Institute *for* Ergonomics

The Bulletin of the Institute for Ergonomics at The Ohio State University

At the forefront of Human Factors since 1950 Volume 4, No. 2, Spring, 2001

The Institute Talks with Two Legends in Ergonomics

The Institute for Ergonomics recently had the privilege to sit down with two leaders in the field of human factors and ergonomics, Dr. Tom Rockwell and Dr. Charles Billings. These individuals began their careers as human factors was in its infancy. Because they also spent a considerable portion of their careers at Ohio State, they have seen how this field developed, not only world-wide, but here at OSU.

Institute for Ergonomics: **What was the HF profession like when you began your careers:**

Tom Rockwell: The Human Factors Society was just beginning in the mid 50's when I began to get interested in the field.

Charles Billings: HF was not the "profession" for many of us. It is not "a discipline" today, but a constellation of approaches to problem solving. You may find physical anthropologists, physiologists, physicians, psychologists, and various stripes of engineers all working together on a different HF problem in a military aircraft.

IE: It's been a problem in this field that many people still don't understand what ergonomists do. How did you explain that early in your careers?

TR: There was less interest in explaining the profession in those days. Instead, emphasis was on problem areas and the ability to use scientific methods to solve them in, for example, highway accidents (use of psychological principles to explain driver behavior; the effect of uncertainty on response time).

CB: My "early career" was in aviation and space medicine, not HF or ergonomics.

IE: What changes/advances in the field have been most unexpected to you? Most anticipated?

TR: The most unexpected might be the rapid emergence of physical ergonomics and its impact on industry. The most expected was the reach of HF to aviation, highway, power and medical systems.

CB: Most unexpected is the degree to which HF science lags technology, and the degree to which government (e.g., FAA, NASA) is opting out of research. The most anticipated (and needed) is the emphasis on cognitive science and engineering.

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Dr. Charles Billings received his M.D. from New York University in 1953. He began as an instructor in the Department of Preventive Medicine in 1960, later taught in the departments of Physiology, Aviation, and Physical Education, and came to the IWSE Department in 1992. Dr. Billings is a Clinical Professor Emeritus in the School of Public Health. In his career, Dr. Billings has published over 125 journal articles, book chapters, and research reports.

Dr. Tom Rockwell has been a leading researcher in transportation human factors since 1959. He received his Ph.D. here at Ohio State, in the Industrial Engineering Department. In the late 1950's, Dr. Rockwell introduced human factors subjects, particularly regarding driver behavior. Although he is now a Professor Emeritus at OSU, he continues to study human factors issues with his company, R&R Research. Recently he has been examining visual search patterns for truck drivers.

In This Issue . . .

Several major media sources reported on recent research conducted by **Bill Marras** and **Cathy Heaney**. Findings from their investigations suggest that high levels of stress in the workplace may increase the likelihood that employees will injure their backs when lifting heavy objects. Coverage has been reported in:

- *London Daily Telegraph* and Reuters News Service (12/2)
- Scripps Howard News Service (12/5)
- CBS Evening News (12/6)
- *Chicago Sun-Times* (12/13)
- *Philadelphia Enquirer* (12/21)
- *Denver Post* (12/31)
- *New York Times* (1/14)
- *National Post* (1/15)
- *Chicago Tribune* (1/21)
- *Detroit Free Press* and *Detroit News* (2/5)
- *Tampa Tribune* (2/18)
- *First for Women* (2/19)
- *Self* magazine (March issue)
- *Men's Exercise* magazine (May-June issue)

In March, **Bill Marras** was interviewed for National Public Radio's program *All Things Considered*. The report focused on the Congressional vote to repeal OSHA's Ergonomics Program Standard. In the story, Dr. Marras stated that research supports the use of ergonomics to protect the health of workers.

Bill Marras was quoted in a March 11th *Los Angeles Times* article about ergonomics and women. In the article, Marras discussed factors that relate to load tolerances on the body–including strength, size, age, and gender.

In the Spring/Summer issue of The Columbus Dispatch's *HomeScapes* magazine, **Gary Allread** compiled a list of tips for designing an ergonomically correct computer workstation. This was featured in a story on home offices, called "Doing Home Work."

David Woods was quoted in an April 29th *Chicago Tribune* article on voter errors. Dr. Woods pointed out that voting mistakes are predictable and result from poorly designed ballots, including mis-entries and mis-alignments when several issues are crowded onto single ballots.

Legends - *Continued from page 1*

IE: What interesting/amusing stories can you share?

TR: I wrote an article titled, "I Thought You'd Tell Me When To Look" that summarizes these stories (the article is reprinted in this issue, beginning on page 5).

CB: Few people at OSU are aware of the University's role in aviation, physiology, medicine, psychology, and engineering ever since World War II.

IE: What has been your most significant contribution to HF/ergonomics?

TR: The production of 88 Masters and Doctoral theses–11 as teachers in major universities. These and my impact on driver HF, especially visual search using eye movement research. I might add I'm probably the only HF scientist who has done research in highway, railroad and aviation systems.

CB: Probably the design and implementation of the NASA Aviation Safety Reporting System, which now contains the world's largest body of applied HF data.

IE: What type of work are you doing now?

TR: At the present I do a lot of volunteer work for the Transportation Research Board and the Society of Automotive Engineers, and I review papers for three journals. Also, I just finished writing a standard for the SAE, and I usually have about 6-8 forensics cases on-going.

CB: I am working with Phil Smith and Dave Woods in Cognitive Engineering Systems Lab here at OSU.

IE: Why do HF professionals always feel the need to justify their existence and the utility of this discipline?

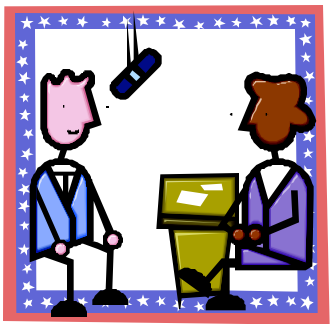
TR: Probably the lack of hard science (against common sense), but I was too busy problem-solving to worry about it.

CB: Perhaps because HF has not always been utilitarian and helpful to design engineers who most need its help.

IE: What advice can you give students who are interested in studying ergonomics and choosing this as their careers?

TR: Start with solid computer skills, good presentation skills, the ability test human subjects, an inquisitive mind about how humans behave, and the chance to work with a leader in the field.

CB: I don't think it should be a "first" career. I think a strong disciplinary grounding in one of the directly relevant disciplines is the best foundation, augmented by HF training and some applied experience, though others may disagree. ■



PUBLISH
or perish

Some of the recent publications written by Institute members:

Aiding the Intelligence Analyst in Situations of Data Overload: From Problem Definition to Design Concept Exploration, E.S. Patterson, D.D. Woods, D. Tinapple, E.M. Roth, J.M. Finley, & G.G. Kuperman, Institute for Ergonomics/Cognitive Systems Engineering Laboratory Report, ERGO-CSEL 01-TR-01, The Ohio State University, Columbus OH, 2001.

Cost-Benefit of Muscle Co-contraction in Protecting Against Spinal Instability, K.P. Granata and W.S. Marras, in *Spine*, 25(11):1398-1404, 2000.

Disenfranchised by Design: Voting Systems and the Election Process, S. Roth King, in *Information Design Journal*, 9(1), 1998.
Note: Though this article was originally published in 1998, it was re-issued in the wake of the recent U.S. Presidential election controversy. It can be downloaded for free off the web, at: **http://www.informationdesign.org/pubs/roth1998.html**.

The Effects of Motion on Trunk Biomechanics, K.G. Davis and W.S. Marras, in *Clinical Biomechanics* 15(10):703-717, 2000.

Female and Male Trunk Geometry: Size and Prediction of the Spine Loading Trunk Muscles Derived from MRI, W.S. Marras, M.J. Jorgensen, K.P. Granta, and B. Wiand, in *Clinical Biomechanics*, 16:38-46, 2000.

How Unexpected Events Produce an Escalation of Cognitive and Coordinative Demands, D.D. Woods and E.S. Patterson, in P.A. Hancock and P.A. Desmond, eds., *Stress Workload and Fatigue*, Lawrence Erlbaum, Hillsdale, NJ, pp. 290-304, 2001.

Human Performance Theory-based Approach to Patient Safety and the Clinical Nurse Specialist, P. Ebright, M.L. Render, R.I. Cook, D.D. Woods, E.S. Patterson, and A. Eisenlohr, Proceedings of the National Association of Clinical Nurse Specialists National Conference, March 8-10, Indianapolis, Indiana, 2001.

Impairment Magnification During Dynamic Trunk Motions, W.S. Marras, K.E. Lewis, S.A. Ferguson, and M. Parnianpour, in *Spine*, 25(5):587-595, 2000.

The Influence of Psychosocial Stress, Gender, and Personality on Mechanical Loading of the Lumbar Spine, W.S. Marras, K.G. Davis, C.A. Heaney, A.B. Maronitis, and W.G. Allread, in *Spine*, 25(23), 2000.

Medication Administration Error and BCMA: Preliminary Findings, E.S. Patterson, D.A. Coelho, M.L. Render, G. Coyle, D.D. Woods, and R.I. Cook, Proceedings of the 19th Annual Meeting VA Health Services Research: Improving Access and Outcomes. February 14-16, Washington D.C., Plenary paper, 2001.

MRI-derived Moment-arms of the Female and Male Spine Loading Muscles, M.J. Jorgensen, W.S. Marras, K.P. Granata, and J.W. Wiand, in *Clinical Biomechanics*, 16:182-193, 2001.

A Non-MVC EMG Normalization Technique for the Trunk Musculature: Part 1. Method Development, W.S. Marras and K.G. Davis, in *Journal of Electromyography and Kinesiology*, 11:1-9, 2001.

A Non-MVC EMG Normalization Technique for the Trunk Musculature: Part 2. Validation and Use to Predict Spinal Loads, W.S. Marras, K.G. Davis, and A.B. Maronitis, in *Journal of Electromyography and Kinesiology*, 11:11-18, 2001.

Occupational Low Back Disorder Causation and Control, W.S. Marras, in *Ergonomics*, 43(7):880-902, 2000.

Predicting Recovery Using Continuous Low Back Pain Outcome Measures, S.A. Ferguson, W.S. Marras, P. Gupta, and C. Heaney, in *The Spine Journal*, (in press). ■

Graduate Student Update

Three new graduate students have recently begun with the Biodynamics Laboratory. Please welcome them!

Naira Kyureghyan Campbell
(kyureghyan.1@osu.edu)
Advisor: William S. Marras
Hometown: Yerevan, Armenia

Swetha Sivakumar
(sivakumar.3@osu.edu)
Advisor: William S. Marras
Hometown: Chennai, India

Erich Theado
(theado.5@osu.edu)
Advisor: William S. Marras
Hometown: Columbus, Ohio

On the Move

Marta Render, **Emily Patterson**, and **David Woods** received a $425,000 grant from the VA Health Service and Research Division, for "Creating Safety and Reducing Medical Errors with Bar Coding." This two-year project is scheduled to begin in July, 2001. Congratulations!

The following presentations were given at the 11th International Symposium for Aviation Psychology, held in Columbus, Ohio (March, 2001).

- *Analysis of Pilots' Monitoring and Performance on an Automated Flight Deck*, Mumaw, R., **Sarter, N.B**., and Wickens, C.
- *Limitations of Management-By-Consent: The Role of Conflict Type, Time Pressure, and Display Design in the Failure to Detect Conflicts with Gated Data-Link Clearances*, Olson, W.A. and **Sarter, N.B.**
- *Supporting Decision-Making and Action Selection Under Time Pressure and Uncertainty: The Case of In-flight Icing*, Schroeder, B. and **Sarter, N.B.**
- *Why Onsets Don't Always Capture Attention: The Importance of Context in Display Design*, **Nikolic, M.I.**, Orr, J., and **Sarter, N.B.**

At the 4th Annual Applied Ergonomics Conference, **Gary Allread** lectured on a *Biomechanical Task Analysis Using the Lumbar Motion Monitor* at a pre-conference seminar (Orlando, Florida, March, 2001).

David Woods presented a Congressional briefing titled, *Human Factors and the Technology of Voting*, for the seminar "The Mechanics of Election Reform: From Registration to Results." The seminar was sponsored by the American Political Science Association, the American Psychological Association, and the Consortium of Social Science Associations (Washington, DC, March 16th, 2001).

Establishing an Effective Ergonomics Process was the focus of a talk given by **Gary Allread** at the Ohio Safety Congress & Expo (Columbus, Ohio, April, 2001). The Institute also sponsored a booth in the exhibit hall.

Gary Allread gave one of the keynote speeches at Central Ohio AIHA's annual conference, "Ergonomics: Problems and Solutions." The focus of his talk was *Ergonomics Standard: Past, Present, and Future* At this same conference, **Sue Ferguson** spoke on *Returning to Work After a Low-Back Injury*. (Westerville, Ohio, April, 2001). ■

New Book on MSDs Now Available

The National Academy of Sciences is now offering for sale the book, **"Musculoskeletal Disorders and the Workplace: Low Back and Upper Extremities."** This book "examines the scientific basis for connecting musculoskeletal disorders with the workplace, considering people, job tasks, and work environments. A multidisciplinary panel [which included **Bill Marras**] draws conclusions about the likelihood of causal links and the effectiveness of various intervention strategies. The panel also offers recommendations for what actions can be considered on the basis of current information and for closing information gaps. This book presents the latest information on the prevalence, incidence, and costs of musculoskeletal disorders and identifies factors that influence injury reporting. It reviews the broad scope of evidence: epidemiological studies of physical and psychosocial variables, basic biology, biomechanics, and physical and behavioral responses to stress. Given the magnitude of the problem-approximately 1 million people miss some work each year-and the current trends in workplace practices, this volume will be a must for advocates for workplace health, policy makers, employers, employees, medical professionals, engineers, lawyers, and labor officials. "

Details for purchasing and reading this document on-line (for free) can be found at The National Academy Press web site, http://books.nap.edu/catalog/10032.html. ■

Research Corner

Predicting Recovery Using Continuous Low Back Pain Outcome Measures, S.A. Ferguson, W.S. Marras, P. Gupta, and C. Heaney, in *The Spine Journal*, (in press).

There is a lack of research evaluating the rate of low back pain recovery. Therefore, a prospective study using continuous outcome measures was developed. Thirty-two acute low back pain patients were recruited. Patients were evaluated every two weeks for three months. There were four major outcome measures, including functional performance probability, symptom intensity, impairment of activities of daily living and a summary outcome measure. Twenty-eight patients completed the study. Regression models were constructed using the initial conditions to predict the rate of recovery for each outcome measure. The R^2 values for the rate of recovery regression models were 0.77 (symptom intensity prediction), 0.85 (activities of daily living prediction), 0.87 (functional performance probability prediction), and 0.96 (summary outcome measure prediction). Two functional performance patterns of recovery were found including a steady improvement and a large jump improvement. A discriminant function model identified the pattern of recovery in 91% of cases given initial conditions. In conclusion, continuous outcome measures can be accurately predicted given the initial conditions. ■

"I Thought You'd Tell Me When To Look"

Published in the Human Factors Society **Bulletin** (Volume 35(11), Nov., 1992) as *Recollections of the Unpredictable in 20 Years of Road Research*

By Tom H. Rockwell

The following event illustrates the unpredictable and sometimes humorous side of "on the road" testing of human subjects over the period, 1960-1980 at OSU. After the introduction of corneal reflex eye movement techniques in the mid-1960s, a wide variety of studies were conducted to capitalize on our ability to know where test subjects were fixating over time.

One of our interests (and this was not a sponsored study) was to ascertain the priority of visual cues for the driver. Recalling John Senders' moveable flap which periodically obscured vision to test subjects, we decided to let the subjects use their eye lids to control visual inputs. These so called "no peek" experiments asked subjects to close their eyes while driving with the eye marker system installed and to open them as needed to obtain information. In this way we could note the location and duration of the first fixations after opening the eyes.

These studies involved open road freeway driving. This subject (as subjects are wont to do) misunderstood the instructions. After he closed his eyes for 11 seconds and the car was careening on to the shoulder, he finally responded to the screams of the researcher to "look." Once control was restored we asked him to explain this strange behavior. His innocent answer was, "I thought you would tell me when to look."

Despite attempts to ensure safety, there were always surprises that led to near incidents. Some studies were conducted before the National Institutes of Health guidelines on human subject testing were initiated. Others, after detailed protocols were approved within NIH guidelines, led to surprising experiences because of the unpredictable behavior of test subjects. The following memories only prove that graduate students have guardian angels who never sleep.

One of the earliest studies demonstrated the need for controlled research. We outfitted a "cab over" tractor with a large black box on the roof, which contained a camera that took time to lapse pictures of the road scene ahead. We thought we could study true truck driver behavior since it wasn't obvious the box contained a camera. We thought we might check the driver's car following behavior by positioning a lead car ahead of the truck and forcing the driver to follow this car (also equipped with a disguised, rear facing camera). Passing the truck driver on a four-lane road prior to a long stretch of a no-passing zone we throttled back the lead car to observe truck driver behavior. While the expletives were apparent, what was not anticipated was the wrath exhibited by a truck driver as he crowded the lead car off the road when passing was permitted. These studies were finally stopped when a truck driver parked at a private residence in the middle of his scheduled run and we ended up taking pictures of a garage door for two hours.

In the late 1960s, we decided to record headway and relative velocity between vehicles by use of an electric, motor-driven take-up reel on the following car keeping a drum of 400 foot wire taut as headways changed. Because this wire between the two cars was virtually invisible, it was necessary to post a large sign on the back of the following car: "Keep Left–Pass Next Two Cars." Of course, curious members of the driving public wanted to know why and thus proceeded to enter the space between the two test vehicles. At this the lead driver and the test subject were told to bail out to the right shoulder. Sad to say, we were not always successful as several curious drivers went home with 400 feet of wire wrapped up under their cars.

It was with this set-up that we had the only accident (but no injuries) of our testing history (if you don't include spin-outs by subjects overacting to commands). We were testing driver car-following responses to a lead car driver (one who couldn't decide how fast to drive–frequently coasting or braking without provocation). In this instance, we were also measuring the heart rate of the test subject in the following car. As Murphy's Law suggests, the unthinkable happened–a complete brake failure of the following car (this was before dual brake cylinders). Despite entreaties by the experimenter for the lead driver to accelerate, a rear end collision occurred (measured precisely at 15 mph speed differential). The heart rate of our test subject surged after impact. The subject later marveled at our ability to set up such an experiment. (So did we.)

Of course, we had less traumatic incidents such as driving over curbs when we introduced two-directional Venetian blinds to control what portion of the road was visible to the driver. Right turns are difficult if one can't

Continued on page 6

"I Thought ..." *Continued from page 5*
see the first 100 feet ahead of a vehicle. Head-up displays depicting continuous headway and relative velocity caused drivers to often become enraptured by the display at the expense of lane tracking.

Some of the incidents were not involved on the roadway. One eye-movement crew made it a practice to recalibrate the system after each run. Unfortunately, they picked a poor location–a rural, residential driveway. On the fourth recalibration, they were asked by an angry father with a shotgun to leave before the police were called. The farmer believed our experimenters were sophisticated "peeping Toms" with special equipment to peer into the daughter's room.

Testing subjects under the influence of carbon monoxide was stickier. We had a physician administer a calibrated concentration of CO through a regulator for a given period before each test run. Breathalyzer type tests and blood samples were periodically taken to ensure proper carboxyhemoglobin levels in the blood. Surprisingly, we got many subjects to volunteer. Oddly enough, the protocol required us to read to the subjects a consent form which included the statement that there was "no therapeutic effect of the blood drawings."

In some studies we were only allowed to test older subjects who could demonstrate good health and an active driving history. To get such subjects we found that ads near the obituary section of local papers would attract older volunteers. Our standards must have been pretty tight as two of the four subjects over age 65 drove convertibles complete with young girlfriends. So much for representative subjects!

To get special subjects we elicited cooperation from a local judge to offer suspended sentences and participation in road tests in lieu of normal sentences. We wanted to compare visual search patterns of those who were "violation-free" with repeated offenders. Such offenders made poor subjects due to their poor attitudes; some even threatened our graduate students with switchblades.

The most difficult of our studies may have been those involving 24-hour driving. Here, subjects made eight continuous round trips between Columbus and Cincinnati, stopping only for gas and carry-out snacks, and changing experimenters every 8 hours. Whether we measured visual search patterns or lane and speed tracking we were always apprehensive. Subjects were told they could engage in any practice they customarily used to keep awake. This ranged from chain cigar smoking (and sick experimenters) to loud radio playing and open windows on February nights. When I would take a shift late in the experiment, I sometimes had to terminate the test. One subject became severely paranoid, questioning our real intentions. Others would unexpectedly leave the freeway at an exit ramp as they fixated on the right edge marker. Early in the study we had to require that test subjects clear passing decisions with the experimenters before executing, since a few last-minute maneuvers resulted in such close shaves that even our graduate students were ashen faced the end of their shift.

Subjects could terminate an experiment any time they wished. This occurred rarely except for the temporary help–older subjects who told us what we could do with our tests in no uncertain terms. Students, of course, will volunteer to do almost any test for money, even a 36-hour driving study.

Subjects were not the only reason experiments had to be cancelled. In addition to inclement weather, e.g., rain, snow and sleet; test environments often changed unpredictably. In a gap-acceptance study on the campus property, subjects were asked to elect and drive into the smallest gap they would deem acceptable. Gaps and speeds were established by experimental vehicles. In one trial before the lead car passed, a bicycle entered the traffic stream followed by many more–200 in fact–as part of a bike race scheduled through the campus area.

A study with very novice drivers led to one of the few cases in which the experimenters had to terminate testing; with good reason. We were interested in how novice drivers develop their visual search patterns. The study was directed at virginal (in terms of driving) test subjects and how their freeway visual search patterns change with driver training. The initial baseline tests were, of course, interesting to say the least. It was here that graduate students often had to exercise complete control. If subjects wandered down the road we had to terminate the tests. Amazingly enough some 14 to 20 novices got through their first runs without incident. The behavior of these subjects was even more unpredictable than low level alcohol test subjects where velocity and lane tracking excursions were used to terminate such studies.

Today, the clear choice for some of these experiments would be the use of driving simulators. Yet, the richness and validity of the above experiments seemed to justify the potential hazards involved. I will always respect our graduate students who with ingenuity and dedication were able to test hundreds of subjects in unique test situations with an overall perfect safety record.

These recollections are dedicated to the graduate students who earned MS & PhD degrees from me–the hard way–testing subjects in a wide variety of unique, highway test experiments. I must acknowledge the undergraduates who supported these studies and the guileless test subjects from ages 15 to 70 who did their best to "drive normally" (when that was possible). ■

OSHA's Ergonomics Program Standard Repealed

With a stroke of his pen, President Bush signed into law a repeal of OSHA's Ergonomics Program Standard. A vote for the repeal had previously passed both houses of Congress.

What has been the fallout since the repeal? What are the opinions of business and labor groups? Several comments are listed below.

"Congress could repeal the ergonomics standard, but that won't repeal an ergonomic hazard or prevent a single ergonomic injury. The toll of disabling ergonomic injuries just keeps mounting up, increasing by nearly 5,000 a day."

William Henning
Board Chair, New York Committee for Occupational Safety and Health
March 20, 2001

"The safety and health of our Nation's workforce is a priority for my administration. Together we will pursue a comprehensive approach to ergonomics that addresses the concerns surrounding the ergonomics rule repealed today. We will work with the Congress, the business community, and our Nation's workers to address this important issue."

President George W. Bush
March 20th, 2001

"… we should be working with all parties—American businesses, labor, and state governments, to develop a workable ergonomics standard that considers all costs and benefits and protects the health and welfare of the American workforce."

George V. Voinovich
U.S. Senator (R-Ohio)
March 23, 2001

"NAM members have some of the best ergonomics programs in the country, and we welcome the chance to share what we've learned with OSHA and the Department of Labor in order to help develop effective ergonomics measures."

Jerry Jasinowski
President, National Assn. of Manufacturers
March 7, 2001

Many web sites post updated information about recent activities related to the future of ergonomics regulation. Among them:

OSHA	http://www.osha_slc.gov/ergonomics_standard/index.html
ErgoWeb	http://www.ergoweb.com/news/

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Institute for Ergonomics

Dr. William S. Marras
Co-Director

Dr. Philip J. Smith
Co-Director

Dr. W. Gary Allread
Program Director

Candi McCain
Office Administrative Assistant

To contact the Institute:
Phone: 614-292-4565
Fax: 614-292-7852
E-mail: ergoinst@osuergo.eng.ohio-state.edu
Web: http://osuergo.eng.ohio-state.edu/Institute/index.htm

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Columbus, OH 43210

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