SLIPPERY WATER:
A DEMONSTRATED ADVANCE IN FIRE-FIGHTING TECHNOLOGY

Edward H. Blum

June 1969
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INTRODUCTION

This document is the first of a series about "slippery water." Because it has been prepared for distribution outside RAND, its contents have been restricted to material already released publicly by the City of New York. Subsequent documents in the series will include detailed technical information and describe more thoroughly RAND's part in the major developments.
PREFACE

Part of RAND's work with the Fire Department of the City of New York (FDNY) is to help develop new technology to enhance the protection that the Fire Department can provide. The objectives of this research are to:

- Find new technology that shows promise of enhancing the Department's over-all effectiveness

- Analyze this technology to assess its relevance to Departmental needs and to devise means of applying it effectively

- Stimulate and, where possible, accelerate development and application of especially promising items.

One product of this work, for which all the objectives have been fulfilled, is "slippery water" - water containing minute quantities of a special chemical that enables it to flow with far less resistance, and thus with much greater speed, than had previously been possible. Only a laboratory curiosity less than six months ago, slippery water is now in advanced stages of a development program aimed at bringing it into routine Fire Department practice. Its feasibility and prospective use have now been demonstrated convincingly - in Fire Department tests and in public.

RAND initiated and catalyzed this development, which has been hailed by Mayor John V. Lindsay as "a major technological breakthrough." And RAND is continuing to provide major technical assistance and coordination as development proceeds.

On May 13, 1969, Mayor Lindsay and the FDNY publicly displayed slippery water at the Fire Department's training center on Welfare Island. This document contains the press release, background information, and remarks prepared for that demonstration.
I. PRESS RELEASE ISSUED BY THE OFFICE OF THE MAYOR

OFFICE OF THE MAYOR       JOHN V. LINDSAY       CITY HALL       NEW YORK CITY

Tel:  566-5090                              241-69
For Release
Tuesday, May 13, 1969

Mayor John V. Lindsay today participated in a demonstration of "slippery water," water containing minute quantities of a special chemical that enables it to flow through fire hoses with far less resistance, and thus with much greater speed than had previously been possible.

"Slippery Water" will permit the use of a smaller, less bulky hose with the same water flow as in the present equipment. With this lighter hose fire fighters will be able to climb stairs and reach remote locations more rapidly. It will also permit the delivery of large volumes of water over greater distances in conventional size hose.

Initiated by The RAND Corporation, as part of its work with the New York Fire Department, the "slippery water" system is being developed and adapted by the Fire Department with assistance by the Union Carbide Corporation, which produces the special chemical.

The "slippery water" program was hailed by the Mayor as "a major technological breakthrough."

The Mayor said:

"Technology has not always been kind to the quality of urban life. But there are solutions in science for some of our urban problems, and slippery water is one of them.

"When this development is completed, our fire fighters will have an important new tool in their difficult and dangerous work. The homeowner and tenant will also benefit because the firemen will be able to extinguish fires more quickly and effectively.

"New York is today pioneering in new organizational relationships which are necessary to bring creative solutions to the problems of our cities. With help from RAND and Union Carbide, this recently discovered phenomenon has been removed from the laboratory, and the New York Fire
Department and its partners are beginning to transform it into a live, operating system that will help protect the citizens of New York."

The Mayor stressed that slippery water is a clear, tangible result of the innovative expertise brought to New York by The RAND Corporation.

The Mayor stressed that RAND and Union Carbide participation in the project was a healthy sign of "the concern for urban problems which should be shown by the private sector of our economy."

Fire Commissioner Robert O. Lowery explained that the special chemical contains very large molecules, consisting of many thousands of small molecular units strung together into a long chain. These molecules, called "long-chain polymers," make the water more stable than it would ordinarily be.

Rapidly flowing water usually wastes much of its energy in turbulence. "Slippery water," on the other hand, flows more smoothly at high velocity, with much more energy going into forward motion.

It is not an ordinary lubrication or coating, for it occurs only when the flow is turbulent. The other properties of "slippery water," including its ability to extinguish fires, are identical to ordinary water. This is hardly surprising, because the chemicals added are so minute - only one polymer molecule for roughly every ten billion water molecules.
II. BACKGROUND INFORMATION ABOUT SLIPPERY WATER

WHAT IS SLIPPERY WATER? HOW DOES IT WORK?

(1) "Slippery water" consists of an extremely dilute solution of high molecular weight, straight-chain polymer* in water. The polymer we have used thus far, and are developing for operational use, is polyethylene-oxide which Union Carbide (sole producer of this polymer) has given the trademark Polyox. Polyox is so effective that 30 pounds, in solution, are enough to make "slippery" one million pounds of water (about 120,000 gallons). We put "slippery" in quotation marks because the phenomenon is unusual: "Slippery" water requires much less energy than ordinary water to be pumped under otherwise identical conditions (same flow rate, same hose, etc.) in turbulent flow - the random chaotic flow that occurs when water flows rapidly, as it does in fire hoses. But in non-turbulent, quiescent flows, "slippery" water is nearly indistinguishable from ordinary water. Most of its properties, including the conventional viscosity, are nearly identical to pure water, which is not really surprising, since there are roughly 10 billion water molecules for every Polyox molecule in the solution.

The "slippery" effect, then, is not an ordinary lubrication, coating, or viscosity effect, but a basic change in the nature of fluid turbulence. When one pumps water through a 1-1/2" diameter hose at a volume flow rate of 100 gallons per minute, for example, the pressure loss per one hundred feet of hose is approximately 25 pounds per square inch. Of this pressure, only two percent, 0.5 psi, is lost in overcoming true friction - the molecular attraction between parts of the fluid, and between the fluid and the hose wall. The remaining 98% is lost (dissipated) in the chaos of the turbulence.

Somehow, in a way not yet well understood, the long polymer molecules damp or reduce the chaotic fluid motions that normally occur in this turbulent flow, and hence reduce the energy dissipated in these unproductive motions. An analogy might be a crowd of people pushing and shoving

*That is, very large molecules, whose backbones consist of many thousands of small molecular units strung together into a long chain.
wildly to get out of a packed corridor. As long as the crowd is chaotic, and people expend a lot of effort jostling each other, forward progress will be slow. If we put guide rails or ropes (like those used in theaters) into the corridor, however, and thus get people to walk briskly in relatively narrow lines, we may be able to reduce the extent of the chaos and get the crowd to move more quickly. It is believed that, in "slippery water," the long polymer molecules uncoil and align themselves in the direction of the main flow, then act something like those guide ropes. Slippery water, then, is actually water with reduced chaos, that is, reduced turbulent:"friction."

(2) Polyox's effects are significant. In flows where virtually all the pressure head is used to overcome turbulent "friction," such as large water conduits or storm sewers, Polyox has been found to increase flow rates 140 to 160 percent (that is, the flows with Polyox in solution were 2.4 to 2.6 times those without). In fire hoses, how much of an increase in the flow rate can be achieved depends on the extent to which the flow with ordinary water is limited by friction. In early feasibility tests performed with Fire Department equipment, gains of 50 to 70 percent were achieved easily.

(3) Although Polyox is not the only polymer with friction-reducing properties, it appears to be the one that merits serious attention now. Polyox is more effective in smaller quantities, is known to be non-toxic, and is substantially lower in price than other alternatives. Polyox is available in large quantities, in a variety of forms, and at a relatively low price, especially considering the small amounts required to achieve a significant reduction in energy loss.

Furthermore, it has undergone extensive tests to determine its biological effects, which appear to be nil. It has had no noticeable effect, even when ingested in large amounts for long periods of time, on dogs and rats, and has had no noticeable effects on algae, other aquatic life, or "biological oxygen demand." Moreover, it has recently received approval of the U.S. Food and Drug Administration as a food additive, now intended as a head-stabilizer for beer. It is also widely used in pills, denture adhesives, and cosmetics, where it has had no noticeable effects even when used extensively, for long periods
of time, in concentrations far higher than those used in "slippery water." (See the letter from the Associate Medical Director of the Union Carbide Corporation on the following page.)
March 5, 1969

Commissioner Robert O. Lowery  
Fire Department  
City of New York  
Municipal Building  
New York, New York 10007  

Dear Commissioner Lowery:

I have been asked to comment to you on the safety of POLYOX as far as human contact is concerned. In experimental studies, the largest dose of POLYOX that we could get into the stomach of a rat was harmless and feeding dogs for two years on a diet of which 5% was POLYOX had no harmful effect. POLYOX does not irritate the skin or eyes of animals and patch tests on 50 humans showed it was neither an irritant nor a sensitizer.

In my opinion, at the use levels proposed for "slippery water", POLYOX will have no harmful effects on those working with it. That this is so is suggested by the widespread use of POLYOX as a denture adhesive where people hold in the mouth and swallow each day a considerable quantity of POLYOX. No harm has come from this after years of use. POLYOX has also been approved by the Food and Drug Administration for use as a direct additive to beer as a foam stabilizer and also for use as a pill binder for vitamins and medicines.

Finally, POLYOX enjoys wide application in cosmetic lotions, creams and soaps where it is used in concentrations many times higher than the concentration contemplated as an additive to water used in fire fighting.

These many uses for POLYOX in which human exposure occurs both by swallowing and by skin contact and which time and experience have shown to be safe are evidence supporting the safety for firemen of adding parts per million quantities of POLYOX to water used in fighting fires.

Very truly yours,

(signed by C. V. Dernehl, M.D.)  
Associate Medical Director  
Union Carbide Corporation

C. U. Dernehl, M.D.  
lk
WHAT SLIPPERY WATER CAN DO FOR THE FIREMAN

Fluid friction - the resistance water meets as it flows through a hose - can severely limit fire fighting performance. This limitation is particularly serious in interior building fires and in fires distant from hydrants and other water sources.

In interior fires, especially in multiple dwellings such as tenements and apartment houses, potential damage from fire spread and potential hazards to human life are great. Firemen thus need (a) speed and mobility, to get water on the fire quickly and to protect vital hallways, stairways, etc., even if the fire continues to spread, and (b) enough water to control and extinguish even intense fires and to protect themselves, the building, and the remaining occupants. Unfortunately, in large part because of the limitations of turbulent friction, these two needs conflict.

For speed and mobility, and ease of movement inside a building, one wants the fire hose to be light and maneuverable, even when filled with water. Since the weight of water in a given length of hose is proportional to the square of the hose diameter, light weight inescapably means small diameter. On the other hand, the smaller the hose diameter, the less water can be pumped through a given length with a given pressure at the pump. The low capacity is not due only to the smaller cross-sectional area. Fluid friction is disproportionately higher in smaller-diameter hoses, so that as the hose diameter is decreased, effective capacity (the volume flow rate achievable through a given length with a given pump pressure) is decreased nearly as the cube of the hose diameter, while weight is decreased only as the square. One can compensate for this lowered capacity by pumping through small hose at pressures higher than those used for large hose and, indeed, such pressure increases are standard operating practice. But the pressure needed to maintain capacity becomes quite large as the hose becomes small, and, for hoses that are light, far exceeds the pressure ceiling imposed by the bursting strength of the hose.

Systems studies by Chiefs in the New York Fire Department, indicate that, for interior fires in multiple dwellings, the flow from an
individual hose should be about 150 to 250 gallons per minute. Much more water appears, except in unusually large and intense fires, to be unnecessary; much less appears to be too risky too often.

The main application of slippery water, therefore, will be in expanding the water carrying capabilities of a small hose system so that it can transmit nearly as much water as a 2-1/2" hose, which is the standard hand-held hose in most fire fighting applications. We hope to make a light, small-diameter hose the standard fire fighting weapon in tenement fires and structural fires of virtually all kinds. The advantage of a small-diameter hose is that it is light, highly mobile, weighs (after it is filled with water) roughly one-third as much as a 2-1/2" hose and hence can be handled more easily. This permits an engine company to have a larger total volume of water on the fire much more quickly. (In Fire Department tests, a 1-1/2" hose has been hauled to the top of a three-story building in substantially less time than a 2-1/2" hose.) A small hose carrying slippery water has all the advantages of speed and mobility that the fireman wants in fighting a structural fire; yet it allows him to get enough water on the fire quickly.

Use of Polyox additives will eventually also reduce the extent of relay pumping required in order to pump large volumes of water over long distances.

Under almost any fixed set of circumstances — pump pressure, hose length and diameter — the use of slippery water will result in greater rates of flow through the hose and greater pressures at the nozzle. The end result is more water delivered to the fire, with a more coherent stream. Since the rate at which water is applied to a fire is important in determining the time it takes to extinguish the fire, less damage and shorter, safer fire operations should result from operational use of slippery water.
"Slippery water" is planned to be compatible with standard Fire Department operations. The development program aims, therefore, to ensure that "slippery water" works well with existing fire equipment and procedures. The program now centers on developing "slippery water" for use on Fire Department pumpers (engines), but ultimately fireboats may be included, too. Polyox is completely compatible with salt water and river water as well as the fresh water in the City's mains.

To turn "slippery water" into an operational capability in the Fire Department, RAND, Union Carbide, and the Fire Department have begun a step by step development program. The following steps have been completed:

(a) Specifications for eighty new pumpers in the 1970 Capital Budget have been modified to provide tank space and interconnections for a "slippery water" system. These changes do not affect the way the pumpers perform with plain water, and cost no more than a few hundred dollars on these $40,000 vehicles.

(b) The Fire Department has appointed a full-time project officer with engineering experience to the "slippery water" development program. He is Battalion Chief Milton Brodey.

(c) A Department pumper has been assigned to the project. Fire Department personnel, and engineers and scientists contributed by Union Carbide, are modifying this vehicle to carry the Polyox solution. First tests with the adapted vehicle were completed last month. The experimenters still must find out whether a power-driven pump is needed to inject Polyox into solution in appropriate concentrations, and if so, what kind of pump is best.

To minimize the amount of Polyox that must be carried aboard a vehicle, the development team must also determine the highest concentration of pre-mixed Polyox solution that can be used in regular operations. Once the adapted vehicle is ready, it will be tested in regular fire operation to check out tactical fire-fighting problems and to ascertain what is needed for the logistical system.

Fire chiefs will learn with experimentation and experience how
best to use the enhanced capabilities of various hose systems. Guidelines will be developed for the use of "slippery water" in pumping operations.

A logistics system must be developed and tested to refill Polyox tanks in the firehouse and at major fires. Existing service groups, such as the Mask Service Unit, may have a role in this system. The logistics system must be optimized for storage and distribution of Polyox, to minimize both wastage and incidents in which no Polyox solution is available. The form in which Union Carbide will deliver Polyox must be determined; then the structure of a Department-wide distribution system must be established (there are over 220 engine companies).

A development project such as this one has, by its very nature, unresolved problems at its inception and its early stages. It is difficult to set a schedule for answering all these questions.

Pumpers received in 1970 will be equipped to use "slippery water." In the interim, extensive field tests will be carried out. The developmental phase of the program is expected to be complete by the time these vehicles are delivered.

How much a complete "slippery water" system will cost depends on how many vehicles are adapted, and the types of fires which are put out using "slippery water." However, the concentrations of Polyox used are so small that the total cost is low. Even if "slippery water" is used by every engine company, at all fires in the City, its total cost will be less than one-third of the yearly cost of a single engine company.
HISTORY OF THE SLIPPERY WATER PROJECT

Though laboratory tests in 1948 indicated that certain high molecular weight additives - polymers - had the effect of reducing resistance to turbulent flow in pipes, no concerted effort to adapt this phenomenon for fire fighting had been made until the New York "Slippery Water" project.

Initial experiments discovered the friction-reducing effect with the use of polymethylmethacrylate in benzene, though the same phenomenon was later observed with a variety of polymers in water. In the late 1950's there were a few experiments which explored the use of friction reducing additives in fire fighting. However, the experiments were limited, excited only mild interest, and the project was never carried any further.

Though Union Carbide manufactures Polyox, they never proceeded to develop the fire fighting application of the material, in part because Polyox was in short supply. In fact, as late as December 1968, the grade of Polyox which is most desirable in friction reduction application was very scarce and available only in very small amounts.

In the Fall of 1968, RAND entered the scene as part of its work with the New York Fire Department. The RAND staff suggested that a friction-reducing additive might greatly increase the pumping capacity of present equipment. Systems studies conducted by the Department had outlined the advantages of maneuverability in 1-1/2" hose, but also indicated the need for the water delivery capability of the 2-1/2" hose. By increasing flows through the 1-1/2" hose, "slippery water" offered a potential for combining these advantages. When the Department agreed to the importance of the development, Dr. Edward H. Blum, the RAND Project Leader and a chemical engineer, contacted people in the research and development division of Union Carbide's chemicals and plastics division. In September, Dr. Blum met with Dr. Arthur K. Ingberman, the marketing and product manager of the Polyox operation within Union Carbide. Dr. Ingberman stressed that Polyox was still in short supply, and the difficulties of injecting the polymer into solution had not been overcome.

Though Carbide was pessimistic, October meetings revealed that a
plant under construction would assure a sizeable supply of Polyox early in 1969. However, the technical obstacles of putting Polyox into solution in quantities adequate for fire fighting application had not been solved.

On November 13th, RAND staff members met with Chief Lewis J. Harris of the Fire Department and Dr. Ingberman of Carbide. The Fire Department excited Carbide's interest in using Polyox in fire fighting, and for the first time, all parties saw possible ways to solve the practical problems of "slippery water." Carbide agreed to a small effort to pursue the experiment further.

Progress continued through December and in the third week of January, Carbide under the supervision of Dr. Fred Stone (Polyox Technology Manager) assembled the necessary test equipment at the Welfare Island training site. First results were disappointing because only hydrant pressure and a short length of hose was used; however, on the following day, regular pumping pressures and a longer stretch of hose were used. Flow was increased by 40-60%. On the 6th of February, these results were repeated in a demonstration before a Fire Department audience including Commissioners Ward and Canick and Chief O'Hagan and Harris. In this demonstration, with eight lengths of 1-1/2" hose and a pumping pressure of 200 psi, flows increased from roughly 120-130 gpm to roughly 200 gpm with the addition of Polyox at 30 parts per million. In addition, the differences in the throw of the water and compact shape of the stream were clearly visible.

Following this successful demonstration, RAND, Carbide and the New York Fire Department embarked on the full scale development program described today. Initial tests with a preliminary version of an adapted, self-contained apparatus are already underway.
III. AGENDA FOR THE SLIPPERY WATER DEMONSTRATION

FIRE DEPARTMENT
CITY OF NEW YORK

POLYOX "SLIPPERY WATER" DEMONSTRATION AT THE BUREAU OF TRAINING, MAY 13, 1969.

AGENDA

1. Welcome to the Bureau of Training of the New York Fire Department, at the Administration Building.

2. Briefing on the effects of the addition of the Polyox compound to fire service hose streams, at the Administration Building:
   Mr. Edward H. Blum, the Rand Corporation.
   Mr. Warren Anderson, Union Carbide Corporation.

3. Field demonstrations at the Training Tower:
   A. Comparison of streams-Nozzle pressure, reach and quantity effects using fire streams for visual observation. Instruments will also be used to measure the effects.
   B. Mobile target—a mobile target will be introduced to demonstrate the reach of the streams.
   C. Quantity effects using a measuring tank. Instruments will also be used to measure the effects.

4. Question and answer period after the demonstrations, at the Administration Building.

HERBERT F. WHYTE
DEPUTY ASSISTANT CHIEF
BUREAU OF TRAINING.
NOTE: The red dye is used for visual effects only. It does not affect the stream.

Graphics—FDNY
IV. REMARKS BY EDWARD H. BLUM

(The RAND Corporation, New York, N. Y.)

SLIPPERY WATER DEMONSTRATION
May 13, 1969

I would like briefly to describe how "slippery water" got to where it is today, and what "slippery water" is and does - to add to the material you may already have in hand.

What you will see demonstrated today was only a laboratory curiosity a few months ago. It left the laboratory and reached development only through a novel joint effort of a City agency, a private corporation, and a technically expert consultant working with the City on policy problems. All three partners were essential to this enterprise:

- The City agency had to be willing and able to try new approaches to its problems, even venturesome ones that occasionally sounded a bit like science fiction.
- The corporation had to have an excellent product, the know-how to back it up, and the public spirit to pursue a novel venture that might have no immediate financial return.
- And there had to be a match-maker close enough to both the City and the world of high technology to recognize the possibility and the importance of the match, and to bring the other partners together.

Technological advances such as this do not just happen. Bringing "slippery water" to where it is today required someone to

- Identify problems in the City agency and the potential value of modern technology to solve them.
- Be able to convince the agency that the end results would make a development effort worthwhile.
- Recognize what the obstacles were to developing the technology, and see that the time was ripe to overcome them.
- Know who in private industry had the appropriate product and the necessary know-how.
Interest the industrial organization in investing its resources and talent in a program aimed at solving the technical problems that prevented immediate application, and

Bring and keep the company and the agency together

In the private sector, it is a venerable New York tradition to bring together people with needs and people with potential solutions. There are many financial institutions for whom stimulating private innovation is a major raison d'etre.

But there have been no such institutions in the public sector. There has been no one to stimulate innovation in government, particularly at the local level where the lure of large contracts is not present.

Thus RAND is quite proud to have been able to fill this vital need — to have been able to bring the Fire Department and Union Carbide together, to catalyze and initiate the development of "slippery water." We are also very pleased to continue to serve as a participant in the development program.

What you will see demonstrated shortly is water that contains minute amounts of a special chemical: less than one ounce of the chemical per 200 gallons. This minute addition greatly reduces the water's resistance to flow. For example, in the demonstration today, you will see the water flow increased about 60% — and you will see that the reach of the fire hose stream is roughly doubled.

Mr. Anderson of Union Carbide will now talk about the special chemical, and then Chief O'Hagan will describe what this breakthrough means to the Fire Department.
V. PREPARED REMARKS - MAYOR JOHN V. LINDSAY

Slippery Water Demonstration - May 13, 1969

It is a great pleasure for me to be here today for a demonstration of "slippery water." I find the subject a bit difficult to grasp, technically, but it is a significant development for New York, and for all the cities of America.

Technology has not always been kind to the quality of urban life. Science and technology are often blamed for the breakdown of our cities - for the polluted air, the tangled transportation networks, the harsh and impersonal buildings, the cold, inhuman pressures of city living.

There are also solutions in science for some of our urban problems. The "slippery water" program is a major technological breakthrough. When this development is completed, our fire-fighters will have an important new tool in their difficult and dangerous work.

New York is today pioneering in the new organizational relationships which are necessary to bring creative solutions to the problems of our cities. This demonstration is a clear, tangible result of the innovative expertise which RAND brings to New York, for RAND scientists and the New York Fire Department are responsible for transferring this development from the laboratory to the fire engine. The development of "slippery water" is an example of the practical cooperative arrangements which can be developed between RAND and City Departments.

Union Carbide, too, has made a major contribution to urban progress in this new commitment to our City. Carbide has contributed expensive equipment and valuable engineering talent to the solution of the operational problems in this new system. The participation of Union Carbide in this project is a healthy sign of the concern for urban problems which should be shown by the private sector of our economy.

The New York Fire Department, RAND, and Union Carbide are here, today, pioneering a development of great significance to Fire Departments throughout the United States. I am proud that New York City is taking the lead in this vital but unexplored area of fire-fighting research.
VI. NARRATIVE FOR SLIPPERY WATER DEMONSTRATION

(A) COMPARISON OF STREAMS

The plain water and slippery water are being pumped at the same pumping pressure through identical hose and nozzles - the differences are due entirely to the effects of minute amounts of Polyox (about one ounce of Polyox powder transforms 200 gallons of plain water into slippery water).

Note the large difference in "reach" - the slippery water stream contains more water, and leaves the nozzle much faster. Slippery water gives the fire-fighter greater capability with the same hose - capability equivalent to that now attainable only with much larger hose.

Note also that the slippery water stream holds together better than the plain water stream, despite the greater stress imposed on it by its faster flow out the nozzle. This increased coherence is another feature of slippery water that aids the fire-fighter by giving him a much more effective fire-fighting stream.

If you are able to get close enough to the streams, near the nozzles - without getting wet! - you may also notice two other features of slippery water that reflect its much lower level of turbulence:

1. The slippery water stream is clearer, more translucent than the plain water, which has the milky-white appearance that all fast-flowing water had until now.

2. The slippery water stream sounds different from the plain water stream. Part of the sound difference arises from the faster flow. The rest stems from the much lower extent of turbulence, which makes possible the faster flow.

(B) MOBILE TARGET DEMONSTRATION

The slippery water stream reaches far beyond where the plain water stops - and strikes the target forcefully beyond where plain water falls to the ground. Slippery water thus enhances the fire-fighters "reach" as well as his mobility.

This same effect can be used to pump water in the hose much longer distances to fires in remote areas or areas not convenient to ordinary
sources of water supply. Fires in outlying areas of Queens and the Bronx, for example, and in the brush fire areas of Staten Island, thus will be able to be brought under control more quickly and effectively. Fires in the upper floors of apartment and office buildings will become more amenable to rapid control.

Note especially that slippery water is an especially important breakthrough in fire-fighting technology - because, unlike most other new developments, it is compatible with current fire department equipment and operations. When fully developed, it may be used in all parts of the City as part of normal fire operations. When fully installed in the Fire Department pumper fleet, it will be in service wherever and whenever the Fire Department is. It can even be used with fire boats, since slippery water works as well with salt water and river water as with fresh water.

(C) FILLING TANK

The greater throw, mobility, and reach of slippery water are possible because it flows much faster than plain water under otherwise identical conditions. You have seen how this faster flow looks when slippery water is used as it will be used in action. Now observe just how much faster the flow really is.

To show you how much faster the flow is with slippery water, we have constructed two identical tanks, one for plain water and one for slippery water. We will put the nozzles into the tanks, to catch all the water from both. At the signal, we will start both hoses simultaneously. Note that the slippery water tank fills much more rapidly, and overflows before the plain water tank is barely two-thirds filled. Imagine the relative effects of these two hose streams against a fire.

*(Note added after the demonstration):

Both tanks hold 485 gallons. The tank filled with slippery water overflowed after 2 minutes and 33 seconds. That filled with plain water took 4 minutes and 10 seconds to overflow. Thus, in this arrangement (400 feet of 1-1/2" hose, approximately 220 psi pumping pressure) the slippery water flowed 60 percent faster than plain water: 190 gallons per minute with slippery water versus 120 without.
At least as important in these days of tight City budgets, slippery water is quite inexpensive. The amount of Polyox used in all of today's demonstrations costs less than five dollars. Even if slippery water is eventually used by every engine company in the New York Fire Department (all 225 of them) at every fire in the City, its total annual cost would be less than one-third the annual cost of one engine company.

Increased flow, reach, coherence, speed and mobility. Ready deployment, compatible with current equipment and operations, at low cost; and it overthrows the old laws of fluid motion. That is slippery water - a major breakthrough now under development, by The RAND Corporation, the Union Carbide Corporation, for the New York Fire Department.
VII. SLIPPERY WATER IN ACTION

PICTURE #1

"Slippery Water" (issuing from the hose on the left) soars above plain water in the May 13th demonstration at Welfare Island. Pumped through identical lengths of hose, at the same pumping pressure, with identical nozzle openings, the two streams had identical trajectories only moments earlier — before Polyox was added to the stream on the left.

Before the Polyox was added, both streams were aligned to hit the target hanging on the truck. Now, as the truck moves away, the plain water stream falls short. But the "slippery water" — flowing sixty percent faster than the plain water — shoots well over the target, even well beyond the truck.

In the front row (from right to left): Mayor John V. Lindsay, First Deputy Fire Commissioner James T. Ward, Dr. Edward H. Blum, Deputy Assistant Chief Herbert F. Whyte.
"Slippery Water" more than doubles the fireman's reach. The plain water stream here barely reaches fifty feet (note the range signs on the poles) – a few feet short of where the slippery water stream attains the peak of its trajectory.

In the first picture the target was about thirty feet from the nozzles, and the plain water stream was already falling short. In the second picture, the target has moved to seventy-five feet, but the slippery water stream is still able to overshoot it. Indeed, the slippery water stream shown here fell short only after the target moved beyond ninety feet.