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THE WISCONSIN ENGINEER

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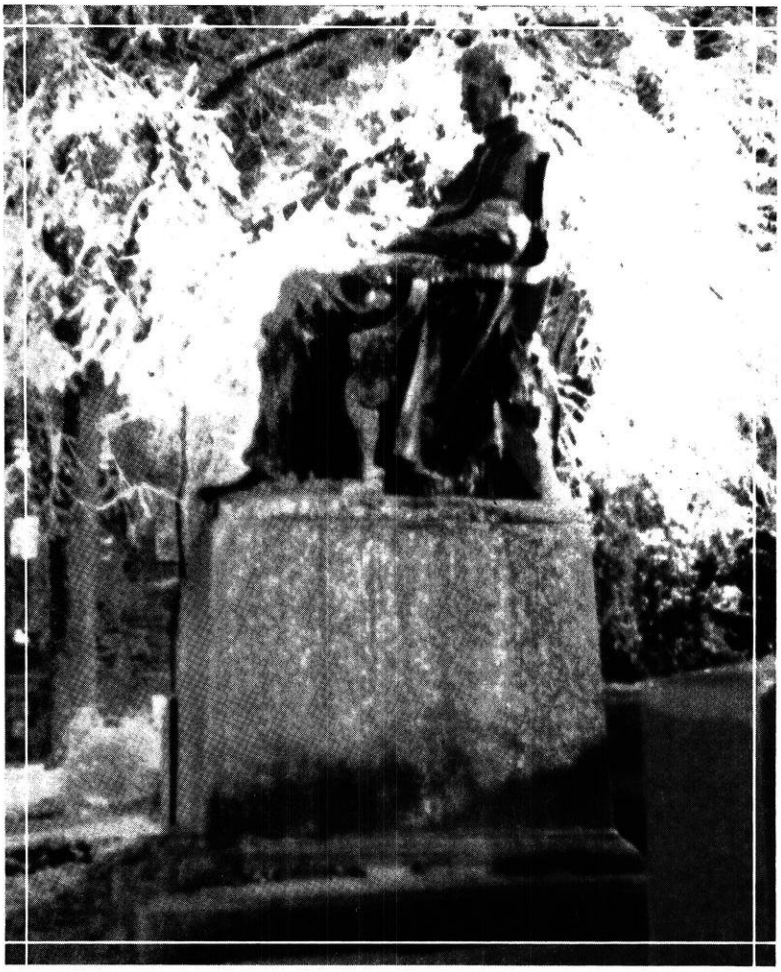
WELDING

WATER HAMMER

The Engineer on the WITNESS STAND



FEBRUARY 1937

Member, Engineering College Magazines, Associated

Better . . because IT'S WELDED

Welding eliminates overlapping joints in the modern tank car. This materially reduces dead weight and makes the car easier to clean and maintain. It completely prevents loss or contamination of the contents from rusted joints.

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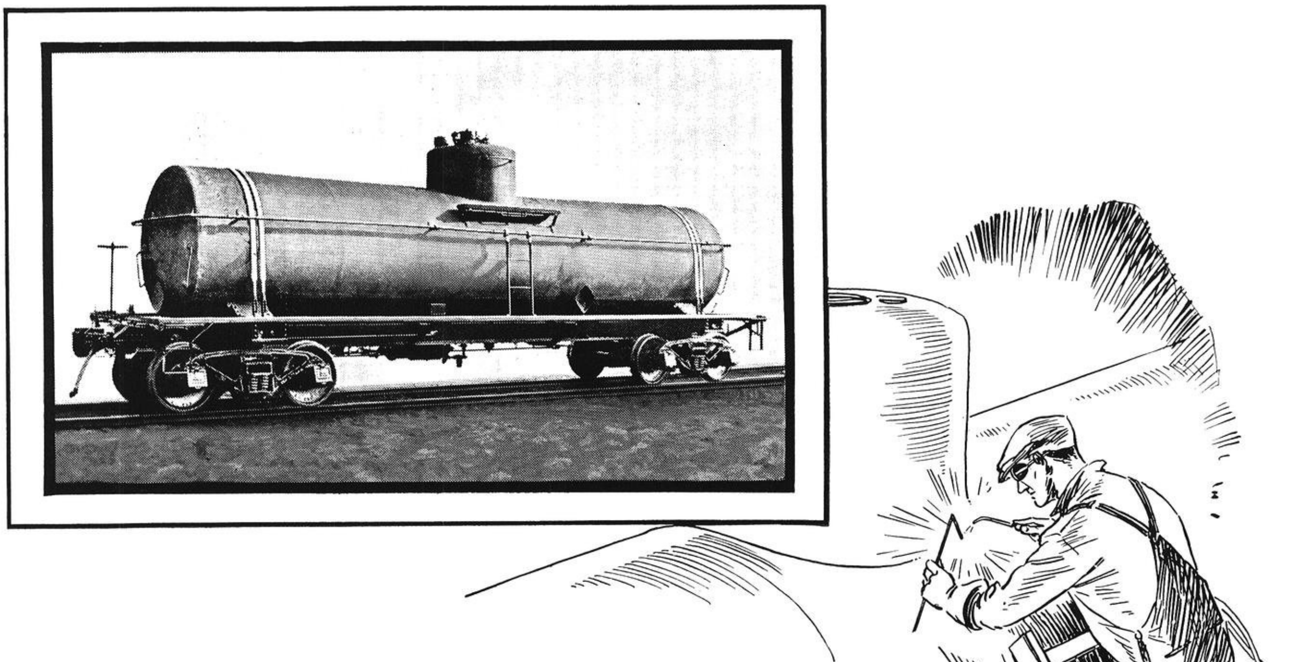

Everything for Oxy-Acetylene Welding and Cutting

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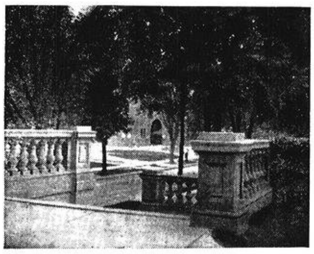

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WITH THE CONTRIBUTORS . . .

• On our cover this month is a picture of Lincoln's statue in front of Bascom Hall taken during the period when everything was covered with sleet. It was taken by Farrington Daniels, Jr.

• Do you know what water hammer is? Do you know how it is partially eliminated? See the lead article on page 83.

• We have a real welding laboratory in the Mechanical Engineering building. For an account of what is done out there, and the importance of welding in industry, see page 86.

• The humor page is back again this month after being crowded out in January. See page 92.

• Engineers are frequently called to the witness stand to defend valuations they have made of properties of public utilities whose rates are being investigated by regulatory commissions. On page 95, Mr. Bennett sets forth what the engineer on the witness stand should do and what he should avoid.

The Wisconsin Engineer

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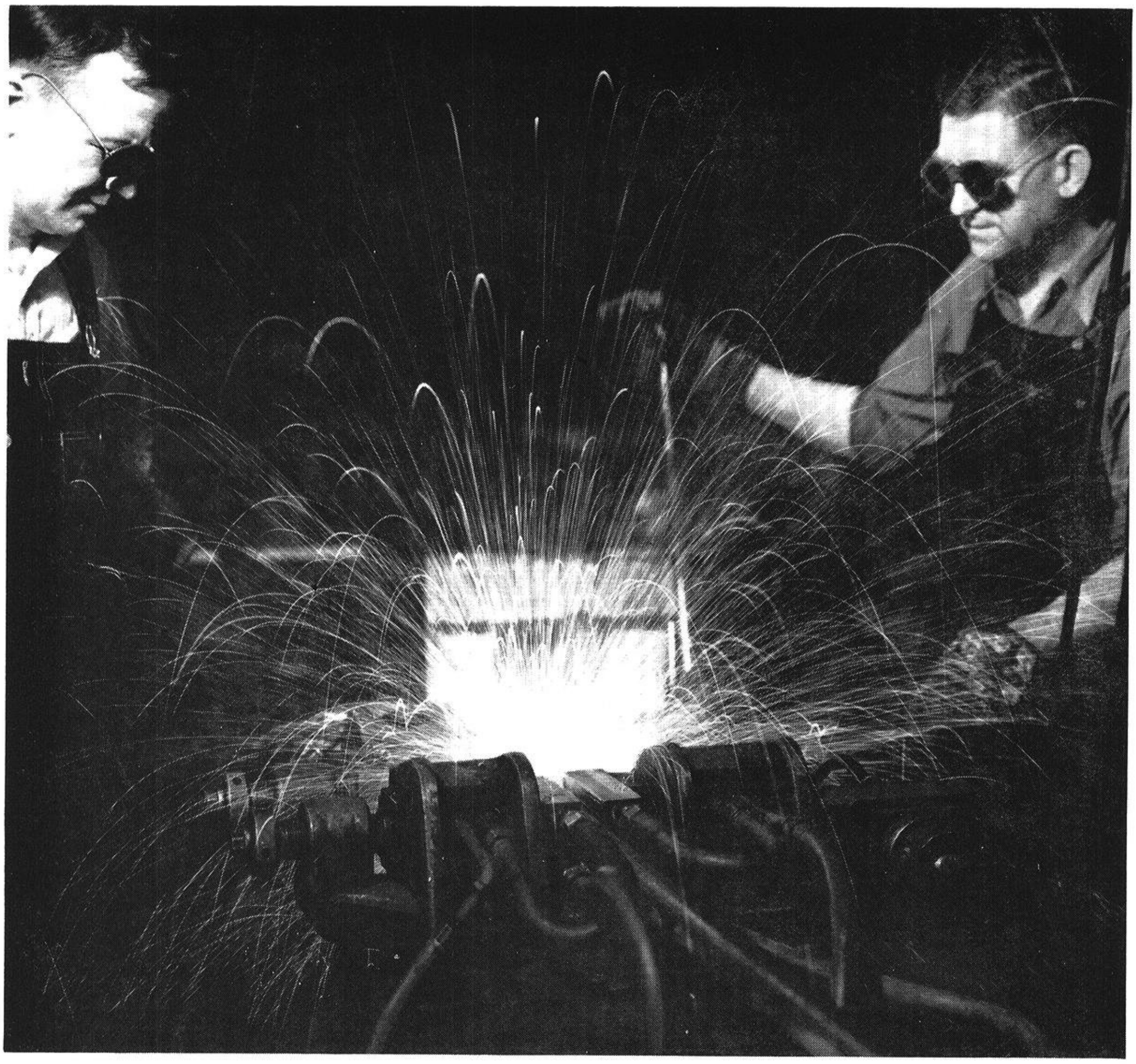


THE SMITH,

. . . A Mighty Man Is He

• The "Smith" of Longfellow's day was literally a mighty man . . . a man of brawn and stamina who fittingly symbolized the "muscular" civilization of his time. He was an admirable character well worthy of the Poet's eulogy, for his moral as well as his physical virtues. The picture Longfellow has given us of him will live forever in our hearts and serve to remind us of a simpler and, perhaps, a more satisfying age.

• The village blacksmith is no more, the spreading Chestnut tree has long since withered and died as have the children who looked in at the forge and caught "the burning sparks that fly like chaff from a threshing floor." The modern blacksmith is a different type of individual. His brawn has given way to knowledge of strange new forces and their control. By the merest touch of a lever or switch he calls into play forces ten thousand times greater than those known to the village blacksmith. And the sparks of the modern smithy are of a kind and quality that startle and fascinate both children and grown-ups alike. Study the myriad flaming parabolas in the photograph above and see if you cannot read in their very trajectories the scientific nature of the processes which give rise to their being. In the resistance welding process, electricity does in an instant that which the village blacksmith could have accomplished in hours.

Water Hammer Arrester Performance

by GERARD A. ROHLICH, c'36 and LEWIS H. KESSLER, c'22

Research Fellow and Assistant Professor, respectively,
Department of Hydraulic and Sanitary Engineering

NEARLY everyone has encountered the phenomenon of **water hammer.** Usually the contact has been made when, upon closing a water faucet suddenly, a sound like that of a hammer striking a pipe is heard. Water hammer has been described as follows: "When a liquid is flowing in a pipe, there is a definite amount of energy in the liquid and if we stop the flow suddenly the energy of the liquid is used up in doing work on the pipe, by stretching it or increasing its diameter. If the liquid is compressible, the energy of the liquid is used up in compressing the liquid and stretching the pipe." The increase in pressure above that pressure in the pipe while the water is flowing under steady flow conditions is called water hammer.

The causes and control of water hammer are of primary significance to the engineer. The effect in causing pipe fracture, loosening of joints and damaging of fixtures, in addition to the undesirable noise is a consideration that engineers have long sought to overcome. Despite the importance of the problem of water hammer and the manifestation of its destructiveness in water works distribution systems as well as in house plumbing systems, the technical literature is not so voluminous as might be expected. Notable contributions have been made during the past 50 years and the theory has been developed that shows the magnitude in pressures that can be expected when a valve is closed suddenly.

The problem is complex, and because of the fact that our pipes are compound in nature, i.e., involving looping and branching pipe lines of various sizes and materials of construction, different methods of jointing, coating of pipes, types of valves and various methods of caring for contraction and expansion, the prediction of water hammer characteristics is difficult. Eminent engineers and scientists have investigated the phenomenon wherever possible and practical. The earliest work was done by J. Michaud in 1878. He noted the oscillating character of water hammer and considered the influence of the elasticity of the pipe and of the water as a form of air reservoir furnishing relief. The work of Prof. Joukowsky in 1898 in developing the formula for maximum water hammer pressure likely to occur is considered by authorities one of the most outstanding contributions. The work by Lorenzo Allievi in 1903 and subsequent translation and publication has proven invaluable as a basis for the development of recent theory. A symposium arranged by the A.S.M.E. Committee on water hammer was presented at the Palmer House, Chicago, June 30, 1933, under the joint auspices of the A.S.M.E. Hydraulic and the A.S.C.E. Power divisions. This symposium and the supplement is the most comprehensive summary of reported theory and its verification by experiment on the characteristics and behavior of water hammer in all sizes of conduits.

Theory permits the prediction of the maximum amount of water hammer pressure likely to occur due to closure of a valve, faucet or control device. The theory is not wholly adequate in explaining the behavior of pressures in compound pipes or the effect or modification due to dead ends. For practical purposes, however, it has been shown that a water hammer pressure of about 60 pounds per square inch above flow pressure can be expected to occur in small pipes for each foot per second of velocity of flow that is stopped in a pipe line by the sudden closure of a valve. This means that if a velocity of 10 feet per second is stopped instantly a maximum

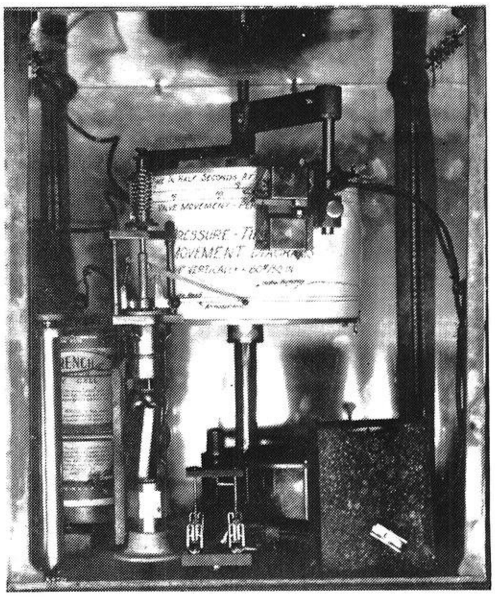
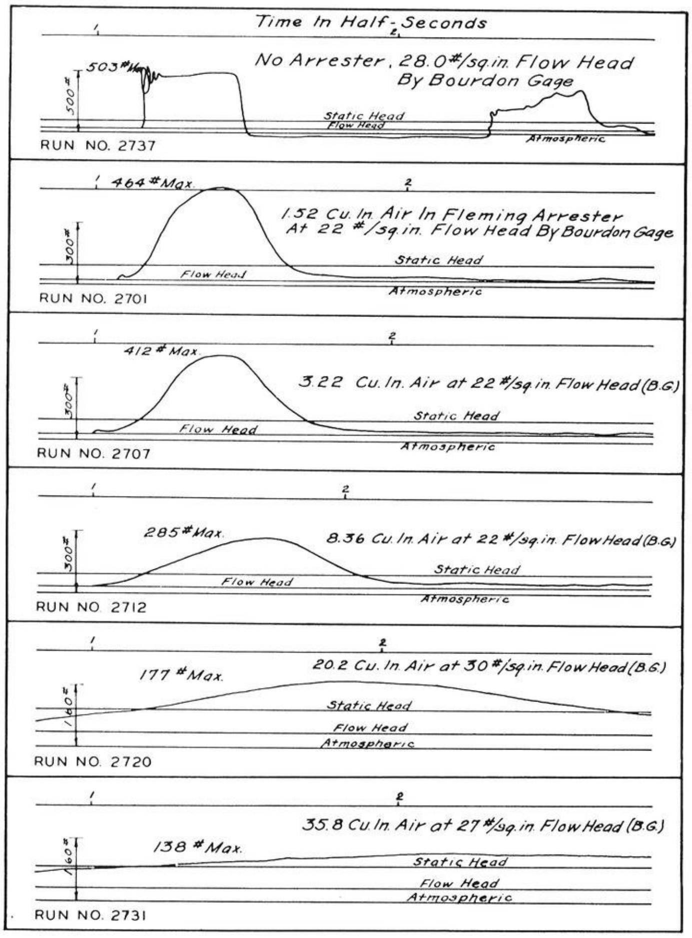


Fig. 1

water hammer pressure of 600 pounds per square inch may occur. "Instant closure" is defined as the time of closure of a valve that is faster than the time required for the pressure wave, set up by the valve movement, to go to the source and return. The speed of this wave travel approximates that of sound in water and is about 4,000 feet per second, depending upon the rigidity of the pipe, its thickness and diameter. Closure of valves slower than "instant closure" also cause water hammer but of lesser intensity. The closure in this case is termed "slow closure."

Relief from water hammer pressure may be accomplished in several ways, although there are some disadvantages present in the relief methods. A certain way to prevent water hammer is by closing all valves slowly. However, for particular types of use this would be impractical and many valves are sold today **because** they have fast and positive closing. Relief valves, surge tanks and automatic surge suppressors have been widely used to provide relief and have proven valuable in overcoming water hammer pressures.

Air chambers, which are extra lengths of pipe closed on one end, in which is imprisoned a column of air that compresses and absorbs the shock, provide a sure and positive method of relief. It is necessary, of course, that the air chamber be installed in a vertical position and the difficulty in keeping air in the chamber and preventing it from being absorbed by the liquid due to the repeated shocks has made the air chamber of small value in reducing hammer where the chambers are not easily maintained.



WATER HAMMER PRESSURE - TIME DIAGRAMS
CAUSED BY VALVE CLOSURE
SHOWING RELIEF OBTAINED
WITH FLEMING WATER HAMMER ARRESTERS

GENERAL DATA

NOMINAL DIAMETER OF PIPE 1/2 in. — DISCHARGE AT FAUCET 5.97 G.P.M.
LENGTH OF PIPE 379 ft. 0 in. — VELOCITY IN SUPPLY LINE 6.57 ft./sec

TESTS CONDUCTED AT HYDRAULIC & SANITARY LABORATORY
UNIVERSITY OF WISCONSIN — JULY 1936
BY L. H. KESSLER G. A. DOHLICH M. GAMET C. SLICK

Fig. 2

Research on water hammer has been conducted by Professor Kessler from time to time at the Hydraulic laboratory and in the field on practical problems that have presented themselves. At the present time, the project is the investigation to provide relief in the smaller pipes of the plumbing systems of buildings. The problem here is tremendous when one considers that in a single hotel, hospital or office building there may be as many miles of pipe and as great a number of valves and faucets as there are in a small municipality. More than 2,500 tests have been made on sizes of pipe up to and including 2-inch diameter. Lengths of pipe to 380 feet have been tested. Relief has been obtained by the use of a combination mechanical-pneumatic arrester made by the Fleming Manufacturing Company of Milwaukee and perfected at the hydraulic and sanitary laboratory. The device shows characteristics and behavior similar to an end chamber, but the construction is such that the air can neither escape nor be absorbed by the water. The device consists of a spring tempered phosphor bronze container, a known portion of which is filled with air or gas (hydrogen has been used) and the remainder with an emulsifying liquid. The liquid prevents the container or bellows from being compressed beyond its elastic limit and allows a balancing of pressures inside and outside of the bellows preventing failure.

The devices are made to contain different volumes of air. This volume is known and the volume at any flow head can be computed. This fact permits a means of correlation between water hammer pressure obtained and volume of air in the chamber.

Two water hammer recording devices are used, one of which is shown in Fig. 1. It consists of a high speed Diesel engine type indicator mounted on the pipe line directly behind the valve and relief device. The history of the pressure-time diagram is recorded on the indicator card which is mounted on a drum that is caused to rotate by a spring driven gear movement. The magnetic timing device is operated by a clock movement, and as the drum rotates a pencil mark is made each half second on the card. In this way the speed of the drum and consequently the speed of the water hammer pressure wave is obtained. The maximum pressure set up in the pipe line is found from the calibration of the spring and the height of the wave trace.

The new indicator, used for particularly high pressures, is a Maihak (German make) high speed engine indicator in which a cantilever bar spring is used in place of the conventional helical spring. The chronomatic drum on which the indicator card is mounted is of the free rotating type set in motion by a helical spring encircling the drum shaft. The spring is wound by rotating the drum slowly in a clockwise direction. The speed in feet per minute at which the drum rotates at any instant is indicated by a magnetic tachometer, mounted on the top of the drum.

A series of pressure-time cards using varying amounts of air in the arresters was obtained for lengths of pipe of about 50, 120, 160, 220, and 380 feet in the smaller pipe diameters. Such a set of cards was taken for a number of velocities covering the range likely to occur in piping systems.

Logarithmic curves of these data were plotted and from these curves tables have been prepared that can be used to determine the amount of air required to reduce the maximum water hammer pressure to a magnitude considered safe for the pipe line, fittings or fixtures.

Fig. 2 shows a series of water hammer pressure-time diagrams. This gives a clear picture of the relief obtained with different volumes of air in the arresters. The first card (Run No. 2737) shows that the maximum water hammer in the ½-inch pipe line of length 379 feet with a discharge of 5.97 gallons per minute at the faucet to be 503 pounds per square inch. No relief device was used. (Note initial indicator whip.) Run 2701 shows the maximum to be 464 pounds per square inch when an arrester containing 1.52 cubic inches of air was on the line acting as a cushioning effect. With all other hydraulic conditions remaining the same, Runs 2707, 2712 and 2720 show the decrease in pressure with an increase of air in the arrester. Run 2731 shows the reduction of maximum pressure to 138 pounds per square inch when 53.8 cubic inches of air were available. This pressure is not very much greater than static head.

Table No. 1 is one of several that has been prepared for use by architects and engineers who design plumbing systems in buildings. For the ½-inch pipe size, it represents what would be considered a maximum velocity of flow so that too high a pressure does not have to be maintained in the building or at the water main. It is above the velocity as used in tests of Fig. 2. The table may be interpreted as follows: with 7.7 feet per second velocity in a ½-inch pipe, the maximum water hammer possible is 490 pounds per square inch absolute above **flow head.** In order to produce this velocity in a pipe 100 feet long, a **static** pressure of at least 49.7 pounds per square inch absolute must be available. Most faucets would require a greater pressure than shown. This static head shown will in general be a guide as to whether 7.7 feet per second is likely to be the velocity in the pipe. If the static head is less than this amount the designer should use a table (not shown here) in which his static head appears. He will be guided, of course, by the length of pipe of his particular layout. Assuming Table 1 applies to his problem and he wishes to select an arrester that will lower the maximum water hammer pressure from 490 pounds per square inch, a possible maximum, to 82 pounds per square inch, an arrester containing 15 cubic inches of air at **flow head** must be used; 82 pounds per square inch in this case is well below twice static head, and it is believed most systems will safely handle pressures up to twice static head. The arrester selected due to its design will actually contain more air at atmospheric pressure and therefore the designer must specify or give his estimate of what the pressure will be directly in front of the faucet while the water is flowing.

Gallons per Minute = 7.0 Velocity = 7.7 ft./sec.									
	½" Galv. Pipe of Lengths in Feet								
	25	50	75	100	125	150	200	300	400
Max. Water Hammer Pressure Possible	← 490.7 →								
Min. Static Head	33.7	39.7	42.7	49.7	55.7	63.7	75.7	103.7	120.7
Volume of Air Req'd. at Flow Head	All Pressures in Lbs. per Sq. In. Absolute								
2 Cu. In	105	175	235	295	352	405	490	491	491
3.5 "	84	140	190	240	285	335	400	475	491
5 "	65	102	142	179	215	260	325	405	455
7.5 "	58	78	103	130	160	195	250	335	395
10 "	54	68	**85**	103	130	156	205	285	350
15 "	49	59	69	82	96	119	160	230	280
20 "	45	54	63	73	84	100	132	193	250
25 "	42	50	59	67	76	90	117	171	220
50 "	36	46	49	56	63	73	92	128	160
75 "	33	39	45	51	57	66	81	108	135
100 Cu. In.	31	37	42	47	53	60	73	97	120

Table 1

The table is complete for lengths of from 25 feet to 400 feet and for possible pressure reductions down to static head. Actually devices that are extra large require a time period for the pressure to compress the air in the arrester up to a pressure equal to static head. This means that the pipe line pressure will be below static head for a certain period of time after valve closure. This may not appear logical but it is a fact and has been one of the interesting findings in the investigation.

Theory verified by experiment shows conclusively that for instant valve closure the length of pipe does not change the maximum hammer pressure. As soon as a relief device is placed on or in the line, it is possible for the water that is stopped by the valve closure to partially continue its movement into the arrester. In this case the energy in a pipe line, which for a given velocity increases with the length of pipe, becomes very significant. The investigation at present shows no simple relationship as to effect of length of pipe on water hammer pressure. While several lengths of pipe have been tested, it has, as yet, been impossible to verify pressures predicted by theoretical equations. This does not mean that the theory involving mechanics of fluids and gases does not apply, but that possibly, due to the many variables affecting the problem of relief from water hammer, theory and practice may not agree precisely. For example, perhaps the influence of friction, neglected in some theory, may warrant reconsideration.

Summary

Experimental investigation has shown that certain water hammer relief devices can be built that will adequately insure safe pressures within either hot or cold water piping systems of buildings at all times and under any condition of operation. These devices involve known amounts of air or gases for the absorption of the water ram or shock and each device has a limited utility or a definite range within which it will be a successful appliance. Fatigue tests have shown that the devices will require very little maintenance since by the nature of their construction and operation replacing the gas periodically is unnecessary. The arresters used in this investigation have not failed or fractured regardless of the amount of external pressure applied. As a matter of fact, they operate at all times under balanced pressure. The water hammer pressure decreases with an increase in the volume of gas in the arrester. This is pointed out in Table 1 and Fig. 2. For a given volume of gas in the arrester, the relief from water hammer decreases as the length of pipe increases. The investigation is not complete and at this time we have not arrived at a formula for the empirical relationship. All hydraulicians are agreed that more experimental evidence is needed in order to explain the phenomenon of water hammer when relief devices are used. It is believed that the research project now in progress at this university is one of the most comprehensive ever attempted in obtaining data for this purpose.

The writers are particularly indebted to the men on Works Progress Administration Project 3987 from May, 1936, to date who have assisted in the erection, operation and maintenance of all apparatus. The State Emergency Board, through the WPA, has contributed some funds for materials.

WELDING

by **MARTIN B. CONRAD, m'38**

VISITORS have frequently remarked, as they have been taken through the various departments of the Mechanical Engineering building, as to the excellent equipment and layout of the welding department. Some have even gone so far as to ask if the purpose of the department was to make welders of the mechanical engineers. Such is not the case and one can rest assured that these individuals are not acquainted with the extensive development of welding in industry today.

Welding is offered to the student in engineering in two different lab courses. He is first introduced to the subject in his freshman year as a part of a general metal course. This course briefly offers the fundamental principles of electric arc and acetylene welding, their application and safe practice.

There is an advanced course in welding, which is a requirement for engineers taking the aeronautics course. This course may be taken as an elective by engineering students. The students are split up into two groups of equal numbers. One group will be on the arc welders while the others are operating the acetylene torches.

It takes concentration on the part of the student to get the feel of the arc so that his attention can be concentrated upon the appearance of the weld metal and try and control what is happening in that molten pool of metal.

At the beginning, the arc welders are very exasperating because the welding rod sticks to the material being welded. However, after a couple of hours the even crackle of the arc and the blue light playing steadily on the ceiling informs the instructor that things are going better. After the students have had some experience in bead practice, they are given the opportunity to apply this experience in making plain butt, and other types of welds, afterwards breaking the welds by the nick and brake test, and later by the tensile testing machine, and examining the defects which are present. In this way, the student is able to distinguish and analyze good and poor welds. With the assistance of the instructor, good welds soon develop and about this time in the course one begins to see the application of welded design to industry.

In gas welding the question of a neutral flame, the proper temperature control for different types, design and material are the main problems involved. Soon the operator notices the difference in the appearance of the metal when he has an oxidizing or carbonizing flame and is able to check the flame as soon as it gets one way or the other.

The lack of penetration is another undesirable condition which is common to both the acetylene and the electric welders. This condition shows up when the welds are pulled apart and appear as unfused sections in the center of the weld.

In progressive steps, one moves from steel to cast iron welding, bronze welding, aluminum welding, gas cutting, and the use of the carbon arc. Each student is given some welding project, which serves to acquaint him with the general procedure of design, laying out a job, and with the corrections which must be made because of the contraction of the weld. The student also has an opportunity to use many different types of welds and in this way more firmly establish them in his mind, this information to be used in future welded design.

Toward the latter part of the course the class progresses to aircraft welding. Each student prepares different types of aircraft joints, and welds them. This last step in the course tends to destroy any ego which may have developed up to this time and offers an appreciation of the practice necessary to make good aircraft welds.

Although the students are capable of making good welds when they finish the course, the major aim of this course is to enable the young engineer to adopt welding as a means of fabrication and to permit him to appreciate the possibilities of welded construction and its application to design that decreases the cost of production and also results in a superior product.

Welding as a Means of Fabrication

Practically all of the motor cars of today contain welded parts in the process of manufacture. Under the smooth painted surface of the modern body design of today's motor car, there is the story of a gas or electric weld. The Lincoln Zephyr's frame and body are completely fabricated by welding, 3,435 spot welds, 130 arc welds and 175 gas welds.

It is common knowledge that one of the biggest pipes in the world was constructed for the Boulder Dam project. These pipes were too large and heavy to be shipped to the site, so a special plant was constructed on a mountain side about a mile from the dam site. The sections of pipe 12 feet long and some as large as 30 feet in diameter were made up in this plant by welding together three pieces of large plate steel. A special roll had to be constructed for the job. Some of the plates were more than two inches thick. All the welds were tested by X-rays and heat treated before leaving the plant. The fabrication of the pipes for the dam required more than 400,000 linear feet of welding. Two 12 foot sections of this pipe, when welded together with a fillet insert between them, with support brackets and stiffing rings, weighed more than 170 tons.

The designers of steel structures are realizing the importance of welding as a means of fabrication. Designs which were suitable for riveted construction are often not at all suitable for welding. From an economic standpoint just as little welding metal should be used on the job as possible. An economy in this way can often be accomplished by having special shapers rolled in the mill of metal which only costs a few cents a pound. A saving of weld metal which may cost as much as 50 cents or more a pound and the labor involved on the job can be made by changes of design in this way.

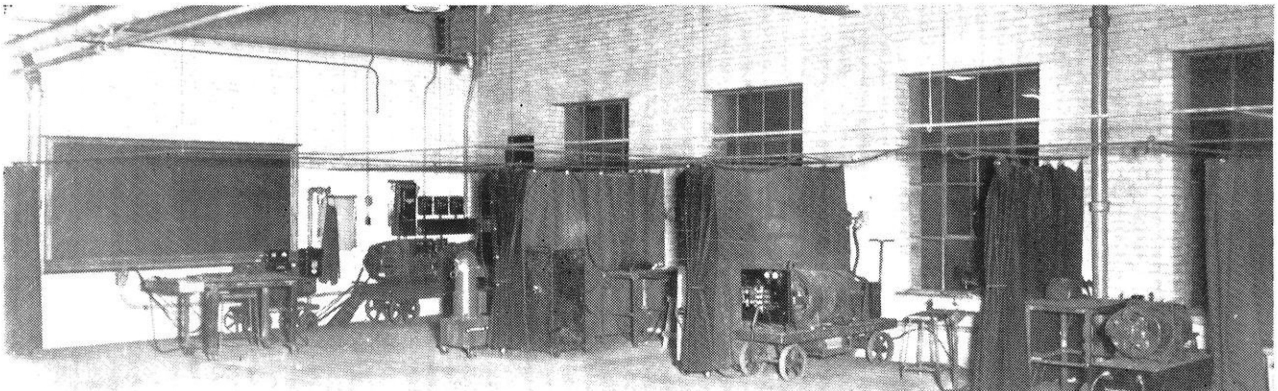
There are many advantages of welding in building construction. One of the most noticeable in the big cities is the silence accompanying welded construction. When proper equipment is available, welded construction has proved to be much faster than the riveted type.

The steel structure of the Spring Grove Hospital, in Baltimore, weighed more than 100 tons. It was estimated that arc welding saved seven tons of steel. Where changes or additions to buildings are made, welding has proved to be a very convenient method of attaching new beams to columns, for it necessitates the minimum removal of masonry. With a gas torch on the job, odd lengths can be cut with a very small expenditure of money, labor, and time.

A welded structure is always rigid. This feature is of special importance in a region where earthquakes are likely to occur. Welded school houses and office buildings are becoming quite the common thing where this hazard is present. The superiority of the welded joint was proven when the Girls' High School in San Francisco was wrecked. Many a riveted joint gave way but not a single welded joint was found broken.

A great deal of welding is done in the aircraft industry. The wooden fuselage with its maze of bracing wires was soon replaced by the welded fuselage which was more rigid and lighter, eliminating the danger of splinters in case of a crash. The early metal fuselages were of carbon steel tubing. Shortly chromium molybdenum tubing began to replace the carbon steel because of its light weight and the ease with which it could be welded. Chromium molybdenum steel when welded has a tensile strength of about 80,000 pounds per square inch. After being normalized properly the tensile strength rises to 90,000 pounds per square inch. With proper heat treatment the steel has been known to have a tensile strength as high as 200,000 pounds per square inch. When chromium molybdenum steels are subjected to vibration such as would be the case in wing beams, the steel is heat treated so that it will have a maximum strength of about 180,000 pounds per square inch. In this way a higher elongation value is obtained and above these figures the fatigue values do not increase proportionally.

As the monocoque fuselage began to take its place in the aircraft industry, and spot welding was found to be the



Electric arc welding equipment in welding laboratory best means of fabrication, chromium molybdenum steel no longer satisfied the demands of the manufacturer, for the spot welds were very brittle and often broke when the work was heat treated. Another objection to chromium molybdenum steel was that it was not corrosion proof when subjected to salt air or salt water.

As the result of the demand for steel that was strong and at the same time easily spot welded and non-corrosive, stainless steels came onto the market. Stainless steels did not chill at the welds after spot welding and the spots were found to be able to carry from 80 to 1,500 pounds, depending upon the thickness of the material.

A trouble known as "weld decay" was experienced when stainless steels were fusion welded; that is, after welding the steel was not corrosion proof around the weld. It was found that this trouble was due to the deposition of chromium carbide within certain temperature ranges, and along with crystal boundaries, leaving that region low in available chromium. By the addition of titanium or columbium to the steel, the carbon is taken up as titanium carbide or columbium carbide, which prevents interference with the chromium.

The relatively new process known as metallizing is an outgrowth of the welding field. This process is adopted to many different types of jobs and is covering a greater field all the time.

The equipment necessary to metallize consists of an air compressor, air tank, oxygen tank, acetylene tank, hoses, metallizing gun, and sand blasting equipment.

In this process a small wire is fed into an acetylene flame where it is melted. A strong blast of air blows this molten metal onto the object which is being metallized. To metallize properly it is necessary to have a surface which is absolutely clean. This clean surface is generally obtained by sand blasting, which also tends to roughen the surface, giving the sprayed metal a better chance to cling to it.

Metallizing is used extensively to coat a base metal with some metal especially adapted to the conditions of the locality. Thus structures which are near the salt water are coated with some metal which is resistant to corrosion. Ornamental iron grill work on the outside of buildings is metallized to give the desired appearance. Material such as concrete is frequently metallized to give a metallic appearance. In San Clemente, California, two concrete statues were metallized with bronze seven years ago and have been subjected to the most severe weather conditions ever since and still the job shows no sign of deterioration. The inside of tanks which are carrying corrosive liquids or gases are metallized with a resistant metal.

Many machine shops find metallizing equipment indispensable. Worn babbited bearings can be built up with much less expense than having them replaced. Mistakes in machining can be remedied by building up the part. Armature shafts can be made to size with harder metal than is ordinarily used. The insertion of stainless or high carbon steel on cold rolled or machine steel makes a hard resistant steel only where it is required. Cracked boilers or defective castings can be easily repaired by metallurgy and no preheating is required.

The College Magazine

The world is full of magazines—I tumble for them all; the postman opens wide my door and piles them in the hall. I stumble over Rustic Life when I start off at morn and wipe my feet at evening on the Bolshevistic Thorn. I cannot read the printed stream that riots through my door for I'm too busy striving to increase my worldly store. I haven't time to masticate this mass of printer's ink, and if I tried to read it all I'd have no time to think. I amble gently on my way and let the flood roll by, but now and then a sparkling sheet attracts my eagle eye. I fish it out and open it and bless old Caxton then, for he has made it possible to print the thoughts of men. And first among these choicest ones I count the magazine that comes to me with college news that keeps my memories green. The college journal that the boys so gravely labor o'er! They have my full comprendez vous,—I too have done that chore. I labored early, labored late and drained my think-pot dry to get December's issue out e'er June exams rolled by. I wrestled with our students who were frozen to their pelf and pleaded with alumni who were centered all in self. I rustled ads around the town until the merchants there arose in righteous self defense and chased me off the square. And when I thought I had a bone hid in our treasury, the printer sent a billet due and took that bone from me. I thought my efforts would exalt my alma mater dear. Perhaps so, but the profs took stock and conned me out that year. I think of those old college days as each fall rolls around and when they ask me to subscribe I'm eager as a hound. I send that measly dollar bill akiting on its way. I know I'll get my money's worth and make some young hearts gay. I waste a plenty every year, but one investment pays,—the coin I spend to buy a breath of dear old college days. The host of famous magazines lies piled up on the floor; I tear the wrapper from the little piebald two by four. I read about the happenings upon the campus where I used to hustle up and down with pals and co-eds fair. I read about the old boys first and then those campus notes. I chuckle at the law-stude squibs; we still have got their goats. From A to Iz I read it through, including Eds and Ads, and then I heave a solemn sigh and say, "God bless them lads." You too, my son, will bless them if you'll loosen up your roll and spend one lone simoleon for tonic for your soul.

—MALT BASIN.

The Wisconsin Engineer, September, 1919.

ALUMNI NOTES

Mechanicals

ADAMS, C. W., '37, has an offer from the Stearns Magnetic Mfg. Co. of Milwaukee, where he will be an assistant engineer.

BAUM, R. H., '37, is starting work immediately with the Linde Air Products Co., subsidiary of the Union Carbide and Carbon Corp. He is to be located in Boston, Mass.

BORER, WALTER M., '33, beginning with the new semester is an instructor in the mechanics department of the College of Engineering of the University of Wisconsin.

GRIFFITH, LEROY, '37, is going to the Ex-Cello-O Co. of Detroit. The Ex-Cello-O Co. manufactures aircraft equipment and special tools.

GROSS, EDWARD W., '36, formerly with the Allis-Chalmers Mfg. Co. of Milwaukee has now become affiliated with the M. W. Kellogg Co. of New York, where he is an engineer in the mechanical equipment department.

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Civils

ADLER, ORVAL C., '31, is sales engineer with W. H. Reinecke of Milwaukee, handling various building specialties.

BOGOST, MEYER S., '36, has been appointed sanitarian for Dane county, Wis. The Dane County Sanitary Unit is a project which has ben set up for one year as an experiment.

FAULKES, GEORGE S., '36, spent the summer as inspector on sewer construction for the Federal Housing project at Congress and Capitol Drive in Milwaukee. On September 1 he began work with the highway commission at Madison on the Statewide Highway Survey.

HARVEY, STANLEY T., '36, is in the bridge engineering department of the Sante Fe Railroad system. His address is: 826 S. Wabash Ave., Chicago.

KING, MAX W., '09, has recently been made superintendent of construction for the Comision Nacional de Irrigacion on the Azucar dam on the San Juan River in Mexico.

KRASIN, L. L., '32, is with the Chicago Bridge and Iron Works at Chicago.

KUELLING, HERBERT J., '08, in connection with W. E. Jeffrey, has opened a consulting office in Lancaster.

LAURGAARD, OLAF, '03, has been appointed construction engineer on the new Hiwassee dam being built by TVA. He was recently initiated into Chi Epsilon by members of that fraternity living in Knoxville.

SAVAGE, JOHN L., '03, chief designing engineer of the Bureau of Reclamation, will go to England as guest of the Institution of Civil Engineers of Great Britain to deliver an address on April 15 in London. The invitation to foreign engineers to address the Institution is considered an honor. In this case the honor is conferred in recognition of Mr. Savage's work in connection with Boulder Dam.

VEERHUSEN, HERMAN H., '12, died sometime in January. He had been connected with the American Telephone and Telegraph Co. in New York for many years.

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Chemicals

FRANK, DAVID S., '23, is in charge of combustion problems at the Pure Oil Co., Chicago.

JANETT, LESLIE G., '35, former editor of the **Wisconsin Engineer**, is with the J. O. Ross Engineering Corp., at 201 N. Wells St., Chicago.

LACHER, JACK H., '31, one time business manager of the **Wisconsin Engineer**, had a son, John Hammit, born on December 23, 1936. The Lachers home is in Old Hickory, Tenn.

SEABORN, BLAINE, '35, is working in the control and production laboratory of the Archer-Daniels-Midland Co., of Chicago.

TRUEBLOOD, WILSON D., '22, who was on the staff of the **Wisconsin Engineer** in 1921-22, is with the Leeds & Northrup Co., Chicago.

WENGER, HAROLD A. E., '32, is operating the Regnew Laboratories at Madison. This company manufactures such chemical specialties as mosquito ointments and fishing line dressings.

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Miners and Metallurgists

HEYDA, CHARLES, '33, has the very interesting position of being assistant manager of the Banganilid lode properties in the Philippines. The Banganilid Corp. is engaged in gold dredging.

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Electricals

HAMILTON, LESLIE E., '32, is now with the Consumers Power Co., Jackson, Mich.

SOULE, JOHN W., '35, has a position with the Wisconsin Public Service Corp., Green Bay, Wis.

Alumni at Allis-Chalmers Manufacturing Co., Milwaukee

ALMON, GROVER, m'17, M.S.'31, has a position as material tester in the research department.

BLOEDORN, CHARLES, m'34, has taken up the study of steam turbines as his specialized line in the Students Course.

BRAINARD, F. K., e'32, is an electrical engineer in AC design.

BRUEGGEMAN, LESLIE, e'32, is employed as a draftsman in the Texrope department.

BALDING, H. A., '02, manages the Milwaukee district sales office.

CONNIT, F. L., m'16, has the very important position of superintendent of maintenance.

EDELMAN, J. E., e'35, does estimating work for the electrical department.

ENGELHARDT, ROBERT, c'34, is enrolled in the Graduate Students Course.

ERWIN, ARTHUR, m'35, also in the Students Course, has elected to specialize in engines and condensers.

GREISEN, E. C., m'07, is sales engineer in the crushing and cement department.

GOLLNICK, A. J., c'35, is employed as a draftsman in the hydraulic department.

KAPP, LAWRENCE, m'33, is another student at the company.

KUEHLTHAU, J. L., e'32, M.S.'34, is an engineer in the electrical department.

MATTERS, ROBERT, ch'34, is engaged in research work.

MUTH, H. J., e'21, has employment as an assistant engineer in the hydraulic turbine department.

POTTER, R. P., '20, is connected with the Milwaukee office as sales engineer.

PUERNER, B. H., m'20, has a position as sales engineer in the crushing and cement department.

ROWE, RICHARD, e'34, student enrolled in the Graduate Course.

RHEINGANS, W. V., c'20, is an assistant engineer in the hydraulic turbine department.

SHONG, ALBERT, e'34, is another student. He will specialize in switchgears.

SILVER, HAROLD S., e'28, is in the patent department.

WARTH, E. C., e'12, is another sales engineer in the Milwaukee sales office.

WILSON, RUSHEN, m'35, student in the Graduate Course.

The Wisconsin Engineer realizes this list is incomplete due to lack of information. Additions to it would be appreciated and duly recognized.

ON THE CAMPUS

HOLD DIESEL SHORT COURSE HERE

A four-weeks residence class and laboratory course on the operation, servicing, care, and maintenance of Diesel engines of the high-speed automotive type was held here from January 25 to February 20 in the Mechanical Engineering building. The course was one of several being conducted at the University of Wisconsin, University of Minnesota, Iowa State College, University of Nebraska, Purdue University, Michigan State College, and Ohio State University, as cooperative educational projects under the joint sponsorship of these educational institutions and a number of manufacturers of Diesel engines and Diesel equipment. These were the Fairbanks-Morse & Company, Caterpillar Company, International Harvester, Inc., Allis - Chalmers, Inc., and the Waukesha and Hercules Motor Company. By conducting the course in several universities, the manufacturers were able to provide much more in the way of demonstration equipment.

The purpose of the course was to provide instruction on the fundamental principles of the Diesel engine, together with actual training in the operation, servicing, care, and maintenance of up-to-date modern Diesel engine equipment. The work consisted of two parts: class room instruction under the direction of the staff of the Mechanical Engineering Department of the university, and shop and laboratory work under the supervision of service men from the various cooperating manufacturers who are furnishing up-to-date modern engines, tools, and demonstration equipment.

In addition, extensive use was made of slides, moving picture films, and models. Visits to important Diesel engine manufacturers were also made during the course.

During the first week the classroom work consisted of general treatment of the fundamental working principles of internal combustion Diesel engines; Diesel fuels; combustion in the Diesel engine; combustion chambers; fuel systems; pumps and nozzles; Diesel engine parts; cylinder pistons; piston rings; valves and valve mechanism; bearings; crankshafts; Diesel engine lubrication and cooling; Diesel engine starting. The shop work consisted of demonstrations of fundamental shop operations and laboratory work on Diesel engine operations and tests on lubricating oils and Diesel fuels.

The second, third, and fourth weeks were devoted to a detailed consideration of the general field discussed during the first week from the viewpoint of the operator, serviceman, and repairman. Classroom instruction was given on the details of the particular engines or equipment being worked upon in the laboratory. Attention was given to sources of trouble, trouble shooting, running repairs; fuel systems, nozzles, line filters, corrosion of fuel lines; fit and maintenance of cylinders, heads, pistons and piston rings, valves and valve seats, wristpins, bearings; balancers and vibration elimination; lubrication systems, selection of oil, oil purification; cooling systems; governing; spark ignition; fuel injection engines; overhaul, dismantling, and general repair operations. The laboratory work consisted of the operation, service, and maintenance of actual engines under the direction of expert servicemen representing the cooperating manufacturers.

PROFESSOR OWEN WORKING ON FLOOD RELIEF

Ray S. Owen, professor of T. E., and his daughter, Dr. Merle Owen Hamel, are working in the flood area near Evansville, Indiana. Dr. Charles Ihle also accompanied them to Indiana in Professor Owen's trailer, which is now being used as an emergency transport for nurses and flood victims. The party was sponsored by Madison, Dane county, and the Madison unit of the American Legion. The two doctors plan to stay in the flood area for some time, and it is not known just when Professor Owen is planning on returning.

WHA OPERATOR ACTIVE IN FLOOD AREA

A. L. Bell, e'31, control operator for WHA and on leave of absence, is now working with the U. S. Army installing short wave transmitters and was expected to be assigned one of the flooded corps areas. Bell has been active in WHA's technical development for five years and also worked on construction of the new transmitters and studio equipment.

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M. E. DEPARTMENT INSTALLS NEW EQUIPMENT

Two new pieces of equipment have been installed in the Mechanical Engineering building in the last few weeks. The first and more important of the two is the South Bend engine lathe, with enclosed motor drive, which replaces one of the badly worn lathes now in use. The other is an electric tempering furnace which allows absolute control of the temperature while tempering work.

FRESHMAN HONOR LIST NOW READY

The freshman honor list shows an impressive number of freshmen doing better than ordinary work during their first semester here. Ten of them have reached the high honor rate with an average of 2.75 grade-points per credit or better, while 27 more have done honor rate work, piling up an average of 2.25 grade-points per credit. The list of the freshmen who, at the end of the first semester, are working at the honor or high honor rate is given below:

HIGH HONOR RATE	Credits	Gr.-Pt. Ave.
Robert J. McCarter	17	2.94
Bertrand J. Mayland	16	2.93
Stewart E. Miller	17	2.88
John M. Erickson	18	2.83
Clifford J. Bedore	17	2.82
John F. Elliott	17	2.82
Edwin R. Stellacher	16	2.81
Oscar O. Nerenberg	15	2.81
Victor S. Burstein	16	2.75
HONOR RATE		
Charles F. Eck	14	2.72
Charles Hahn	17	2.71
Charles J. Finn	17	2.71
E. Chester Foster	17	2.71
Anthony L. Casciaro	18	2.67
Mary Jane Clarke	17	2.65
Donald A. Pike	17	2.65
Robert J. Bryan	14	2.59
Eugene D. Ermenc	17	2.53
Francis L. Kurek	17	2.53
George D. Smithwick	17	2.53
Arthur J. Pinard	18	2.50
Harold Vik	14	2.43
Edward Freschl	15	2.40
Nathan Itzkowitz	17	2.35
Henry Schein	17	2.35
Herbert A. Zartner	17	2.35
Donald S. De Munck	18	2.33
Leonard E. Broberg	17	2.29
Boyd E. McKnight	17	2.29
Carl F. Matthies	17	2.29
Alexander Temmer	17	2.29
Charles W. Higgins	18	2.28
Robert J. Kolar	18	2.28
Felix Waitkus	18	2.28
John B. Woerfel	16	2.25

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WELCOME TO OUR RANKS

Thirteen new students from other schools have registered in the School of Engineering for the coming semester and we hope they do not find their number unlucky. They are: Fred Cape, junior civil, who studied for his first two years at the University Extension Division at Milwaukee; Harold Fass, sophomore civil, from La Crosse State Teachers College; Arthur Grebler, freshman chemical, from the University of Illinois; Paul C. Hanke, freshman civil from the Milwaukee School of Engineering; Sydney Jacobson, freshman civil, from the Fresno State Teachers College; R. P. Lambeck, sophomore mechanical, of Baylor University; Laurence P. Layman, sophomore miner, of Marquette; Raymond Lutz, freshman civil, from the University Extension Division; Charles Pierce, freshman chemical, from Lawrence College and the University Extension Division; William S. Ramsey, sophomore electrical, from the Extension Division; James C. Schopp, freshman mechanical, also from the Extension Division; Starkie L. Swenson, sophomore civil, from the Milwaukee State Teachers College; Curtis C. Steuber, freshman chemical, from the Extension Division.

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SEVERAL NEW INSTRUCTORS ASSIGNED

To replace the vacancies caused by present faculty members leaving and to take care of the increased enrollment in the School of Engineering, there have been several appointments of instructors made. L. O. Hanson, instructor in the mechanics department for the last seven years, has left to travel for the Portland Cement Association in Wisconsin and Illinois. Walter M. Borea, m'33, will take his position, and Allan Freas, instructor in rails, will also help out by instructing a course in mechanics.

The two new instructors in the chemical engineering department are W. A. Bain and H. F. Hoerig. Mr. Bain held a College of Engineering research fellowship last semester, while Mr. Hoerig is a graduate of the university chemistry department and has been with the Goodyear Tire and Rubber Company since graduation.

Allan Byll, m'35, has been awarded the College of Engineering research fellowship for the coming semester. It has been held by W. A. Bain who was forced to relinquish it to take over his appointment as instructor in the chemical engineering department. The subject of his research will be heat recovery from Diesel exhaust, and will be conducted with the aid of a four cycle Diesel furnished for the tests by Fairbanks-Morse & Company.

GUEST SPEAKERS

As a guest speaker on the program of the Wisconsin Farm and Home Week held from February 1 to 5 here on the university campus, Prof. G. L. Larson of the mechanical engineering department presented a talk on the "Value of Insulation." R. E. Johnson of the electrical engineering department was also asked to give a talk on the results of the electrical appliance testing as carried on in the testing lab. The title of his talk was "How to Tell Quality in Home Appliances."

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PAPERS GAIN RECOGNITION IN WATER WORKS ENGINEER

Three alumni of the University of Wisconsin, College of Engineering, presented papers at the Wisconsin section meeting of the A.W.W.A. held at Waukesha October 6 and 7. "Design Features of the Milwaukee Filtration Plant" was the subject of the paper presented by H. H. Brown, c'17. Mr. Brown is the engineer in charge of construction and design in Milwaukee. C. S. Greutzmacher, c'14, engineer in charge of distribution for Milwaukee, presented a paper, "Hydrants and Gate Valves," while the workings of the Wisconsin Public Service Commission were explained by F. C. Thiessen, c'10, who is the valuation engineer of the commission.

The publication "Water Works Engineer" thought them to be of sufficient interest to warrant publication of a synopsis of each of the papers.

"STATIC"

By ENGIN EARS

Candid camera shots on Deadline Day: Senft writing squibs about himself and dropping them in our basket . . . someone turning in a lot of unprintable gossip about someone he dislikes . . . your correspondent still searching wistfully for someone, anyone, who'll admit missing last month's Static . . . F. C. Alexander busy writing some L. & S. lug's term paper for him . . . our incorruptible editor pleading with each passer-by to write him just one weeny editorial . . . Stanley digging for a musty cut with disrespectful comment on the famous m'08 who has been so inconsiderate as to die just as we're ready to run off the galleys.

» » « «

Back in the old rut. For the enlightenment of our readers, if any, who missed this page last month, that pause that refreshes came to you through the joint courtesy of the editor, who need this space in which to stuff his filthy ads, and ourself, who suffered a severe nervous collapse upon actually finding a contribution in our box at the foot of the Engineering stairs.

» » « «

Prom in the meantime has came and went. We didn't see a single pair of hi-tops there; either the Civils are going sissy or they can't get dates any more. We saw the reassuring b u l g e of the old slip-stick under Pamperin's tails—at least, that's what he said it was.

» » « «

They claim we have a freshie so dumb that he let his room-mate sign him up for a blind date with Allis Chalmers.

» » « «

Those little girls who used to want all day suckers now only want 'em for the evening.

» » « «

The only difference between me and any big consulting engineer, says Karn, is that he's probably busy making his second million, and I'm still on my first.

» » « «

A pedestrian is a man whose son is home from college for the holidays.—**North Dakota State Engineer.**

» » « «

Rucks (hitch hiking): Hey, mister, I'm going your way.
Motorist: So I notice, but I bet I get there first.

Before Christmas we watched all the Eta Kappa Nu neophytes filing wearily away on those 20 pound pig iron castings. They got discouraged when the stress analysis showed they would need watch chains by Roebling Bros., hence the featherweight c h a r m s they now flash on us.

» » « «

Speaking of slide-rules, we must admit that the tiny bacteria have 'em beat . . . they multiply by dividing.

» » « «

What we want to know is: who was the Soph who asserted on the Physics final that the telegram was a unit of mass in the c.g.s. system?

» » « «

We were reading the other day that drinking lots of water keeps you from getting stiff in the joints. But, as Pritchard says, not all the joints will serve you water.

» » « «

As they say along Fraternity Row . . . no one cares how bad your English is as long as your Scotch is good.

» » « «

From some omar khayyam of the test floor we have a pome:

I ask but little here below:
A little car, a radio,
A little cash to spend at will,
A little house upon the hill,
A little brook where fishes lurk,
And very, **very** little work.

—Minnesota Techno-log.

» » « «

Mr. Stanley (of the Mechanical Stanleys) went into the Co-op to buy a steam table the other day, but the non-engineering clerk as much as told him that there was a kitchen supply agency up on the Square. Or was it a Turkish bath?

» » « «

Among the tall tales of holiday happenings is that of Hal Leviton, m.e. 2, who was right in the midst of buying a suit in Newark, New Jersey, one evening when that city's power supply failed. Nothing daunted, he finished his purchase and groped his way homeward. When the lights came on some five hours later, he found he had bought the pants of one suit and the coat of another.

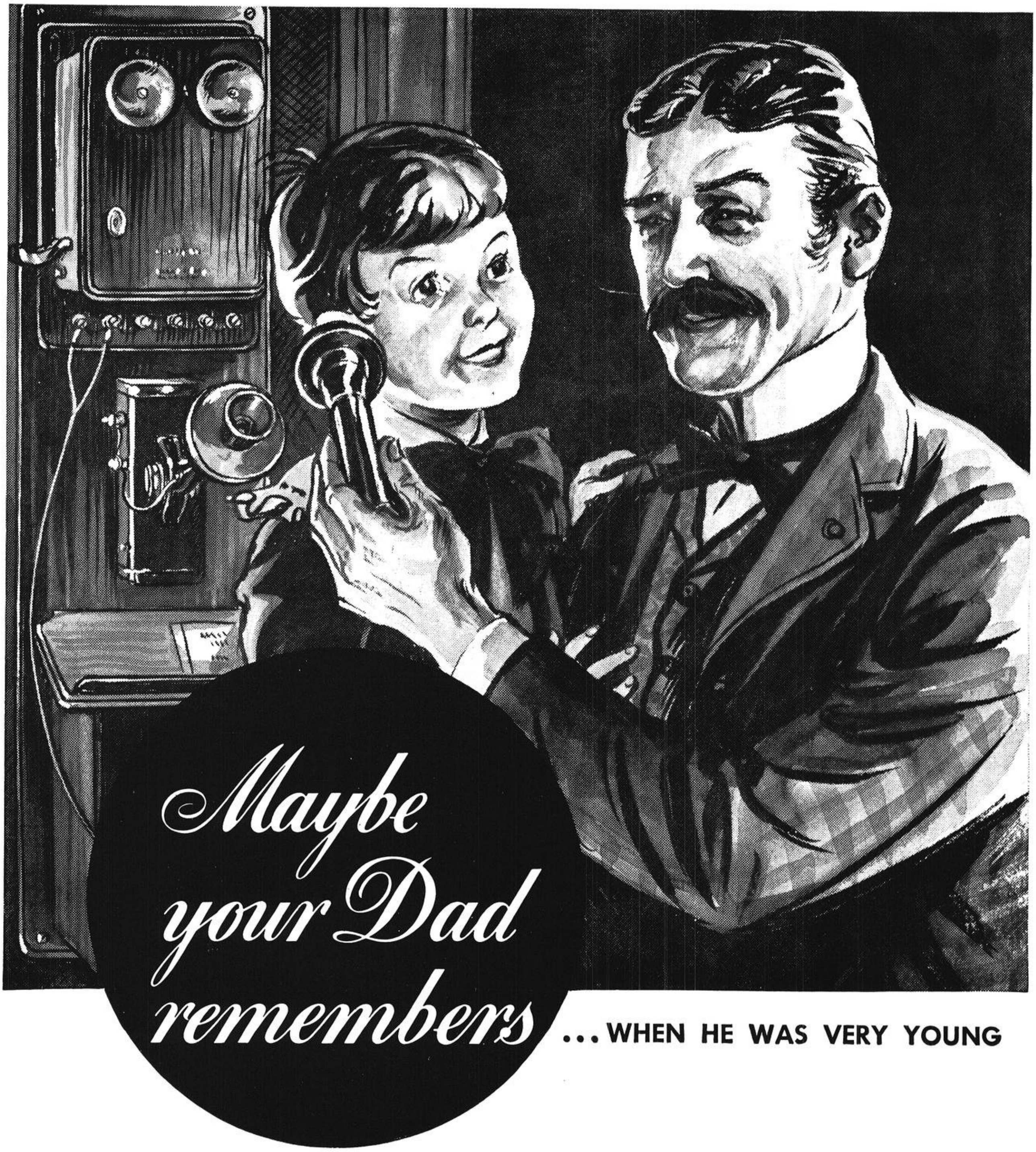
» » « «

Here's one for the Math 55 boys:

If you square a negative number, you get a positive number. If you cube a negative number, you get a negative number. But what, Mr. Sokolnikoff, will you get if you raise it to the 2.5 power?

» » « «

Phi Eta Sigma A. H. Eron has the dubious distinction of being the first engineer ever to live in the Gamma Eta Gamma, law fraternity, hovel. As Allen puts it, "I just want to see how it feels to live among the lower classes for awhile."



... WHEN HE WAS VERY YOUNG

As small boys, many fathers now living knew the telephone only as a little used curiosity. It grew into today's constantly used necessity largely because the Bell System never ceased looking for the new and better way. It stayed *young* in its thinking.

Young ideas developed "conference service", enabling several nearby or widely separated persons to talk on one telephone connection. Young ideas steadily made Long Distance service better, quicker, yet cheaper.

Young ideas are at work day and night to make sure America continues to get more and better service for its telephone dollar.

Why not call Mother or Dad tonight?
Rates to most points are lowest after 7 P. M.

AMERICAN TELEPHONE & TELEGRAPH CO. AND ASSOCIATED COMPANIES — BELL SYSTEM

BELL TELEPHONE SYSTEM

WITH THE SOCIETIES

A.S.C.E.

On Tuesday evening, January 19, the student branch of the American Society of Civil Engineers met in the auditorium of the hydraulics laboratory to elect officers for the second semester. Theodore Hoffmann was chosen president to succeed Edwin Voss, and Ray Voelker was elected to the vice-presidency. William Polk became the new secretary, and William Littleton was elected treasurer.

Following installation of the new officers, the members attending enjoyed cider and doughnuts served over an improvised bar in the sanitary lab.

CHI EPSILON

The Wisconsin chapter of Chi Epsilon, national honorary civil engineering fraternity, has elected the following officers for the coming semester:

President, Edwin Voss; vice-president, Charles Miller; secretary, Russell Langteau; treasurer, Spaulding Norris; associate editor of Transit, Lewis Sheerar.

The new officers, elected January 14, will replace president, H. R. Jensen; vice-president, E. Voss; secretary, W. W. Johnson; treasurer, J. Eppler; associate editor of Transit, A. Luecker.

The associate editor of Transit is elected for a term of one year; other officers are elected each semester.

A.S.M.E. INSPECTION TRIP

Mechanical methods for procuring weight measurements to an accuracy closer than one-five hundredth part of an ounce were illustrated to the members of the student branch of the American Society of Mechanical Engineers at the Gisholt Machine Company recently. A new balancing machine, developed by a University of Wisconsin alumnus, is now used to not only measure the discrepancies in rotating machine parts but also to point out, by means of a stroboscopic lamp, the exact spot at which the part is overweighted. By getting this desired accuracy, the troublesome vibrations and attendant noises that are common in household refrigerators and motor driven appliances can be eliminated. The balancer is distinctly a production machine since approximately one hundred parts can be completely checked for weight discrepancies in an hour.

Static unbalance is determined while the article is at rest. The exact spot of dynamic unbalance in a rotating part is shown by a stroboscopic lamp, which flickers at every vibration of the material and only lights the portion in question. The spot can then be easily located when the article is at rest.

The Wisconsin Engineer Announces Its Fourth Annual

MECHANICAL DRAWING CONTEST

Sponsored by

ALPHA TAU SIGMA

National Honorary Engineering Journalism Fraternity

..CONTEST RULES..

1. All students who are freshmen in the College of Engineering of the University of Wisconsin are eligible for competition.

2. A pencil mechanical drawing accompanied by an ink tracing to be assigned by the instructional staff of the drawing department as a part of the regular work in Drawing 2 will serve as the entry in the contest.

3. Entries will be received by the drawing department up to and including April 17, 1937.

4. The three best drawings shall be awarded first, second, and third places, respectively, by the judges. The three winners will receive material prizes as announced in the April issue of the *Wisconsin Engineer*.

5. The entries will be judged under the general headings given below, which are listed in the order of their weighted values, the first receiving the greatest weight:
   1. Technique and Theory
   2. Accuracy
   3. Lettering
   4. Neatness

6. One or more of the winning entries will be reproduced in the pages of the May issue of the *Wisconsin Engineer*.

7. The judges are J. W. McNaul, assistant professor of machine design; W. S. Cottingham, assistant professor of structural engineering; and R. W. Fowler, assistant professor of drawing, Extension Division. Their decisions will be final.

The Engineer on the Witness Stand

by **MARTIN T. BENNETT, ch'25**

Gas and Water Utilities Engineer, Public Service Commission of Wisconsin

Through the courtesy of the editor of ENGINEERING NEWS-RECORD, the *Wisconsin Engineer* is able to reprint this valuable article.

"A VALUATION is only as good as the testimony supporting it" is a statement as true as it is old. No matter how carefully and skillfully a valuation has been prepared, it becomes valueless as evidence if it cannot be supported by testimony that breathes confidence in it, and is convincing to the tribunals that are to pass upon it. The purpose of this discussion is to assist those who are to testify by pointing out the more important legal and psychological factors involved in testifying in order that the value of the work which has been done may be utilized to its fullest extent.

An engineer on the witness stand must be more than a good engineer. He must be somewhat of a lawyer, an accountant, an orator, and a showman. Yet he must not exaggerate any of these lest he be accused, mentally at least, of substituting proficiency at one or more of these for a deficiency in his engineering ability. He must understand thoroughly the purposes for which he is there, and he must know his rights and duties as a witness. His conduct, his manner and mode of speech, and his apparent attitude strongly influence the amount of credence which is placed in his work both by those that hear his testimony and by those that later might read the transcript. A transcript that is shot full of remarks such as "Speak up, please, so the reporter can hear you" or is full of quibbling answers indicates that the witness did not have confidence in his own testimony or was trying to hide something. The best piece of work can be made to appear valueless upon the transcript as well as to those who actually hear the testimony by a combination of good cross-examiner and a poor witness.

Most of engineering testimony in public utility work relates to valuations. For that reason valuation work will be discussed almost exclusively, but the general principles so illustrated are applicable to almost all testimony. Testimony may be given in Commission hearings or in a court of appeal. The latter might be thought to be more difficult, but as a matter of fact the witness has some rights that are not extended to him ordinarily in Commission hearings. The lack of formality in Commission hearings can be taken as an advantage by the lawyer as well as by the witness.

As far as the engineers are concerned, the primary fact to be established by Commission proceedings is the value of a property. The engineer makes his estimate of value of the physical property which is material evidence tending to prove a value which the Commission itself must find. The engineer assembles facts and organizes them in a way that tends to show a certain value. In many cases, these facts which he assembles are not in themselves susceptible of proof, but their existence is strongly indicated by other facts and the engineer, having been qualified as an expert, is allowed to use his judgment or opinion. In such cases he must be prepared to justify the conclusion he reached by showing the process of logic by which he went from undisputed facts or from facts of common knowledge to his conclusion.

The written valuation which an engineer submits and which is entered into the record as an exhibit is really material evidence only so long as it is unchallenged. Since this is almost never the case, the valuation becomes a memorandum which alleges the existence, as a matter of the engineer's knowledge and opinion, of a lot of facts. Any number or all of these allegations may be disputed by interested parties. Disputation may take the form of evidence tending to show that something different is a fact or may take the form of cross-examination tending to show that the allegations are not founded on fact or are illogical conclusions.

The purpose of the direct testimony is to indicate the accuracy with which the conclusions expressed in the valuation have been drawn. This testimony should be very carefully prepared and in important cases should be submitted for suggestions and criticisms to the witness' counsel in the form of written narrative sometime before the hearing. The purpose of writing it out beforehand is to provide a means of organizing an orderly presentation and to inform counsel of what the witness has to say so that he may frame his questions in a manner that will make an orderly record. If the testimony flits around from high spot to low spot and back over the same ground again, no person of ordinary intelligence can get a clear impression of anything other than the confusion of the witness' thought. On the other hand, the testimony should not be memorized because in all probability the witness will be interrupted several times and the manner of presentation may be changed because of developments during the hearing.

A witness is allowed considerable latitude on direct examination. Counsel generally will frame the questions in a manner that will allow the witness to expand upon the train of thought which the question starts. Advantage should be taken of this where important details are involved, but not in relatively minor matters. A cryptic answer may force counsel to a line of leading questions which will bring objections from the other side and will be disturbing to his line of thought as well as to the witness'. On the other hand, a witness who rambles on about relatively minor matters is destined to be mired in words where he makes an easy target for a good cross-examiner.

Generally, the direct testimony starts with a statement of experience and qualifications of the witness. This consists of a statement or a series of statements about the training and work which the witness has done in the past with emphasis upon the experiences which have been in a similar or allied field. This is not an opportunity to brag nor is it a time to be self-consciously modest. The witness should be just as matter-of-fact as if he were telling about someone else—neither praising, defending, nor depreciating what that person had done. Those experiences which indicate solely the confidence which has been placed in him should be enumerated in a general manner. Those experiences which are similar to the present case should be presented in more detail and similarities should be indicated if not expressed.

The next in order is a definition of the responsibilities of the witness in connection with what he is to testify about. If details were done by a subordinate, the witness should state that the work was done under his direction. If the witness actually did a large amount of work but had help of calculators, field inventory men, etc., he may state that he did the work with assistance. In some cases, the witness will testify regarding the results obtained from someone else's work, but should not want to take responsibility for data and methods used. In such cases the witness should state that the figures were reported to him by this other person and that responsibilty for them lies with the other person. Where a witness has testified that work has been done under his direction, he takes responsibility for a great amount of the detail which may be asked for, although if some particular part of the work receives a large amount of attention, the subordinate who did the work may be called to the stand. Conversely, if a witness has worked under someone's supervision or has received advice and instructions from a superior, he should say so. This leaves the way open to call the superior to the stand in order to testify about matters for which the subordinate is not competent.

Testimony regarding the work itself should be reported by divisions. Any general statements regarding methods which were used throughout the job should be stated first. Then it is well to say that the work naturally falls into certain divisions such as structures, production equipment, distribution equipment, etc. Then each division may be taken up in order. The amount of time and testimony devoted to each of the divisions should be determined by the significance of the result. Thus if there is no other valuation which shows differences from that of the witness, the amount of time and detail should be determined by the dollar amount involved. However, if a certain portion of the work differs widely in result from some other evidence, considerable time should be spent explaining methods, and incidentally but not obviously, giving the advantages of the methods which were followed by the witness.

Stating advantages of one method over someone else's method is a delicate task. Care should be taken as far as possible to avoid giving testimony about someone else's work because it encourages the cross-examiner to try to show that the witness is not acquainted with the other work. This can be done easily in a complicated case by asking somewhat vague questions about details and then by showing that the answers are not accurate. It is far safer to state the other method as though it were a hypothetical case and to then state the advantages of the witness' method. If the witness is asked regarding the similarity between the hypothetical method and the one he is indirectly criticizing, he may reply in a general way about the similarity.

Vulnerability of the direct testimony may be greatly reduced by anticipating cross-examination. If the witness' work has any shortcomings, it is well to call attention to these, rather than wait for cross-examination to do this. An opportunity is thereby given to the witness to depreciate the shortcomings to the fullest extent, either by showing that they are not material or are insignificant in relation to the entire work. However, care should be taken to avoid any appearance of apologizing for the work and minor things should be avoided.

The most difficult part of giving direct testimony is the placing of proper emphasis on the more material part of the evidence. The part of the work that might have been the most difficult and most interesting to the witness may not be in issue. Hence the forgivable pride of the witness in that phase of the work should not be allowed to tempt him into a long dissertation that dulls the auditors' senses to an extent that insufficient attention is given to the significance of the testimony regarding contested issues. Often a table showing wherein the differences between two valuations lie is a good aid to organizing direct testimony.

In planning direct testimony, help may be obtained by setting up what one might call a standard of significance. Where this standard is to be set depends entirely upon the importance of the case, and upon the importance of the testimony with relation to the whole case. Help may be obtained by talking over the proposed testimony with the examiner or counsel about the importance of the case and about the part the witness is to play. When the witness has a fairly definite idea of what this standard should be, determination of whether or not parts of the proposed testimony measure up to this becomes almost an automatic mental process.

All testimony should take the form of referring results back to what the witness believes to be undisputed facts. Thus to say that the value of a piece of equipment was obtained from certain sources of prices by a certain process or computation immediately divides the proof into two parts. The sources of prices may be indisputable or may appear to be. Then for the time being, at least, that part of the evidence is proven. The process by which the value is obtained from the prices may be based partially on undisputed methods and partially on methods which required the use of judgment. Emphasis should be placed upon what is expected to be undisputed or is empirical so that the opinions of the witness which are not susceptible to definite proof do not appear to have had too much effect upon the answer. Courts prefer to form their own opinions. In fact, they seem to delight in overruling opinions of highly regarded authorities and experts on the strength of well marshalled facts which they can recognize in other forms of evidence.

While the witness is given leeway on direct examination, opposing counsel has the advantage on cross-examination. His aim is to draw out and emphasize the weaknesses in the witness' work and thus tear down its value as evidence. His questions can be as leading as he wants to make them, and he has scored a serious blow if he can force the witness to make an apparently untrue or contradictory statement. The opportunity to repair the damage which has been done is afforded by re-direct testimony and the witness should not try to worm-in explanations against the wishes of the opposing counsel. Probably the hardest part of testifying under cross-examination is resisting the impulse to give an explanation, "why" as an answer to a question, "what." Better is it to answer the

question directly followed by "because" and to add the explanation, if counsel allows it. If he does not, witness' counsel can make a note of the point to be drawn out on redirect examination. Generally an attempt to explain is not advisable except where the questioning has made it appear that part of the evidence is poor and is significant.

A great amount of inaccuracy, expense, time, and effort could be saved if the first direct and first cross-examination in Commission cases were required to be submitted and exchanged in writing before the hearing, and that subsequent examination be limited to matters which are germane to the written examination. Far too much is wasted as a result of the efforts of lawyers with weak cases to fill the record with masses of questioning on inconsequential details. While this is not done to any extent now, the engineers may demonstrate the value of this by submitting as an exhibit with their valuation, a written report on the valuation which states in considerable detail the methods which were used much in the manner that it would be presented in direct testimony. When this is done, the necessity for avoiding technical language does not occur in the written part, because the report in all probability will be turned over to engineers on the other side.

Assuming that a witness has his subject well in hand, one might generalize that the extent to which his testimony stands up under cross-examination will be determined by his attitude and conduct on the stand. In nearly all matters the witness must choose a balance between two extremes of conduct, either of which might prejudice the tribunal against his testimony. It is a game of wits in which he must try to see several moves ahead. The rules of the game vary and cannot be written down and memorized, but are matters of judgment which must be influenced by the circumstances of the occasion.

Nervousness on the stand is not a matter to be worried about nor should any attempt be made to conceal it. Trying to suppress it will exaggerate it; taking it for granted will utilize it. In fact, if a sudden calm comes over a witness, he is likely to acquire a sort of mental torpor wherein he becomes an easy subject of suggestion and may find himself saying things he doesn't mean. Good lawyers are known to do their best work while they are nervous and on edge. The same should apply to good witnesses.

A new witness is often concerned about the proper degree of quickness with which he should answer. To be concerned about this, indicates a degree of self-consciousness which should be eliminated. What should concern the witness is the ability to distinguish the importance of the question promptly. If the question is important or involved he will be expected to take considerable time. In fact, if the question were very involved, he would be justified in an extreme case in asking the reporter to read the question slowly while he wrote it down in long-hand. Then he could keep a mental finger on all of the qualifications in the question while he formulated an answer which would fit these qualifications. This might easily take five minutes. Simple questions should be answered promptly, although not hurriedly, because the auditors will naturally make allowance for what appears to be the witness' natural speed of response and rapidity of speech.

A good witness will not encumber his answers with unnecessary qualifications. Thus if he is asked, "How old are you?," he will answer, "Thirty-five." Whether he was thirty-five at his last birthday or whether that is his age at the nearest birthday is not important. Nor is it important to say "years" nor to give any of the other qualifications that might be thought of. If an apparent inconsistency should be pointed out later as the result of an unqualified answer, it is time enough to explain that the witness assumed everyone knew what he meant. In some cases it might be even better to forsake making the explanation if it is obvious that everyone knew what was meant and that the questioner was trying to make a mountain out of a mole-hill.

Quibbling is a method of evading a question by requiring that the question be unnecessarily qualified or be precisely framed. The distinction between precision of speech and preciseness of speech is necessarily fine but is one that must be made all during cross-examination. A witness who is extremely precise in his speech or who draws fine distinctions is bound to give the impression that he is hiding something or is trying not to reveal some weaknesses in his evidence. If weaknesses are present, it is better to show them in a straightforward manner which will prevent to a considerable extent their importance being exaggerated. The unknown is always suspected to be the worst.

Loquaciousness is to be avoided. It not only produces the impression that the witness is trying to cover a deficiency with words, but it puts a lot of material into the record which may be used to ensnare the witness. For a mild example: a sentence unnecessarily prefaced with "In my opinion" is robbed of much of its value because the speaker thereby concedes that it is a matter of opinion and not of fact. Relatively few facts can be proven beyond any shadow of doubt but that does not mean that everything else is opinion. Far more important than good grammar and the ability to use big words is the ability to express an idea in a few simple words. The aim of the witness on cross-examination as well as on direct should be to give information and to make everyone understand what he means.

A dogmatic or a patronizing manner should be avoided. In an over-zealous attempt to make himself understood, a witness runs the danger of appearing to think that he knows more than anyone else. One's argument becomes easily exploded if room is not left for the other person's argument. A respectful attitude inspires respect in others.

While many necessities of conduct are a balance between two extremes that cannot be definitely defined, some precautions apply at practically all times. The witness should speak clearly, and slowly, much as if he were dictating. His answers should be positive and responsive. He should not allow himself to worry about the impressions he is making. He is not in an argument. He is giving what he believes to be facts, the lawyers are doing the arguing, and the commission or the court is forming the opinion or conclusion.

EDITORIALS

"*The chief art of learning, as Locke has observed, is to attempt but little at a time. The widest excursions of the mind are made by short flights frequently repeated; the most lofty fabrics of science are formed by the continued accumulation of single propositions.*"

—JOHNSON

THE INTERVIEWER —HARBINGER OF SPRING

Now comes the advance guard of interviewers from the various industries, and the thoughts of the senior turn to spring and that JOB, which is to enable him to pay his debts, marry the girl, raise a family, and make a reputation in the field of engineering that will go thundering down the long corridors of Time.

It is still an employer's market; the senior goes into the interview with at least one strike called on him before the pitcher winds up. It takes a lot of confidence in oneself—and perhaps a modicum of luck—to keep from striking out. It is no small feat to convince some hard-headed businessman that your services will yield him a profit after deducting your salary; and profit is still a desideratum in the minds of businessmen in spite of the present-day efforts to outlaw profit from business.

A lack of genuine confidence in oneself is a serious handicap. It cannot be simulated with much success, although it is a common practice for humans to cover their inferiority complexes with a false front of bluff and bluster. Such camouflage does not deceive those who are familiar with human nature, and interviewers of any experience are in that category. Genuine confidence rests upon proven ability which, in turn, must rest upon experience. It is one of the purposes of a professional education to give the student experience and confidence. The student who has made the best possible use of his opportunities will not be lacking in these essentials.

The senior has almost reached the end of the trail so far as school and its opportunities are concerned; he must now assume the burden of responsibility for his future. But the juniors and the underclassmen still have within their grasp the opportunity to acquire confidence in themselves by serious, conscientious, and intelligent application to the tasks immediately at hand, and each man has a yardstick by which he can measure his confidence. The man who can walk into a quiz or examination with confidence need not worry unduly about the result when the time comes for him to face the inevitable interview that precedes the getting of any job.

SUBSIDIZING NEEDY STUDENTS

During the last few weeks a committee composed of several of the university deans has been drafting particulars of a plan to subsidize needy students with good scholastic records during their university days and then allow them to enter the state service for a time after graduation to pay off their debt to the state. After they had cleared up their obligation, the option would be theirs as to whether they would remain with the state or seek private employment.

This plan has several points that are worth considering carefully. Will the opportunity be open to state and out-of-state students on an equal basis? Even though theoretically self-supporting, it would undoubtedly cost Wisconsin's taxpayers something and it is only reasonable to suppose that Wisconsin students ought to have first consideration. Will the proposal "pad" the state service with employees who can not hold down jobs in private industry? Several years from now will it still be an opportunity for needy students to get an education, or will it have degenerated to a method whereby anybody with the proper "pull" can get his expenses paid while going to college? If it continued to give worthy, needy students additional opportunities for an education which would not otherwise be available, there would be no doubt of its usefulness; on the other hand, it might change into something which people considered as a "right"—the chance for everyone, whether suited for college or not, to go to school with the state paying the bills.

In any event, the good and bad points of this plan must be considered carefully before it is adopted or rejected.

CUT OUT THE NOISE

One day during the examination period which has just passed, while doing some writing in the **Engineer** office, we were interrupted by a nerve-shattering noise coming from the north wing of the Engineering Building. Investigation showed that service department men were installing conduit and electric lights to illuminate the landings of the back stairway. They had an electric hammer, working on the principle of the pneumatic hammer and making just as much noise, and were driving holes through the stairway landing so that the conduit could pass. The noise continued intermittently for most of the day, in spite of the fact that final exams were being conducted in several of the rooms throughout this time.

We believe that it is poor policy for any work to be done on the physical plant of the university which will interfere with classes—much less final examinations. The people writing are under a great enough strain during this time without imposing the additional handicap of distraction by external noise.

After all, the real purpose of the university is to provide a means whereby students may get an education, and it is not consistent to interfere with this air to keep the institution's plant in running order. Maintenance work should be done at some time which will not interfere with the primary purpose — giving people an opportunity to acquire an education.

Beauty Treatments FOR FINER FRUIT

IN THE growing of crops, man can rarely leave nature to her own devices. On one hand she is bountiful—on the other destructive.

No one is more conscious of this dual capacity than are those whose business it is to supply the tables of American homes with fruit and vegetables.

When, for instance, the apple tree puts forth its best efforts to produce fruit of faultless quality, there is a host of pestiferous insects and sundry diseases constantly out to defeat that purpose.

Should they succeed, they rob the apple of its beauty and quality—the fruit grower of his profits. And, this danger extends to the peach, pear, cherry and to countless vegetables as well.

Protecting crops against the ravages of insects and disease is one of the most urgent tasks of the fruit and vegetable grower.

Aiding him in his fight are such organizations as The Dow Chemical Company. Well in the forefront of Dow's research program is the development of better insecticides and fungicides.

In 1936, Dow was able to bring to fruit growers two new developments in spray materials. One, a superior wettable sulfur that possesses a particle size of such microscopic fineness that, when sprayed in solution, it literally envelops fruit and foliage in a fog-like blanket. Thus, it provides protection more positive than has been possible heretofore. The second is a better dormant type spray that goes further in its protective power yet avoids danger to the operator or his equipment and offers in addition, several important technical advantages.

When you next pause to admire the smooth, unblemished texture of an apple, the perfection of a peach, or the excellence of many vegetables, remember that day in and day out laboratory technicians, experimental stations and, above all, the grower have striven hard to attain such perfection.

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DOW

CHEMICALS INDISPENSABLE TO INDUSTRY

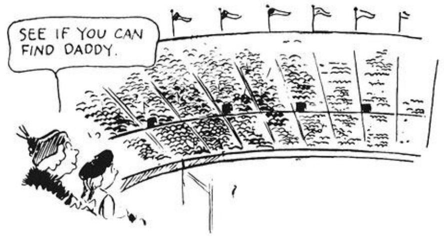
G-E *Campus News*

LOSE A NEEDLE?

Not a needle in a haystack, but perhaps a needle in a rug. During the manufacture of rugs, needles may become broken and embedded in the finished product. Former methods of inspection were tedious and time-wasting, but a new magnetic device indicates the exact location of the steel fragment.

This iron detector, developed in the General Engineering Laboratory of the General Electric Company, consists of a test coil, a motor-generator set, and an amplifier. The rug is passed through the magnetic field twice in directions at right angles. The presence of a broken needle causes a distortion in the magnetic field and consequently an unbalanced voltage in the secondary coil. This unbalance is amplified, and the relays cause signal lights to glow.

Detectors of similar principle have previously been developed for such uses as detecting scrap iron in sugar cane and in scrap cellophane. The General Engineering Laboratory is constantly receiving problems from industrial concerns and is developing equipment or giving suggestions to solve these problems.

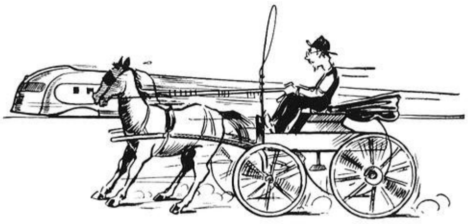


MICROANALYSIS

Two millionths of a gram of material present in a 25-cubic-centimeter sample is almost as inconspicuous as one man in a group composed of the combined populations of New York City, Chicago, and Detroit gathered in one huge stadium, yet the phototube and the recently developed spectrophotometer can accurately determine such microscopic quantities. This detector has been commercially developed in the laboratories of the General Electric Company from the original design by Professor A. C. Hardy of M. I. T.

In medical science, the spectrophotometer should prove very useful. The presence and amount of almost any element which will form a colored compound when combined with some reagent can be determined. In the industrial field, paints have been studied and the effects of heat, light, ultraviolet radiation, humidity, and surface greases have been measured. This has proved a reliable guide to purchase of these materials.

The spectrophotometer is admirably adapted to the study of problems involving colored substances. Its scope extends far beyond chemistry, physics, or industry. In fact, it is in the biological sciences that the instrument will probably find its most important applications.



BY A NOSE

A century ago there was a race between a horse and a locomotive. No such race will be necessary to determine the supremacy of the steam-electric locomotive being built for the Union Pacific Railroad by the General Electric Company. This new unit will get its first trial run on the test tracks at the Erie, Pa., Works early this year.

This new passenger unit will carry a steam-turbine electric generating plant to feed power to the traction motors. The turbine will exhaust through condensers, using the same water over and over with small additions to make up for leakage. A new, highly efficient type of steam boiler has been built, and heavy fuel oil similar to that used in present-day locomotives will be used.

The new unit will be a double-cab locomotive, streamlined, practically smokeless, and provided with power equipment for air-conditioning the trailing passenger cars. It is rated at 5000 horse-power and is capable of hauling 1000-ton trains at a speed of 110 miles an hour. The efficient fuel consumption will allow runs of hundreds of miles at top speed without a stop.

The many desirable constructional features of the modern high-speed electric locomotive will be incorporated in the design as a result of General Electric's many years of experience in building and equipping electric locomotives.

96-353DH

GENERAL ELECTRIC