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STATE ENGINEERING EXPERIMENT STATION
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PROGRESS REPORT NO. 16

PROJECT NO. 141-64

CABLE DEVELOPMENT

By

F. BELLINGER AND W.H. SACHS, JR.

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CONTRACT NO. NObs-47441

INDEX NO. NS-410100

BUREAU OF SHIPS, BRANCH 620

DEPARTMENT OF THE NAVY

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JULY 31, 1950

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I. SUMMARY

An explosive streamer which departs somewhat from the original line charge concept is described. The proposed streamer has a loading equivalent to one pound of cast HBX-1 per foot of streamer. The exploding charges (of 25 pounds each) are contained in three inch diameter aluminum tubes suspended beneath a towing cable and are spaced at intervals of 25 feet along the entire length of the streamer. Initial explosion tests indicate that the charges can be exploded without damaging the towing cables. A study of buoyancy calculations indicates that steel tubes six inches in diameter or larger may be required to provide buoyancy if it becomes necessary for such tubes to withstand explosion pressures from large (600 pound) explosive charges. If the tubes need to withstand only the pressure from explosions of adjacent explosive sections, tubes of four inches diameter may suffice.

II. CONTAINER DESIGN

Progress Report No. 15 contained a tabulation of dimensions and buoyancies of several possible arrangements of float tubes for an explosive streamer. The streamer considered was designed for a line charge of explosive 25 feet long having a cast HBX-1 charge weighing one pound per foot. The tabulated data indicated that, in order to achieve neutral or slightly negative buoyancy with hollow tubes which would withstand the explosion of other units of the streamer, containers having overall dimensions as great as 3x6-1/2x96 inches would be required. Therefore, it was believed desirable to consider other arrangements which might eliminate some of the disadvantages of having the explosive charge in three separate units.

[redacted]

At a conference with Bureau of Ships, Code 620 personnel on June 13, 1950, a streamer was proposed in which an explosive charge consisting of 25 pounds of cast HBX-1 is carried in one tube approximately 7-1/2 feet long suspended below a towing cable. A hollow tube attached to the explosive container by means of a pair of cast aluminum yokes provided buoyancy for the assembly. Cast aluminum was chosen for the yoke material because of its light weight and because of its ability to shatter during the detonation of the explosive charge. The first yokes were made of Alcoa Alloy #212 because it was available locally. Tests will be made using yokes cast with Alcoa Alloy 195-T6. This alloy must be heat treated to develop its maximum strength. It is believed that its use will effect a considerable weight saving over the use of the #212 alloy.

Figure 1 is a photograph of the explosive unit with its float tube. A complete 400 foot streamer would consist of 16 such units separated by two three-inch-diameter, 8-1/3-foot-long spacer units. The spacers would contain the necessary actuator units. Each actuator unit would initiate the nearest 25-pound explosive charge and would initiate a charge which would blow the spacer tubes on each side of the main charge clear of the cable. Thus, with the explosion of each 25 pound charge, 25 feet of the streamer would be expended.

In a streamer assembly such as that described above, it would be possible to obtain the necessary buoyancy in several ways:

1. Use an air-filled float tube in the explosive unit of a size sufficient to give neutral or slightly negative buoyancy to the 25 foot section of the streamer. The spacer units would be water-filled to resist collapse and would provide no buoyancy.

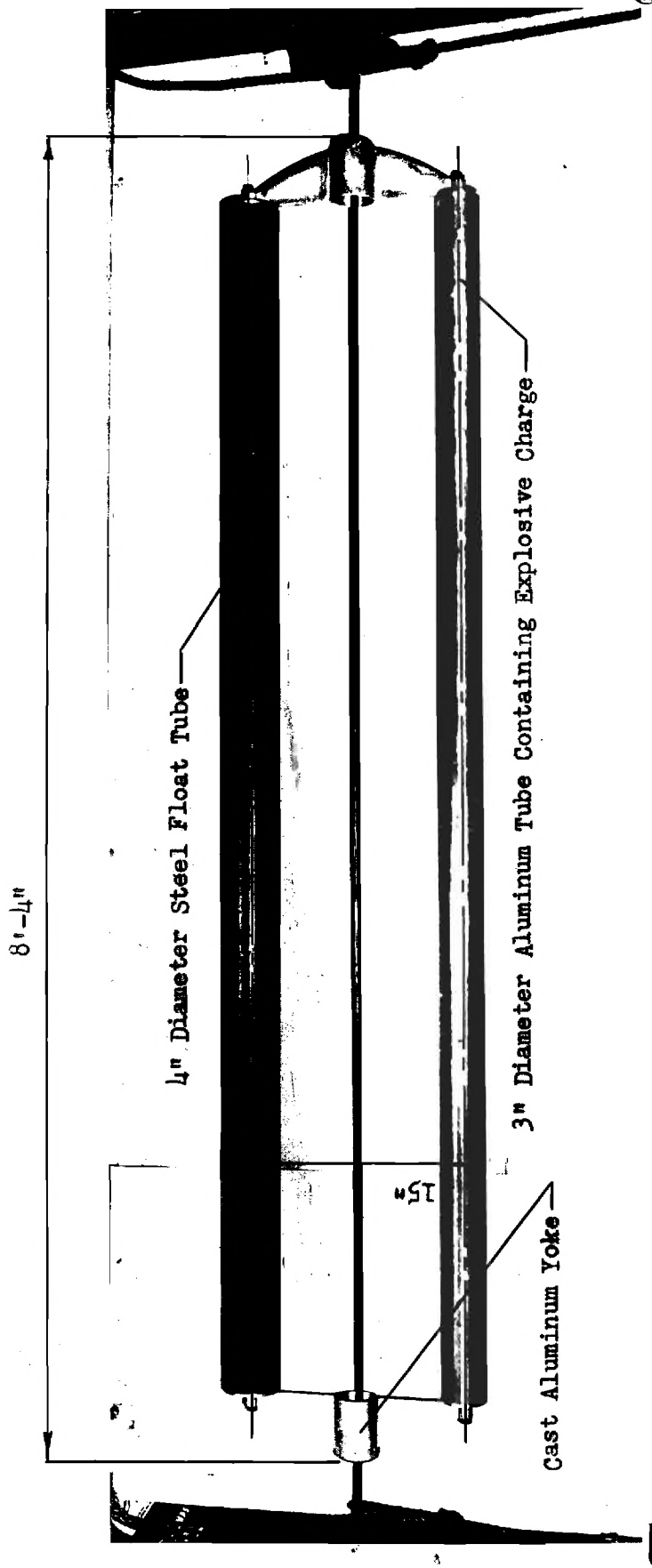

Figure 1. Explosive Unit of Proposed Streamer

2. Use an air-filled float tube in the explosive section of a size sufficient to give neutral or slightly negative buoyancy to the explosive unit only, with wood-filled spacer tubes on each side of the explosive units to provide the desired displacement.

3. Use a wood float of a size sufficient to give neutral or slightly negative buoyancy to an entire 25 foot section of streamer. The spacer units would be water-filled and would provide no buoyancy.

4. Use a wood float of a size sufficient to give neutral or slightly negative buoyancy to the explosive unit only, with wood-filled spacer tubes on each side of the explosive unit to provide the desired displacement.

Buoyancy calculations have been made to determine float tube sizes required for the four possible arrangements suggested above. The tubes were assumed to be of steel, and wall thicknesses were estimated to withstand (a) pressures 25 feet from a 600 pound charge of cast HBX-1, (b) pressures 25 feet from a 25 pound charge of cast HBX-1. Wall thickness/diameter ratios (t/D) were based on ASME-UPV Code for design of tubes for external pressure loading. It was assumed that the peak explosion pressure required for collapsing the tubes would be approximately five times the static pressure required for collapse.

Results of the calculations are assembled in Table I. Steel tubes six or more inches in diameter are indicated if the floats must withstand pressures from large explosive charges and provide only slightly negative buoyancy. At present, the use of tubes of such a size would seem to be impracticable. However, before final rejection of the high-strength float tube concept, data should be obtained relative to the resistance of those

TABLE I

BUOYANCY DATA FOR 25 FOOT EXPLOSIVE STREAMER ASSEMBLY

Source of Buoyancy	To Withstand Pressure of 600 Lb. Torpex Charge at 25 Feet.				To Withstand Pressure of 25 Lb. HBX-1 Charge at 25 Ft. (1 Lb. per Foot Nominal Loading)			
	t/D = 0.027				t/D = 0.016			
	Float Dia. (Inches)	Weight of Unit (Pounds)	Water Displaced (Pounds)	Buoyancy Factor*	Float Dia. (Inches)	Weight of Unit (Pounds)	Water Displaced Pounds)	Buoyancy Factor*
1. Air-filled Float Tube, Water-filled Spacers	4	111.9	78	1.43	4	98.1	78.0	1.25
	6	154.6	132	1.17	5	110.7	102.5	1.08
	8	215.1	207	1.04	6	123.1	132.0	.93
	9	252.1	253	.99	8	159.6	207.0	.77
2. Air-filled Float Tube Water-filled Spacers	4	127.2	110.6	1.1	4	113.4	110.6	1.03
	6	169.9	164.6	1.03	4-1/2	118.5	122.6	.97
	8	230.4	239.6	.97	5	126.0	135.1	.93
3. Wood Float Water-filled Spacers	4	100.5	78.5	1.28	Weight in Air of Individual Components of 25 Foot Section			
	5	111.9	103.0	1.09				
	6	125.6	132.0	.95	Cable (25 Feet)		12.5 Pounds	
4. Wood Float Wood-filled Spacers	4	118.7	110.0	1.08	2 Cast Al Yokes		6.4 Pounds	
	4-1/2	120.0	120.0	1.00	2 Al Spacer Tubes		14.0 Pounds	
	5	129.8	135.0	.96	1 Al Explosive Tube		7.0 Pounds	
					2 Actuators		6.0 Pounds	
					Miscellaneous Fittings		5.0 Pounds	
					Explosive (Sp.Gr. 1.7)		25.0 Pounds	
					Wood - 30 lb/ft^3			

* Buoyancy Factor = Weight of Unit ÷ Water Displaced

tubes to collapse by underwater explosions. If hollow cylinders are to withstand only the explosion of the charge in the next streamer section, it is possible that float tubes having a diameter of four inches may suffice.

The possibility of utilizing wood floats for the streamer unit was pointed out in Progress Report No. 15. Practicability of this type of float must be determined by subjecting units to the explosion pressure from large charges.

Plans are being formulated for tests to determine resistance of the various possible float tubes to large scale explosions and to determine towing characteristics of the streamer assembly.

Preliminary tests are being made to obtain design data for streamlined ends for the explosive units. These ends will be shaped to minimize drag and turbulence when the streamer is towed at operational speeds. This work is being carried out by Mr. H.W.S. LaVier who is associated with the Engineering Experiment Station and the Georgia Tech School of Aeronautics.

III. EXPERIMENTAL WORK

Underwater explosion tests have been made using explosive units similar to that shown in Figure 1. The explosive charge contained in the three-inch-diameter aluminum tube was approximately 28 pounds of cast HBX-1 and was initiated by a pentolite booster.

Two successive explosive charges did not damage a 1/2-inch 8x19 wire rope used as a suspension cable. The aluminum yokes, which were cast Alcoa Alloy #212, were blown clear of the cable.

A 5/32-inch 1x19, rubber-covered aircraft strand was broken by the explosion of a similar charge. The break occurred at or near one of the yokes. When this test was repeated, the cable was not broken, but the aluminum yokes cut through the rubber to the steel cable.

Cable GT-10, a 1/2-inch nominal diameter armored electrical conductor, was undamaged by two successive shots using the explosive assembly described above. Neither the electrical conductor nor the insulation was damaged by the two tests.

IV. PROGRAM FOR IMMEDIATE FUTURE

Additional explosion tests will be made using explosive units similar to that shown in Figure 1. The aluminum yokes for these assemblies will be cast of Alcoa Alloy #195-T6.

Towing and explosion tests in full-scale will be planned to determine the hydrodynamic characteristics of the streamer units and their resistance to underwater explosives.

Respectfully submitted,

Frederick Bellinger,
Project Director

Ward H. Sachs, Jr.,
Assistant Project Director

Approved:

Gerald A. Rosselot, Director
State Engineering Experiment Station

Georgia Institute of Technology
STATE ENGINEERING EXPERIMENT STATION
Atlanta, Ga.

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PROGRESS REPORT NO. 17

PROJECT NO. 141-64

CABLE DEVELOPMENT

By

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I. SUMMARY

Towing tests of a 100 foot length of non-streamlined prototype of the explosive streamer proposed by Georgia Tech have been conducted at The U.S. Navy Mine Countermeasures Station, Panama City, Florida.

The noise level of the disturbance caused by movement of the non-streamlined assemblies through the water was no higher than the background noise of the hydrophone system with which the measurements were made. At a towing speed of eight knots, the float tube-explosive units appeared to be quite stable. Rotation of the units about an axis coincident with the towing cable was limited to an arc of about six degrees as indicated by an inclinometer mounted in one of the sections. Towing drags of the non-streamlined assemblies at 6, 8, 10 and 12 knots were 400, 850, 1250 and 1800 pounds respectively. These drags will be materially reduced by streamlining of the float tube-explosive units in the final assembly design.

II. EXPERIMENTAL WORK

During the week of August 13, 1950, units of the explosive streamer proposed by Georgia Tech were subjected to towing tests at the U.S. Navy Mine Countermeasure Station (USNMCS), Panama City, Florida, in order to determine towing drag and to measure the noise level of the water disturbances caused by passage of the streamer through the water. The streamer consisted of four dummy explosive assemblies with two aluminum spacer tubes (three inches in diameter) between explosive units. One spacer tube was placed ahead of the leading explosive unit and one spacer was placed after the last explosive unit. Spacer units were wood-filled to make them of slightly positive buoyancy. The dummy explosive assemblies

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were similar to that shown in Figure 1, Progress Report No. 16, July 31, 1950, except that the four inch diameter steel tube was replaced by a 4-1/2 inch diameter wood float. The float and explosive tubing were not streamlined for these tests. Spacer sections and explosive assemblies were approximately eight feet long, so that the total length of the streamer tested was approximately 100 feet. The streamer units were slightly buoyant. An inclinometer and a hydrophone were mounted in the spacer tube on the after end of the streamer with this tube rigidly secured to the explosive assembly immediately ahead of it. With this arrangement, any rotation of the explosive assembly away from the vertical position would be transmitted to the inclinometer. The streamer tow cable was a 0.3-inch diameter, six conductor armored cable.

Streamer units were launched by hand, one at a time, over the stern of an AMc while the vessel was dead in the water. The streamer cable passed through a snatch block secured to a paravane by a ten-foot pendant so that, when the paravane was launched from the starboard quarter, the streamer was pulled out of the towing vessel's wake. The paravane was set to tow at a depth of 30 feet. The length of the paravane tow cable was approximately 150 feet, while the length of the streamer tow wire was approximately 250 feet.

Table I shows towing drags as indicated by tensiometers when the streamer was towed at various speed.

During the towing operation the paravane maintained a position approximately 135 degrees relative to the towing vessels course.

The noise level of the disturbance caused by the streamer when towed at eight knots appeared to be no higher than the background noise of the hydrophone system, which, it is understood, would be insignificant in comparison with torpedo noise.

[redacted]

TABLE I

TOWING DRAG OF EXPLOSIVE STREAMER

Speed	Streamer Drag	Paravane Drag
6 knots	400 pounds	600 pounds
8 knots	850 pounds	1500 pounds
10 knots	1250 pounds	2300 pounds
12 knots	1800 pounds	-

[redacted]

Inclinometer recordings at eight knots indicated orientation of the dummy explosive units with the vertical within ± 3 degrees. Stability apparently decreased when speed was increased to ten knots, but the instruments ceased functioning before reliable data could be recorded.

The streamer, as observed from a PT boat, appeared to be quite stable and towed without snaking or cork-screwing when submerged. Towing depth, as estimated by sonar gear on the PT boat, was approximately 27 feet. Readings at several points along the streamer did not vary more than two or three feet.

The load on the streamer tow cable was a steady strain without jerks, although there was some vibration of the cable. The amplitude of the vibration was approximately 1-1/2 inches. Examination of the tow cable after the tests failed to show evidence of any tendency of the cable to untwist.

A mark near the water's edge on the paravane tow cable, which, except for the swells or crests of the waves, remained at the water's edge, and the steady strain on the paravane tow cable indicated absence of hunting or excessive snaking of the streamer.

A wedge stopper on the after end of the streamer tow cable gave way shortly after the towing vessel's speed was increased to 12 knots and the streamer units slipped from the cable.

III. STREAMER DESIGN

Units are being assembled for towing tests of 400 foot streamers. These units will have streamlined ends to reduce towing drag. Figure 1 shows the end of one explosive assembly and a portion of the adjacent spacer tube.

Steel and aluminum cylinders of various diameters and wall thick-

TABLE I

BUOYANCY DATA FOR 25 FOOT EXPLOSIVE STREAMER ASSEMBLY

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	t/D = 0.027				t/D = 0.016			
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	8	215.1	207	1.04	6	123.1	132.0	.93
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	6	169.9	164.6	1.03	4-1/2	118.5	122.6	.97
	8	230.4	239.6	.97	5	126.0	135.1	.93
3. Wood Float Water-filled Spacers	4	100.5	78.5	1.28	Weight in Air of Individual Components of 25 Foot Section			
	5	111.9	103.0	1.09				
	6	125.6	132.0	.95	Cable (25 Feet)		12.5 Pounds	
4. Wood Float Wood-filled Spacers	4	118.7	110.0	1.08	2 Cast Al Yokes		6.4 Pounds	
	4-1/2	120.0	120.0	1.00	2 Al Spacer Tubes		14.0 Pounds	
	5	129.8	135.0	.96	1 Al Explosive Tube		7.0 Pounds	
					2 Actuators		6.0 Pounds	
					Miscellaneous Fittings		5.0 Pounds	
					Explosive (Sp.Gr. 1.7)		25.0 Pounds	
					Wood - 30 lb/ft^3			

* Buoyancy Factor = Weight of Unit ÷ Water Displaced

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nesses are being prepared for use in large scale explosion tests at USNMCS. They will be exposed to underwater explosions of 600 pound HBX charges to simulate explosion of a torpedo warhead. Collapse data will be utilized in the design of float tubes for the explosive streamer.

IV. PLANS FOR IMMEDIATE FUTURE

It is anticipated that towing tests of streamlined units will be conducted at the USNMCS during the week of September 10, 1950. Collapse tests of hollow cylinders using 600 pound explosive charges will be carried out shortly thereafter. It is expected that explosive tests on special rubber-coated aircraft strand will be carried out during the coming month.

Respectfully submitted,

Frederick Bellinger,
Project Director

Ward H. Sachs, Jr.
Assistant Project Director

Approved:

for Gerald A. Rosselot, Director
State Engineering Experiment Station

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PROGRESS REPORT NO. 18

PROJECT NO. 141-64

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DEPARTMENT OF THE NAVY

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SEPTEMBER 30, 1950

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I. SUMMARY

Towing tests of 400-foot streamlined prototypes of explosive streamers were carried out at the U.S. Navy Mine Countermeasure Station during the month of September.

During towing of a 400-foot streamer employing 4-1/2-inch diameter wood floats capped with non-cavitating points, the drags were 800, 1100, and 1800 pounds at 10, 12 and 15 knots respectively. Towing drag was increased somewhat by increasing the diameter of the wood floats to 5-1/2 inches.

Underwater explosion of 600-pound HBX-1 torpedo warheads crushed hollow, seamless steel floats having wall thickness to diameter ratios of less than 0.030, where the distance between the explosion and the hollow tubes was less than about 30 feet. The effect of the explosion on the other streamer components is described briefly.

II. EXPERIMENTAL WORK

A. Towing Tests

Tests using streamlined, dummy explosive units were made at the U.S. Navy Mine Countermeasure Station (USNMCS) during the month of September to determine stability and drag characteristics of full-length streamers when towed at operational speeds. Three separate streamers were employed during these tests: (1) a 400-foot streamer with 4-1/2-inch diameter wood floats and the three-inch diameter explosive tubes capped with long, non-cavitating points for streamlining, (2) a 400-foot streamer similar to (1), but with floats and explosive tubes capped with blunt nose ogives for streamlining, and (3) a 300-foot streamer employing 5-1/2-inch diameter wood floats and three-inch diameter explo-

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sive tubes capped with long, non-cavitating points.

The streamers were towed from the stern of the towing vessel using a "silent" type paravane which carried the streamer out of the towing vessel's wake. The streamers possessed moderate positive buoyancy to permit recovery in the event of the parting of a tow cable. The positive buoyancy caused the after end of the streamer to ride at or near the surface of the water at speeds of eight knots or less when the paravane was set for a depth of 30 feet. At speeds greater than eight knots, the after end of the streamer was submerged so that it was not visible from the towing vessel.

As was the case in the tests previously reported in Progress Report No. 17, August 31, 1950, an inclinometer was mounted in the last section of the streamer to furnish an indication of the stability of that unit. During tests at towing speeds of 12 knots, the total angle of rotation of the float-explosive-tube assembly averaged from 16 to 18 degrees with occasional peaks up to 25 degrees. At towing speeds of 15 knots the average rotation indicated by the inclinometer was 30 to 32 degrees with occasional peaks as high as 50 degrees. Radical course changes of the towing vessel had no apparent effect on the stability of the unit.

In comparison with the six degree arc of rotation previously reported for a towing speed of eight knots, it appears that the above figures may be somewhat high. Additional tests are to be carried out to check these data.

The towing drags, as indicated by tensiometers when the streamers were towed at various speeds, are tabulated in Table I.

Throughout the periods of towing of all streamers, tensiometers indicated steady strains on paravane and streamer tow cables. When towed at 15 knots, several of the aluminum yokes broke near the point

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TABLE I

Towing Drags of Explosive Streamers

Speed	4-1/2-inch Float Long Non-cavitating Caps (400 Ft. Streamer)		4-1/2-inch Float Blunt Caps (600 Ft. Streamer)		5-1/2-inch Float Long Non-cavitating Cap (300 Ft. Streamer)	
Knots	Streamer Drag Pounds	Paravane Drag Pounds	Streamer Drag Pounds	Paravane Drag Pounds	Streamer Drag Pounds	Paravane Drag Pounds
6	200	600	300	900	250	1000
8	400	1300	600	1750	350	2000
10	600	2250	900	2500	500	3500
12	1100	2800	1250	3500	600	4000
15	1800	4500	-	-	1250	6500

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of fastening to the wood floats. Patterns will be modified to increase the strength of the castings in the areas where fracture occurred.

B. Explosive Tests

In order to obtain data for the design of streamer floats able to resist the nearby explosion of a torpedo warhead, an array of hollow, seamless steel cylinders having various diameters and wall thicknesses were exposed to the underwater explosion of 600-pound charges of HBX-1. In addition to the hollow steel cylinders, typical wood-filled spacers and wood floats were placed at several different distances from the explosions. The explosive charges were detonated at a depth of approximately 45 feet in about 80 feet of water.

The peak pressure 25 feet from the explosion was estimated to be approximately 5000 pounds per square inch at a depth of approximately 30 feet.

Table II shows the condition of the hollow cylinders after the explosions.

All steel tubes having wall thickness to outside diameter ratios less than 0.030 were crushed when closer to the explosion than about 30 feet. These included steel tubes of diameters 3, 4, 6, 7 and 8 inches and wall thickness to diameter ratios of 0.016, 0.017, 0.018, 0.020, 0.028 and 0.030. Four-inch diameter tubes having a wall thickness of 0.120-inch did not collapse at distance greater than 30 feet.

An eight-foot, cast HBX-1 charge approximately three inches in diameter, similar to that which will be used in the explosive streamer, was cracked slightly by the explosion at a distance of approximately 30 feet. The slight damage, however, would not impair its effectiveness in subsequent use.

Typical wood floats which have been used in streamer towing tests

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TABLE II

Distance from Explosion to Speciman Feet	4" O.D. 0.065" Wall	7" O.D. 0.120" Wall	6" O.D. 0.110" Wall	8" O.D. 0.156" Wall	3" O.D. 0.083" Wall	4" O.D. 0.120" Wall
15					Crushed	Crushed
17		Crushed		Crushed		
18			Crushed			
19					Crushed	
21		Crushed	Crushed			Crushed
22			Crushed			
24		Crushed			Crushed	Crushed
26						
27			Crushed			
29					Crushed	Undamaged
31						
33			Crushed			
35	Crushed		Crushed	Crushed	Crushed	Undamaged
39			Crushed			
40	Crushed			Undamaged		Undamaged
44			Undamaged			
47	Crushed			Undamaged		

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were crushed slightly and in some cases were broken in the center as a result of breakage of the dowels with which the two four-foot sections were joined to make eight foot floats.

III. PLANS FOR IMMEDIATE FUTURE

Explosion tests will be made at Lake Arabia employing assemblies made up of aluminum yokes manufactured by the Aluminum Company of America. These tests will be carried out with special rubber-covered cable manufactured by the B.F. Goodrich Company.

Yoke patterns will be altered to increase the strength of the castings at the points where they are secured to the wood floats.

Consideration will be given to the design of a split yoke which possibly would not require shattering in order to accomplish clearing of the tow cable.

Respectfully submitted,

Frederick Bellinger
Project Director

Approved:

Ward N. Bacon, Jr.
Assistant Project Director

Gerald A. Rosselot, Director
State Engineering Experiment Station

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OCTOBER 30, 1950

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I. SUMMARY

Underwater explosion tests carried out in October at Lake Arabia have shown that damage to Goodrich, rubber-coated aircraft strand is confined to the points at which the cable passes through the hubs of the yokes with which the floats and explosive tubes are secured. The damage resulting from the detonation of 28-pound charges of explosives in the explosive tube of the streamer units can be materially reduced by insertion of rubber bushings in the hubs of the yokes.

Work has been started on the design of a streamer which will employ float-explosive units approximately 13-feet long. Detector-actuator units will be integral parts of the float-explosive tube assembly.

Patterns are being completed for casting two-piece yokes. These yokes will be split in such a manner that they may fall clear of the cable after the explosive charge has been detonated.

II. EXPERIMENTAL WORK

During October a number of underwater explosion tests were carried out at Lake Arabia in order to determine the resistance of B.F. Goodrich rubber-coated aircraft strand to the explosion of streamer units. The float-explosive tube assemblies employed in these tests were similar to that shown in Figure 1, Progress Report No. 17, August 31, 1950. The cast aluminum yokes utilized in fabricating the assemblies were Alcoa Alloy 319T6. They were cast and heat treated in the Aluminum Company of America plant at Cleveland, Ohio. The floats and the explosive tubes were approximately eight feet long. Explosive charges weighed about 28-pounds. The cables used to simulate the streamer tow line were 5/16-inch aircraft strand coated with rubber to an outside diameter of 9/16-inch.

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Underwater detonation of the explosive charges resulted in cutting the rubber covering of the cables where they passed through the hub of each yoke. Otherwise, the cables were undamaged.

Subsequent tests indicated that damage to the cable covering could be materially reduced by insertion of tough rubber bushings into the yoke hubs.

In all of eight test firings, the 319T6 alloy aluminum castings cleared the cables completely.

III. STREAMER DESIGN

As a result of a conference with Bureau of Ships, Code 620 and U.S. Navy Mine Countermeasures Station (USNMCS) personnel, consideration is being given to the design of a streamer in which the detector-actuator units will be carried in the float-explosive tube assembly. The overall length of the assembly will be approximately 13-feet. Work on the long streamer units is being carried forward concurrently with development of the original 8-1/3-foot units.

Georgia Tech personnel have been working in close cooperation with USNMCS personnel in combining structural features of floats and yokes which will be compatible with electronic and acoustic requirements of the detector system.

Patterns are being completed for casting two-piece yokes. The bottom arm of these yokes will be split in such a manner that the yokes will be free to fall from the tow cable after the explosive charge has been detonated. The hub of the yokes will be of a size and shape to accommodate the power take-off transformer of the detector-actuator units.

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IV. PLANS FOR IMMEDIATE FUTURE

Upon completion of the patterns, a number of "split" yokes will be cast and subjected to strength and explosion tests.

Processing of steel cable for rubber-coating will be discussed with representatives of the B.F. Goodrich Company and additional cable specimens will be secured for testing.

Respectfully submitted,

Frederick Bellinger,
Project Director

Ward H. Sachs, Jr.,
Assistant Project Director

Approved:

Gerald A. Rosselot, Director,
State Engineering Experiment Station

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PROGRESS REPORT NO. 20

PROJECT NO. 141-64

CABLE DEVELOPMENT

By

F. BELLINGER and W.H. SACHS, JR.

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PROGRESS REPORT NO. 20

PROJECT NO. 141-64

CABLE DEVELOPMENT

By

F. BELLINGER and W.H. SACHS, JR.

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I. SUMMARY

Underwater explosion tests have been performed at Lake Arabia using streamer assemblies which carried 44 pounds of cast HBX-1. 5/16-inch wire rope having an independent wire rope core was used to simulate the tow wire. Slight damage to the bare cable occurred as a result of two successive explosions on the same specimen. Samples of the wire rope have been sent to the B.F. Goodrich Company for rubber-coating. Test assemblies used in the experiments were fabricated with special yokes. The lower arms of these yokes were made in two pieces, one section being hinged to the main yoke body at the hub. Detonation of the explosive charge initiators shattered the connection at the lower end of the arm, permitting the hinged section to open and fall free of the tow cable. Models of the split yokes have been sent to the Bureau of Ships, Code 620 and the U.S. Navy Mine Countermeasures Station for examination and criticism. These yokes have spaces for electronic components of the detector-actuator units cast as integral parts of the yoke arms.

Work has been started to determine the most suitable protective coating for streamer floats.

II. DESIGN

A. Tow Cable

A Georgia Tech representative visited the plant of the B.F. Goodrich Company in Akron, Ohio, to discuss the design of tow cables for the explosive streamer. Mr. C.W. Leguillon, Manager of the Special Products Division has been in charge of the work in connection with the processing of aircraft strand for explosion tests at Georgia Tech. From the discussion of the type of damage that the rubber covered cables had been suffering, it was concluded that the most likely solution would be to insert tough rubber

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sleeves into the hubs of yokes of the streamer assemblies. This, it was believed, would permit a reduction in thickness of the jacket which must be bonded to the cable.

It was pointed out that the 5/16-inch 1x19 aircraft strand used in the past tests was extremely stiff, a factor which greatly increased the difficulty in processing the cable for jacketing. It was the opinion of Mr. Leguillon that use of a flexible cable would make possible the securing of a much more uniform adhesion to the cable than has been possible with the stiff strand. With this in mind, a 5/16-inch 6x19 improved plow steel cable having a wire rope center was processed for testing at Lake Arabia. It was agreed that, if the bare wire rope was undamaged by explosion tests, rubber-coating should be attempted and further explosion tests should be carried out.

A process is under development at Goodrich whereby individual wires may be rubber-coated prior to stranding for wire rope construction. This development has not reached a stage to be of immediate value in the present problem.

Correspondence with the Borg-Warner Corporation has revealed that one of their products (TYPLY) is used as a bonding agent by several of the manufacturers of electric wires and cables. The Simplex Wire and Cable Company was among the manufacturers listed. A special submarine mine cable has been ordered from the Simplex Company for use in tests in connection with the explosive streamer. This cable will be an armored electrical conductor having a neoprene jacket bonded to the armor wires.

B. Streamer Yokes

Figure 1 shows the main features of one of this first split yoke designs. In the most recent design, the pad at the end of the upper arm

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Figure 1. Split Yoke

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has been replaced by a hollow ogive 5-1/2 inches in diameter and having an overall length, from base to point, of 12 inches. This ogive will be an integral part of the yoke casting, and will have sufficient volume, it is believed, to house the electronic components of the detector-actuator device, as well as one of the hydrophone crystals. The power transformer of the unit will be housed in the split hub of the yoke. The three-inch-diameter cup shown on the bottom arm of the yoke has been lengthened on the most recent models to provide space for one of the hydrophone crystals.

Models of the split yoke have been furnished to the Bureau of Ships, Code 620 and the U.S. Navy Mine Countermeasures Station for examination and criticism.

C. Streamer Floats

Work has been started to find a suitable protective coating which can be easily applied to the streamer floats to prevent the wood from absorbing water and losing its buoyancy. A number of specimens are being prepared for water immersion tests. Coating to be tested will include rubber base paints, synthetic resin coatings and varnish.

III. EXPERIMENTAL WORK

Explosion tests have been carried out at Lake Arabia in order to ascertain whether or not a 5/16-inch 6x19 wire rope tow cable would be damaged by the detonation of an explosive streamer unit. The cable specimen tested was a 5/16-inch 6x19 improved plow steel wire rope having an independent wire rope core. The breaking strength of the cable was approximately 10,000 pounds. The float-explosive tube assembly was made up using the split yokes which were mentioned in Progress Report No. 19. The wood float was 5-1/2 inches in diameter and 12 feet long. The explosive charge

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weighed approximately 44 pounds and was contained in an aluminum tube three inches in diameter.

The center lines of float and explosive were approximately 15 inches apart and the tow cable was located half way between the two center lines. In an attempt to reduce the explosive force against the lower arms of the yokes and in turn, reduce the force with which the yokes would be driven against the cable, the ends of the explosive charge were located approximately six inches from the yokes. The charges were initiated at each end by blasting caps located in detonator wells provided near the lower end of the split half of the yoke. A small quantity of composition C_3 was placed in the detonation well around the blasting cap. It was believed that the detonation of the cap and plastic explosive would shatter the lower extremity of the yoke so that the hinged or split portion could open and permit any remaining pieces of float and yoke to slip free of the tow cable. Detonation of the caps would be picked up by short lengths of primacord which led 2-pound pentolite booster charges.

Two underwater shots were made on the bare 6x19 wire rope described above, with the part of the cable passing through the yoke hubs protected by Harris rubber bushings. Eight of the small individual wires of the cable were broken on the first shot. These breaks occurred several feet from the yokes. No damage was observed in the vicinity of the yokes, and only minor cuts were observed on the Harris Bushings.

The second shot on the same cable broke a few more individual wires in the six or eight foot portion near the center of the assembly, but none of the damage was considered serious. Bits of wood fiber were found imbedded in the portion of the wire rope which was located near the center of the

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assembly. This could possibly indicate that the cable was perhaps thrown against the wood floats before the float disintegrated. Such an explanation might also account for the broken wires.

The performance of the cable was considered sufficiently promising to warrant rubber-jacketing. A 100 foot sample of the rope was sent to Goodrich for processing.

IV. PLANS FOR IMMEDIATE FUTURE

The 5/16-inch 6x19 rubber-jacketed wire rope will be tested under explosion conditions as soon as samples are received from the B.F. Goodrich Company.

Upon receipt of comments from the Bureau of Ships regarding the structural features of the split yokes, all necessary changes will be incorporated in the design and the necessary patterns for casting the yokes will be made.

Water immersion tests of float samples will be initiated as soon as the specimens have been coated and cured.

The procurement of materials will be initiated for carrying out tests with streamer explosive units carrying approximately 90 pounds of cast HBX-1.

Respectfully submitted,

Frederick Bellinger,
Project Director

Ward H. Sachs, Jr.,
Assistant Project Director

Approved:

Gerald A. Rosselot, Director
State Engineering Experiment Station

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PROGRESS REPORT NO. 21

PROJECT NO. 141-64

CABLE DEVELOPMENT

By

F. BELLINGER and W.H. SACHS, JR.

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PROGRESS REPORT NO. 21

PROJECT NO. 141-64

CABLE DEVELOPMENT

By

F. BELLINGER and W.N. SACHS, JR.

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I. SUMMARY

Explosion tests have been made at Lake Arabia in which spacer sections and all components of the float-explosive tube assemblies have been blown clear of the suspension cable. Splitting of spacer tubes was accomplished by use of 100-grain plastic coated primacord imbedded in the faces of the yoke and spacer section ends and extended the entire length of the spacer section.

Wood test specimens have been prepared to determine the effectiveness of coating materials in preventing water absorption by float sections.

II. STREAMER DESIGN

Among the specifications relating to the design of the explosive streamer under development at Georgia Tech, it was required that spacer sections adjacent to an expended explosive section be blown clear of the towing cable. A method has been devised for accomplishing this operation. The success of the method depends upon the propagation of detonation between pieces of primacord imbedded in the faces of the end plugs of the spacer sections and the yokes of the explosive-float assemblies. Figure 1 shows the arrangement of the primacord in the yoke hub and spacer tube end plug. The primacord is Ensign-Bickford's 100-grain plastic coated detonating cord. The primacord in the yoke hub leads to the detonator for the main explosive charge and is initiated simultaneously with the main charge. The explosion is propagated across the interface between the yoke and the spacer tube and is picked up by the primacord sections which extend the entire length of the spacer tube. Detonation of these long sections splits the spacer tube so that it will fall from the tow cable.

Preliminary reports from the U.S. Navy Mine Countermeasures Station,

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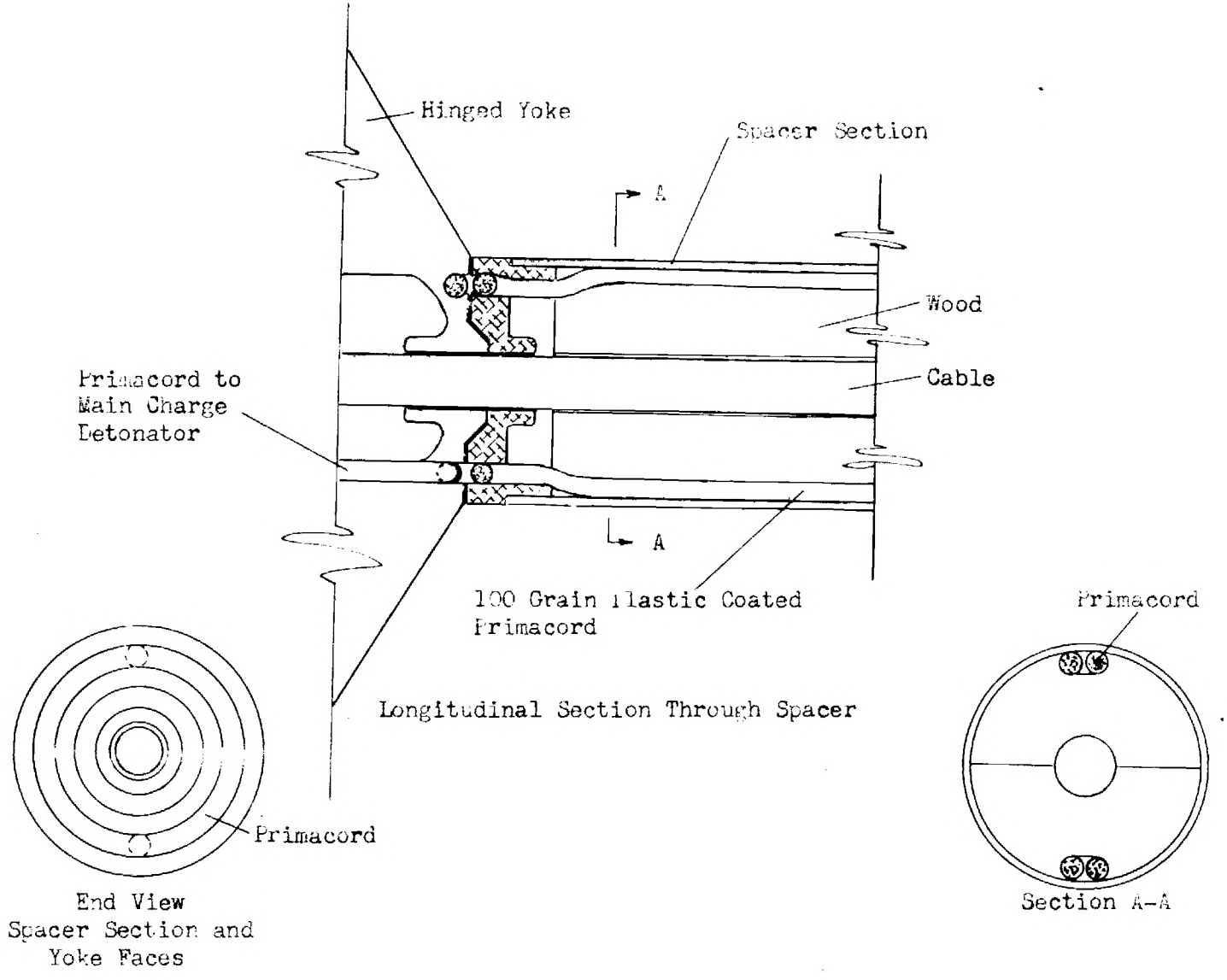

Figure 1. Arrangement of Primacord for Removing Spacer Sections from Streamer Tow Cable

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Panama City, Florida, indicate that the space requirements for the electronic components of the detector-actuator units will be fulfilled by the hollow ogives of the yokes described in Progress Report No. 20, November 30, 1950.

III. EXPERIMENTAL WORK

Experiments have been carried out at Lake Arabia to test the functioning of the system described above. Figure 2 shows the arrangement of units for the first explosion test. Ends of adjacent units were held in contact with each other by heavy rubber strips. A bare steel cable was used to simulate the tow cable. In order to investigate the possibility of insulating the exposed cable between the yokes of the float-explosive tube assembly, a piece of 1/2-inch saran pipe was used as a sheath for that portion of the cable.

When the charge was detonated, units B, C and D (Figure 2) and the saran pipe were completely removed from the cable. The thrust bearing was undamaged. The end plug of Unit "A" at the extreme left end of the unit in Figure 2 was knocked loose but no other damage was observed.

A second test was made with two spacer sections in position B and D and with the explosive unit in position C. One of the spacers used in the second test was unit "A" which had been previously exposed to the explosion in the first test. Detonation of the second shot removed all units and the saran pipe from the cable.

IV. CABLE DESIGN

Samples of wire rope furnished to the B.F. Goodrich Company are being processed and shipment is anticipated the second week in January.

Samples of wire ropes with copper conductor core are being shipped to Georgia Tech from the American Steel and Wire Company. It is believed

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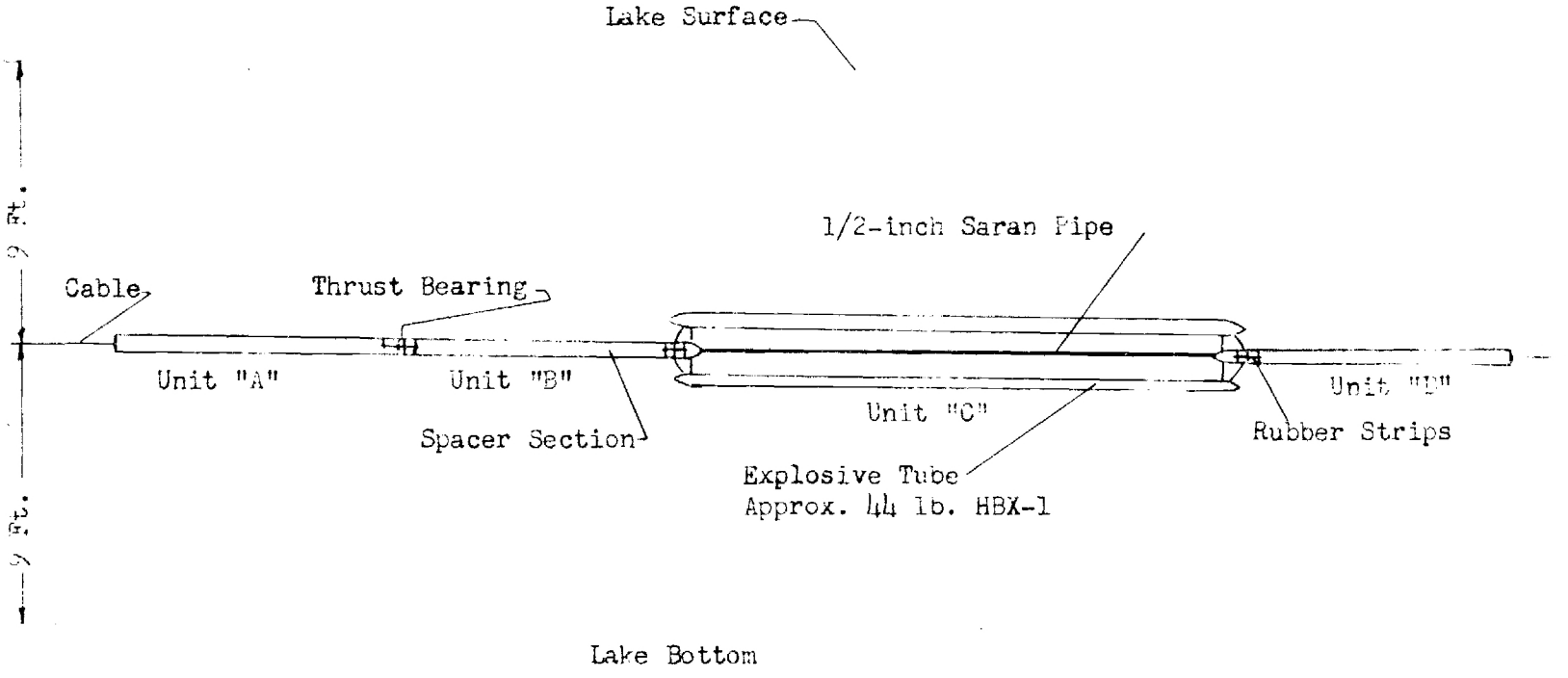

Figure 2. Arrangement of Streamer Units for Explosion Tests

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that, if the rubber-coated cables do not prove satisfactory, an alternative will be to use the wire rope with conductor core in conjunction with an insulated sheath for the exposed portion of the cable in the vicinity of the explosive tube assemblies.

V. WATERPROOF FLOAT COATINGS

Several wood test specimens have been coated with paints and varnishes for use in water immersion tests. Coatings which have been applied include rubber base paints and synthetic resins. These specimens will be sent to Panama City for water absorption tests. Additional specimens will be prepared as chemicals are received.

VI. PLANS FOR IMMEDIATE FUTURE

Explosion tests of rubber-jacketed cable will be made at Lake Arabia, when the cable is received.

Coated wood specimens for water immersion tests will be sent to Panama City for long period immersion at operational depths.

Assembly of streamer units will be initiated for explosion tests under tow at Panama City.

Respectfully submitted,

Frederick Bellinger,
Project Director

Ward H. Sachs, Jr.
Assistant Project Director

Approved:

Gerald A. Rosselot, Director
State Engineering Experiment Station

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PROGRESS REPORT NO. 22

PROJECT NO. 141-64

CABLE DEVELOPMENT

By

F. BELLINGER and W.H. SACHS, JR.

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PROGRESS REPORT NO. 22

PROJECT NO. 141-64

CABLE DEVELOPMENT

By

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I. SUMMARY

Explosion tests of 25-foot streamer units have been continued at Lake Arabia. Minor scars and cuts in the jacket were the only damage sustained by a rubber covered 5/16-inch 6x19 wire rope with independent wire rope center which was used as the tow cable.

Attempts at waterproofing wood float units by painting with various paints and resins have met with no success. The method giving the most promising results involved the coating of the float with 1/16-inch gauge tread gum rubber. This gives a tough, elastic coating which has been applied to short specimens of the 5-1/2-inch diameter float material.

Streamer units are being fabricated for explosion tests underway at the U.S. Navy Mine Countermeasures Station early in March 1951.

II. EXPERIMENTAL WORK

A. Explosion Tests

Further explosion tests of streamer units have been carried out at Lake Arabia in order to determine the resistance of the suspension cable to damage by streamer explosions. The tests were made using a float-explosive tube assembly fabricated with hinged yokes. The wire rope used as the tow cable was a 5/16-inch 6x19 wire rope with independent wire rope center which had been covered with a rubber sheath by the B.F. Goodrich Company. The nominal outside diameter of the coated cable was 1/2 inch. The part of the cable which passed through the hub of the yokes was protected by rubber bushings made from 1/2-inch rubber steam hose. This additional protection was provided to prevent the yokes from cutting into the cable sheath. The streamer unit was suspended in the same manner as in

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the tests which have been described in previous reports.

Two successive shots on the same cable specimen resulted in only minor scars and cuts in the rubber jacket.

B. Waterproof Float Coatings

Test specimens of wood float material have been painted with several different water repellant coatings and have been submerged in water at Lake Arabia for a period of several weeks. Wood blocks coated with the following materials have been tested in this manner: Phenoplast, Spar varnish, pliolite base laboratory paint, polyvinyl chloride-alkyl resin, and urea formaldehyde resin. None of the coatings proved to be waterproof under these conditions. All of the specimens were warped and water soaked after a period of three weeks. Furthermore, these coatings were easily cracked by moderately rough handling.

III. DESIGN

A. Tow Cable

It is understood that tests which have been carried out at the U.S. Navy Mine Countermeasures Station, Panama City, Florida, indicate that the steel cables may have insufficient electrical conductance to permit their use as streamer tow lines. With this in mind, the American Steel and Wire Company has been requested to furnish information with regard to manufacturing wire rope with a stranded copper core. A 3/8-inch 6x19 improved plow steel rope with copper core would have a breaking strength of approximately 12,000 pounds. The copper core would be the approximate equivalent of a 10 gage conductor. This cable would be rubber-jacketed to a nominal 1/2-inch diameter with the same type rubber sheath that has been

applied to samples previously by the Goodrich Company.

B. Waterproof Float Coatings

The Forest Products Laboratory of the U.S. Department of Agriculture at Madison, Wisconsin, has given no encouragement in the search for a waterproof paint coating. The following quotation is an excerpt from recent correspondance with that laboratory: "It is doubtful whether any surface coating will stand up very well under the conditions involved. Difficulty arises because of the change in pressure of the air trapped within the wood cavities and the consequent tendency to rupture protective coatings, as well as from the adverse effect of the prolonged water immersion on the coatings themselves."

The most promising results have been obtained when the wood cylinders have been wrapped with 1/16-inch gauge thread gum rubber, which is then vulcanized. Test specimens of wood 5-1/2 inches in diameter by 12 inches long jacketed in this manner have been exposed to the explosion of streamer units at a distance of 12 feet without breaking the rubber jacket. Equipment is being fabricated which will make possible the jacketing of 12-foot float sections.

IV. PROPOSED STREAMER TESTS

Work is currently underway on the fabrication of the various components required for conducting explosion tests of towed streamer units. Tentative plans are being made for performing explosion tests underway at the U.S. Navy Mine Countermeasures Station, Panama City, Florida early in March. The purpose of these tests will be to determine the effect of the explo-

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sion of one 25-foot streamer section upon the tow cable and nearby units when the streamer is being towed at operational speeds.

V. PLANS FOR IMMEDIATE FUTURE

Fabrication of streamer units for tests underway will be continued.

Techniques for rubber-jacketing full-length wood float sections will be developed.

Steps for the procurement of a flexible, copper-cored wire rope which can be rubber-jacketed will be initiated.

Respectfully submitted,

W.H. Sachs, Jr.,
Assistant Project Director

Approved:

F. Bellinger,
Project Director

Gerald A. Rosselot, Director,
State Engineering Experiment Station

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PROGRESS REPORT NO. 23

PROJECT NO. 141-64

CABLE DEVELOPMENT

BY

WARD H. SACHS, JR.

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PROGRESS REPORT NO. 23

PROJECT NO. 141-64

CABLE DEVELOPMENT

BY

WARD H. SACHS, JR.

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I. SUMMARY

Units for approximately 600 feet of a required 1500 feet of explosive streamers have been assembled for tests at the U.S. Navy Mine Countermeasure Station and Charleston Naval Shipyard.

Explosion tests underway of 400-foot streamers have resulted in modification of the yoke casting to increase its strength. Explosion tests of streamer units assembled with the modified yokes show the yokes to have sufficient strength to prevent breakage by routine handling, as well as by the explosion of adjacent units. The rubber jacket of the tow cable used in the explosion tests was shown to be very poorly bonded to the steel cable.

Preliminary discussions have been held with Naval Ordnance Laboratory personnel relative to the design of a mechanical detonator-safe mechanism for use in the explosive streamer.

II. INTRODUCTION

On February 5 and 6, 1951, a conference was held at the Bureau of Ships between representatives of Georgia Tech, Charleston Naval Shipyard, the Navy Mine Countermeasures Station (USNMCS), the Bureau of Ordnance, the Naval Ordnance Laboratory (NOL) and the Bureau of Ships Code 620. The purpose of the conference was to review progress in the development of the Georgia Tech explosive streamer, to discuss minor design modifications, and to plan for the production of streamers which would be required for test purposes.

Anticipated streamer requirements for test purposes during March and April are approximately 1500 feet. Units for a total of 900 feet of streamer were requested for use at USNMCS. 600 feet of streamer will be required for tests at the Charleston Naval Shipyard.

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The month of February was spent in the production of streamer units to meet the above requirements. Details of the production work were not considered to be of sufficient importance to warrant preparation of a formal monthly report. The present report therefore covers the period from February 1 to March 31, 1951.

III. EXPERIMENTAL WORK

On March 6, 1951, the first explosion tests of a 400-foot streamer were carried out underway at the USNMCS. The purpose of the tests was to determine the affect of the detonation of an explosive section upon the tow cable and upon the units forward and aft of the expended unit. The 400-foot streamer consisted of 16 float-explosive tube assemblies with their spacer sections. The three assemblies on the after end of the streamer were loaded with cast HBX-1. Three units in the center of the streamer were also loaded with explosive. The balance of the float-explosive tube assemblies were ballasted with concrete so that they possessed moderate positive buoyancy. Spacer sections forward and aft of the explosive-loaded units were loaded with primacord for blowing the spacers from the cable. Stainless steel thrust bearings separated adjacent spacer tubes. The tow cable was a 5/16-inch 6x19 IWRC wire rope which had been rubber-coated by the B.F. Goodrich Company. The streamer was towed at a speed of about nine knots from the stern of the towing vessel with a paravane depth setting of 30 feet. The paravane was towed approximately 200 feet from the ship. 600 feet of tow cable were used with the streamer.

The explosive charges were fired electrically by a system devised by personnel of the USNMCS. An alternating potential was applied to the tow cable, the cable serving as the primary winding of a transformer. Electric detonator leads were connected to the secondary winding of the transformer

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which was housed in the hub of the yoke of the explosive-loaded streamer units. The yokes used in the float-explosive tube assemblies for these tests were of the design shown in Figure 1.

The first unit fired was the assembly immediately forward of the unit on the after end of the streamer. With the exception of the transformer for firing the detonators, the float assembly as well as the spacer sections forward and aft of the assembly were blown clear of the tow cable. The rubber jacket of the cable was badly stripped. Inspection of the tow wire indicated that the sheath was very poorly bonded to the cable. The cast aluminum yokes of the assemblies forward and aft of the exploded unit were broken.

In the second test an explosive-loaded assembly near the center of the streamer was detonated. The explosive assembly and spacer tubes were again blown clear of the cable, but the power transformer remained. The poorly bonded rubber jacket was again stripped and torn from the tow cable. Yokes of the assemblies forward and aft of the explosive unit were broken as in the first test.

As a result of the yoke breakage in these tests, the pattern was modified in order to strengthen the weak sections where fractures had occurred. Figure 2 shows a yoke casting of the revised design. The new yokes were utilized in the assembly of explosive units for further testing underway.

On March 23, 1951, explosion tests of a 400-foot streamer were carried out at USNMCS to check the strength of the revised yokes.

The yokes of the four assemblies at the after end of the streamer were of the new design. Yokes of the other assemblies in the streamer were of the old type shown in Figure 1. This streamer was towed dead astern of the towing vessel. A streamlined weight was used to obtain submergence of the streamer. The tow cable was the same rubber-covered cable which had been used in the March 6 tests.

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Figure 1. Hinged Yoke Without 5-1/2-inch Ogive

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Figure 2. Hinged Yoke with 5-1/2-inch Ogive

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The third unit from the after end of the streamer was detonated in the first of two explosions. The power transformer was the only part of the 25-foot assembly which was not blown from the cable. The rubber sheath on the cable was stripped and torn as in the previous tests. None of the yokes in the streamer was damaged.

The second unit from the after end of the streamer was detonated for the second test. None of the yokes was damaged. One of the spacer sections failed to clear the cable when the primacord did not detonate. It is believed that this failure was a result of a cut in the plastic coating which permitted entry of water and resulting desensitization of the explosive in the primacord.

Results of the tests described indicate that the yokes of the latest design (Figure 2) have sufficient strength to prevent breakage during normal handling, as well as breakage by explosion of the streamer units in adjacent positions. Yokes of this design will be used in assembling streamers for Charleston and the balance of the streamers to be sent to USNMCS.

IV. STREAMER COMPONENTS

A. Tow Cable

One thousand feet of 5/16-inch 6x19 rubber-covered wire rope have been received from the B.F. Goodrich Company since the tests described above were made. The adhesion of the rubber sheath to the cable in this particular sample appears to be extremely good. This length of cable is scheduled for shipment to Charleston with streamer units for launching and towing tests.

Five thousand feet of copper-cored wire rope have been ordered from the American Steel and Wire Company for delivery about April 15, 1951.

This cable will be rubber-coated by the B.F. Goodrich Company

B. Floats

To date the most satisfactory protective coating for the wood floats of the explosive streamer has been rubber. After 1/16-inch thick tread gum rubber had been successfully applied to short test samples, a steam autoclave was constructed in which the 12-foot floats could be cured. The present method of waterproofing the units is to wrap the float with the tread gum sheet. the float is then placed in the autoclave and the rubber is cured at a temperature of about 300°F.

Soft spots of partially cured rubber were found on some of the first floats covered in this manner. The soft rubber was scraped off in some cases during the handling incident to the explosion tests described in this report. It is believed that this difficulty can be overcome in the curing process.

Tests are being undertaken to determine the most effective means of sealing the interfaces between the ends of the floats and the metallic components which must be attached to them.

C. Detonator Safety Device

On March 20, 1951, Messrs. Allen B. Dietemann and Charles A. Borcher of the Naval Ordnance Laboratory visited Georgia Tech to discuss general safety features which must be considered in the explosive streamer design. The design of a mechanical detonator-safe feature for the explosive train was discussed. A system actuated by a pressure sensitive metallic bellows was proposed by Georgia Tech. An unusual feature of the arrangement is that the bellows would be filled with liquid to prevent damage by underwater explosions. The facilities at Georgia Tech were offered for the development of the idea either under the present contract or under a separate contract

[redacted]

with the Bureau of Ordnance. It is understood that the NOL representatives will make recommendations which will form the basis for action to initiate the development work.

V. PLANS FOR IMMEDIATE FUTURE

The production of streamers for use in proposed tests at Charleston and USNMCS will be continued. Detail and assembly drawings of streamer components will be forwarded to the Bureau.

Respectfully submitted:

Ward H. Sachs, Jr.,
Project Director

Approved:

Gerald A. Rosselot, Director,
State Engineering Experiment Station

[redacted]

Georgia Institute of Technology
STATE ENGINEERING EXPERIMENT STATION
ATLANTA, GEORGIA

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PROGRESS REPORT NO. 24

PROJECT NO. 141-64

CABLE DEVELOPMENT

BY

WARD H. SACHS, JR.

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STATE ENGINEERING EXPERIMENT STATION
Atlanta, Georgia

PROGRESS REPORT NO. 24

PROJECT NO. 141-64

CABLE DEVELOPMENT

BY

WARD H. SACHS, JR.

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I. SUMMARY

During April and May components for 900 feet of streamer were delivered to Naval activities for use in launching and towing tests.

Work has been started on the design of an arming device for the explosive streamer. The development has been undertaken by Georgia Tech under technical supervision of the Naval Ordnance Laboratory. Tests in which the proposed actuating mechanism, a fluid-filled metallic bellows, was exposed to underwater explosion of 50 pounds of cast HBX-1 indicated that use of this mechanism is feasible with respect to resistance to damage by nearby explosions.

Tow cable design has been discussed with engineers of several cable manufacturers. Nylon covered cables and cables having rubber coverings reinforced with textile and glass fibers are being procured for test.

II. PROGRESS

A. Production of Streamer Assemblies

Production of streamer components was continued throughout April and May. On April 26, 1951, float-explosive tube (dummy) assemblies and buffer sections for 600 feet of streamer, together with thrust bearings and 1000 feet of tow cable, were delivered to the Charleston Naval Shipyard. These units are to be used in launching and towing tests scheduled for early June. Yokes, floats and buffer sections for 300 feet of streamer were delivered to the USNMCS on May 21, 1951. Electronic components will be mounted in yokes of these units for testing by USNMCS personnel.

B. Arming Device, MH-6A

In order that components of the explosive streamer may comply with

[redacted]

certain safety requirements specified by the Bureau of Ordnance, it will be necessary to incorporate an out-of-line detonator safety device in the explosive train of the assembly. Georgia Tech has agreed to undertake the development of such a device under technical supervision of the Naval Ordnance Laboratory (NOL). General specifications for the arming device were discussed at a conference at NOL attended by representatives from the Bureau of Ships (Code 520), NOL and Georgia Tech.

In the device which is proposed by Georgia Tech, the forces required for actuating the mechanism will be produced by a combination of a compression spring and a metallic bellows. In order to prevent damage by nearby underwater explosions, a quantity of fluid will be sealed within the bellows so that, when compressed to the armed position, the bellows will be completely filled. The compression spring opposing the bellows will be of sufficient strength to expand the bellows at water depths less than those at which the device is required to arm.

In order to observe the effect of underwater explosions upon completely filled bellows, an explosion test was carried out at Lake Arabia in which several water-filled bellows were exposed to the pressure resulting from the underwater detonation of a 50-pound charge of cast HBX-1. The charge was suspended at a depth of approximately 10 feet in 18 feet of water and the test specimens were placed at horizontal distances of about 12 and 17 feet from the charge. The bellows were housed in 2-1/2-inch pipe nipples which were capped at one end. The nipples were water-filled and a rubber diaphragm was placed over the other end. The bellows were approximately 1-1/2 inches in diameter, 1-1/2 inches long and had 12 active corrugations. The material was brass about 0.008 inch thick. Explosion of the charge caused no apparent damage to the water-filled bellows.

[redacted]

Results of these tests appeared to warrant further development of the bellows-spring combination as an actuating mechanism for the safety device and design is proceeding along these lines. Preliminary design sketches are being prepared for submission to NOL personnel for comment.

C. Tow Cable

On April 20, 1951, streamer explosion tests were again carried out underway at the USNMCS in order to test the resistance of rubber-covered cable to the explosion of streamer units. The tow cable utilized was another sample prepared by the B.F. Goodrich Company. The rubber sheath appeared to be extremely well bonded to the 5/16-inch 6x19 IWRC cable. However, two successive detonations of streamer units cut and tore the covering badly.

Since submission of the last report, the design of the streamer tow cable has been discussed with a number of engineers representing the wire and cable industry. Engineers of the Simplex Wire and Cable Company, The American Steel and Wire Company and The B.F. Goodrich Company have been consulted on the problem. Mr. W.A. Smith of the Goodrich Company observed that, since very nearly maximum possible adhesion has been obtained in preparation of rubber covered samples which have been damaged in tests at USNMCS, a different approach should be attempted. He suggested imbedding a textile fabric between two well-bonded layers of rubber in an attempt to secure increased resistance to tearing. Similar suggestions were made by engineers of the Simplex Company and American Steel and Wire Company. Orders have been placed for samples of cable incorporating this modification. Glass and nylon braids and standard cotton seine twine will be utilized.

[redacted]

[redacted]

Two samples of nylon covered wire rope are being procured from Danielson Manufacturing Company for testing.

III. PLANS FOR IMMEDIATE FUTURE

Production of streamer units will be continued. A preliminary design of the arming device will be submitted to representatives of NOL for comment and approval.

The nylon covered wire rope manufactured by the Danielson Company will be subjected to explosion tests at Lake Arabia.

Respectfully submitted:

Ward H. Sachs, Jr.,
Project Director

Approved:

Gerald A. Rosselot, Director
State Engineering Experiment Station

[redacted]

Georgia Institute of Technology
STATE ENGINEERING EXPERIMENT STATION
Atlanta, Georgia

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PROGRESS REPORT NO. 25

PROJECT NO. 141-64

CABLE DEVELOPMENT

By

WARD H. SACHS, JR.

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PROGRESS REPORT NO. 25

PROJECT NO. 141-64

CABLE DEVELOPMENT

By

WARD H. SACHS, JR.

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I. SUMMARY

Components for 400 feet of dummy explosive streamers were produced during the month of June.

Georgia Tech representatives conferred with B.F. Goodrich personnel with reference to improved methods for water-proofing streamer floats and buffer tube fillers.

A sample of nylon covered wire rope was badly cut by one of the yoke castings in an explosion test at Lake Arabia.

II. PROGRESS

A. Production of Streamer Components

Production of streamer components was continued during June. Yoke castings, floats and buffer assemblies for 400 feet of streamer were produced during the month. Units will be delivered to USNMCS, Panama City, Florida, to replace components which have been lost or damaged during previous tests.

B. Streamer Components

1. Floats

Georgia Tech representatives visited the B.F. Goodrich Company, Akron, Ohio, on June 21, 1951, to discuss the water-proofing of the streamer floats and the buffer tube wood fillers. Although the vulcanized tread gum currently being used as the float covering appears to be satisfactory, a more economical method of water-proofing was sought. Furthermore, the tread stock covering does not appear to be an economical solution for the water-proofing of the buffer tube fillers. Georgia Tech has made arrangements to send three full-size floats to the Goodrich plant to be covered with a heat sealing Hycar stock. In addition, several buffer tube fillers have been

[redacted]

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sent to American Anode, Inc., a subsidiary of B.F. Goodrich, for an attempt to cover the wood fillers by a dipping process.

2. Tow Cable

The B.F. Goodrich Company has completed processing a sample of cable which they covered with a GRS stock. The GRS stock is not as tough and has lower cutting and tearing resistance than previous stocks used in tests but the adhesion is believed to be much superior. The sample will be explosion-tested at Lake Arabia when received. Goodrich has procured some nylon cord which will be used in production of a cable having a nylon braid imbedded in the rubber covering.

A 5/16-inch 7x19 wire rope covered to a nominal 1/2-inch diameter with an extruded nylon jacket was subjected to explosion tests at Lake Arabia in order to determine the resistance of the covering to damage by detonation of a streamer explosive assembly. The covering sustained two bad cuts at one end of the float-explosive assembly. The cuts were approximately ten inches apart (yoke hub length). One cut was on top of the cable and the other was on the bottom. These results would appear to indicate that the difference in initiation delay of the two detonators utilized in the test was large enough that the main explosive charge was initiated at one end only. Consequently the longitudinal force of the detonating charge was exerted on the yoke casting where the cable damage occurred before the yoke was disintegrated by the primacord threaded through the yoke web.

Damage to the nylon covered cable was reduced in the next test by cementing rubber pads in the yoke hubs at the points where the cable came in contact with the yoke. In the previous tests the cable had been protected at these points by rubber bushings which fitted rather loosely in the yoke hub. It is doubtful that these loose bushings had remained in

their proper positions at the time of the explosion.

Insertion of the potted transformer cores into the yoke hubs in the final assembly will add a variable which has not been taken into account in past explosive tests of cable because of lack of transformer material. The presence of the potted plastic material around the cable in the yoke may aggravate the damage when a complete streamer assembly is detonated. Potted transformer assemblies will be procured from [redacted] as soon as materials are available. Cable tests will then be continued to determine the effect of the added transformer.

III. FUTURE WORK

Production of streamer units will be continued.

Explosion tests of cable will be continued when potted transformer assemblies are received for yoke hubs.

Tests will be made to determine whether or not the plastic coated primecord adopted as standard by Buord can be used in the streamer units in lieu of the 100 grain material being used at present.

Respectfully submitted,

J. . Sachs, Jr.,
Project Director

Approved:

Gerald A. Rosselot, Director
State Engineering Experiment Station

Georgia Institute of Technology
STATE ENGINEERING EXPERIMENT STATION
Atlanta, Georgia

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PROGRESS REPORT NO. 26

PROJECT NO. 141-64

CABLE DEVELOPMENT

By

WARD H. SACHS, JR.

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CABLE DEVELOPMENT

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I. SUMMARY

Components for 400 feet of dummy explosive streamers were produced during the month of July.

An explosion test was carried out at Lake Arabia in which the GR-S stock insulation of the tow cable was badly cut when a streamer unit equipped with potted transformer assemblies was detonated.

Results of the explosive streamer-torpedo warhead test made at USNMCS on June 28, 1951 are discussed.

II. PROGRESS

A. Production of Streamer Components

Production of streamer units was continued during the month of July. Assemblies for 400 feet of streamer have been fabricated. These units will be delivered to USNMCS at an early date.

B. Tow Cable

Another sample of B.F. Goodrich rubber covered cable has been explosion tested at Lake Arabia. This particular sample was 5/16" - 6x19 IWRC brass plated wire rope covered with the GR-S formula 79781J. The physical properties of this compound were reported to be good though not so high in tear and cutting resistance as the natural rubber stocks previously tested. The adhesion between rubber and cable in this sample was believed by Goodrich representatives to be the best obtained to date. This cable was subjected to the explosion of a streamer assembly. In the yokes of this assembly were mounted potted transformer units which had been obtained from NMCS. This unit simulated, more nearly than any of previous arrangements, the actual assembly which will be used in the streamer. Two lengths of prima-

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cord were threaded through the potted transformer assembly to tear it apart when the explosive charge was detonated.

Detonation of the main explosive charge and the primacord cut the cable at each yoke, and inflicted several cuts in the covering between the yokes. The plastic potting compound of one of the transformers was completely shattered but two of the cores were unbroken and remained on the cable. The other potted transformer was fractured, but the transformer cores were not broken and the potted units remained on the cable. The cable was badly cut at the point where the transformers had been located. There was no damage to the cable where it passed through the ends of the yoke hubs. These points were protected by rubber pads which had been vulcanized to the yoke castings.

It is understood that the transformers which will be used in the final design will be more easily broken apart. This material will be procured from USNRCS but is, as yet, unavailable for test.

A sample of cable which will incorporate a woven fabric mesh imbedded in the rubber coating is expected from the B.F. Goodrich Co. about August 10. Additional cables having a similar construction using glass and nylon fabrics are being prepared by the American Steel and Wire Co. These cables require brass plated steel wire for bonding of the rubber insulation, and delivery is not expected before October 15, 1951.

Five hundred feet of 3/8-inch diameter, teflon tape insulated copper core wire rope is being covered with nylon by the Danielson Manufacturing Co. for use by USNRCS in tests of their equipment in August. Delivery of the cable to Panama City is expected by August 15, 1951.

III. WARHEAD SHOT - JUNE 28, 1951

Georgia Tech personnel visited USNRCS on July 5, 1951, at which time photographs of the streamer units recovered from the torpedo warhead test

[redacted]

of June 28, 1951, were examined. As a result of the extreme damage sustained by the streamer in this test, consideration has been given to strengthening of the float assemblies, particularly the yokes. However, very little evidence is available on which to base modification in the yoke pattern, since only one of the damaged yokes was recovered. It is believed that the first step toward strengthening the yoke castings should be the use of a stronger aluminum alloy. Such a step would require no alteration in the patterns and would not delay delivery of streamers required for testing. Steps have been taken to procure 2600 pounds of Alcoa Alloy #195. This alloy in the heat treated condition possesses physical properties approximately 50% higher than the #212 alloy currently being used.

Substitution of a stronger metal for the aluminum is not believed to be warranted or practicable because such a step would require reduction in cross sections to keep the weight equal to that of the aluminum units, the net result being a metal casting having physical properties only slightly superior to the Alcoa #195 alloy. If the weight is not maintained constant, float diameters will necessarily be increased and the assembly would become even more cumbersome than it is at present.

Further modification of the yokes appears to be unwarranted until alterations which may be required in order to blow the transformer from the cable are determined.

With reference to strengthening of the floats, the torpedo warhead tests made at USNOTS in September of 1950 are recalled. In these tests an array of hollow steel tubes and wood floats was subjected to the explosion of a 6000 pound torpedo warhead at distances varying from 15 feet to 30 feet or more. Reference is made to data in Progress Report No. 18, September 30, 1950, which indicated that steel tubes which possessed very little buoyancy in

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excess of that required to float themselves were collapsed 15 to 20 feet from the warhead.

It is believed that the rubber covered wood floats used at present possess the best combination of flexibility, buoyancy, and resistance to underwater explosions of any materials yet considered. It is true that the wood floats can be strengthened by utilizing a more dense wood. It should be borne in mind, however, that increasing the density of the wood from 31 pounds per cubic foot to 40 pounds per cubic foot would increase the float diameter approximately one inch.

It is felt at Georgia Tech that the loss of 50% of the streamer units does not truly reflect the actual damage sustained by the units, and that the loss can be materially decreased if it can be determined where the failure occurred. It is hoped that the FBI will produce some evidence at an early date.

IV. FUTURE PROGRAM

Production of streamer units will be continued. Yoke castings of a stronger aluminum alloy will be made as soon as ingot can be procured.

Explosion tests on cables will be resumed when cable samples and transformer assemblies are received.

Respectfully submitted:

Ward E. Hacks, Jr.
Project Director

Approved:

Gerald A. Rossiter, Director
State Engineering Experiment Station

Georgia Institute of Technology
STATE ENGINEERING EXPERIMENT STATION
Atlanta, Georgia

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PROGRESS REPORT NO. 28

PROJECT NO. 141-64

CABLE DEVELOPMENT

By

WARD H. SACHS, JR.

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Georgia Institute of Technology
STATE ENGINEERING EXPERIMENT STATION
Atlanta, Georgia

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PROGRESS REPORT NO. 28

PROJECT NO. 141-64

CABLE DEVELOPMENT

By

HARRY H. SACHS, JR.

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I. SUMMARY

Pattern work has been completed for molding one-piece aluminum yokes which will replace the hinged yokes utilized heretofore in explosive streamer assemblies. The new yokes will permit retention of the power transformers on the cable after detonation of the explosive charge of a 25-foot section.

An experimental water turbine has been ordered for use in developing an independent source of power for each individual explosive assembly of the streamer.

Streamer floats covered by the B.F. Goodrich Company with a heat-sealing HYCAR stock will be tested for durability along with floats covered at Georgia Tech.

II. PROGRESS

As a result of damage sustained by cables when attempts were made to blow transformer assemblies from the cables by the use of primacord, it was decided in a conference with Bureau of Ships, Code 520 personnel that it would be permissable to leave the power transformer on the streamer tow cable. Modifications in the design of the aluminum yoke casting have been made which will provide for cutting the arms of the yoke simultaneously with the detonation of the main explosive charge. The hubs of the yoke, together with the transformers which they will house, will then remain on the cable. The new yoke will no longer have a hinged arm extending downward to the explosive tube, but will be a one-piece member. The one-piece yoke should be considerably more durable and should be more resistant to damage by torpedo warhead explosions than the earlier yokes. Patterns for the revised yoke are complete, and it is expected that the

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first castings will be ready for testing about October 8, 1951.

To date, none of the cables which have been exposed to explosion tests at sea can be considered as satisfactory tow cables for the explosive streamer, because large areas of bare steel cable were exposed when the rubber insulation was torn away during the tests. The current modifications in the yoke design to permit retention of the power transformer on the tow cable should reduce the damage to the cable covering. However, in view of the difficulties experienced in the past in connection with cable performance, it was believed desirable to investigate an independent source of electrical power for each explosive assembly. One possible source of power for the detector-actuator units in each assembly would be a generator driven by a small water turbine. The generator and turbine could be housed in the large, forward ogive of each explosive assembly. Utilization of such power source would eliminate the necessity of insulating the tow cable and would solve other problems associated with a current-carrying tow wire.

During a conference at the Bureau of Ships, Code 520, it was proposed that the feasibility of developing a hydraulic generator system for use with the streamer units be investigated. Verbal approval was granted by the Bureau to carry on the work concurrently with the cable development. It was agreed that Georgia Tech would procure the water turbine and that the U.S. Navy Mine Countermeasure Station (USNMCS) would provide a generator with characteristics suitable for testing the output of the turbine. Georgia Tech has placed a purchase order with the James Leffel Company, Springfield, Ohio for an experimental turbine unit which will be utilized in determining available power and noise characteristics of the proposed system.

[redacted]

Two 5-1/2-inch diameter wood streamer floats covered with a heat-sealing HYCAR stock have been received from the B.F. Goodrich Company. These units will be sent to USNMCS for life tests with floats covered at Georgia Tech.

III. FUTURE PROGRAM

A streamer assembly fabricated with the new one-piece yokes will be explosion tested at Lake Arabia. The B.F Goodrich rubber coated cable jacketed with a woven nylon cover will be used in the tests.

If the yokes are satisfactory with respect to performance in the explosive test, and if they fulfill the requirements of USNMCS so far as the electronic equipment is concerned, production will be started.

Respectfully submitted,

Marvin L. Fuchs, Jr.,
Project Director

Approved:

Gerald A. Musselot, Director
State Engineering Experiment Station

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Atlanta, Georgia

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CABLE DEVELOPMENT

By

WARD H. SACHS, JR.

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PROGRESS REPORT NO. 29

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CABLE DEVELOPMENT

BY

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I. SUMMARY

Explosion tests of streamer tow cable samples were made using float-explosion units assembled with one-piece cast aluminum yokes. A rubber-covered cable having a nylon basket weave jacket survived the explosion of the 51-pound HBX-2 charge with only slight damage, when smooth and rounded steel end plugs of the yoke hubs were in contact with the cable.

Special heavy-walled, cast aluminum test containers are being made for pressure testing in an attempt to develop a water-tight cavity in the upper ogive of the yoke to house the actuator-detector units.

The B.F. Goodrich Company is developing a special cable design which may prove to be a satisfactory tow cable. However, delivery of samples is several months away. A unique feature in the construction of this cable is that each individual wire of the rope will be rubber-coated prior to stranding.

Completion of the experimental water turbine being made by The James Leffel Company is expected in about four to six weeks.

II. PROGRESS

A. Explosion Tests

On October 9, 1951, an explosion test was made at Lake Arabia in order to observe the affect of the detonation of an explosive streamer unit upon a tow cable having a woven nylon jacket over a rubber covered wire rope. The float-explosive tube assembly was fabricated using the one-piece yokes described briefly in Progress Report No. 28, dated September 29, 1951. The yokes were made in such a manner that the hub, which will house the power transformer, will remain on the tow cable when the assembly is detonated. One of the yokes, loaded with prima-

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cord is shown in Figure 1. In the final design the primacord will not be exposed as shown in the figure, but will be protected by a metallic disc. The end plugs in the hub of the yokes were lined with rubber bushings to protect the tow cable. Primacord-loaded spacer tubes approximately three feet long were placed against the outer face of each yoke. The main explosive charge consisted of 51 pounds of cast HBX-2. Detonation of the explosive units cleared the cable of all streamer components except the yoke hubs. The cable covering was severely cut at the ends of the yoke hubs, since the rubber bushings afforded no protection to the cable.

On October 17 a similar test was conducted. However, the holes in the steal end plugs for the yoke hubs were not rubber-lined for this test. Instead, the cable rested directly against the smoothly finished steel. The entrances to the holes were rounded so that no sharp edges would contact the cable.

Very slight damage was inflicted upon the cable in the vicinity of the yokes when the charge was detonated. The nylon basket-weave jacket was frayed near the center of the unit where the cable had apparently been thrown against the wood float. The nylon jacket was also frayed at the points where the split end plugs of the spacer sections were located. These defects were not considered to be serious.

B. Yoke Design

On October 25 a conference was held at the Bureau of Ships, Code 520 to discuss the design of the aluminum yokes. Personnel from USNMCS and Georgia Tech were present. It was reported that attempts to waterproof the electronic components of the detector-actuator units by use of a

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Figure 1. One-Piece Aluminum Yoke

[redacted]

plastic potting material had met with little success, and that it could be desirable to make the large cavity in the upper ogive of the yoke a water-tight chamber. Mr. Zimmerman of Georgia Tech pointed to the possibility of increasing the thickness of the chamber wall sufficiently to prevent water seepage resulting from metal porosity. The thickness of the wall would also have to be sufficient to prevent collapse of the chamber under explosion pressures resulting from the detonation of other streamer units. On October 30 Mr. Zimmerman conferred further with personnel at USNMCS to obtain details relative to size and shape of the components of the detector-actuator which must be housed in the chamber. Methods for waterproofing electrical leads to hydrophones and the arming device were also considered. In view of the potting difficulties experienced it was concluded that the construction of a watertight chamber should be attempted. Consequently, patterns are being made at Georgia Tech for molding a chamber which can be incorporated into the design of the one-piece yoke shown in Figure 1. It is expected that aluminum castings will be available for explosion and porosity tests the week of November 4, 1951.

C. Tow Cable

On October 18 Georgia Tech personnel conferred at the Bureau of Ships with B.F. Goodrich Company and Code 520 representatives with regard to cable design. Mr. C.W. Leguillon of Goodrich submitted a sample of hemp-centered wire rope, the individual wires of which had been coated with an air-curing rubber compound before they were stranded. The rope was reported to have extremely high fatigue resistance. General specifications were drawn up for a streamer tow cable having a

[redacted]

construction similar to the sample mentioned above. Tentative specifications are as follows:

#10 A.W.G. Stranded copper core.

1/32-inch wall rubber.

6x7 wire rope stranding, each wire rubber covered.

Rubber cement impregnation between strands and around central core.

Nylon basket weave braid.

Rubber jacket.

Ultimate strength 12,000-15,000 pounds

Nominal O.D. 5/8 inch.

At a subsequent meeting on October 31, at the B.F. Goodrich plant in Akron, Ohio, Mr. Leguillon estimated delivery of four 150-foot lengths of the cable in January, if no unforseen difficulties were met.

In addition to the samples mentioned above, an order has been placed with Goodrich for 800 feet of rubber covered cable having a nylon braid imbedded in the rubber jacket. It is thought that the additional rubber outside the nylon will reduce the damage to the cable observed in the explosion tests conducted in October.

Two samples of rubber covered cables will be received from the American Steel and Wire Company about November 12.

C. Experimental Turbine

On October 30, 1951, a visit was made to the James Leffel Company, Springfield, Ohio. Progress of the work on the construction of the experimental turbine was reviewed. All patterns have been completed, and all necessary materials are on hand. It was expected that four to six weeks more work would be required to complete the unit.

[redacted]

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III. FUTURE PROGRAM

Test sections simulating the cavity in the large ogive of the cast aluminum yoke will be tested for explosion resistance and water-tightness.

The American Steel and Wire Company tow cable will be explosion tested and orders will be placed for tow cable required for life and prototype tests.

Respectfully submitted,

Ward H. Sachs, Jr.,
Project Director

Approved:

Gerald A. Rosselot, Director
State Engineering Experiment Station

Georgia Institute of Technology
STATE ENGINEERING EXPERIMENT STATION
Atlanta, Georgia

[redacted] GA TECH CONTROL NO. E00-27

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PROGRESS REPORT NO. 30

PROJECT NO. 141-64

CABLE DEVELOPMENT

By

WARD H. SACHS, JR.

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CONTRACT NO. NObs-47441

INDEX NO. NS-410100

BUREAU OF SHIPS, BRANCH 520

DEPARTMENT OF THE NAVY

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DECEMBER 31, 1951

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Georgia Institute of Technology
[illegible]
Atlanta, Georgia

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PROGRESS REPORT NO. 3[illegible]

PROJECT NO. 1l1-6L

[illegible] DEVELOPMENT

By

[illegible] H. [illegible], JR.

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CONTRACT NO. N[illegible]s-[illegible]7441

[illegible] NO. N[illegible]-410100

BUREAU OF SHIPS, [illegible] 520

DEPARTMENT OF THE NAVY

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DECEMBER 31, 19[illegible]1

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I. SUMMARY

The yoke casting for Project General streamer assemblies has been redesigned to provide a water-tight compartment for detector-actuator equipment.

Orders have been placed for streamer tow cables which will be required for explosion and life tests of streamer components.

Production of streamer units for explosion and life tests has been started.

An experimental water turbine for a preliminary investigation of the feasibility of a water driven generator as a power source for detector-actuator units has been received. Equipment is being set up for testing the unit at Georgia Tech.

II. INTRODUCTION

This Progress Report covers the period from November 1 through December 31, 1951. For the sake of completeness, information which was included in Memorandum Progress Report dated November 30, 1951, will be included herein.

III. PROGRESS

A. Yoke Design

The desirability of a water-tight chamber for housing electronic detector-actuator components of the explosive streamer was pointed out in Progress Report No. 29, October 31, 1951. Preliminary steps in redesign of the streamer yoke casting to provide such a chamber were taken in November, when aluminum castings of a size and shape duplicating the proposed chamber were subjected to hydrostatic tests and underwater explosion tests.

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After several improvements in foundry technique over that which had been employed previously, non-porous castings were produced. These withstood underwater explosion pressures resulting from the detonation of a 5-pound point charge of cast "B" at a distance of 12 feet. Castings have been tested with internal water pressures as high as 400 psi without leakage either before and after the specimens had been subjected to the explosion tests.

Figure 1 shows a yoke of the latest design. Passages for electrical leads from the transformer, housed in the yoke hub, to the detector-actuator and from the detector-actuator to hydrophone and detonator leads are concealed in the arms of the yoke. Steel stuffing-box inserts provide water-tight seals at one end of these passages. A brass hydrophone receptacle is also inserted into the mold prior to casting. This receptacle can be seen in the lower chamber of the yoke in Figure 1. The fitting is connected with the large upper chamber by a small copper tube in the yoke arms. Prima-cord will be used in the same manner as before to break the yoke arms. The plug in the right hand end of the hub of the yoke shown in the figure will be a steel insert around which the aluminum will be cast. The aluminum plug in the opposite end of the yoke hub is removable in order that the power transformer can be installed from this end. The rounded ogive closing the lower chamber, which will house the arming device, is a screwed fitting. Water-tight closure of the upper chamber will be accomplished by the dome-shaped cover which will be secured with cap screws.

Because of the complexity of the yoke shown, it appears that two castings per day will be the production limit in the Georgia Tech facilities. As soon as preliminary explosion and life tests indicate that this

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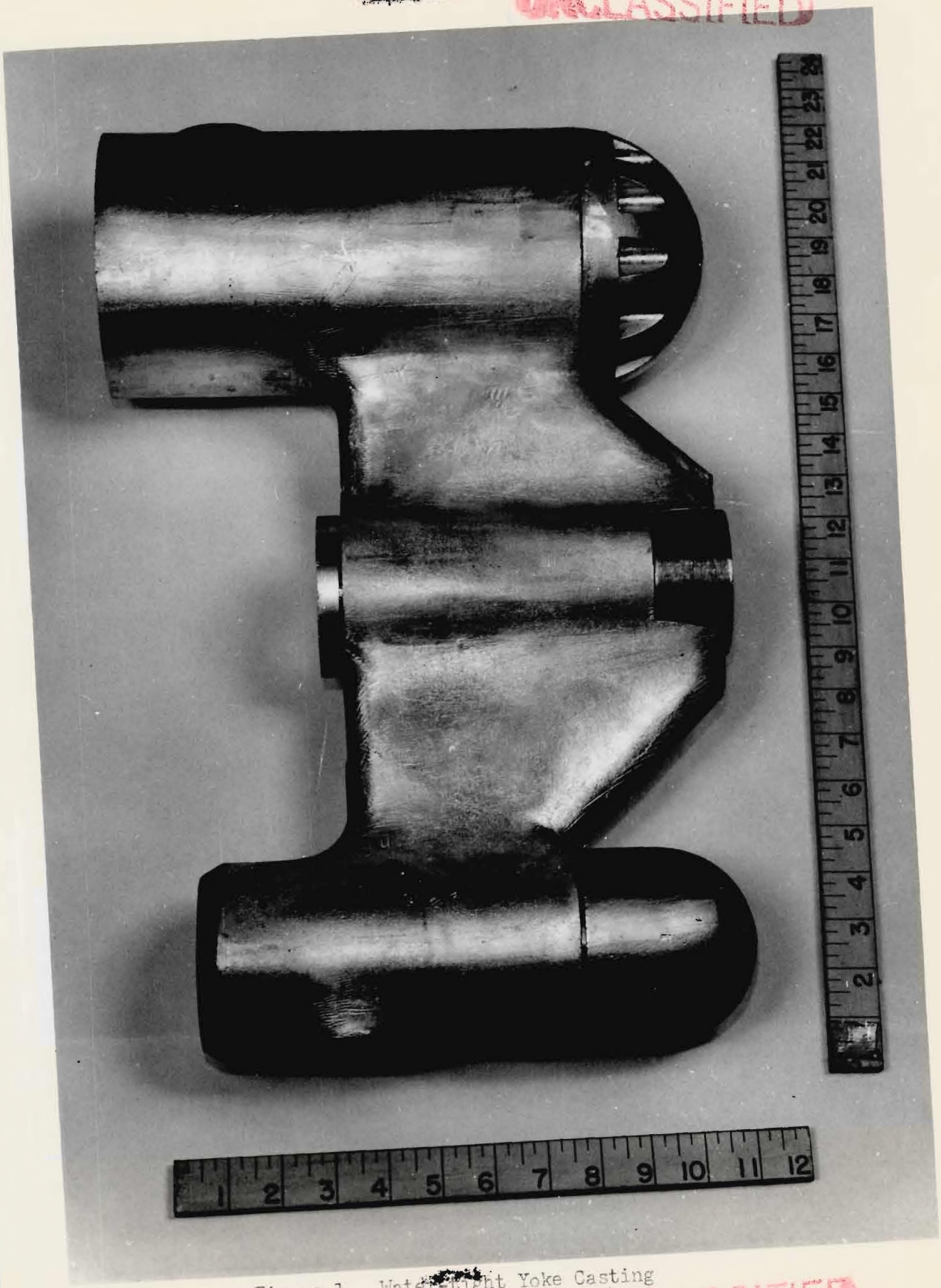

Figure 1. Water-tight Yoke Casting

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design will be satisfactory, another source for yoke castings will be sought.

F. Tow Cables

Orders have been placed with the American Steel and Wire Company for cables which will be utilized in life tests and in further development tests. Eleven 1200-foot reels of cable, designated CT-16 and having the following construction, have been ordered for life tests:

#10-19W tinned copper.

0.034-inch 30% rubber

7 Strands brass plated steel.

0.045-inch 60% rubber.

Skeleton nylon braid.

0.045-inch 60% rubber jacket.

Nominal OD. 0.620 inch.

Ultimate strength 12,000--15,000 pounds.

For further development work in cooperation with the B.F. Goodrich Company, ten 1200-foot reels of cable, designated CT-17 and having the following construction, have been ordered:

#10-19W tinned copper.

0.034-inch 30% rubber.

7 Strands of bright steel.

Nominal O.D. 0.440 inch.

G. Streamer Units for Tests

Project facilities have been, and will continue to be, producing streamer components for use in explosion and life tests scheduled for the winter and early spring at USNMCS. It is anticipated that components for 400 feet of streamer of the latest design will be ready for shipment

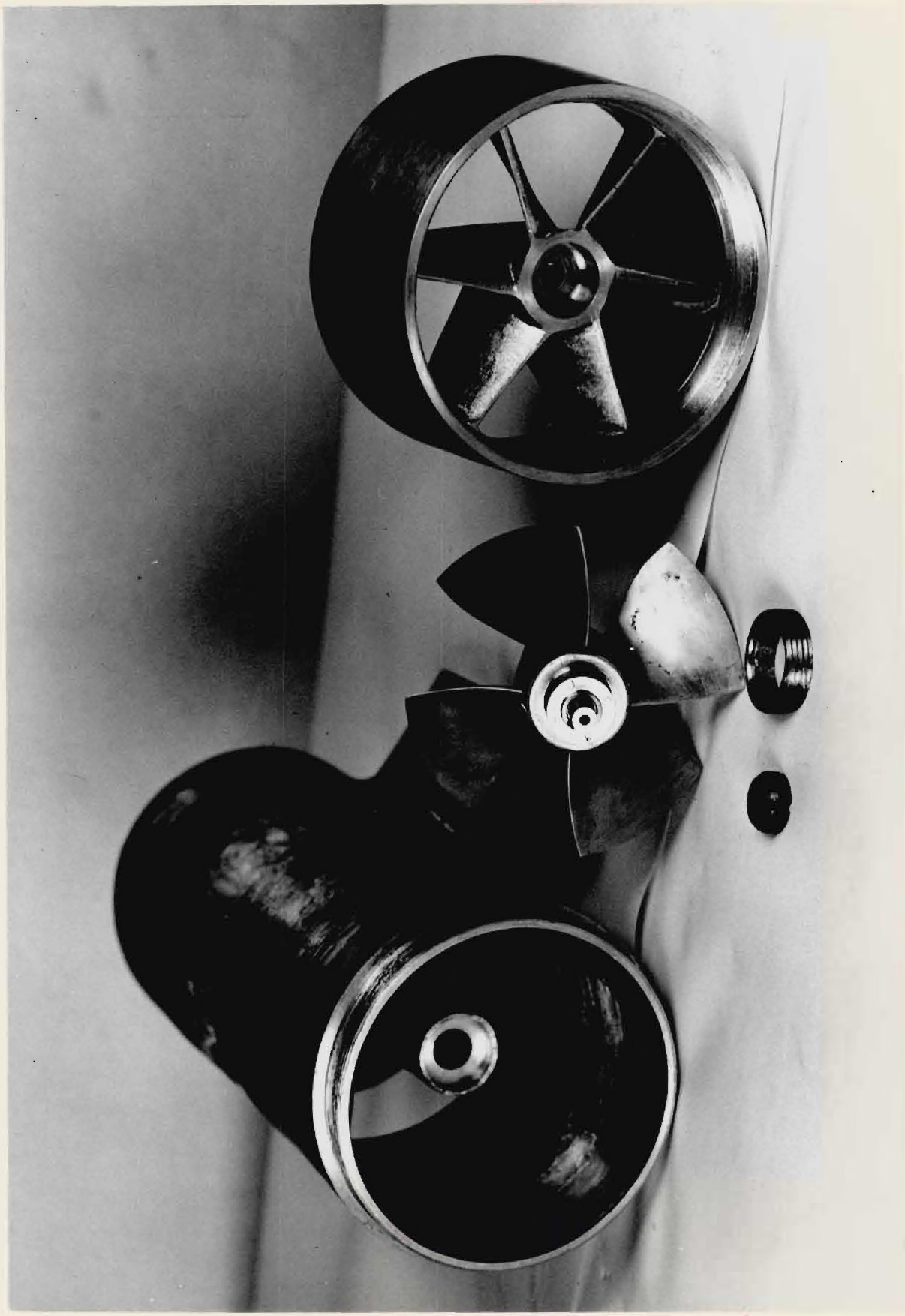

Figure 2. Experimental Water Turbine Components. (Runner 4-1/2" Diameter)

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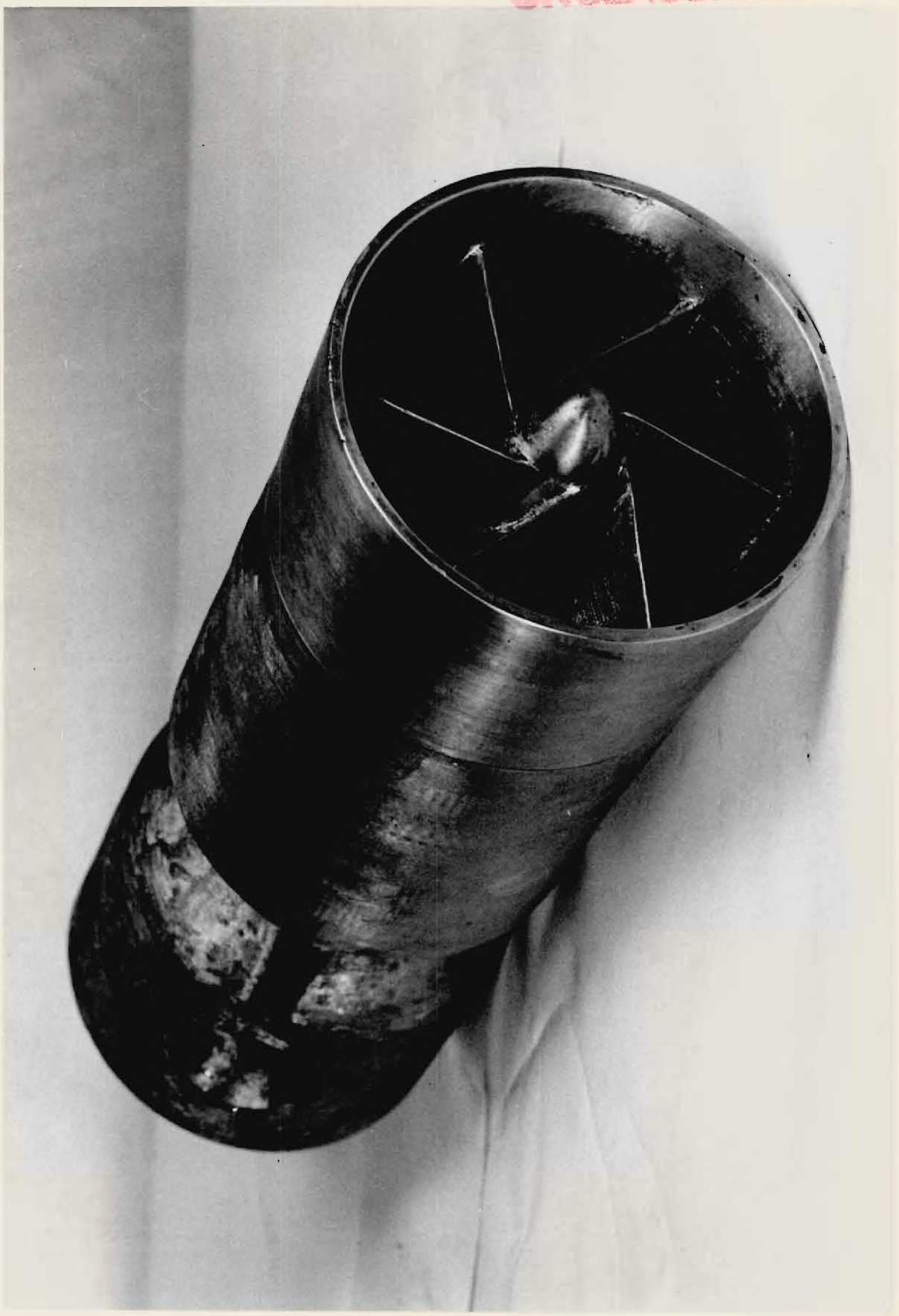

Figure 3. Experimental Water Turbine

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to [illegible] about January 15, 1957, and that a production of 100 feet per month can be maintained until the yoke design is frozen and a commercial source can be developed.

D. Experimental Turbine

The experimental water turbine for preliminary investigation of the feasibility of a water driven generator as a source of power for the detector-actuator units has been received from the James Leffel and Company. The components of the turbine are shown in Figure 2. Figure 3 shows the assembled unit. Overall length of the unit is approximately 14 inches.

The housing is 5-1/2 inches outside diameter, flaring out to 6 inches at the forward end. This model is made of bronze and weighs approximately 34 pounds. An aluminum turbine having the same dimensions would weigh in the neighborhood of 11 pounds. Equipment is being set up in the Georgia Tech Hydraulics Laboratory to make preliminary tests on the unit.

IV. FUTURE PROGRAM

Production of streamer components will be continued.

Georgia Tech will cooperate with USNRDL personnel in conducting explosion tests of towed streamers when all components are completed.

Performance tests on the experimental water turbine will be started in January.

Respectfully submitted,

R.W. Fuchs, Jr.,
Project Director

Approved:

Gerald A. Rosselot, Director
State Engineering Experiment Station

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