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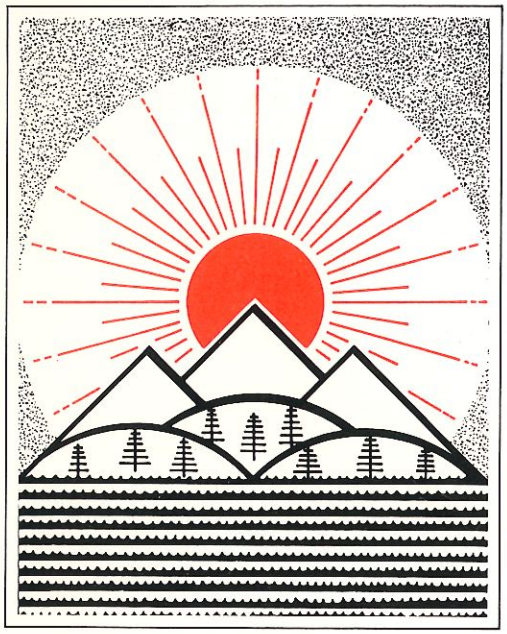

RESEARCH NEEDS IN HVAC SYSTEMS

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RESEARCH NEEDS
IN
HVAC SYSTEMS

Proceedings of a Workshop sponsored by the
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David E. Claridge, Editor

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The Influence of the Forces of Commerce on Engineering Design and Education

William Coad

Charles J.R. McClure and Associates

Don Bahnfleth initially contacted me and asked me to participate in this conference. As we got into the details, and I was working with Dave Claridge on the phone, I was trying to figure out just what the objective of this conference was. The impression was that some specific examples of research needs were what we desired; so I came up with this concept of "system losses", which, incidentally, is very much in need of research, and is also very specific.

I wrote a paper and was going to mail a copy. Then I started looking at the roster of people who were going to be attending. It became clear to me that the time might be better spent if I would share some of my thoughts on a topic to which I've dedicated the last 30 years of my life.

The problem isn't new. I grew up in the air conditioning business (starting as a mechanic in the late 40's). My father was a contractor. When I graduated from college all the other students were going into aerospace - the romance industry where the money was at that time. I went into the heating and air conditioning business. (Of course it had gotten me through college so I figured there was something good about it.) I was in contracting for a few years and I wanted to get more into where the action was in design, so I went to work for a consulting firm.

In 1957 I started teaching because I heard people in our industry in 1957 asking the same questions, having the same complaints, and the same concerns that Lou Bacon was talking about this morning.

I would like to share with you my perspective as a consultant. I've made a living designing systems. I've also had the opportunity of being very active for over 25 years as a lecturer and affiliate professor working with students and educational programs. I would like to approach the problem that we've been talking about here in two ways. First, philosophical perspective,

and then what I might call the "nitty-gritty" problems, with the educational systems. It's easy for me to talk about the education systems to you professors because I'm just on the periphery of it. I ask you to bear with me and I think you'll appreciate my concern.

Let's start off, then, with the philosophy.

> The difference between confidence and excellence in engineering lies more with the difference in philosophy than with a difference in technical skills.

To be simply competent an engineer has to have a high degree of technical skill. But what separates the competent engineer from the excellent engineer? It is philosophy! In systems design there are two philosophies. One philosophy is that the designer will develop an inventory of knowledge of products and components. Then, given a specific design problem, he will draw upon that inventory to construct the solution. This is the philosophy that's invoked by the majority of systems designers, much like a child working with an erector set who builds a structure out of the available components he has at his disposal. Some engineers have become very competent designing this way. Their degree of proficiency is directly related to their knowledge of available components. They have massive catalog libraries, they read trade magazines, they continually upgrade their ability by expanding their inventory of components so they can produce better designs, and it works.

Then, there's another philosophy of engineering design. This requires a creative imagination and a well-educated engineer who has a strong background in all the physical principles relating to the need at hand. In the case of engineering systems for HVAC, this includes thermodynamics, heat transfer, fluid mechanics, electric theory, materials and mechanics. When this engineer approaches a design problem he goes through a rigorous procedure of trying to identify every parameter related to the problem. Then he says, now, these are the parameters. This is what I'm setting out to do. With my knowledge of physics I will try to idealize the best system to satisfy all of those parameters. He's limited only by his ability to define the parameters, his understanding of physics, and his imagination. Then he idealizes a solution. Once he's got the best solution that he can think of for that problem he looks for the components he needs. If he can't quite get all

the components he needs he may either come up with a new product idea and get someone to make it (this is entrepreneurship), or he may yield a little on his idealized solution just because he can't find the exact components to fill that particular need.

Now, the engineer that uses the first philosophy is limited by his knowledge of available components. The engineer that follows the second philosophy is totally unlimited in his ability to come up with an ideal solution to the problem. But why do most engineers out of the vast majority of them use the first alternative? The reason is that we live in a commercial society!

The force of commerce puts pressure on the design community to use the former approach. As an example, think back to the mid-50's. There was a product, "double-duct high velocity boxes." The firms that made them wanted to convince the engineering community that every building should have a double duct high velocity system. That was in their best commercial interest, and they were very, very successful in doing that. If all the engineers had tried to idealize the best systems solutions maybe just a few of them would have ever used a double-duct high velocity box. That wouldn't have been advantageous to the commercial interest making the double-duct high-velocity boxes. So they went out and tried to convince engineers: "Here's a product to incorporate in your system."

Virtually every major building built in the late '50's and the '60's had double-duct high-velocity systems. This thing sort of festers on itself. The fan industry found they were selling great big fans instead of little bitty fans; so they were gaining by it, by giving the engineer another building block, another tinker toy. Then came the spiral duct industry; they were gaining by giving the engineer another tinker toy. This became the engineer's repertoire, his inventory of products.

In retrospect it is clear to see that everything's been moving on fads. Little innovation in day-to-day design. Building system design has been fads! The engineers have grabbed the tinker toys that were given to them. We have had the radiant floor panel system, we have had the double duct high velocity, we have the radiant ceiling systems, we have had the fan coil units--all these fads come along and then they go.

It's difficult to buy a double-duct high-velocity box today. The fad has gone and we have a new tinker toy called variable volume. Now the industry is offering a myriad of variable volume boxes and engineers are designing the systems to use them. I'll make a confession, I never did design a double-duct high-velocity system in my life, yet I was practicing during that whole era. I looked at the problem and I could never find a reason to do it.

Let's consider how commercial interests are so successful in dictating the philosophy practiced by these design engineers. They start when the engineers are very young (in educational progression terms). Our research comes from commercial interests. That's where all the money is, so that's where the research comes from. Every manufacturer's first line of research is product development. Most of it is done in-house.

Industry then says "we have to be looking at the future, so we're going to try to encourage some theoretical or pure research, something a little more fundamental than product development." We don't do that in-house, in most cases; at this level they go out to the universities. They may go directly to the university or they may go to their engineering society to fund the research at the university. They may convince the government through lobbying, that something is good and that it should be researched. Then the government will support the research at the universities.

However, with the funds emanating from commercial interest, the research is all aimed ultimately at developing a product. Developing a thing that solves a problem isn't aimed at systems design. With the research aimed at product development we go one further step into the hole. The professors doing the research are also teaching students. The graduate students who are looking for something for a thesis are working with the professors to conduct the research so they're being product oriented, component oriented, not systems oriented.

Now let's back off the philosophical side and look at the questions that Lou posed to us a few minutes ago and Fred Kohloss touched on. I have heard the problems repeated for at least 30 years. There are two problems, particularly from consulting engineers, those in my business. The consulting engineers say "with the amount of money these kids out of college are getting

today we just can't afford to hire them. In salaries we're forced to compete against government subsidized industry, and we can't afford to hire these kids out of school. We hear another comment all the time. Consulting engineers say you universities should give us somebody who can do something. We hire one of these graduates even if we subsidize his income for a few years, but he can't do anything. We have to train these students to do what we need."

Consultants, then, have a double barrelled complaint. First they say they can't afford to pay them the inflated wages. Then they say they can't afford to train them.

The fact of the matter is if the Universities gave the design industry what we want we could afford to pay them. That's a fact. I have a small consulting firm. We are not heavily funded or financed with large cash reserves. But if you give us what we need we can afford to pay them. So what's the problem?

The problem is that the price is fixed by the marketplace. I don't think that in an undergraduate program you can give me, as a consulting engineer, a student with the skills that I require at the current starting salary of, perhaps, $27,500. I don't think you can give me more than the five or ten basic courses in thermodynamics, heat transfer, fluid mechanics, etc. He's not worth $27,500 unless I want to invest that sum for a couple of years to train him. The problem is that this is a high productivity high tech industry, although it didn't use to be. The machinery and systems in a building are very, very complex. They use a lot of energy and they're doing an important job. Without the environmental systems the buildings of 1986 will not function.

We can't have people who are simply trained to solve the current problems that we're facing in this industry. We have to have engineers who are educated. Educated in all the basics of physics, thermodynamics, thermal heat transfer, fluid mechanics, materials, kinematics, electricity and electronics, machine design, the humanities, writing, and English. We have to have engineers who can write. Engineers have to be educated and if you can do that in four years you're doing a magnificent job.

After they're educated we want them to specialize and that's where we're looking to you educators. I think that we need graduate programs. Masters level graduate programs take well-educated engineers and turn them into producers for my office and then I'll pay an extra 3 or 4 thousand dollars and I'll go up to $31,500. Then I'll have someone I can use, and someone I can build my business from. I don't want a person that's just trained, I want one who wants my job and has the ability to take it. So that's where, as a consulting engineer, I'm looking to the education profession.

Why can't we get that? A search for that answer is the reason I'm vitally interested in the topic of this conference. If we're going to have graduate programs to educate the engineer that the design profession can hire we have to have professors who are as good at designing as the practitioners in the consulting office. We must have professors who are design-oriented. You have to have professors with a design philosophy, not a product philosophy.

Unfortunately we cannot built that kind of staff in the universities unless we can provide the funding that supports that type of staff in the universities. That is what I see is the purpose of this conference.

The National Science Foundation is not new at this. In 1969 our university was providing a product--graduates for the aerospace industry. The aerospace industry was going into a slump at that time. We were looking for a new market for our product. One of the professors at the university, and I, saw that the building industry was the industry of tomorrow. We felt that that was where we were going to need our engineers in the '70's and '80's. We asked the National Science Foundation to help fund a Masters program in the mechanical engineering graduate school in Building Environmental Systems. Instead of having a research thesis for these students, we said, we'll have a design thesis. They'll have to design systems and they'll go through the rigors of every design decision and we'll teach them design philosophy in this effort.

We received the funding and started the program. The program has been going now for about 16 or 17 years with success. Every student paid full tuition, no grants. It was the biggest program we had in our graduate school. Then 6 or 7 years ago the professor who worked with me died suddenly

(he was an exceptional man and dear friend). To this day the university will not replace that man because they can't find someone who will come in and carry his weight on research grants. As a result, the whole program has essentially gone down the tubes. I've been carrying on myself as an affiliate and I've gotten tired. The university couldn't hire a professor because they couldn't get research money to support him, pure and simple. We do need the research money, and we need it directed to the proper channels -- to education in engineering design!

I don't have the answer, but at this point, I clearly understand the problem!