [laughter]

[We] used to go and collect it in those big [conical] tip-up cans. And as I [. . .] said, they built equipment [for us]. I drew a design for a photochemical apparatus, took it up there, "Yes, that'll take us about a month." And [so] a big wooden box about three feet by three feet by four, which [contained] an optical bench, [lenses and so on was quickly produced]. I could do all [the] external glassware [myself, and then] connect everything up. I [soon] had a complete system for doing [gas phase] organic photochemistry [and] kinetics.

GRAYSON: So was this something for which you paid, or was this something that—

HOLMES: [No]. NRC made these things [for free]. It was grace and favor. There was no payment involved. Those were happy times. [laughter]

GRAYSON: I can see that you prefer those times to these times.

HOLMES: [. . .] But it was very constructive, and it meant, of course, that the professorial staff at the university also contributed to NRC, because [their] postdoctoral fellows would come to lectures or seminars at the university, and we would certainly go there. [Thus] it was a two-way flow of people.

GRAYSON: A nice informal arrangement that you probably couldn't work out today if you wanted to.

HOLMES: Oh, just say the word "security" and you've knocked it on the head almost immediately.

GRAYSON: [. . .] I noticed when we went between buildings there was a lot of keys involved and the locking all the doors, and getting into various rooms and what not.

HOLMES: [Yes]. Well, what can I say? The old chemistry building is the next building over, and that was open to the street, big front doors open to the street all day. Every now and again, you would indeed find a shady looking individual sloping down a corridor and peeping into offices [or labs], and a sharp word would send them scuttling, because there was a small [but rare] amount of theft [. . .]. We had a custodian as well who sat in the hall, as a kind of gate guard. But he wasn't there all the time. He had [his] lunch break and [so on]. . . . But it was indeed a much more freewheeling kind of time.

GRAYSON: So [. . .], you've had your little stint in industry. You didn't even—well, I guess being associated with NRC was as close as you got to the government, in terms of interacting.

HOLMES: Yes.

GRAYSON: Because isn't NRC a government type operation, I guess?

HOLMES: It [most certainly] is now. It wasn't [so much] then [. . .]. [Its splendid reputation] was entirely [Steacie's] doing. [He was someone] who could speak to **<T: 120 min>** government with authority, and they listened to what he said. The [then] small, scientific component of the government used [Steacie] as an advisor, and [he pointed out that], "If we want to develop science, we've got to have a route for getting [young] scientists to [come to]

Canada. I suggest postdoctoral fellowships at [the] Sussex Drive and Montreal Road [Laboratories]." When I was at Sussex Drive, there were probably about fifty [recent PhDs] in my age group from all over the world, and a significant [number] of them stayed to become academics in Canada [perhaps as many as one third?] So it was [a] politically driven [venture], but by a [remarkable] scientist, not by politicians.

GRAYSON: But there was a desire by the Canadian government to promote science?

HOLMES: Oh, yes, because [. . .] it was [clear] that science had won the war, you see. Science could do no wrong for a [considerable] period after the war; it was the way of the future. And [thus] it was very popular.

I [recall that] when I first came to Ottawa, the teaching of chemistry in the high schools [. . .] was [excellent. They would come to the University to] borrow stuff from us—and we would] go to schools taking liquid nitrogen and chemicals], so that we could do [. . .] demonstrations.

GRAYSON: So you actually had interactions—

HOLMES: Oh, there [were] a lot of high school interactions. That's [much less now, at least to the same level].

GRAYSON: So was this. . . how was this promoted? Was it through a formal program, or informal, or—
HOLMES: Informally. [. . .] You got to know [teachers] and they asked, "Can you come out [to my school] and give a talk to the [senior years]?" [Gladly]—When?"

GRAYSON: Sure.

HOLMES: And [off away] you went.

GRAYSON: And the high schools were promoting this? [. . .] This would be up to the teacher to [initiate]?

HOLMES: [Yes]. When I came [back] to Ottawa, I discovered that had I instead chosen to be a high school teacher, I would have been paid rather [more] than [as an Assistant Prof at the U of O]. [laughter]

GRAYSON: That's interesting.

HOLMES: Not anymore.

GRAYSON: Well, not anymore.

HOLMES: Not anymore. No. High school teachers were [then] regarded as significant members of the community. It was a good profession. Now [. . .] they [appear to] have [lost that position].

GRAYSON: Did that come out of the Canadian world view, or was it something left over from the UK, or the influence of the UK? How much influence relative to say the French and the English is there in this part of Canada? [. . .] Or how much did you observe?

HOLMES: Well, that's quite difficult [to say]. When I first came to Canada [. . .]—this doesn't sound very nice—but French-Canadians were regarded as the hewers-of-wood and the drawers-of-water. They were [regarded somewhat], if you like, [as] a peasant class [. . .]. [In the 1950s] Québec [life and] politics were to a great extent governed by the Catholic Church. The Catholic Church was immensely powerful in Québec, [but] then in the sixties [and] into [the] seventies, [there came] what they called [the] Quiet Revolution [. . .]. The old politicians were thrown out, and [the province] became. . . in many ways as, or more progressive [. . .], than the rest of [. . .] Canada.

GRAYSON: So I guess I'm not clear as to how the church influenced. . . I mean, they had politicians in place that—

HOLMES: They had a major influence on every aspect of society. [Large families; youngest son goes into the Church etc.]. That's politics, law, education, and so to a great extent they controlled what went on. But this had to end. [It] was far too backward-looking.

GRAYSON: And it wasn't a very progressive control?

HOLMES: It was very, very conservative, large C conservative.

GRAYSON: Okay. So education of the French-Canadians was not considered to be an important—

HOLMES: Oh, [but] it was, provided they toed the religious party line [. . .]. [Sorry to digress, but] another thing that struck me [on arrival] in Canada, [when] sitting and having coffee or lunch with the [Canadians] at **<T: 125 min>** NRC and you [listened to their conversation], they all [seemed to know what everyone] else's religious denomination was, [something that was not a feature of UK life].

GRAYSON: Oh, really?

HOLMES: [Yes]. You'd hear, "Oh [dear], so-and-so's son, he's going out with a Catholic/[Anglican/Baptist/etc.] girl. [. . .] And [there] was awe, shock, [dismay. This was] something that I had never encountered in the UK. But [in Canada it seemed to matter greatly], and this [social] aspect of religious interference in personal life was quite strong.

GRAYSON: [Yes]. That's interesting. That's—

HOLMES: But needless to say, that doesn't hold much sway now.

GRAYSON: [Yes]. Well, I think it was that way in the States for some time. I know when my father and mother got married in Laredo, Texas, he was a Southern Baptist and she was a Catholic, and that was anathema. [laughter]

HOLMES: [. . .] Gosh, hellfire for both of them.

GRAYSON: Yes. Right. Exactly. [. . .] So you started out doing more photochemistry when you got here?

HOLMES: [. . .] Yes. I wanted to do hydrogen atom reactions, and it seemed that quite a good way of producing hydrogen atoms with different temperatures [energies] was to photolyze hydrogen iodide at different wavelengths, and also to thermalize the hydrogen atoms by having

a [variable] density of inert gas atoms. So I did [several studies] of [the] kinetics of hydrogen atom reactions with substrates of one sort or another.[11]

GRAYSON: What happens to the [iodine atoms] when you do this hydrogen iodide photolysis experiment?

HOLMES: [They end] up as [molecular] iodine. [. . .]

GRAYSON: So why does it want to go back to H_2?

HOLMES: [. . .] There's a bit of background [missing] here. In all the physical chemistry textbooks [to that time], it was believed that the perfect, [classic] example of a [simple], second order bimolecular reaction was HI plus HI equals H_2 plus I_2. [But to everyone's surprise John H]. Sullivan in the States did a very clever piece of photochemistry [when] he showed [that] the reaction [was not the elementary bimolecular process, but that it proceeded by the participation of H and I atoms. So it involved] atoms [and] was [not a simple bimolecular process].[12]

I also [. . .] carried on with thermal decompositions in the Allan Maccoll sense. [Sorry but I must digress again]—one of the [experimental] problems is [that when you perform the] static pyrolysis of an organic compound in a glass or quartz reaction vessel, there will be surface catalyzed processes [interfering with the kinetics] until the surface has been essentially ["neutralized"] by the deposition of [a carbonaceous] polymer [. . .]. And so treating the surface of a reaction vessel before attempting [to measure the kinetics of a] pyrolysis, was a key experiment. Now the [current recipe from Maccoll's group] for treating the surface was to [. . .] pre-[pyrolyse] allyl bromide [therein], and that produces a carbonaceous film, which after several treatments is just visible. The glass becomes [slightly] translucent as you deposit [the] carbon.

[A key] question which had been raised was, "Yeah, that's all very well. We can see from the kinetics [measured in] packed vessel experiments that [the reaction is] homogeneous [. . .] **<T: 130 min>**, but what [exactly] is this surface [that appears to be chemically inert?" One] argument was that the surface [may well] contain free radicals [and be a part of the overall decomposition. I contacted] a friend at NRC [John Morton, an ex UCL friend who suggested that I] make some of this carbon, bring it down to [his] ESR [electron spin resonance lab, for

[11] J.L. Holmes and E.V. Sundaram, "Gas Phase Photolysis of Hydrogen Iodide I. Inhibition with Nitric Oxide at 25`C," *Transactions of the Faraday Society* 62 (1966): 910-918; J.L. Holmes and E.V. Sundaram, "Gas Phase Photolysis of Hydrogen Iodide II. Effect of Nitric Oxide at 6`C and -20`C," *Transactions of the Faraday Society* 62 (1966): 1822-1830; J.L. Holmes and P. Rodgers, "Gas Phase Photolysis of Hydrogen Iodide. III. Hot Atom Effects," *Transactions of the Faraday Society* 64 (1968): 2348-2352.

[12] John H. Sullivan, "Rates of Reaction of Hydrogen with Iodine. II," *The Journal of Chemical Physics* 36, no. 7 (1962): 1925-1932.

him to] have a look. So I made pyrolytic carbon samples, [took] them to NRC, and sure enough, big [signals appeared], free electrons [abounded] in the surface material. [This possibly opened a new line of research for me].

Perkin-Elmer Corporation [. . .] in those days sold, made, or had available, a benchtop ESR apparatus. Not particularly sensitive, but very workman-like, [that] would give you spectra. I hadn't got [about] six thousand dollars [in grant monies to spare], and I wasn't going to [be able to raise] it in a hurry. [That] was [quite] a lot of money then. [For a present day comparison you've should] multiply by probably a factor of at least [twenty]. Anyway, I buttonholed the Perkin-Elmer [salesman] when he [next] came through [the Department, and I [asked] "How about a rental? Could I rent [a small] ESR machine from you for a year? I [reckon that] I can get enough work done in a year to perhaps raise a grant for [an instrument] of my own." [He replied that that would be] no problem at all. "Write to me [with] an outline of what you want to do." [Shortly after he phoned to say, "Yes, I think it's going to fly, and we'll have a machine delivered] to you next month."

GRAYSON: So you got your ESR machine?

HOLMES: [But PE] management said, "What's this? You're going to rent out one of these instruments? You should be selling it, not renting it out."
O

GRAYSON: Oh, no.

HOLMES: And so that [project] died, which [was hugely frustrating]. I had a [. . .] planned series of experiments to [. . .] see what happened [to the spin signals] when you admitted different materials to [the radicals—anyway, that avenue of research closed].[13]

However, by happenstance at the same time, at a staff meeting, Keith came in [. . .] smiling from ear to ear, and he said, "Right," he said, "we've got fifty-five thousand dollars to go out and get our first mass spectrometer."[Hurrah. He then said "I need somebody to volunteer to be responsible for this. Because I don't think anyone here knows anything about mass spectrometers, I need somebody to be prepared to look after this." There was a silence].

[13] J.L. Holmes and M.R. Bridge, "Surface Problems in Kinetic Studies of the Gas Phase Pyrolysis of Alkyl Halides. I. Reaction Vessel Coatings of Pyrolytic Carbon," *Journal of the Chemical Society B: Physical Organic* (1966): 713-716; J.L. Holmes and S.M. Ruo, "Some Physical and Chemical Properties of Pyrolytic Carbons and their Relevance to Kinetic Studies in the Gas Phase," *Journal of the Chemical Society A: Inorganic, Physical, Theoretical* (1968): 123l-1237; J.L. Holmes and G. Choudhary, "Surface Problems in Kinetic Studies of the Gas Phase Pyrolyses of Alkyl Halides. II. Pyrolyses of Alkyl Iodides," *Journal of the Chemical Society B: Physical Organic* (1968): 1265-1270; J.L. Holmes and S.M. Ruo, "A Gas Kinetic Investigation of the n-Butene Equilibria," *Journal of the Chemical Society A: Inorganic, Physical, Theoretical* (1969): 1924-1926.

[. . .] I thought about it [quickly, and decided to volunteer—thus breaking the First Law of Academic Life which is "Never volunteer."] "Well, I'll do it. I'll do it." [. . .] Keith [replied, "OK], off you go [to] see Fred Lossing [at NRC. He told me recently that] they're interested in getting an instrument as well. So you go and have a chat with Fred [to] see what [should] be done." So [away] I went [to talk to] Fred—who I hadn't seen for quite a long time—and he said, "Oh, [. . .] great. [Come with me as] I'm going down to Norwalk, [Connecticut], to Perkin-Elmer, where they are the agents for Hitachi [. . .]; I've heard good things about the Hitachi instruments. We'll make a plan [and then] we'll fly down."

[. . .] Away we went [. . .] to Norwalk to [spend] a couple of days [at Perkin-Elmer. I was impressed by the size of the apparatus], all pumps and meters and God knows what all [else, but] I [reckoned that] I could manage it. Fred put [the demonstration RMU-6D] through its motions, and he liked what he saw. [He concluded that it was] a well-designed piece of equipment [and he had] no hesitation that NRC should buy [one] for all its future analytical mass spectrometry needs. So far be it from me to say [otherwise. And thus] two RMU-6D's came to Ottawa. It was a single-focusing analytical mass spectrometer with a mass range of [about] one thousand. And—

GRAYSON: EI [electron ionization] source?

HOLMES: [Yes an] EI source. I [went to] the Dean [to] arrange accommodation [for the apparatus and] negotiated a room for it in the old chemistry building [. . .]. The room was [duly] cleaned and cleared out and extra power brought in, and [soon after our visit, the PE engineers arrived with the] crates. They assembled [the MS] and a representative from Perkin-Elmer gave me a quick run through [and presented me with the—Japanese—] manuals [. . .].

GRAYSON: Yeah right. [laughter]

HOLMES: "And away **<T: 135 min>** you go."

GRAYSON: This was 1960—

HOLMES: [No;] this was [late in] 1964 [. . .]. So I shut the door and played with it for a while, [until I felt that I had] got some idea [as to] what the hell was going on and then [carefully read] the manual, [which] had been written by the Japanese.

GRAYSON: In English?

HOLMES: [Well], it was in Pidgin English. [Indeed], I can quote from it. It said, "When loudly the pump gargles, do not begin the high vacuum." [laughter] That was the tenor of its [presentation. I next] I hung my shingle outside the lab [that announced], "One or two days a week I'll be available to the organic chemists to run mass spectra [. . .]." And so of course, [the] synthetic [chemists] came flooding in. I explained that I could] only do so many samples [a day], gases [or liquids] preferably. The solids probe was an ingenious [damned] device. [There] was a [clever] rotatable turret [arranged such that one of the two probes was always] sticking vertically up. I [tried] to find a picture somewhere [. . .], [but alas have found none. You rotated the turret and the probe could then enter the ion source].The other probe, the companion probe, was now vertical, and ready for a new sample. It was a [neat] device. [. . .]

And [as for] the organic chemists [. . .]—they were [at first] delighted, and then they were really [cross, because for example, one of them] would come down, [to] say, "Right, we've got this sterol, and by this reaction, that reaction, and so on with the double bond, we should have [added] three more methyl groups [to] it. [Please] run it through [to confirm]." Sometimes my reply would be "Sorry, you've got four [more] methyl groups." [This would be impossible to them.] "I'm sorry, [look—there's the—intense—] molecular ion, and [it is] fourteen mass units [higher than your prediction]. That means you've got another [methyl group. With luck this result would be confirmed by—early—NMR, which] was in a fairly infant stage then. With this they would return looking crestfallen [that their carefully planned synthesis had failed. So slowly, sample by sample, MS gained acceptance].

GRAYSON: So you got to do this instead of ESR?

HOLMES: [Yes], I did that instead of [the wished-for] ESR. [The MS work soon became popular and thus] a [considerable] chore. I asked if possibly we could [hire] some youngster [. . .] who would run [at least] some of the samples. And [so] I got a part-time assistant [alas, name forgotten]. Servicing the [MS] was [a big chore], because it was all old-fashioned [vacuum tube] electronics, and the voltages carried by the condensers were not to be laughed at. You had to remember to ground everything in sight before you put your hand in. I got some nasty burns.

GRAYSON: I can imagine.

HOLMES: [There was] glassblowing [required] as well. [. . .] The ion source was held in place [via a glass inlet tube. I was quite a good glassblower, having done Jim Frost's superb course at UCL] but there was a long graded seal going into the source, and [so whenever a filament required replacing I needed professional help from our glassblower, Egon Kristoff. Egon was a master glassblower, who had walked into the Chemistry Department one day in 1961, newly arrived from Yugoslavia, and asked for a job. He demonstrated his skills that same day and was

hired immediately. A department could do things like that, then]. So the glassblower [was required every time] the filament had to be changed [. . .]. [But] it was a good machine.

You know what the best feature [. . .] was, [one that has] never been repeated? The ion source [was a typical metal box and the gaseous] sample inlet was from the [rear] of the box. [The ion exit slit was at the other end]. On either side [of the gas inlet was] a pair of [ion] repeller plates. So by putting voltages on each plate, you could focus the beam, and [moreover] you could change the residence time of the ions in the source. I thought that was fabulous and [decided that it had potential as] a physical chemistry machine [and for the study of metastable ions] <**T: 140 min**>.

So for about two years I was burdened by this [chore. But serendipity struck when] a friend at the [University of Reading] in the UK [Neil Isaacs] sent me a sample. He [wrote that], "The mass spectrometer at Reading hardly ever works. I've got fed up with waiting. Is it [OK] if I send you a sample? I think [that it could be] fumaric acid. That's trans-ethylene dicarboxylic acid." And so a little sample duly arrived through the [regular mail]. I don't know if you could do [that] now?

GRAYSON: Oh, no.

HOLMES: Anyway, the sample came, I ran it, and indeed it was fumaric acid. I looked in the book of [reference mass] spectra—[the Dow certified MS]—and sure enough, there was a spectrum of fumaric acid, but the mass spectrum of maleic acid, the cis-isomer, was reported as having no molecular ion. I [considered that to be] peculiar. I [found a sample], ran it, and there was a [fine] molecular ion. [I decided that] the inlet system [used for the reference spectrum had been too hot, thus dehydrating the sample to yield maleic anhydride. However, my mass spectra of these two isomers were clearly different, therefore ruling out a possible rotation—and therefore free carboxyl-carboxyl interactions—about the double bond in the molecular ions. That was a nice "new" result; an explicit tiny piece of mechanistic gas phase ion chemistry].

[. . .] And [so] I was hooked. So I had a [PhD] student, [Frank Benoit, and I proposed that he run the MS of] a lot of dicarboxylic acids [to see if or] how the carboxyl groups [interacted]. So we [bought] in a whole slew of [. . .] them [and recorded their EI MS. We found that we could] make sense out of [the results], all related [to their] molecular geometry in the neutral state [. . .]. [I think that my life in MS] started from there, [as we continued with an even wider range of dicarboxylic acids].[14]

[14] J.L. Holmes, F. Benoit and N.S. Isaacs, "The Mass Spectra of Carboxylic Acids. I. Fragmentation Mechanisms in Maleic and Fumaric Acids and Related Compounds," *Organic Mass Spectrometry* 2 (1969): 591-601; J.L. Holmes and T. St. Jean, "The Mass Spectra of Carboxylic Acids. II. Fragmentation Mechanisms in the Homologous Series HOOC $(CH_2)_n$COOH," *Organic Mass Spectrometry* 3 (1970): 1505-15l8; J.L. Holmes and F. Benoit, "The Mass Spectra of Carboxylic Acids. III. The Structures of Molecular and Fragment Ions in Benzoic Acid and Related Molecules," *Organic Mass Spectrometry* 4 (1970): 97-107; F. Benoit and J.L. Holmes, "The Mass Spectra of Carboxylic Acids. IV. Carboxyl-Carboxyl Interaction in some Cycloalkane 1, 2-Dicarboxylic Acids and its

GRAYSON: So [. . .] Neil Isaacs [. . .] kind of got you—

HOLMES: [Yes. Neil] was a friend from NRC days.

GRAYSON: But he [. . .] got you pointed in this whole direction, by accident. Up until then, you were just [. . .] running samples?

HOLMES: Up until then, I was the dogsbody, keeping the [. . .] thing running and doing samples.

GRAYSON: So did you have a—[electronic gear]—I mean, most of the labs at that time had a tube tester, so you could check your tubes and what not [. . .]?

HOLMES: Oh, [yes]. That's right.

GRAYSON: Did you ever—were you able to bring in an engineer to look at the machine at any time, or was it just a—

HOLMES: We had a major [electronic] breakdown, [and our department] electronics guy said, "I don't think I ought to meddle with that." I phoned Norwalk and said, "Listen, I've not bothered you before. Can you send an engineer?" [Then] they told me what the cost would be [. . .]. [I had to ask Prof Laidler for financial aid. A] Perkin-Elmer [technician came], and he was useless. I knew far more than him. So I kicked him out [. . .] and [also wrote a very] sharp letter to Perkin-Elmer [. . .].

GRAYSON: [. . .] We're going to charge for this. You've got to send someone who knows what they're doing.

Relationship with Molecular Geometry," *Organic Mass Spectrometry* 6 (1972): 541-548; F. Benoit and J.L. Holmes, "The Mass Spectra of Carboxylic Acids. V. Carboxyl-Carboxyl Interaction in the Fragmentation of some Cycloalkene-l, 2-Dicarboxylic Acids," *Organic Mass Spectrometry* 6 (1972):549-557; J.L. Holmes, "The Mass Spectra of Carboxylic Acids. VI. Metastable Dissociations of Isomeric Ions in the Mass Spectra of Oxalic and Formic Acids and Malonic and Acetic Acids," *Organic Mass Spectrometry* 7 (1973): 341-346.

HOLMES: [Exactly]. I sent it to the chairman of the company [. . .], who [then was Admiral Chester W.] Nimitz.

GRAYSON: [. . .] Oh, wow [. . .]. [laughter]

HOLMES: [I was really furious, because this technician who] had come up from Norwalk obviously [knew far too little about the RMU-6D. Before anyone else could come], we fixed it ourselves—a very good learning experience].

GRAYSON: And I guess you didn't have to pay for that.

HOLMES: It [turned out to be blown] resistor chains. So yes, [the repair] was a long, laborious business, component by component—as it was in those non-solid state days.

GRAYSON: But you had schematics, right?

HOLMES: We had [good] circuit diagrams, and we had a proper tube tester, [AVO-meters etc.].

GRAYSON: Yes. Those were fun times. And so what kind of recording device did you have?

HOLMES: Visicorder. [It was a good Visicorder—not the kind where you had to immerse the paper to develop the four traces at different sensitivities].

GRAYSON: [. . .] <**T: 145 min**> The paper [. . .]?

HOLMES: [The UV sensitive optical paper gave a semi-permanent trace—it did fade if left long exposed to daylight].

GRAYSON: [. . .] This was a magnetic scanning [instrument]?—

HOLMES: [. . .] Yes. It just had an electromagnet [. . .].

GRAYSON: [. . .] Sixty, ninety, one hundred eighty? What was. . . do you recall the sector angle [. . .]?

HOLMES: I [. . .] think [that the angle was 120 degrees].

GRAYSON: [. . .] Did it have a Faraday cage/cup detector, or did it have electron multiplier.

HOLMES: Oh, [an] electron multiplier, [yes]. And I learned from Fred Lossing how to resuscitate your electron multiplier.

GRAYSON: Oh?

HOLMES: You took it out, [. . .] put it into a large glass tube, [. . .] evacuated [. . .] it and then you filled [it] with a reasonable pressure of oxygen, [sealed it] and [put] it in an oven [at] about [300-400°Celsius You then cut the tube open and found that it had— with luck— recovered] about 50 percent of its original gain [. . .]. But it didn't last [too] long—you would [usually] get several more months out of a multiplier by doing that.

GRAYSON: Now did you—obviously, you had to replace the filament, but what about cleaning the ion source? Was that an issue? Did you have to—

HOLMES: No, it was just a fiddly job. [. . .] Making filaments was [. . .] a bit of a challenge.

GRAYSON: You had tungsten [wire]?

HOLMES: [We used] thoriated tungsten and spot [welded the wire] onto the mounts. [Yes]. Those were the days.

GRAYSON: So once you [had] discovered this exciting bit of chemistry, you became more of a mass spec—

HOLMES: Well, I [began] reading the books [about mass spectra. Of course] I had a copy of Fred McLafferty's *Interpretation of Mass Spectra* the little original paperback book. [15] I read this [carefully] from cover to cover and thought, "Yes. We don't really know much about this mass spectrometry game, but there's a huge wealth of [ion chemistry hiding in there, waiting to be understood." Fred McLafferty was the real father of organic mass spectrometry and has never, in my view, got the credit that he undoubtedly deserved. He created a subject where none had existed before].

[. . .] I think [it was] about this time [that Seymour] Meyerson, John [H.] Beynon and [Dudley Williams's groups] had started [regularly] doing isotopic labeling, [. . .] showing, for example, that in many small hydrocarbon ions, the carbon and the hydrogen atoms [had lost some, or all] of their positional identity before fragmentation.[16] [. . .] Of course, benzene [provided] the key example [. . .]. [When its molecular ion fragments to lose C_2H_2 all the H and C atoms have lost their positional identity; the same happens with t-butyl cations before their loss of CH_4.

Fortunately I had an MSc] graduate student then [still in town, actually], who was a synthetic whiz.

GRAYSON: Oh, boy.

HOLMES: It always worked. His name is Raj Capoor. We called him "Captain Chemistry." I used to give him dreadful [labelled] molecules to make. [For example]: "Can you [make] me spiropentane with four deuteriums on one side of the spiral?"

"No problem," says Raj, and a couple of weeks later he'd bring in the [pure] sample with [its] NMR and everything [. . .]. [Wonderful].

GRAYSON: A good man to know.

HOLMES: A good man to know [indeed. Back to] Neil in England, **<T: 150 min>** we had corresponded a lot about the maleic/fumaric [acids story and then he suggested trying some] norbornyl excitements. About the non-classical and classical ions? [. . .] It was a great topic in solution chemistry [but the gas phase cation analogs had not been considered. I asked] Neil to

---

[15] Fred W. McLafferty and Frantisek Tureek, *Interpretation of Mass Spectra*, 4th ed. (Herndon, VA: University Science Books, 1993).

[16] Seymour Meyerson, interview by Michael A. Grayson in Gary, Indiana, 7 March 1991 (Philadelphia: Chemical Heritage Foundation, Oral History Transcript # 0398); John H. Beynon, interview by Michael A. Grayson in Swansea, Wales, United Kingdom, 22 April 2008 (Philadelphia: Chemical Heritage Foundation, Oral History Transcript # 0420).

make us a sample of exo-2 norbornyl chloride with carbon-13 at a [the C-3] position, and [he] made it, starting from carbon-13 CO_2.[17]

GRAYSON: [. . .] Oh, God.

HOLMES: Which [was very impressive].

GRAYSON: He's a pretty good chemist.

HOLMES: Yes, [indeed; and so] we completed that [part of the] project together.[18]

GRAYSON: So this guy that got you kind of hooked on mass spec, you continued to collaborate with him?

HOLMES: [Yes, but] only when something of mutual interest arose [—such as] the norbornyl cation [in] the gas phase [. . .].

[By now it was becoming] obvious that the only way we were ever going to [properly] interpret mass spectra was to find out what the structures of the ions [really were. You may recall the vogue for fragmentation mechanisms accompanying most newly reported mass spectra—entirely speculative and without any foundation, with a plethora of three and four membered rings and other energetically "impossible" items].

[It was then that] I went [to have] a chat with Fred Lossing, because I could see that if you could measure [ion] energetics accurately, you could [obtain ion enthalpies] of formation,

---

[17] J.L. Holmes, D.L. McGillivray and N.S. Isaacs, "The Mass Spectrum of exo-2-norbornyl Chloride. The Elucidation of the Fragmentation Mechanism and Ion Structures by Metastable Ion Analysis," *Canadian Journal of Chemistry* 48 (1970): 2791-2797; J.L. Holmes and D.L. McGillivray, "A Feature of the Fragmentation Mechanism of exo-2-Norbornyl Chloride; Stereoselective Hydrogen Atom Abstraction Revealed by Metastable Ion Studies," *Organic Mass Spectrometry* 5 (1971): 1339-1341; J.L. Holmes and D.L. McGillivray, "The Mass Spectrum and Fragmentation Mechanism of exo- and endo-Norborneol," *Organic Mass Spectrometry* 7 (1973): 559-572; J.L. Holmes, D.L. McGillivray and N.S. Isaacs, "Degenerate Skeletal Rearrangement and Energy Partitioning in the Fragmentation of the Norbornyl Cation," *Organic Mass Spectrometry* 9 (1974): 510-513.

[18] J.L. Holmes and D.L. McGillivray, "The Mass Spectrum and Fragmentation Mechanism of exo- and endo-Norborneol," *Organic Mass Spectrometry* 7 (1973): 559-572; J.L. Holmes, D.L. McGillivray and N.S. Isaacs, "Degenerate Skeletal Rearrangement and Energy Partitioning in the Fragmentation of the Norbornyl Cation," *Organic Mass Spectrometry* 9 (1974): 510-513.

which would be structure characteristic. [Fred asked me] "What are you working on now?" [I told him that we were completing a study of] nitroaromatics.[19] [. . .]

[He replied, "You're doing what?] Son of a gun, that's what we're doing here." So I said, "Right, Fred. This has got to stop. We must communicate better in future." [laughter]

[And so our long collaboration began from that day, and he started measuring appearance energies for our research.[20] About that time I went to the 1976 triennial MS meeting in Edinburgh. The dinner by the way, was marked by the very formal piping in of the haggis and the rows of whisky bottles down each table].

GRAYSON: Oh, really?

HOLMES: [Oh yes]. Anyway, sitting opposite me was a [Dutch scientist, Geoff Dijkstra who was the Chair of Chemistry at the University of Utrecht].

GRAYSON: That name's familiar.

HOLMES: [. . .] Geoff said, "I've got a young scientist who's just started working in my laboratory as a lecturer, and his master's degree and his PhD were [both] on analytical mass spectrometry [. . .]. Could he come and spend a year with you?" I [replied], "Yes, sure. Glad to have him."

And so I [soon arranged to meet] Hans Terlouw. We got on very well, and he came to Canada for [the year 1974/5. He's been a wonderful research catalyst and many, many happy times were spent with him and Fred Lossing, talking about the baffling ions. We have collaborated ever since. Because of research] funding difficulties in Canada, I used to go to Holland **<T: 155 min>** to carry out experiments, [he being better equipped]. I would go for three month chunks, and [as Hans had relatively light] teaching duties and [also had some excellent post-graduate students, we would have a wonderful, uninterrupted time in his MS lab.

Our first collaborative venture in Ottawa was studies of metastable ions—MI—as ion structure determinants and we published extensively on them, with students and colleagues from

---

[19] J.L. Holmes, G. Neville and I.C. Nigam, "Ketones in Cyperus: NMR and Mass Spectral examination of the 2, 4-dinitrophenylhydrazones," *Tetrahedron* 24 (1968): 3891-3897; J.L. Holmes and F Benoit, "Mass Spectra and Fragmentation Mechanisms of some Nitrophenylhydrazines and Nitrophenylhydrazones," *Canadian Journal of Chemistry* 47 (1969): 3611-3621; J.L. Holmes and F. Benoit, "Ortho Effects. I. Fragmentation Mechanisms in some Ortho-substituted Nitroarenes," *Organic Mass Spectrometry* 3 (1970): 993-1007; J.L. Holmes and F. Benoit, "The Mechanism of NO Loss from the Molecular Ion of Nitrobenzene and the Fragmentation Behaviour of the Phenoxy and p-Amino-phenoxy Cations," *Chemical Communication* (1970): 1031-1032.

[20] J.L. Holmes, J.K. Terlouw and F.P. Lossing, "The Thermochemistry of $C_2H_4O^+$ Ions," *Journal of Physical Chemistry* 80 (1976): 2860-2863.

other Universities. By then I had acquired an AEI MS-902S instrument, excellent for energy resolved metastable ion MI studies—by accelerating voltage scans—work that I began with Frank Benoit]. [21]

But Hans had very good technical support through one of his students, [Alexander Sander Mommers], who is here now [. . .] and [is a vital part of] the mass spec. [center] downstairs. He [obtained his Utrecht] PhD with me and Hans [. . .]. What Sander doesn't know about [a] mass spectrometer isn't worth knowing. So he [has] built [accessories etc.] for us, from scratch. [Whenever] Hans and[/or] I thought of a new experiment, we'd make a little sketch, talk it over with Sander, and he'd say, "[Yes], I can make that. What we need [are]—" and we'd assemble the components, he'd [machine items], put it all together, and we'd have a new piece of equipment, for doing something strange, like field ionizing neutrals and all [manner of NRMS, Neutralization-reionization mass spectra, experiments, e.g. those involving metal vapors].[22]

GRAYSON: [. . .] Your mass spec had been here long enough that it was no longer a novelty.

HOLMES: [By the time that Hans Terlouw came we had just got the AEI Associated Electrical Industries MS-902S. The S signified an energy resolving β-slit].

[. . .] I had applied for a high resolution apparatus through the [Canadian] granting agency, [not least because my colleagues now believed that mass spectrometry was of some considerable use to organic chemists, and so there was a lot of support within the department. At that time—70s—] we were interested particularly in metastable ions. With an MS-902S, you could defocus metastable ions and do energy resolved acceleration voltage scans [. . .] on [them. When we got the grant for a high resolution MS, I] phoned the AEI representative in Canada, [who] said, "Oh, great, we'll set up a visit for you in Manchester, [United Kingdom], to go and

---

[21] J.L. Holmes, D.L. McGillivray and N.S. Isaacs, "The Mass Spectrum of exo-2-norbornyl Chloride. The Elucidation of the Fragmentation Mechanism and Ion Structures by Metastable Ion Analysis," *Canadian Journal of Chemistry* 48 (1970): 2791-2797; J.L. Holmes and F. Benoit, "Metastable Peak Analysis; a Method for Elucidating Fragmentation Mechanisms and Ion Structures in Mass Spectrometry. Part II. Water Loss from the Molecular Ion of 1,2-Cyclohexanediol," *Canadian Journal of Chemistry* 49 (1971): 1161-1164; J.L. Holmes, "The Mass Spectra of Carboxylic Acids. VI. Metastable Dissociations of Isomeric Ions in the Mass Spectra of Oxalic and Formic Acids and Malonic and Acetic Acids," *Organic Mass Spectrometry* 7 (1973): 341-346; J.L. Holmes, D.L. McGillivray and R.T.B. Rye, "Specific and Random Processes in the Fragmentation of Cyclohexanol," *Organic Mass Spectrometry* 7 (1973): 347-356; J.L. Holmes, "The Mass Spectra of Isomeric Hydrocarbons II. The C_5H_8 Isomers, Spiropentane, Cyclopentene, l,3-Pentadiene and Isoprene: the Mechanisms and Energetics of their Fragmentations," *Organic Mass Spectrometry* 8 (1974): 247-255; J.L. Holmes and G.M. Weese, "Thermochemistry and Metastable Energy Release for the Dissociation $C_3H_7^+ \rightarrow C_3H_5^+ + H_2$," *Organic Mass Spectrometry* 9 (1974): 618-621; J.L. Holmes, A.D. Osborne and G.M. Weese, "Metastable Ion Studies III; Composite Metastable Peaks in the Fragmentations of some Small Hydrocarbon Cations," *Organic Mass Spectrometry* 10 (1975): 867-875.

[22] M.C. Blanchette, J. Bordas-Nagy, J.L. Holmes, C.E.C.A. Hop, A.A. Mommers and J.K. Terlouw. "Neutralization-Reionization Experiments; a Simple Metal Vapour Cell for V.G. Analytical ZAB-2F Mass Spectrometers." *Organic Mass Spectrometry* 23 (1988): 804-807.

play with an MS-[902S to] see what [it can] do for you." "That's very nice." I said, "I'm also going to MAT [Mass und Analysen Technik] in Bremen, [Germany], as an addition to the journey."

And so the trip was arranged [. . .]. [When] I arrived in Manchester, I went to the hotel and to my [surprise], there was [the] Canadian representative standing in the entranceway [. . .]. He said, "Oh, hi, John. [. . .] I don't know how to tell you this, [. . .] but [. . .] the instrument that you were going to have for yourself tomorrow has been sold and it's gone." I [was dismayed], "I've come three thousand miles for this [. . .] What's going on here?" [He replied], "Well, you know, [it's] nothing to do with me. The sale was made, and it was dismantled [and shipped out] yesterday." So [. . .] that wasn't [a] very good [beginning].

GRAYSON: No.

HOLMES: [However] I [. . .] spent [the] day with AEI [. . .]. That was [quite] an education [. . .]; they had a separate, walled-off, glass-enclosed area with Hitachi computerized milling machines, high precision [lathes etc.] and they were just learning how to use them. Out in the general area were all these men in long brown coats diligently micromachining on lathes to a [great] degree of precision. I [should explain, with] AEI equipment then, you could take [a] component [off one apparatus], and it would fit [perfectly, on any other]. It doesn't work like that anymore. [. . .] That was [very] impressive. [Next] I went to MAT in Bremen, and I'm afraid the contrast was terrible, because I was met at the airport and taken to the factory, [where it was all German efficiency and, "We have all the instruments ready for you. Come to the laboratory." Immediately people were hurrying around, demonstrating this, demonstrating that, and then on to the next laboratory. It was a superb, thoroughly professional display. I don't know if you remember how the beam resolving slits were adjusted? They were spring-loaded slits which were held apart by a wire. The wire was heated electrically so that its expansion allowed the slits to close by tiny increments. That was very clever, but rather difficult to service]. **<T: 160 min>**

[And so I was very impressed with MAT. But in the end I bought an MS-902S]. Because the vibes of [our] building were unsatisfactory for an MS-[902S, the apparatus had to be isolated] from the building. [. . .] A hole [was cut] in the floor, [. . .] about [. . .] ten feet by five feet, and [a cement-filled steel tray was placed on the building's beams, but] separated from them by [six] inflatable [double rubber] doughnuts. You've probably seen these? [The MS sits on top] and the whole rig has a characteristic frequency of about two per second. That's fine for high [mass] resolution.

The AEI [engineer], Ernie Mills, came [to install] it. And he [announced] "Come and have a look. Come and have a look. [See. A] dynamic resolution, [of 170,000]." [And so it was].

GRAYSON: Oh, wow.

HOLMES: [The specification was for] 120,000. [. . .] Brilliant, but of course, that [sort of resolution lasts for only] about one week. [laughter]

GRAYSON: If that long. [. . .] Did you—I was wondering, when you were in the UK, was Brian Green there at that time, or do you remember Brian Green?

HOLMES: No. [I only met him at Vacuum Generators]. I think they were in the [early] stages of [. . .] setting up VG [Micromass]. [But] VG quickly became by far the best company, wonderfully inventive. I liked the VG people. [. . .] Did you ever meet [John Race]?

GRAYSON: [Yes].

HOLMES: John [Race and of course the technical whiz], Bob Bateman. [I recall] that Michael Gross had [a VG] instrument built specially. [. . .] It had a great [steel] lid, [. . .]—like a tureen top—[because it had the Mattauch-Herzog ion optics arrangement]. Anyway, [while] this was [still under test] Bob Bateman phoned and [. . .] said, "John, are you going to be in the UK in the next little while?" I said, "Well, I could be." He [replied], "Well, if you'd like to come [along to VG] for a couple of days, you can come and have a [run with] Mike's new instrument." He was [perhaps] thinking of selling me one.

GRAYSON: [Yes].

HOLMES: I took them up on that, and [so] I had two days of playing on the [new design]. But that was VG [for you. I suppose] that [perhaps] by present day standards, this was not good company policy? VG were completely free [. . .] of secrets [so far as I could tell]. If they designed something for you, they didn't care who you told about it. We have a patent with VG for the radiative emission from ion beams.[23] [. . .] Now, of course, it's Waters [Corporation] and—

GRAYSON: Oh, [yes]. Well, it's—

HOLMES: It's a whole different ballgame.

---

[23] John L. Holmes and Alexander A. Mommers, "Mass spectrometer having means for observing the radiation emitted when ions collide with a target gas" U.S. Patent 5,347,125, issued September 13, 1994.

GRAYSON: I was pretty much disappointed to see VG get taken over by, you know, the corporate culture thing, but—

HOLMES: [They were] originally [. . .] financed by [a UK] insurance company.

GRAYSON: I remember Jerry Kearns was with VG. I think at the time I was at McDonnell Douglas, and we were thinking about buying a machine, and Jerry was [. . .] their big man that would come [. . .] to put the pressure on you to make a decision. And I went to the ASMS [American Society for Mass Spectrometry] meeting in Florida **<T: 165 min>** at that time, one of the early ones, and he had just moved from AEI to VG. You know, it was like, just—

HOLMES: [Indeed], visiting VG was always a [great] pleasure, because they would always [be open about their developments], "Hey, look. Look. Look, we're developing this. Let's show you how it works." And [in contrast] AEI were completely secretive.

GRAYSON: [. . .] So [at this time] you ended up with this MS-902S, and did you actually—how much of the higher resolving power capability of the instrument did you end up using in your science, in your research? [. . .]

HOLMES: Hans Terlouw and I did metastable ion studies with the MS-902S, because you could isolate the metastable peaks [from the mass spectrum and] under high resolution, [investigate] their shapes.

GRAYSON: So this is an EB [electrostatic-magnetic] machine, right?

HOLMES: [Yes**,** an] electric sector and then [a] magnetic sector. So you'd have to use the accelerating voltage scan method [to separate MI peaks. We persuaded] our [. . .] electronics technician [. . .] to build a motor-driven scanner.

GRAYSON: Oh, there you go.

HOLMES: [A slow, motor] driven [potentiometer] scanned the accelerating voltage [which appeared] incrementally [on] a big [. . .] digital meter. So for want of a better [description], you could set [the scan to begin] at X volts, and over a period of one minute, two minutes, it would scan to X plus 20 volts. [Thus your well energy-resolved] metastable peak would come out in [great] detail on your [paper] trace—with [voltage blips where you had pressed a little switch—

showing] the characteristics of the kinetic energy release—[and therefore information as to the potential surface over which the ion was dissociating].

[. . .] When Hans came [for his year] we [considered what to] do. I [suggested that we] look [at the MI characteristics of] some simple isomeric ions, [to] see if they [structurally] interchange before [dissociating], or whether they do their own thing. And by sheer happenstance, we chose acetaldehyde, vinyl alcohol, and oxirane—or ethylene oxide. [Two of] the [. . .] C_2H_4O isomers you can get in a bottle, or out of a cylinder, and making vinyl alcohol [ions] is not difficult [e.g. by a McLafferty rearrangement dissociation of butanal].

GRAYSON: So these were the same molecular—

HOLMES: [The] same—C_2H_4O, [but different] structures. [. . .] They [differed] in their dissociation characteristics with regard to the loss of a hydrogen atom. The three [metastable ion MI] signals were completely different. I mean, really completely different.[24] [. . .]

So having explicitly identified these three alternative structures for [. . .] the [C_2H_4O ions, we expanded the] story [with] further [examples]. I guess [that] after [. . .] two or three years work, we [concluded] that this was a [somewhat] limited technique [for ion structure determination, not least] because so many [isomeric] gas phase ions lose their initial structure before they dissociate. [Nevertheless we pursued MI studies for several years to fully understand] their [properties].[25]

[. . .] **<T: 170 min>** [Some years before this, two reports had appeared] in the literature. They came out within a month of each other, in different journals.[26] [Both] of them said, effectively, [that if you had] a double focusing mass spectrometer and there was a [small] leak in your flight tube, [then a great many] spurious signals [appeared in your mass spectra. When] Fred McLafferty saw this, [. . .] he thought [that perhaps] there's some information [to be found in these new "spectra." And so Collisionally Activated Mass Spectrometry was born. The information related closely with ion structures and so provided a major new exploratory tool for MS. The other author merely reported the observations and drew no new conclusions other than a leak being a nuisance.]

---

[24] J.L. Holmes and J.K. Terlouw, "Metastable Ion Studies V. The Identification of $C_2H_4O^+$ Ion Structures from their Characteristic Kinetic Energy Releases," *Canadian Journal of Chemistry* 53 (1975): 1076-1083.
[25] J.L Holmes and F. Benoit, "Metastable Ions in Mass Spectrometry," chap. 8, in *Mass Spectrometry* Vol. 5 (London: M.T.P. International Review of Science, 1972); J.L. Holmes and J.K. Terlouw, "The Scope of Metastable Peak Observations," *Organic Mass Spectrometry* 15 (1980): 383-397; J.L. Holmes, "Metastable Ions in Mass Spectrometry" and "Ion Energetics and Thermochemistry," in *Encyclopedia of Spectroscopy and Spectrometry* (London: Academic Press, 1999); J.L. Holmes, "Thermochemical Correlations," in chap. 5 in *Encyclopedia of Mass Spectrometry* Vol. 1 (Amsterdam: Elsevier, 2003).
[26] K.R.Jennings, *International Journal of Mass Spectrometry and on Physics* 1 **(**1968): 227; W.K. Haddon and F.W.J. McLafferty, *Journal of American Society for Mass Spectrometry* 90 **(**1968): 4745.

GRAYSON: What an excellent example of serendipity.

HOLMES: **[**Needless to say, like most others at that time], we couldn't do collision-induced dissociation [MS] with [our] MS-902S. [After] Hans [and I] had collaborated for a couple of years, [. . .] he [was] promoted [. . .] and he also [was awarded sufficient] money for a VG-ZAB—[mass spectrometer of reversed geometry—BE, the opposite of the MS9 series that were EB. ZAB indicates "zero aberration" in the ion optics]. With this type of MS you [can] select your ion of interest [by its mass] and then perform [any experiment you like to devise] on it.

I applied here for a ZAB, [but] the [academics] who came to do the [on-site] review [of my application] were both synthetic organic chemists, and I have to say, [I don't think that] they [knew] what I was talking about [and] so I got turned down. I was understandably quite [distressed] by this and a few letters exchanged hands. [I applied again in] the [following] year [. . .]. [A knowledgeable] committee [came this time, Canadian and US] people [with skills in mass spectrometry and practical physical chemistry. In the two] years [between], I used to go to Holland to do experiments on Hans's [ZAB MS].

<T: 175 min> [To make my grant proposal more attractive I included a second mass spectrometer, a VG 7070, for use as a routine analytical instrument and I suggested that the laboratory offer service work to the Chemistry Division of NRC—relieving Fred Lossing of a chore that he did not enjoy—and the Chemistry Department at Carleton University which had no MS, as well as all schools in our University. The first two willingly joined my venture and also offered operating funds for additional annual financial support. Finally, the University of Ottawa offered financial support as well. This arrangement was accepted and the funds to set up the center were approved. This was a great step forward with very secure finances for at least several years in place. I then hired Clem Kazakoff to be the analyst. A friend of great analytical skills, Clem retired in 2014 and has been replaced by Sharon Curtis, another excellent mass spectroscopist—who also enjoys giving a course in analytical MS to a large class of graduate students every year].

GRAYSON: So this was the ZAB instrument?

HOLMES: This was the ZAB and a [VG] 7070. [The former was of course only for research in gas phase ion chemistry].

GRAYSON: [. . .] So the ZAB was reverse geometry, but the 7070 was forward, or was it reversed?

HOLMES: The 7070 [was a geometry instrument]. But you could [also] buy it with [reversed] geometry. [. . .] I don't know if you remember, but Hitachi [made] a double focusing

instrument—not the RM-H2 [that Fred McLafferty had—and] called an RMU-7, which was the same size as the RMU-6D, but with an [added] electric sector. [. . .] Hitachi produced it as an EB apparatus, but it [was designed so that sector reversal was easy to do].

GRAYSON: It all worked.

HOLMES: [Indeed] it all worked. [. . .] A friend [and collaborator at Concordia University] in Montreal, [Québec], Robin Rye, had a [Hitachi] RMU-7 and he [reversed] the geometry [EB to BE without any problems at] all [. . .].

GRAYSON: [. . .] That's nice. [. . .] Very interesting. Is Hitachi in the mass spec business anymore?

HOLMES: No. [. . .] The big double focusing [BE] instrument that Fred McLafferty had [was the Hitachi] RM-H2, [and] at the time I put in for the ZAB, I asked Hitachi if they would make me an RM-H2 and how much? And they sort of might—but they didn't show [much] interest.

GRAYSON: They weren't enthusiastic?

HOLMES: They weren't enthusiastic. No. That's a pity, because that was a fine instrument as well.

GRAYSON: [Yes]. All those wonderful old [machines], and wonderful different things. So what did you want to [do with the ZAB]?

HOLMES: [VG were always interested in doing new things. In 1989 I obtained funds for apparatus and so we asked them to completely overhaul the ZAB in situ and add another experimental section and another electric sector. They produced a metal box with a rail down the center, aligned with the ion beam, on which we could mount any experiment we liked. The box also had a silica window opposite a collision cell so that we could monitor the intensities and wavelengths of radiation emitted from a collisionally excited ion beam. Paul Mayer did this work and we were very excited by the first results, obtained using optical filters.[27] They showed that the radiation emitted from collisionally excited $C_2H_4O^+$ ions was ion structure dependent.

[27] J.L. Holmes, P.M. Mayer and A.A. Mommers. "The Emission of Radiation by Collisionally Activated Ions." *Journal of the American Chemical Society* 113 (1991): 9405-9406.

The addition of a monochromator and detector soon showed that all such radiation comes essentially only from mono- or diatomic species; informative but rather disappointing].[28]

GRAYSON: Let's take a break for food. [. . .]

[END OF AUDIO, FILE 1.1]

GRAYSON: I was wondering if you could repeat a little bit of that story about moving the instrument up the stairs, or would you rather not tell that particular story?

HOLMES: Oh, no. I don't mind.

GRAYSON: I think it's kind of a fun story about mass spectrometry in general and the things that people have to deal with when they receive instruments [. . .].

HOLMES: I could [indeed]. When [our] ZAB arrived, it had to come up a flight of stairs [. . .], [that being] the only possible way of getting it into the lab. And so the question was how to maneuver the [base, frame and magnet] of the machine [. . .] up this flight of stairs [. . .]. [Of course] it weighed an appreciable amount. The way [we] decided to do it was with a come-along—you know, that's a winch device with a lever—[. . .] attach a cable to it [and to the ZAB components] and haul it upstairs on a wooden sledge. [We braced the hauling gear by a timber across the doorway of an adjacent office at the top of the stairs]. We attached everything in the way that we thought it should be done, and started to haul it up the stairs. We noticed [with alarm] that while the cable was coming in, nothing [useful] was moving. It turned out that the [breeze-block wall of the selected office] was being moved instead. So we had to stop and [reconsider. We next attached] the cable to one of the building beams in the ceiling of the hallway. [However], once we got the ZAB's frame started [up] the stairway, we noticed that it wasn't going to [work] because the stairway was just a [very] little bit too narrow, the stair rail on one side [being in the way by a mere matter of inches. By now it] was [. . .] after [nine at night and we] had [agreed with the administration that our task would be through by 7 pm].

[Next we got] an oxyacetylene torch and cut out the [offending] stair rails [. . .]. [No problems now—up the stairs, along] the corridor [. . .] and into the [waiting] lab [. . .]. [Next,

[28] J.L. Holmes, P.M. Mayer and A.A. Mommers. "The Collision Induced Emission of Radiation; Lifetimes of Excited States Formed in the Collision Induced Dissociation Process and the Excitation of Target Gas Molecules." *Organic Mass Spectrometry* 27 (1992): 537-539; J.L. Holmes, P.M. Mayer and A.A. Mommers. Photon Emissions from $N_2^{\bullet+}$ Ion Beam-Target Gas Collisions in a Modified Commercial Sector Mass Spectrometer. *International Journal of Mass Spectrometry and Ion Processes* 135 (1994): 213-228; J.L. Holmes and P.M. Mayer, "Collision Induced Photon Emissions from 8 kV O_2^+ and CO_2^+ Ion Beams," *Journal Mass Spectrometry* 30 (1995):52-56.

the] rails were [. . .] welded back into place [and given] a quick dab of paint [. . .]; [a sledgehammer shifted the disturbed office wall and to our later delight, no-one noticed what we had been up to. We retired to Sam's—a nearby restaurant—for a very late night beer].

[Years later I told our administration] officer [—Jean Baignee—about this adventure. He laughed in the end] and pointed out that [. . .] any [. . .] official [request] would [most certainly] have been [denied]. [When] the devil drives, you [. . .] get it done. [laughter]

GRAYSON: Well, I think probably just about every mass spec installation has some story along those lines, because of the size of the equipment, and the difficulty in getting it to the point—

HOLMES: [Yes]. [. . .] Many go in through windows as well.

GRAYSON: [Yes]. And then as you mentioned before, the floor had to be removed [for] the [MS-902S].

HOLMES: [Indeed]; that was [. . .] a [heavy MS too], several tons.

GRAYSON: [. . .] You also were mentioning that you had a rain shower in the lab at one time.

HOLMES: When we first had the ZAB and the 7070, the [professor] in the lab above ours, an organic chemist, was rather flood prone. On one occasion, there was a very serious flood, and the ZAB looked as if it had had buckets of water thrown over it when we came in [one morning]. Needless to say, a great deal of circuitry was lost, and anything which had to carry 8,000 volts was a write-off [. . .]. [However], when we got it all together again, and [. . .] working properly, we [assembled] a large amount of heavy steel flex-frame, [many Plexiglas] sheets, [. . .] and erected a series of permanent umbrellas over all the apparatus in the lab. [. . .] We did have one more flood, but then [. . .] it just landed on the floor.

GRAYSON: How long did it take you to get the equipment back underway after being—

HOLMES: We were down for two months. [. . .] What a mess [. . .]. We did most of [the work] ourselves. We got [some] parts from VG, but we had <**T: 05 min**> Sander Mommers [with us] then, and so that kind of work was not beyond [our capabilities].

GRAYSON: So before we left for lunch, you had just gotten the ZAB in the lab, I think, and were—

HOLMES: [The ZAB] was, of course, a revelation of an instrument, because you could select an ion by its mass to charge ratio and [then] do whatever [. . .] you liked with it afterwards. In the earlier days, of course, all you could do was collision induced dissociation MS, and [also] look at [well-resolved] unimolecular metastable ion mass spectra. But [in 1983] Fred McLafferty [. . .] produced a paper in which he had admitted a beam of mercury vapor [into] a collision cell and neutralized the ions in flight, and then with another collision [cell containing] an inert gas a little further along the way, the high velocity neutrals were re-ionized [. . .].[29] [This] was great [news], because it was [being done] it on a commercial instrument.

[This] technique had [first] been introduced at Cornell [University] by [Richard F] Porter [in 1980].[30] [He] was a chemical physicist who had [built] an extremely simple homemade [MS] in which he actually used sodium vapor to neutralize very small hydrocarbon ions. [. . .] In Dick Porter's lab, it was a bit of a curiosity [. . .]. [However] Fred clearly [extended] the idea that we could make wonderful, exotic neutrals perhaps [by this technique. One interesting example from Porter's experiments was that it appeared] that [. . .] CD_5 represented a stable neutral. It turned out [to be] a [. . .] quasi-neutral, [namely] protonated methane—or deuteronated perdeuteromethane—with a spectator electron in a high Rydberg state, [where "n"] of the carbon atom [equals about twenty-five. Thus the] ion [. . .] core [remained], but it behaved [overall] as if it was a neutral entity.

GRAYSON: So are you saying it had this electron—

HOLMES: The electron was in a high principal quantum number sitting out way out [from the ion core]. So the whole thing was neutral—

GRAYSON: So the CD_5^+ core knew the electron was there.

HOLMES: [Exactly. In] our own research, some [similar but] completely unexpected things turned up [. . .]. [For example], if you make protonated dimethyl ether— where the proton is on the oxygen atom [. . .]—and [. . .] you [then] do a neutralization experiment, you'll find to your [surprise] that the neutral CH_3OHCH_3 apparently is stable, but it too is a Rydberg species, with

[29] P.O.Danis, C. Wesdemiotis and F. W. McLafferty, *Journal of the Americ*an *Chemical Society* 103 **(**1981): 12.
[30] B.W.Williams and R.F. Porter, "Energetics of Fragmentation of CH_5, H_3O and NH_4 from Neutralized Ion-Beam Experiments." *The Journal of Chemical Physics* 73 (1980): 5598.

the electron in a high principal quantum number [orbital] of the oxygen atom. These high Rydberg—quasi-neutrals—pop up from time to time [. . .].[31]

[An] experiment that [gave us much pleasure was to re-ionize these species] by field ionization. [Sander] made a little field ionization grid, which involved investigating in the States to [discover] the finest possible metal mesh that we could [purchase, and we found the] Buckbee-Mears Corporation [BMC Industries, Inc.]. They produced [a copper mesh which] had eight strands to the millimeter, and more than 70 percent transmission. So it was visible, but it was as fragile as a spider's web. The only way we found [to] move it around was in alcohol. If you tried to [handle it] dry, it would [easily] curl up on itself and disintegrate. [However], if you kept it in a puddle of alcohol, you could move it around safely. [. . .] **<T: 10 min>** [Sander] spot welded [a piece between a pair of rings, which when mounted, were separated] to within just less than a millimeter. [. . .] When everything was properly—[and lengthily]—evacuated, we could put 2 kilovolts across [the meshes without a flash disintegration].

[. . .] The field [gradient] was [then about] 20,000 volts per centimeter. And that was enough to field ionize these [Rydberg species].[32]

GRAYSON: So what happens?

HOLMES: [You get] the ions back, then.

GRAYSON: But it seems you also had the chance of having an arc develop and then wiping out—

HOLMES: I'm afraid the experimental lifetime of the gear was quite short. But you could get one which would last about a week before something shorted [. . .] and blew it away.

GRAYSON: So the idea is the high electric field between the two grids was sufficient to take that Rydberg electron away.

---

[31] J.L. Holmes and M. Sirois. "Hypervalent Radicals; the Generation of $CH_3O(H)CH_3$, $CH_3O(H)C_2H_5$ and their O-(D) Analogues by Neutralization of the Corresponding Cations." *Organic Mass Spectrometry* 25 (1990): 481-482.
[32] J. Bordas-Nagy, J.L. Holmes and A.A. Mommers. "Field Ionization of High Velocity Neutral Species. Rydberg States in Noble Gas Atoms; the Measurement of Translational Energy Loss in Neutralization-Reionization Mass Spectra." *Organic Mass Spectrometry* 21 (1986): 629-636; J. Bordas-Nagy and J.L. Holmes. "Kinetic Energy Spectra of high Rydberg Fragments from keV Collisions between Small Ions and Inert Gas Atoms." *International Journal of Mass Spectrometry and Ion Processes* 82 (1988): 81-99; J. Bordas-Nagy, J.L. Holmes and C.E.C.A. Hop. "keV Collisions of Methonium Ions. The Properties of CH_5^+ and CH_5^{++} and the Generation of High Rydberg Fragments therefrom." *International Journal of Mass Spectrometry and Ion Processes* 85 (1988): 241-258.

HOLMES: [Yes]. That's right. [. . .]

GRAYSON: [. . .] Wow. This is a pretty esoteric experiment, I think [. . .].

HOLMES: Well, it was a fun experiment. The [idea of using] field ionization came about because [of an older technique]. Way back [in the 60s], a topic [. . .] was developed in the UK called field ionization kinetics [. . .]. [Its] main architect [. . .] was [. . .] Peter Derrick, who you may have heard of. [. . .] Peter Derrick's now in [Auckland] New Zealand. [. . .] Anyway, while he was in London, [at Kings College] doing his PhD, and [thereafter], he did these [clever] field ionization kinetics experiments [. . .]. [This required] you [. . .] to build yourself a field ionization source. [First], you would write, for example, to the Schick razor company, and [. . .] ask for untreated razor blades. [. . .] I remember [that] when we asked Schick for some untreated razor blades, we said [that] half a dozen would be fine, and so of course they sent us a set of fifty [. . .]. The untreated razor blade had not had a silicone [surface applied to] it, and so when you put this in vacuo [with] a very high voltage on it and admitted [a compound such as benzonitrile], little carbonaceous dendrites would grow on the surface, on the tip of the razor blade [. . .]. This made a wonderful field ionization source. [We originally] built a little device for the MS-902S as a field ionization source [and so ran some] field ionization spectra in the MS-902S with [Schick] razor [blades].[33]

GRAYSON: How long did it take you to grow your dendrites [. . .]?

HOLMES: A few hours. [. . .] You couldn't [easily] see them, you needed a microscope [. . .] and then you could easily see the little [black hairs] sticking up [. . .].

GRAYSON: Yes. So field ionization seemed to have a lot of promise, but I think a lot of people were put off by the—

HOLMES: [Yes; it was] so easy to destroy your [dendrites via a discharge]. So if you had to take the source apart every time you wanted to [run] a new sample, that was not [a very practical arrangement . . . moreover, you had to] wait a couple of hours for the [new] dendrites to grow.

GRAYSON: [. . .] Derrick was doing this work in the UK—

---

[33] J.L. Holmes, G.M. Weese, A.S. Blair and J.K. Terlouw, "Metastable Ion Studies IX. Thermochemistry and Ion Structures among Fragmenting $C_4H_8^+$ Ions. An Electron Impact and Field Ionization Investigation," *Organic Mass Spectrometry* 12 (1977): 424-431.

HOLMES: He did this in London. He and I shared an office in 1973 at University College, when I was on a sabbatical leave. We became good friends then and he was working on field ionization at the time. [We collaborated on a study].[34]

GRAYSON: And you decided to use this as an ancillary technique in your re-ionization experiment?

HOLMES: [No. We made the razor-blade FI device for the MS-902S as part of our MI studies and the grids were for high Rydberg neutrals].

GRAYSON: [. . .] There's part of the lab that's still doing routine analytical mass spectrometry this period?

HOLMES: [. . .] Oh, yes. [. . .] <**T: 15 min**> [We] had Clem Kazakoff, who was an ace at getting just about anything into the mass spectrometers, and getting a mass spectrum. He had all the [analytical] methods at his fingertips [and so was in great demand].

GRAYSON: Did this activity bring funds into the—

HOLMES: Yes. We had contract work [from various sources]. In order to keep everything running, we needed a fair influx of money and so we did contract work for industry, and for universities which hadn't got a good mass spectrometer. So [there] was a continuous run of outside work.

GRAYSON: Were the Ottawa departmental chemists able to get their samples run free of charge, or did they have to pay a nominal charge?

HOLMES: In the early days, it seemed right and proper that it should be free. But Carleton University and [then] this university decided unilaterally that they weren't going to support us anymore, [I suspect] because they'd heard we had contract money, which was about a quarter of what they gave us, but never mind. NRC [also] went into one of its terrible bureaucratic times, and we were cut swiftly. [. . .] So we were down to nothing, [after I think about ten years], except for [the] contract work. [. . .]

---

[34] P.J. Derrick, J.L. Holmes and R.P. Morgan, "Kinetics and Mechanism of the Loss of Water from the Cyclohexanol Radical Ion at Times from 50 Picoseconds to l0 Microseconds following Field Ionization," *Journal of the American Chemical Society* 97 (1975): 4936-4944.

So the [inevitable] question then came, [perhaps] we should introduce a departmental charge of two dollars a sample, which you can imagine [did not go down too well at a staff] meeting. Nobody really wanted [to pay] two dollars a sample, but it was a question of [pay up] or go without. So they agreed to [the small levy]. I think it's twenty-five [dollars] now. That's not my problem [any longer], but the whole question of keeping equipment running is something that the granting agencies don't want to know about [at present]. They'll say, "Oh, no, no, no, no. It's the responsibility of the receiving institution." [Impasse].

GRAYSON: So this would be paying the heat and electric bill type money?

HOLMES: No. [. . .] This is [just] to keep everything running. This is to [replace an electron multiplier when it] dies, or [. . .] any [other] part—filaments etc. You name it. It's quite expensive to keep [these instruments] ticking over. And [so in the end] we had to raise the external fees. [And institute internal fees].

GRAYSON: [Yes]. Definitely.

HOLMES: So Carleton and NRC found themselves having to pay far more than they were pleased with, but it was [that or no service].

GRAYSON: Well, I mean, you were also delivering the product, right? I mean, the lab was producing [. . .] the results and people got what they paid for.

HOLMES: Oh, that's certainly true. Yes.

GRAYSON: So how highly involved were you in this funding act or trying to work out the funding issues? [. . .]

HOLMES: It was my [never-ending] problem.

GRAYSON: Oh, okay. Now you kind of basically, when you got this instrument early on, you kind of became the mass spec go to person. Is that fair to say?

HOLMES: Yes.

GRAYSON: So you were recognized amongst the faculty and the staff that this is. . . he's Mr. Mass Spec, and—

HOLMES: [Yes].

GRAYSON: So the development, evolution of the lab and research and so on basically is all under your tutelage?

HOLMES: [. . .] Yes.

GRAYSON: Well, it sounds like you [. . .] started out [very securely], but then money became tight, [. . .] things got less friendly.

HOLMES: [Yes]. The granting agency, at the time we got the ZAB, had just begun a series of support [funds] which they called "infrastructure support", which meant [. . .] <**T: 20 min**> [upkeep monies]. We got an [initial] infrastructure support grant [. . .] which I think was about twenty-five or thirty thousand dollars [. . .]. [This] partly paid for the salary of the analytical mass spectrometrist, and the rest went into [such things as] liquid nitrogen [. . .]—because [then] the [MS-902S] traps were cooled [therewith]. We hadn't got [turbomolecular pumps and therefore] we had liquid nitrogen cooled traps on the older instruments. I'm afraid the money side became a bigger and bigger headache.

GRAYSON: That's a shame.

HOLMES: As [. . .] I'm sure it does everywhere.

GRAYSON: Yes. And funding is getting to be a bigger and bigger headache everywhere these days. Do you know if the lab still gets industry support from outside in terms of samples and the—

HOLMES: Yes. I was talking to Sharon [Curtis] the other day [. . .]—Clem's successor—and she has [. . .] some [outside] work coming in [. . .]. [Some are government, some] industrial or university [. . .].

GRAYSON: So basically, you're kind of up there doing the old marketing thing, trying to get money to come [. . .] from outside to keep [. . .] the lights on and keep the people paid and keep going.

HOLMES: [Yes. Paul Mayer is the director of the lab now].

GRAYSON: Well, not fun, but it's something that's important to do.

HOLMES: I was on the National Chemistry Granting Committee for [some years], a four year term. . . I'll make this very brief. There were three kinds of application you could make [then]. One [was] for major installations, [such as] a big mass spectrometer, NMR [etc.]. The second [was small] apparatus funding. And the third [was] operating funding. Operating funding paid the grad students and bought the chemicals and [the] low end stuff. The middle, apparatus funding, [was for you to obtain for example a GC gas chromatograph] mass spec that cost, [say], ninety thousand dollars [. . .]. The idea was that the Chemistry Committee would receive this stack of middle equipment applications, and [we committee members would] be divided into three teams, and between us, we would go to every department in the country, to [interview for] these individual [apparatus] requests [. . .]. [Now] you [. . .] and I know, that you can write [a persuasive text, but] the reality, when [you interview the applicant, can quickly show whether it is simply another] piece of equipment [that he might like to have or whether it is vital for his ongoing research]. So we would do this tour, and I thought it was hugely valuable. Not only did you pick out the people who had written the [. . .] grant, but you also picked out the people who are not very good at writing grant applications, but had a super idea [that] they wanted to run [with]. So it seemed to me, fair, [just and very valuable].

Well, [after I left the Chemistry Committee, I was recalled two years later] because [. . .] outside consultants [had been called in] who were looking at the costing of the [granting] process [. . .]. [They claimed that] all this traveling around the country at public expense, [was a huge] waste of money. I tried to point [. . .] that if you didn't do this, you might as well stand at the top of a tall stairway, toss [the written applications] down, and pick the ones that fell furthest, because you had no idea whether this was a good [or bogus application from the mere written version].

However, we lost that. [I have to say that our method] really worked. [. . .] A quick example; a big university, big chemistry department, fifty members; three [applicants] might ask [for] the same piece of equipment. No communication between them. The chair of [their] department has [not told them to combine and share the apparatus. Our committee would see all three separately and quickly discover this lack of communication. No grant would be awarded. What they had to do was to put in a new joint application with a very high probability of funding].

[. . .] **<T: 25 min>** [So now the travel is cancelled and decisions are to be made on the strength—or weakness—of the written proposal alone. Our visits were not a wasteful procedure because it —obviously—saved money by not funding poor applications—the cost of our journeying was roughly equal to one piece of apparatus. Moreover, a considerable bonus was that we became aware of the overall health of our discipline from such travels—in my time I visited almost every chemistry department in Canada].

GRAYSON: But, you know, the consultant came up with the result.

HOLMES: Oh, I know. Yes. It wasn't a lot of money, either. [. . .] Think of the money [the visits saved by not funding unworthy applications].

GRAYSON: Yes. So let's continue with your scientific career. When did you get into the neutralization re-ionization? That was pretty much later on, wasn't it? [. . .] Before that, you were working on just—

HOLMES: CID [collision induced dissociation] and energetics [. . .]. [When] Fred [Lossing retired from NRC, we moved him and all his equipment to an annex to our lab. Fred] was a super guy to work with, because [his] approach was [that] there is no such thing as a silly idea until we've chewed it over carefully to make sure that it's silly [. . .]. [Thus] he and I and Hans Terlouw [worked happily together]. If I was in Holland, [. . .] I would pick up the phone and call Fred, Hans would pick up another phone, and we'd have a three way conversation about what we're going to measure next, and why. [Oh yes, it] was a wonderful collaboration.

GRAYSON: [. . .] Did anybody come to blows during these conversations?

HOLMES: [Certainly not]. Fred was a wonderful colleague, because he was knowledgeable [and] supportive [. . .]; as often as not, he'd suggest [. . .] a better experiment than the one we had proposed that he [should] do.

GRAYSON: Did he spend his whole career at NRC, or—

HOLMES: [Almost all]. When he retired from NRC, we brought his [apparatus] on the back of a truck, first of all to the adjacent—old chemistry—building, and then into the lab here. So I suppose we worked together [here at the University] for ten, [or] twelve years or more.

GRAYSON: So this kind of triumvirate of intellectual discussion was able to resolve issues and get—

HOLMES: [Yes]. [. . .] Something would come out of any discussion that would [indicate] what [we should] do next. What looked like [the best] experiment to do [to solve the current riddle].

GRAYSON: [. . .] Did you like go through this exercise every time you decided to go into a new world, so to speak?

HOLMES: Well, very often one [idea] would follow [. . .] another [logically, or it would arise from happenstance—that all-important chance observation].

[An experiment of great significance was done by Hans in Utrecht in 1981. He inspected the MS of 1,3-propanediol and noted that a mass 46 ion was produced, $C_2H_6O^+$.[35] What is this fragment ion? It is unlikely to be ionized CH_3OCH_3 and so perhaps it should be ionized ethanol $CH_3CH_2OH^+$? However this ion showed only one MI signal, an extremely narrow peak at m/z 28, $C_2H_4^+$, for the loss of H_2O, and therefore it was wholly unlike ionized ethanol. He proposed it to be an ion molecule complex of ionized ethene and water. Exciting, new and perhaps the first recognized ion-dipole species]?

GRAYSON: That's an interesting fellow. **<T: 30 min>**

HOLMES: [. . .] Hans discussed this with me, and I said, "Well, we must rush to the lab and see if we can make [other ion-dipole species with ethene ions bound to] ammonia, halogen acid, hydrogen sulfide [etc.] by choosing the appropriate molecules." [To our delight], in every case, it worked. [. . .] We reckoned [that we had discovered] a whole new field. This wasn't [quite] true, of course [we had not discovered distonic ions].

The way [this] came about [. . .] was [when I was at a conference] in Australia [. . .]. [There] was a poster presentation which [described a combined theoretical and experimental topic], about some [ionized] halogenated compounds. Right at the bottom, [as a footnote, were some *ab initio* computations by] Leo Radom, [. . .] a theoretician at [University of] Sydney, [that predicted], for example, that $CH_2OH_2^+$ is more stable than ionized methyl alcohol. [. . .] I [discussed this with] Leo [. . .] and I [suggested that I immediately knew how to make that species, and the experimentalist] that [. . .] he was working with [Willem Bouma] said, "Yes,

[35] J. K. Terlouw, W. Heerma and G. Dijkstra, "On the Structure of the Odd Electron $[C_2H_6O]^+$ Ions in the Mass Spectrum of [1, 3-propanediol] $^+$. *Journal of Mass Spectrometry* 16 **(**1981): 326-327.

we've got an idea, too." I [suggested] "Well, why don't we compare notes, and if it all works out, we'll publish side-by-side?" [And so we did].[36]

[. . .] And so that's how distonic ions came into being. It was obvious that the ions we had called ion-dipole complexes were really distonic ions, where the charge and the radical site are on separate atoms, and it was Leo's name, distonic, [that was proposed for such species]. In the next few months, we must have made, I don't know, twenty or more, and Fred Lossing measured their heats of formation [. . .].[37] Of course [such ions are now ubiquitous, and are] commonplace entities. No neutral equivalent, of course. But they're [almost all] thermodynamically more stable than the conventional ion structures.[38] [Thereafter] I collaborated with Leo on other ventures of this kind.

GRAYSON: So this shows the utility of going to meetings and reading posters.

HOLMES: Well, yes.

GRAYSON: But you're saying this was like a footnote of—

HOLMES: This was just a footnote on something else which wasn't [as] interesting. But it just [happened to catch] the eye. [. . .]

GRAYSON: Now if that paper had been given in an oral session maybe that interaction would have never happened.

HOLMES: That's possible. [Yes indeed; serendipity strikes again]. **<T: 35 min>**

---

[36] J.L. Holmes, F.P. Lossing, P.C. Burgers and J.K Terlouw, "The Radical Cation $CH_2OH_2^{+\bullet}$ and Related Stable Gas Phase Ion-Dipole Complexes," *Journal of the American Chemical Society* 104 (1982): 2931-2932; W. J. Bouma, J. K. MacLeod and L. Radom, *Journal of the American Chemical Society* 104 **(**1982): 3290.

[37] J.L. Holmes, F.P. Lossing, P.C. Burgers and J.K Terlouw. "The Radical Cation $CH_2OH_2^{+\bullet}$ and Related Stable Gas Phase Ion-Dipole Complexes." *Journal of the American Chemical Society* 104 (1982): 2931-2932; J.L. Holmes, P.C. Burgers, J.K. Terlouw, H. Schwarz, B. Ciommer and H. Halim. "Stable $C_2H_5X^{+\bullet}$ .Radical Cations (X=Cl,Br) of Structure CH_3CHXH^+; their Energetics and Dissociation Characteristics." *Organic Mass Spectrometry* 18 (1983): 208-211.

[38] M.C. Blanchette, J.L. Holmes and F.P. Lossing. "The Ethyl Halides; Stable Neutral and Radical Cation Isomers $[C_2,H_5,X]$ where X = F,Cl,Br,I." *Organic Mass Spectrometry* 22 (1987): 701-709; C.E.C.A. Hop, J. Bordas-Nagy, J.L. Holmes and J.K. Terlouw. "The Elusive Methylene Ylides CH_2ClH, CH_2FH and CH_2OH_2." *Organic Mass Spectrometry* 23 (1988): 155-165; R. Postma, S.P. van Helden, J.H. van Lenthe, P.J.A. Ruttink, J.K. Terlouw and J.L. Holmes. "The $[CH_2CHOH/H_2O]^{+\bullet}$ System. A Theoretical Study of Distonic Ions, Hydrogen Bridged Ions and Ion-Dipole Complexes." *Organic Mass Spectrometry* 23 (1988): 503-510.

GRAYSON: [. . .] Well, the old scientific meeting comes in good for something. [. . .] So how hard was it to get to these [meetings]? You've been to scientific conferences in Australia and all around the world. [Was] it easy to get funds for travel to scientific conferences, or—

HOLMES: [. . .] I have to confess that [many] of them [were] invitations, [. . .] the Aussie ones were invitations, and Israel, and so on, and New Zealand [etc.].

GRAYSON: Well, you know, that helps.

HOLMES: Yes, it does help.

GRAYSON: What about [. . .] your students, were [. . .] they able to go to conferences pretty easily?

HOLMES: [Not too bad]. For ASMS, [I] used to take as many students as [I] could afford—[very often all of them, and of course, most certainly all those who were to give a presentation, oral or poster].

GRAYSON: How big of a stable of graduate students did you have?

HOLMES: Never very large. When I shifted over to mass spectrometry and stopped doing photochemistry and gas kinetics, I only had postdocs for a few years. [Thereafter] I had one, two, maybe [a] maximum [of] four graduate students, because apparatus time is not infinite. And besides, I kind of lived in the lab as well. [. . .] It was great to be with the students, and [sometimes] looking over their shoulder, and saying, "What's that, then?" [. . .]

GRAYSON: So your mentoring style was to kind of be close by and—

HOLMES: It was very hands on, really [. . .]. [Also] Fred [Lossing] was in the [adjacent] lab too, [. . .] and so [students were encouraged to] drop in and chat [with him]. Fred was [always ready to talk] about anything, so they'd drop [to] say, "We've got this silly result," and he'd reply, "Have you told John about it?" "No, we thought we'd [better] tell you first." [. . .] So it was good. It was really, really nice. [laughter]

GRAYSON: Were you more skeptical [than Fred]?

HOLMES: [No]. But I'd like to see the [data] run again, of course.

GRAYSON: Particularly if it was an unexpected result.

HOLMES: Particularly if a completely unexpected result, [sometimes], as you well know with mass spectrometers, it's not too difficult to get an artifact [signal] by some means or other [. . .], [when], there shouldn't be any signal there at all.

GRAYSON: [. . .] You said the early graduate students were some of your best students, earlier in your career, when you were here? [. . .] You mentioned earlier that some of them were, you know, quite stellar.

HOLMES: [. . .] I think [that] the success of a graduate student, in my opinion, depends [significantly] on how much you interact with them. If they're left [to] their own [devices], and there isn't even a senior postdoc in the lab, and [moreover], with complex equipment, they [do] need somebody to talk to, [frequently]. They need to be able to ask silly questions every day. And of course, one out of [every] ten is a super question.

GRAYSON: So there's no question that is beyond being asked?

HOLMES: No. I go with Fred. There's no such thing as a silly question. It [may mean that] something isn't understood. [. . .] It means [that] there's a [knowledge] gap, and we'd better fill it.

GRAYSON: So it's a way of educating, if it's a silly question, and if it's not a silly question, it's a way of doing research?

HOLMES: [Yes]. That's right. [. . .] Absolutely.

GRAYSON: It's interesting, because some people's style, I remember when I interviewed [Alfred] Nier, his advisors, [John] Tate, essentially just, you know, left him to his own devices and didn't interact with him hardly at all, so—[39]

HOLMES: That [could] work, but not with the majority of students. [. . .] I can think of students who were **<T: 40 min>** [. . .] sufficiently self-motivated to take the next step, and do it, and then come and tell you all about it [afterwards]. Of course, they're the better ones. But there's still [plenty of] endless interaction with them.

GRAYSON: I assume that eventually, as a result of the interactions, they become more independent and then able to proceed on their own.

HOLMES: Yes, indeed. They're [then] more likely to have ideas of their own.

GRAYSON: So you're talking about most graduate students who had a typical tenure of what, three, four, five—

HOLMES: Three years, [on average, sometimes longer].

GRAYSON: [. . .] When you came, Ottawa University was a fairly small institution.

HOLMES: [Yes], it was.

GRAYSON: So that was fifty some odd years ago, right?

HOLMES: Yes, it is. Oh, yes. [laughter]

GRAYSON: So how is it, size-wise now compared to then?

HOLMES: The first year classes? I'd [estimate that they are] between ten and fifteen times bigger. And the fourth year honors [chemistry] class, three [to four] times bigger. It tells you

[39] Alfred O.C. Nier, interview by Michael A. Grayson and Thomas Krick at the University of Minnesota, Minneapolis, Minnesota, 7-10 April 1989 (Philadelphia: Chemical Heritage Foundation, Oral History Transcript #0112).

[perhaps] that [part of] the bottom of the pyramid has no business [being] here at all. [Final high-school] exams are now run by the schools [themselves. They used to be] set and run by [a Provincial] education committee, which consisted largely of university professors, and the exams were set independently of the schools. The curriculum was there, and the marking was done by the professoriate. Marking grade thirteen papers [was] a huge chore. But it meant that you got a fairly reasonable bell curve of results, [without the mark inflation that is so common nowadays. Now], with the high schools having the major responsibility [for grading students, too many marks are] up in the A and A+ region, and so the [usefulness of the] measurement is [lost]. It's the same everywhere. Marks have been pushed up and up. [If someone scores 100 percent, then they haven't been measured]. I can remember getting a note from the dean's office saying that my results for [the] Christmas exam [for] physical chemistry, say one hundred students, didn't fit the bell curve. So I simply wrote back [. . .]: "No, [it happens that] there's a really stupid, non-working core in this group, and so they deserve their 40 percent." So I didn't hear any more about it. But the pressure was [that] your score should be normalized [upwards].

[I might mention that in Edinburgh we had to decide on the mark ranges for the final year exams to give first and second class and pass degrees. In 1962 there was one student with an average of over 80 percent; this was exceptionally high and so he automatically received a first. The cut off to seconds was 73 percent].

GRAYSON: So they wanted the bell curve on the high side, and your bell curve was on the low side?

HOLMES: It just so happened, yes. [A less talented] or a lazy group [of about sixty to seventy students] who hadn't got off their butts [in time for] the Christmas exam. The end of the year looked much better. [. . .]

GRAYSON: So when you say grade thirteen [. . .]?

HOLMES: There are twelve grades [in Ontario High Schools] now. Grade thirteen was really the university entry [level], and the exams [that] you took at the end were about the equivalent of the school leaving higher exams in the UK—[A levels].

GRAYSON: [. . .] And the grade twelve would be below that?

HOLMES: Yes. Grade twelve is where it ends now, [and] so a lot of first year [in] university is making up for what they didn't get in [the missing] grade thirteen.

GRAYSON: Interesting. What about mathematics in your career? [. . .] In a scientific career, mathematics is important. But did you have to take additional math?

HOLMES: Only [as a] pre-degree subject. [Nowadays many scientists] use computational chemistry [. . .] in order to find a quick answer to a problem. And **<T: 45 min>** depending on the level of theory, sometimes you get a good answer, and sometimes you [don't]. But it's not a sphere [that] I've immersed in.

GRAYSON: So how big is the chemistry department at this point? [. . .]

HOLMES: Now? Oh, maybe twenty [or so final] honors year students [. . .]. [For] second year phys. chem.—this is a bit of a guess—but I would say there are probably six hundred students in second year phys. chem. [arising] from two thousand plus first year students. The engineers don't have to do a second year of phys. chem. anymore. The biochemists do. [. . .]

GRAYSON: Would phys. chem. be considered as a, kind of a filtering course in—

HOLMES: It's reckoned to be tough, and there's a lab course with it, which is [good]. It's really very [challenging] to dream up a large number of physical chemistry experiments that don't get [one into] trouble with health and safety [concerns].

GRAYSON: So the whole educational experience has kind of evolved into a completely different beast compared to when you first got here?

HOLMES: It's mass production now. [I would suggest that the "University Experience" doesn't really begin until fourth year, when some small classes may be encountered].

GRAYSON: What about the nature of the student body? It seems like, you know, walking around the halls, there seem to be a fair amount of what I would classify as either foreign faces or people from Asian areas.

HOLMES: [. . .] Of course. [Yes], quite right. [In part] that's their family work ethic. You'll find that many Asian, Indian, and Middle Eastern families reckon that their children will get on [in life] through pursuing [higher] education. And so there are quite [significant] familial pressures. [Moreover], if you want to see a [good] work ethic, just take an average Chinese student. They may not [all be particularly] bright, but they work [. . .] extremely hard, and as

[graduate] students it's [sometimes] quite difficult to get them to go home [at the end of the day]. Because they feel they've got to do the next experiment.

GRAYSON: Now are these. . . Canadian citizens, or you're getting Chinese students from out of the country?

HOLMES: Both.

GRAYSON: Both?

HOLMES: [. . .] Both. A change has happened. Up till about ten or more years ago, if a Chinese student came from China, they would do their PhD, and [. . .] particularly if they were a good student, they'd do a postdoc, and if they stayed [even longer] in Canada, they would become Canadian citizens. With China a rather different place now, far more of them go home again.

GRAYSON: Really?

HOLMES: Many of them to academic positions. Several of my old Chinese students are [staff members] in Chinese universities.

GRAYSON: So that change has occurred like in the last ten or fifteen [years]?

HOLMES: I would say [that in] ten to fifteen years that change has been quite sharp.

GRAYSON: Yes. China is an interesting story, the evolution of their society, and kind of meshing with the West [. . .].

HOLMES: But education was/[is] always rated high and respected in China.

GRAYSON: So did you have any serious, how would you say, negative experiences with the administration here over your career, or was it all roses and good times? Any things you can talk about?

HOLMES: There's nothing I would particularly like to record. [. . .] But then I suspect that's the same in many universities, as the bureaucracy gets bigger and bigger and bigger [and money tends to become the prime interest].

GRAYSON: So the old Oblate fathers ran a pretty loose ship compared to—

HOLMES: They did. They did [indeed. Although] the first **<T: 50 min>** [lay] administrators were [. . .] quite skilled in their own right. [However, one] major change that happened in the official attitude of the university was when bilingualism became an article of faith. We now [are expected to provide] all courses up to graduate level in both [of Canada's] official languages, which [although it is politically sound, is rather unnecessary] for the sciences [. . .]. [Like it or not, the international language] of [. . .] science, [is] English [. . .]. So [the francophone influence is in part] an emotional, nationalistic kind of thing [. . .].

[My feelings on the issue are of course, tempered by my being an immigrant—from 1958. Canadian] policy is one of supporting bilingualism. [. . .] But in science, it makes [something of] a burden, because sooner or later, any budding young scientist whose native tongue is [not English], is going to have to learn to communicate in his chosen field in [that language. I could point out that when I was a student, the second language of science was German, and we had a no-dictionary-allowed translation of an article in German as part in our final BSc exam].

[But in this] University, we have to provide [the] parallel program [. . .] in French. [. . .]

GRAYSON: Right. Is this a provincial directive, or is it a Canadian directive?

HOLMES: [I guess it's both]. This university is [officially] bilingual [. . .]. Carleton [University, across town, is not. However], if you work in the national capital region, it's very advantageous to be fluently bilingual, because it'll [. . .] almost certainly [get you a job], whereas if you're unilingual, it'll be more difficult.

My wife tells a [little] story, it goes thus. If she goes into town to go shopping, and [enters] a dress shop and [an] assistant comes up and says, "Ah, bonjour, madame, comment ça va?" she knows that she's looking [very] smart and respectable. If she goes [. . .] dressed [casually], they'll say, "Hi. Can I help you?" [laughter] But [that's] very true. [. . .] If you go to Montreal, you will see that on the whole, the ladies [there] dress with a bit of French flair.

GRAYSON: Interesting. My impression is that the Eastern part of the country is much more into the bilingual thing than as you go further west.

HOLMES: [Yes. In] Québec, of course, it's essential that you're a Francophone [. . .]. It [also makes the province seem more cosmopolitan].

GRAYSON: Cosmopolitan?

HOLMES: Well, it [certainly] enriches the country but it makes life complicated at the learning-of-science level.

GRAYSON: So [do] all the instructors, the teachers, the professors, [. . .] do they have to demonstrate some facility in [both] French and English [. . .]?

HOLMES: If they are going to teach in French, their French had better be [very] good. It's very difficult, of course, to write a middle-of-the-road requirement. [It's] a matter of policy <**T: 55 min**> that [most of us have] to be at least functionally bilingual. But, [to be fair], if you're going to have a [detailed serious] discussion about the significance of this [ion] peak at mass forty-seven you don't want to have to [do it] with [schoolboy] French [. . .].

GRAYSON: [. . .] So that's an interesting requirement. And I guess you're out of the loop now?

HOLMES: It's not my problem [any longer]. No.

GRAYSON: [. . .] And do you recall the time when this was done exactly, when they went to this bilingual thing?

HOLMES: Oh, [. . .] I would [guess] at least thirty [to thirty five] years ago [. . .]. [Then], in the arts faculty, it had always been taken for granted. [The post-Oblate] administration [observed these professors] in [the Faculty of] Science who were [teaching exclusively] in English, and felt that something must be done to increase the bilingual nature of the science courses [. . .]. [That was] very easy to justify, but in the first stages, it was done [rather clumsily. In the chemistry department a group of us volunteered to take an intense, biweekly French course. This was excellent, conducted by a Madame Krupka, a very fine, humorous and entertaining teacher. We enjoyed her classes greatly, and diligently wrote our weekly essays on a huge variety of topics. We learned a great deal in a short time and became conversationally quite good. Alas, the central administration learned of our venture and decided that formal

written examinations were required instead. As a result our classes were terminated there and then and so we all withdrew our support]. On the whole, [however, bilingualism] works. It's expensive. [One difficulty is that it very greatly] reduces the number of [eligible] candidates that you can have for an academic position [. . .] in terms of their scientific ability [having to be combined with] their linguistic ability. [. . .]

So it's [largely] a political thing. And [can be] very emotional, of course, for French-Canadians.

GRAYSON: Interesting. This is a problem we don't have in the States, at least not in most places. I think [that] close to the [Mexican] border [there are] some bilingual issues, but that's another story, in the South. [. . .] Well, it's amazing how many packages you can pick up in the store and you have Spanish instructions as well in the United States. [. . .]

HOLMES: Yes. [. . .] .

GRAYSON: So your funding landscape has kind of gotten sufficiently more challenging than it used to be.

HOLMES: Yes.

GRAYSON: [. . .] I think that's probably just a given for everyone in the sciences these days. And you've had good experiences in your relationships with other academic institutions in Canada and abroad.

HOLMES: Yes.

GRAYSON: Industrial institutions.

HOLMES: Yes. By happenstance, I found myself consulting for [the pharmaceutical companies] Burroughs Wellcome [& Company located in the UK, and then GlaxoSmithKline], for analytical chemistry.

GRAYSON: That's good.

HOLMES: For patent infringements in pharmaceuticals. [That provided] a window on [an] area of a completely different kind. [It] was fascinating. I got quite a lot of traveling out of that, to go [to courtrooms and laboratories].

GRAYSON: This was. . . you had to go to the UK for—

HOLMES: For Burroughs Wellcome it was [the] UK. For Glaxo, it was mainly the UK, and then the Research Triangle [in North Carolina and also Spain]. But it [. . .] **<T: 60 min>** [certainly threw a] different light on science.

GRAYSON: And this—

HOLMES: [Being expert witness at] court proceedings, to help produce the analytical chemistry] proof of infringement of a patent. [This is] not very easy to do, because the other side employs expert witnesses who want to trash your analytical chemistry. [Glaxo funded a small analytical lab at the University here, where some students of mine were employed to develop new analytical methods]. [laughter]

GRAYSON: So this is kind of a challenging intellectual exercise?

HOLMES: [Yes]. It's a kind of a game, [but an] expensive game.

GRAYSON: Oh, yes. Yes.

HOLMES: [In one] case that was won in Canada—I won't tell you the participants—the fine [for an infringement] was eighty million [dollars].

GRAYSON: [. . .] So that proved infringement, then? [. . .] And, of course, legal fees.

HOLMES: I can't imagine that they were [very small].

GRAYSON: It's an interesting business. Well, one thing is true. You know, you get in those situations, the people that come out winning are the lawyers. They make their money [. . .] —

HOLMES: [. . .] Did you ever come across [Robert H.] Shapiro?

GRAYSON: The name is familiar.

HOLMES: He was [North American] Editor of *OMS* [*Organic Mass Spectrometry*] before me. I took over from Bob [. . .]. [He] had done some consulting for analytical chemistry [involving MS analyses I believe that] he got involved with some very shady characters to help them shoot down the government witnesses and so on.

GRAYSON: Since you've mentioned the [journal], you said you were the editor of what, *Organic—*

HOLMES: *Organic Mass Spectrometry*, [yes] for seventeen years I did that.

GRAYSON: What did that involve?

HOLMES: Receiving articles, getting them reviewed, and persuading the authors to make the appropriate changes, keeping all the paperwork [moving].

GRAYSON: Did you have any help at all?

HOLMES: Yes. [. . .] It started with Heyden and Son [Ltd.], who were a family company of publishers in the UK. *OMS* was started in 1968 by Allan Maccoll and Gunter Heyden. By the way, I think Keith Jennings got that wrong in his spiel.[40] But it was Gunter Heyden and Allan Maccoll who started the journal at the 1967 [triennial MS] meeting in Berlin, [Germany]. [. . .] They set up *OMS* then [and] at the same time, *International Journal of Mass Spectrometry and Ion Processes* was started. So the two journals kicked off in '68, [having] been dreamed up in '67.

GRAYSON: And so you did have some help with doing the *OMS* editorial?

[40] Keith R. Jennings, interview by Michael A. Grayson in Leamington Spa, Warwickshire, United Kingdom, 24 and 25 April 2008 (Philadelphia: Chemical Heritage Foundation, Oral History Transcript # 0419).

HOLMES: [Yes. Heyden provided secretarial support]. I started [as editor in 1976 and "retired" therefrom in 1993].

GRAYSON: Did you ever come down on the side of the author if a reviewer—

HOLMES: Oh, [yes sometimes]. The most difficult thing of all was finding a stable of good and reliable reviewers. Let's suppose that you took twenty significant names from the field—I would guess that of them, maybe two or possibly three would [turn out to be reliable reviewers, prepared to take the time and trouble to do a decent job].

GRAYSON: And get it back to you.

HOLMES: [Yes]. You quickly learned; [for example, that if] you sent a paper to X, and he [did a very] good [. . .], [careful review, second reviewer Y might] send back [a one line report saying] "publish as [it] stands [. . .]." [My reaction would be to cut the second reviewer] off my list because [they had contributed nothing] towards helping the journal along.

[. . .] I had [only] one threatening letter. And I carried on [an entertaining] correspondence **<T: 65 min>** with Maurice [M.] Bursey. Do you know Maurice Bursey?

GRAYSON: Yes.

HOLMES: [. . .]. It got a little out of hand, because it finished [with] Maurice producing a sonnet in proper sonnet form "to a [CAD ion." But it was very] entertaining. Most of our rhymes were Gilbert and Sullivan takeoffs. It was great fun. I kept a file of them all.

GRAYSON: Oh, that would be fun to see. You should put that together and publish it sometime. [laughter]

HOLMES: Yes, it [certainly provided some light moments].

GRAYSON: So you were acting as editor, and he was acting as the author?

HOLMES: [Yes. On receiving the reviews from me], he [would sometimes reply] in [the form of] a little poem. So I thought, "Oh, right, Maurice, you asked for this." [And] so I replied in rhyme [. . .]. It was [very] funny. [laughter]

GRAYSON: [. . .] Well, what other experiences did you have that were exciting or interesting or fun with the journal?

HOLMES: [. . .] I [dealt with maybe one hundred papers] in a year.

GRAYSON: Oh, really?

HOLMES: It wasn't [a] huge [burden]. I was sufficiently familiar [. . .] with most of [. . .] the [science that I could] see right away whether the referee's comments were reasonable or unreasonable [. . .].

GRAYSON: So you were the arbiter of the referee's comments versus what the fellow had written.

HOLMES: [Yes]. That's right. Yes.

GRAYSON: Did you ever like reject a paper just because it wasn't appropriate for [. . .] the journal, or before it [. . .] was sent out for review?

HOLMES: [Sometimes, yes]. I don't suppose you remember this, but in the earlier days of mass spectrometry, and certainly in the early days of *OMS*, a paper would [arrive describing how the writer had] measured the mass spectra of fifteen isomeric [or related species. There would be a discussion section including a large series of entirely speculative fragmentation mechanisms, making—say—up to] five pages of pure guesswork. I [recall] sitting down with Allan [Maccoll] and saying, "We've got to stop this flood of nonsense," because the mass spectrum [may be] interesting [but the] "interpretation" is wholly bogus. [And unsupported by any evidence. Thus] we opened a [new journal] section which was called "New Mass Spectra," which were [only] that.

[Thus] quite a number of papers which had no serious supporting physicochemical [material, could be returned] to the author [saying], "Sorry, you sustain any of your mechanistic proposals by [hard science; they are all or mostly guesswork. This report] should reappear as

["New Mass Spectra." This filled] a small section at the back [of the journal. Needless to say it] was very unpopular in the beginning.

GRAYSON: Oh, sure. [. . .] **<T: 70 min>**

HOLMES: [. . .] Well, it was the commercial journals that started [to publish the more speculative science reports. I think that] the first commercial journal was [in] 1957, *Tetrahedron Letters* [. . .].

GRAYSON: When you say commercial journal—

HOLMES: One which [existed] to make a profit for the publisher [rather than being produced under the aegis of a chemical] society [or similar body].

GRAYSON: Like *Journal of American Chemical Society*?

HOLMES: Yes, or the Faraday Society, the [UK] Chemical Society, *Comptes rendus de* [*l'Académie des sciences*], and all the German journals. They were [essentially] all society journals, and [were] not intended to make them a fortune.

GRAYSON: [Yes] and then I think lately, hasn't the idea of a fee for publishing come into vogue, and some journals are charging [. . .] to publish?

HOLMES: [Yes].

GRAYSON: [. . .] Patents. You mentioned you had a patent with VG, was it?

HOLMES: [Yes]. That was for measuring the radiation emitted from excited ions.

GRAYSON: [. . .] When did you discover this?

HOLMES: I had a grad student—who is now chair of the department here—Paul Mayer. [Our] idea had been around for quite a [while]. When we got the [. . .] ZAB [upgrade in '90], with its

[experimental] box, I asked VG to put [a] quartz window in it, in case we wanted to shine light in. [However] it occurred to us that if we put a collision cell underneath the window, and could arrange a monochromator on top, outside the window, we could [. . .] see if ions emitted [radiation] when they were collisionally excited.

And so that problem was given to Paul, and the first experiments that we did were [for] visible emission [. . .]. We used gelatin in glass filters for band-pass regions. [. . .] The three [trial ions that] we chose [. . .] were—[of course]—acetaldehyde, vinyl alcohol, and [. . .] oxirane [. . .] which [we knew] were easily distinguishable by their metastable ion peaks [for the loss of H]. The filtered [radiations] from the three [ions] were quite different. [Great excitement].[41] So we [immediately] applied for money for a grating monochromator, liquid nitrogen cooled [photomultiplier], and all the [electronics] to go with it. [Thus we were] set up to investigate [any UV-vis radiation transmitted through the silica window]. I kept VG informed all the time, and they said, "Look it, if this ever goes anywhere, could we patent it with you?" I said, "Yes, of course you can [and] so we took out a patent with them. It's [possibly] died by now?

GRAYSON: [Yes]. Well, patents are kind of an [. . .] iffy, so-so kind of thing. [. . .] Some schools in the United States have legal departments that assist faculty with getting their ideas patented. I don't know if that's being done here.

HOLMES: I don't know [either]. VG provided the legal assistance, and I **<T: 75 min>** made sure [that] I could understand what it said. [laughter] We signed up; and the University, of course, carries a portion of that as well.

GRAYSON: So [. . .] where [does] the light emitted photon . . . where do they come from?

HOLMES: In high energy collisions?

GRAYSON: [Yes].

HOLMES: It [turns out to be mostly atomic emissions]. The ions, which are traveling at [hundreds of] kilometers a second [. . .], [collide with the] essentially stationary target [atom], and of course, as well as producing interesting fragment ions, they're also blown to pieces. [However what you see are atomic emission from] carbon, hydrogen, oxygen, nitrogen, [etc. plus emissions from a few diatomic species]. So they're mainly line spectra. [Disappointing.

[41] J.L. Holmes, P.M. Mayer and A.A. Mommers. "The Emission of Radiation by Collisionally Activated Ions." *Journal of the American Chemical Society* 113 (1991): 9405-9406.

Polyatomic species of interest must be dissociating faster than they can emit any UV/vis radiation].

GRAYSON: [Yes]. I was going to ask you about this interstellar business.

HOLMES: [. . .] I did an analysis for the Enceladus people.[42] You remember [that NASA] sent a probe with a mass spectrometer on it to planetary moons? The spectra came back with a [mass] resolution of about 120 [or less]. Anyway, they sent me all the spectra and asked my opinion. [Quite reasonably] they wanted mass[/charge] seventy-eight to be benzene. There was [indeed also] a big seventy-seven, so [benzene sounds OK]. But there was [also a significant ion at m/e] sixty-five.

GRAYSON: Oh, there was?

HOLMES: [Ionized] benzene does lose a methyl [radical to give a small peak at m/e 63]. [. . .] But here, there's a [fairly large sixty-three. I asked if] it could be a phenomenon of [their] apparatus [. . .], which uses a quadrupole [MS] system [. . .]. [Personally I doubt] that; however it might be an isomer of benzene? Note that benzene ions can isomerize into many structures prior to methyl loss—recall the complete loss of atom positional identity—and perhaps it could perhaps be 2,4-hexatriyne? So I don't think that they have irrefutable evidence for benzene as the] material being ejected from the surface of the moon [. . .]. [There is also] a new probe on the way there. I've forgotten which year it arrives [. . .], [but it has] better equipment [aboard].

[. . .] It's very [instructive and] entertaining to talk to these [interstellar] people. [. . .] **<T: 80 min>** [Indeed], quite a few polyaromatics have been identified in the interstellar medium now. [Seeing] these data [was very stimulating].

GRAYSON: [Yes definitely]. I was browsing through your CV and your papers. It seems to me that you've done all this [. . .] very fundamental chemistry, olefin formation, gas phase ion chemistry, pyrolysis, thermochemical radical studies, proton affinities. This is all kind of really fundamental stuff.

HOLMES: [Well, yes].

[42] In 2005 the NASA spacecraft *Cassini* collected atmospheric data from Saturn's moon, Enceladus. J. Hunter Waite, Michael R. Combi, Wing-Huen Ip, Thomas E. Cravens, Ralph L. McNutt, Wayne Kasprzak, Roger Yelle et al. "Cassini ion and neutral mass spectrometer: Enceladus plume composition and structure." *Science* 311, no. 5766 (2006): 1419-1422.

GRAYSON: These experiments you described, this light and the photon emissions. So you're kind of going back to your earlier study [. . .] based on photolysis, or with photons, but from a [completely] different angle [. . .]?

HOLMES: No, [not deliberately;] I think that's just the way it turned out, [picking out the interesting ideas and seeing where they led]. [. . .] I don't have any [graduate] students anymore. I just interact with Paul's [. . .] students. [. . .] They drop in for a chat every now and again.

GRAYSON: But this [. . .] kind of fundamental. . . that seems to be common with what I—when I talked to Alex [G.] Harrison and also with Paul Kebarle.[43] There seems to be in the Canadian theater this very strong interest in these very basic, fundamental properties of ions, and. Is there a reason for that [particularly] strong I don't think it's so strong in other parts of the [. . .] United States [. . .]?

HOLMES: It's not because we [know] each other [well]. I knew Alex Harrison when I was at NRC [in 1958-60, but then] he was just some guy who was working with Fred Lossing [. . .]. What Fred Lossing did [then had] nothing to do with my photochemistry, so I never really knew [him back then]. It wasn't until we started the Trent meetings that I saw Alex Harrison fairly regularly. The Trent meetings [by the way, are essentially graduate student] meetings.

GRAYSON: So when you say Trent meetings?

HOLMES: [They took place first at Trent University, a small] university in the middle of Ontario—[Peterborough. I started the meetings thirty-one years ago, with Alex Harrison — University of Toronto—and Ray [Raymond E.] March—Trent. It has always been a showcase for graduate students about their research and sometimes listen to us or a visiting Professor as well].

In a good year, [there are] maybe thirty or forty grad students from across Canada [and the nearby USA], all doing some [research] related to mass spectrometry, [plus] a few [professorial] supervisors, and [there is usually a nearby] lake with canoes and swimming and [so on. It is] a [fine social meeting. It usually occupies a weekend plus a day].

GRAYSON: And then you've got oral and poster papers presented?

---

[43] Alex G. Harrison, interview by Michael A. Grayson at the University of Toronto, Toronto, Ontario, Canada, 13 November 2013 (Philadelphia: Chemical Heritage Foundation, #0905); Paul Kebarle, interview by Michael A. Grayson at the University of Alberta, Edmonton, Canada, 22 May 2013 (Philadelphia: Chemical Heritage Foundation, #0899).

HOLMES: [Yes].

GRAYSON: And just general interaction?

HOLMES: [Indeed, lots of it. The students get to] meet students from other places. Chrys Wesdemiotis [from Akron, Ohio has] come on a fairly regular basis. [. . .] The first [few meetings were] all conducted in a single day, which was quite an ordeal, because we would leave here at [five] o'clock in the morning, [to] drive—fast—to Peterborough, [Ontario].

GRAYSON: Which is how far?

HOLMES: [. . .] Peterborough [about] one hundred and fifty miles.

GRAYSON: A couple of hours for sure.

HOLMES: [But] it's [only] a two lane highway, so [it's nearer to] four hours. [So there would] be morning talks, lunch, afternoon talks, dinner, and we'd get back home here about two o'clock the [next] morning. But the students loved it. [. . .] It was quite [an experience, socially as well as scientifically].

GRAYSON: So it was really focused on them more than anything else?

HOLMES: [Yes].

GRAYSON: [. . .] Did you have [. . .] big guns come in and give a plenary or overall talk—

HOLMES: [. . .] <**T: 85 min**> [Not every time. Sometimes one of us would give a talk about some general topic]. I think I gave one the year [that] I retired [. . .]. But the meeting is now a three day [affair with] overnight lodgings and all the rest.

GRAYSON: And whose brain child was this?

HOLMES: I think that Alex and I started it and March at Trent [joined us after a trial run at Ottawa U]. But Trent was [far more] convenient [than Toronto], because it was [roughly] equidistant. [. . .] It [has] been [a]very successful [venture].

GRAYSON: Now [. . .] do you have a registration fee for this? Or does it cost—

HOLMES: Oh, [no. It's a sponsored venture. Originally] *OMS* used to give us money [. . .]; in the good old days Gunter Heyden would chip in. [Later] VG gave us [a] thousand dollars. [It has always been] pretty well supported from outside. I don't think it costs the grad students much more than [a] beer and a snack on the way to or from.

GRAYSON: [. . .] That sounds good. Well, [. . .] I don't think there's anything like that in the States.

HOLMES: [No]. Chris [Wesdemiotis] used to [complain] "I wish we had something like this in the States, because this [is so good for] the grad students [to] get to chat and know one another."

GRAYSON: [Yes]. That's good. That's good. Important. Let's see. I've got a number of people with whom you've published a lot of work, and we've talked about several of them. There's a fellow by the name of Peter [C.] Burgers. Did we talk about Peter Burgers at all?

HOLMES: Peter was a grad student of Hans Terlouw. [He] then became a postdoc with me. Peter is a [fine scientist and] he's a rather gentle soul [. . .]. [I don't think that he would suit an academic career]. [laughter] He's extremely intelligent, and full of ideas. [At present] he works in [the Erasmus Medical Center] in the Netherlands [. . .] as their [mass] spectroscopist for [a wide variety of projects].

GRAYSON: We've talked about Mommers. His name is actually Alexander, but he goes by Sander.

HOLMES: [Yes; Sander. He's a technical whiz; an absolute master of all apparatus]. He [. . .] is in [great] demand in Canada, because people [with his skills simply] don't exist anymore. He can fix anybody's instrument. He also buys and sells them [as a side venture]. He has his own company. And so he [is often] away [. . .], installing [or fixing someone's instrument].

GRAYSON: Zagorevskii?

HOLMES: [. . .] Dmitri Zagorevskii is [an] extremely hard working [scientist]. He's [now] somewhere in the States. We [have presently] lost touch [. . .]. [His specialty was the work on organometallics and we had twenty joint publications].

GRAYSON: There's a person by the name of Hop [in your list].

HOLMES: Marcel Hop, [another] Dutchman. He did [the] experimental work [for his Utrecht PhD] in my lab [. . .]. [He works in the USA too].

GRAYSON: Aubry? [. . .]

HOLMES: Christiane Aubry. I still work with Christiane. She was a [very special] graduate student [of mine]. We're still publishing together [and] we write [chiefly] about energetics and correlation schemes. [She works as a professional translator of technical and scientific material. We also had a contract together, with NIST in Washington]. Did you know Sharon Lias?

GRAYSON: Yes.

HOLMES: Well, when Sharon died, there was a terrible gap [at NIST] because Peter Ausloos had retired, and there was [. . .] <**T: 90 min**> [no-one to keep up the data collections].[44] Some years after Sharon had died, NIST got in touch with me [to ask] would I and/or a colleague be prepared to help in [updating the energetics data collection]? Christiane and I took a contract with NIST for [this task]. And I don't know how many hundred data items we co-collected over two or three years, but they were all sent off to NIST [and also] I went down there and talked [with] them. [About that time President George W.] Bush happened, and the funding went. [If I] go on [their website] now [. . .], [I find that] data which we had sent down four [or] five years ago [still] hasn't [appeared] yet. It [is a great] shame, because [the NIST source is the major source] in the world.

GRAYSON: [Yes]. It's just something that needs to be done.

[44] W.G Lias, J.E. Bartmess, R.D. Levin, J.L. Holmes, J.F. Liebmann and W.G. Mallard, *Gas Phase Ion and Neutral Thermochemistry* (College Park, MD: American Institute of Physics, 1988).

HOLMES: Yes. You've got to stand up, America.

GRAYSON: Well, we don't want to go there. Paul Mayer?

HOLMES: Paul's chairman [of the department] here. [He was] the student who did the emission [studies] with me. [Now he is also] in charge of the [MS center]. They're [. . .] his grad students down there.

GRAYSON: [. . .] Let's see . . . Benoit. [. . .]

HOLMES: Frank Benoit. Frank Benoit was my first mass spec. grad student. He was the maleic, fumaric, and other carboxylic acids guy. He [now works] for the Canadian government. He went to work with Health Canada, I think, as an analyst.

GRAYSON: Cao [. . .]?

HOLMES: Oh, Jie. Jie is in China. [My wife] Sheila [Robertson-Holmes] and I are honorary grandparents [to her son].

GRAYSON: Oh, there you go.

HOLMES: When I went to China, I was met at Beijing [Capital International] Airport. I was told [that] I'd be met [there] because I had six hours [to kill] before the flight on to Changchun, [China]. So [there was] Jie, [. . .] a charming young lady, waiting to meet me, good English [too, I quickly] discovered [. . .] that she was a chemistry student, and what would I like to do? So I said, "Well, I didn't care much for the meal on Canadian Pacific [Air Lines]. What I'd really like is to have Beijing duck." [. . .] She fell about laughing and said, "Come along. Come along." So we went and we had a splendid meal. [Then she saw me onto] the plane, and away I went to Changchun.

I was in Changchun for [about] four weeks giving talks and so on [. . .] and [while there] I met another [interesting young scientist, Ya-Ping Tu], who came [to this lab] as a postdoc. When I got back to Beijing, there was an international conference [at which] I was to [speak]. So I was in Beijing for another ten days or so and Jie [continued to be] my personal guide [. . .]. [Towards the end of my stay] Jie asked if she could do graduate studies with me, to which I replied "Yes]. No problem. Get the paperwork done [and you will be welcome indeed."] So Jie came here and did [a fine] PhD, and after a lot of [indecision] she went home [. . .] to China

[where she soon] got a university job. She married [. . .] her high school sweetheart, and they have a little boy called [Tom]. And so we [send] birthday cards, [etc., to Tom], and he calls us his honorary grandparents.

GRAYSON: That's neat.

HOLMES: Which is [very] nice.

GRAYSON: It's interesting how a random relationship turns into a long term [friendship]—

HOLMES: Yes. Yes. That's right.

GRAYSON: George? M. George?

HOLMES: Oh, [Mathai] George is from India. **<T: 95 min>** He's [at Cochin University]. He keeps in touch from time to time, because he's still [actively] doing chemistry there. In the subcontinent, the tendency is to rise in the administrative stream, if possible, and not have to do nasty things like work in a lab. And that's like Africa as well. But George is an experimentalist. He's [very accomplished]. He comes to ASMS [from time to time].

GRAYSON: [. . .] Mike Gross had a relationship with an Indian fellow that was similar to that. He would come to work in Mike's lab for, you know, three or four weeks in the summer or whatever, and then go back to India. And it sounds like a similar kind of a thing. And then there's this—I guess—Hungarian fellow, Bordas-Nagy?

HOLMES: [. . .] Jozsef, Jozsef Bordas-Nagy. He's [a] clever [scientist]. He's Polish [by birth and was a] very, very clever student indeed. He was [. . .] quiet, rather withdrawn, [but] good humored, and full of ideas. He did a lot of [work] with the Rydberg species.

GRAYSON: Very good.

HOLMES: [He also did the] experiments [in which we used metal] vapors to interact with the ion beam.

GRAYSON: [. . .] So how did he decide what metal [. . .] to use in collision cell for these [experiments]?

HOLMES: [. . .] Well, we simply wanted [some modest] volatility; and so after sodium, potassium, and cesium, we then switched to [zinc], cadmium [and] mercury.[45] [. . .] But any metal which had a reasonable vapor pressure at about 600 centigrade was fair game to put in the little cell; [another fine design by Sander].

GRAYSON: That's pretty warm.

HOLMES: Yes. That's why we could get [zinc vapor].

GRAYSON: And [. . .] opposite that with the cold liquid nitrogen—

HOLMES: [. . .] Oh, it [all worked] very well. .

GRAYSON: You had I guess, [some] competitors in the business, with the guys like Kebarle and Harrison [. . .]?

HOLMES: Paul Kebarle I never interacted with, because he was essentially interested in [cation] affinities. [Our own] interest in proton affinities [appeared] as a side issue with [. . .] the so-called kinetic method for measuring proton affinities. [An excellent] method [but] which works in limited circumstances. [. . .] Alex Harrison I simply knew [. . .] because we always met at least at Trent. But we never collaborated in anything.

GRAYSON: And nor did you consider him to be a competitor [. . .]?

HOLMES: [No]. I didn't—

GRAYSON: Were there any Americans or Europeans that were competitors, you would say, or did you end up collaborating with everyone?

---

[45] M.C. Blanchette, J. Bordas-Nagy, J.L. Holmes, C.E.C.A. Hop, A.A. Mommers and J.K. Terlouw. "Neutralization-Reionization Experiments; a Simple Metal Vapour Cell for V.G. Analytical ZAB-2F Mass Spectrometers." *Organic Mass Spectrometry* 23 (1988): 804-807.

HOLMES: Competitors? [. . .] Fred McLafferty got upset with me once.

GRAYSON: He's gotten upset with everyone. [. . .] <**T: 100 min**>

HOLMES: [It's a pity that Fred appears to take his research personally, something that I believe a scientist should never do, difficult though it certainly may be at times. We had challenged some results of his, believing his interpretation to be incorrect.[46] Fred was] very upset by this], and he phoned me about it and [suggested that I was] after him or something? [. . .] I [replied], "Well, I'm sorry you were upset, Fred. There was no intention to wound or injure you in any way. It's just the way the chips fell. [Should] you prove something that I've done is wrong, that's fine by me. That's the way science goes." So we [. . .] had [this] little friction. But I like Fred, he's a nice guy. And he ran one hell of a group [at Cornell].

GRAYSON: Definitely. So I guess most of the people that you did have outside of your own lab [. . .] you ended up being [in] a collaborative arrangement as much as possible, rather than getting into competitive type of—

HOLMES: [. . .] The only other person I can think of who was competitive, [is] Helmut Schwarz [in Berlin]. Have you met Helmut?

GRAYSON: I'm sure I have.

HOLMES: Well, Helmut [is], I think, [chiefly] an administrator of some kind now. [. . .] But Helmut was hugely energetic, and very competitive. I guess [that] we probably disagreed on a number of occasions, but, you know, c'est la vie—and it's not really very important [in the long run]. But [he is] immensely hard working. A very nice experiment that Helmut did was with C_{60}^+ ions.[47] [Did] you know that you can trap things in [the C_{60}] cage?

GRAYSON: [Yes].

HOLMES: Well, the experiment that [. . .] first showed that that was true was to take C_{60}^+ ions, pass them through helium as a collision gas, and to your astonishment, [ions of mass]—C_{60}^+

[46] C.E.C.A. Hop, J. Bordas-Nagy, J.L. Holmes and J.K. Terlouw. "The Elusive Methylene Ylides CH_2ClH, CH_2FH and CH_2OH_2." *Organic Mass Spectrometry* 23 (1988): 155-165.
[47] T. Weiske, D.K. Boehme, and H. Schwarz, "Injection of Helium Atoms into Doubly and Triply Charged Carbon (C60) Cations," *The Journal of Physical Chemistry* 95, no. 22 (1991): 8451-8452.

4^+— came out the other end. [. . .] Diethard [K.] Boehme—Toronto—was with him and did the experiment. I thought that's really [a] pretty nice experiment. You've blown your helium into the cage, and it [is] stuck in there. And they could neutralize it as well, and so here you have [molecular] C_{60} with a helium atom bouncing about inside.

GRAYSON: Yes. The endohedral complex. That's kind of interesting.

HOLMES: Yes. [. . .] I'll tell you a little story about Helmut Schwarz which was [quite amusing]. At one of the NATO [North Atlantic Treaty Organization] meetings, Helmut was giving [a] plenary [talk]. Helmut is very expansive on the podium, and [usually] half through his lecture, [and] because [. . .] Berlin is [such] a wonderful city, he would say, "Now I am going to take a break, and I will tell you just for a few minutes [about] the wonderful things [that] we have in Berlin." And so up come slides [of] all these superb things in galleries and museums and so on, and [the] wonderful head of Nefertiti came up, and [other classical artifacts]. Helmut got near [to] the end of his exposition and we're all sitting there, and way up in the back of the auditorium, a British voice [called] down. It said, "Oh, hey, Helmut, how did they [all] get there?" And of course, the place collapsed with laughter, and Helmut after a moment laughed as well, because he could see the funny side of it. But of course, [many] of them had got there by means we don't speak about anymore. But it was a sort of classical moment. [. . .]

GRAYSON: Oh, boy. That was a brave soul. I wonder who that was.

HOLMES: [Yes]. I don't know [who it was. But] the great thing was that it didn't offend Helmut.

GRAYSON: [. . .] Interesting. I [wanted] to maybe [retrace] a little bit your educational ancestors. You got your PhD working under— <**T: 105 min**>

HOLMES: Allan Maccoll.

GRAYSON: Maccoll, and then do you recall [. . .] who his advisor was?

HOLMES: Yes. His advisor was [Prof Thomas Iredale]; I met him [several times]. He was a [Professor] at Armidale University [University of New England] in New South Wales, [Australia]. [. . .] Allan [Maccoll] was born in Scotland and went to Australia as a baby. And so he grew up in Australia.

GRAYSON: Are you. . . you're a Canadian citizen?

HOLMES: I am now. Yes.

GRAYSON: So you went ahead and took [. . .] Canadian [citizenship]. Did you give up your UK for Canadian?

HOLMES: No, I can [have] both. [. . .]

GRAYSON: I was curious about that. Because there [was] this fellow [Arthur] Dempster. The Dempster mass spec?

HOLMES: Yes, yes.

GRAYSON: He was a Canadian.

HOLMES: Oh, yes; so he was. [. . .]

GRAYSON: And ended up taking American citizenship for reasons which I never quite understood, but he was Canadian. So I wondering—it'd be interesting if—as far back as we could, to trace the academic parentage back—

HOLMES: That was something that Keith Laidler did. In his history of physical chemistry he's got some family scientific trees.

GRAYSON: [. . .] So what do you consider to be your most significant publications, plural or singular?

HOLMES: Oh, [that's] not something that I can answer [easily], but I can tell you those that were the most fun.

GRAYSON: Well, that's good.

HOLMES: Which is not the same at all, I hope. The work I did with Hans Terlouw on metastable ions [. . .] was [particularly] exciting for us. That was for the identification of the isomers of C_2H_4O, simply by the virtue of their [metastable ion] peak shapes [. . .].[48] [We did] a follow on from that [. . .], [showing that when ionized isopropanol lost methane, it produced a mixture of vinyl alcohol and acetaldehyde ions. And so the MI peak came out with an extremely broad component corresponding to vinyl alcohol] and superimposed upon it, the narrow spike of acetaldehyde. And if you do [an OD] deuterium labeling study, you can separate those two [signals out showing the competing losses of CH_4]. So it [very] worked nicely.

GRAYSON: [Yes]. Pretty nice.

HOLMES: The emission [experiments] with Paul [Mayer were] very exciting, because it had never been done before, at least not as far as we knew.[49] Oh, the distonic ions, the [work] with [Leo] Radom [the] making [of] CH_2OH_2 ions, the first real distonic ion, and then of course renaming all the ion dipole complexes in [the] right way. They're all distonic ions, and so [. . .] soon [it appeared] that [. . .] this kind of ion [was] everywhere.[50]

And some of the things I did with Fred [Lossing], when we showed that the enol ions were all thermodynamically more stable than their keto [counterparts]; that's an exact reversal of neutral chemistry [where] keto is more stable than enol.[51] A rare neutral [exception] is [. . .] phenol [. . .].[52]

I don't know. Most of [my science] has been **<T: 110 min>** [happily] entertaining. [If something] seemed like a good idea and it [proved to have been] worth following up, that was a huge pleasure. It's difficult to pick anything [special] out, [. . .] we used to call them mini-eureka moments. [. . .] One was when I went to Holland [to work with Hans; I had] stopped off in Swansea to see John Beynon, and they were doing experiments with argon, [the] mass spectrometry of argon ion beams. And I was talking to the chap [doing the study who explained] how [very] efficient the charge exchange is between argon ion and argon neutral. And I thought, "Yes, we don't need to worry in Holland about trying to make a mercury neutralization source

---

[48] J.L. Holmes and J.K. Terlouw, "Metastable Ion Studies V: The Identification of $C_2H_4O^{+\bullet}$ Ion Structures from their Characteristic Kinetic Energy Releases," *Canadian Journal of Chemistry* 53, no. 14 (1975): 2076-2083.
[49] J.L. Holmes, P.M. Mayer, and A. A. Mommers, "Emission of Radiation by Collisionally Activated Ions: A New Approach to Ion Structure Determination," *Journal of the American Chemical Society* 113, no. 24 (1991): 9405-9406.
[50] J.K. Terlouw, W. Heerma, G. Dijkstra, J.L. Holmes and P.C. Burgers, "Characterisation of Radical Ion Dipole Complexes by Collisional Activation and Collisional Ionization Mass Spectrometry," *Journal of Mass Spectrometry and Ion Physics* 47 (1983): 147-150.
[51] J.L. Holmes and F.P. Lossing, "Gas Phase Heats of Formation of Keto and Enol Ions of Carbonyl Compounds," *Journal of the American Chemical Society* 102 (1980): 1591-1595.
[52] John L. Holmes and F. P. Lossing, "Keto and enol forms of methyl acetate molecular ions, their stability and interconvertibility prior to fragmentation in the gas phase," *Organic Mass Spectrometry* 14, no. 9 (1979): 512-513.

cell, [as] Fred McLafferty [has done—not least] because mercury [vapor] in a mass spectrometer is not a good idea. We should of course, try xenon."[53]

GRAYSON: Right.

HOLMES: As soon as I arrived off the plane, I said, "Hans, have we got a cylinder of xenon anywhere in the university?" And he said, "We'll find one. We'll find one." And [indeed], xenon [turned out to be] the [. . .] perfect [neutralization gas]. [Most recently of all was the fortuitous discovery of an easy method for making the anions of the alkali—and other metals; things that one's high school chemistry says should not exist].[54]

GRAYSON: Well, I was looking at your publications, and one of the most highly cited publications was "Assigning Structures to Ions in the Gas Phase." That was published in '85.[55]

HOLMES: That was a review [article].

GRAYSON: So that gives you a lot of [. . .] citations. "Heats of Formation of Oxygen-Containing Organic Free Radicals from Appearance Energy Measurements."[56]

HOLMES: Oh, that was a fun thing with Fred, because in many [ion] dissociations you get a stable ion and an interesting free radical. And if the process takes place at a carefully measured energy, and you know the heat of formation of the starter [molecule] and the ion, the missing datum is the heat of formation of the neutral. And so it was a backdoor method for measuring heats of formation of free radicals. And that was fun.

GRAYSON: Fun seems to be the operative word.

---

[53]J.K. Terlouw, W.M. Kieskamp, J.L. Holmes, A.A. Mommers and P.C. Burgers, "The Neutralisation and Reionization of Mass Selected Positive Ions by Inert Gas Atoms," *International Journal of Mass Spectrometry and Ion Processes* 64 (1985): 245-250.

[54] S. Curtis, J. Renaud, J.L. Holmes and P.M. Mayer. "Old Acid, New Chemistry; Negative Metal Anions Generated from Metal Oxalates and Others." *Journal of the American Society for Mass Spectrometry* 21 (2010): 1944-1946.

[55] Holmes, John L, "Assigning Structures to Ions in the Gas Phase." *Organic Mass Spectrometry* 20, no. 3 (1985): 169-183.

[56] John L. Holmes, Fred P. Lossing, and Paul M. Mayer, "Heats of formation of oxygen-containing organic free radicals from appearance energy measurements," *Journal of the American Chemical Society* 113, no. 26 (1991): 9723-9728.

HOLMES: Well, I [have] picked out one [more] thing for you.

GRAYSON: Oh, good.

HOLMES: Which is off the beaten track.

GRAYSON: I think I've seen this title.

HOLMES: Peter Derrick asked me to write something about mass spectrometry [for *OMS*]. And so I said, "I'm not going to write [yet another] review article. I'm going to write about [doing it]." And he said, "[OK], go for it." So that's what it's about. [I hope that you can get the feeling of all this science from this invited paper for *OMS*, "Mass Spectrometry and the Pleasures of Science."][57]

GRAYSON: Well, I will—

HOLMES: It was an opportunity, you see, to write about science in a way that a commercial journal does not normally pursue.

GRAYSON: Yes. Very good. Well, thank you for this. I'll add that to my reading in the process, and we'll make that part of the record. There's also this paper that I think you published that was about the lecture that you gave about your garden of science, or the garden of—

HOLMES: Oh, "Cultivating my chemical garden?"

GRAYSON: [Yes]. Cultivating your—

HOLMES: My chemical garden. That was a university research award lecture.

GRAYSON: What was the gist of that? It sounds like an intriguing kind of [talk]—

---

[57] J.L. Holmes. "Mass Spectrometry and the Pleasures of Science." *Organic Mass Spectrometry* 28 (1993): 1388-1394.

HOLMES: [. . .] The purpose was to show that the best science you do is what you want to do and not what you're told to do, so that if you are in an environment where [your work is] controlled, you [must] do this today and you [must] do that tomorrow, I don't [like] that [approach at all]. Ignore that. That's not the way to do science. The way to do it is to just let it [happen]. So [many ideas] will [turn out to] be dead ends, but that doesn't matter. That's par for the course; but if you don't let the ideas fan out, you're **<T: 115 min>** never going to get anywhere. You're just going to get routine facts piled up. And so I tried to make [that] the [central] idea. I gave [two public lectures on that theme], in West Africa. I went to Ghana as a visiting prof, to teach, and—

GRAYSON: How long were you there?

HOLMES: Six months. It was in [1971]. It was a Nuffield Award [invitation to teach for a term], and what came with it was the duty of giving two public lectures in two cities. So I gave one in Accra, [Ghana], the capital [. . .] and that was fine, because I [reckon that] about one hundred people [came], black and white, [. . .] and [there were plenty of] questions. It was a very—a general layman's lecture, if you like. Then I had to go to Cape Coast, [Ghana]. Cape Coast is a place where the slave [traders] used to leave from. They built a university at Cape Coast [University of Cape Coast], which is very beautiful, [a] wonderful campus, just like in Accra. I [asked], "May I drive myself? I don't really want to have a driver. I'd like to go under my own steam."

[. . .] So I had a car, and I drove up to Cape Coast, arrived at the university, and marched up to the wicket, and said, "I've come here to give a public lecture." Nobody knew who I was and what I was about. So [there was some] telephoning, and I was duly hustled off to a bungalow. It was [now] just about getting dark, and a couple of fellows arrived [soon after] and said, "This hasn't been very well publicized. Will you come along to the auditorium, please?" I decided afterwards that this is an experience which every university prof should have to undergo.

Anyway, they wheeled me into [an] auditorium, which seated six hundred, and there were five people in the front row. So I was [just a tiny bit upset]. I said, "You know, [. . .] I've driven a long way [today], and this [has] sort of [gone] pear-shaped, [hasn't] it?" [However] they were nice enough people, some black, some white, and I [asked], "Do you want me to go ahead with this?" They said, "Well, you know, you've come all this way. You'd better do it."

[. . .] So I gave my talk to this huge audience, and then I remembered [something, and afterwards I suggested], "Well, come on. I believe the refrigerator in my bungalow is stuffed with beer. Let's go and check it out." And it was. So we went back and I drank a large quantity of beer with the whole audience. Well giving a public lecture to an audience of five [. . .] I [certainly] think that's something everybody should have to undergo. [It was] a bit of a shock.

GRAYSON: [. . .] That's got to be [an unusual experience]. Well, the least they can do is find a smaller room for you to give your presentation in [. . .], so it doesn't seem [quite] so ridiculous.

HOLMES: Yes. It was a beautiful auditorium, plush tip-up seats.

GRAYSON: So you mentioned NATO. There seems to be a theme running through some of these interviews, that people get involved in NATO activities with the [sciences].

HOLMES: [Yes]. The NATO scientific meetings were really excellent. You know the rule. They have to be in a remote place, and so one was at [a] nunnery in the Vosges Mountains. The one [at which] Henry Rosenstock died [. . .], was on the Portuguese coast. Another one was at Les Arcs, a ski resort—out of season—in the French Alps. [. . .] There was [also] one in Holland, in a tiny little town on the coast. [. . .] I think I only went to four. [. . .] But they were very, very good. They were [. . .] workshops, if you like.

GRAYSON: So who came to these? They were locals, or were they supposed to be—

HOLMES: It was [well] known that these [events] happened, and [they] were [well] supported? [. . .] You applied to go. My recollection is that an advertisement [appeared, or] a friend or a colleague would say, "Hey, look, there's a **<T: 120 min>** gas phase ion chemistry NATO meeting in Portugal." [Then] you read about it see who might be going, and [then] you [signed] up. Away you go to Portugal, and [there are] a couple hundred people there.

GRAYSON: So this would be you get a chance to interact with your colleagues, but then you'd also be able to explain your science to an audience of other people?

HOLMES: No. It's [always] in a [defined] field. So they'd all be gas phase ion chemistry/mass spec people.

GRAYSON: But the audience would be interested in learning or knowing more about your work?

HOLMES: We'd all be swapping information about what we did.

GRAYSON: It sounds like a Gordon [Research] Conference?

HOLMES: It's [very] like a Gordon Conference. [. . .]

GRAYSON: In a different place.

HOLMES: Yes. That's right; [and it must be a remote location].

GRAYSON: Okay. And so you could sign up for these, and—

HOLMES: [. . .] They were excellent. Oh, there was [also] one in Israel, of course. [. . .]

GRAYSON: The NATO requirement was they had to be in an out of the way place?

HOLMES: They had to be in a remote spot.

GRAYSON: It sounds [very] like a Gordon Conference—

HOLMES: Which was a good idea. It meant there were no flesh pots to steal you away. [. . .] The one in the Vosges was in the middle of [good] hiking country. The one in Portugal had beaches, tennis courts, [and] nobody else there. And trips [too, they always provided day] trips. There were always coach trips to somewhere or other, and a guide.

I'll tell you a quick short story. At the Portuguese meeting, the organizer, [Professor Maria Almoster-Ferreir], stood up one morning and [announced], "This morning I have to [remind you that this is a free] afternoon [. . .]. We have an invitation from the mayor of Torres Vedras." Torres Vedras is famous [for its involvement in the] Napoleonic [. . .] Peninsular [wars]. "The mayor would like to meet these scientists, so any of you who would volunteer to go [. . .] the coach will be outside at one o'clock."

[The general feeling was], "Do we really want to go and meet the mayor of Torres Vedras and have [perhaps a history lecture?" However, a number] of us got together and [decided that we should] go; otherwise, poor Maria [may] be awfully embarrassed. So [about] thirty [. . .] of us volunteered [. . .], climbed [onto] the bus, and [away] it went into the hills, and [on] down into this little town, [finally going] along a street which was just wide enough to accommodate the bus. "Everybody out," and we [were guided] into [a] building. When we got

to the top of the stairs, we [found ourselves in] what looked like a classroom with a stage and a lectern [and rows of benches]. The walls were all wood-paneled [. . .].

We all sat down, and nothing much happened [until] a little gentleman came on, and it was the mayor of Torres Vedras. His English was perfect, and his humor was wonderful. So before long, he had us all in fits of laughter. [We wondered" What will] happen after this?" At the end of his lecture, he waved his arms, he said, "And now more entertainment." [The wall panels] were folded back, and in the [large] room behind [. . .] were tables and bottles, and young ladies, [who] all spoke English. [laughter] So we had a whale of a time. There was a huge quantity of food, plenty to drink, and [some] very pleasant young Portuguese ladies to talk to.

GRAYSON: My goodness.

HOLMES: So when we got off the coach at the end of the day [. . .] we [were able to say "You certainly] missed out by not coming."

GRAYSON: Oh, my.

HOLMES: It was so unexpected. We thought it might [well] be [dull and formal, but it certainly wasn't. It was great].

GRAYSON: So what did the mayor have to say? Do you recall?

HOLMES: He told [us] the history [. . .] of [Torres Vedras. Much involved] what [Arthur Wellesley, Duke of] Wellington did, what Napoleon [Bonaparte] did, and who said what, and what happened when [during the Peninsular War, all in a very humorous way. It was quite exceptionally light-hearted, amusing and informative].

GRAYSON: Oh, my. You had a good experience there. So the guys that decided to take the bait end up winning, I guess.

HOLMES: [Yes]. That's [certainly] right. [. . .]

GRAYSON: Had a fun day. Plus I guess the countryside is probably pretty in Portugal as well.

HOLMES: [It is indeed].

GRAYSON: It's an interesting kind of a slip of land there **<T: 125 min>** on the coast of Spain. Has an interesting way of trying to stay in existence, I imagine. I'm sure Spain would love to gobble it up.

HOLMES: [. . .] We [also] went on a boat trip [. . .] to [the Berlengas] Islands offshore. [Before we left] I got up [onto] the harbor wall and looked out, and I saw [that] the Atlantic [Ocean] was quite [rough]. So when we got [onto] this quite small motorboat, which would only [just] accommodate all of us, I made sure [that] I stayed on deck. [Soon after we left those who were in the cabin] were quickly calling for seasick buckets. And so it was a very green lot [of scientists] who got off at the island. It was not [really] a success. [Ah], well.

GRAYSON: Well, there's a couple of things that I wanted to cover. [. . .] Let me tell you what my plan was, because I would like to spend some time talking about your interest in sailing, which I think is really an interesting part of your life. And then important message for the future vitality of chemical research and development? I noticed a recent news article about Canada investigates [. . .] scientists being put down by the government [. . .].

HOLMES: [The government wishes to control what is publicly said by scientists in their employ. Such areas as] pollution, preservation of species, global warming, and [also] medical [and] pharmaceutical matters. My son [Jonathan] works for the [Canadian] government, and I brought him home a big cutting from one of the British daily papers, which [discussed] this problem in Canada. And he [commented that such a report should be on his office's] notice board. It is a problem. It means that people in senior positions in government laboratories may not make a statement about [any of their work] without clearing it with the politicians, and that's not a good idea. Not a good idea.

[. . .] It's bad enough that global warming is considered [by so many Canadians in positions of responsibility to be] a non-issue. That's [largely] because of the tar sands. You're not supposed to call them the tar sands. You'll notice that they're the oil sands now. But [. . .] the amount of energy that's used to win [useful] oil from this [mess] is huge, and [needless to say], it [. . .] goes up to the chimney as CO_2. In my [fifty-seven] years in Canada, the climate has obviously changed, self-evidently. The permafrost is inching further north all the time. So if by some very weird chance [it has] nothing to do with man's [operations], that's fine, but if it is, and I'm [. . .] convinced that it is, and we do [nothing] about it, then I'm afraid the grandchildren and the great-grandchildren are in for a pretty awful time. [I fear that] things [. . .] will [. . .] have to get [much] worse before [anything serious is] done.

GRAYSON: **<T: 130 min>** [. . .] Well, I've always wondered if you could get at least the antis, or the people who don't subscribe to climate change, to at least agree to the fact that the amount of carbon dioxide in the atmosphere is increasing. Now if you can't get them to admit that fact, then there's no rational way to go forward from there. [. . .]

HOLMES: Oh, yes. It's [certainly] well-known. [. . .] My friend Ken [Pearce] in England used to work for the atomic energy people [. . .] at Seascale, [United Kingdom], where they did all the uranium refining and so on. And apart from monitoring everything else that came out of their stacks, they too were concerned about the CO_2 levels in the atmosphere. So Ken had a running record of this [steady increase]. It's over four hundred parts per million now [. . .].

GRAYSON: Well, the world community doesn't seem to be able to move forward. The United States is not exactly being an honorary citizen in that regard.

HOLMES: [No]. They wouldn't sign on to [the] Kyoto [Protocol].

GRAYSON: [Yes]. The politics are just really way out.

HOLMES: [. . .] In a way, it's the weakness of democracy, because if you can persuade a lot of the people [to believe] an untruth [. . .] they will vote [in ignorance of the true state of affair]. I suppose it's always been thus. But [these] issues are a little more important than whether we should eat [fish] on Fridays or something [like that].

GRAYSON: Well, I see a certain amount of Orwellian reality here [. . .].

HOLMES: Yes.

GRAYSON: [. . .] You know, if you say it long enough. . .

HOLMES: [Yes]. People will tend to believe [. . .].

GRAYSON: So what is important for the future vitality of chemical research and development? What's your message to the future for science and research and development?

HOLMES: Let [academic scientists] do what they want to do.

GRAYSON: How are you going to fund them?

HOLMES: Generously.

GRAYSON: Well, that's not going to happen, I'm afraid.

HOLMES: No, of course it isn't. We've had that [era. Indeed] I grew up in it [. . .]. When I went to University College, obviously then, science could do no wrong. [Plentiful] funding was there if you knew how to ask for it. When I came to North America, I could get money from the US Air Force, because they thought [the chemistry of] free radicals might have some vague importance with the future of aviation. [Thus] you could get money from the US Air Force to support photochemistry. And so on and so on [. . .]. Our original NSERC grants were meant to be exploration grants, [to] do what you like. If [the first three years do not turn out very well, a second chance was very likely]. If it doesn't turn out very well again, [then you're likely to fall off the funding wagon. But if you find something new], and run with it, we'll support you.

Now there's talk about the end products, and commercial spinoff. [. . .] We would be nowhere if we waited for commercial spinoff. [. . .]

GRAYSON: Well, I was impressed [. . .] coming through [. . .] O'Hare [International] Airport. The <**T: 135 min**> development of aviation has been a huge commercial impact, these huge facilities. People from all over the world, literally. Hundreds of airplanes. People buying food, buying goods, you know. All because of the commercial development of getting this airplane up in the air. Who would have ever come to see the commercial worth of the Wright brothers trying to—

The shortsightedness that has come with what I call the MBA [Master's in Business Administration] mentality is [. . .], I think it's, going to do us in. [. . .] No understanding of the fact that you just don't legislate production of creation of, new science.

HOLMES: No, you can't. You [certainly] can't do that. You can make a better mousetrap any day, but a new idea? Let people mess about in their labs if they're any good and they spot something, you never know what [that] might be. And remember, you've seen all the fuss about graphene?

GRAYSON: Yes.

HOLMES: That was a complete shot in the dark. I've forgotten the exact description of their original production of graphene, but it involved [simple] materials.[58] It was not intended to [discover] a monomolecular layer of interlocked benzene rings [. . .].

GRAYSON: Well, unfortunately, the mentality has shifted from what it was at the end of World War II—

HOLMES: It's gone a long way [from those halcyon days].

GRAYSON: So I'm not sure if it'll ever come back. But at any rate, I think I've gotten at least a sense of your feelings on this subject of the future of science and chemical research and development.

HOLMES: It's not easy, because when I was on the [grants] committee, our feelings then were that research proposal—[that are considered to be very important now]—are not really much good, because they just indicate what you think you might do. Far more important, is what have you [achieved] in the last granting period. Where's the originality? In other words, track record was what we felt was important. Give a guy a start, give him a reasonable length of time, two granting periods, six years, see what he's done. He either remains the same or goes down or shoots up.

I'm sorry. Now all the pressure is [different]. "Oh, we don't care [so much about the] track record. No, no, no, no. We don't care [so much about] what he's published. What's his research proposal?" [This, needless to say, results in a new kind of "grantsmanship", in which you hold back your recent successful results and report them as "proposed" work a foregone success].

GRAYSON: Well, can we take a little bit of time, unless you have any other things you want to talk about in terms of your scientific career this would be a good time, but I know that you have expressed an interest in sailing, and I'd like to explore that with you a little bit, because I think it's an interesting—

HOLMES: Oh [okay]. When I was a child, I was going to go in the Navy.

---

[58] A.K. Geim, K.S. Novoselov, O.V. Yazyev, S.G. Louie, S. Ghosh, W. Bao, D.L. Nika et al., "Nobel Prize for Graphene," *Nature Materials* 6 (2007): 183-192.

GRAYSON: Ah, okay. [. . .] Was this your decision or your parents' decision?

HOLMES: No, no. It was me. [. . .] I liked the idea of being on ships and so on [. . .]. I have a child's diary, [around 1939, in which included possible choices] of career, and I've got a big ring around [the Royal Navy. However] World War II suggested to me that the military life was not very [. . .] much of a life [and science became a goal]. But I wanted to go on the sea, [nevertheless. Now] a bicycle was cheap, and you could [easily] travel all over Europe, [especially in the 1950s, encountering very little traffic]. To sail around Europe [would involve a relatively] huge capital outlay, for starters, [plus a lot of sailing] experience, and so on.

[In my last school year, 1948, I went sailing on the Norfolk Broads with a school friend and his father, my first experience]. When I was at University College, we used to go [in the spring and fall to the same area]. It's a series of lakes and rivers in Norfolk, in **<T: 140 min>** Eastern England, where you [could] rent sailboats. [We would go there] as a group from college [twice a year]. It was a week's jolly [for a group of young men. I also] learned to sail racing dinghies at the University Sailing Club, which was on a lake in North London, [the Welsh Harp, a reservoir for water for the Grand Union and Grand Junction Canal], actually in industrial North London.

GRAYSON: Oh, boy.

HOLMES: Anyway, my friend John [Morton]—who currently lives in Ottawa—[declared that], "We really ought to go to sea [next]. We should extend our experience." And so [in 1957] we chartered a little [eighteen foot cruising boat on the East Coast of England, from Maldon on the Blackwater River], and for the first time we went out on the briny. [. . .] It was great experience]. The following year, we chartered a [considerably] larger boat, again from the [Blackwater River], and we sailed a great deal further up the East Coast and [. . .] back again. In the summer before I came to Canada, we chartered a boat out of Copenhagen, [Denmark]. And that was a beautiful [forty-two foot] yacht, built in 1924, very old fashioned, very wet, very fast, and it slept six. And we covered the whole of the Kattegat and the Skagerrak and down through the islands, back to Copenhagen.

Then I came to Canada, and of course there were like people at NRC, so I [suggested that we] do a charter in the States [the] next summer—[1959]. So we chartered a boat out of City Island, New York. The boat was called [RoeBoat]—it belonged to [one] Jim Roe. Jim raced this [. . .] offshore racing boat, about thirty-eight, forty feet overall, and it was a yawl, so it had two masts. He was quite nervous about letting the boat go to all these youngsters, but we had our affidavits from [UK and Danish] charter companies which said we were okay, we hadn't sunk anything yet, and so he said, "Okay, you can take her up the coast [. . .]. We'll meet you in New London, [Connecticut]." [Thus] we took off for two weeks up the East Coast of the

States, and found out how foggy it gets [in] June. And we [successfully] handed the boat [back] to Jim.

[. . .] When I came back to England [in 1960], I had saved enough money to buy a small [cruising sailboat]. So we bought [this] small cruiser in [Scotland], and sailed, I don't know, maybe a third of the way around the British Isles in her in two summers. [Before returning to Canada in 1962] I sold her to a New Zealand [dentist—Brian Spruce—who was working in the Midlands, and who], with his wife, [was] intending to return [under sail] to New Zealand. They got as far as the West Indies, and [then his] wife discovered she was pregnant. She was sold then to a journalist [John Guthrie], who sailed her back to the UK, and it was such a fast passage [for so small a yacht, that] it made a little column in *The Times*. He [much later] sold her on [to the current owners, Simon and Penny Richardson. This] boat ["Askadil"] was built in 1934, of wood, to a classic design [by Harrison Butler]. She still exists; she still floats, down near Southampton, [United Kingdom], and I [have met] the current owners—[Simon and Penny very kindly took me for a wonderful sail down the Hamble in November 2014—after this interview was recorded].

GRAYSON: My goodness.

HOLMES: So [. . .] that was a lot of sea and small ocean sailing. When I came back to Canada, there wasn't [any nearby ocean] and so I decided I'd try competitive sailing. I started racing keel boats out [at] the west end of the city here, [at the] Britannia Yacht Club [on Lake Deschenes], and became quite good at it, [and very] enthusiastic. So [I] would spend [quite] a lot of time training crew and so on. [We took the boat—a Shark Class—to national championships and the like on the Great Lakes and St Lawrence. This small] keel boat weighs about a ton. My daughter became interested in sailing, and my son, too. My son was a good competitive sailor.

When my daughter [Susan] married, she and her husband [Dan Gandy], decided, when they had their first child, [Emma], that before everything got too expensive, [they would buy] a cruising yacht, and think about [where] to [go]. They bought a fifty foot steel cutter—[built in Brisbane, Australia—and that had] belonged to a Frenchman, **<T: 145 min>** [in the Magdalen Islands, Québec]. The Frenchman had sailed her round the world [and put her up for sale] in the Magdalen Islands. That's a little group of islands in the mouth of the Saint Lawrence [River]. So Dan bought her there, and I worked her [most of the way] back to Georgian Bay, up the Saint Lawrence, [through the Great Lakes], with a group of old college friends, [a very fine trip indeed]. So I [became] very familiar with the boat. [Her original name was "Farouche" a very difficult to translate French word. Dan and Susan renamed her "Koshlong" after the Ontario Lake in cottage country].

[By] then Susan and Dan had three [daughters, Emma, Rachel and Chloe], and they said, "We think we're going to take a year off on the boat and take the girls." So—[of course]—I [asked], "Can I do the transatlantic [portion] with you?" [Thus] I sailed across the Atlantic [to the Azores in August-September] 2005. [. . .]

And in the meantime, as another occupation, I became an International Judge [for Yacht Racing for about twelve years]. Do you know [. . .] sailboat racing works? If you're racing and you believe you have been fouled or interfered with, or another boat has done an illegal act, you raise a little red flag. When you come ashore, you lodge a protest in writing, and a little court sits, with usually a minimum of three judges, and evidence is given [as if] it's a little trial. You have [boat] models and [the sailors] explain what they believe [to have] happened. On the basis of your [sailing experiences, your] knowledge of the rules and your knowledge of sailors, you come to a conclusion. Either there is no penalty, or one, or sometimes both, are disqualified. [. . .] So it's interesting in its own right, not least because it's a [reflection] of human nature. You have these two adversarial guys trying to make their story stick they have their crew come in [to] tell their version [of events]. And they can be cross-examined, and so on. [When] I became an International Judge, I [. . .] used to travel around to world [and other] championships in Europe and the States and that was [even more] interesting [. . .] because of the extraordinary people that you met.

GRAYSON: Did you ever have any really nasty adversarial judgments to deal with?

HOLMES: No. But there have been some nasty adversarial things arising that have gone to a high court in the States, [but they] all involved money. Sometimes the hearing could be downright funny or on occasion quite unpleasant. In general, the experience was constructive for the sport. It was noteworthy how very well prepared the sailors from Iron Curtain countries were; articulate, knowledgeable and courteous. Sometimes the hearing was very amusing, as a competitor brazenly tried to talk their way out of a penalty]. <**T: 150 min**>

GRAYSON: [. . .] So this craft is what fifty feet, you think? Is this a two-masted sailboat?

HOLMES: No, it's a sloop [and so] a single mast, [. . .] about sixty-five feet long [. . .].

GRAYSON: [Did] you have [a] backup motor?

HOLMES: Oh, yes. We had a diesel [. . .], a new [Japanese] diesel engine. [. . .]

GRAYSON: And how many knots are you getting?

HOLMES: Well, it's a heavy keel boat, [a displacement yacht]. Its maximum speed under normal [. . .] conditions [is very approximately equal, in knots, to] the square root of its

waterline length [in feet] times one and a half. So this boat might with great effort get up to ten or eleven knots. In other words, in a [very] good day's sailing, you might have done one hundred fifty nautical miles. That's pretty good going. [This eastbound voyage was with four blokes, Susan and the daughters joining the crew in the Azores—the others, apart from Dan came home]. It took us twenty-three days to get to the Azores, [Portugal from Halifax, Nova Scotia]. We had a twenty minute radio telephone slot every day with a guy who lives in Hamilton, Ontario, a German, [named Herbert. His great] interest is in weather and small boats. [Thus] he would have [all] the synoptic charts of the Atlantic and how [the depressions etc. were] moving, and we would have a twenty minute discussion with him, [when for example he might] say, "You know, [. . .] I suggest [that] you steer significantly further to the north so that this depression will go through below you." [He was a great help and he communicated regularly with many small boats in the Atlantic]. I don't think we had [any severe weather at all]—about twenty-five knots was the maximum wind speed we encountered, which is quite a lot of wind, but it's not [scary].

GRAYSON: And the seas were not overly. . . you didn't have any rough seas or anything?

HOLMES: [No]. [My rough sea experiences were] all had in the North Sea. The thing about sailing around the [northern] British Isles is that you spend quite a lot of time being cold and wet and frightened, because seventy knots of wind is really pretty breathtaking. It really is. The surface of the sea just blows horizontally at you, the waves are quite big, and [are] inclined to break. [We experienced] some [nasty] gales in the North Sea, which were quite memorable. But ["Askadil"] was very well found [after all], she's done **<T: 155 min>** six more Atlantic crossings since [1963]. But a very classy cruising boat, [even though only thirty feet overall].

GRAYSON: So what's it like being out in the middle of the great big Atlantic, and there is nothing to be seen for miles?

HOLMES: There's always something. The seascape is never the same. It's like going to the [Australian outback] desert. I thought [that] the desert would be monotonous. It's not. It changes with every hour of the day, [just] as the sun changes the illumination of the ground. The Australian desert is [likewise] a great place [to visit].

When [our navigation showed that] we were halfway across—more or less—it so happened [that] we were becalmed. And so Dan, my son-in-law, broke out the bottle of champagne. [We decided to] all go for a swim first. [Thus] we all leapt over the side and swam around the boat [and] climbed back on board again. [It was] a bit spooky, because the depth of water there is nearly three thousand meters, and you think, "Hey, wait a minute, I've got nearly ten thousand feet of water under me to this [Mid-Atlantic Ridge], and here am I flannelling about nervously beside the boat. [Another surprising thing was meeting turtles in that region].

GRAYSON: Turtles?

HOLMES: We met turtles. [. . .] Right out in the middle. They're going to the West Indies to lay their eggs. Quite [a surprise—so never a dull moment at sea. We spoke—by radio—to the few merchant ships that came nearby].

GRAYSON: Interesting. That's got to be a great experience for a child. How old was the youngest or oldest? I mean, you said there were three children?

HOLMES: Oh, Emma was probably about twelve.

GRAYSON: Oh, my.

HOLMES: Rachel would have been ten, and Chloe would have been eight. So they were just kiddies. When I left them, [the girls had all arrived and] they went on south to the [Canary Islands, where] they met up with other cruising yachts for the trade wind passage to the [. . .] southern West Indies. They spent the rest of their time [there before coming up the inland waterway to the Chesapeake—where they sold Koshlong. If it had been me, I would have gone to European waters, to the Mediterranean and so on, but they wanted to come back. The girls did not lose their school year, thanks to correspondence courses overseen—clearly very well—by Susan and Dan].

GRAYSON: That would be, I'd say, a great experience for a child, and that's going to be something they'll always remember forever. [. . .] Outstanding. I don't know if you have any other things that you want to say?

HOLMES: No. [. . .] Let me just have a quick look at the list you gave me. [No], I haven't had a previous interview. The person I've interacted with far more than any other is Hans Terlouw. Far more than [anyone] else. We just have to sit down together and an idea [tends to materialize. It has been] a great collaboration. [I helped with a Festschrift for Hans recently, in *European Mass Spectrometry* in 2012].[59] I wrote the "story" part [. . .].

GRAYSON: Now when you published this, were you the editor?

[59] J.L. Holmes, "Johan Klaas Terlouw, Scientist," *European Journal of Mass Spectrometry* 18, no 2 (2012): 76.

HOLMES: [No. No, my own publications in *OMS* would be sent] to [. . .] the UK [. . .] for [review etc.. **<T: 160 min>** During my seventeen years as North American Editor of *Organic Mass Spectrometry* I received only one threatening letter, but also there was the comic verse that I exchanged with Maurice Bursey].

[I will leave you with the following: this and some other rhymes were all similar doggerel. Here then, to conclude, is a rhyme by one] Percy Bysshe Shelley-Bursey.

"Four months have passed, my paper's deader,
Than if it had been in the shredder.
But is it worse or is it bedder,
To get the hated reject ledder?
Shall I send a sharp rebuke,
With all the subtlety of nuke,
Or shall I wait it out in calm,
Assured that refs can do no harm
to work so good?
It must go through.
More minor changes shall be its due."

And it continues later—this is Maurice again,
"Here's the mailman, Holmes be praised,
My foulest thoughts are all erased.
—I can't believe what I am reading,
My scientific heart lies bleeding.
The referees both agreed—major revision is the need.
So back to desk and lab again.
That damned Canadian is my bane." [laughter]

[Oh], dear. We kept that [exchange] going for several manuscripts, and it was [very funny—at least to us. And so I'll leave you with that].

GRAYSON: It lightens up the excitement of getting your manuscript rejected.

HOLMES: [Yes. It eased] difficult days.

GRAYSON: [Yes. It] put a little light and lightness to that which is not always unappreciated.

HOLMES: Well [Mike], you've been very, [very patient, listening to me rabbiting on about so many things].

GRAYSON: Well, you've been a very good subject—

[END OF AUDIO, FILE 1.2]

[END OF INTERVIEW]

PUBLICATION LIST

BOOKS

1. W.G Lias, J.E. Bartmess, R.D. Levin, J.L. Holmes, J.F. Liebmann and W.G. Mallard. *Gas Phase Ion and Neutral Thermochemistry*. College Park, MD: American Institute of Physics, 1988.

2. J.C. Lindon, J.L. Holmes, and O.E. Tranter. *Encyclopedia of Spectroscopy and Spectrometry*. London: Academic Press, London, 1999.

3. C. Aubry, P. M. Mayer, and J. L. Holmes. *Assigning Structures to Ions in Mass Spectrometry*. Boca Raton: CRC Press, 2006).

REVIEW ARTICLES, CHAPTERS, etc.:

1. J.L. Holmes and D. Armstrong. "Halides and Derivatives," chap. 4 in *Comprehensive Chemical Kinetics*. Vol. 4. Amsterdam: Elsevier, 1971.

2. J.L Holmes and F. Benoit. "Metastable Ions in Mass Spectrometry," chap. 8, in *Mass Spectrometry*. Vol. 5. London: M.T.P. International Review of Science, 1972.

3. J.L. Holmes. "The Determination of Mass Spectral Fragmentation Mechanisms by Isotopic Labelling," chap. 7 in *Isotopes in Organic Chemistry*. Amsterdam: Elsevier, 1975.

4. J.L. Holmes. "Isotopic Labelling in Mass Spectrometry," chap. 4 in *Mass Spectrometry.* London: M.T.P. International Review of Science, 1975.

5. J.L. Holmes and J.K. Terlouw. "The Scope of Metastable Peak Observations." *Organic Mass Spectrometry* 15 (1980): 383-397.

6. J.L. Holmes. "Assigning Structures to Ions in the Gas Phase." *Organic Mass Spectrometry* 20 (1985): 169-183.

7. J.L. Holmes. "The Neutralization of Organic Cations." *Mass Spectrometry Reviews* 8 (1989): 513-539.

8. D.V. Zagorevskii and J.L. Holmes. "Neutralization-Reionization Mass Spectrometry applied to Organometallic and Coordination Chemistry." *Mass Spectrometry Reviews* 13 (1994): 133-154.

9. J.L. Holmes. “Metastable Ions in Mass Spectrometry” and “Ion Energetics and Thermochemistry,” in *Encyclopedia of Spectroscopy and Spectrometry*. London: Academic Press, 1999.

10. D.V. Zagorevskii and J.L. Holmes. “Neutralization-Reionization Mass Spectrometry applied to Organometallic and Coordination Chemistry.” *Mass Spectrometry Reviews* 18 (1999): 87-118

11. J. L. Holmes. “Metastable Ions,” chap. 3 in *Encyclopedia of Mass Spectrometry*. Vol 1. Amsterdam: Elsevier, 2003.

12. J.L. Holmes. “Thermochemical Correlations,” in chap. 5 in *Encyclopedia of Mass Spectrometry*. Vol. 1. Amsterdam: Elsevier, 2003.

13. J.L. Holmes and J. K. Terlouw. “Structure and Mechanism in Organic Ions,” in chap. 3 *Encyclopedia of Mass Spectrometry*. Vol. 4. Amsterdam: Elsevier, 2005.

14. J.L. Holmes, K. J. Jobst, and J. K. Terlouw. “Isotopic labelling in mass spectrometry as a tool for studying reaction mechanisms of ion dissociations.” *Journal of Labelled Compounds and Radiopharmaceuticals* 50, no. 11-12 (2007): 1115-1123.

15. J.L. Holmes. “Metastable Ions in Mass Spectrometry” and “Ion Energetics and Thermochemistry,” in *Encyclopedia of Spectroscopy and Spectrometry*. London: Academic Press, 2013.

PAPERS IN REFEREED SCIENTIFIC JOURNALS

1. J.L. Holmes and Allan Maccoll. “The Pyrolysis of sec-Propyl Iodide.” *Proceedings of the Chemical Society* (1957): 175

2. J.L. Holmes and K.O. Kutschke. “Reactions of Trifluoromethyl Radicals with Benzene and Toluene.” *Transactions of the Faraday Society* 58 (1962): 333-341.

3. J.L. Holmes. “The Kinetics of the Reaction between Nitric Oxide and Hydrogen Iodide and the Dissociation Energy D(H-NO).” *Proceedings of the Chemical Society* (1962): 75.

4. J.L. Holmes and Allan Maccoll. “Gas Phase Eliminations, Part IV. The Pyrolyses of Isopropyl and s-Butyl Iodide.” *Journal of the Chemical Society* (1963): 5919-5929.

5. J.L. Holmes and E.V. Sundaram. “Gas Phase Photolysis of Hydrogen Iodide I. Inhibition with Nitric Oxide at 25`C.” *Transactions of the Faraday Society* 62 (1966): 910-918.

6. J.L. Holmes and E.V. Sundaram. “Gas Phase Photolysis of Hydrogen Iodide II. Effect of Nitric Oxide at 6`C and -20`C.” *Transactions of the Faraday Society* 62 (1966): 1822-1830.

7. J.L. Holmes and M.R. Bridge. “Surface Problems in Kinetic Studies of the Gas Phase Pyrolysis of Alkyl Halides. I. Reaction Vessel Coatings of Pyrolytic Carbon.” *Journal of the Chemical Society B: Physical Organic* (1966): 713-716.

8. J.L. Holmes and M.R. Bridge. “Studies of Olefin Formation in the Pyrolysis of n-Butyl Bromide.” *Journal of the Chemical Society B: Physical Organic* (1967): 1008-1010.

9. J.L. Holmes and S.M. Ruo. “Some Physical and Chemical Properties of Pyrolytic Carbons and their Relevance to Kinetic Studies in the Gas Phase.” *Journal of the Chemical Society A: Inorganic, Physical, Theoretical* (1968): 123l-1237.

10. J.L. Holmes and P. Rodgers. “Gas Phase Photolysis of Hydrogen Iodide. III. Hot Atom Effects.” *Transactions of the Faraday Society* 64 (1968): 2348-2352.

11. J.L. Holmes, G. Neville and I.C. Nigam. “Ketones in Cyperus: NMR and Mass Spectral examination of the 2,4-dinitrophenylhydrazones.” *Tetrahedron* 24 (1968): 3891-3897.

12. J.L. Holmes and G. Choudhary. “Surface Problems in Kinetic Studies of the Gas Phase Pyrolyses of Alkyl Halides. II. Pyrolyses of Alkyl Iodides.” *Journal of the Chemical Society B: Physical Organic* (1968): 1265-1270.

13. J.L. Holmes and I.C. Nigam. “Mass Spectrometry of Lysergic Acid Diethylamide.” *Journal of Pharmaceutical Sciences* 58 (1969): 506-507.

14. J.L. Holmes and S.M. Ruo. “A Gas Kinetic Investigation of the n-Butene Equilibria.” *Journal of the Chemical Society A: Inorganic, Physical, Theoretical* (1969): 1924-1926.

15. J.L. Holmes, F. Benoit and N.S. Isaacs. “The Mass Spectra of Carboxylic Acids. I. Fragmentation Mechanisms in Maleic and Fumaric Acids and Related Compounds.” *Organic Mass Spectrometry* 2 (1969): 591-601.

16. J.L. Holmes and F Benoit. “Mass Spectra and Fragmentation Mechanisms of some Nitrophenylhydrazines and Nitrophenylhydrazones.” *Canadian Journal of Chemistry* 47 (1969): 3611-3621.

17. J.L. Holmes and F. Benoit. “Ortho Effects. I. Fragmentation Mechanisms in some Ortho-substituted Nitroarenes.” *Organic Mass Spectrometry* 3 (1970): 993-1007.

18. J.L. Holmes, D.L. McGillivray and N.S. Isaacs. “The Mass Spectrum of exo-2-norbornyl Chloride. The Elucidation of the Fragmentation Mechanism and Ion Structures by Metastable Ion Analysis.” *Canadian Journal of Chemistry* 48 (1970): 2791-2797.

19. J.L. Holmes and F. Benoit. “The Mechanism of NO Loss from the Molecular Ion of Nitrobenzene and the Fragmentation Behaviour of the Phenoxy and p-Amino-phenoxy Cations.” *Chemical Communication* (1970): 1031-1032.

20. J.L. Holmes and T. St. Jean. “The Mass Spectra of Carboxylic Acids. II. Fragmentation Mechanisms in the Homologous Series $HOOC(CH_2)_nCOOH$.” *Organic Mass Spectrometry* 3 (1970): 1505-15l8.

21. J.L. Holmes and F. Benoit. “The Mass Spectra of Carboxylic Acids. III. The Structures of Molecular and Fragment Ions in Benzoic Acid and Related Molecules.” *Organic Mass Spectrometry* 4 (1970): 97-107.

22. J.L. Holmes and M. Dakubu. “Strain Energy Effects in the Gas-Phase Elimination Reactions of Cycloalkyl Chlorides.” *Journal of the Chemical Society B: Physical Organic* (1971): 1040-1042.

23. J.L. Holmes and F. Benoit. “Metastable Peak Analysis; a Method for Elucidating Fragmentation Mechanisms and Ion Structures in Mass Spectrometry. Part II. Water Loss from the Molecular Ion of 1,2-Cyclohexanediol.” *Canadian Journal of Chemistry* 49 (1971): 1161-1164.

24. J.L. Holmes and F. Benoit. “The Mass Spectra of Benzamide and Thiobenzamide.” *Organic Mass Spectrometry* 5 (1971): 525-530.

25. J.L. Holmes and D.L. McGillivray. “Ion Structures in Norbornyl Compounds.” *Advances in Mass Spectrometry* 5 (1971): 706-708.

26. J.L. Holmes and D.L. McGillivray. “The Mass Spectra of Isomeric Hydrocarbons. I. Norbornene and Nortricyclene; the Mechanisms and Energetics of their Fragmentations.” *Organic Mass Spectrometry* 5 (1971): 1349-1362.

27. J.L. Holmes and D.L. McGillivray. “A Feature of the Fragmentation Mechanism of exo-2-Norbornyl Chloride; Stereoselective Hydrogen Atom Abstraction Revealed by Metastable Ion Studies.” *Organic Mass Spectrometry* 5 (1971): 1339-1341.

28. F. Benoit and J.L. Holmes. “The Mass Spectra of Carboxylic Acids. IV. Carboxyl-Carboxyl Interaction in some Cycloalkane 1,2-Dicarboxylic Acids and its Relationship with Molecular Geometry.” *Organic Mass Spectrometry* 6 (1972): 541-548.

29. F. Benoit and J.L. Holmes. “The Mass Spectra of Carboxylic Acids. V. Carboxyl-Carboxyl Interaction in the Fragmentation of some Cycloalkene-l,2-Dicarboxylic Acids.” *Organic Mass Spectrometry* 6 (1972):549-557.

30. J.L. Holmes, R.T.B. Rye and D. Tong. "Specific and Random Fragmentations in the Mass Spectra of some Deuterium and ^{13}C labeled Neopentyl Compounds." *Organic Mass Spectrometry* 6 (1972): 897-903.

31. J.L. Holmes and M. Dakubu. "Kinetics of the Thermal Decompositions of 4-Chlorocyclohexene and 3-Chlorocyclohexene." *Journal of the Chemical Society, Perkin Transactions 2* (1972): 1336-1338.

32. J.L. Holmes. "Intramolecular Amide-amide Interaction in the Mass Spectra of some Geometric Isomers." *Organic Mass Spectrometry* 7 (1973): 335-339.

33. J.L. Holmes. "The Mass Spectra of Carboxylic Acids. VI. Metastable Dissociations of Isomeric Ions in the Mass Spectra of Oxalic and Formic Acids and Malonic and Acetic Acids." *Organic Mass Spectrometry* 7 (1973): 341-346.

34. J.L. Holmes, D.L. McGillivray and R.T.B. Rye. "Specific and Random Processes in the Fragmentation of Cyclohexanol." *Organic Mass Spectrometry* 7 (1973): 347-356.

35. J.L. Holmes and D.L. McGillivray. "The Mass Spectrum and Fragmentation Mechanism of exo- and endo-Norborneol." *Organic Mass Spectrometry* 7 (1973): 559-572.

36. J.L. Holmes and R.T.B. Rye. "The Fragmentation Mechanism of Cyclobutanol." *Canadian Journal of Chemistry* 51 (1973): 2342-2346.

37. J.L. Holmes. "The Mass Spectra of Isomeric Hydrocarbons II. The C_5H_8 Isomers, Spiropentane, Cyclopentene, l,3-Pentadiene and Isoprene: the Mechanisms and Energetics of their Fragmentations." *Organic Mass Spectrometry* 8 (1974): 247-255.

38. J.L. Holmes, D.L. McGillivray and N.S. Isaacs. "Degenerate Skeletal Rearrangement and Energy Partitioning in the Fragmentation of the Norbornyl Cation." *Organic Mass Spectrometry* 9 (1974): 510-513.

39. J.L. Holmes and G.M. Weese. "Thermochemistry and Metastable Energy Release for the Dissociation $C_3H_7^+ \rightarrow C_3H_5^+ + H_2$." *Organic Mass Spectrometry* 9 (1974): 618-621.

40. J.L. Holmes. "Shapes and Relative Abundances of Metastable Ion Peaks as an Aid to Ion Structure Determination." *Advances in Mass Spectrometry* 6 (1974): 865-869.

41. J.L. Holmes, A.D. Osborne and G.M. Weese. "Metastable Ion Studies III; Composite Metastable Peaks in the Fragmentations of some Small Hydrocarbon Cations." *Organic Mass Spectrometry* 10 (1975): 867-875.

42. J.L. Holmes and J.K. Terlouw. "Metastable Ion Studies IV. Thermochemistry and Ion Structures among Fragmenting $C_3H_6^+$ Ions." *Organic Mass Spectrometry* 10 (1975): 787-796.

43. J.L. Holmes and J.K. Terlouw. "Metastable Ion Studies V. The Identification of $C_2H_4O^+$ Ion Structures from their Characteristic Kinetic Energy Releases." *Canadian Journal of Chemistry* 53 (1975): 1076-1083.

44. P.J. Derrick, J.L. Holmes and R.P. Morgan. "Kinetics and Mechanism of the Loss of Water from the Cyclohexanol Radical Ion at Times from 50 Picoseconds to l0 Microseconds following Field Ionization." *Journal of the American Chemical Society* 97 (1975): 4936-4944.

45. J.L. Holmes, A.D. Osborne and G.M. Weese. "Metastable Ion Studies II. Calculations of the Shapes of Metastable Ion Peaks." *International Journal of Mass Spectrometry and Ion Physics* 19 (1976): 207-218.

46. J.L. Holmes and J.K. Terlouw. "Metastable Ion Studies VI. The Identification of $C_2H_5N^+$ Ion Structures from their Characteristic Kinetic Energy Releases." *Canadian Journal of Chemistry* 54 (1976): 1007-1014.

47. J.L. Holmes, J.K. Terlouw and F.P. Lossing. "The Thermochemistry of $C_2H_4O^+$ Ions." *Journal of Physical Chemistry* 80 (1976): 2860-2863.

48. J.L. Holmes, G.M. Weese, A.S. Blair and J.K. Terlouw. "Metastable Ion Studies IX. Thermochemistry and Ion Structures among Fragmenting $C_4H_8^+$ Ions. An Electron Impact and Field Ionization Investigation." *Organic Mass Spectrometry* 12 (1977): 424-431.

49. J.L. Holmes and A.D. Osborne. "Metastable Ion Studies VIII. An Analytical Method for Deriving Kinetic Energy Release Distributions from Metastable Peaks." *International Journal of Mass Spectrometry and Ion Physics* 23 (1977): 189-200.

50. J.L. Holmes, D. Yuan and R.T.B. Rye. "Metastable Ion Studies VII. Loss of Water from the Molecular Ion of Cyclopentanol." *Organic Mass Spectrometry* 12 (1977): 254-257.

51. J.L. Holmes, A.S. Blair, G.M. Weese, A.D. Osborne and J.K. Terlouw. "Deriving Ion Structures from Metastable Peak Characteristics." *Advances in Mass Spectrometry* 7 (1977): 1227-1230.

52. J.L. Holmes and R.T.B. Rye. "Metastable Peak Shape as a Guide to the Mechanism of Water Loss in the Mass Spectra of Cyclic Alcohols." *Advances in Mass Spectrometry* 7 (1977): 1234-1238.

53. J.L. Holmes and P. Wolkoff. "The Isomerisation of $C_2H_4S^+$ Ions: Thioacetaldehyde as the only Species Fragmenting by H Atom Loss." *Journal of Chemical Society, Chemical Communications* (1977): 492-493.

54. A.D. Osborne and J.L. Holmes. “Metastable Ion Studies X. A Monte Carlo Method for the Computation of Metastable Peak Shapes.” Int J. Mass Spectrom. Ion. Phys. 27, 271-282 (1978).

55. P. Wolkoff and J.L. Holmes. “Complete Isomerisation of the Molecular Ion of 2,4,6-trimethyl-1,3,5-trithiane to that of 3,5,6-trimethyl-1,2,4-trithiane before Decomposition in the Gas Phase.” *Organic Mass Spectrometry* 13 (1978): 338-340.

56. J.L. Holmes and A.D. Osborne. “Energy Partitioning in the Metastable Fragmentation. $C_3H_7^+ \rightarrow C_3H_5^+ + H_2$.” *Organic Mass Spectrometry* 13 (1978): 133-134.

57. P.C. Burgers, J.K. Terlouw, P.C. Vijfhuizen and J.L. Holmes. “On the Mechanism of Isomerisation Reactions in the Esters of Some Simple Unsaturated Carboxylic Acids.” *Organic Mass Spectrometry* 13 (1978): 470-476.

58. J.L. Holmes and P. Wolkoff. “Fragmentations of Alkane Molecular Ions.” *Journal of the American Chemical Society* 100 (1978): 7346-7352.

59. J.L. Holmes, A.D. Osborne and K. Cartledge. “Metastable Ion Studies XI. A Monte Carlo Method for the Simulation of Consecutive Metastable Fragmentations.” *International Journal of Mass Spectrometry and Ion Physics* 29 (l979): 171-178.

60. J.L. Holmes, J.K. Terlouw and P.C. Burgers. “The Generation and Thermochemistry of Vinylketene.” *Journal of the American Chemical Society* 101 (1979): 225.

61. J.L. Holmes and F.P. Lossing. “Reactivity of $C_3H_3^+$ Ions. A Thermochemical Study.” *Canadian Journal of Chemistry* 57 (1979): 249-252.

62. J.L. Holmes, N. Hijazi and J.K. Terlouw. “Metastable Peaks of Exponential Shape.” *Organic Mass Spectrometr*y 14 (1979): 119-120.

63. J.L. Holmes and P. Wolkoff. “Isomeric Cyclic $C_6H_{10}^+$ Ions. The Energy Barrier to Ring Opening.” *Canadian Journal of Chemistry* 57 (1979): 348-353.

64. J.L. Holmes, J.K. Terlouw, P.C. Vijfhuizen ad C.A'Campo. “Metastable Ion Studies XII. Molecular and Fragment Ion Structures for Isomeric $C_4H_6O_2$ Acids.” *Organic Mass Spectrometr*y 14 (1979): 204-212.

65. J.L. Holmes and J.K. Terlouw. “The Structures of $C_4H_4O^+$ Ions Produced from 2- and 4-Pyrone.” *Journal of the American Chemical Society* 101 (1979): 4973-4975.

66. J.L. Holmes, P. Wolkoff and R.T.B. Rye. “The extrusions of $^{12}CH_3$ and $^{12}CH_4$ from the Molecular Ion of $^{13}CH_3CH_2CH_2{}^{13}CH_3$.” *Journal of the Chemical Society, Chemical Communications* (1979): 544-545

67. J.L. Holmes and F.P. Lossing. “Keto and Enol Forms of Methyl Acetate Molecular Ions, their Stability and Interconvertibility Prior to Fragmentation in the Gas Phase.” *Organic Mass Spectrometr*y 14 (1979): 512-513.

68. J.L. Holmes and D.L. McGillivray. “The Kinetics and Mechanisms of the Gas Phase Pyrolyses of Exo-2-Norbornyl Chloride and Cyclopentyl Chloride.” *Canadian Journal of Chemistry* 57 (1979): 2621-2625.

69. J.L. Holmes, R.T.B. Rye and J. K. Terlouw. “On the Loss of Ethene from $C_3H_7O^+$ Ions of Structure $CH_3CH_2{}^+CHOH$.” *Organic Mass Spectrometr*y 14 (1979): 606-608.

70. J.L. Holmes and F.P. Lossing. “Thermochemistry and Unimolecular Reactions of Ionized Acetic Acid and its Enol in the Gas Phase.” *Journal of the American Chemical Society* 102 (1980): 3732-3735.

71. J.L. Holmes and F.P. Lossing. “Gas Phase Heats of Formation of Keto and Enol Ions of Carbonyl Compounds.” *Journal of the American Chemical Society* 102 (1980): 1591-1595.

72. J.L. Holmes, P. Wolkoff and F.P. Lossing. “Energetics of Molecular Ion Rearrangements in Alkadienes and Alkynes. The Formation of Cyclopentenium$^+$ from all $C_6H_{10}^+$ Isomers.” *Canadian Journal of Chemistry* 58 (1980): 251-257.

73. J.L. Holmes, M. Dakubu and R.T.B. Rye. “Isomerisation and Extrusion Processes in the Fragmentation of $C_5H_{10}^+$ Ions.” *Advances in Mass Spectrometr*y 8 (1980): 847-852.

74. J.L. Holmes and P. Wolkoff. “Ubiquitous Cyclopentenium Ion Formation from C_6H_{10} Molecular Ions and Some Higher Homologues.” *Advances in Mass Spectrometr*y 8 (1980): 743-747.

75. J.L. Holmes, J.K. Terlouw and P.C. Burgers. ‘Reacting and Stable Configurations of $C_3H_3O^+$ Ions.” *Organic Mass Spectrometry* 15 (1980): 140-144.

76. J.L. Holmes, P.C. Burgers and J.K. Terlouw. “Charge Stripping Mass Spectra of C_5H_8 and C_3H_6 Ions; their Utility in Ion Structure Identification.” *Organic Mass Spectrometry* 15 (1980): 149-152.

77. J.L. Holmes and J.K. Terlouw. “The Scope of Metastable Peak Studies.” *Organic Mass Spectrometry* 15 (1980): 383-397.

78. J.L. Holmes, P. Wolkoff and R.T.B. Rye. “Evidence Against Isomerisation in Alkane Molecular Ions.” *Advances in Mass Spectrometr*y 8 (1980): 651-656.

79. J.K. Terlouw, W. Heerma, P.C. Burgers and J.L. Holmes. “Structure and Formation of Gaseous $C_4H_6O^+$ ions.” *Organic Mass Spectrometry* 15 (1980): 582-586.

80. J.L. Holmes, M. Fingas and F.P. Lossing. “Towards a General Scheme for Estimating the Heats of Formation of Organic Ions in the Gas Phase. I. Odd Electron Cations.” *Canadian Journal of Chemistry* 59 (1981): 80-93.

81. J.L. Holmes, M. Dakubu and R.T.B. Rye. “Water Loss from $C_5H_{10}O^{+\bullet}$ Isomers; a Reassessment.” *Organic Mass Spectrometry* 16 (1981): 1-4.

82. J.K. Terlouw, W. Heerma and J.L. Holmes. “Assigning Structures to $C_2H_3O^+$ Ions.” *Organic Mass Spectrometry* 16 (1981): 306-308.

83. J.L. Holmes and A.D. Osborne. “A Simple Method for the Evaluation of the Average Kinetic Energy Released in a Fragmentation Producing a Gaussian-type Metastable Peak.” *Organic Mass Spectrometry* 16 (1981): 236.

84. J.L. Holmes, P.C. Burgers and J.K. Terlouw. “Water Elimination from the Keto and Enol Tautomers of Ionized Ethyl Acetate.” *Canadian Journal of Chemistry* 59 (1981): 1805-1809.

85. J.L. Holmes, P.C. Burgers, M.Y.A. Mollah and P. Wolkoff. “Isomerisation of Alkane Molecular Ions.” *Journal of the American Chemical Society* 104 (1982): 2879-2884.

86. J.L. Holmes, P.C. Burgers and M.Y.A. Mollah. “Alkane Eliminations from Alkanols.” *Organic Mass Spectrometry* 17 (1982): 127-130.

87. J.L. Holmes and P.C. Burgers. “Metastable Ion Studies XIII. Appearance Energies of Metastable Peaks.” *Organic Mass Spectrometry* 17 (1982): 123-126.

88. H.M. Rosenstock, R. Buff, M.A.A. Ferreira, S.G. Lias, A.C. Parr, R.L. Stockbauer and J.L. Holmes. “Fragmentation Mechanism and Energetics of some Alkyl Halide Ions.” *Journal of the American Chemical Society* 104 (1982): 2337-2345.

89. J.L. Holmes and F.P. Lossing. “The Uses of Gas Phase Ion Thermochemistry,” in *Current Topics in Mass Spectrometry and Chemical Kinetics*. London: Heyden and Son, 1982.

90. P.C. Burgers, J.K. Terlouw and J.L. Holmes. “The Vinyl Oxonium Cation, $CH_2{=}CHOH_2^+$, a Stable $C_2H_5O^+$ Species in the Gas Phase.” *Organic Mass Spectrometry* 17 (1982): 369-372.

91. J.L. Holmes and F.P. Lossing. “Heats of Formation of the Ionic and Neutral Enols of Acetaldehyde and Acetone.” *Journal of the American Chemical Society* 104 (1982): 2648-2649.

92. J.L. Holmes and F.P. Lossing. "Towards a General Scheme for Estimating the Heats of Formation of Organic Ions in the Gas Phase. Part II. The Effect of Substitution at Charge-Bearing Sites." *Canadian Journal of Chemistry* 60 (1982): 2365-2371.

93. J.L. Holmes, F.P. Lossing, P.C. Burgers and J.K Terlouw. "The Radical Cation $CH_2OH_2^+$ and Related Stable Gas Phase Ion-Dipole Complexes." *Journal of the American Chemical Society* 104 (1982): 2931-2932.

94. P.C. Burgers, J.L. Holmes, F.P. Lossing, A.A. Mommers, F.R. Povel and J.K. Terlouw. "Isomeric and Tautomeric $C_4H_4O^+$ Ions; their Thermochemistry and Collisionally Induced Fragmentation Characteristics." *Canadian Journal of Chemistry* 60 (1982): 2246-2255.

95. P. Wolkoff and J.L. Holmes. "The Cope Rearrangement and Ring Closure of the l,5-hexadiene Radical Cation prior to Decomposition in the Gas Phase." *The Journal of Organic Chemistry* 47 (1982): 3342-3344.

96. J.L. Holmes, F.P. Lossing and P.C. Burgers. "The Need for Adequate Thermochemical Data for the Interpretation of Fragmentation Mechanisms and Ion Structure Assignments." *International Journal of Mass Spectrometry and Ion Physics* 347 (1983): 133-136.

97. P. Wolkoff, S. Hammerum and J.L. Holmes. "The Behaviour of $C6H14^+$ Ions." *International Journal of Mass Spectrometry and Ion Physics* 47 (1983): 343-346.

98. P. Wolkoff and J.L. Holmes. "The Importance of Measuring Metastable Peak Shapes in Conjunction with D-Labelling Experiments." *Journal of Mass Spectrometry and Ion Physics* 47 (1983): 89-92.

99. J.K. Terlouw, W. Heerma, G. Dijkstra, J.L. Holmes and P.C. Burgers. "Characterisation of Radical Ion Dipole Complexes by Collisional Activation and Collisional Ionization Mass Spectrometry." *Journal of Mass Spectrometry and Ion Physics* 47 (1983): 147-150.

100. J.L. Holmes and P.C. Burgers. "HOC^+: Laboratory Observation of a Proposed Interstellar Species." *Chemical Physical Letters* 97 (1983): 236-238.

101. J.L. Holmes, P.C. Burgers, J.K. Terlouw, H. Schwarz, B. Ciommer and H. Halim. "Stable $C_2H_5X^+$ Radical Cations (X=Cl,Br) of Structure CH_3CHXH^+ their Energetics and Dissociation Characteristics." *Organic Mass Spectrometry* 18 (1983): 208-211.

102. P.C. Burgers, J.L. Holmes, J.E. Szulejko, A.A. Mommers and J.K. Terlouw. "The Gas Phase Ion Chemistry of the Acetyl Cation and Isomeric $C_2H_3O^+$ Ions." *Organic Mass Spectrometry* 18 (1983): 254-262.

103. J.L. Holmes and J.E. Szulejko. “Energy Discrimination in Ion Detection Systems; the Performance of Conversion Dynodes.” *Organic Mass Spectrometry* 18 (1983): 273.

104. J.K. Terlouw, J.L. Holmes and F.P. Lossing. “Ionized Ethylidene Ketene and its Homologue Methylene Ketene.” *Canadian Journal of Chemistry* 61 (1983): 1722-1724.

105. J.K. Terlouw, C.G. deKoster, W. Heerma, J.L. Holmes and P.C. Burgers. “Two $C_2H_4O_2^+$ Ions of Unusual Structure.” *Organic Mass Spectrometry* 18 (1983): 222-223.

106. P.C. Burgers, J.L. Holmes, F.P. Lossing, F.R. Povel and J.K. Terlouw. “The Role of Charge-Site Location in Fragmenting Ions. I. $CH_3CHXCOOCH_3^+$ and $CH_2XCH_2COOCH_3^+$ Ions and the Structures of Daughter Ions Derived from the Loss of X; (X=I, Br, Cl and CH_3).” *Organic Mass Spectrometry* 18 (1983): 335-339.

107. J.L. Holmes, F.P. Lossing, J.K. Terlouw and P.C. Burgers. “Novel Gas Phase Ions. The Radical Cations CX_2XH^+, (X=F,Cl, Br, I, OH, NH_2, SH) and $CH_2CH_2NH_3^{+\cdot}$” *Canadian Journal of Chemistry* 61 (1983): 2305-2309.

108. P.C. Burgers, J.L. Holmes and A.A. Mommers. “The Isotope Effect Associated with the Loss of an Oxygen Atom from CO_2D^+ Ions.” *International Journal of Mass Spectrometry and Ion Physics* 54 (1983): 283-288.

109. P.C. Burgers, A.A. Mommers and J.L. Holmes. “Ionized Oxycarbenes; COH^+, $HCOH^+$, $C(OH)_2^+$, HCO_2^+ and $COOH^+$, their Generation, Identification, Heat of Formation and Dissociation Characteristics.” *Journal of the American Chemical Society* 105 (1983): 5976-5979.

110. J.K. Terlouw, J. Wezenberg, P.C. Burgers and J.L. Holmes. “New Stable Isomers of $C_2H_4O^{+\bullet}$ and $C_2H_4O_2^+$; the Radical Cations $CH_3COH^{+\bullet}$ and CH_3OCOH^+.” *Journal of the Chemical Society, Chemical Communications* (1983): 1121-1123.

111. P.C. Burgers, J.L. Holmes, A.A. Mommers and J.E. Szulejko. “The Collisionally Induced Dissociation of Allyl and 2-Propenyl Cations.” *Organic Mass Spectrometry* 18 (1983): 596-600.

112. P.C. Burgers, J.L. Holmes, A.A. Mommers and J.K. Terlouw. “Neutral Products of Ion Fragmentations. HCN and HNC Identified by their Collisionally Induced Dissociative Ionization.” *Chemical Physical Letters* 102 (1983): 1-3.

113. A.A. Mommers, P.C. Burgers, J.L. Holmes and J.K. Terlouw. “Isomeric $C_3H_4^+$ Ions. Their Identification and Generation in Dissociative Ionizations.” *Organic Mass Spectrometry* 19 (1984): 7-9.

114. P.C. Burgers and J.L. Holmes. “Fragmentation Rate Constants and Appearance Energies for Reactions having a large Kinetic Shift and the Energy Partitioning in their Metastable

Decomposition." *International Journal of Mass Spectrometry and Ion Physics* 58 (1984): 15-24.

115. J.L. Holmes and F.P. Lossing. "The Heats of Formation of Organic Radicals from Appearance Energies." *International Journal of Mass Spectrometry and Ion Physics* 58 (1984): 113-120.

116. J.K. Terlouw, W. Heerma, P.C. Burgers and J.L. Holmes. "Novel Gas Phase Ions. CH_2=CHOH/$CH_3OH^{+\bullet}$ and CH_2=CHOH/H_2O^+." *Canadian Journal of Chemistry* 62 (1984): 289-292.

117. P.C. Burgers, J.L. Holmes, A.A. Mommers and J.E. Szulejko. "The Generation and Identification of Four Stable $C_3H_3^+$ Ions by Direct Dissociative Ionization or by Charge Reversal of Anions." *Journal of the American Chemical Society* 106 (1984): 521-525.

118. P.C. Burgers, J.L. Holmes, A.A. Mommers, J.E. Szulejko and J.K. Terlouw. "Collisionally Induced Dissociative Ionization of Neutral Products from Unimolecular Ion Fragmentations. I. Neutral Product Structures." *Organic Mass Spectrometry* 19 (1984).

119. P.C. Burgers, J.L. Holmes and J.E. Szulejko. "The Collisionally Induced Dissociations of the Carboxyl and Formate Positive and Negative Ions." *International Journal of Mass Spectrometry and Ion Processes* 57 (1984): 159-166.

120. J.L. Holmes, A.A. Mommers, J.E. Szulejko and J.K. Terlouw. "Two New Stable $C_3H_8O^{+\bullet}$ Isomers; the Radical Cations $C_3H_6OH_2^+$." *Journal of the Chemical Society, Chemical Communication* (1984): 165-167.

121. P.C. Burgers and J.L. Holmes. "The Generation of Triplet Methoxy Cations." *Organic Mass Spectrometry* 19 (1984): 452-456.

122. J.L. Holmes and J.E. Szulejko. "The Generation and Identification of the Transient Vinylidene Cation $H_2C{=}C^+$." *Chemical Physical Letters* 107 (1984): 301-303.

123. P.C. Burgers, J.L. Holmes and J.K. Terlouw. "The Generation, Heat of Formation and Dissociation Characteristics of H_2CN^+, $HCNH^+$, CNH_2^+, H_2CNH^+ and $HCNH_2^+$. *Journal of the American Chemical Society* 106 (1984): 1762-1764.

124. J.L. Holmes and J.E. Szulejko. "Vibrational Fine Structure in the Collisonally Induced Charge Reversal and Fragmentation of OH^- Ions." *Chemical Physical Letters* 106 (1984): 292-296.

125. P.C. Burgers, J.L. Holmes and J.K. Terlouw. "Energy Barriers for Exothermic Gas Phase Ion Radical Recombinations." *Journal of the Chemical Society, Chemical Communications* (1984): 642-643.

126. J.L. Holmes and A.A. Mommers. “An Ion Beam Deflector for Use in the Analysis of Neutral Products of Ion Fragmentations.” *Organic Mass Spectrometry* 19 (1984): 460-461.

127. F.P. Lossing and J.L. Holmes. “Stabilisation Energy and Ion Size in Carbocations in the Gas Phase.” *Journal of the American Chemical Society* 106 (1984): 6917-6920.

128. P. Wolkoff, J.L. Holmes and F.P. Lossing. “The Dichotomy of Methyl Loss from 2-Methylalkane Molecular Ions.” *Organic Mass Spectrometry* 20 (1985): 14-17.

129. J.L. Holmes. “Assigning Structures to Ions in the Gas Phase.” *Organic Mass Spectrometry* 20 (1985): 169-183.

130. R. Clair, J.L. Holmes, A.A. Mommers and P.C. Burgers. “Collisionally Induced Dissociative Ionization of Neutral Products of Ion Fragmentations. II. Collision Gas Effects and Related Phenomena.” *Organic Mass Spectrometry* 20 (1985): 207-215.

131. P.C. Burgers, J.L. Holmes and A.A. Mommers. “Laboratory Experiments on the Interstellar Species HCO^+ and COH^+.” *Journal of the American Chemical Society* 107 (1985): 1099-1101.

132. P.C. Burgers, J.L. Holmes, J.K. Terlouw and B. van Baar. “Three New Isomers of $C_2H_6O^+$, the Radical Cations $CH_3O(H)CH_2^+$, $CH_3CHOH_2^+$ and a Low Energy Isomer of Unassigned Structure.” *Organic Mass Spectrometry* 20 (1985): 202-206.

133. P.C. Burgers, J.K. Terlouw and J.L. Holmes. “The Loss of $H^\bullet$ from Vinylalcohol Radical Cations.” *International Journal of Mass Spectrometry and Ion Processes* 64 (1985): 91-95.

134. R. Postma, P.J.A. Ruttink, F.B. Van Duijneveldt, J.K. Terlouw and J.L. Holmes. “An Ab Initio Study of the Structure and Stability of the Hydrogen Bridged Radical Cation-Molecule Pairs CH_2=$CHOH/H_2O^{+\bullet}$ and CH_2CHOH/CH_3OH^+.” *Canadian Journal of Chemistry* 63 (1985): 2798-2804.

135. J.K. Terlouw, W.M. Kieskamp, J.L. Holmes, A.A. Mommers and P.C. Burgers. “The Neutralisation and Reionization of Mass Selected Positive Ions by Inert Gas Atoms.” *International Journal of Mass Spectrometry and Ion Processes* 64 (1985): 245-250.

136. J.L. Holmes, A.A. Mommers, C. DeKoster, W. Heerma and J.K. Terlouw. “Four Isomeric $C,H_3O_2^+$ Ions.” *Chemical Physics Letters* 115 (1985): 437-440.

137. J.K. Terlouw, J.L. Holmes and P.C. Burgers. “On the Loss of $^\bullet CH_2OH$ Radicals from Ionized Methyl Acetate.” *International Journal of Mass Spectrometry and Ion Processes* 66 (1985): 239-244.

138. W.J. Bouma, P.C. Burgers, J.L. Holmes and L. Radom. "Rearrangement and Dissociative Processes in the H_2,C,O^+ Potential Energy Surface. An Example of Non-Ergodic Behaviour?" *Journal of the American Chemical Society* 108 (1986): 1767-1770.

139. J.L. Holmes, A.A. Mommers, J.K. Terlouw and C.E.C.A. Hop. "The Mass Spectrometry of Neutral Species produced from Mass Selected Ions by Collision and by Charge Exchange: Experiments with Tandem Collision Cells." *International Journal of Mass Spectrometry and Ion Processes* 68 (1986): 249-264.

140. R. Postma, P.J.A. Ruttink, B. van Baar, J.K. Terlouw, J.L. Holmes and P.C. Burgers. "Isomeric Distonic and H-Bridged $C_2H_6O^+$ Radical Cations." *Chemical Physics Letters* 123 (1986): 409-415.

141. J.L. Holmes. "Ion Thermochemistry and Energetics; a Convergence of Theory and Experiment." *Advances in Mass Spectrometry* 9 (1986): 263-269.

142. R. Postma, P.A. Ruttink, B. van Baar, J.K. Terlouw, J.L. Holmes and P.C. Burgers. "Ylide, Distonic and H-bridged Radical Cations; the $C_2H_6O^+$ Isomers." *Advances in Mass Spectrometry* 9 (1986): 819-820.

143. W.J. Bouma, P.C. Burgers, J.L. Holmes and L. Radom. "The Unimolecular Chemistry of $H_2,C,O^{+\bullet}$ Ions; an Example of Non-Ergodic Behaviour." *Advances in Mass Spectrometry* 9 (1986): 743-744.

144. J.L. Holmes, P.C. Burgers, R. Clair, A.A. Mommers, J.K. Terlouw and C.E.C.A. Hop. "The Generation and Properties of Beams of Fast Neutral Radicals and Molecules." *Advances in Mass Spectrometry* 9 (1986): 1105-1106.

145. J. Main-Bobo, S. Olesik, W. Gase, T. Baer, A.A. Mommers and J.L. Holmes. "The Thermochemistry and Dissociation Dynamics of Internal Energy Selected Pyrazole and Imidazole Ions." *Journal of the American Chemical Society* 108 (1986), 677-683.

146. M.B. Stringer, D.J. Underwood, J.H. Bowie, J.L. Holmes, A.A. Mommers and J.E. Szulejko. "Is the Collision Induced Loss of Ethene from the $[M\text{-}H^+]^-$ Ion of Butyrophenone a (-hydrogen Rearrangement?" *Canadian Journal of Chemistry* 64 (1986): 764-768.

147. J.L. Holmes, F.P Lossing and J.K. Terlouw. "Heats of Formation and Homolytic Bond Dissociation Energies in the Keto-Enol Tautomers C_2H_4O, C_3H_6O." *Journal of the American Chemical Society* 108 (1986): 1086-1087.

148. R. Postma, P.J.A. Ruttink, J.K. Terlouw and J.L. Holmes. The Ketene-Water Radical Cation Dipole Complex, $[CH_2CO.H_2O]^{\bullet+}$. *Journal of the Chemical Society, Chemical Communications* (1986): 683-685.

149. J.K. Terlouw, T. Weiske, H. Schwarz and J.L. Holmes. "A Study of Ion Structures Produced by the Reaction of 2-Propyl Cations with Water and Methanol; Covalently Bound vs. Hydrogen-Bridged Adducts." *Organic Mass Spectrometry* 21 (1986): 665-672.

150. J. Bordas-Nagy, J.L. Holmes and A.A. Mommers. "Field Ionization of High Velocity Neutral Species. Rydberg States in Noble Gas Atoms; the Measurement of Translational Energy Loss in Neutralization-Reionization Mass Spectra." *Organic Mass Spectrometry* 21 (1986): 629-636.

151. P.C. Burgers, J.L Holmes, C.E.C.A. Hop and J.K. Terlouw. "The Gas Phase Ion Chemistry of Methyl Acetate, Methyl Propanoate and their Enolic Tautomers. I. An Experimental Approach." *Organic Mass Spectrometry* 21 (1986): 549-556.

152. M.B. Stringer, J.H. Bowie and J.L. Holmes. "Carbanion Rearrangements. Collision Induced Dissociations of the Enolate Ion of Heptan-4-one." *Journal of the American Chemical Society* 108 (1986): 3888-3893.

153. M.C. Blanchette, J.L. Holmes, C.E.C.A. Hop, F.P. Lossing, R. Postma, P.J. Ruttink and J.K. Terlouw. "Theory and Experiment in Concert; the CH_3OCO^+ Ion and its Isomers." *Journal of the American Chemical Society* 108 (1986): 7589-7594.

154. J.M. Buschek, J.L. Holmes and F.P. Lossing. "The Mass Spectrometric Generation of Neutral Ethynamine, $HC{=}CNH_2$ and other C_2H_3N Isomers." *Organic Mass Spectrometry* 21 (1986): 729-731.

155. J. Bordas-Nagy and J.L. Holmes. "Kinetic Energy Spectroscopy of High Rydberg Fragments from keV Collisions of H_2^+, D_2^+, N_2^+ and C_2^+ Ions with Inert Gas Atoms." *Chemical Physics Letters* 132 (1986): 200-204.

156. J.L. Holmes, C.E.C.A. Hop and J.K. Terlouw. "Does the Unimolecular Dissociation of Ionized Methyl Acetate produce CH_3O or CH_2OH Radicals?" *Organic Mass Spectrometry* 21 (1986): 776-778.

157. G.J. Currie, M.B. Stringer, J.H. Bowie and J.L. Holmes. "Collision Induced Carbanion Rearrangements. The Elimination of Ethene from the 3,3-dimethylheptan-4-one Enolate Ion." *Australian Journal of Chemistry* 40 (1987): 1365-1373.

158. M.C. Blanchette, J.L. Holmes and F.P. Lossing. "Characterizing the Norbornyl Cation in the Gas Phase." *Journal of the American Chemical Society* 109 (1987): 1392-1395.

159. J.H.O.J. Wijenberg, J.H. van Lenthe, P.J.A. Ruttink, J.L. Holmes and P.C. Burgers. "On the Dissociation Characteristics of H_2COH^+ Ions and their Participation in the H_2 Catalyzed Isomerization of COH^+ to HCO^+." *International Journal of Mass Spectrometry and Ion Processes* 77 (1987): 141-154.

160. J.M. Buschek, J.L. Holmes and J.K. Terlouw. "CH_3OCH^+ a New Stable $C_2H_4O^+$ Isomer and a Reassessment of the Oxirane$^+$ Potential Surface." *Journal of the American Chemical Society* 109 7321-7325 (1987): 7321-7325.

161. C.E.C.A. Hop, P.C. Burgers, R. Postma, J.K. Terlouw and J.L. Holmes. "The Isomeric $[C_2H_6O_2]^+$ Hydrogen Bridged Radical Cations $[CH_2O(H)..H..OCH_2]^+$, $[CH_3$-$O(H)...H...OCH]^+$ and $[CH_3$-$O(H)...H...OCH]^+$; Theory and Experiment." *Journal of the American Chemical Society* 109 (1987): 7315-7321.

162. C.E.C.A. Hop, K.J. van den Berg, J.L. Holmes and J.K. Terlouw. "$[HCNO]^{+\bullet}$, $[HNCO]^{+\bullet}$ and their Neutral Counterparts Studied by Mass Spectrometry." *Rapid Communication in Mass Spectrometry* 1 (1987): 52-55.

163. M.C. Blanchette, J.L. Holmes and F.P. Lossing. "The Ethyl Halides; Stable Neutral and Radical Cation Isomers $[C_2,H_5,X]$ where X = F,Cl,Br,I." *Organic Mass Spectrometry* 22 (1987): 701-709.

164. J. Bordas-Nagy and J.L. Holmes. "Kinetic Energy Spectra of high Rydberg Fragments from keV Collisions between Small Ions and Inert Gas Atoms." *International Journal of Mass Spectrometry and Ion Processes* 82 (1988): 81-99.

165. C.E.C.A. Hop, J. Bordas-Nagy, J.L. Holmes and J.K. Terlouw. "The Elusive Methylene Ylides CH_2ClH, CH_2FH and CH_2OH_2." *Organic Mass Spectrometry* 23 (1988): 155-165.

166. J. Bordas-Nagy and J.L. Holmes. "The Effect of Vibrational Energy Content on the Neutralization-Reionization Mass Spectra of $H_2^{+\bullet}$ Ions." *Organic Mass Spectrometry* 23 (1988): 334-337.

167. B.L.M. van Baar, P.C. Burgers, J.L. Holmes and J.K. Terlouw. "The Unimolecular Chemistry of $[1,2$-Propanediol$]^{+\bullet}$: A Rationale in Terms of Hydrogen Bridged Radical Cations." *Organic Mass Spectrometry* 23 (1988): 355-363.

168. M.C. Blanchette, J.L. Holmes, C.E.C.A. Hop and A.A. Mommers. "The Ionization of Fast Neutrals by Electron Impact in the Second Field Free Region of a Mass Spectrometer of Reversed Geometry." *Organic Mass Spectrometry* 23 (1988): 495-498.

169. R. Postma, S.P. van Helden, J.H. van Lenthe, P.J.A. Ruttink, J.K. Terlouw and J.L. Holmes. "The $[CH_2CHOH/H_2O]^{+\bullet}$ System. A Theoretical Study of Distonic Ions, Hydrogen Bridged Ions and Ion-Dipole Complexes." *Organic Mass Spectrometry* 23 (1988): 503-510.

170. J.M. Buschek, J.J. Ridal and J.L. Holmes. "A Reinvestigation of the Collisional Activation Mass Spectra of $C_7H_7^+$ Mixtures." *Organic Mass Spectrometry* 23 (1988): 543-549.

171. C.E.C.A. Hop, J.L. Holmes, F.P. Lossing and J.K. Terlouw. "The Stability of $[CCl_4]^+$, $[Cl_2C\text{-}Cl\text{-}Cl]^+$, their Dications and Neutral Counterparts. *International Journal of Mass Spectrometry and Ion Processes* 83 (1988): 285-294.

172. C.E.C.A. Hop, M. Dakubu and J.L. Holmes. "Do the Aminopyridine Molecular Ions display Aniline or Pyridine-type Behaviour?" *Organic Mass Spectrometry* 23 (1988): 609-612.

173. C.E.C.A. Hop and J.L. Holmes. "Charge Reversal of the Hydrogen Dichloride Anion [ClHCl]." *International Journal of Mass Spectrometry and Ion Processes* 84 (1988): 331-335.

174. J.L. Holmes. "The Search for Novel Small Molecules and Radicals," in *The Structure of Small Molecules and Radicals.* New York: Plenum, 1988.

175. J.L. Holmes, F.P. Lossing and R.A. McFarlane. "Stabilization Energy and Positional Effects in Halogen Substituted Alkyl Ions." *International Journal of Mass Spectrometry and Ion Processes* 84 (1988): 209-215.

176. J.M. Buschek and J.L. Holmes. "$[C_7H_7]$ Radicals Studied by Neutralization-Reionization Mass Spectrometry; the o-Tolyl to Benzyl Radical Rearrangement." *Organic Mass Spectrometry* 23 (1988): 765-769

177. M.C. Blanchette, J. Bordas-Nagy, J.L. Holmes, C.E.C.A. Hop, A.A. Mommers and J.K. Terlouw. "Neutralization-Reionization Experiments; a Simple Metal Vapour Cell for V.G. Analytical ZAB-2F Mass Spectrometers." *Organic Mass Spectrometry* 23 (1988): 804-807.

178. J. Bordas-Nagy, J.L. Holmes and C.E.C.A. Hop. "keV Collisions of Methonium Ions. The Properties of CH_5^+ and CH_5^{++} and the Generation of High Rydberg Fragments therefrom." *International Journal of Mass Spectrometry and Ion Processes* 85 (1988): 241-258.

179. J.L. Holmes, F.P. Lossing and A. Maccoll. "The Heats of Formation of Alkyl Radicals from Appearance Energies." *Journal of the American Chemical Society* 110 (1988): 7339-7342.

180. J.L. Holmes and F.P. Lossing. "Heats of Formation and Bond Dissociation Energies in Halogen Substituted Methyl and Ethyl Radicals." *Journal of the American Chemical Society* 110 (1988): 7343-7345.

181. J. Bordas-Nagy and J.L. Holmes. "keV Collisions of $[H_3]^+$ and Isotopomer Ions." *Chemical Physics* 127 (1988): 419-434.

182. S. Olesik, T. Baer, J.J. Ridal, J.M. Buschek, J.L. Holmes and J.C. Morrow. "The Dissociation Dynamics of Halotoluenes; the Production of Tolyl, Benzyl and Tropylium $(C_7H_7)^+$ Ions." *Organic Mass Spectrometry* 24 (1989): 1008-1016.

183. J.L. Holmes. "Ion Structures, Neutral Structures. Explorations in Mass Spectrometry." *Advances in Mass Spectrometry* 11 (1989): 53-79.

184. M.C. Blanchette, J.L. Holmes, C.E.C.A. Hop and A.A. Mommers. "Electron Impact Ionization of Fast Neutral Species in the Second Field Free Region of a Mass Spectrometer of Reversed Geometry." *Advances in Mass Spectrometry* 11 (1989): 192-193.

185. J. Bordas-Nagy and J.L. Holmes. "Collision Induced Dissociations of H_3^+ The Role of a Non-adiabatic Transition in H^+ Fragment Generation; the Dependence of Spin Conservation on the Target Gas." *Advances in Mass Spectrometry* 11 (1989): 752-753.

186. P.C. Burgers and J.L. Holmes. "Kinetic Energy Release in Metastable Fragmentations." *Advances in Mass Spectrometry* 11 760-761 (1989).

187. C.E.C.A. Hop, J.L. Holmes, G. Schaftenaar and J.K. Terlouw. "The Gas Phase Protonation of Isocyanic and Fulminic Acids." *Advances in Mass Spectrometry* 11 (1989): 960-961.

188. C.E.C.A. Hop, J.L. Holmes and J.K. Terlouw. "A Combined Collisional Activation and Neutralization-Reionization Study of Two Long-sought $C_2H_2O^+$ Isomers; $[Oxirene]^{+\bullet}$ and $[COCH_2]^+$." *Advances in Mass Spectrometry* 11 (1989): 962-963.

189. M.C. Blanchette, J. Bordas-Nagy, J.L. Holmes, C.E.C.A. Hop and J.K. Terlouw. Neutralization-Reionization Mass Spectra of Isotopically Labelled H_3O^+ and CH_5^+ Ions. *Advances in Mass Spectrometry* 11 (1989): 1014-1015.

190. K.J. van den Berg, J.L. Holmes. "C.E.C.A. Hop and J.K. Terlouw. $[HNCO]^{\bullet+}$, $[HCNO]^{\bullet+}$, $[CNOH]^{\bullet+}$ and their Neutral Counterparts Studied by Mass Spectrometry." *Journal of the American Chemical Society* 111 (1989): 72-75.

191. C.E.C.A. Hop, J.L. Holmes and J.K. Terlouw. "The Oxirene Radical Cation and its Neutralization in the Gas Phase." *Journal of the American Chemical Society* 111 (1989): 441-445.

192. J.L. Holmes and F.P. Lossing. "Bond Strengths in Even Electron Ions and the Proton Affinities of Free Radicals." *International Journal of Mass Spectrometry and Ion Processes* 92 111-122 (1989): 111-122.

193. M. Dakubu and J.L. Holmes. "The Halo-acetyl Ions; a Thermochemical Study." *Organic Mass Spectrometry* 24 (1989): 461-464.

194. C.E.C.A. Hop, J.L. Holmes, P.J.A. Ruttink, G. Shaftenaar and J.K. Terlouw. "The Isomeric Ions produced by the Gas Phase Protonation of HNCO and HCNO." *Chemical Physics Letters* 156 (1989): 251-259.

195. C.E.C.A. Hop, J.L. Holmes, M.W. Wong and L. Radom. "Neutralization-Reionization of CH_4^+ at which Stage does Fragmentation Occur?" *Chemical Physics Letters* 159 (1989): 580-586.

196. J. Bordas-Nagy, J.L. Holmes and C.E.C.A. Hop. "Translational Energy Spectroscopy of Neutralization-Reionization Processes." *International Journal of Mass Spectrometry and Ion Processes* 94 (1989): 189-203.

197. M.C. Blanchette, J.L. Holmes and F.P. Lossing. "The Fragmentation of Ionized Alkyl Phenyl Ethers." *Organic Mass Spectrometry* 24 (1989): 673-678.

198. J.L. Holmes. "The Neutralization of Organic Cations." *Mass Spectrometry Reviews* 8 (1989): 513-539.

199. P.C. Burgers and J.L. Holmes. "Kinetic Energy Release in Metastable Ion Fragmentations." *Rapid Communication in Mass Spectrometry* 3 (1989): 279-280.

200. M. Sirois, J.L. Holmes and C.E.C.A. Hop. "The Low Energy Fragmentations of Five Isomeric $(H_3,C,N,O_2)^+$ Ions." *Organic Mass Spectrometry* 25 (1990): 167-173.

201. J.L. Holmes, F.P. Lossing, A.A. Mommers, A. Maccoll and M. Mruzek "Assigning Structures to Isomeric $[C_5H_{10}]^+$ Ions; the Generation of Ionized Ethylcyclopropane from Pentan-1-ol and 1-chloropentane." *Organic Mass Spectrometry* 25 (1990): 381-385.

202. M.C. Bissonnette, M. George and J.L. Holmes. "The Experimental Investigation of $[C_5H_{12}O]^{+\bullet}$ Ion Structures Related to Neopentyl Alcohol and its Methyl Ether." *International Journal of Mass Spectrometry and Ion Processes* 101 (1990): 309-324.

203. J.L. Holmes and M. Sirois. "Hypervalent Radicals; the Generation of $CH_3O(H)CH_3$, $CH_3O(H)C_2H_5$ and their O-(D) Analogues by Neutralization of the Corresponding Cations." *Organic Mass Spectrometry* 25 (1990): 481-482.

204. M. George and J.L. Holmes. “Intermediate Ion Structures in the Fragmentation of Metastable 3-methyl-2-butanol Radical Cations.” *Organic Mass Spectrometry* 25 (1990): 605-608.

205. M.C. Bissonnette, M. George and J.L. Holmes. “Ion/Radical and Ion/Molecule Complexes: Experimental Evidence for their Participation in the Fragmentation of Ionized Neopentanol.” *Organic Mass Spectrometry* 25 (1990): 689-693.

206. C.E.C.A. Hop and J.L. Holmes. “Fragmentation Characteristics of the Unstable $[CH_3CO]^X$ Radicals generated by Neutralization of $[CH_3CO]^+$ Cations.” *International Journal of Mass Spectrometry and Ion Processes* 104 (1991): 213-226.

207. C.E.C.A. Hop and J.L. Holmes. “Neutralization-Reionization Mass Spectrometry: Efficiency of the Charge Exchange Process.” *Organic Mass Spectrometry* 26 (1991): 476-480.

208. J.R. Cao, M. George and J.L. Holmes. “Searching for the $[C_2H_4^{+\bullet}/CH_3OH]$ and $[C_2H_4^{+\bullet}/C_2H_5OH]$ Ion Molecule Complexes.” *Organic Mass Spectrometry* 26 (1991): 481-485.

209. J.L. Holmes and F.P. Lossing. “Ionization Energies of Homologous Organic Compounds; the Correlation with Molecular Size.” *Organic Mass Spectrometry* 26 (1991): 537-541.

210. C.E.C.A. Hop, P.J.A. Ruttink, H. Chen and J.L. Holmes. “Isomeric $[C,H_3,N,O]^{+\bullet}$ Ions and their Neutral Counterparts.” *Organic Mass Spectrometry* 26 (1991): 679-687.

211. M.C. Bissonnette, M. George and J.L. Holmes. “Aryl Cations; Searching for and Assigning Structures to $C_7H_5^+$ Isomers.” *Organic Mass Spectrometry* 26 (1991): 1019-1022.

212. J.L. Holmes, F.P. Lossing and P. Mayer. “Heats of Formation of Oxygen Containing Organic Free Radicals from Appearance Energy Measurements.” *Journal of the American Chemical Society* 113 (1991): 9723-9728.

213. D. Harnish and J.L. Holmes. “Ion-Radical Complexes in the Gas Phase; Structure and Mechanism in the Fragmentation of Ionized Alkyl Phenyl Ethers.” *Journal of the American Chemical Society* 113 (1991): 9729-9734.

214. J.L. Holmes, P.M. Mayer and A.A. Mommers. “The Emission of Radiation by Collisionally Activated Ions.” *Journal of the American Chemical Society* 113 (1991): 9405-9406.

215. J.R. Cao, M. George and J.L. Holmes. "The Fragmentation of 1- and 3-Methoxypropene Ions; Another Part of the $C_4H_8O^+$ Potential Surface." *Journal of American Society for Mass Spectrometry* 3 (1992): 99-107.

216. J.L. Holmes. "The Present State and Utility of Thermochemistry." *International Journal of Mass Spectrometry and Ion Processes* 118 (1992): 381-394.

217. J.R. Cao, M. George, J.L. Holmes, M. Sirois, J.K. Terlouw and P.C. Burgers. "The Test of an Analogy: Are Intramolecular Hydrogen Bonds in ∃-Diols and ∃-Hydroxyethers Preserved in their Molecular Ions?" *Journal of the American Chemical Society* 114 (1992): 2017-2020.

218. J.L. Holmes, P.M. Mayer and A.A. Mommers. "The Collision Induced Emission of Radiation; Lifetimes of Excited States Formed in the Collision Induced Dissociation Process and the Excitation of Target Gas Molecules." *Organic Mass Spectrometry* 27 (1992): 537-539.

219. J.L. Holmes, F.P. Lossing and P.M. Mayer. "Concerning the Heats of Formation of CH_2NH and CH_2NH^+." *Chemical Physics Letters* 193 (1992): 211-213.

220. D.V. Zagorevskii and J.L. Holmes. "Observation of Rhodocenium and Substituted-Rhodocenium Ions and their Neutral Counterparts by Mass Spectrometry." *Organometallics* 11 (1992): 3224-3227.

221. Y.R. Luo and J.L. Holmes. "The Estimation of the Heats of Formation for Vinyl Derivatives." *Journal of Physical Chemistry* 96 (1992): 9568-9571.

222. D.V. Zagorevskii and J.L. Holmes. "The Characterization of Titanocenium and Titanocene by Tandem Mass Spectrometry." *Organic Mass Spectrometry* 28 (1993): 49-55.

223. Y.R. Luo, and J.L. Holmes. "The Prediction of Bond Dissociation Energies for Common Organic Compounds." *Journal of Molecular Structure: THEOCHEM Theory and Computation in Chemistry* 281 (1993): 123-129.

224. D.V. Zagorevskii, Y.S. Nekrasov and J.L. Holmes. "A Metastable Ion Study of Substituted Cyclopentadienylmanganese Cations in the Gas Phase." *Journal of American Society for Mass Spectrometry* 4 (1993): 216-222.

225. D.V. Zagorevskii, H. Chen, J.L. Holmes, Y.S. Nekrasov, I.T. Chizhevski, N.V. Rastova and N.E. Kolobova. "Mass Spectrometry of Transition Metal B-complexes, 40. (0^4-Norbornadiene)-(0^5-cyclopentadienyl) rhodium Derivatives." *Organic Mass Spectrometry* 28 (1993): 463-469.

226. J.C. Traeger and J.L. Holmes. "The Heat of Formation of CH_2OH." *Journal of Physical Chemistry* 97 (1993): 3453-3455.

227. J.L. Holmes, P.M. Mayer, M. Vasseur and P.C. Burgers. "The Effect of -CN Substitution on the Heats of Formation of Organic Ions and Neutrals." *Journal of Physical Chemistry* 97 (1993): 4865-4870.

228. J.L. Holmes, F.P. Lossing and P.M. Mayer. "The Effects of Methyl Substitution on the Structure and Thermochemistry of the Cyanomethyl Radical and Cation." *Chemical Physics Letters* 212 (1993): 134-140.

229. J.L. Holmes. "Mass Spectrometry and the Pleasures of Science." *Organic Mass Spectrometry* 28 (1993): 1388-1394.

230. M. Sirois, M. George and J.L. Holmes. "The Neutral Counterparts of the $C_2H_7O^+$ Isomers." *Organic Mass Spectrometry* 29 (1994): 11-17.

231. Y.R. Luo and J.L. Holmes. "Homo- and Heterolytic X-C Bond Energies. Part I; Homolytic Bond Energies in Common Unsaturated Organic Compounds." *Journal of Physical Chemistry* 98 (1994): 303-312.

232. D. Harnish and J.L. Holmes. "The Efficiency of Collision Induced Ionization of Fast Neutrals; Effects of Neutral Internal Energy and Neutral Translational Energy." *Organic Mass Spectrometry* 29 (1994): 213-219.

233. H. Chen and J.L. Holmes. "The Generation of $[C_2O_2]^+$ and C_2O_2 and a Study of Ionized OC_3O and C_2O by Tandem Mass Spectrometry." *International Journal of Mass Spectrometry and Ion Processes* 133 (1994): 111-119.

234. Y.R. Luo and J.L. Holmes. "The Φ-B and n-B Conjugation Stabilization Energies in Vinyl and Phenyl Compounds." *Journal of Physical Organic Chemistry* 7 (1994): 403-411.

235. M. George, C.A. Kingsmill, D. Suh, J.K. Terlouw and J.L. Holmes. "The Hydrogen Bridged Ions $[CH_3CO—H—OCH_2]^+$ $[CH_2C(H)O—H\text{-}OCH_2]^+$ and $[CH_3C(H)O—H—OCH]^+$ and the Ion Dipole Complex $[CH_3C(O)^{+\cdots}O(H)CH_2]$ their Role in the Dissociation Chemistry of Ionized Acetol $[CH_3COCH_2OH]^+$." *Journal of the American Chemical Society* 116 (1994): 7807-7814.

236. J.L. Holmes, P.M. Mayer and A.A. Mommers. "Photon Emissions from $N_2^{\bullet+}$ Ion Beam-Target Gas Collisions in a Modified Commercial Sector Mass Spectrometer." *International Journal of Mass Spectrometry and Ion Processes* 135 (1994): 213-228.

237. D.V. Zagorevski and J.L. Holmes. "A Tandem Mass Spectrometry Study of the Gas Phase $RSC_6H_5Cr^+L$(R=H, C_6H_5; L = arene) and $C_6H_5SSC_6H_5Cr^+$ Ions." *Journal of American Society for Mass Spectrometry* 9 (1994): 928-934.

238. D.V. Zagorevskii, S.P. Palii and J.L. Holmes. "A Tandem Mass Spectrometric Investigation of $(C_2H_5)_2X^+$ Ions (X=Cl, Br, I); The Involvement of Classical and Non-Classical Ethyl Structures Therein." J *Journal of American Society for Mass Spectrometry* 9 (1994): 814-825.

239. D.V. Zagorevskii and J.L. Holmes. "A Tandem Mass Spectrometric Study of $C_2H_5I^+CH_3$ Ions; a Search for the Non-Classical Ethyl Cation Stabilized by Methyl Iodide." *Organic Mass Spectrometry* 29 (1994): 594-600.

240. Y.R. Luo, Yan An and J.L. Holmes. "Heats of Formation of Multi-substituted Positive Ions of Organic Species." *Organic Mass Spectrometry* 29 (1994): 579-586.

241. D.V. Zagorevskii and J.L. Holmes. "Neutralization-Reionization Mass Spectrometry Applied to Organometallic and Coordination Chemistry." *Mass Spectrometry Reviews* 13 (1994): 133-154.

242. Y.R. Luo and J.L. Holmes. "Homo- and Heterolytic Bond Dissociation Energies II. Heterolytic Bond Energies in Unsaturated Organic Chain Compounds." *Journal of Physical Chemistry* 98 (1994) 10368-10372.

243. Y.R. Luo and J.L. Holmes. "The Stabilization Energies of Polyene Radicals." *Chemical Physics Letters* 228 (1994): 329-332.

244. J.L. Holmes and P.M. Mayer. "Collision Induced Photon Emissions from 8 kV O_2^+ and $CO2^+$ Ion Beams." *Journal Mass Spectrometry* 30 (1995): 52-56.

245. J.L. Holmes and P.M. Mayer. "A Combined Mass Spectrometric and Thermochemical Examination of the C_2, H_2, N Family of Cations and Radicals." *Journal of Physical Chemistry 99* (1995): 1366-1370.

246. H. Chen and J.L. Holmes. "The Effects of Molecular Geometry on the Fragmentation of Ionized Maleic and Fumaric Acids; an Overdue Reappraisal." *Journal Mass Spectrometry* 30 (1995): 1083-1088.

247. J.L. Holmes and P.M. Mayer. "Collision-induced Photon Emissions from 8 keV Polyatomic Ions of Composition C_2, H_4, O^+ and C_2,H_5,Cl^+." *European Journal of Mass Spectrometry* 1 (1995): 23-31.

248. M. Dakubu, D.V. Zagorevskii and J.L. Holmes. "The Generation and Characterization of Neutral Silaethene by Neutralization - Reionization Mass Spectrometry." *European Journal of Mass Spectrometry* 1 (1995): 327-329.

249. D.V. Zagorevskii, J.L. Holmes, D.V. Zverev, Tatiana Y. Orlova and Y.S. Nekrasov. "The Structure of $C_5H_5RFe^+$ (R = F, Cl, Br, I, O, OH, OCH_3, C_6H_5, H) Ions in the Gas Phase and the Generation of their Neutral Counterparts by Neutralization-Reionization Mass Spectrometry." *Journal of American Society for Mass Spectrometry* 6 (1995): 1142-1153.

250. D.V. Zagorevskii and J.L. Holmes. "A Tandem Mass Spectrometry Study of the Zirconocenium Ion; the Generation of Zirconocene in the Gas Phase." *Organometallics* 14 (1995): 5041-5043.

251. D.V. Zagorevskii, M. Sirois, J.R. Cao, M. George, J.L. Holmes and C.W. Ross III. "Continuing the Search for a Non-classical Ethyl Cation Stabilized by Organic Molecules; the Triethyloxonium Ion." *Journal Mass Spectrometry* 31 (1996): 55-61.

252. D.V. Zagorevskii, J.L. Holmes and J.A. Stone. "The Characterisation of $HOC_6H_4^+$ and $C_6H_5O^+$ Ions by Ion-Molecule Reactions." *European Journal of Mass Spectrometry* 2 (1996): 341-345.

253. D. Dawson, H. Chen and J.L. Holmes. On the Structure of $C_2O_2^+$ Generated from $C_3O_2^+$." *European Journal of Mass Spectrometry* 2 (1996): 373-375.

254. D.V. Zagorevskii, J.M. Regimbal and J.L.Holmes. "A Tandem Mass Spectrometry Study of $[C_6,H_5,O]^+$ Ions." *International Journal of Mass Spectrometry and Ion Processes* 160 (1997): 211-222.

255. D.V. Zagorevskii, J.L. Holmes, C.H. Watson and J.R. Eyler. "A Tandem Mass Spectrometry and FTICR Study of RMn^+ (Crown Ether) Complexes in the Gas Phase." *European Journal of Mass Spectrometry* 3 (1997): 27-36.

256. J.W. Gauld, J.L. Holmes and L. Radom. "An Evaluation of Additivity Schemes for the Estimation of Heats of Formation of Distonic Radical Cations." *Acta Chemica Scandinavica* 51 (1997): 641-645.

257. D.V. Zagorevskii, J. L. Holmes and C.W. Ross III. "A Tandem Mass Spectrometry and FTICR Study of Ionized Ethylated Acetone and Deuterated Analogues. " J*Journal of American Society for Mass Spectrometry* 8 (1997): 327-336.

258. D.V. Zagorevskii and J.L. Holmes. "The Generation and Identification of Neutral $CpFeC_5H_4X$ (X = O, CH_2, CO) Complexes in the Gas Phase by Tandem Mass Spectrometry" *Organometallics* 16 (1997): 1969-1973.

259. D.V. Zagorevskii and J.L. Holmes. "The Heat of Formation of the $[C_6, H_5, O]^+$ Isomeric Ion, Protonated 6-Oxafulvalene." *International Journal of Mass Spectrometry and Ion Processes* 167/168 (1997): 231-234.

260. L.M. Fell, J.T. Francis, J.L. Holmes and J.K. Terlouw. The Intriguing Behaviour of (ionized) Oxalacetic Acid investigated by Tandem Mass Spectrometry. *Int. J. Mass Spectrom*., Ion Processes 165/166 (1997): 179-194.

261. C. Aubry, J.L. Holmes and J.K. Terlouw. "The Effect of Methyl Substitution on the Thermochemistry of Ketene." *Journal of Physical Chemistry* 101 (1997): 5958-5961.

262. D.V. Zagorevskii and J.L. Holmes. False Recovery Signals in Neutralization-Reionization Mass Spectra. *European Mass Spectrometry* 3 (1997): 317-319.

263. C. Aubry, M.J. Polce, J.L. Holmes, P.M. Mayer and L. Radom. Dimethyl Carbene, its Radical Cation and Dication. *Journal of the American Chemical Society* 119 (1997): 9039-9041.

264. C. Aubry, J.L. Holmes and J.C. Walton. "The Thermochemistry of the 1- and 2-Adamantyl Radicals and Cations." *Journal of Physical Chemistry* 102 (1998): 1389-1393.

265. C. Aubry and J.L. Holmes. "Butyl Cations and their Gas-Phase Dissociation Chemistry: Uniting Experiments with Theory." *Journal of Physical Chemistry* 102 (1998): 6441-6447.

266. J.L. Holmes, C. Aubry and P.M. Mayer. "Proton Affinities of Primary Alkanols: An Appraisal of the Kinetic Method." *Journal of Physical Chemistry* 103 (1999): 705-709.

267. Ya-Ping Tu and J.L. Holmes. "Fragmentation of Substituted Oxonium Ions. The Role of Ion-Neutral Complexes." *Journal of the American Society of Mass Spectrometry* 10 (1999): 386-392.

268. J. Cao and J.L. Holmes. "Determining Proton Affinities of Nitriles by the Kinetic Method." *European Journal of Mass Spectrometry* 5 (1999): 19-22.

269. D.F. Dawson and J.L. Holmes. "The Generation of CF_2CO and CF_2CO^+ from Ionized CF_2CFOCF_3. The First Experimental Observation of Gas Phase Neutral Perfluoroketene." *Journal of Physical Chemistry* 103 (1999): 5217-5220.

270. D.V. Zagorevskii and J.L. Holmes. "Neutralization-Reionization Mass Spectrometry applied to Organometallic and Coordination Chemistry." *Mass Spectrometry Reviews* 18 (1999): 87-118.

271. Ya-Ping Tu and J.L. Holmes. "Selective Radical Removal from Proton-bound Dimers. A Strategy for Studying Solvated Distonic Ions." *Journal of the American Chemical Society* 122 (2000): 3695-3700.

272. J. Cao and J.L. Holmes. “The Proton Affinities of Amino-alkanes; a Test Case for the Kinetic Method.” *International Journal of Mass Spectrometry* 195/196 (2000): 525-532.

273. D.V. Zagorevskii, C. Aubry and J.L. Holmes. “A Tandem Mass Spectrometry Study of $[CH_2X_2Si]^+$ Ions [X=H,D,Cl] and the Generation of their Neutral Counterparts.” *European Journal of Mass Spectrometry* 6 (2000): 89-96.

274. Ya Ping Tu and J.L. Holmes. “The Chemistry of Solvated Distonic Ions: Preparation, Isomerisation and Fragmentation.” *Journal of the American Chemical Society* 122 (2000): 5597-5602.

275. C. Aubry, J. Cao and J.L. Holmes. “The Proton Affinities of Simple Amines; Activation Entropies and their Effect on the Kinetic Method for Evaluating Proton Affinities.” *The Journal of Physical Chemistry A* 104 (2000): 10045-10052.

276. C. Aubry and J.L. Holmes. “The Behaviour of Oxygen as a Collision-Induced Dissociation Target Gas.” *Journal of American Society for Mass Spectrometry* 12 (2001): 23-29.

277. C. Aubry and J.L. Holmes. “Correlating Thermochemical Data for Gas Phase Ion Chemistry.” *International Journal of Mass Spectrometry* 200 (2000): 277-284.

278. C. Aubry and J.L. Holmes. “The Effect of Phenyl Substitution on the Thermochemistry of Gas Phase Ions and their Neutral Counterparts.” E*uropean Journal of Mass Spectrometry* 6 (2000): 369-376.

279. Ya-Ping Tu and J.L. Holmes. “Ion-Neutral-Neutral Complexes in Unimolecular Reactions: Formation of Proton-Bound Alkanol Dimers from Alkoxylated Oxonium Ions.” *Journal of the Chemical Society, Perkins Transactions 2* (2001): 1378-1382.

280. N. Morlender-Vais and J L. Holmes. “The Proton Affinities of Two Weakly Bidentate Molecules; 1,2-Dimethoxyethane and Methoxyacetone.” *International Journal of Mass Spectrometry* 210/211 (2001): 147-152.

281. J Cao and J. L. Holmes. “The Determination of Proton Affinities of Secondary Alcohols from the Dissociation of Proton Bound Molecular Trios. A New Application of the Kinetic Method.” *European Journal of Mass Spectrometry* 7 (2001): 243-246.

282. J.Cao, W. Sun and J. L. Holmes. “The Ions CH_6O^+ and CH_7O^+.” *International Journal of Mass Spectrometry* 217 (2002): 179-184.

283. J. Cao, W. Sun, Ya-Ping Tu and J. L. Holmes. “The Water Solvated Methanol Ion and its Isomers, Experiment and Theory.” *International Journal of Mass Spectrometry* 222 (2003): 41-48.

284. T. D. Fridgen and J. L. Holmes. “A Computational Study of the Methane Catalyzed Isomerization of HCO^+ to HOC^+ and the Elimination of Methane from the Metastable Methoxymethyl Cation.” *European Journal of Mass Spectrometry* 10 (2005): 747-754.

285. X. Wang and J. L. Holmes. “Exploring the Potential Energy Surface of Ion-Molecule Pairs by Experiment and Theory; Acetaldehyde and Methanol.” *International Journal of Mass Spectrometry* 242 (2005): 75-85.

286. X. Wang and J. L. Holmes. “A Study of the Isomerization and Dissociation of Formal [Acetone/Methanol] Ion-Molecule Complexes.” *Canadian Journal of Chemistry* 83 (2005): 1903-1912.

287. X. Wang and J. L. Holmes. “The Unexpected Decarbonylation of Ionized 2,3-Pentanedione and Related Diketones.” *International Journal of Mass Spectrometry* 249-250 (2006): 222-229.

288. X. Wang, W. Sun and J. L. Holmes. “The Water-Assisted Interconvertions and Dissociations of the Acetaldehyde Ion and its Isomers. An Experimental and Theoretical Study.” *The Journal of Physical Chemistry A* 110 (2006): 8409-8417.

289. J. L. Holmes, C. Aubry and X. Wang. “Assessing Thermochemical Data.” *International Journal of Mass Spectrometry* 267 (2007): 263-267

290. J. L. Holmes, K. J. Jobst and J. K. Terlouw.” Small (poly)unsaturated Oxygen Containing Ions and Molecules; a Brief Assessment of their Thermochemistry Based on Computational Chemistry.” *European Journal of Mass Spectrometry* 15 (2009): 261-273.

291. J. L. Holmes and Christiane Aubry. “Neutral and Ion Thermochemistry; an Account of its Present Status and Significance.” *Mass Spectrometry Reviews* 28 (2009): 694-700.

292. J. L. Holmes and Christiane Aubry. “Group Additivity Values for Estimating the Enthalpy of Formation of Organic Compounds; an Update and Reappraisal. 1. C, H and O.” *The Journal of Physical Chemistry A* 115 (2011): 10576-10586.

293. S. Curtis, J. Renaud, J. L. Holmes and P. M. Mayer. “Old Acid, New Chemistry; Negative Metal Anions Generated from Metal Oxalates and Others.” *Journal of American Society for Mass Spectrometry* 21 (2010): 1944-1946.

294. J. L Holmes and Christiane Aubry. “Group Additivity Values for Estimating the Enthalpy of Formation of Organic Compounds; an Update and Reappraisal: 2. C, H, N, O and Halogen.” *The Journal of Physical Chemistry A* 116 (2012): 7196-7209.

295. J. L. Holmes and Christiane Aubry. "A Practical Guide to Gas Phase Neutral and Ion Thermochemistry." *International Reviews in Physical Chemistry* 33, no. 2 (2014): 209-218.

296. N. A. van Huizen, T. M. Luider, K. J. Jobst, J. K. Terlouw, J. L. Holmes and P. C. Burgers. Interaction of Metal Cations with Functionalized Hydrocarbons in the Gas Phase; further experimental evidence for solvation of Metal Cations by the Hydrocarbon Chain. *European Journal of Mass Spectrometry* 22 (2016): 61-70.

297. P. C. Burgers, J. L. Holmes and J. K. Terlouw. Metal Ion Hydrocarbon Bidentate Bonding in Alkyl Acetates, Methyl Alkanoates, Alcohols and 1-Alkenes: A Comparative Study. *European Journal of Mass Spectrometry* 22 (2016): 297-306.

INDEX