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DOE/CE/15529--T1

August 22, 1994

Mr. Fred Hart
Mail Stop 5E052
U. S. Department of Energy
1000 Independence Ave.
Washington, D. C. 20585

Subject: Invention # 529 ERIP Program, Super Heated Vapor Drying Process

Ref.: Our telephone call for help, your request for data.

f:529-doe6.doc

Dear Mr. Hart:

I apologize for the delay in getting you this information but our efforts have been mostly in construction and records for the little testing we have done are pretty scattered. The University has however pulled them together and they are attached for your review. Vacations are slowing our ability to respond quickly as they usually do in the summers. But here is the summary you asked for with the results of the short brief testing we have been able to do to date with the funding remaining after construction.

It has now been about two years since the initial release of the DOE grant (529) for us to progress to almost completion of the hardware stage for Phase 1 of this project. We now have an excellent oven to tell us our design needs in order to progress further to design the prototype 10% scale dryer so badly needed. We will list some specific industrial targets that are being considered as objectives below. It was mentioned in the NIST report (the report that led to ERIP 529 grant) that their first impression was that we would save the pulp and paper industry alone some 35,000,000 barrels of oil annually or it's equivalent. Broadening this assumption to the wide range of American industry that could benefit from the development of this invention, (partial list follows) that amount of energy savings now seems to be on the very low side.

Let us summarize a partial list of owner benefits for advancing this invention to commercialization:

- Education

MASTER

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- Economy
- Environment
- Energy
- Export

All of above benefit from the use of this invention.

Industrial drying often generates VOC's and PCB's and formaldehyde which are presently exhausted to the atmosphere directly from the dryers. In our invention, we condense the atmospherically harmful products and retain most of them from escaping through the dryer exhaust system. Along with the other condensed products they are then treated and sewered in controlled fashion.

As for the best benefit of this system, it's economy, unit manufacturing costs. The predicted drying speeds without loss of product quality, and indeed, in many instances, enhancing quality, should be much faster than the use of air drying at present. That will really bring down unit manufacturing costs and insure good economics for improved job security in a manufacturing environment. Americans have been losing drying technology to foreign competition for many years now.

As you can pull from our files, our initial application for funding was for a three phase program: Here are some photographs showing our plans coming to reality.

1. Pilot laboratory oven to expose advantages and disadvantages of superheated vapor drying in a controlled chamber
2. Scale model dryer to demonstrate on line production qualities of manufactured goods. This actual dryer would be in the order of 10% of a full scale dryer.
3. Research articles covering the subjects of advanced technology superheated vapor drying as opposed to air drying, the industry conventional practice today. Such items as how air is a contamination to the drying process for energy, economy and the environment was recommended by Dr. Ralph Webb of the Penn State University as he completed the second phase of analyses for NIST and the ultimate #529 recommendation for funding to DOE.

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**Jenness Hall, University of Maine
Orono, Maine**

The 50 KW pilot lab system is close to completion at the University of Maine in Orono, Maine. (See lab at the left.) This is the same facility that has championed the development of a pilot paper machine to accompany their basic training of students in Chemical Engineering leading to a degree in Pulp & Paper Technology. If America wants to stretch out ahead of the rest of the world in this fundamental but advanced manufacturing technology,

then we have the right place to be working and everyone here is totally thankful for the support and assistance rendered by the University and DOE.

Interestingly, there has been much research and development work in America on pressing (squeezing) of paper sheets to "wring" out as much water as possible before the high energy intensive thermal drying process starts. Strange, there has been little research into alternate forms of thermal drying. Mechanical de-watering of cellulose is the least expensive way to remove water from goods. It is, however, limited to specific industries. For example, it would not work too well trying to make raisins from grapes, although it probably does a good job at making grape juice. This brings me back to an earlier subject in this letter of where just a few applications of this investment will or can be used in American industry. Here are a few we have worked up.

Sheet Goods

Paper Products

Fine Paper	Molded Articles	Newsprint
Coated Products	Tissue	Boxboard
Pulp Manufacturing	Linerboard	Corrugating Media

Textiles

Synthetics

Nylon, Rayon, Polyesters

Natural Fibers

Wool, Cotton

Food Products

Raisins, Prunes, Dogfood, Cereals

Building Products

Ceiling Tiles
 Wall Board (Gypsum)
 Dimension Lumber
 Wood Shingles, Clipboards
 Wafer Board, Strand Board
 Plywood Plies
 Tarpaper
 Ceramic Insulators

Granular Solids Processing

Coal Industry
 Cement Industry (dry grind)

No doubt we have left off dozens of unique applications where we just may not be familiar with the operations.

Within specific applications, it is theoretically possible for products to be dried faster and better with superheated water vapor (steam) than with air. High temperature air drying produces stresses in products when the surface has been dried but the inside is still wet and flexible. This stress relationship creates sheet curl in the paper industry and molded articles will just warp. We know that hot air will cause surface discoloration (browning) and that the absence of oxygen in the air as you have in steam drying is going to eliminate or reduce this problem. The research we are doing is needed to quantify exactly where these poor qualities enter the air drying market and exactly where the new steam drying apparatus eliminates or reduces the problem. Once these benefits are well documented to industry, they will begin investing on their own.

View Showing the 50 Kilowatt Electric Heaters

The view on the left is that of the test system with the beginnings of construction dating to about the summer of 1993. It is located at Jenness Hall at the University of Maine. The other equipment you see in the background will complement the ability of the researchers to do their job well.

This is a side view of the oven showing the frontal area where we will load the test articles in the oven. There is considerable instrumentation remaining to be installed in the system as these photos were taken. Much has been accomplished over the past months and the insulation is now on the system. It is quite exciting now to know that years of work, tracing back to concept drawings we have for this process in 1984 are coming to life. As we mentioned earlier though there are others in the world that are catching on to the discovery. I would like to name a few here and give you some understanding of our concern for speed at this point because we do need further assistance and we will outline that later.

View Showing the Oven Side With Door to the Left

Perhaps the most distressing thing here is the fact that we continue to see foreign competition making gains. Perhaps, someday, someone will see where America did pick up the science to move ahead and try to reclaim the industrial drying market that we once held 50 years ago. When I traveled through Europe in 1987, studying the effects of electromagnetic radiation on the drying processes, I discovered how

advanced they were in understanding typical paper mill applications. They were aware of the differences between the infra-red spectrums of gas and electric, the different absorption factors associated with different wavelengths and indeed had taken the time and expense to put both systems, side by side, on pilot machines. I was most impressed with the setup, at Heindel in Wolsum, Germany. They concluded in 1987 that electric systems burning at 4,000°F would not cut the energy costs anywhere as near as much as gas fired systems running at 1,900°F would. Both systems however would heat the cellulose as well as the water when all you really want to do in a drying system is heat the water in the product.

It was the Europeans, Germans specifically, that commercialized infra-red drying for the paper industry and brought it to this country.

Following that trip I went to Raytheon in Massachusetts and worked extensively on the possibility of elevating the frequency of radiation from the infra-red region to the microwave region. That offered great possibilities of improved heat transfer efficiency as only the water in the product would absorb the microwave energy. When we costed out the price of the magnetrons, their replacement costs, the shield protection workers would need from the waveguides, it became obvious that the use of any form of

electromagnetic energy, infra-red or microwave or other would have limited application and service for the industry. The kilowatts input to pound of water evaporated was just too expensive.

That's when I returned to the drawing boards and scientifically attacked the main problem of drying expense. Everyone was developing new ways to deliver heat to the product, faster if you will and little work was done to use the heat generated in the drying process as the means to liberate more water from the product. I must admit that it buffaloes me for some time too. The breakthrough came when we realized that increasing the humidity in the drying process did not alter the drying rate as long as you eliminated the air (found a way to do it which we did) and raised the temperature of the recirculating flux above 370°F. From that point on, heat transfer was incredibly high and energy recovery was most feasible to almost any level desired with a minimum of expense. Simultaneously with this research work, Keyes Fiber of Waterville Maine, manufacturers of molded articles (Chinet plates and egg cartons for example) allowed us to rebuild their biggest dryer in Waterville Maine. Our engineering was right on target for what was accomplished and we increased the humidity ratio so we could decrease exhaust to save energy. We met our new targets of production as promised. We have since rebuilt large dryers in South America and a textile dryers in Canada and the United States. In the latter case we doubled production and brought the unit manufacturing cost in half.

These experiences were all on air dryers, modified as far as we could take them for efficiency. A current air dryer cannot be economically remade into a superheated steam dryer (or a Thermodyne as we call them) because the basic dryer construction will not support the temperatures we need and the inside walls of the dryers are not sealed to contain the high vapor pressures we will need. Thus the whole new field of manufacturing industrial dryers as well as their use to make product will be the challenge in the coming years.

We have maintained an accounting system specific for this project detailing every cent spent and in addition, Merrill has contributed a lot of money, for example all my time and travel expenses, are not charged it to the job. We did not use any of the grant money for the U. S. Patent. We used our own and in this prolonged paper industry recession that money is now scarce to none. We need to call on you for help. Is there something we can do? If there is please let us know and we will follow up on it. Would a visit to the University of Maine help along with a conference with all the staff on the project?

We hope you will be successful in rendering assistance to see if there are any programs there in Washington that would assist us in this remaining work as outlined in the University of Maine's budget attached.

Please call either myself or Dr. Ceckler or Dr. Boyle if you have any questions.

Phones: Don Curry = 207-871-7551
Dr. Ceckler = 207-581-2280
Dr. Boyle = 207-871-2144

Very truly yours,

A handwritten signature in cursive script that reads "Don Curry". The signature is fluid and extends to the right with a long, sweeping tail.

Donald P. Curry, P. E.