# DESIGN AND TESTING OF AN IRRIGATION SYSTEM FOR BLACKBIRD CONTROL

BY

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OF

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Special thanks to my mother for typing this paper and my father for his suggestions.

# INDEX

## INTORODUCTION:

This paper is about designing a layout, installing, operating and testing the performance of two portable irrigation systems used to control blackbirds. This was done for the Wildlife Section of the Department of Renewable Resources, of MacDonald Campus, McGill University. The two systems were tested consecutively, the first one used two "Big Gun" sprinklers and the second setup used seven full circle impact sprinklers and two Toro geared rotor sprinklers. They were tested during the end of March, and through the month of April 1982. They were installed in a swamp which caused many difficulties and delays in the installation and operation of the systems.

## PROJECT OBJECTIVE:

To control the blackbird population, thereby decreasing the yearly corn damage caused by them.

## DISCUSSION:

To control the blackbird population the Wildlife Group of the Department of Renewable Resources came up with an idea to spray the birds with a diluted detergent that would remove the birds natural oils from their feathers causing them to die - very painlessly - of exposure. This method could be used where a high bird density occured. This occurance only happens once a year in the spring, when the birds return from wintering habitats. When they return - normally males retuns first - they gather every night in an area called a roost, until the nightly temperatures stay above freezing.

During the day they leave the roost to feed. The roost is on the south side of the Beauharnois Canal. (fig. 1) and it covers many square miles. The Wildlife group divised a method basically by making noises, that would maneuver the birds into one small section ( 1000' x 1200' ) of the roost (fig.2) that was prepared by the Wildlife Department.

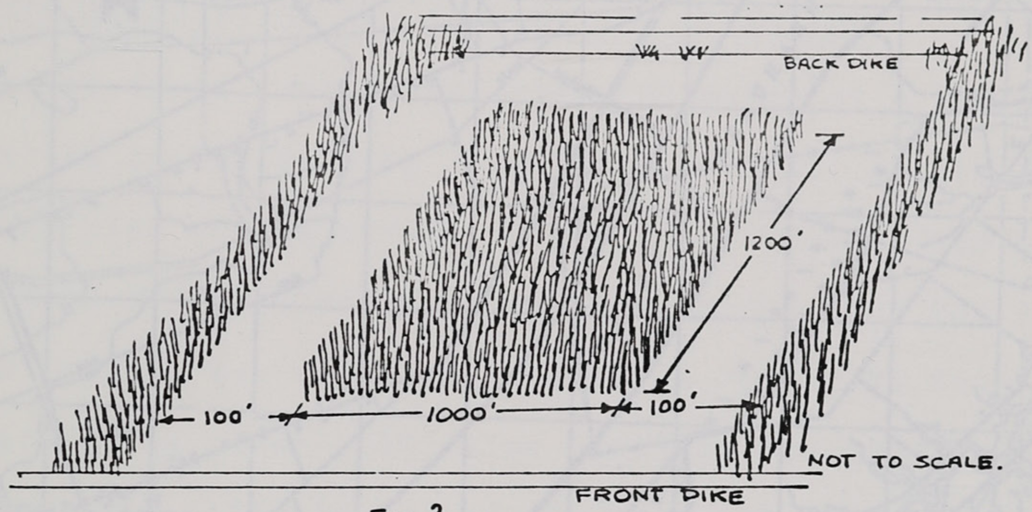



Fig. 2

It was in this section where the irrigation was to be installed.

ENGINEERING OBJECTIVE:

To design and install an irrigation system that would distribute the water with the detergent evenly over a section of the roost.

CONDITION OF THE TERRAIN WHERE THE IRRIGATION SYSTEM WAS INSTALLED:

The irrigation system was installed in a bird sanctuary which was a swamp, on the southern side of the Beauharnois canal. (fig.2). The water depth in the swamp, varies from 6 inches to 6 feet, with a heavy growth of fragmittes 7 feet tall. The

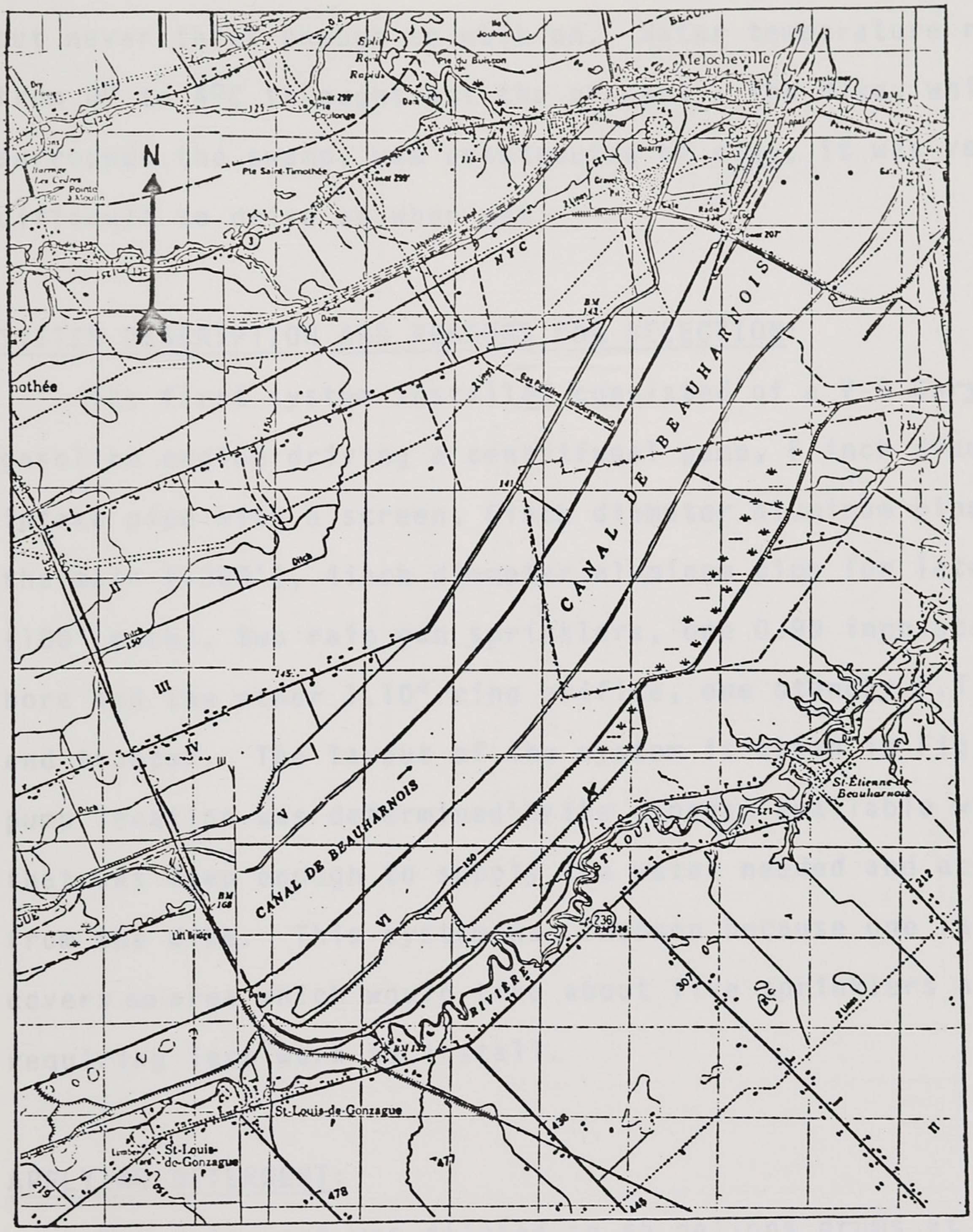



Fig. 1 CANAL DE BEAUHARNOIS

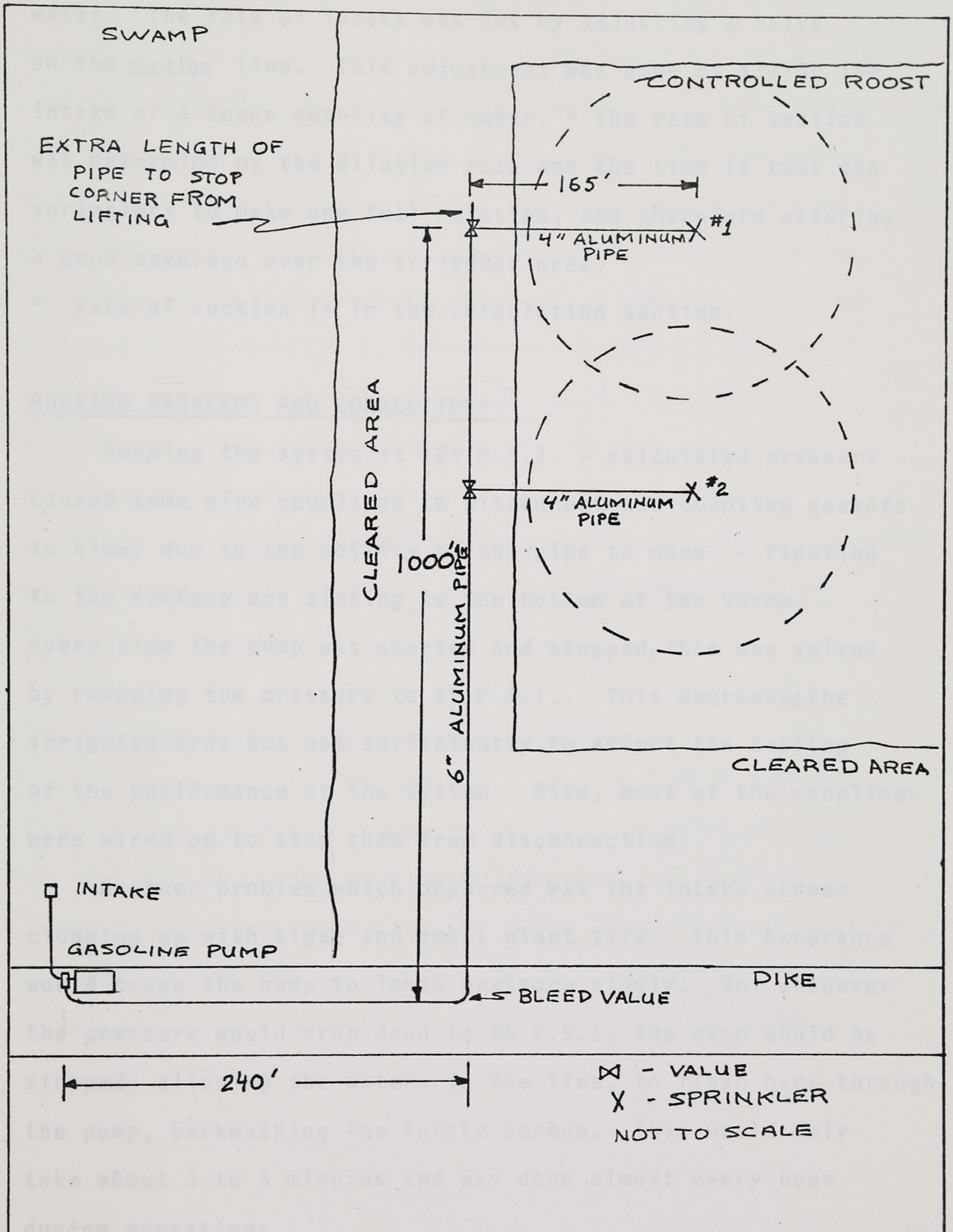
The weather was cold and warm, varying from $-10^{o}C$ to $10^{o}C$ throught out the month of April causing ice to form normally but never thick enough to walk on. Water temperature range from $0^{o}$ to $4^{o}C$ throught out the project. The dike, which surrounds the swamp, was constructed of clay, it was very difficult to drive on when wet.

SYSTEM DESCRIPTION AND REASONS FOR SELECTION:

The first system installed consisted of a V-8 Chrysler gasoline engine driving a centrifugal pump, 6 inch diameter intake pipe with a screen, 6inch diameter aluminum pipe for the main (1300'), 4inch diameter aluminum pipe for laterials (180' each), two rain gun sprinklers, one 0.99 inch straight bore and the other 1.10" ring orifice, one standby P.T.O. pump and tractor. The layout of the system is shown in Fig. 3. The pump location was determined by the closest available water spot that was deep enough to supply the water needed and accessible from the dike. This system was choosen because one rain gun covers an area which would take about five sprinklers and therefore requiring less work to install.

APPLYING DETERGENT:

The detergent was diluted in 45 gallons drums at the college. This diluted detergent was introduced into the system by connecting a small 1.0" I.D. hose to the suction side of the pump. This allowed us to inject the solution into the system slowly, therefore, diluting it with the irrigation




LAYOUT OF SYSTEM 1

Fig. 3

water. The rate of intake was set by adjusting a valve on the suction line. This adjustment was done by timing the intake of a known quantity of water. * The rate of suction was determine by the dilution rate and the time it took the sprinklers to make one full rotation, and therefore assuring a good coverage over the irrigated area.

* Rate of suction is in the calculation section.

RUNNING PROBLEMS AND CORRECTIONS:

Running the system at 125 P.S.I. - calculated pressure - caused some pipe couplings to disconnect and coupling gaskets to blow, due to the ability of the pipe to move - floating to the surface and sinking to the bottom of the swamp, - every time the pump was started and stopped, this was solved by reducing the pressure to 95 P.S.I.. This decreased the irrigated area but not sufficiently to affect the testing of the performance of the system. Also, most of the couplings were wired on to stop them from disconnecting.

Another problem which occurred was the intake screen clogging up with algae and small plant life. This occurance would cause the pump to loose pressure slowly. So, whenever the pressure would drop down to 85 P.S.I. the pump would be stopped, allowing the water in the line, to flush back through the pump, backwashing the intake screen. This would only take about 3 to 5 minutes and was done almost every hour during operations.

The main problem which caused the system to fail was cannon like noises, made by air expanding after it discharged from the sprinkler guns, when the system started up, Scaring the birds out of the roost. This problem was not forseen because we were informed that the birds would remain in the roost after dark no matter what type of noise was made. This cannon like noise was caused by the air in the line being forced out through the guns when starting up. To reduce the amount of air going through the line, a bleed valve was installed on the last elbow in the pipe on top of the dike (see fig. 3). The pump was also started slowly so the escaping air from the bleed valve could be reduced below sonic speed, since the bleed valve was only 1.5" in diameter. The bleed valve did not help reducing the noise considerably and therefore, this system did not work and an alternate system was tried.

DESCRIPTION OF SYSTEM #2 AND REASON FOR SELECTION:

The second system installed (Fig.4) used seven 70 EB Rain Bird sprinklers and two Toro 670 series Greared Rotor sprinklers with 240 feet of 4 inch aluminum pipe plus all equipment used in system #1 except for the gun sprinklers. This system was used since it required only small changes from system #1 and therefore installation time would be much shorter than system #1. Also, with the smaller sprinklers slow start ups the initial air noise was reduced.

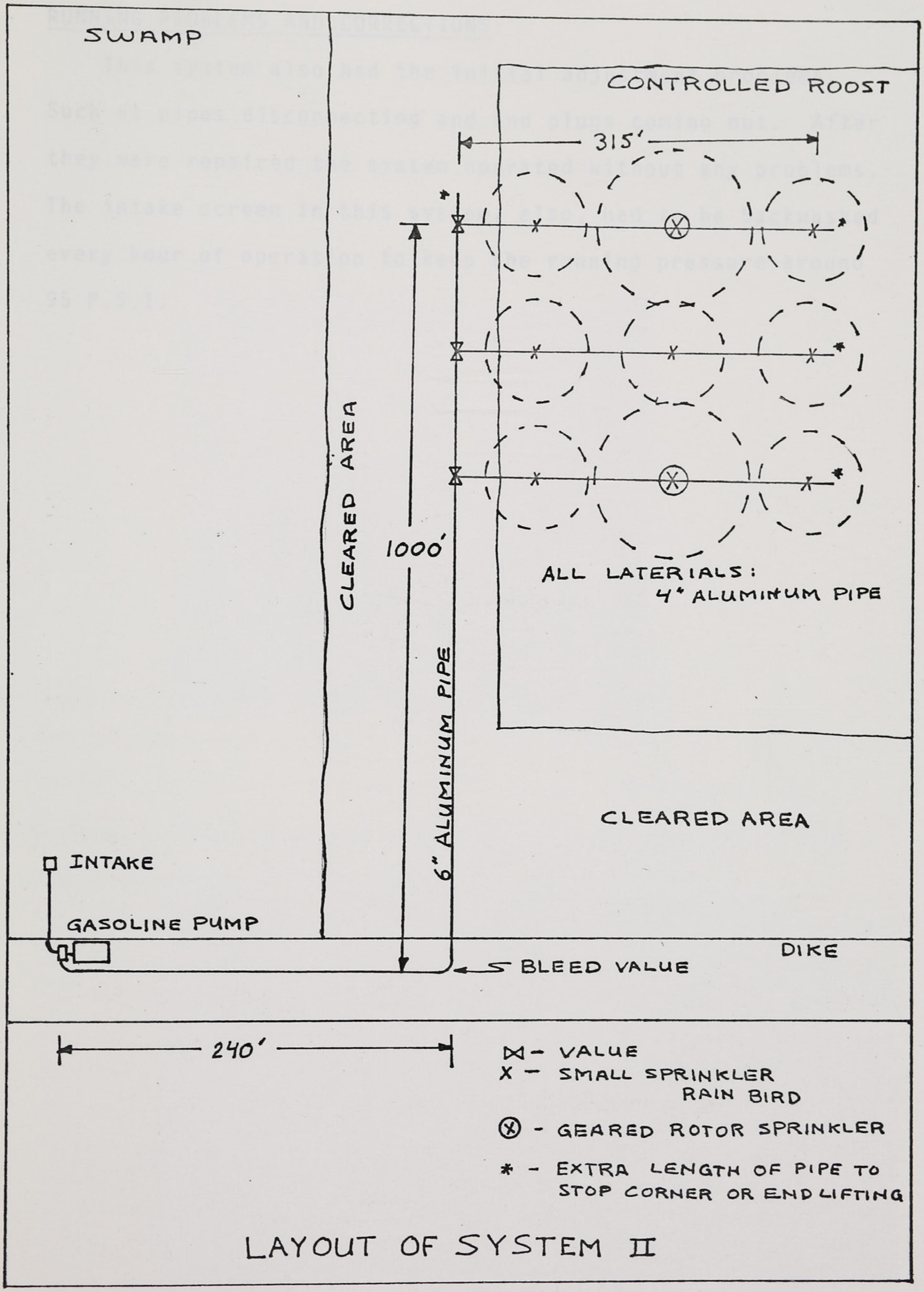

SWAMP
CONTROLLED ROOST
315'
CLEARED AREA
1000'
ALL LATERIALS:
4" ALUMINUM PIPE
6" ALUMINUM PIPE
CLEARED AREA
INTAKE
GASOLINE PUMP
DIKE
BLEED VALUE
240'
⋈ - VALUE
X - SMALL SPRINKLER RAIN BIRD
⊗ - GEARED ROTOR SPRINKLER
* - EXTRA LENGTH OF PIPE TO STOP CORNER OR END LIFTING
LAYOUT OF SYSTEM II

Fig. 4

RUNNING PROBLEMS AND CORRECTIONS:

This system also had the initial adjustment problems. Such as pipes disconnecting and end plugs coming out. After they were repaired the system operated without any problems. The intake screen in this system, also, had to be backwashed every hour of operation to keep the running pressure around 95 P.S.I.

INSTALLATION OF THE SYSTEMS:

Installing the first system took approximately one week due to the hard working conditions. Initially, each length of pipe installed had to be pulled through the swamp in icy condition (picture 1) which was very time consuming.

Picture 1

For example it took one man 20 minutes to move one 30' length of pipe to the first valve in the line, approximately 600'. Later, a flat bottom boat was obtained and used by placing the pipe on top of it.(picture 2).

Picture 2

It was then pushed through the swamp (picture 3)

Picture 3

sometimes on ice and sometimes in the water - to where the pipe had to be installed. This would also take approximately 15 minutes to get to the first valve. Each length of pipe for a lateral still had to be pulled through the fragmittes to be placed, which was very time consuming. (picture 4)

Picture 4

The installation of the second system took approximately two and half days. It required extending the two existing laterials by 150' and adding on a third one 300' long. (fig.4)

RESULTS AND DISCCUSSION:

As stated before, the first system did not work. The system was tried twice. Both times it was confirmed by Professor Bider that the birds were in the roost. The pumping was started two hours after dark (around 10 PM) allowing the birds to settle down. When the irrigation was started Professor Bider reported seeing a flock of birds leaving the roost, but he could not estimate the amount so the operation continued. After running for fifteen minutes the detergent was introduced into the system for about two and a half hours applying approximately 0.60 inches over 88% of the total area planned. It was reported by the Wildlife Group that in both cases there were no birds killed.

The second setup was tried out twice. In both tries the birds were in the roost. The first try was a total failure since a series of problem occured, end plugs coming out and pipes disconnnecting which a whole night was spent correcting. The second try ran successfully. The rate of intake for the detergent was slower then the first system since a higher concentration and less detergent was used. This system distributed approximately 0.4 inches of water in two and a half hours covering 95 % of total area planned. The Wildlife Group reported that approximately 160 birds were killed, not making it a success but showing that the technique can work.

While installing the system we noticed that the birds were very sensitive to high frequency noises, such as the one made by metal hitting metal. Therefore if any work (hitting) were to be done during the night a wooden mallet was used. Another tool that was useful was the walkie-talkie. Because of the large work area it saved us a tremendous amount of time in communicating.

SUGGESTIONS:

Some suggestions that might be helpful, are given below. They must be tested before it will be known.

As we know, the air escaping through the sprinklers is a big problem. By placing a tee at the first bend and placing a gate valve at the end of one length of pipe after the tee (fig.5) to act like a manual releif valve. This way we can control the velocity of the water so that the main can be filled slowly allowing the air to escape slowly and therefore stopping the whistling noises caused by the high velocity escaping air. The gate is then closed when the line is full, bringing the system up to operating pressure.

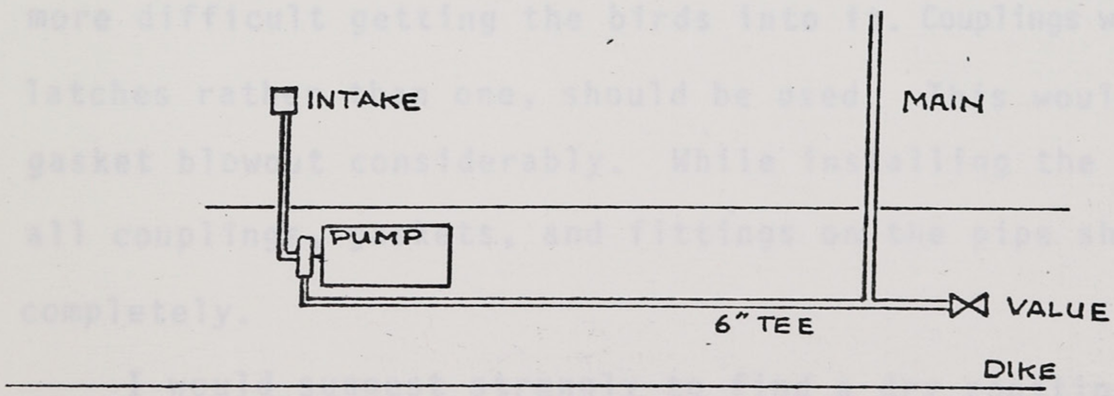



Fig.5

Moving the sprinklers out to the corners of the roost would reduce the noise inside, therefore not scaring the birds as much. For example setting four big guns on each corner of the roost (fig. 6)

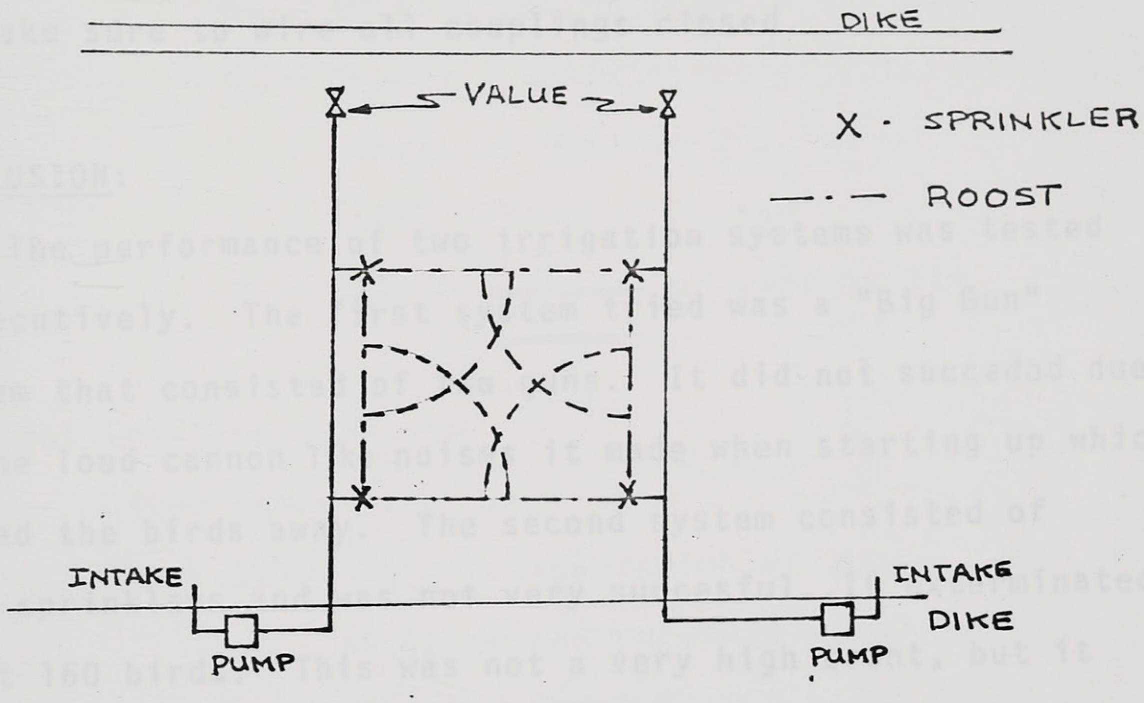



Fig. 6

with the manual releif valve at each end, close to the opposite dike so it could be easily controlled. The roost would have to be small (300' x 300') for this system, and therefore may be more difficult getting the birds into it. Couplings with two latches rather than one, should be used. This would reduce gasket blowout considerably. While installing the system all couplings, gaskets, and fittings on the pipe should be checked. completely.

I would suggest strongly to find a dry roosting area or at least with water no deeper than six inches. This would reduce installation time considerably, for example it would probably take only about one day to install the first system which took us one week. If a dry roost is not available I would suggest to install the system mainly the part in the swamp at the beginning of March when everything is frozen over, and make sure to wire all couplings closed.

CONCLUSION:

The performance of two irrigation systems was tested consecutively. The first system tried was a "Big Gun" system that consisted of two guns. It did not succeded due to the loud cannon like noises it made when starting up which scared the birds away. The second system consisted of nine sprinklers and was not very succesful. It exterminated about 160 birds. This was not a very high count, but it showed us that the idea of a portable irrigation system used to control the blackbirds population is still a possibility.

## FRICTION AND PRESSURE CALCULATIONS

Scobey's Equation :

$$H_f = \frac{K_s L Q^{1.9}}{D^{4.9}} (1.45 \times 10^{-8})$$

$H_f$ = total friction loss in the line in ft.

$K_s$ = Scobey's coefficient of retardation = 0.4

L = length of pipe in ft.

Q = total discharge in gpm

D = inside diameter of pipe in ft.

First Irrigation System

from table 1.

1.10" ring orfice sprinkler gun:

| | |
|---|---|
| at operating pressure | = 100 psi |
| diameter covered | = 348 ft. |
| G. P. M. | = 238 US gal. |

o.99" smooth sprinkler gun:

| | |
|---|---|
| at operating pressure | = 100 psi |
| diameter covered | = 357 ft. |
| G.P.M. | = 235 US gal. |

$H_f$ For Main:

for the first section (up to first value)

Q = 478 gpm

L = 910 ft.

D = 5.949 in.

$H_f = 20.3$ ft.

for the second section (after first value)

$Q = 235$ gpm

$L = 330$ ft.

$D = 5.949$ in.

$H_f = 1.9$ ft.

$H_f$ For The Laterials:

$Q = 235$ gpm

$L = 164$ ft.

$D = 3.949$ ft.

$H_f = 7.1$ ft. for each lateral

Average Head in laterials, $H_a$ :

$$H_a = H_o + \frac{1}{4} H_f$$

$H_o$ = pressure at the sprinkler on the farthest end = 100 psi = 231 ft.

$H_f$ = friction in the laterials = 14.2 ft.

$H_a = 234.6$ ft.

Head at the Main, $H_n$:

$$H_n = H_a + 3/4\ H_f + H_r \pm 3/4\ H_e$$

$H_r$ = the riser height = 7 ft.

$H_e$ = Maximun difference in elevation between the first and last sprinkler on the laterial = o ft.

$H_n = 258.3$ ft.

Operating Pressure, $H_t$:

$$Ht = H_n + H_m + H_j + H_s$$

$H_m$ = head loss in main = 22.2 ft.

$H_j$ = elevation difference between the pump and the junction of the laterial and the main =-5 ft

$H_s$ = elevation difference between the pump and the water supply after drawdown = 5 ft.

$H_t$ = 280.5 ft. = 122 psi

therefore, operating pressure = 125 psi for allowance of friction losses of bends and value connections.

When the pressure was reduced to 95 psi. at the pump the pressure at the sprinklers reduced to 75 psi.

TABLE 2 Running Performance of First System

| | SYSTEM I | SYSTEM I |
|---|---|---|
| Operating pressure | 125 psi. | 95 psi. |
| Pressure at sprinkler | 100 psi. | 75 psi. |
| Diameter sprayed | | |
| Gun #1 | 357 ft. | 324 ft. |
| Gun #2 | 348 ft. | 314 ft. |
| GPM(US.) | | |
| Gun #1 | 235gal. | 199 gal. |
| Gun #2 | 238 gal. | 200 gal. |
| volume pumped | 473 gpm. | 399 gpm. |
| Application rate | 0.41 in/hr. | 0.3 in/hr. |

TABLE 3 Running Performance of Second System

| | SYSTEM II |
|---|---|
| Operating pressure | 95 psi. |
| Pressure at sprinklers | 70 psi. |
| Diameter sprayed | |
| #1 sprinklers* | 100 ft. |
| #2 sprinklers** | 164 ft. |
| G.P.M. per sprinkler | |
| #1 sprinklers* | 30 (us.)gpm. |
| #2 sprinklers** | 50 (us) gpm. |
| Volume pumped | 310 (US.)gpm. |
| rate of application | 0.16 in./hr. |

* 7- 70 EB Rain Bird sprinkler (Table 4)
** 2 - Toro 670 Series Geared Rotor

SUCTION RATE OF DETERGENT*:

- for sprinklers to do two rotations it requires approximately 15 minutes.

System I :

in 15 mintues 450 gallons of detergent was introduced into the system therefore, rate of suction = 30 gpm.. The dilution was 1:13 since 400 gpm was pumped.

System II:

in 10 minutes 90 gallons of detergent** was introduced into the system therefore, rate of suction = 9 gpm.. The dilution was 1:34 since 310 gpm was pumped.

* detergent used: a diluted solution of tergital non-15-5-9-150-propyl, alcohol and water.

** A higher concentrated detergent was used.

EQUIPMENT USED:

1 - V-8 CHRYSLER GASOLINE ENGINE 120 H.P. MAX.

1 - PTO PUMP

1 - TRACTOR

1- 150 GAL. GAS TANK

2 - TORO 670 SERIES GEARED ROTOR

7 - 30 EB RAIN BIRD SPRINKLER

1 - 0.99 INCH STRAIGHT BORE RAIN GUN SPRINKLER

1 - 1.10 INCH RING ORIFICE RAIN GUN SPRINKLER

43 - 30 FT. LENGTH OF 6" ALUMINUM PIPE

30 - 30 FT. LENGTH OF 4" ALUMINUM PIPE

2 - 90$^{o}$ ELBOWS

32 0 6" COUPLINGS

26 - 4" COUPLINGS

2 - 4" END PLUGS

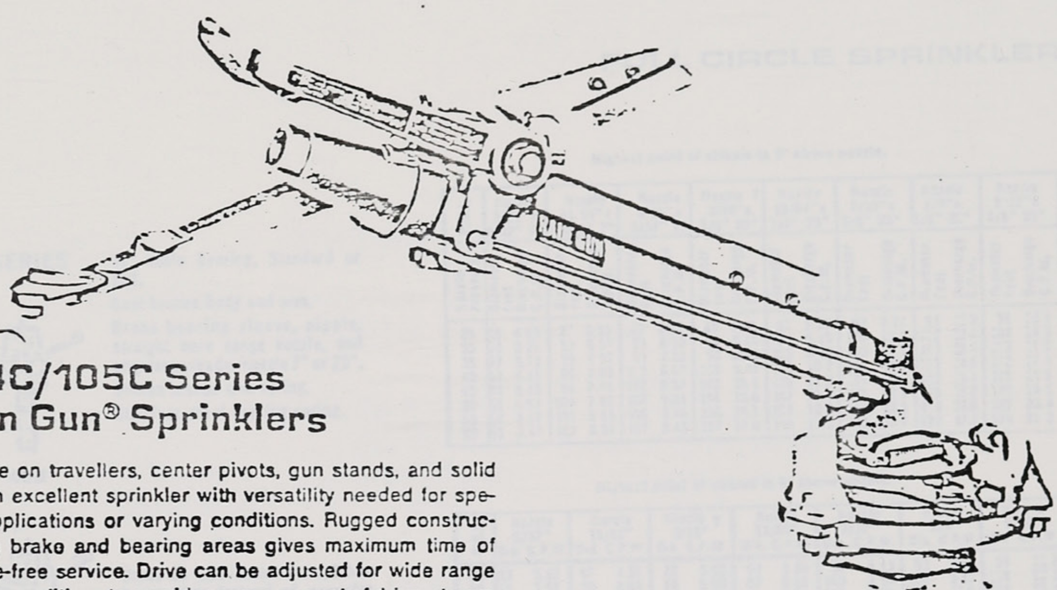
1 - PRESSURE RELEASE VALVE

3 - 6" VALVES

3 - WALKIE - TALKIE

1 - GASOLINE ELECTRIC GENERATOR WITH EXTENSION CORDS AND LIGHTS

## RAIN GUN® IMPACT SPRINKLERS 3



105CS

## 104C/105C Series Rain Gun® Sprinklers

For use on travellers, center pivots, gun stands, and solid set. An excellent sprinkler with versatility needed for special applications or varying conditions. Rugged construction in brake and bearing areas gives maximum time of trouble-free service. Drive can be adjusted for wide range of field conditions to provide proper amount of drive, stream break-up, or alter distribution profile. Large diameter range tube with straitening vanes gives excellent diameter of throw.

**For Full Circle operation, use 104C**
**For Part Circle operation, use 105C**

### PERFORMANCE

**Ring Orifice Performance for 104C/105C Rain Gun Sprinklers — 23° Trajectory**

| P.S.I. @ Elbow | .870" | | .990" | | 1.100" | | 1.201" | | 1.293" | | 1.380" | | 1.450" | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Dia. | GPM | Dia. | GPM | Dia. | GPM | Dia. | GPM | Dia. | GPM | Dia. | GPM | Dia. | GPM |
| 60 | 264 | 110 | 284 | 142 | 300 | 185 | 318 | 226 | 335 | 275 | 352 | 324 | 365 | 385 |
| 70 | 275 | 118 | 295 | 154 | 314 | 200 | 332 | 243 | 350 | 295 | 367 | 353 | 383 | 418 |
| 80 | 285 | 127 | 306 | 164 | 326 | 213 | 345 | 263 | 364 | 315 | 383 | 374 | 398 | 447 |
| 90 | 295 | 136 | 315 | 175 | 337 | 227 | 358 | 276 | 378 | 336 | 396 | 400 | 414 | 475 |
| 100 | 305 | 142 | 326 | 185 | 348 | 238 | 371 | 290 | 390 | 352 | 409 | 422 | 425 | 500 |
| 110 | 315 | 150 | 335 | 195 | 357 | 250 | 382 | 305 | 402 | 372 | 421 | 441 | 438 | 525 |
| 120 | 322 | 157 | 344 | 202 | 366 | 259 | 392 | 323 | 412 | 392 | 431 | 465 | 450 | 550 |

**Straight Bore Performance for 104CS/105CS Rain Gun Sprinklers — 23° Trajectory**

| P.S.I. @ Elbow | 0.613" | | 0.690" | | 0.790" | | 0.890" | | 0.990" | | 1.090" | | 1.190" | | 1.290" | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Dia. | GPM | Dia. | GPM | Dia. | GPM | Dia. | GPM | Dia. | GPM | Dia. | GPM | Dia. | GPM | Dia. | GPM |
| 60 | 245 | 86 | 269 | 110 | 292 | 142 | 313 | 185 | 329 | 226 | 348 | 275 | 366 | 331 | 385 | 390 |
| 70 | 255 | 93 | 281 | 118 | 304 | 154 | 324 | 199 | 347 | 245 | 363 | 295 | 381 | 354 | 400 | 418 |
| 80 | 265 | 99 | 291 | 127 | 316 | 164 | 336 | 214 | 357 | 263 | 375 | 315 | 395 | 374 | 414 | 447 |
| 90 | 275 | 105 | 300 | 136 | 325 | 177 | 347 | 227 | 367 | 276 | 390 | 336 | 410 | 400 | 427 | 475 |
| 100 | 285 | 111 | 310 | 142 | 334 | 185 | 357 | 235 | 377 | 290 | 400 | 352 | 420 | 422 | 440 | 500 |
| 110 | 295 | 117 | 320 | 150 | 342 | 195 | 365 | 249 | 386 | 305 | 410 | 372 | 430 | 444 | 450 | 525 |
| 120 | 305 | 122 | 330 | 157 | 351 | 202 | 375 | 262 | 395 | 323 | 420 | 392 | 440 | 463 | 460 | 550 |

## ORDERING INFORMATION:

When ordering the standard 104C or 105C ring orifice model, specify:

Ring Orifice Model No. — [104C or 105C]
Flange Mount — [Flange Mount] OR Female NPT Mount (specify size) — [3" or 3½" FNPT]

When ordering the 104CS or 105CS straight bore model, specify:

Straight Bore Model No. — [104CS or 105CS]
Nozzle Size (specify size) — [0.79"]
Flange Mount — [Flange Mount] OR Female NPT Mount (specify size) — [3" or 3½" FNPT]

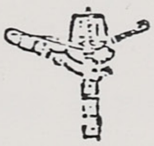


TABLE 1.

RAIN BIRD

## FULL CIRCLE SPRINKLERS [3]

### 40B SERIES



40B

¾" male bearing. Standard or TNT.
Cast bronze body and arm.
Brass bearing sleeve, nipple, straight bore range nozzle, and angular spreader nozzle 7° or 20°.
Silicon bronze arm spring.
Stainless steel bearing spring.

Highest point of stream is 9' above nozzle.

| P.S.I. | Nozzle 5/32" x 3/32" 7° | | Nozzle 11/64" x 3/32" 7° | | Nozzle 3/16" x 3/32" 7° | | Nozzle † 3/16" x 1/8" 20° | | Nozzle 13/64" x 1/8" 20° | | Nozzle 7/32" x 1/8" 20° | | Nozzle 1/4" x 1/8" 20° | | Nozzle 9/32" x 1/8" 20° | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nozzle Pressure | Diameter Feet | Discharge G.P.M. | Diameter Feet | Discharge G.P.M. | Diameter Feet | Discharge G.P.M. | Diameter Feet | Discharge G.P.M. | Diameter Feet | Discharge G.P.M. | Diameter Feet | Discharge G.P.M. | Diameter Feet | Discharge G.P.M. | Diameter Feet | Discharge G.P.M. |
| 25 | 55 | 4.63 | [illegible] | 5.55 | [illegible] | 6.31 | 89 | 7.41 | [illegible] | 8.50 | 92 | 9.24 | 91 | [illegible] | 95 | [illegible] |
| 30 | [illegible] | 5.29 | 92 | [illegible] | 95 | 6.93 | 95 | 8.14 | [illegible] | 9.15 | 100 | 10.2 | [illegible] | [illegible] | [illegible] | [illegible] |
| 35 | [illegible] | 5.71 | 95 | [illegible] | [illegible] | 7.52 | 98 | 8.83 | 100 | [illegible] | 103 | [illegible] | 105 | [illegible] | [illegible] | [illegible] |
| 40 | [illegible] | 6.11 | 55 | 7.03 | [illegible] | 8.07 | 100 | [illegible] | 103 | 10.7 | 106 | 11.9 | [illegible] | [illegible] | [illegible] | [illegible] |
| 45 | [illegible] | 6.49 | 93 | 7.45 | 102 | 8.57 | 102 | 10.1 | 105 | 11.3 | 108 | [illegible] | 112 | [illegible] | 115 | [illegible] |
| 50 | 55 | 6.84 | 100 | 7.87 | 104 | 9.04 | 104 | 10.6 | 107 | 11.9 | 110 | 13.3 | 115 | [illegible] | [illegible] | [illegible] |
| 55 | 57 | 7.17 | 101 | 8.25 | 105 | 9.45 | 106 | 11.1 | 109 | 12.5 | 112 | 13.5 | 118 | 17.0 | 122 | 20.4 |
| 60 | 58 | 7.47 | 102 | 8.53 | 107 | 9.65 | 107 | 11.6 | 110 | 13.0 | 113 | [illegible] | 120 | 17.7 | 124 | 21.3 |

40BW

Same as 40B above except has brass plug instead of spreader nozzle. Single nozzle used for slower precipitation rate.

Highest point of stream is 9' above nozzle.

| P.S.I. | Nozzle 5/32" Dia. | G.P.M. | Nozzle 11/64" Dia. | C.P.M. | Nozzle † 3/16" Dia. | G.P.M. | Nozzle 13/64" Dia. | G.P.M. | Nozzle 7/32" Dia. | G.P.M. | Nozzle 1/4" Dia. | G.P.M. | Nozzle 9/32" Dia. | G.P.M. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | [illegible] | [illegible] | 97 | 4.24 | [illegible] | [illegible] | [illegible] | [illegible] | 92 | [illegible] | 93 | [illegible] | 95 | [illegible] |
| 30 | [illegible] | [illegible] | [illegible] | [illegible] | 95 | [illegible] | 97 | 6.51 | 100 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 35 | 92 | [illegible] | 95 | [illegible] | 98 | 5.57 | 100 | [illegible] | 103 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 40 | 93 | 4.45 | 96 | 5.37 | 100 | 6.41 | 103 | 7.50 | 106 | [illegible] | [illegible] | [illegible] | 112 | [illegible] |
| 45 | 94 | 4.72 | 98 | 5.70 | 102 | 6.81 | 105 | 8.07 | 108 | [illegible] | 112 | [illegible] | 115 | [illegible] |
| 50 | 95 | [illegible] | 100 | 6.01 | 104 | 7.18 | 107 | 8.49 | 110 | 9.83 | 115 | [illegible] | 120 | [illegible] |
| 55 | 97 | 5.22 | 101 | 6.33 | 105 | 7.51 | 109 | 8.87 | 112 | 10.3 | 118 | [illegible] | 122 | [illegible] |
| 60 | 98 | [illegible] | 102 | 6.55 | 107 | 7.82 | 110 | 9.20 | 113 | 10.6 | 120 | [illegible] | 124 | [illegible] |

### 29B-TNT SERIES

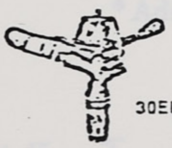
29B-TNT

½" male TNT bearing
Cast bronze body and arm. Body is hooded for a better seal of the bearing assembly.
Brass bearing sleeve (½" & ¾"), nipple, and nozzle.
Stainless steel arm spring and bearing spring.

Highest point of stream is 7' above nozzle.*

| P.S.I. | Nozzle 7/64" Dia. | G.P.M. | Nozzle 1/8" Dia. | G.P.M. | Nozzle 9/64" Dia. | G.P.M. | † Nozzle 5/32" Dia. | G.P.M. | Nozzle 11/64" Dia. | G.P.M. | Nozzle 3/16" Dia. | G.P.M. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | — | — | 72 | 2.61 | 76 | 2.61 | 79 | 3.11 | 82 | 3.73 | 85 | 4.43 |
| 25 | — | — | 73 | 2.75 | 77 | 2.90 | 80 | 3.50 | 83 | 4.22 | 86 | 4.97 |
| 30 | — | — | 74 | 2.67 | 78 | 3.16 | 81 | 3.83 | 84 | 4.62 | 87 | 5.47 |
| 35 | — | — | 75 | 2.93 | 79 | 3.60 | 82 | 4.14 | 85 | 5.00 | 88 | 5.91 |
| 40 | — | — | 76 | 2.97 | 80 | 3.83 | 83 | 4.43 | 86 | 5.35 | 89 | 6.38 |
| 45 | — | — | 77 | 3.05 | 81 | 3.84 | 84 | 4.70 | 87 | 5.63 | 90 | 6.78 |
| 50 | 74 | 2.43 | 78 | 3.22 | 82 | 4.04 | 85 | 4.95 | 88 | 5.93 | 91 | 7.15 |
| 55 | 75 | 2.58 | 79 | 3.39 | 83 | 4.22 | 86 | 5.21 | 89 | 6.28 | 92 | 7.43 |
| 60 | 75 | 2.68 | 80 | 3.55 | 84 | 4.38 | 87 | 5.43 | 90 | 6.54 | 93 | 7.79 |
| 65 | 77 | 2.73 | 81 | 3.67 | 85 | 4.65 | 88 | 5.73 | 91 | 6.83 | 94 | 8.19 |
| 70 | 78 | 2.83 | 82 | 3.80 | 86 | 4.80 | 89 | 5.93 | 92 | 7.09 | 95 | 8.43 |
| 75 | 79 | 3.01 | 83 | 3.95 | 87 | 5.00 | 90 | 6.16 | 93 | 7.34 | 95 | 8.78 |
| 80 | 79 | 3.11 | 84 | 4.07 | 89 | 5.18 | 91 | 6.32 | 94 | 7.58 | 95 | 9.09 |

### 30EB-TNT SERIES



30EB-TNT

¾" male TNT bearing only.
Cast bronze body and arm. Body is hooded for a better seal of the bearing assembly.
Brass bearing sleeve, nipple, straight bore range nozzle and angular spreader nozzle (7° or 20°).
Stainless steel arm spring and bearing spring.

Highest point of stream is 7.5' above nozzle.*

| P.S.I. | Nozzle 1/8" x 3/32" 7° Dia. | G.P.M. | Nozzle 9/64" x 3/32" 7° Dia. | G.P.M. | Nozzle 5/32" x 3/32" 7° Dia. | G.P.M. | † Nozzle 11/64" x 3/32" 7° Dia. | G.P.M. | Nozzle 3/16" x 3/32" 7° Dia. | G.P.M. | Nozzle 3/16" x 1/8" 20° Dia. | G.P.M. | Nozzle 13/64" x 1/8" 20° Dia. | G.P.M. | Nozzle 7/32" x 1/8" 20° Dia. | G.P.M. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | 78 | 3.52 | 80 | 4.03 | 82 | 4.83 | 83 | 5.55 | 85 | 6.31 | 85 | 7.41 | 86 | [illegible] | 83 | [illegible] |
| 30 | 79 | 3.87 | 81 | 4.42 | 85 | 5.22 | 85 | 6.07 | 91 | 6.93 | 91 | 8.14 | 94 | 9.15 | 93 | 10.2 |
| 35 | 80 | 4.53 | 82 | 4.83 | 87 | 5.71 | 90 | 6.57 | 93 | 7.52 | 94 | 8.83 | 97 | 9.94 | 100 | 11.1 |
| 40 | 81 | 4.47 | 83 | 5.16 | 88 | 6.11 | 92 | 7.03 | 95 | 8.07 | 95 | 9.44 | 99 | 10.7 | 102 | 11.9 |
| 45 | 82 | 4.77 | 84 | 5.52 | 89 | 6.48 | 93 | 7.46 | 98 | 8.57 | 98 | 10.1 | 101 | 11.3 | 104 | 12.7 |
| 50 | 83 | 5.02 | 85 | 5.85 | 90 | 6.84 | 95 | 7.87 | 100 | 9.04 | 100 | 10.6 | 103 | 11.9 | 105 | 13.3 |
| 55 | 84 | 5.27 | 85 | 6.10 | 91 | 7.17 | 96 | 8.25 | 101 | 9.46 | 101 | 11.1 | 104 | 12.5 | 107 | 13.9 |
| 60 | 85 | 5.51 | 87 | 6.34 | 92 | 7.47 | 97 | 8.59 | 102 | 9.85 | 102 | 11.6 | 105 | 13.0 | 108 | 14.0 |

30EBW-TNT

Same as the 30B above except has a brass plug instead of spreader nozzle. Single nozzle for slower precipitation rate. TNT bearing only.

Highest point of stream is 7.5' above nozzle.*

| P.S.I. | Nozzle 1/8" Dia. | G.P.M. | Nozzle 9/64" Dia. | G.P.M. | Nozzle 5/32" Dia. | G.P.M. | † Nozzle 11/64" Dia. | G.P.M. | Nozzle 3/16" Dia. | G.P.M. | Nozzle 13/64" Dia. | G.P.M. | Nozzle 7/32" Dia. | G.P.M. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | 78 | 2.25 | 80 | 2.59 | 82 | 3.52 | 83 | 4.23 | 83 | 5.03 | 93 | 5.83 | 94 | 6.83 |
| 30 | 79 | 2.47 | 81 | 3.15 | 85 | 3.85 | 84 | 4.63 | 91 | 5.53 | 94 | 6.51 | 95 | 7.38 |
| 35 | 80 | 2.63 | 82 | 3.40 | 87 | 4.15 | 90 | 5.02 | 94 | 5.97 | 97 | 7.04 | 100 | 8.28 |
| 40 | 81 | 2.87 | 83 | 3.63 | 88 | 4.45 | 92 | 5.37 | 95 | 6.41 | 99 | 7.63 | 102 | 8.97 |
| 45 | 82 | 3.05 | 84 | 3.84 | 89 | 4.77 | 93 | 5.70 | 98 | 6.81 | 101 | 8.07 | 104 | 9.41 |
| 50 | 83 | 3.22 | 85 | 4.04 | 90 | 4.94 | 95 | 6.01 | 100 | 7.14 | 103 | 8.49 | 106 | 9.94 |
| 55 | 84 | 3.39 | 86 | 4.22 | 91 | 5.22 | 96 | 6.30 | 101 | 7.51 | 104 | 8.87 | 107 | 10.3 |
| 60 | 85 | 3.55 | 87 | 4.38 | 92 | 5.44 | 97 | 6.55 | 102 | 7.82 | 105 | 9.20 | 108 | 10.6 |

*Shown for standard nozzle at normal operating pressure.

† Indicates standard nozzle size.
Bold face in chart indicates recommended working pressures for best distribution.
SHADED AREAS IN CHARTS INDICATE ONLY AVAILABLE WITH TNT BEARING

TABLE 4.

SPRINKLER IRRIGATION

TABLE 23.5 CORRECTION FACTOR F FOR FRICTION LOSSES IN ALUMINUM PIPES WITH MULTIPLE OUTLETS*

| No. of Sprinklers | Correction Factor, F: 1st Sprinkler One Sprinkler Interval from Main | Correction Factor, F: 1st Sprinkler One-Half Sprinkler Interval from Main |
|---|---|---|
| 1 | 1.000 | 1.000 |
| 2 | 0.625 | 0.500 |
| 4 | 0.469 | 0.393 |
| 6 | 0.421 | 0.369 |
| 8 | 0.398 | 0.358 |
| 10 | 0.385 | 0.353 |
| 12 | 0.376 | 0.349 |
| 14 | 0.370 | 0.347 |
| 16 | 0.365 | 0.345 |
| 18 | 0.361 | 0.343 |
| 20 | 0.359 | 0.342 |
| 25 | 0.354 | 0.340 |
| 30 | 0.350 | 0.339 |
| 35 | 0.347 | 0.338 |
| 40 | 0.345 | 0.338 |
| 50 | 0.343 | 0.337 |
| 100 | 0.338 | 0.335 |

* Adapted from Christiansen (1948) and Jensen and Frantini (1957).

TABLE 5.

REFERENCES:

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2. Schwab Glenn O., 1976, second edition, Soil and Water Conservation Engineering, John Wiley & Sons, New York.

3. Rain Bird Sprinkler Mfg. Co. (Canada) Ltd., 1979-1980 Irrigation Equipment.