1991

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1991. *Transactions of the Nebraska Academy of Sciences,* XVIII: 167–171

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R. W. Allington

4700 Superior Street
Lincoln, Nebraska 69504

This paper was given as a special lecture at the 1988 annual meeting of the Nebraska Academy of Sciences. It is a personal account of the beginnings of Dr. Allington's successful company—Editor.

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Isco was started as a part-time business in 1957 to repair scientific instruments used at the University of Nebraska. This was at the suggestion of Robert Feeney, then chairman of the University of Nebraska—Lincoln (UNL) Biochemistry Department. While I was a student and still in the hospital recovering from polio, he introduced me to my future business partner, Jacob Schafer. Jake was a toolmaker at the Elgin Watch Company in Lincoln. I was taking what was essentially a dual major in chemistry and electrical engineering at UNL. We started with Jake repairing the microscopes and me repairing almost everything else on weekends when I was furloughed from the hospital. Jake worked in his basement and I worked in my father's garage. After a few months of repair work, we started getting requests for custom one-of-a-kind pieces of scientific apparatus. Pretty soon we started getting jobs that required machine work, but by then we had enough money in the kitty to buy our first machine tool—a little nine-inch South Bend lathe for Jake's basement. (By the way, **Isco** still has this lathe and uses it in its instrument division engineering model shop.)

It was at this time that we got a request for a scientific instrument that wasn't "one-shot." It was a fraction collector for liquid chromatography. This served a market niche I knew something about—biochemical laboratory instruments. My father was a plant-virus researcher and chairman of UNL's Plant Pathology Department, so I knew a little about biochemical- and plant-research methodologies. (Incidentally, **Isco** still makes fraction collectors; it is about a three-million dollar segment of our business.) My father gave me a copy of the United States Department of Agriculture's Agricultural Research Service professional-staff roster. Presto, now I had the makings of a mailing list for marketing fraction collectors by direct mail. It was easy to check off the job titles that had to do with biochemical research. A Lincoln printer of church bulletins printed some not-so-snazzy, but adequate brochures for the product, and suddenly we had a shoestring manufacturing-business going. The electronics in the product were crude (using government-surplus tubes in generic tin-box cases) as were the mechanicals (test-tube reels were punched out of sheet aluminum with a punch activated by a 3-pound sledgehammer), but the important point was that in this one particular market niche—separations apparatus for biochemical research—other companies produced products of no better caliber than ours. Or, looking at it another way, our little shoestring, part-time, garage-and-basement operation could compete because our competitors didn't know much more about what they were doing than we knew about what we were doing.

About this time our first big trial hit. The Elgin Watch Company closed down and Jake had to decide whether to gamble on **Isco** being a full-time business for him or to get another job which would probably involve moving out of town. Since we were starting to receive orders by mail for our fraction collectors and since Timex was the only successful U.S. watch company at the time, Jake decided to stay in Lincoln with **Isco**.

I started looking for other products that we could sell to the same market. The first one was the most obvious—an even cheaper version of our fraction collector. The next was an instrument for fractionating centrifuged density-gradient tubes. It was followed by development work on an ultra-violet detector for liquid chromatography. After it was developed, we had a liquid-chromatography system to sell, which put us in the biochemical-separations business. All of this stuff was patentable and patents were very valuable as competition stiffened up later on in the 60s. We weren't the only ones to recognize biochemical instrumentation as an underserved market area.

Another product line that started during the garage-shop era was plant growth-chambers. We were approached by a professor in UNL's Agronomy Department to make a small plant growth-chamber, not much bigger than a large kitchen refrigerator, with precise humidity control as well as the usual temperature control and solar simulation. Up until then, plant growth-chambers did not have effective humidity controls. We built him one and thus had another item to add to our product line. Later we developed a larger plant-growth chamber, about as large as could be shipped without knocking it down. Both plant growth-chambers were considerably more sophisticated than any other units then available. We were aiming for the "high end" of the market and trying to build a unit that incorporated instrument expertise that other makers didn't have. We were successful but this success was a mixed blessing. As a result, I did not consider **Isco** to be limited to the separation-science business, and this lack of focus prevented us from fully capitalizing on the so-called "HPLC [high-performance liquid chromatography] revolution" ten years later.

In 1959 we were approached for a big one-of-a-kind job by a professor in the Department of Veterinary Science who wanted a radio-telemetering system for monitoring the stomach pressure in ruminant animals. Ruminants, such as sheep and cattle, have a preliminary stomach or rumen which acts more like a fermentation chamber than a true stomach. The fermentation process can produce copious quantities of gas, and if this gas causes the liquid contents to foam so that it can't be burped out, the animal will bloat and probably die if not treated. The purpose of the apparatus was for research on this problem. I was very naive about business at that time and so we just had a "handshake contract" on it. The project was technically difficult (the transmitter had to be small enough to be shoved down the animal's throat, yet had to float with the pressure sensor well out of the stomach contents so that it would not read a falsely high pressure, etc.). The receiver and recorder were not that easy either given 1959 resources. At any rate, the job took almost a year, throughout which I made frequent progress reports to the professor-customer. When it was done, we presented the apparatus and a bill for $3,500. Now we learned that our customer had neglected to get the funding to buy the apparatus. After some preliminary haggling, I was invited to UNL's business office where their chief purchasing agent offered me 10%—$350 take it or leave it. I figured that my pride was worth more than $350 so I flounced out, or flounced at least as well as somebody in a wheelchair can flounce. By the time I got home I wasn't feeling nearly so flouncy, in fact I felt terrible. When I got in the house, my mother told me I had a telephone call from somebody at Feed Service Corporation (now FSC) in Crete, Nebraska. I returned the call to Phil Anderson there, and he asked me if I would consider building another one of these systems which he needed in a big hurry to telemeter oxidation-reduction potential for studies in animal rumens. They made urea-ethanol-based feed supplements in which rumen oxidation-reduction potential was metabolically important. I managed to catch my breath and told him "Why, yes, indeed. We probably could supply you with one of these systems in just a couple of months, and how much would it be worth to you?" We settled on an amount of $10,000 and he immediately mailed me a purchase contract for it. My mother said it was a miracle, and I tend to agree. At the time I had a National Science Foundation Fellowship that precluded me from outside work except during school vacations. This whole business had happened about a week before Thanksgiving, so over Thanksgiving break I whipped up a design for a new transmitter including the electronic circuitry, electrodes and mechanical stuff to hold it together and keep everything where it belonged. Between Thanksgiving and Christmas, Jake Schafer built up all of the mechanical parts and assembled them. Over Christmas vacation I wired it and tested it and we delivered it to them just after New Year's Day. We got the $10,000 check which, by the way, was good. I was very impressed by the fact that there had been no effort to take advantage of me. Up until that time I intended an academic career like my father's and only a temporary or part-time involvement with **Isco**. Now I thought about the reliability of the verbal statements that I'd had from people in UNL about a staff position after I'd gotten a doctorate. I also thought of correspondence with other universities who had written me about my potential there as an NSF Fellow. After I wrote back expressing interest and

mentioning my use of a wheelchair, not one of them replied. On the other hand, I could see that there was going to be a tremendous growth in biochemical and agricultural research during the 1960s, that the instrument markets in these areas were poorly serviced by the current manufacturers and that we had the start of a viable business. A company starting out could just ride the wave up, even if they made a lot of mistakes. By the spring of 1960, I decided I was going to devote myself to **Isco** instead of an academic career. My intent was to be able to support myself, and I had no business plan beyond that.

By this time **Isco** had hired a real employee, Norman Ertl, another former Elgin toolmaker, and had about $12,000 in retained earnings. Most of the earnings were from the Feed Service Corporation rumen-telemetering project. This about describes the state of the company as we embarked upon making it a full-time operation with a real, honest-to-goodness place of business in 1961.

With the $12,000 in the kitty and a $10,000 loan from my father (who had to remortgage his house to get it), we built and equipped a 40-by-46 foot steel building near the Goodyear plant [in Lincoln]. By the way, after several expansions this building grew and was eventually sold to become the present Junior Achievement building at 5630 Seward Avenue. In that first year of 1961 we experienced a positive cash-flow, but lost money due to depreciation. Believe me, this is a lot better position to be in after your first year of business than having a profit with a negative cash-flow. Every year after 1961 **Isco** has made a profit. We paid back my father in 1963 and expanded the building to double its size. By this time we had quite a number of research instruments in our product line and were finding that we were able to market the biochemical ones to biochemists outside of agriculture. This would prove to be very important later on. In 1964 my business partner, Jake Schafer, wanted out of the company and forced me to buy him out. The book value of the company at that time was about $60,000 and Jake wanted half of it. We had no cash, and it looked for a while as if **Isco** might have to be liquidated. However, I was able to have a private sale of stock to some of my friends and relatives and raised about $40,000, for which they got about 35% of the stock. After paying off Jake, this gave **Isco** $10,000 more long-term capital, and it left about 10% of the stock residing in the corporate treasury. This would prove useful for stock options for attracting key employees. Two key employees—Frank Lederer, currently Executive Vice President and John Allington, currently marketing Vice President for the Instrument Division—did join the company at this time.

By 1966 the company employed about 50 people and discontinued manufacturing specialized one-of-a-kind instruments because of their low profit-potential and because they were too disruptive to monkey around with. Even more importantly, one-of-a-kinds diluted the effort to build up a product line to exploit our biochemistry- and agricultural-research markets. Even at that, our product line wasn't very coherent. In addition to separation science, it included light measurement (we had developed the world's first portable spectroradiometer), an apparatus for applying test insecticides topically to insects, and plant growth-chambers. It was becoming apparent that effort expended on bulky agricultural-research products such as plant growth-chambers diluted our efforts in the biochemical separations market, the area in which were a more efficient producer. **Isco** had expanded to the fullest extent possible on our original 200-by-150 foot lot, and there was no possibility for further contiguous land-purchase. We leased some plant space across town and split up the operation with administration, sales, engineering, and research and development at the original location, and manufacturing processes at a leased location on the west side of the municipal airport in an old Air Force building. This did not prove to be very efficient. We needed to buy a large lot and put up a new building, and we needed to do it badly. Furthermore, since neither the manufacturing processes nor the marketing of plant growth environmental chambers fit in with making and marketing biochemical-laboratory instruments, I wanted to split the company into two separate divisions, with one division concentrating on each product line. Fortuitously, a newly-created Environmental Chamber Division could utilize the leased airport-building. In 1967 I tried to get the long-term financing necessary to realize this goal. I tried various sources, expecting success. "Why not?" I thought. "After all, **Isco** has a good financial and growth record; we've been profitable and growing rapidly for five years." I tried the banks. Silly me. There was no way they were going to make a long-term loan to **Isco**. They wanted sure things like financing the fourth gas station at a three-station street intersection. A Small Business Administration loan didn't look feasible; they were reportedly very hard to get without connections and, if you should get one, it carried a burden of reporting requirements that would have made us so top heavy with administrative overhead that the operation would have become inefficient. I had only one positive reply to inquiries about venture capital. This

venture capitalist wanted to sell **Isco** some land and a building at greater than the prevailing price, finance it at greater than the prevailing interest rate plus get 50% ownership of **Isco**. The proposal was so unfavorable that it scared me off immediately. In retrospect, this was lucky since the venture-capital firm was the Commonwealth Industrial Bank. I got a much better offer from a developer in Denver; his price for a completed land-and-building package was reasonable and he didn't want any equity in **Isco**; he just wanted us to make the payments. After all the payments were made, the land and building would be ours. I was about to move **Isco** to Denver when an investment banker from Omaha showed us how we could issue Industrial Development Act (IDA) bonds. This is the type of tax-free bond that the federal government has recently abolished. In 1968 **Isco** issued $485,000 worth of these bonds. The proceeds were used to buy the land and build the initial part of the present building at 48th and Superior Streets [Lincoln] on the original 20-acre lot. The building was built and we moved in very early in 1969. Frank Lederer, who had been **Isco**'s manufacturing manager, was set up as head of a small, newly-formed Environmental Chamber Division at the leased airport building. The rest of **Isco** was designated as the Instrument Division.

At this time something unexpected happened. The heretofore very generous federal funding of agricultural research suddenly dried up. I suppose it was one of the early economic victims of the Vietnam War. By early 1970 the agricultural research-apparatus market was absolutely terrible. Retrospectively, the agricultural-research dynamism of the 1960's did produce the "Green Revolution" which abolished hunger in most of the world except Africa. The loss of the agricultural-research market was not a real blow to the Instrument Division since that division's products and marketing effort had gravitated toward the biochemical-separations market. At the time, biochemically-oriented medical research was starting the rapid growth that it enjoyed during the 1970s, so the Instrument Division continued on with scarcely a bump in its growth, just by a partial redirection of its marketing effort. However, this was not the case with the Environmental Chamber Division; they had a product that was absolutely useless for any other purpose except agricultural research. Not only that, our segment of the environmental-chamber market was at the fancy, highly instrumented and high-priced end—just the thing researchers would not buy if they were short on funds. One obvious possibility would be to lay off Frank Lederer and the three people working for him. However, during the year that the Environmental Chamber Division had been in operation, I could see that Frank was an excellent manager, design engineer, and an entrepreneur in his own right. Further, the Instrument Division had already developed a primitive, first-generation sampler for monitoring the pollution of water. I felt that the time was right for a water-pollution-monitoring product line because it was apparent that the United States was finally going to clean up its water-pollution problems in earnest. For example, at that time large parts of Lake Erie were dead and the Cuyahoga River through Cleveland was so badly polluted that it usually caught on fire at least once each summer. But pollution-control instruments didn't fit into the Instrument Division's market. So I turned this product over to Frank's operation and lopped the word "chamber" off of Environmental Chamber Division to make it Environmental Division. He started manufacturing this pollution sampler, while at the same time developing a greatly improved version. The next year he introduced the improved version, which was the industry's first really good automatic sampler for sewage and polluted water. The Environmental Division's sales improved dramatically as the sampler gained rapid customer acceptance. The following year, a pioneering flow-meter was introduced for measuring flow in sewers. In 1975 this was replaced with a better flow-meter. Over the years, the Environmental Division's product line improved and expanded to the point where it is the dominant force in its part of the wastewater-monitoring market and also an important player in the pure groundwater-monitoring field.

Going back to 1969 at the Instrument Division, because of a late start due to the distraction of unrelated products (we were still selling spectroradiometers) and something that could be described as either bad luck or bad judgment, **Isco** got off to a poor start in HPLC. Our first HPLC pump was a high-pressure syringe type designed for the relatively low flow-rate required by 1-mm-diameter pellicular-columns which were popular at that time. It was a syringe pump because we were developing a heat-of-adsorption type HPLC detector that was more sensitive and easier to use than the available detectors of that kind. The supposed beauty of this type of detector was that it was a universal detector. Its disadvantages were flow-sensitivity and noise even noticeable with a syringe pump, temperature-sensitivity, and its odd peak-shape—almost but not quite the derivative of the concentration peak. We eliminated the flow-sensitivity and noise problem by a unique heat-flux method applied within the detector's packing bed, and eliminated the temperature

sensitivity problem by building the detector-head and heat-exchanger into a "soup Thermos" style Dewar. However, we couldn't do much about the odd peak shape. Unfortunately the popularity of heat-of-adsorption detectors fell drastically by the time the design was complete and we were ready to go into production, so I had to scrap the project before we spent any more money on it. At the same time, 1-mm-diameter pellicular columns were replaced by 4 1/2-mm diameter microparticulate columns whose 2 ml/minute flow-rates would empty our 375-ml syringe-pump in about three operating hours. The syringe-pump turned out to be saleable for industrial chemical applications, but we were left on the sidelines of the HPLC business with only our UV detectors and a digital integrator to offer to the mainstream of the HPLC market.

During this period our competitors developed strong patent positions in HPLC pumps. We made another abortive effort to enter the HPLC market in 1977-1978, but during the 1970s we were selling mostly classical liquid-chromatography equipment. In 1980 a small market for micro LC became apparent, and we developed a special syringe pump and an ultra-micro volume variable-wavelength absorbance detector for it. They are still the best of their kind. In 1982 **Isco** made another try at developing mainstream HPLC instruments and systems, and this time we connected. We now have a very competitive HPLC system line that includes a number of detectors, a good pump, two gradient systems, computer data and system management, columns and ancillary equipment such as a sample changer and injector. This is backed up by a good applications lab and customer-service department. Finally we are doing well in HPLC.

On the financial side from 1970 to 1977, short-term bank loans were used extensively for working capital to finance inventory. As a manufacturer we found out that inventory must be carefully controlled. This was a particular problem for **Isco**. At that time there were about 70,000 different kinds of parts in inventory at the Instrument Division and about a third that many at the Environmental Division. If unwieldy inventory such as this is not well-controlled, it consumes cash at an unbelievable rate. In 1977 and 1978 we installed a computerized "MRP" (Manufacturing Resources Planning) system which integrates inventory control, product structure, manufacturing-process scheduling, purchasing and incoming orders from customers. We developed the system ourselves. It was the first one for our size of business. Before we had this system, we lived from production crisis to production crisis and had plenty of angry customers because we couldn't meet delivery dates even on well-established products. With the use of this system we immediately got our inventory under better control, paid off more than $600,000 in short-term bank loans, and still had cash left over to put into short-term investments. We did this by squeezing over $800,000 out of inventory the first year. The second year of operation of this system we saved another $900,000 in inventory. Before we had this system, we had expediters in every production department who were more or less futilely trying to keep things moving smoothly. After we installed this system, we transferred all the expediters into more productive jobs and didn't lay anyone off. At the same time we greatly improved on-time deliveries to our customers.

In 1980 and 1981 **Isco** issued a total of a bit over $4 million in IDA bonds. The proceeds were used to expand the 48th-and-Superior building from 40,000 square feet to 110,000 square feet, and to acquire and remodel a facility at Westgate Industrial Park [Lincoln] for the Environmental Division. This put the Environmental Division behind Grandmother's Skillet Restaurant, with the Instrument Division still at the last stoplight before the old City Dump. Prestige locations. The Westgate Industrial Park building as we bought it was pretty much a shell, a high-ceilinged warehouse. We spent $1.2 million remodeling it into a plant for the Environmental Division. Since the ceiling was so high we divided it vertically into two floors, making a total of 80,000 square feet. Since then we have increased the Environmental Division plant to 150,000 square feet and have paid off all of the bonds.

In 1985 **Isco** issued stock to the general public for the first time. In this initial public offering, proceeds to the company were about $1.6 million—permanent long-term capital. The remainder of **Isco**'s permanent capital has come from retained operating profit. I feel that, with the new products introduced in the last two years by both divisions for their respective markets, things look good for the future. I am particularly happy about the marketing prospects for the Instrument Division's high-performance liquid chromatographs. HPLC is the largest volume analytical tool in use, and **Isco**'s HPLC systems are direct descendents of our products of the early 60s.