Oral History Center
The Bancroft Library

University of California
Berkeley, California

Global Mining and Materials Research Oral History Project

John Murphy
Mine Safety Research at the US Bureau of Mines and the University of Pittsburgh

Interviews conducted by
Paul Burnett
in 2015

Since 1954 the Oral History Center of the Bancroft Library, formerly the Regional Oral History Office, has been interviewing leading participants in or well-placed witnesses to major events in the development of Northern California, the West, and the nation. Oral History is a method of collecting historical information through tape-recorded interviews between a narrator with firsthand knowledge of historically significant events and a well-informed interviewer, with the goal of preserving substantive additions to the historical record. The tape recording is transcribed, lightly edited for continuity and clarity, and reviewed by the interviewee. The corrected manuscript is bound with photographs and illustrative materials and placed in The Bancroft Library at the University of California, Berkeley, and in other research collections for scholarly use. Because it is primary material, oral history is not intended to present the final, verified, or complete narrative of events. It is a spoken account, offered by the interviewee in response to questioning, and as such it is reflective, partisan, deeply involved, and irreplaceable.

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John Murphy

John Murphy serves as the Executive Director of the McGowan Institute and as a Research Professor in the Department of Chemical and Petroleum Engineering, University of Pittsburgh. His academic interests are primarily related to process and workplace health and safety.

Prior to joining the University, Professor Murphy served as the Research Director of the Pittsburgh Research Center of the U.S. Bureau of Mines from 1978 until 1997. Under his direction, the Center conducted research pertaining to mine health and safety, as well as other studies that were directed toward new mining technology and mine environmental issues.

Professor Murphy is a Registered Professional Engineer. He holds an undergraduate degree from the University of Pittsburgh and a master's degree from Duquesne University. In his tenure at the Pittsburgh Research Center, he served in various technical and supervisory positions. He holds two patents and has authored more than 90 technical publications. He is the recipient of the Department of Interior Distinguished Service Award in 1985, the Presidential Rank Award for Meritorious Executive in 1986, and the Presidential Award for Distinguished Executive in 1993.

He served as the 2011 President of the Society for Mining, Metallurgy and Exploration (SME), and is also the Past President of the SME Foundation, Director and Past Chairman of the Pittsburgh Section of SME, Past President of the National Mine Rescue Association, Member and Past President of the Mine Rescue Veterans of Pittsburgh District, Member of the National Society of Professional Engineers, Senior Member of the Institute of Electrical and Electronics Engineers, Member of the American Institute of Chemical Engineers, Member of the Pennsylvania Society of Professional Engineers, and Member of the Mining and Metallurgy Society of America.

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Global Mining and Materials Research Project

For over twenty years, the Regional Oral History Office (ROHO) produced in-depth oral histories of members of the mining community, under a project called "Western Mining in the Twentieth Century," which was overseen by Eleanor and Langan Swent, Douglas Fuerstenau and others. http://bancroft.berkeley.edu/ROHO/projects/mining/index.html The 104 interviews in the project covered the history of mining in the American Southwest, Mexico, South America, and Australia from the 1940s until the 1990s.

ROHO has recently changed its name to the Oral History Center of the Bancroft Library, and with that change we proudly announce a new project entitled “Global Mining and Materials Research,” which will focus on key transitions in technology, policy, and geopolitics that have brought mining to its current state worldwide.

Much has changed in mining industries in the years since the Western Mining project was in full production, including the increased globalization of mining operations, the decreasing concentration of mineable minerals in ore, increasingly complicated regulatory environments, new systems of environmental remediation, new technology for exploration, extraction, and processing, and new stories of political conflict and resolution. In addition to collecting interviews about mining engineering, metallurgy, and administration, we also hope to explore the history of information technology and data analysis with respect to mining, as well as the legal, regulatory, and policy history of the industries.

This interview was funded with support from the American Institute of Mining Engineers, Metallurgists, and Petroleum Engineers (AIME), the Society for Mining, Metallurgy, and Exploration (SME), the Association for Iron & Steel Technology (AIST), the Minerals, Metals, & Materials Society (TMS), and the Society of Petroleum Engineers (SPE). We are also collaborating with the IEEE to host these oral histories on the Engineering and Technology History Website, located here: http://ethw.org/Oral-History:List_of_all_Oral_Histories. Thanks also to former Western Mining Project Lead Eleanor Swent, Dr. Douglas Fuerstenau, and Noel Kirschenbaum for their advice and support while the Global Mining Project was being established. Finally, we are most grateful to John Murphy for taking time out of a busy schedule to speak to us about the evolution of the mining industry over the past forty years.

Paul Burnett, Berkeley, CA, 2015

Interview #1 February 18, 2015
[Audio file 1]

01-00:00:06
Burnett: This is Paul Burnett interviewing Professor John Murphy for the Global Mining and Materials Research Project of the business series, the Oral History Center of the Bancroft Library. We're here at the Denver Convention Center for the SME Gathering. It's February 18, 2015, and this is audio file one. Professor Murphy, can you tell me a little bit about your family background and early years?

01-00:00:32
Murphy: I was raised in Pittsburgh. Always had an interest in technology. Got a BS in engineering from the University of Pittsburgh and an MBA from Duquesne University.

01-00:00:48
Burnett: And your parents, your family background? What where they doing? What was their occupation?

01-00:00:53
Murphy: My father was a registrar at Duquesne University. My mother was an elementary school teacher.

01-00:01:04
Burnett: How did you first become interested in engineering? What was the spark for you?

01-00:01:11
Murphy: I think, from an early age, I always liked to take things apart, put things back together, devise new techniques and technology, and I liked the hands-on approach that these technologies and opportunities provided.

01-00:01:27
Burnett: So you started at the University of Pittsburgh in 1957. That's kind of the Sputnik era. There's this enthusiasm around science and technology. Was that part of it? Was it just in the air at the time?

01-00:01:42
Murphy: Yes, but it certainly was before that in terms of my early grade-school interest in science and technology.

01-00:01:52
Burnett: Did they have kits and things like that, like radio sets and things like that? Were you interested in—

01-00:01:57
Murphy: Heathkit was one of the opportunities in those early days to put things together and build devices and so forth.

01-00:02:07
Burnett: And that was something that you were enthusiastic about. So you finished your bachelor of science in electrical engineering the early 1960s. What did you do as your first occupation?

01-00:02:24
Murphy: Actually, I went to work for the US Bureau of Mines, in the area of instrument development and instrumentation.

01-00:02:33
Burnett: What kind of instrumentation were you working on?

01-00:02:36
Murphy: My early work was involved in actually monitoring noise and using meteorological conditions to predict the noise effects from blasting operations.

01-00:02:57
Burnett: So you'd measure the decibels in a chamber, that kind of thing?

01-00:03:04
Murphy: The intent was to predict the levels of blast noise off-site from the blasting operation as a function of temperature inversions, wind and weather conditions, and so forth.

01-00:03:22
Burnett: Wow. And the interest in this work that the US Bureau of Mines, was that the result of pressure from—were people complaining about noise? What was being talked about?

01-00:03:42
Murphy: The initial interest was actually in terms of the effects of activities at the research center itself. They had a high propensity for activity in fires, explosions, and explosives research. As perhaps you know, the Bureau of Mines was really formed based on mine disasters, and the initial focus was fires and explosions, and so there was a lot of work at Pittsburgh related to identifying ways to prevent and minimize the consequences of fires and explosions in underground, and the surface mines as well.

01-00:04:24
Burnett: Can you talk a little bit about some of the research and technologies that were developed either in the US Bureau of Mines or associated with the Bureau of Mines that assisted in mitigating disasters, mining disasters and so forth?

01-00:04:38
Murphy: There's a host of answers to that question. There's preventative measures and post-incident measures as well. From a fire and explosion perspective, there was work on various types of active and passive suppression systems, ranging from improvements in rock dusting or stone dusting, showing very clearly the effects of what's called float coal dust, and the fact that very thin layers of float coal dust can be levitated by very weak explosions and cause some very

devastating events. There were developments on various types of active suppression systems. For example, attempting to minimize the ignition at a working face. There was work on various types of urethane coatings that were—let me back up. Urethane coatings came into existence to prevent the weathering of shales that are found in many coal major strata, and while they were effective in terms of preventing the weathering and deterioration of them, and hence minimizing roof-fall the hazards, in some cases these were fire hazards, and you could get flash fires as a result. So there was a lot of work in terms of identifying those problems, assessing different types of urethane foams and so forth.

01-00:06:30
Burnett: The urethane foam itself was a fire hazard.

01-00:06:33
Murphy: Yes. What's interesting about that is that if you look at some of the standard NFPA characterization tests, foams would show as being safe, but if you had big enough surface areas, like the entire cross section of a mine roadway or a tunnel, they turned out to give different results. Some of these problems have been manifested even in other industries, like some of the space shuttle disasters where they had evaluated, for example the flammability of Velcro; and in the launchpad accident where Grissom, Chaffee, and White died on the launchpad, it was basically velcro burning in an oxygen-rich atmosphere. Again, they had evaluated this in a standard test, but if you change the incline of the test sample, you get highly increased propagation rates. Some of these means of evaluating materials from a flammability viewpoint are very sensitive to the environment and the scale in which it's being used.

01-00:08:01
Burnett: Right. So something that is safe at a certain size or volume, it changes dramatically?

01-00:08:08
Murphy: Or geometry.

01-00:08:09
Burnett: Or geometry, right. The angle of incline. Just to back up further with some of these, if you're talking about coal mining, you talked about the levitation of coal dust. This basic problem is that it's this flammable substance, and when the dust is unsettled or comes into the air, it's brought in contact with oxygen, or surrounded by oxygen, and then a spark from work can ignite it. Is that kind of one of the scenarios for fires?

01-00:08:45
Murphy: The typical scenario is as follows. In the course of cutting coal, particularly with mechanized mining techniques, you create dust. There is a fraction of dust that is aerodynamically transportable. There's a smaller fraction of that which is respirable dust which causes a pneumoconiosis problem. But for the dust that's transportable, again typically referred to as float dust, the dust can

be transported and it will settle on surfaces. Standard strategy in most countries around the world is that you apply quantities of limestone or rock dust to inert the coal dust. There are some specifications in terms of the percent of rock dust that is required to ensure that there's no propagation of a dust explosion. So the scenario is that if you have some mechanism—I'll come back to the mechanism in a moment—if you have some mechanism to levitate the settled coal dust that is then ignited, it creates a little poof, so to speak, and that poof levitates some more coal dust, which makes a bigger poof, and it sort of bootstraps itself along to the point that you have some major event. In terms of the initiation mechanism, it's generally a small pocket of methane-air mixture at the face that is ignited. For example, a frictional spark from a tungsten carbide cutting bit hitting some sandstone or rock and so forth. Then that little weak ignition again levitates some settled float coal dust. It gets this bootstrap phenomena started that moves along.

01-00:11:06
Burnett: Were there some significant historic mine disasters and fires that really spurred this kind of research forward?

01-00:11:14
Murphy: Yes, there's a whole host of them that goes back to—actually, the formation of the Bureau of Mines was based on that type of an event. I'm not sure whether it fits your particular format, but there's a very illustrative graphic that the Bureau of Mines has prepared—actually, NIOSH prepared—celebrating the hundredth anniversary of the Bureau of Mines that lists all these disasters and lists the technology advances that were implemented as a result of that. I can share it with you if you have an interest.

01-00:11:48
Burnett: That would be great. We could actually get a copy of it and put it in the oral history, perhaps. That would be really—

01-00:11:53
Murphy: I can email that to you. [Paul….see the attached PDF]

01-00:11:54
Burnett: Absolutely illustrative. During your time there in the 1960s, you were an electrical research engineer starting in 1965.

01-00:12:14
Murphy: Sixty-one.

01-00:12:15
Burnett: In ’61.

01-00:12:16
Murphy: Sixty-one.

01-00:12:18
Burnett: Sixty-one to sixty-seven.

01-00:12:21
Murphy: That just lists various areas of interest and responsibility and progressing through the—

01-00:12:28
Burnett: The ranks. During that time, you were doing work on explosives research. Is that what you were discussing just now?

01-00:12:36
Murphy: Yes.

01-00:12:45
Burnett: This is, again, in 1967 to 1970. You were doing the development of instrumentation systems, and this is the kind of stuff that you were talking about. The definition of performance of large-scale gas and condensed detonations.

01-00:13:04
Murphy: That was some basic science work that I and some of my colleagues were involved in in terms of trying to understand some fundamentals of explosion mechanisms and techniques to suppress them and so forth.

01-00:13:22
Burnett: It says you had done your own research on noise instrumentation and gas-detonation systems. Were you just following your own curiosity at that point?

01-00:13:33
Murphy: There were team efforts, but we were investigating various hypotheses as it relates to those particular areas.

01-00:13:44
Burnett: And pumpable-slurry explosive systems. Can you talk a little bit about that kind of research?

01-00:13:49
Murphy: Certainly. One of the innovations in explosives, both for construction as well as for mining, particularly surface mining, was the introduction of ammonium nitrate fuel oil. Ammonium nitrate/fuel oil was a completely different strategy to using dynamite, which go back to the beginning of time. Ammonium nitrate fuel oil has a variety of advantages and some disadvantages. The advantages are principally cost and the ability to bulk-load boreholes. Some of the disadvantages are that it's not water-repellant. In the case of underground mines, there's an issue called permissibility, which I'll come back to in a minute. We were involved in looking at a variety of formulations of the explosive material that were emulsified mixtures that could be cross-linked and are water-repellant, that could be used in some of these applications. In terms of underground mines, particularly coal mines or any gassy mine where explosives are used, there is this permissibility requirement. Basically, there's a series of assessments or evaluations that are used to assess whether an explosive is configured in a manner that will not cause the following scenario

to happen. The scenario is that you have a borehole which has explosives in it which results in, in some cases, what's called a blown-out shot. Instead of the explosive fragmenting the coal or the rock, it doesn't yield. It just shoots out the material like a cannon, shooting out of the cannon. As a result of that, you have hot combustion products that would likely ignite a methane air mixture if it were present at the face where this activity was taking place. There's various strategies, whether you're using dynamite or whether you're using some other type of formulation, to keep the combustion products cool enough that it would not ignite a gas-air mixture if it were present. In fact, one of the evaluation criteria is to load a quantity of this explosive, this test explosive, in a steel cannon, and fire it into a gas-air mixture, and statistically determine the 50 percent point that would ignite the gas-air mixture. There's thresholds that need to be maintained or met in order to be, quote, "approved as a permissible explosive."

01-00:17:42
Burnett: So this blown-out shot scenario is kind of a worst-case scenario, a perfect storm of events that would precipitate a disaster It was a known thing. It had happened, and they determined this had caused disasters in the past, and so this was the kind of nightmare scenario.

01-00:18:01
Murphy: It's a known phenomenon.

01-00:18:03
Burnett: So you want to figure out ways to make the explosives themselves to have a kind of chemical structure that is—and a physical structure, presumably—sufficient to prevent it from happening.

01-00:18:23
Murphy: That's right. We'd still want the explosive to do the work expected to do. The other part of this recipe is that, both for performance as well as for safety, there's what's called stemming, which is an inert material, like clay, that's inserted into the borehole after the explosives are inserted. Stemming is important in terms of, again, ensuring that the, quote, "approved permissible explosive" works effectively as well as safely.

01-00:19:04
Burnett: What comes to mind is—I know very little about underground mining blasting, but shaped charges. Is that something that evolved over time? The blast goes only in one direction. Is that a kind of shaped charge?

01-00:19:18
Murphy: No. I've had some experience with shaped charges. In fact, a bit of a digression, but one of the interesting phenomena is what's called linear shaped charges, which is used to, for example, cut holes in tanks and launch vehicles and this type of thing. An explosive does what it's supposed to do by two phenomena. One is the shock pressure, and second is what's called the heating capability. One of the ways that we used to evaluate various types of

candidate explosive systems is to actually fire them in a pond underwater, because you can easily measure the peak blast pressure, as well as the decay envelope afterwards. So, depending on what you wanted the explosive to do, you may want peak shock pressure, and you didn't care about the falling shape of the pressure wave. In some cases, if you wanted to heat, you may not need much shock pressure, but you want a lot of heaving capability afterwards.

01-00:20:44
Burnett: That's fascinating. As you were talking about this, I'm thinking about synergies with other kinds of endeavors. I wondered if the US Bureau of Mines had contact with the Department of Defense, or the Aberdeen Proving Ground, because they're interested in explosives, too, for different reasons, but was there any cross-fertilization of experimentation or results?

01-00:21:16
Murphy: There's an incredible amount. In fact, I believe I worked for every federal agency on various fires and explosions and explosive issues while working for the Bureau of Mines.

01-00:21:28
Burnett: So not just Defense, but other.

01-00:21:31
Murphy: Defense. I worked for some of the NASA problems, launch-vehicle problems. One of the projects that comes to mind is that myself and a team of colleagues worked with others in evaluating the destruct system for the Titan II launch vehicle. It's interesting, because the Titan II is a hypergolic propulsion system that uses liquid fuel and a liquid oxidizer, which burns spontaneously when they're mixed together. When you launch a vehicle from Vandenberg or from the Cape, there is a range safety officer that is sitting there with a big red button that is responsible for destroying the vehicle if it goes astray. Because they had never launched a hypergolic propulsion system before, we actually were involved in running half-linear scale tests on a first stage of a Titan II launch vehicle.

01-00:22:43
Burnett: At your facility?

01-00:22:44
Murphy: No, we actually did the work out here near Denver. Lowry Air Force bombing range.

01-00:22:49
Burnett: Interesting. And it's hypergolic?

01-00:22:52
Murphy: Hypergolic. H-Y-P-E-R-G-O-L-I-C.

01-00:23:03
Burnett: Your expertise in explosives can be deployed in a number of different areas, and was deployed in a number of different areas.

01-00:23:09
Murphy: It certainly was.

01-00:23:13
Burnett: It must have been pretty exciting work to go into these different domains and—

01-00:23:18
Murphy: We had a lot of core competencies. We had a lot of unique facilities. As a result of that, we were asked to contribute to a host of different activities and initiatives. In terms of unique tools, for example, we had a high-speed movie camera that would take 1.2 million frames a second. In that era, that was super high speed. Today, there's faster camera systems. You could actually look at initiation mechanisms for explosives. It was a very useful tool, amongst others that we had.

01-00:24:06
Burnett: In the crucial microseconds after a detonation, you can film that.

01-00:24:12
Murphy: Yes, you could film that. In fact, you could film it before the initiation. An example is that there was a team at the Bureau of Mines that identified some interesting initiation mechanisms, and one of the stories is that, back in the seventies, there was a large increase in the use of nitromethane. Nitromethane had been shipped in fifty-five-gallon drums, and because of the increase in volume, it was being shipped in railroad tank cars. There were a number of incidents where a railroad tank car was going through the so-called shunting process, where they make up trains on sidings, and they push a car up a little hill and then it slides down. They set all the switches so it winds up in train number ten or train number eleven.

01-00:25:15
Burnett: It kind of slams into it a little bit.

01-00:25:17
Murphy: It slams into it. A couple of these slamming-in incidents, the tank car detonated. So the question was, how could that happen? There are standard tests to evaluate the shock sensitivity of materials. Using those standard tests, it was impossible to get nitromethane to detonate with the types of pressures, or shock pressures, that you could ever envision having in a shunting-type incident. What happens is that, if you cavitate the liquid, like when you're sloshing the material around, you get micro-initiation sites in the bubbles that are the nitromethane vapor. They turn out to be the initiation sites that then propagate into a full-scale event. Again, using high-speed photography, we were able to actually visually show this particular phenomenon.

01-00:26:29
Burnett: Wow. That's fantastic. So nitromethane was thought to be much more inert prior to that?

01-00:26:40
Murphy: It was demonstrated to be inert by standard shock sensitivity. Inert is the wrong word. It was demonstrated to be less sensitive than it turned out to be, due to the fact that the cavitation—it actually increased the sensitivity by a couple orders of magnitude.

01-00:27:05
Burnett: I have in mind those miners with their boxes of nitroglycerin packed in sawdust, and I'm thinking of that level of sensitivity. But according to the tests, in nitromethane, it was thought to be fine, and then they found that there was this particular kind of agitation of the liquid that it created—

01-00:27:27
Murphy: If you cavitated, if you put, essentially, bubbles in it, and you weakly shock the bubbles, they turn out to be initiation sites that lets the reaction move forward.

01-00:27:48
Burnett: In terms of work practice, this sounds like an experimental laboratory, that you're modeling these kinds of scenarios using different scales, using different kinds of criteria. It sounds like you're getting feedback from the outside world. There's an incident that happens, and you try to recreate those parameters to figure out what's the missing piece?

01-00:28:22
Murphy: Yes, we did this for a variety of activities and needs. We were involved with the Department of Transportation in terms of characterization in the safe transport and handling of various types of reactive materials. I mentioned ammonium nitrate before. There was a number of infamous incidents, like the Texas City explosion of ammonium nitrate. Again, using some of the standard safety characterization tests, ammonium nitrate appeared to be relatively inert, yet it was known that there was Texas City, which there was a major disaster, and there are others as well. The National Fire Protection Association was interested in determining more realistically the safe storage distances for ammonium nitrate and ammonium nitrate/fuel oil. The fire marshals of the United States said, "Unless you can prove to us quantitatively that this is less hazardous than dynamite, we're going to require that it be stored by what's called the American Table of Distances." Which basically says, if you have X pounds of explosives here, you've got to have Y feet before you can have X pounds of explosives there. If you stored ammonium nitrate per the dynamite classification, it would take huge amounts of acreage.

There is a phenomenon that's called the "critical diameter of explosive materials." For dynamite, the critical diameter is, depending on the particular dynamite, is a fraction of an inch. For nitroglycerine, it's millimeters. It turns out that for ammonium nitrate in its typical prill formulation, it's on the order of twenty or thirty inches. If you run experiments, shock sensitivity experiments, with the standard tests that maybe are two to four inches in diameter, ammonium nitrate looks very, very safe and very innocent. If you run it in diameters, say, on the order of sixty inches, you get completely different results. For a series of experiments, that was actually funded by the Manufacturing Chemists' Association, we actually ran some large-scale experiments using up to sixty-inch diameter charges. There was a charge called a donor, which was purposefully initiated, and there was a charge called the acceptor, and the separation distance was then looked at and statistically determined the 50 percent point where you would get go, no-go of the acceptor. If you go out three sigma, you can determine the point where 99 percent probability you would not have an ignition. That was another example using some of these core competencies and skills to address another national interest and national need.

01-00:32:10
Burnett: Did that result in different storage requirements for—

01-00:32:14
Murphy: It did.

01-00:32:16
Burnett: This has applications for farms and other things as well, right?

01-00:32:21
Murphy: Yes, but in terms of storing large quantities, it's basically a distribution system for large projects. In terms of farms, where you might have just a relatively small quantity, it's still important to have that understanding and that data, but it's not having massive quantities of the material on hand.

01-00:32:50
Burnett: You're doing experiments, and you've talked about statistical analysis. Can you talk a little bit about tools that you used, including computing power, in the sixties and seventies, and how that evolved in terms of the work that you were doing?

01-00:33:13
Murphy: There's two sets of answers that come to mind relative to this. In terms of the fires and explosions work, over the course of the years, the team developed a variety of pretty unique tools. For example, one of the matters of interest is the detonation velocity material that's going to detonate or explode. The standard classical technique was that you put a probe in point X and a probe in point Y, and you measure the time between the activation of probe one and probe two, and using a typical time-interval meter, you could calculate the detonation velocity. One of the phenomena that was of particular interest was typically referred to as DDT, a deflagration-to-detonation transition. Deflagration would be a subsonic reaction, and a detonation would be in a supersonic reaction. The team developed some continuous velocity probes that would

actually measure continuously the propagation rate over the entire course of the event. There were also devices developed, that obviously had to be expendable, to measure detonation pressure, shock pressure, and so forth. There were a variety of tools and techniques like that. I mentioned the high-speed cameras and so forth.

In a broader sense, if you look at, for example, the Coal Mine Health and Safety Act of 1969, that provided some responsibilities, provided a lot of funding, there were lots of opportunities to address various needs via the use of the computer technology. One that comes to mind is mine monitoring systems. There was identified a need to try to assess, on a continuous basis, various parameters in an underground mine. Of course, computer technology, telemetry, and the like came into play in that particular regard. What's interesting is that while the computer technology was important, probably the biggest challenge was in terms of devising, identifying, developing, adapting instrumentation to monitor different parameters. For example, air flow is an important parameter, both in terms of the magnitude, as well as the direction. Up to that point, the standard device for measuring air flow was a vane anemometer, which I'm sure you've seen the little windmills. Vane anemometers don't hold up very well in a mine environment when they're asked to work on a continuous 24/7 basis. So there was work with external collaborators in terms of ultrasonic devices, for example, that would measure air flow, both speed and direction. There were various types of studies to remove people from the face in terms of mining activities. We were looking at various types of transducers that could identify, for example, the coal-roof, or the coal-floor interface, that could be used to assist either the operator at a remote location or, in the ultimate case, some type of semiautomatic or automatic control of cutting machines and so forth. Computer technology was important, but the transducers to feed the computers was probably even more challenging and equally important.

01-00:37:54
Burnett: As they say about computing, garbage in, garbage out. So if you don't have the right data coming in, the computer is not going to be useful.

01-00:38:04
Murphy: There are other cases where computer modeling was very effectively used. There were teams at the Bureau that developed various types of pillar design technologies using computer models and so forth. This was important in terms of ground control, roof stability, and this type of thing.

01-00:38:31
Burnett: The transducers on the floor or the roof could detect instability? Is that some of the—

01-00:38:46
Murphy: If you have a coal seam that, for the sake of discussion, is six feet thick, and you have adjacent strata on the top and on the bottom, in many cases, the

bottom is clay. You want to cut to the clay; you don't want to cut through the clay. Perhaps more importantly is what's on top. Sometimes you have hard sandstone. In some cases, you have shale. It's important to not disrupt the adjacent roof strata unless there's a design plan to remove it for some particular reason. The idea was, can you have some type of measurement system that would tell the operator you are at, or close to, that horizon?

01-00:39:55
Burnett: You did a lot of work on industrial hazards. The title that you had from '71 to '78 is Research Supervisor, Industrial Hazards, and Communications. What's the communications part of that title?

01-00:40:13
Murphy: That's an interesting topic, because on the surface, we take two-way communications for granted. You buy Motorola radios, or RCA radios, and as long as you have the proper antenna system, it works like it's supposed to. Those particular devices don't work at all, or don't work well, underground. The reason is that, basically, when you're in a set of mine entries or tunnels, you're effectively in a wave guide. The wave guide does not support propagation of most of those frequencies. So there's a number of strategies that were identified to minimize or overcome some of those issues. First of all, you can either go very low frequency and get some beneficial results, and I'll come back to the pros and cons of that in a moment, or you can go to extremely high frequencies and get some meaningful results. For example, what's typically VHF frequencies of 150, 180 megahertz, you go around one corner in a coal mine and the radios won't work. You can go very low frequency; the principal problem is the antennas for very low frequency are typically large. They're not little whip antennas like you find on a hand-held radio and so forth. You can go to very high frequencies and get some increased propagation, but you don't have long-range capabilities. One of the systems that people have worked on is what's called leaky feeder systems, which are basically a coaxial cable that's got holes cut in the sheath so it leaks, and you can leak signals out and you can leak signals in. With proper design, you can get some fairly wide coverage.

There was an extensive program, both from the theoretical perspective as well as a practical hardware perspective, identifying the capabilities and limitations of various types of radio systems and assessing them in terms of underground applications. One of the philosophies that we always worked on was the best emergency communication system is an operational one which is still effective in emergency or disaster mode. That way, people have it, they're using it, they get daily benefit from it, and if you need it in an emergency situation, it's there and it's working, as long as it still functions under some type of emergency condition. You look at, for example, redundant paths for a leaky feeder and this type of design. There are a number of firms that sell various types of underground wireless communication system that, in some part, were based on these types of studies that were done back in the seventies at this point.

01-00:43:46
Burnett: As part of the redundancy, were there also wired communications through the tunnels?

01-00:43:52
Murphy: There were all these, since back to the fifties at least, probably before. There were wired communications, mine phones. They certainly served a purpose, but when you have a vast expanse of underground, mined-out real estate, they had limitations. One of the issues, of course, is how do you notify people if there's some type of an incident in another part of the mine, to alert them to take corrective action to escape and so forth. As a result, there was an interest in the wireless communications. There was also an interest in wireless communications from mine rescue teams, in terms of operating in those types of scenarios. Of course, when you talk about the application of these in an underground, potentially gassy mine, there was always the issue of intrinsic safety or so-called permissibility. Devices had to be designed and configured to meet that particular requirement. Again, for some of the very low frequency systems with the large antennas, you could get enough stored energy in the loop antenna that, under fault conditions, it could potentially be an ignition source.

01-00:45:27
Burnett: It could discharge as a kind of capacitor, basically?

01-00:45:30
Murphy: If you had enough stored energy in a coil, and the coil was disrupted by some type of an incident, you conceivably could have a spark that would ignite a gas-air mixture. There had to be appropriate precautions in terms of how big the antenna was, how much energy was stored in it, and so forth.

01-00:45:57
Burnett: I imagine that, whether it's high frequency or low frequency, if you want a better propagation, it would be higher-voltage applications?

01-00:46:07
Murphy: Higher power.

01-00:46:08
Burnett: Higher power. More current.

01-00:46:11
Murphy: In terms of a low frequency system, basically it's the amount of current that are pumping through a big loop antenna, and, again, how much stored energy is in that coil or in that device.

01-00:46:31
Burnett: That's really challenging. That's some of the most probably, I imagine, frustrating and exciting work that an engineer can do, is to have multiple conflicting parameters, right?

01-00:46:43
Murphy: There's always trade-offs. In terms of the underground environment, there's extra trade-offs in terms of some of the things I just shared with you.

01-00:46:52
Burnett: Right, absolutely. But it sounds like your researchers and your teams had positive results in developing these systems, or at least sort of laid the ground for future innovation.

01-00:47:05
Murphy: Basically, in terms of the high frequency systems, there were commercial devices that were available on the surface. Basically, there were efforts to adapt these to underground applications, both in terms of environmental conditions, the propagation issues with leaky feeder systems, and so forth. In terms of the low frequency systems, there weren't any commercially available devices, so there were some efforts to develop some prototypes and demonstrate that particular approach, and there are some companies that sell that kind of technology now. There was also an interest and efforts to identify a means to locate trapped miners. There were two basic approaches that were followed. One was a seismic system, where miners who were trapped were instructed to follow a protocol in terms of banging a timber on a roof bolt, for example on a mine roof. The idea was, with a set of seismometers on the surface, you could locate and triangulate the location. There was an emergency capability developed, maintained by the Mining Enforcement and Safety Administration, based on that technology. There were also efforts to devise a system that used electromagnetic location system. Again, using a very low frequency transmitter, hooked to, essentially, a single coil wrapped around a coal pillar that you could generate a magnetic field that you could detect on the surface. There were a series of ways to assess the capability and limitations of that particular approach. Again, some of the limitations were the amount of power that you had available. You assumed that the only power that was available was the cap lamp battery. You also had the limitations in terms of how much power you could put into the antenna in terms of the intrinsic safety issues I mentioned a moment ago. Basically, with those particular limitations, the other important parameter was the electrical conductivity of the overburden. It depends on, for example, how much salinity there was in the overburden. It determined the propagation of the signal.

01-00:49:55
Burnett: These are kind of transponder stations that the miner could get to and plug into.

01-00:50:02
Murphy: You could either have a transponder station, or because, at that time, it was difficult to predict where you might wind up, the idea was to have—you had your cap lamp battery. If you had a coil or roll of wire that could essentially be the antenna, you could set it up wherever you wanted, wherever you find yourself to be. At that time, there were some studies on survival chambers, and there's even, more recently, in some of the more current recent legislation, some additional requirements for survival chambers for miners. If you look here at the show, there's some people promoting their particular commercial versions of survival chambers for underground mines.

01-00:51:01
Burnett: Getting into the late seventies, you're starting to work on an international collaboration and disseminate this information. The Bureau of Mines was not just for the United States, in other words. This research was published, it's out there, and other countries could make use of it. Could you talk a little bit about how knowledge about mine safety and health circulated around the world?

01-00:51:30
Murphy: First of all, let me correct what you said. I submit to you the Bureau of Mines was for the United States. The Bureau of Mines had much to learn from other countries, and the Bureau of Mines was willing to share information with other countries as well, particularly in regards to the disaster area. There are some similarities and there are some differences in the way mines are designed and operate in different countries, principally because of different strata, different depths of coal, and so forth. There was a group of the principal coal mining countries around the world that annually collaborated in terms of exchanging research results, and that was mutually beneficial in terms of the work that the Bureau did and the work that they did that was shared with our scientists and engineers as well. There were exchanges of technology, there was exchanges of devices and prototypes and so forth, that was used to promote and enhance the health and safety of minors in the United States, as well as other parts of the world as well.

01-00:52:59
Burnett: And also, presumably American companies, once they adopt that as standard practice in the United States, wherever they're operating, it's something they would like to implement, if it's applicable or if it's relevant.

01-00:53:12
Murphy: If it's applicable, that's true.

01-00:53:19
Burnett: This is the late seventies. Now you're a research director, 1978 on through the eighties and into the nineties. You're handling a much bigger staff. This is now about 350 people are working with you, and you're handling sort of the bigger picture. Can you talk about that era a little bit and some of the

challenges that the Bureau of Mines was facing and how Bureau of Mines managed requests and helped the mining industry?

01-00:53:57
Murphy: Actually, I'd characterize as challenges and opportunities. The opportunities to have resources to invest in, looking at a variety of issues and needs, was actually an exciting time. If you looked at the mining program of the Bureau of Mines, it basically was managed and implemented by four research centers. There was Pittsburgh, Minneapolis, Denver, and Spokane, Washington. Each of the centers had the core competencies that were used to address their particular needs. In some cases, those needs were on a regional basis. In some cases, because of some of the unique capabilities and facilities, like fires and explosions, the vast majority of that was done in Pittsburgh, regardless of where the need was. As I mentioned before, the Coal Mine Health and Safety Act of 1969, which, if I recall, is Public Law 91-173, provided some mandates and provided funding resources to address those needs. We truly had a multidisciplinary team that was built and put together to work on particular problems. For example, there was the ground control, or strata control. There was the fires and explosion or explosives. There was issues like life support for emergency escape and rescue activities. There was all the industrial hazards areas that you mentioned before. There were industrial hygiene issues in terms of diesel, for example, and problems with handling of other potentially toxic materials and so forth.

01-00:56:05
Burnett: An underground mine, it's an artificial ecosystem, right? It's got to support human life.

01-00:56:13
Murphy: But to be clear, some of these issues exist in surface mines as well.

01-00:56:19
Burnett: Did you do some work for open-pit operations?

01-00:56:22
Murphy: Yes. In terms of ground control, there's more problems in an underground mine, and more needs, but there's slope stability problems, for example, in an open-pit mine as well. Some of the issues—for example, our colleagues in Twin Cities were very involved in visibility for large-haulage vehicles. I'm sure you've seen the haul trucks that the tires are bigger than people. There were, and still continue to be, incidents of people being injured and killed by an operator not being able to see somebody that's in the proximity of one of these vehicles. There were various studies in terms of looking at tools and techniques to deal with that kind of a problem.

01-00:57:20
Burnett: I imagine today, they have cameras all over the place that the operator can see in many directions.

01-00:57:25
Murphy: They have cameras and mirrors and so forth, and they also have some back-up alarms and ultrasonic detectors and this type of thing as well.

01-00:57:35
Burnett: In terms of slope stability, one of the dangers can be the road that goes around the pit. You're hauling massive tonnage up these roads, and you can have problems with the cave-in of the road. Is that the kind of stuff that you worked on?

01-00:57:53
Murphy: Yes, you can essentially lose the high wall, or the slope, and have devastating effects, both in terms of the immediate health and safety issues, as well as the ability to get in and out of the pit and so forth.

01-00:58:06
Burnett: Right, exactly. That's a real serious problem. I imagine, and please correct me if I'm wrong, there's more open-pit mining as time goes on because they develop sort of more profitable techniques for mining ore as opposed to underground, or is it just these are apples and oranges?

01-00:58:37
Murphy: The answer is you mine because there's a commodity that you can gain some economic benefit from. Then, after you identify the ore body or the coal bed, whatever it might be, then you decide the most cost-effective way to remove it. In terms of both ground control, slope stability, accessibility, materials handling and so forth, you ultimately wind up with either an open-pit mine or an underground mine. For example, if it's an underground mine, then you have issues whether it's a slope where you get an incline that goes into the ore body or reserve, whether it's a drift mine, where you go in off a hillside, whether you had a shaft that goes down and then you develop the access from there. Then there's different mining techniques that go from so-called room and pillar mining to longwall mining, which are the two predominant coal mining methods. In Trona, for example, which is a flat tabular—typically a flat tabular deposit which is typically mined with room and pillar or longwall mining, to where you have these massive deposits where you have blockading where you collapse, essentially, the whole ore body into a cavity below. There's veins where you basically are chasing the vein with various tunnels and drifts and so forth. There's a whole both art and science in terms of how you choose the mine. As a generalization, I would say my answer to your question is because the easy-to-find ore bodies have been more frequently found than not found, there's more of a trend towards more underground mining than there is surfacing mining.

01-01:00:43
Burnett: Ah, okay. That's interesting. So it has to be much more targeted to—and go deeper, as the new one that's being sunk in northern Arizona. That's starting off 1,600 feet deep, I guess.

01-01:01:01
Murphy: I think some of the deepest mines in this country are up in Coeur d'Alene. Hecla Mine, for example. Lucky Friday Mine. Some of those there are well over a mile deep.

01-01:01:15
Burnett: So there continues to be a need for underground safety.

01-01:01:18
Murphy: Absolutely.

01-01:01:19
Burnett: And the problems will multiply as it gets hotter down there.

01-01:01:24
Murphy: It gets harder.

01-01:01:26
Burnett: Ventilation problems.

01-01:01:27
Murphy: You have more of a challenge pumping air in and pumping exhaust air back out. In some cases, some of the deeper mines around the world, they actually use cooling stations to cool the air that they pump into the working area.

01-01:01:48
Burnett: You have to keep it safe and workable for humans.

01-01:01:53
Murphy: Exactly.

01-01:01:54
Burnett: This is not a hospitable climate for people.

01-01:01:57
Murphy: True.

01-01:02:01
Burnett: Is there a particular research program that you are the most proud of? That was the most challenging, most interesting, and most rewarding for you personally?

01-01:02:14
Murphy: I'm not sure there's a singular program, because I think that the work that we did in a variety of areas is noteworthy. I'll share a few with you. We've predominantly focused on health and safety in this discussion so far, which is certainly priority one, but with the Bureau of Mines, there were efforts in a number of other areas. For example, there were some very successful program in terms of treating acid-mine drainage with passive treatment systems. There was work on subsidence prediction, subsidence control and so forth. There was some, basically, mining technology programs that certainly had benefits

in terms of health and safety, but were designed to improve the mining extraction as another important aspect of the overall mining operation.

If you ask what are some of the highlights of the program, we talked about communications. I think there were some very pioneering studies that defined the shape and the status of underground mine communications today. There was some pioneering studies that advanced the state of the art of self-contained self-rescuers. If you go back to pre-Mine Health and Safety Act 1969, there were so-called filter self-rescuers, which basically was a carbon monoxide filter. They were designed to remove carbon monoxide from the inspired air. The principal limitations were two-fold. One was, if you had too much carbon monoxide, it wouldn't remove it. The hotter the carbon monoxide got, the hotter the inspired air became. If there wasn't enough oxygen in the inspired air, it didn't matter whether you removed the carbon monoxide or not. Again, the Health and Safety Act of 1969 mandated a self-contained self-rescuer. There was some initial work in that regard. There's been some improvements over the years in the intervening time since then.

We, I think, made some major advances in the fires and explosions area in terms of particularly this float coal dust issue that I mentioned. There was some work started back then that just recently come to fruition in terms of instrumentation to easily measure the incombustible content of a coal dust-rock dust mixture. The old classical technique was that you basically took a sample, and you took it to a lab and you got it analyzed. That took days to get the results, when you want to be able to respond, essentially, instantaneously to a potentially hazardous situation. We initiated a program in ergonomics and human factors and human error, which prior to that time had not been addressed from a mine health and safety perspective. I think there were some major advances made, and NIOSH continues to pursue these types of areas, and continues to make advances in that regard. I mentioned ground control before. There were some major advances in ground control in terms of support systems, analysis techniques, and so forth, that all were important in terms of improving mine health and safety.

There was a very dynamic program in terms of methane control, and particularly both in terms of localized methane control, which, from a localized viewpoint, also goes into dust control, which I'll come back to in a minute, and also techniques to pre-drain coal major strata of methane prior to mining. In those particular days, there were some emerging technologies in terms of long-hole horizontal drilling. The teams that worked on that were able to drill holes over a mile long and stay in the coal seam, after which point you then had a horizontal gas well that you could pre-drain the methane prior to mining. You minimized the amount of liberation that took place during the mining operation. There was also some collaborative work done with some of the mining companies in terms of so-called slant hole drilling, which is now being used very extensively for the Marcellus Shale type activities. So there was a lot of progress made and used fairly extensively for pre-conditioning a coal bed for minimizing methane release.

I started to mention the respirable dust. Again, there's a lot of interest, a lot of focus, on respirable dust, appropriately so because of the pneumoconiosis problem. There are a host of strategies in terms of looking at minimizing dust generation, and also in terms of minimizing dust exposure. Those are actually two separable issues. If you prevent the dust being generated, you don't have to worry about the exposure, but you can also have strategies where you can divert the dust away from miners, from equipment operators, and so forth. For example, there was a team at Bruceton [note of explanation: The community of Bruceton was the location of the experimental research facilities of the Pittsburgh Research Center] that developed some, what I call, micro-ventilation techniques, that could be modeled on a continuous miner using appropriately directed water sprays. Well, let me back up. Water sprays have been traditionally used to suppress dust, and that does work to a point. But it was identified that if you can direct the sprays in certain orientations, you can create micro-ventilation circuits that divert the dust-laden air away from the miners. That was a lot of success, used in that regard, still used even today, to minimize dust exposure.

01-01:10:13
Burnett: Effectively, you create a clean-air bubble around the worker, instead of trying to control the whole area of respirable air.

01-01:10:20
Murphy: You basically divert the dust-laden air away from the operator. Basically, if you have a mining machine, for example, that's driving in an entry or a tunnel, you have fresh air coming up through the face, and there's a way to divert the dust-laden air through a so-called brattice curtain, into the exhaust system. While you have fresh air coming into the working area, because of the turbulence and the various types of recirculation problems, if you don't take appropriate precautions, some of that dust can roll back into the operator position. But through the use of, again, water sprays as air movers, you can minimize those consequences. There was also work on machine-mounted dust scrubbers. While there was progress made in that, you had to have particular caution in terms of recirculation problems and so forth.

01-01:11:39
Burnett: A scrubber, it has an intake for the dirty, polluted air, and it introduces substances that bind with the particulates and—

01-01:11:50
Murphy: Yes, typically water.

01-01:11:51
Burnett: Typically water, and then can remove it from the system. Then you mentioned earlier that you were dealing with problems of a particular kind of coal dust

that's water-repellant. Does that mean that water spray would not be as effective for that kind of coal dust?

01-01:12:11
Murphy: I'm not sure—

01-01:12:14
Burnett: You mentioned you had problems with coal dust that was water-repellant early on. Or, no, did I get that wrong? Maybe I heard you wrong on that. With the float coal dust.

01-01:12:26
Murphy: Oh, float coal dust. When you have a mining operation, a cutting operation, you generate particles. There's two fractions of dust. One is that which is aerodynamically transportable, or so-called float dust, which deals with the dust explosion problem. Then you have a smaller fraction that is respirable, that has the health effect. In either case, people have used water sprays to suppress those particular fractions of dust. One of the other dust control techniques that was evaluated, depending on the type of coal, with some success, was a water infusion. They would actually drill holes in the coal face and pump water into the coal. So when it's mined, it was less prone to produce dust.

01-01:13:40
Burnett: We've discussed the tremendous achievements of the US Bureau of Mines during the time that you were there. The US Bureau of Mines was shut down, I think in 1995, and in 1996 the shutdown became effective. You can correct me if I'm wrong on that. Can you talk about, from your position, from your perspective, how that transpired? We'll start with that.

01-01:14:13
Murphy: The Bureau of Mines shutdown was a political decision. It was ostensibly a budget-saving measure. What's interesting is the Bureau of Mines did not go away. The Organic Act of the Bureau of Mines still exists. It was effectively closed because no funds were appropriated for the operation of the Bureau of Mines. Some of the work that the Bureau of Mines did was taken up by USGS, in terms of mineral availability and mineral needs. The health and safety work was taken up by NIOSH. There were other parts of the Bureau of Mines that the activities ceased and desist. Particularly, there were five metallurgy research centers that were closed as a result of the shutdown of the Bureau of Mines.

01-01:15:18
Burnett: And that's perhaps the most difficult for the industry, because those activities were not shunted somewhere else. They just disappeared.

01-01:15:32
Murphy: Say it again please?

01-01:15:33
Burnett: That the five metallurgy research centers—you mentioned that they transferred out the health and safety stuff, some of it at least, to NIOSH, and that some of the mineral availability went to USGS, but the metallurgy research centers—were you following the arguments that were made about it? Was it just a kind of silent death of the organization? Who made arguments for the dissolution of the bureau, and what were the claims? Was it that it was redundant? It served its purpose in the past, but there are these other agencies that could then do the work as well?

01-01:16:13
Murphy: Basically the latter. I should add that some of the environmental work went to the Department of Energy as well. Basically, this was portrayed, at least from my perspective, as being a budget-cutting measure, that they could save lots of money by eliminating the organization. As I said, they didn't effectively actually eliminate the organization; they eliminated the funding for the organization.

01-01:16:51
Burnett: In terms of your center, was the budget for the research center healthy until that time, or was there a gradual attenuation of its resources through the eighties?

01-01:17:04
Murphy: It was generally pretty stable. There were some slight decreases, but not huge changes.

01-01:17:18
Burnett: Was the writing on the wall or was it a surprise when the news came?

01-01:17:22
Murphy: The writing was on the wall for six to twelve months.

01-01:17:32
Burnett: That must have been difficult, I imagine, especially this is something you had invested in for your career, and you'd made these accomplishments with your teams. Was there a transition plan? Did people move from US Bureau of Mines to NIOSH in the health and safety area and so forth?

01-01:17:55
Murphy: Actually, it was a two-step transition. When the Bureau was abolished, the Pittsburgh research center actually reported into the Department of Energy for a period of time. Then, following that, the health and safety part of the program went to NIOSH.

01-01:18:19
Burnett: You had worked with NIOSH. Or had you worked with NIOSH before?

01-01:18:24
Murphy: Yes, particularly related to health issues. Particularly respirable dust, diesel issues, diesel fumes and so forth. So yes, there was a collaboration before that.

01-01:18:42
Burnett: Is there a difference in research orientation at NIOSH as opposed to the health and safety section of the US Bureau of Mines? It's more all-encompassing, obviously.

01-01:18:56
Murphy: I've been gone since '97, basically, but my sense is that NIOSH has more of a focus on health than they do on safety in terms of the overall program, but they do address both.

01-01:19:17
Burnett: You were, I guess, a senior scientist at the Pittsburgh research lab under NIOSH from '97 to 2001?

01-01:19:25
Murphy: Yes, basically I was on assignment to the University of Pittsburgh at that point, still working for NIOSH.

01-01:19:40
Burnett: Pittsburgh becomes your new home. Can you talk a little bit about that transition?

01-01:19:44
Murphy: Sure. I went to the University of Pittsburgh again, initially on assignment from NIOSH. Wound up in the chemical and petroleum engineering department and was working on various types of laboratory and occupational health and safety issues. Designed some new courses. Actually got involved in designing a new interactive classroom that was the first of its kind around the area.

01-01:20:20
Burnett: Can you talk about that a little bit? How is it interactive?

01-01:20:26
Murphy: Basically, science and engineering tends to be team-based activities these days. We basically built a classroom that had team stations, computer facilitated, with the ability of teams to present to the whole class. It was, at the time, the first of its kind. It's been replicated probably a dozen times at this point. It was recognized with a couple of awards as a result of, at the time, being very innovative. It's pretty standard practice now.

01-01:21:15
Burnett: That was the SMEAME GEM Award for Science education? Is that one of them?

01-01:21:20
Murphy: No, that's a different subject.

01-01:21:23
Burnett: Oh, okay. So you've got multiple awards in the education area.

01-01:21:30
Murphy: Let's come back to that. Where were we?

01-01:21:33
Burnett: We were talking about the interactive classroom and the innovations you developed in education.

01-01:21:40
Murphy: To finish that part of the story, in 2001, the then-chair of the Department of Chemical and Petroleum Engineering was asked for form a research institute on regenerative medicine, so he asked me to be his executive director. I said, "I'm having fun teaching in chemical engineering, but it's also fun to build new organizations." So I continued to teach in chemical engineering and became the executive director of the McGowan Institute for Regenerative Medicine. It started out as a small group of about twenty-five scientists and engineers who were interested in basically artificial organ technology, and has now grown to a group of 230 affiliated faculty members who spend on the order of $50 or $60 million a year on various techniques with artificial organ development, tissue engineering, cell-based therapy, and so forth. It's been an exciting ride and essentially a new career.

01-01:22:47
Burnett: Yes, absolutely. A different domain, and one, at least, happily, that is fairly flush with support, in contrast to what happened to mining health and safety research. When I looked at your CV, I was curious about this. Regenerative medicine is a departure from what you had done before. It's something we skated over at the beginning of this session, but you have an MBA. You trained in management, pretty much after you did your bachelor of science in electrical engineering. In '63, you started and you did—I guess while you were working.

01-01:23:43
Murphy: That's correct.

01-01:23:43
Burnett: Okay, because it was '63 to '67. At Duquesne, you did an MBA.

01-01:23:48
Murphy: That's correct.

01-01:23:51
Burnett: What did you take from that education into your work as a manager, as a director?

01-01:23:59
Murphy: That's an interesting question, because I tell my students today that when I was their age, even going through undergraduate school, I often wondered

why they were making me take this or take that. I can honestly say that every course I was introduced to and took, I've used and in many cases wished I had a lot more of that tool or this tool. Both from an undergraduate perspective and from a graduate perspective, I've been able to put those techniques together and apply them in a variety of environments that turned out to be fairly successful.

01-01:24:45
Burnett: Do you have a particular management style that you had when you were—and did that evolve over time, depending on the project?

01-01:24:53
Murphy: I typically tried to manage by exception. It's important to delegate and to empower people to do what they think is relevant and important.

01-01:25:05
Burnett: And to act, I guess, as—to be the interface with the outside world, I suppose, when requests come in. You talked about when you were executive. Where are we here now? At a senior level, you're research director at the US Bureau of Mines. You had a significant staff. You also had to handle the budget requests to Congress.

01-01:25:35
Murphy: Basically, the budget was primarily administered through the Washington headquarters office, but research directors were asked to help participate in budget hearings and that type of thing, present to Congress and to the administration the proposed work. So yes, I was involved in that.

01-01:26:05
Burnett: Was there an element of—what's the world?—salesmanship to that? Is this something you had to pitch, or was it kind of folded into a larger understanding of the importance of the work, and you were kind of reporting on progress?

01-01:26:20
Murphy: Yes to all of the above.

01-01:26:24
Burnett: Sometimes you really had to convince people that this was important work.

01-01:26:30
Murphy: Yes, you basically had to show that there was a need, show that you had some potential solutions, and when you had a solution, you had to essentially introduce the findings as a result of the commitment, the investment they had made in you up to this point.

01-01:26:49
Burnett: Mining is, today, a pretty safe occupation, is it not?

01-01:26:55
Murphy: It's certainly safer than lots of other occupations.

01-01:26:58
Burnett: And due, in no small part, to the efforts of the US Bureau of Mines during those decades.

01-01:27:03
Murphy: The Bureau of Mines contributed. Companies have contributed. Regulatory agencies have contributed. There's lots of stakeholders and players.

01-01:27:18
Burnett: I wanted to ask you also about your involvement in the organizations, the Society of Mining Engineers and the AIME. Can you talk a little bit about the voluntary, or voluntaristic, part of your career?

01-01:27:38
Murphy: Maybe a place to start is you mentioned the GEM Award before. GEM was an acronym for Government Education and Mining, and was basically a public awareness, public-outreach initiative that has now become part of the Minerals Education Coalition. I've always been a strong advocate of promoting interest in science. I've done that both on a national basis through SME, and I've done it on a local basis through the Carnegie Science Center in Pittsburgh. I found lots of interest and lots of opportunities to make people aware of both the opportunities in science careers, and also the need for mined materials, minerals, and so forth. That was some of my early involvement in SME. I became involved in the coal division because my principal area of interest and activity was in coal. I had an opportunity to become part of the SME Foundation, and ultimately became the president of the SME Foundation. Served on the SME Board of Directors in 2011 and became the SME president.

01-01:29:19
Burnett: What do you think is the value of this kind of voluntary work? It's a theme I've been talking about with a number of folks. Essentially, so much scientific and engineering work depends on the kind of voluntary contributions of folks in the industry. Can you talk about how SME is important to the furtherance of research and the networks and collaboration of experts and members of the industry?

01-01:29:59
Murphy: First of all, you only get out of it what you put into it. If you want to derive some benefit from an organization, you need to be prepared to contribute and lead where the opportunities present itself. As the SME strategic plan says, SME works to be the indispensable resource to minerals professionals. One simple but very illustrative example is onemine.org, which I presume you're familiar with.

01-01:30:39
Burnett: Yes.

01-01:30:42
Murphy: One Mine now has some two million pages of reference material that, prior to the formation of this database with seven participating partners, that information was relatively inaccessible. I know from the SME member survey it's deemed by the membership to be one of the most important resources that SME provides. SME provides networking. It provides lots of tools and techniques to facilitate the pursuit of individual careers. It's certainly been a valuable resource to me.

01-01:31:34
Burnett: You mentioned earlier the closure of the Bureau of Mines being political. Some of the folks I've talked to have felt that the mining industry is a bit under the gun these days, that there's a lot of pressure, especially in the coal industry, to decrease emissions, or pressure to close plants down. Can you talk about what the industry is doing and can do to sort of improve the public perception of mining, and how they can manage the challenges that they're facing right now?

01-01:32:19
Murphy: First of all, I think we all need to reflect and appreciate the role of mining in terms of our society, our way of life, economic stability, and national defense. As I presume you know, the cell phone, the PDA, that you and I make good use of, and lots of other people do, requires thirty-one different minerals to make it work. That's something we take for granted when we use them every day. Without mining and without the minerals, there wouldn't be such a device. Of course, you can extrapolate that to lots of other things that we depend on for electronics and techniques and tools and so forth. I think there needs to be a continual effort to make people aware of the importance of mining. Various companies, some more proactive than others in terms of being good stewards, but I think the industry overall at this point works diligently and hard to be good stewards of the land and to make people aware of the role that they play in our society.

01-01:33:54
Burnett: Professor Murphy, I want to thank you for your time.

01-01:33:56
Murphy: It's been a pleasure.

[End of Interview]