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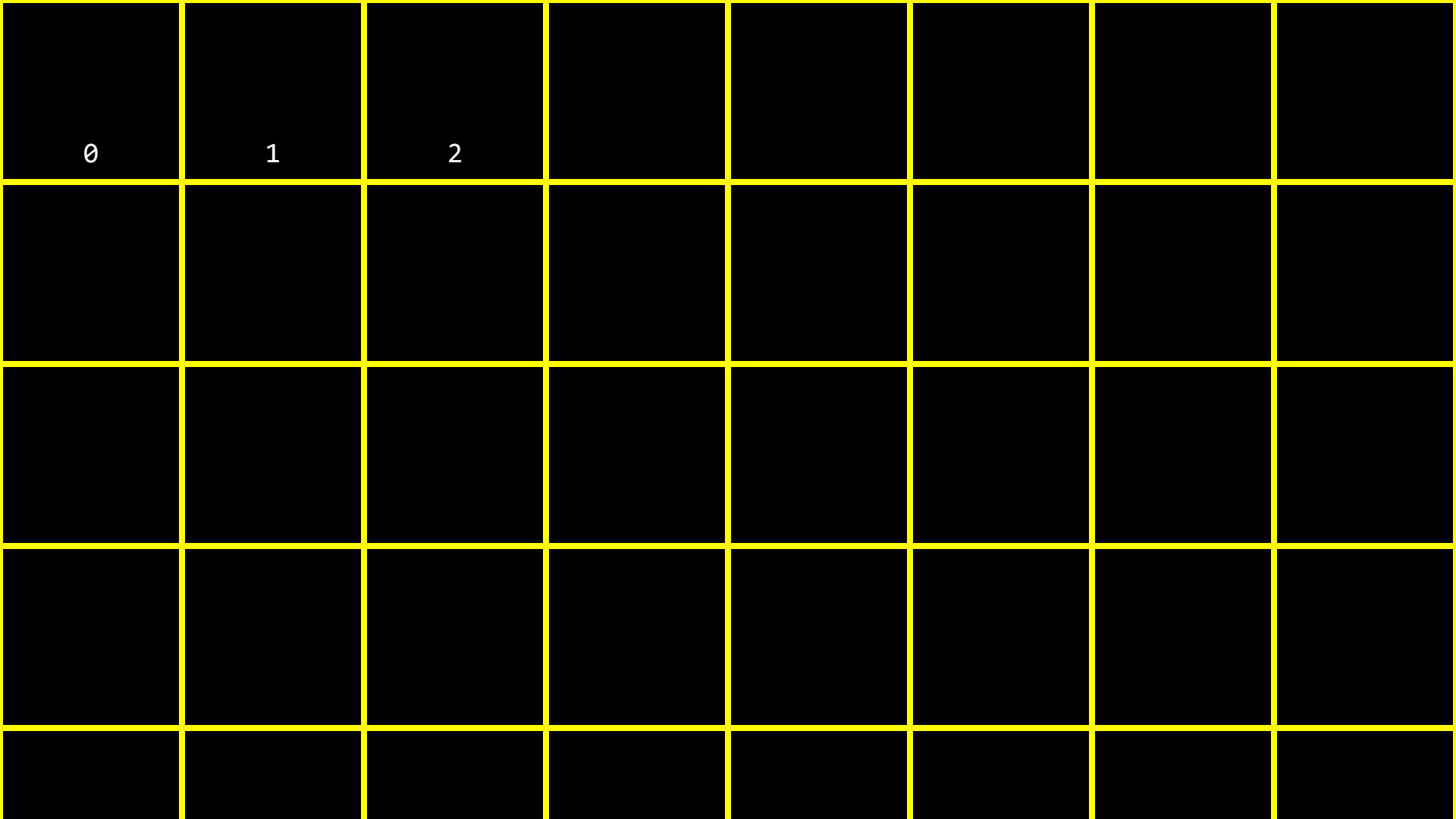
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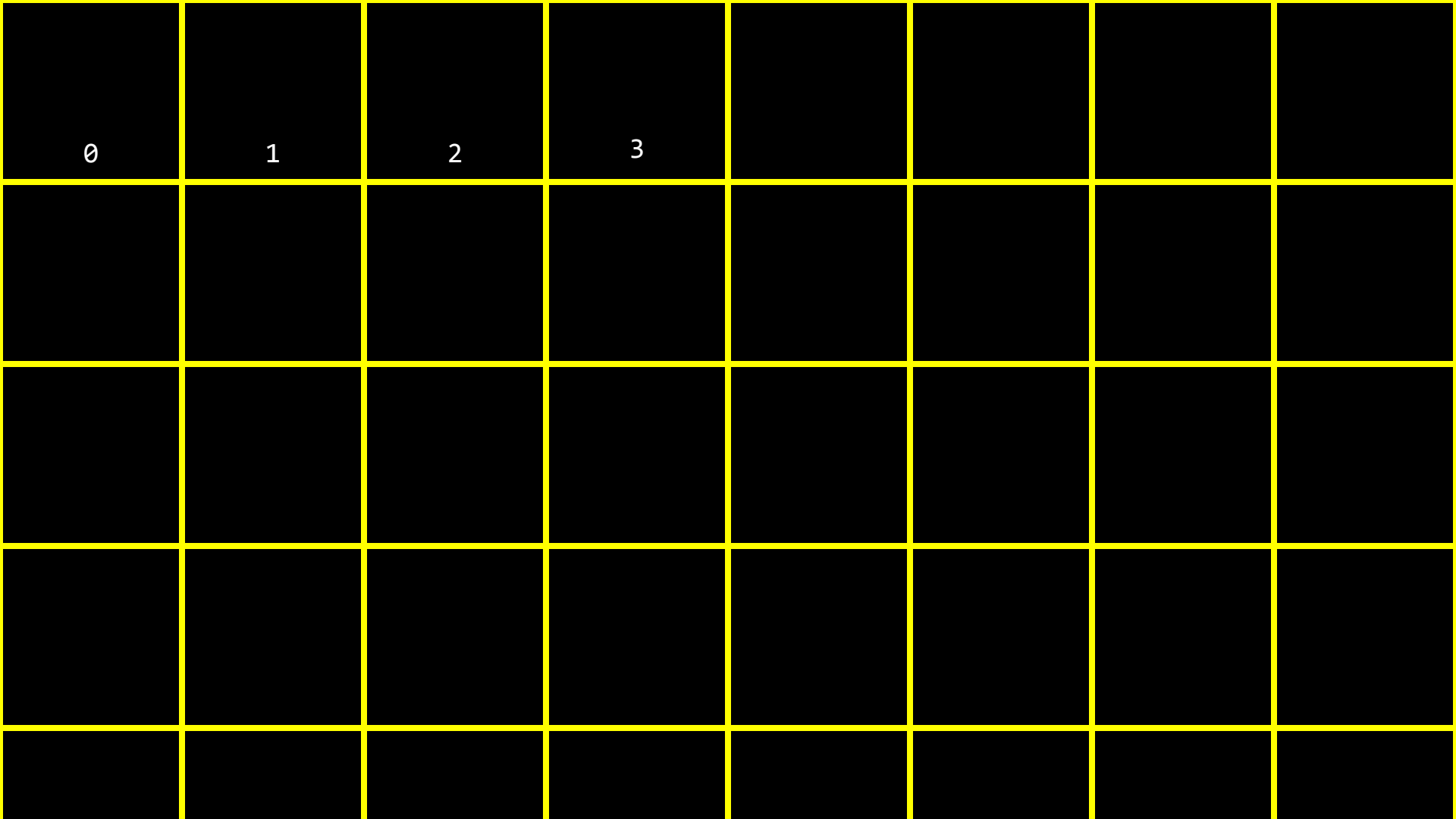
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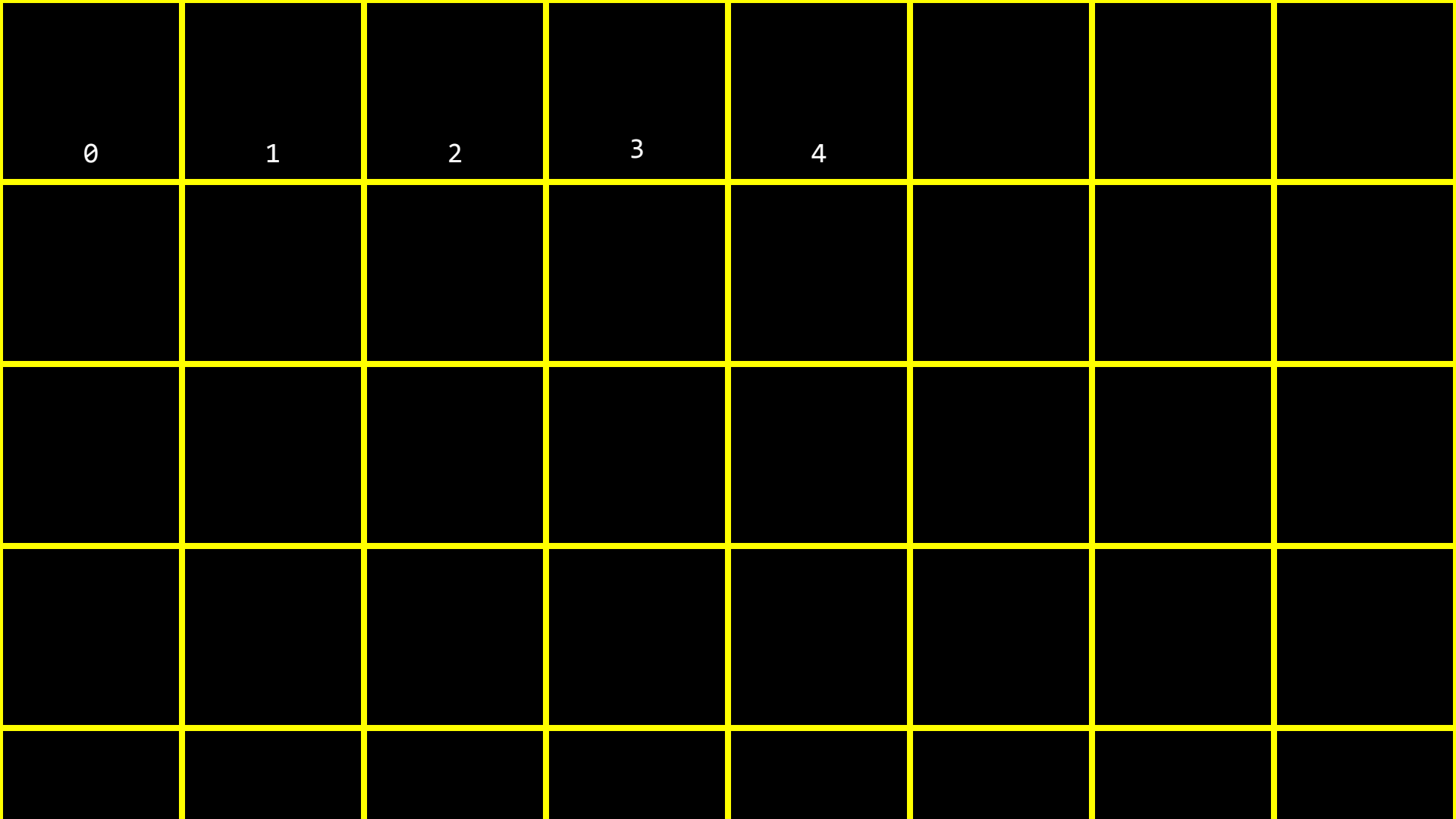
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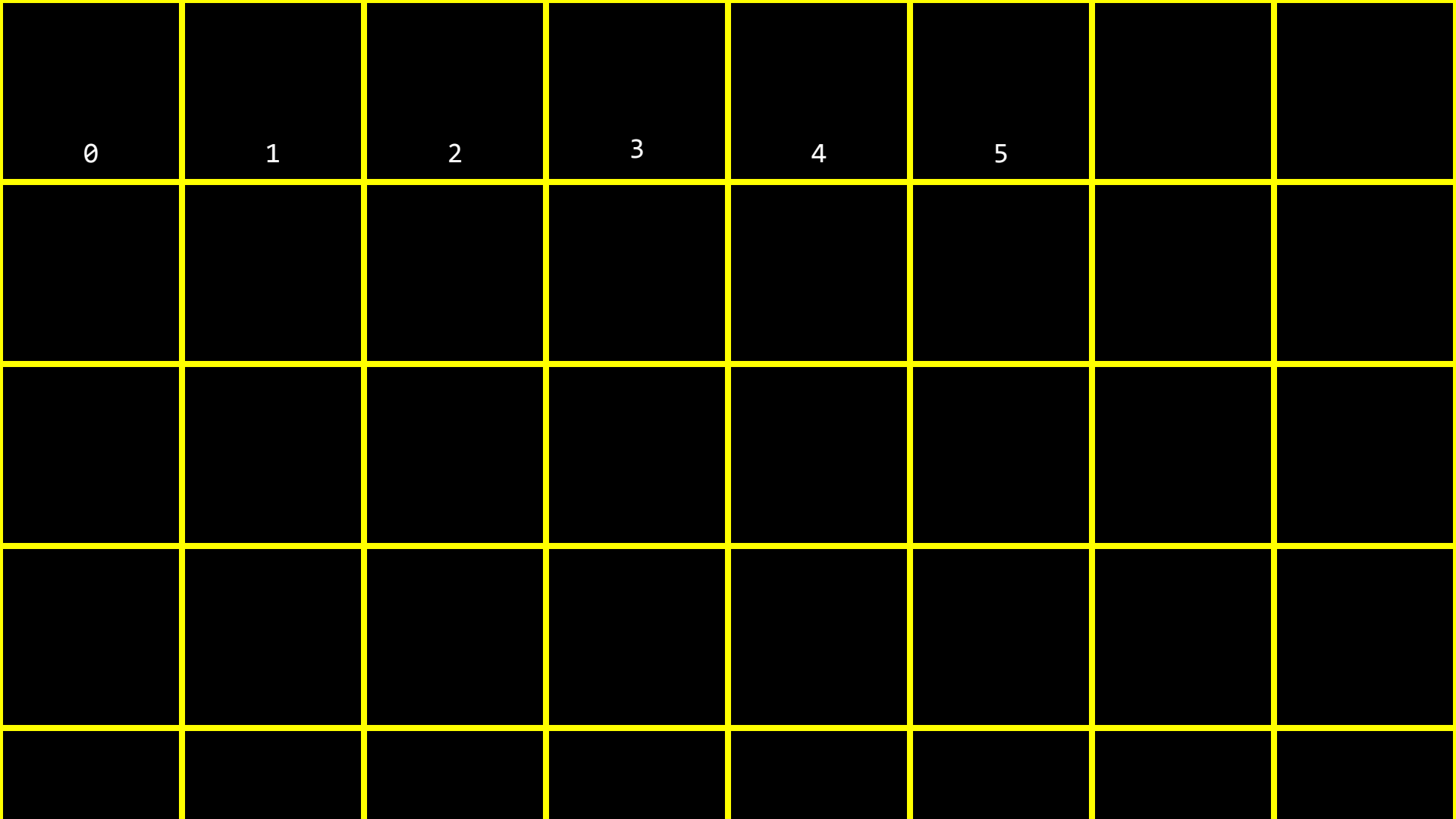
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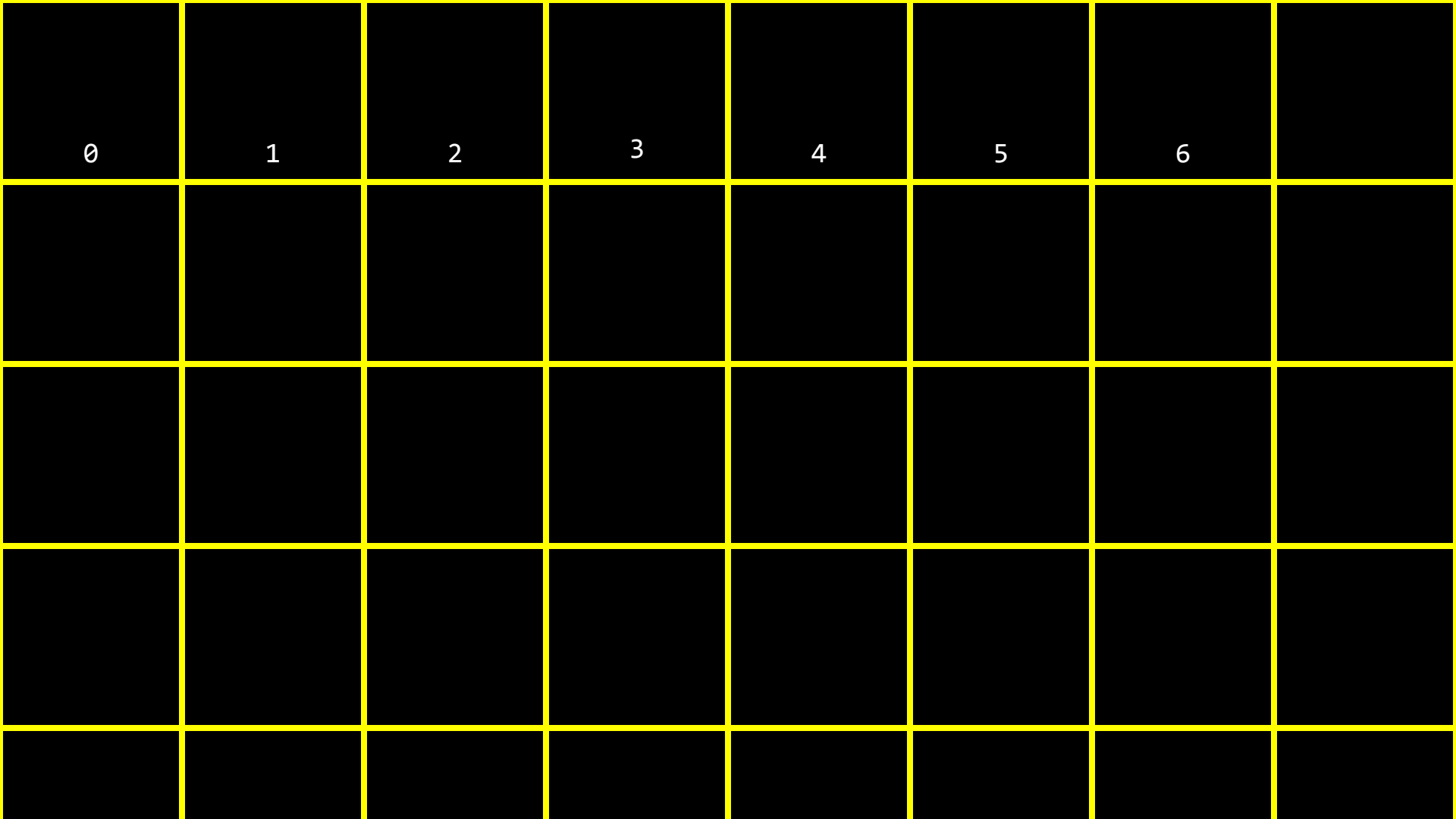
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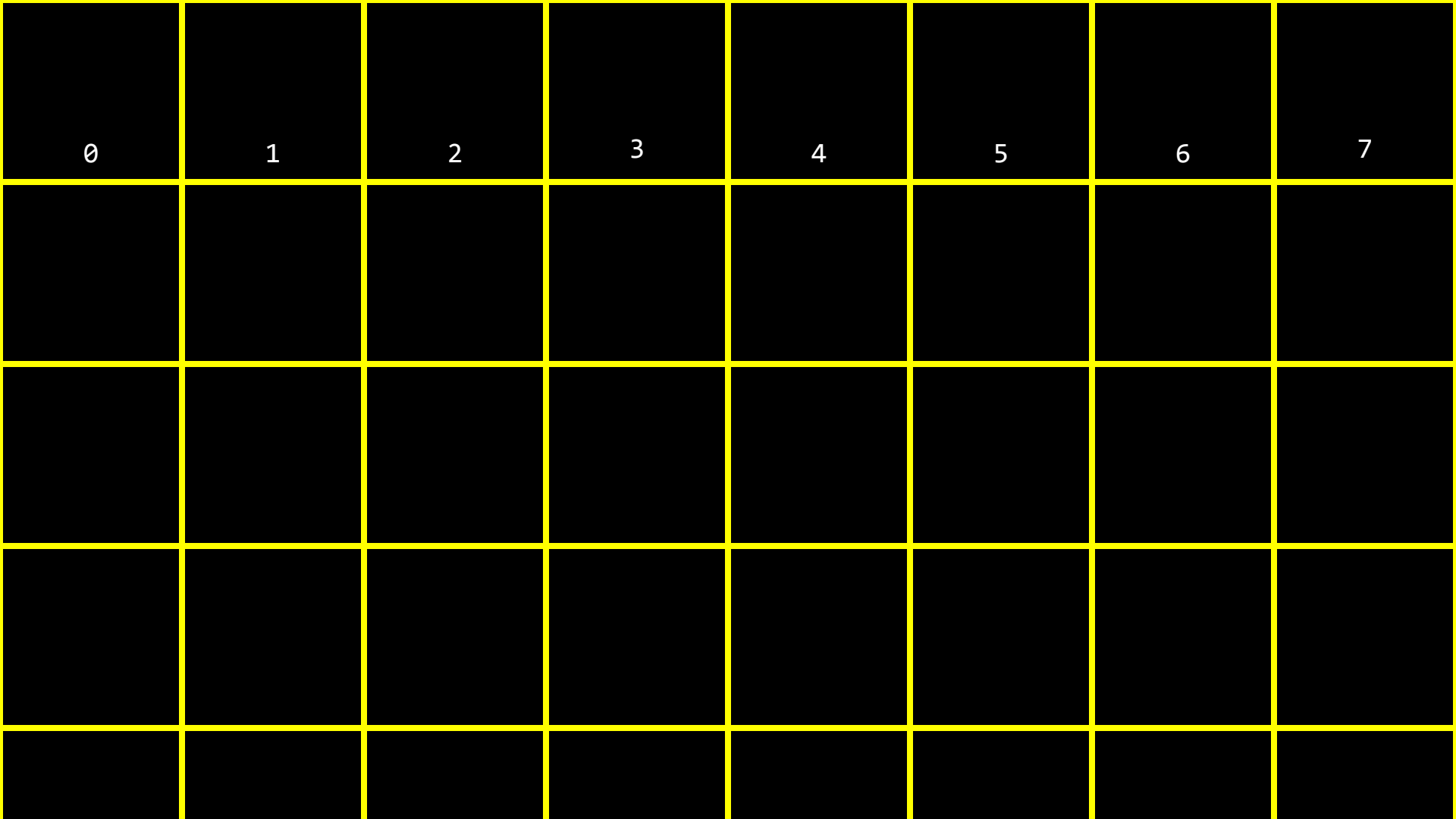
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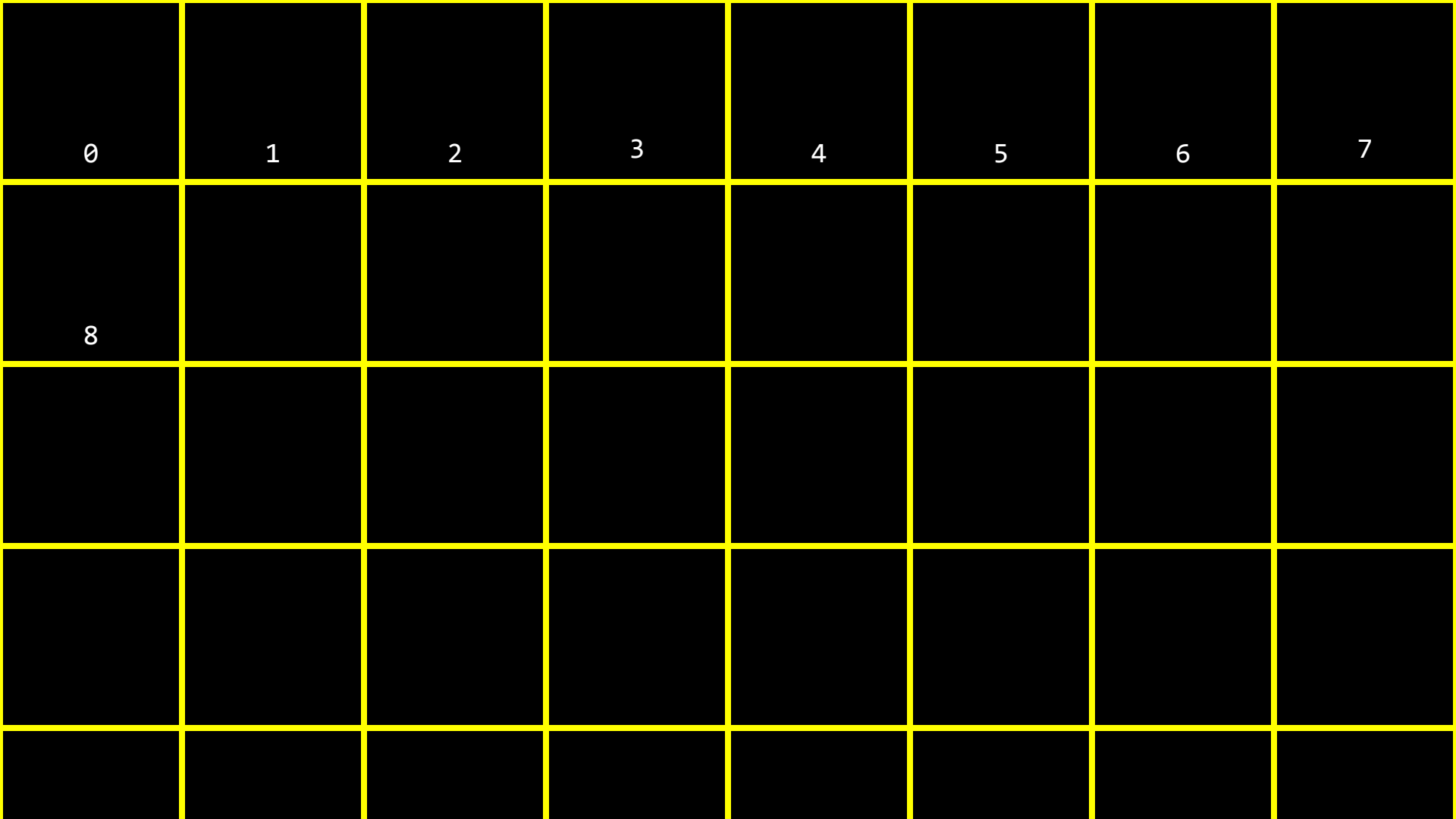
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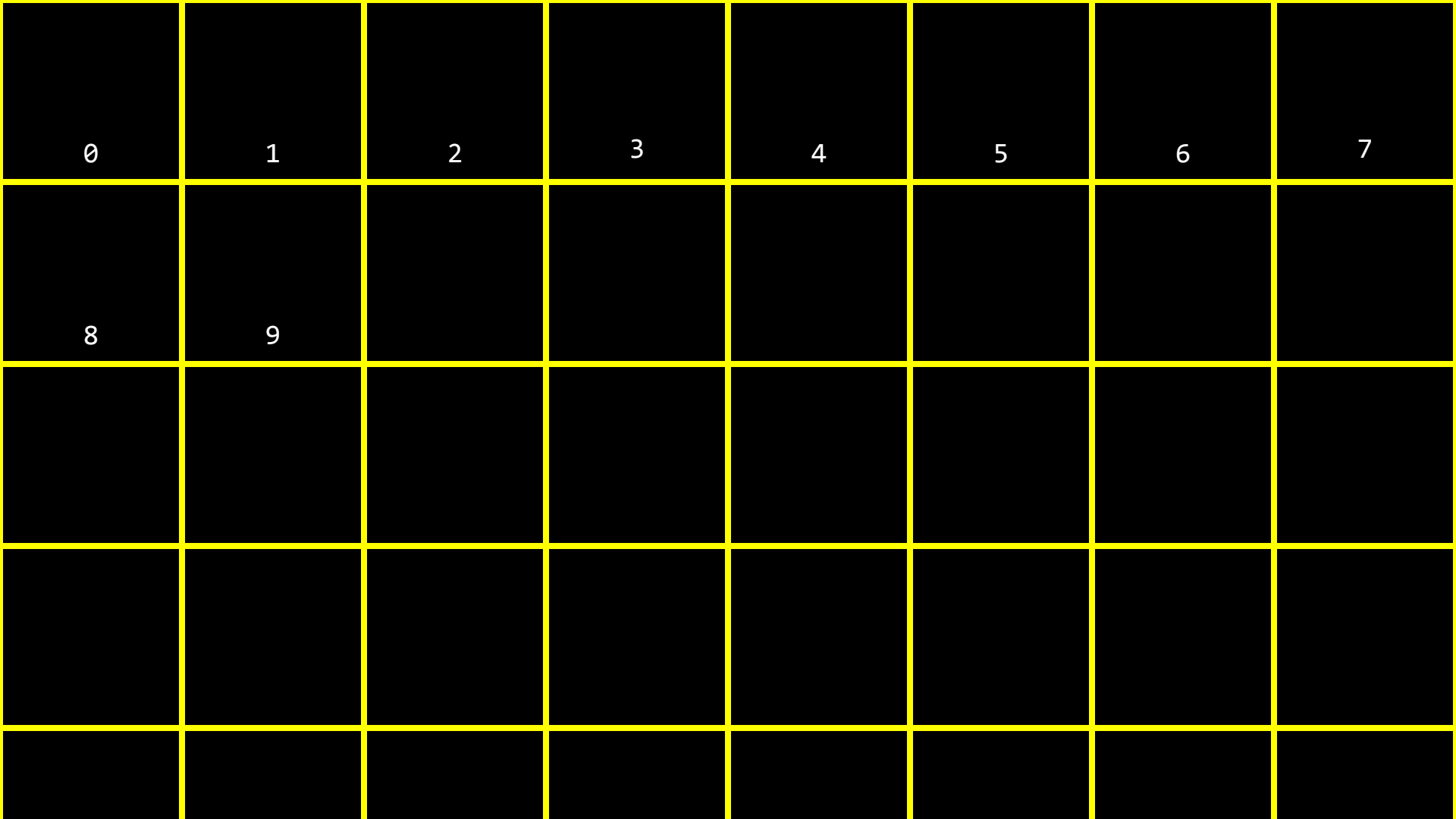
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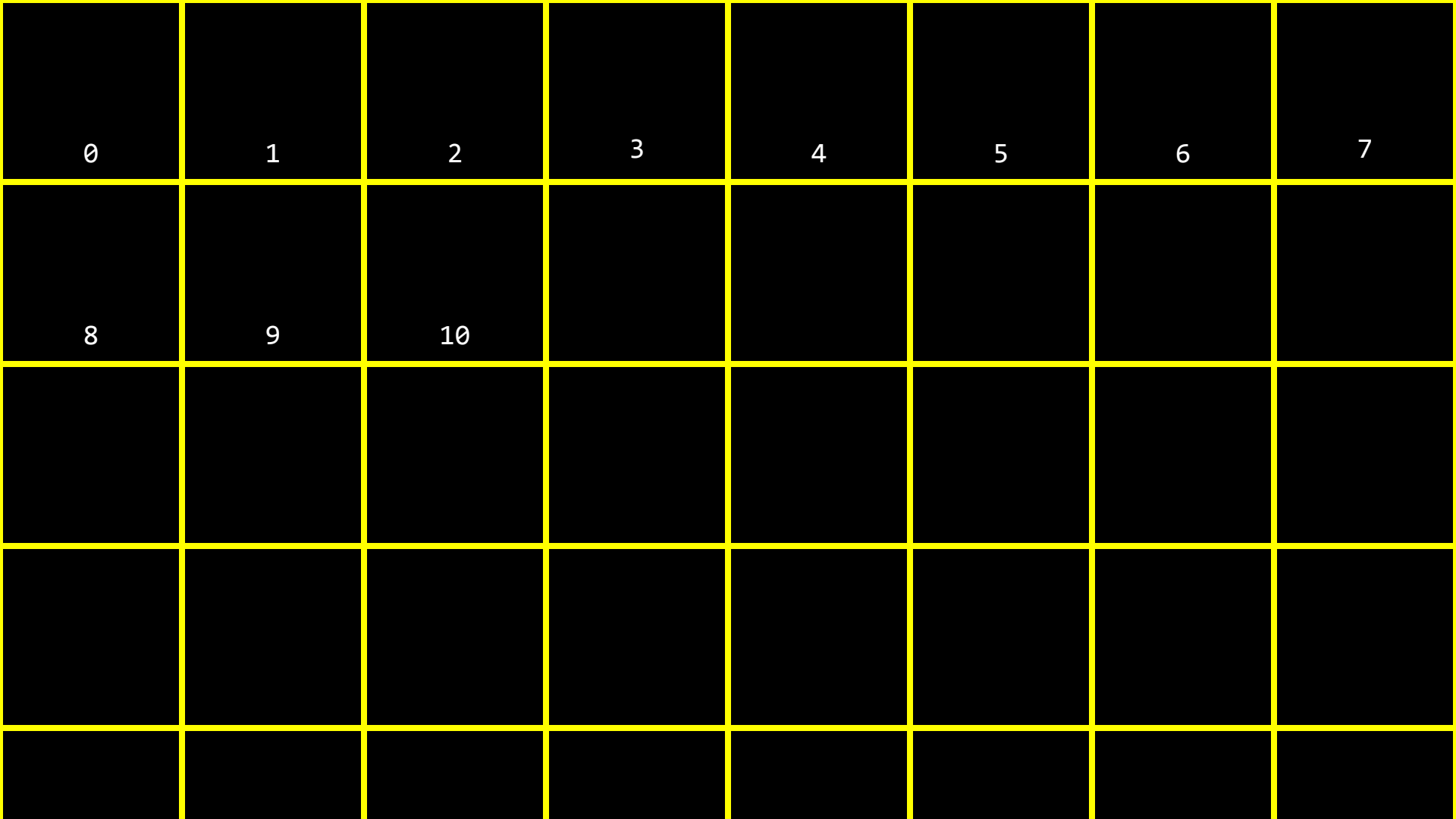
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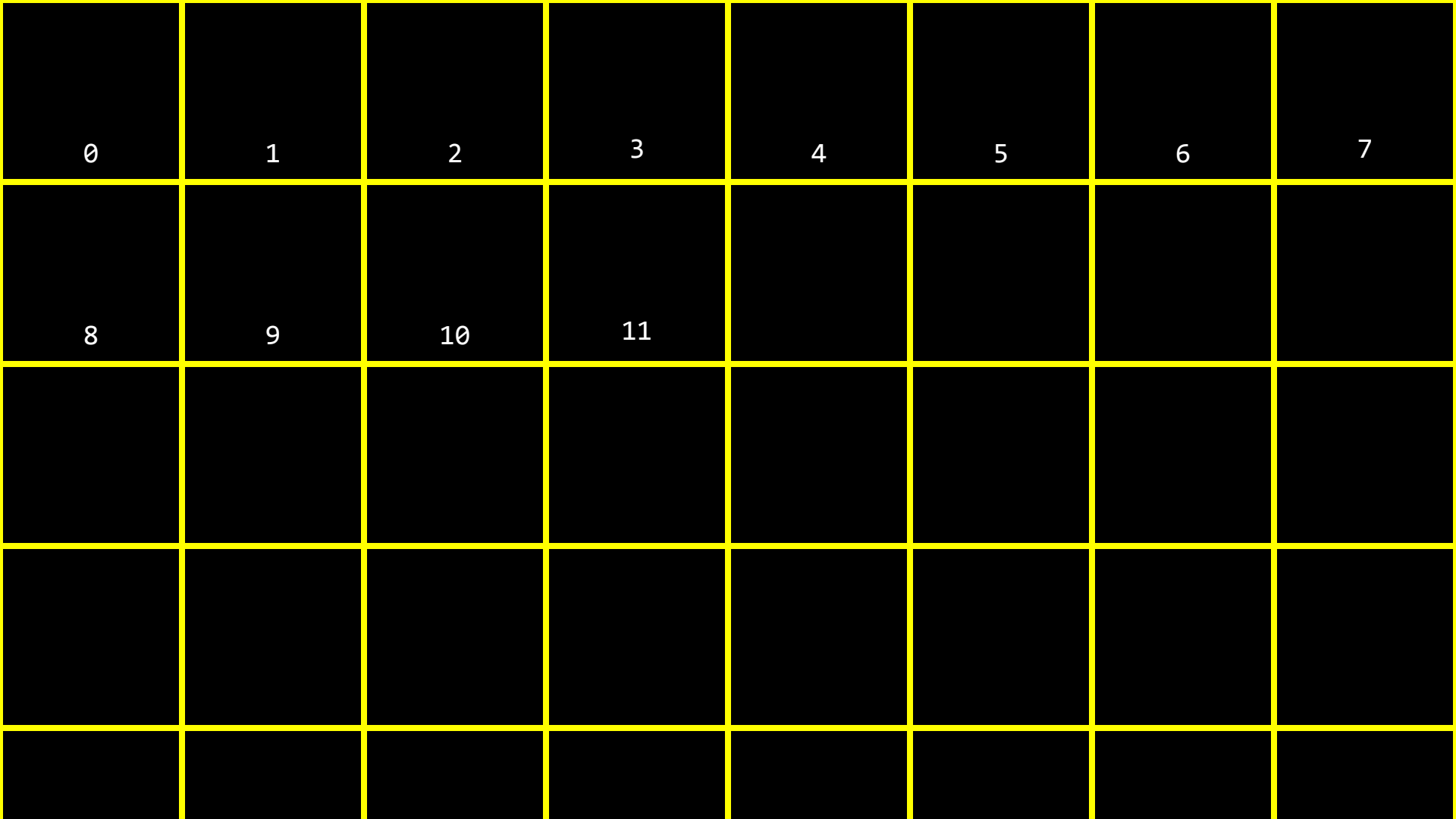
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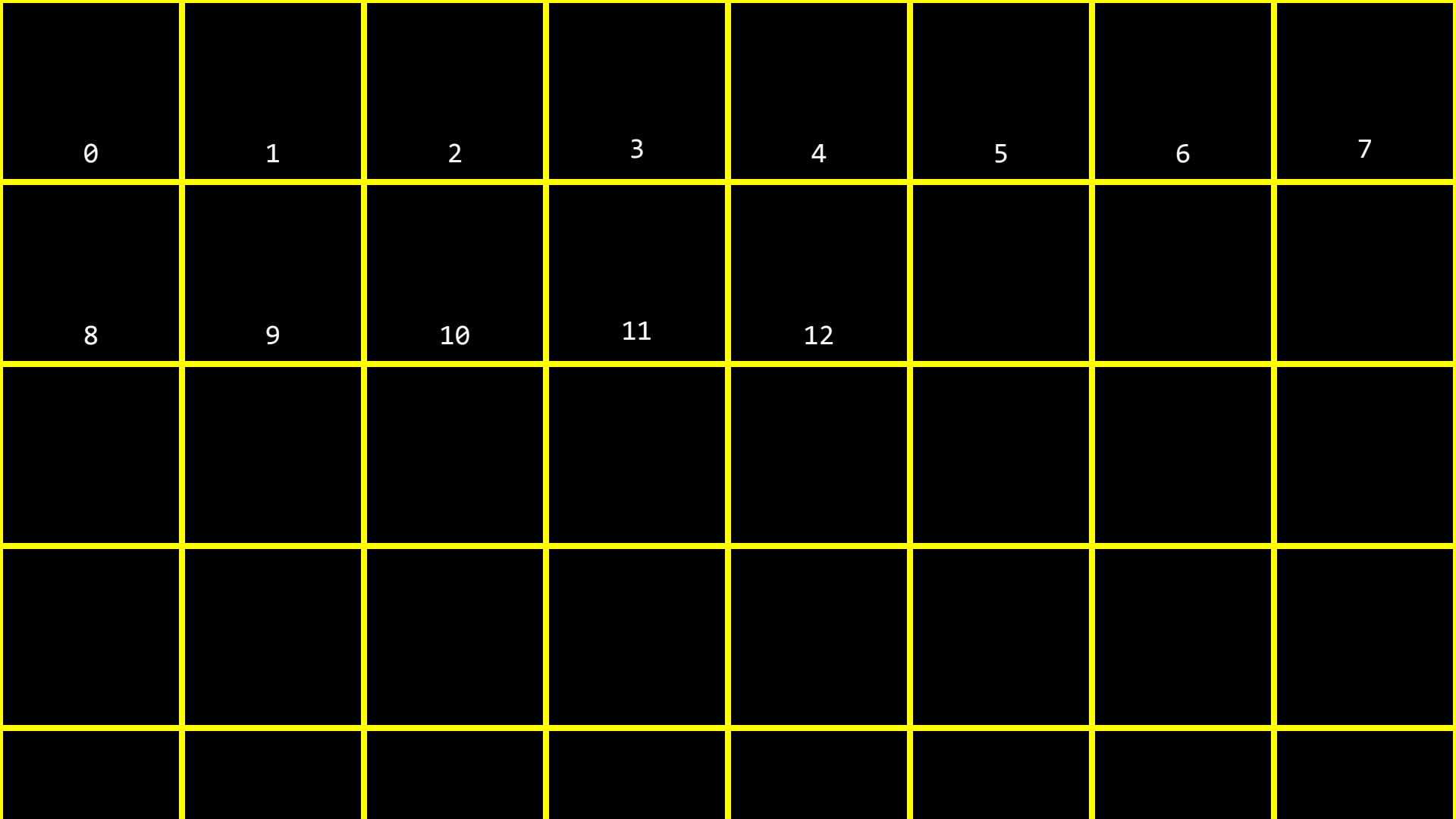
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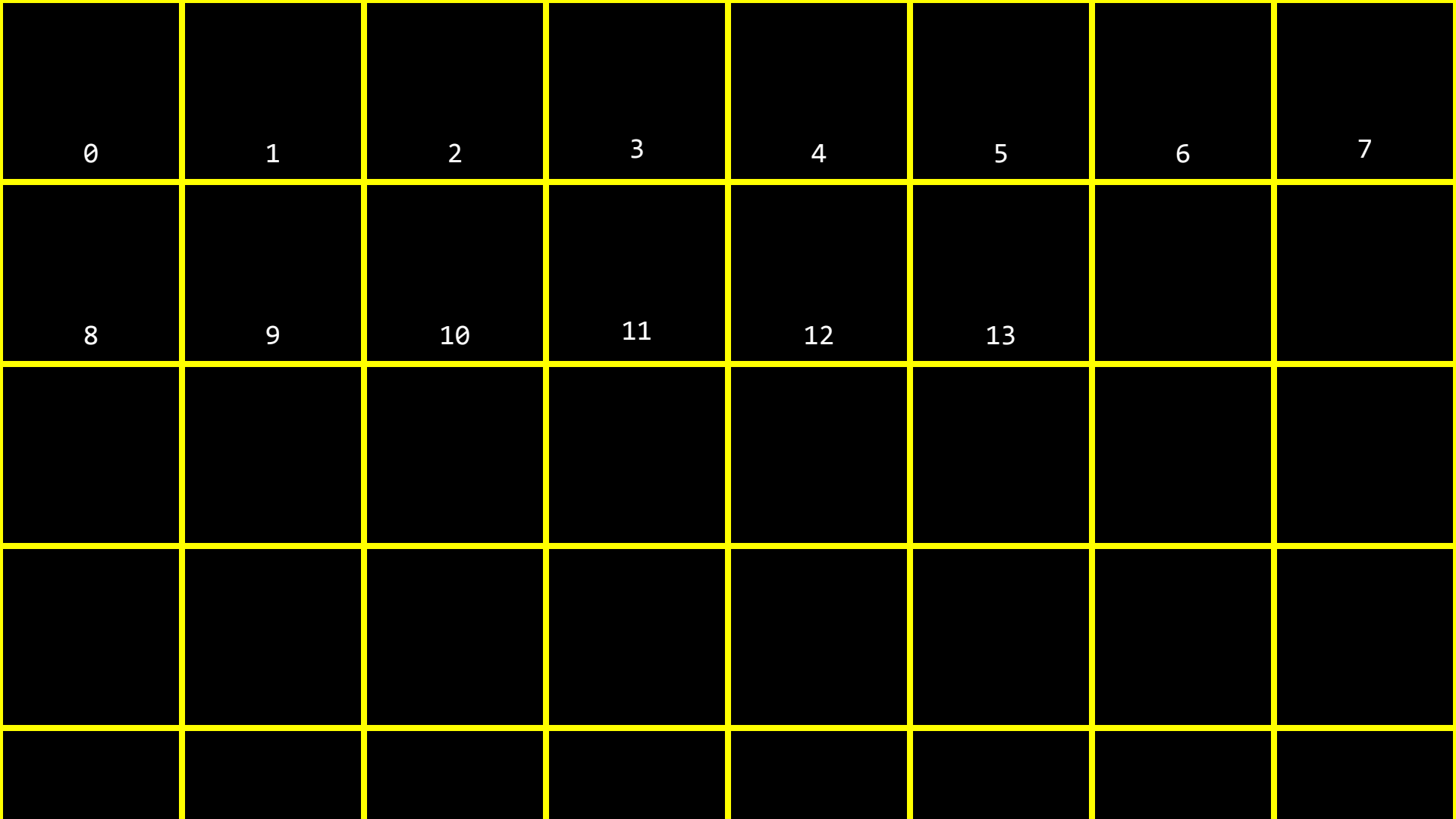
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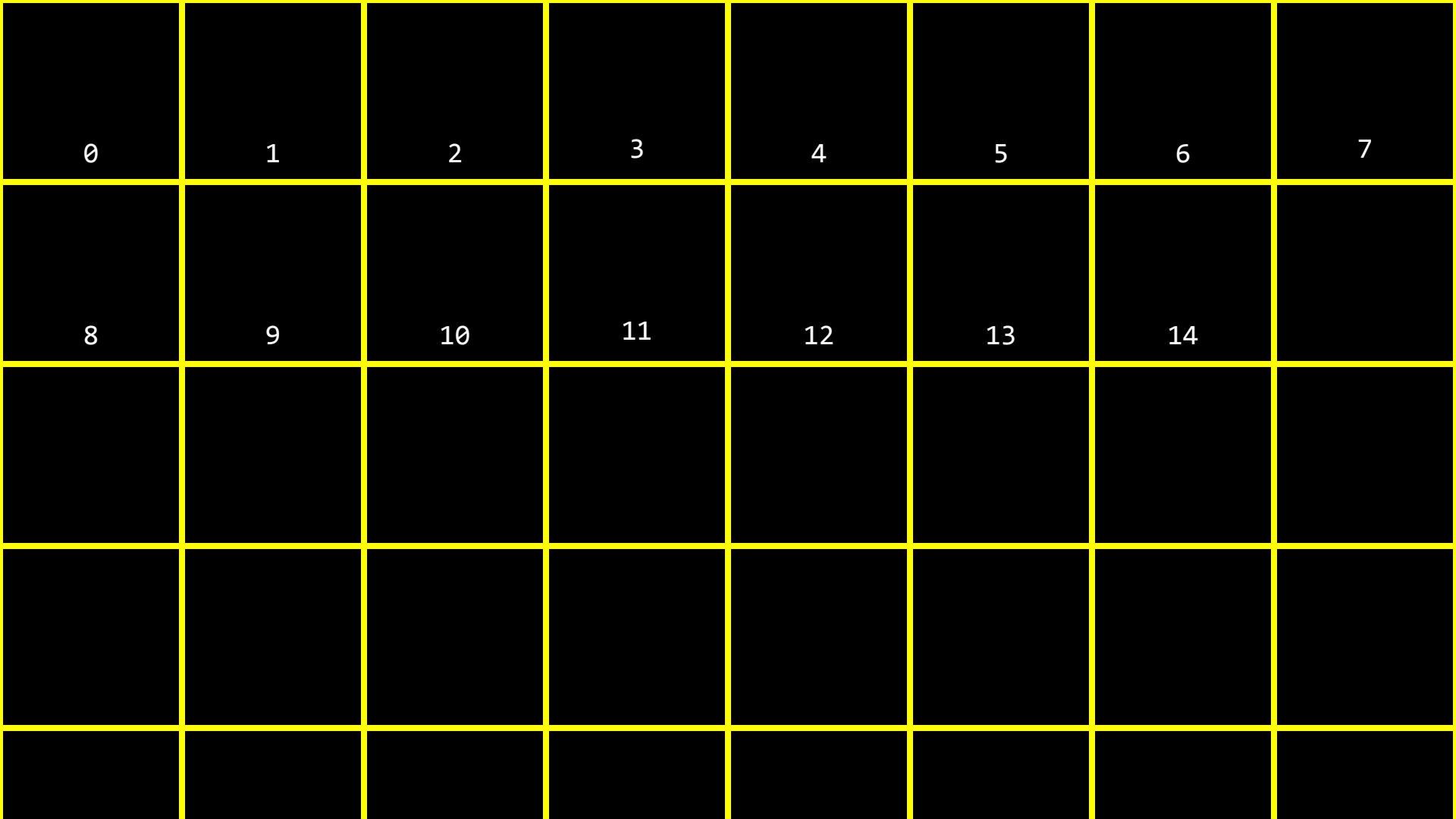
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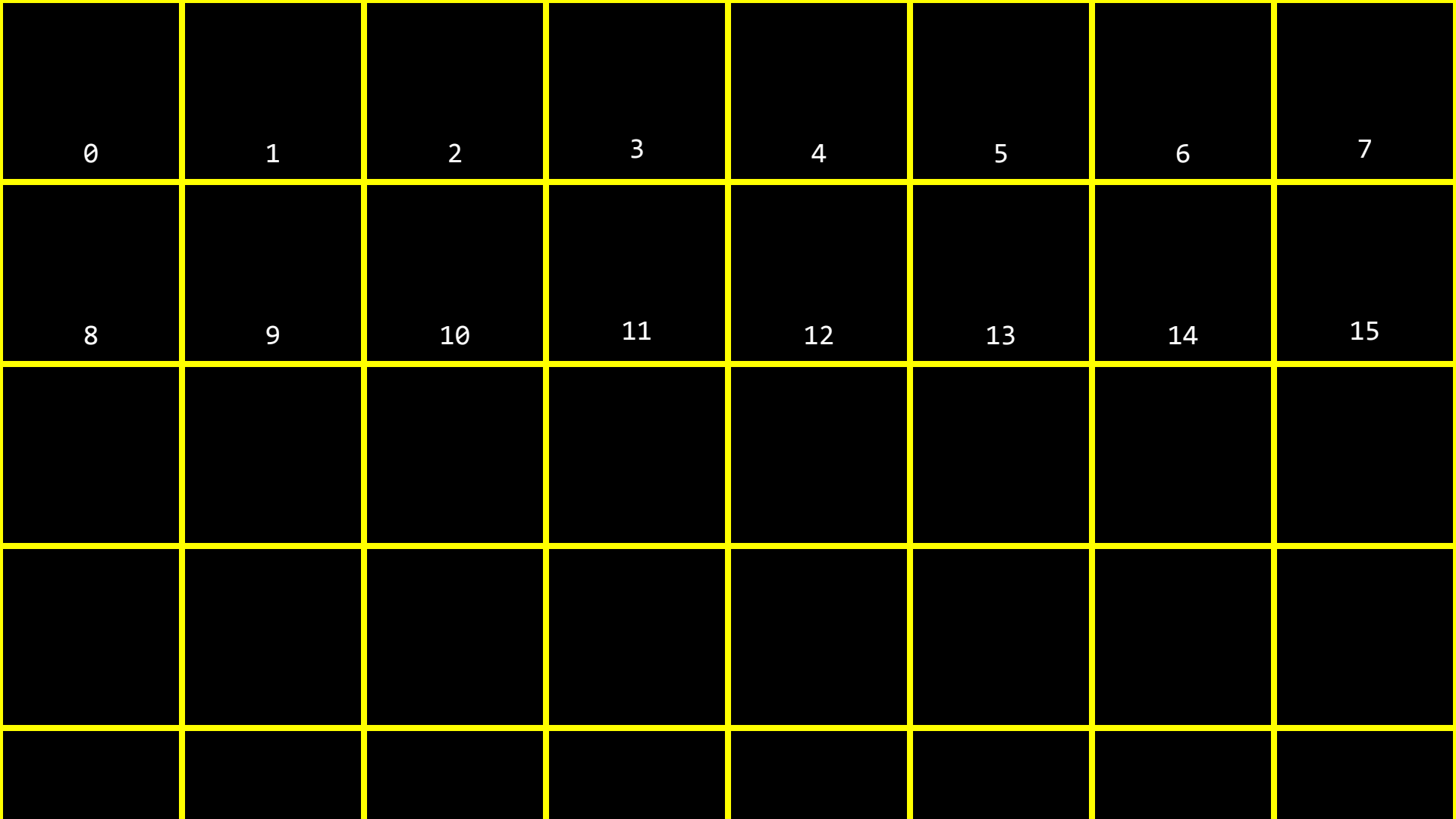
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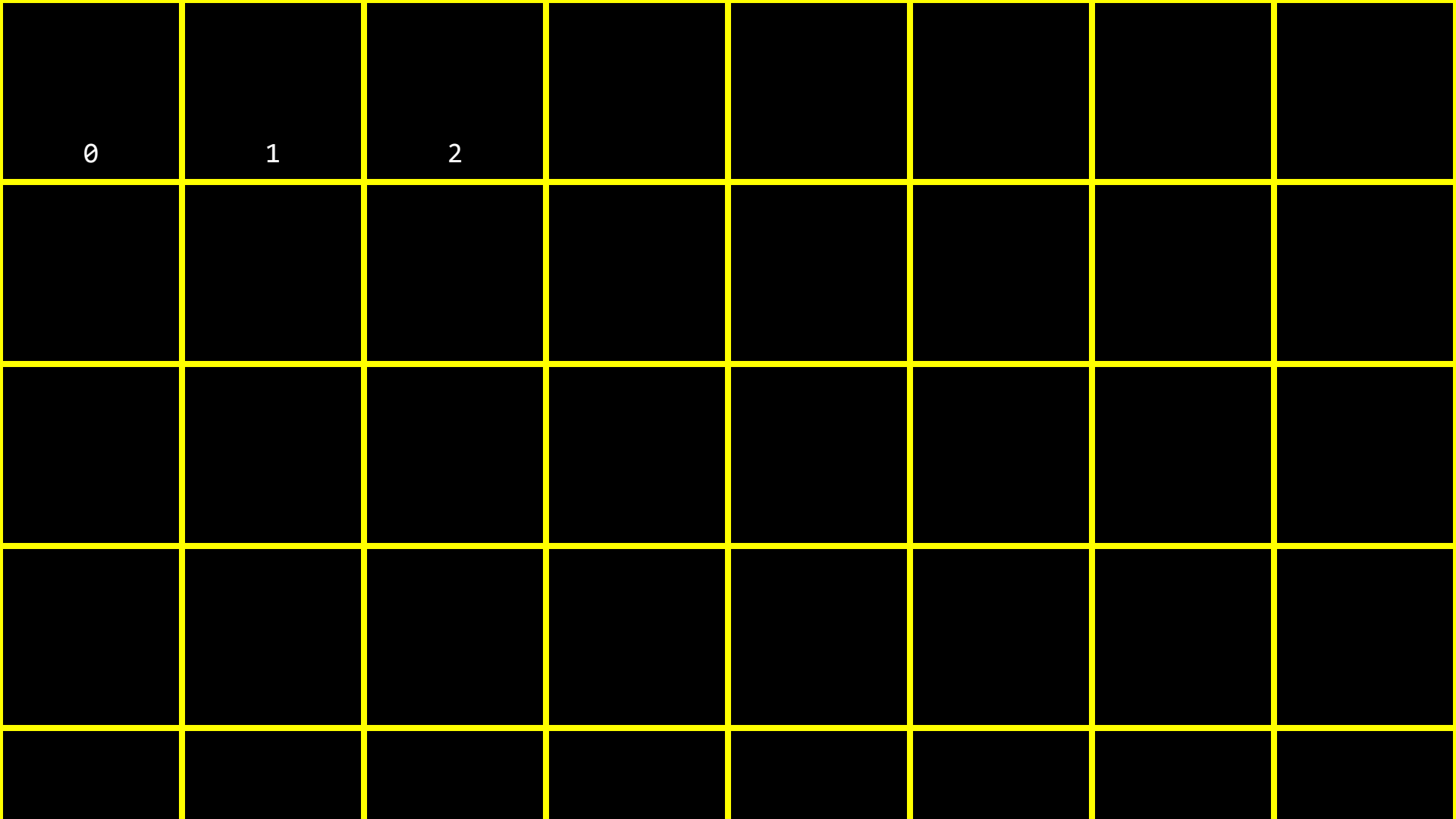
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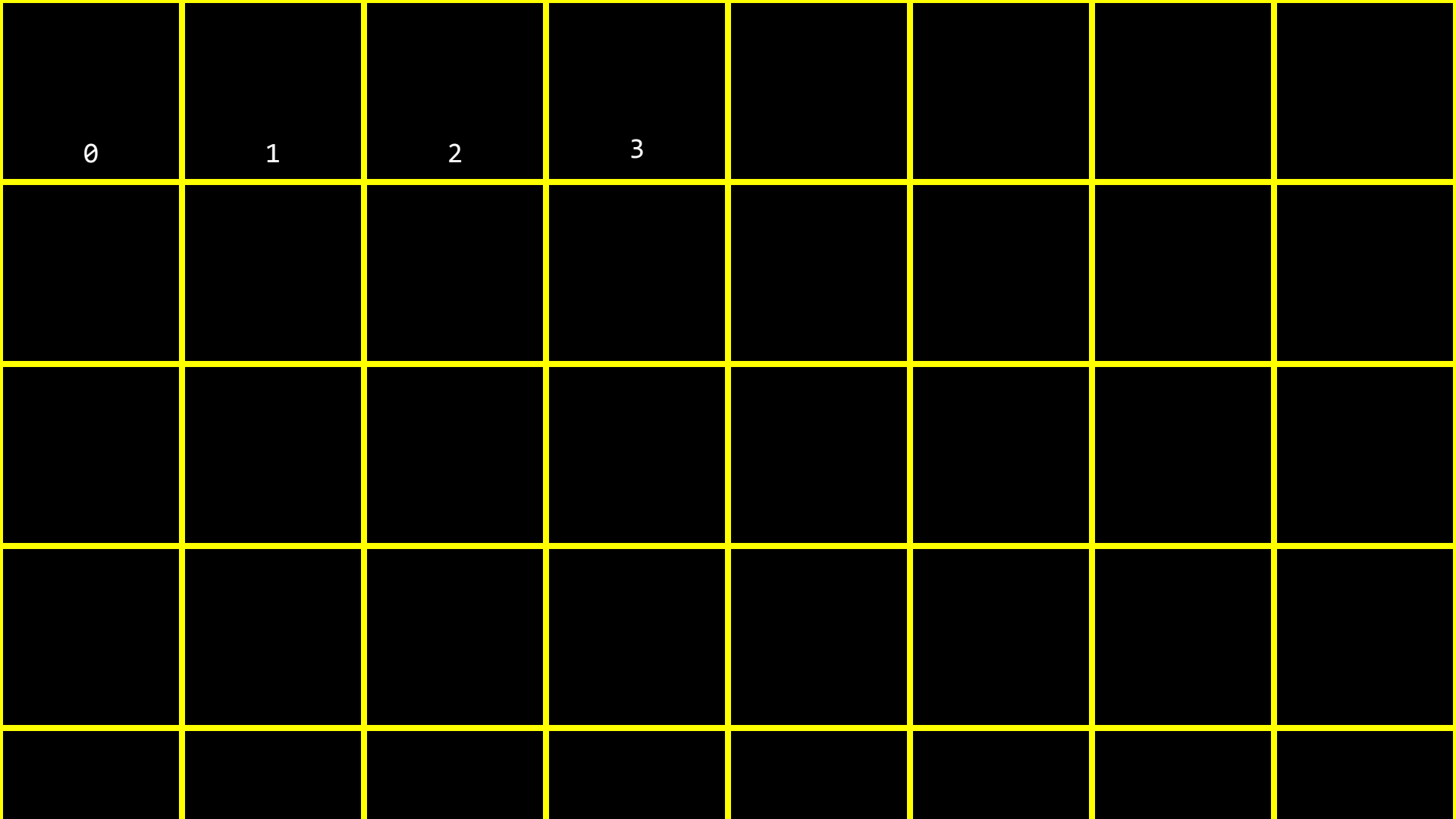
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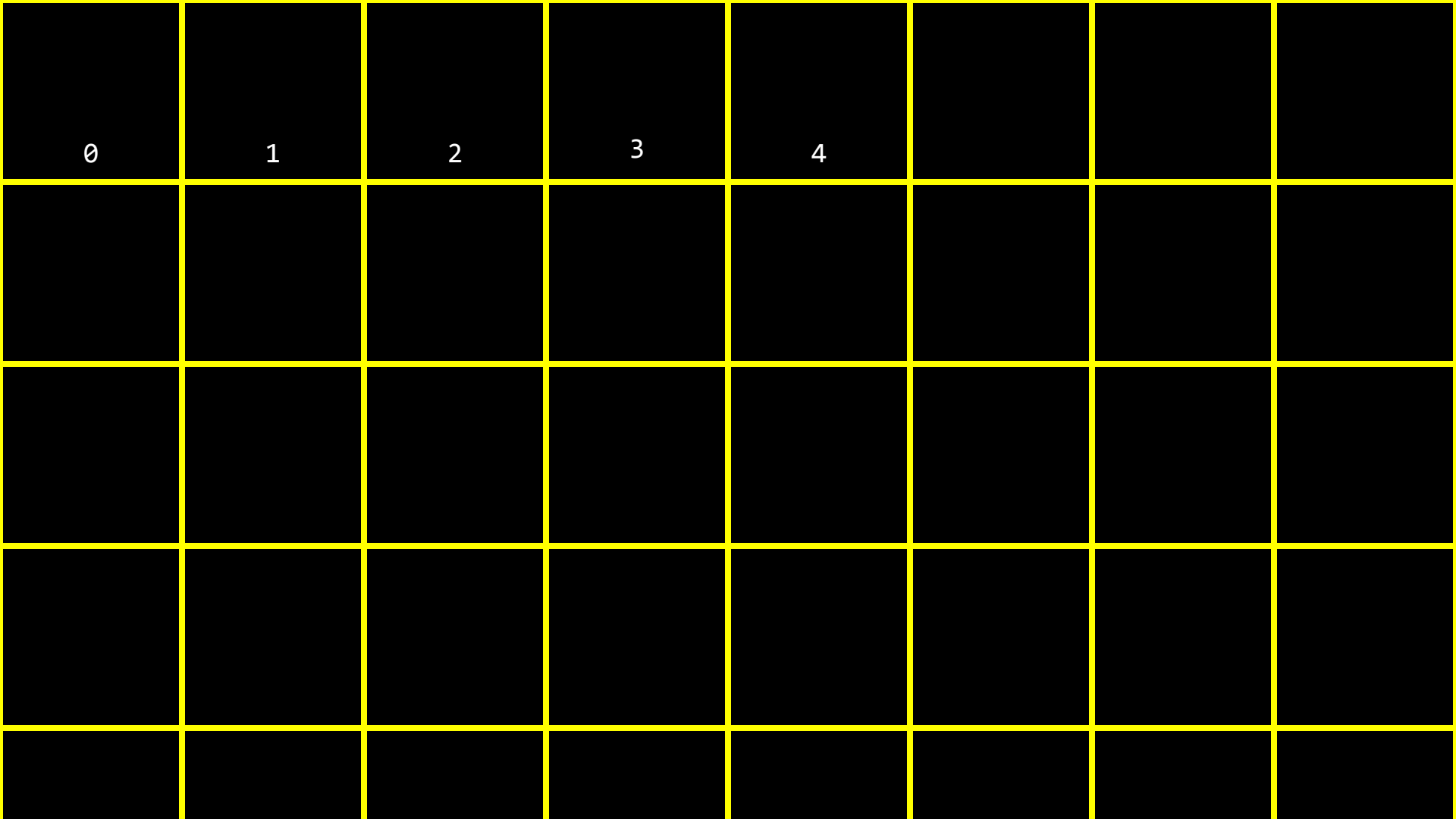
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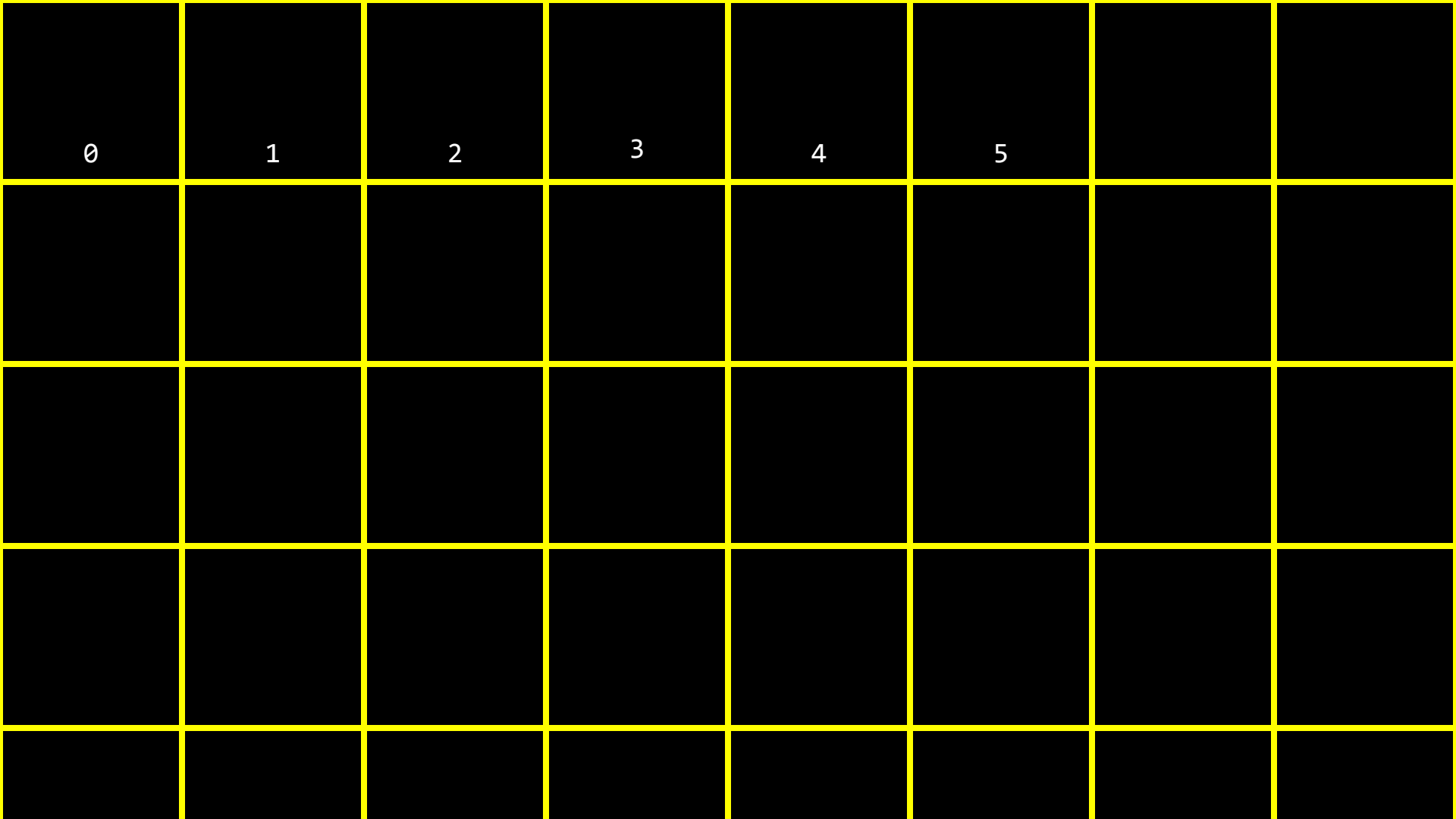
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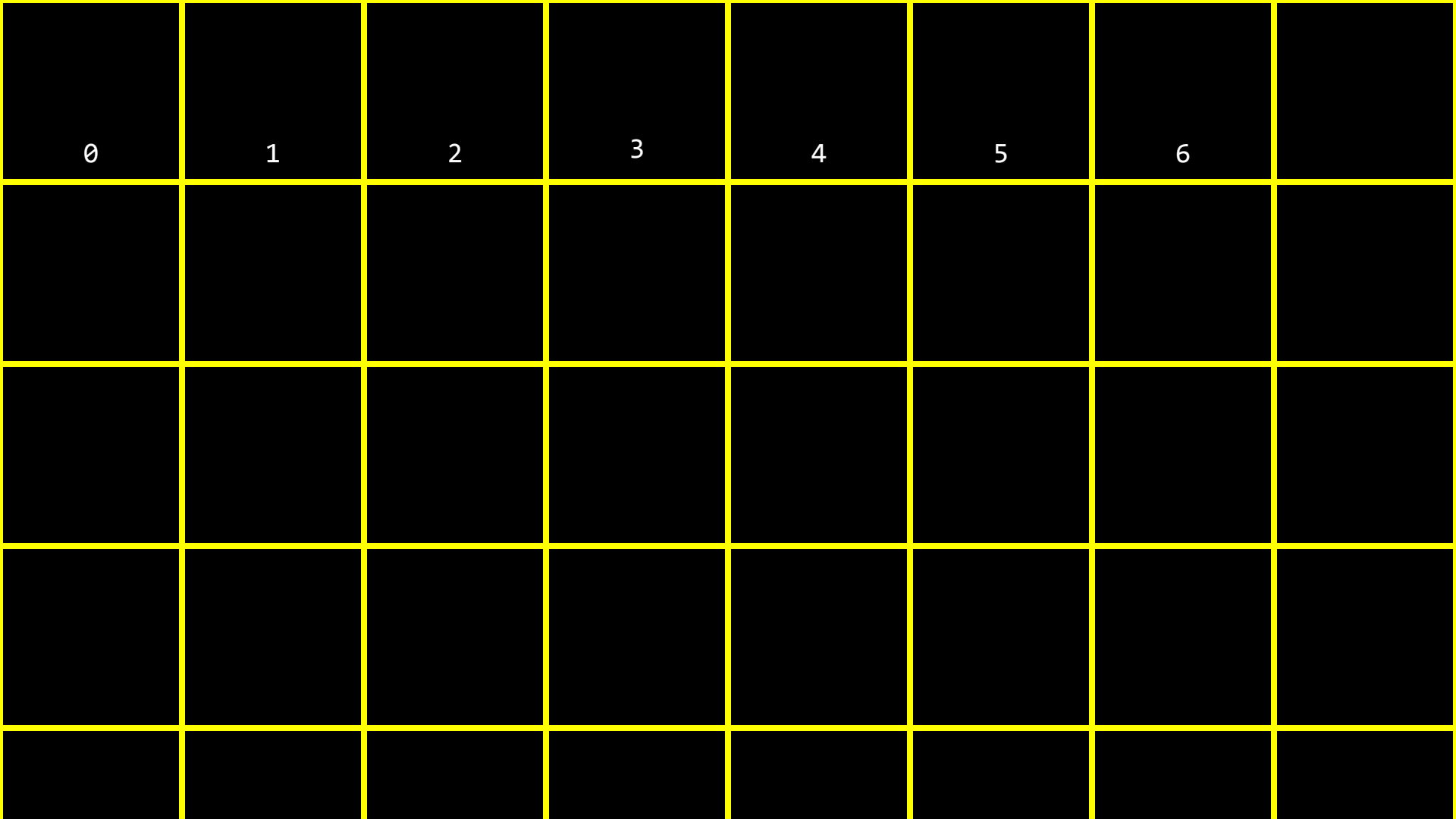
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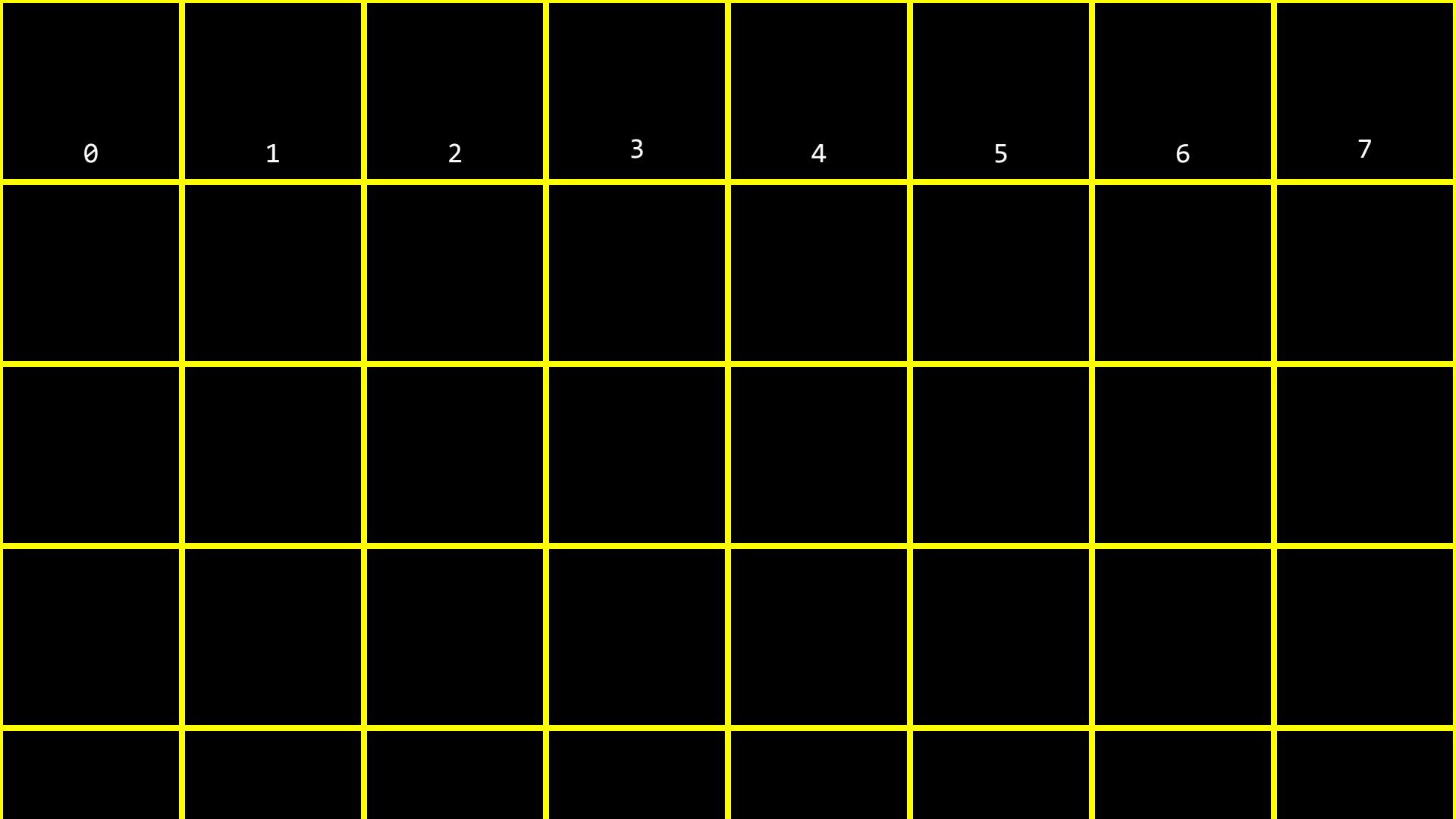
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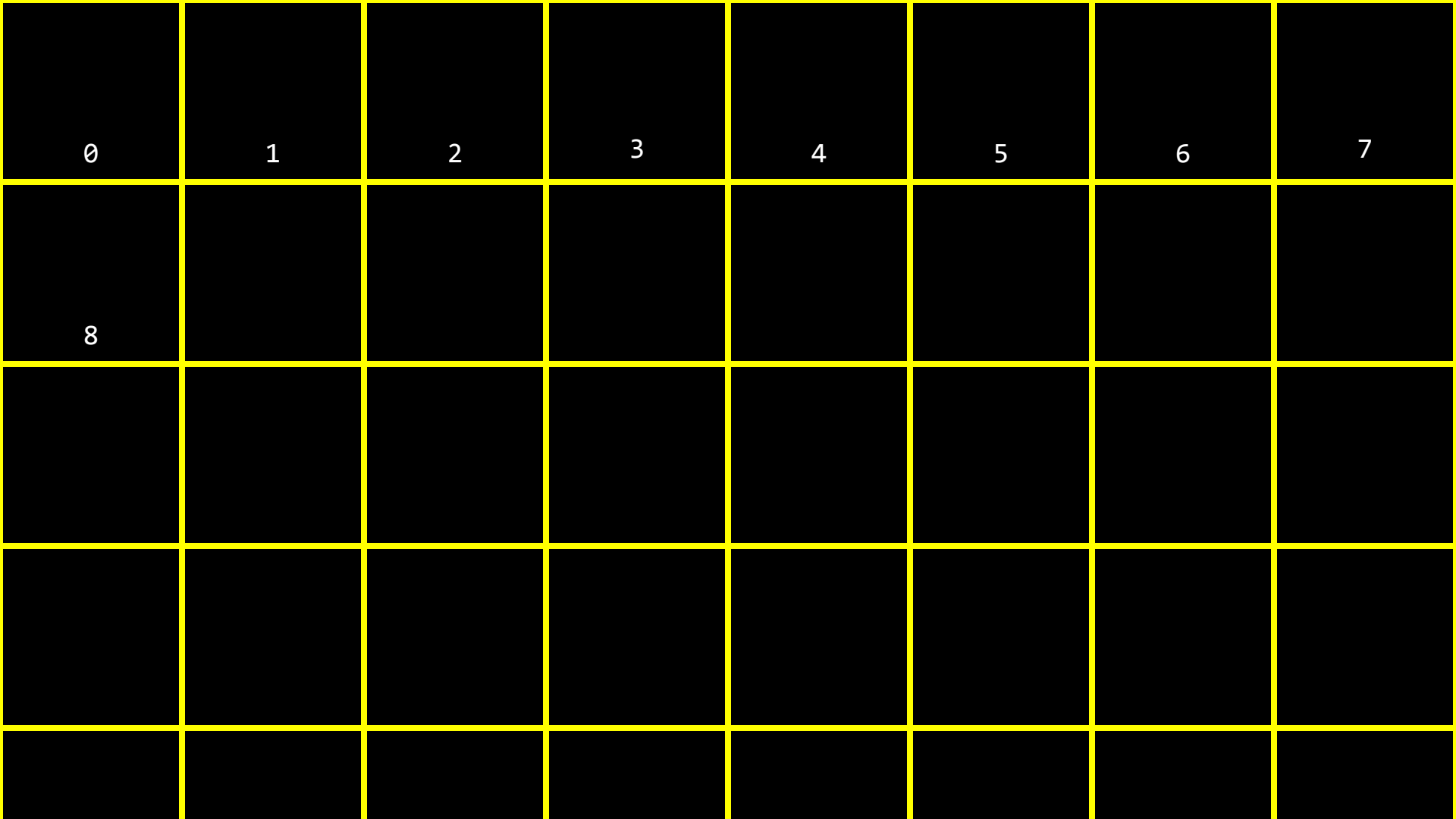
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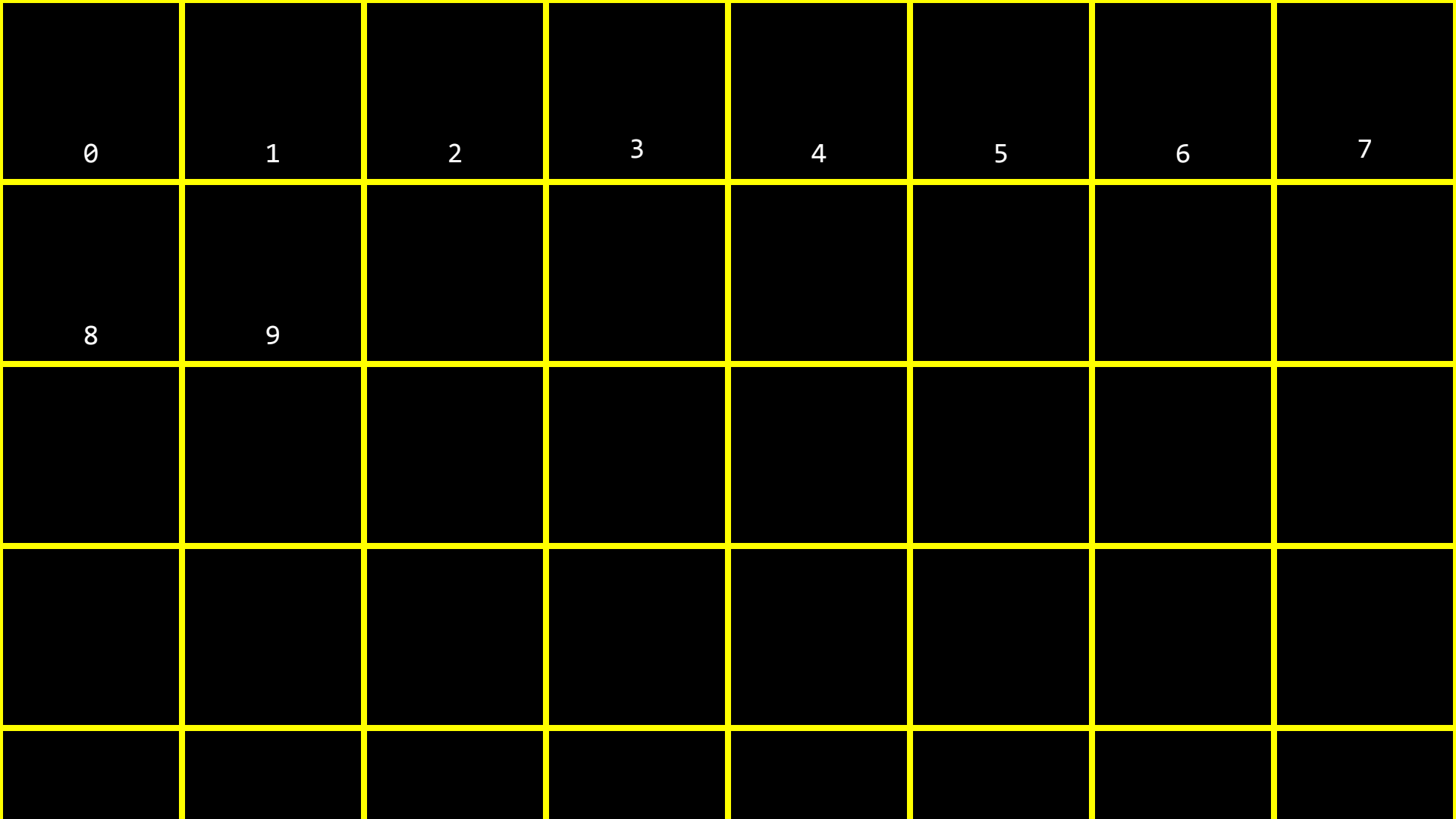
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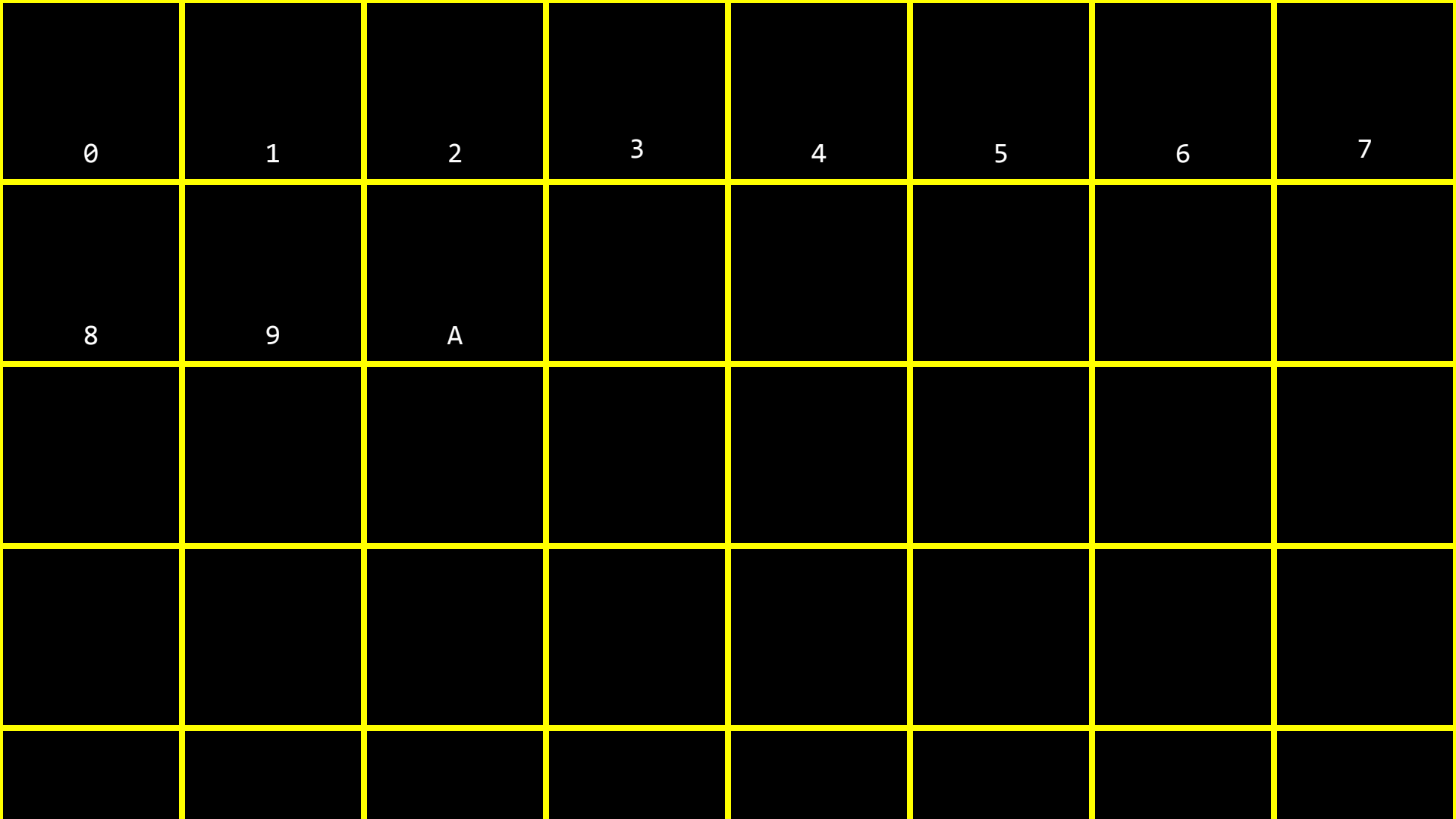
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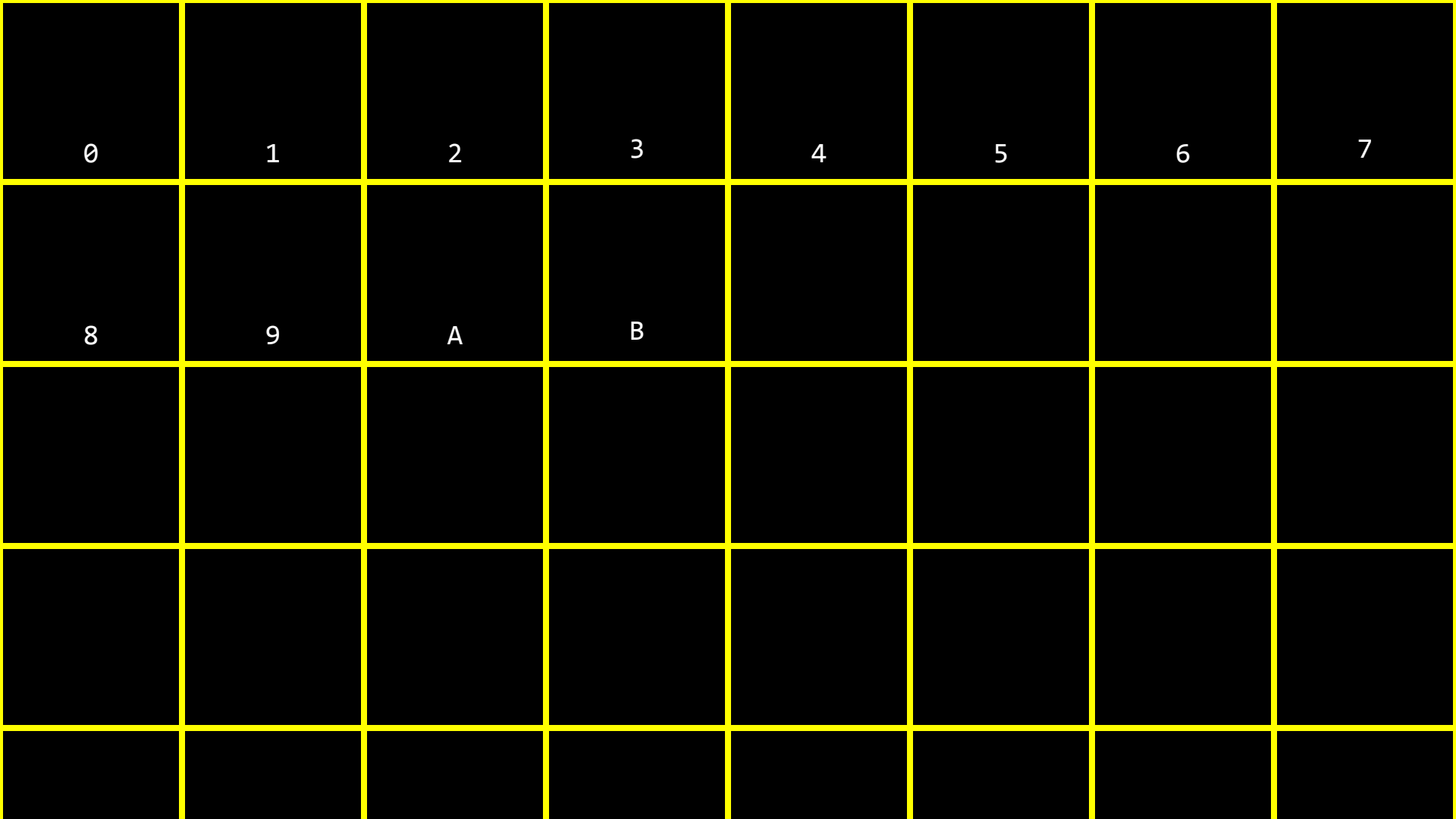
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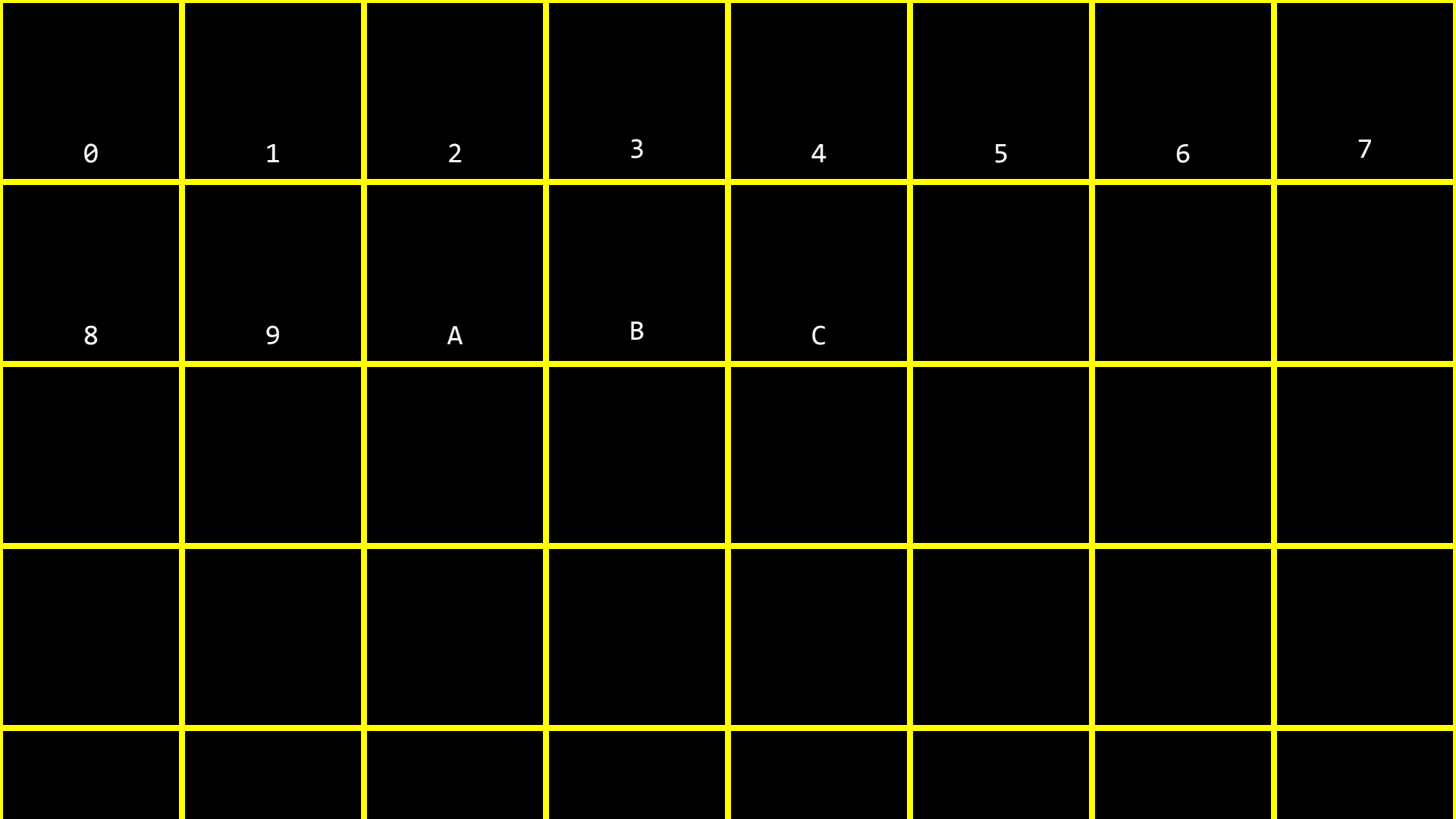
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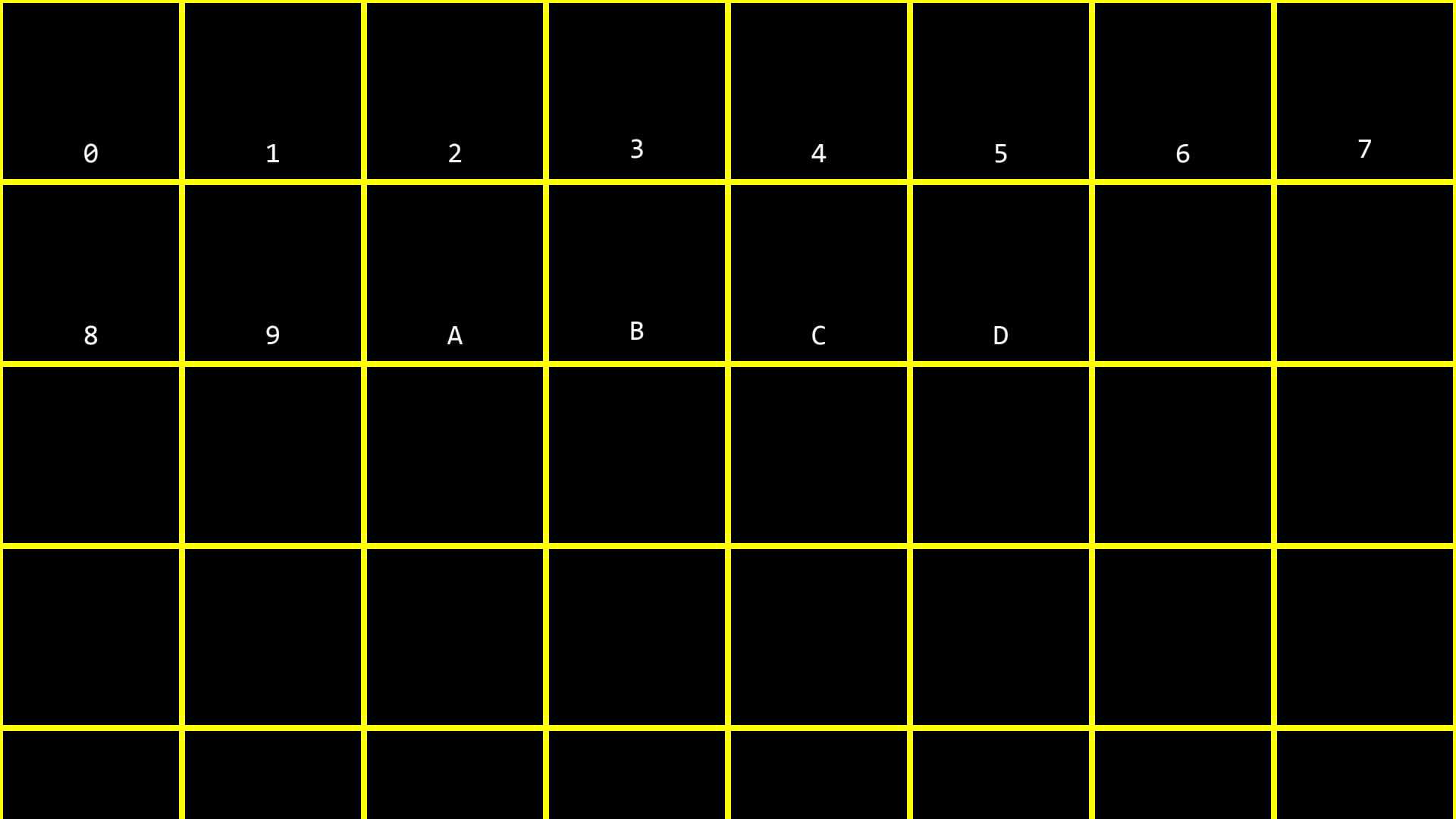
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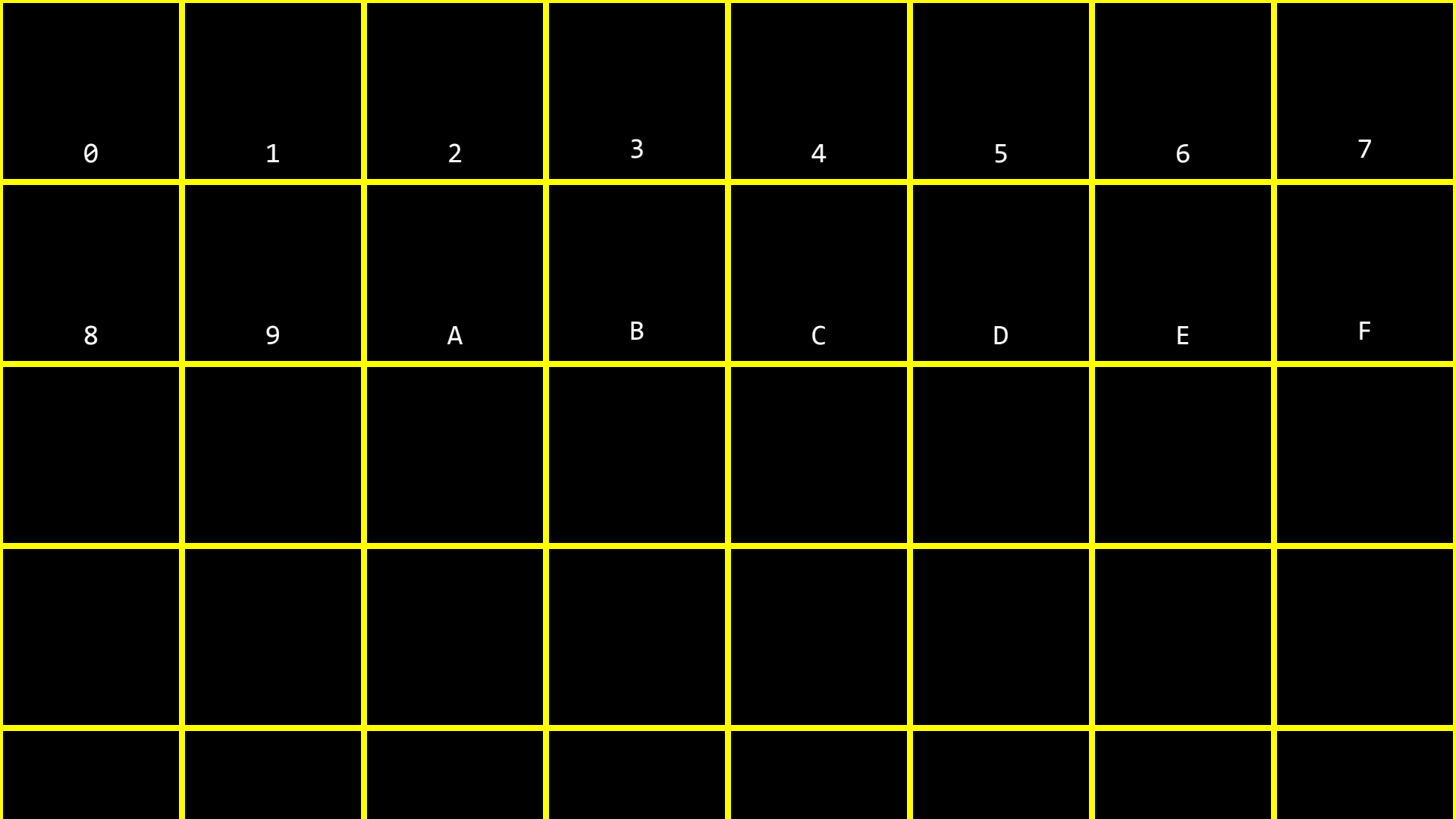
8	9	A	B	C	D	E	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0 1 2 3 4 5 6 7 8 9 A B C D E F

2^7 2^6 2^5 2^4 2^3 2^2 2^1 2^0

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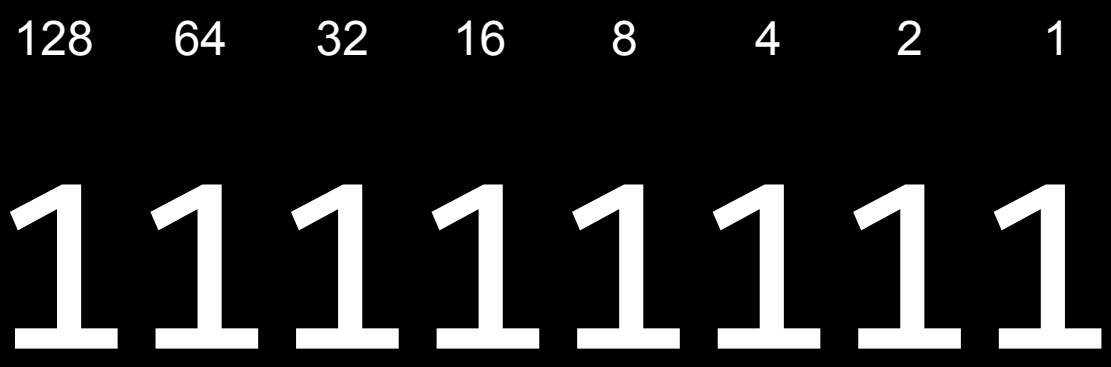
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10^2 10^1 10^0

255

100 10 1

255

16^1 16^0

F F

16 1

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16 1

F F

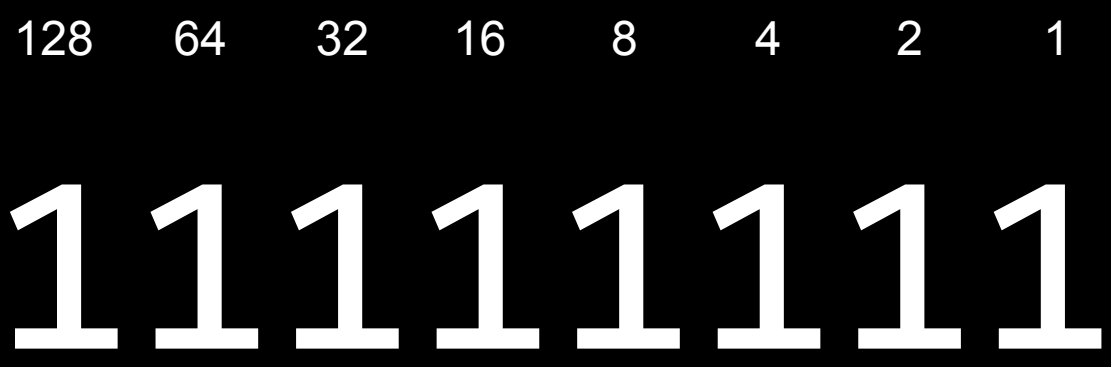
240 + 15

16 1

255

100 10 1

255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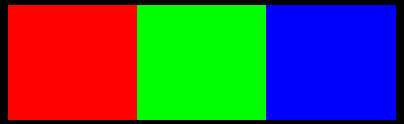

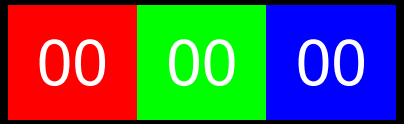
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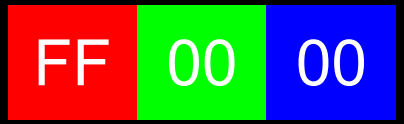
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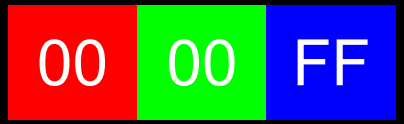
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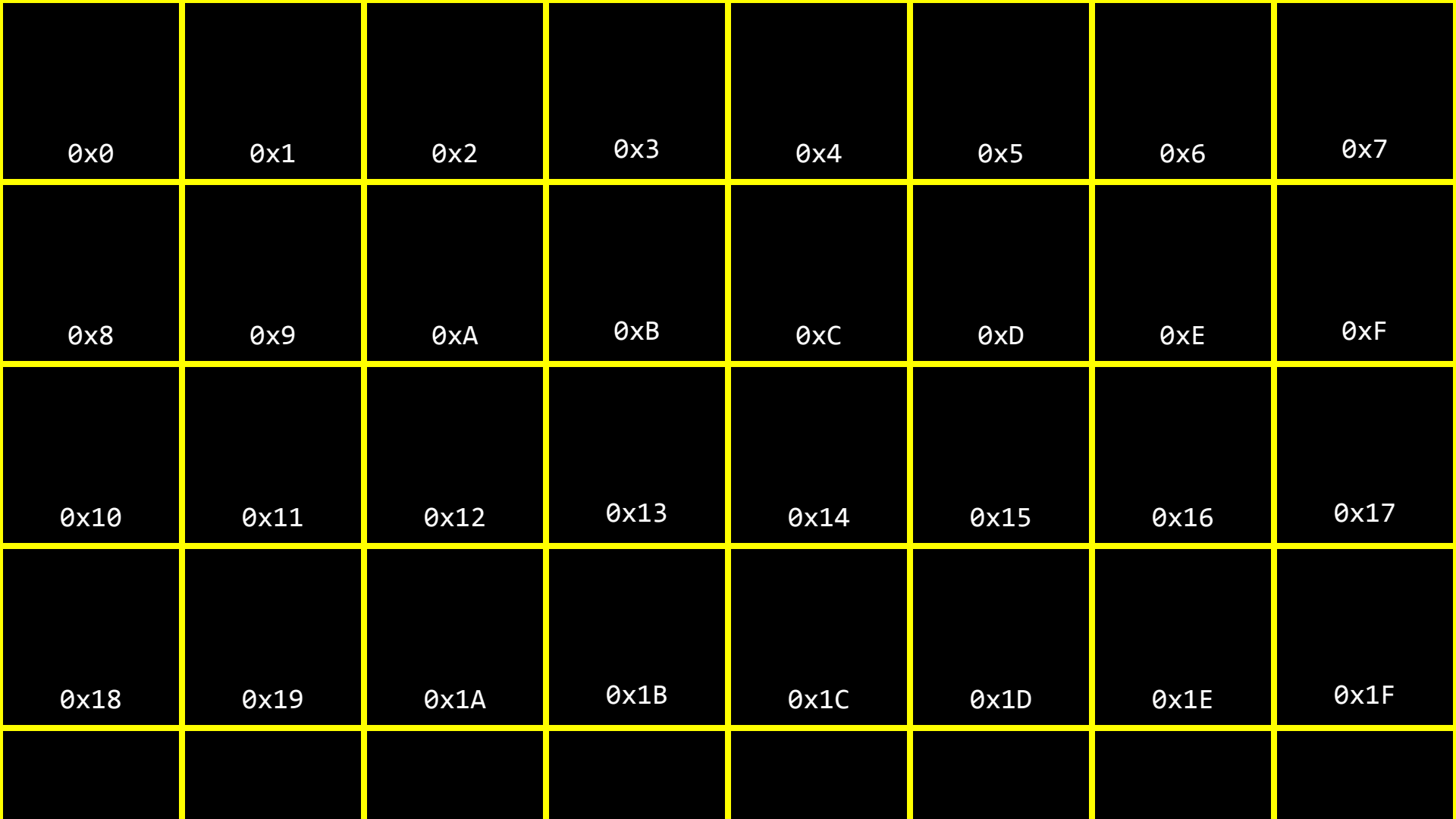
18	19	1B	1B	1C	1D	1E	1F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0x9
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0x17
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0x1A
0x1B
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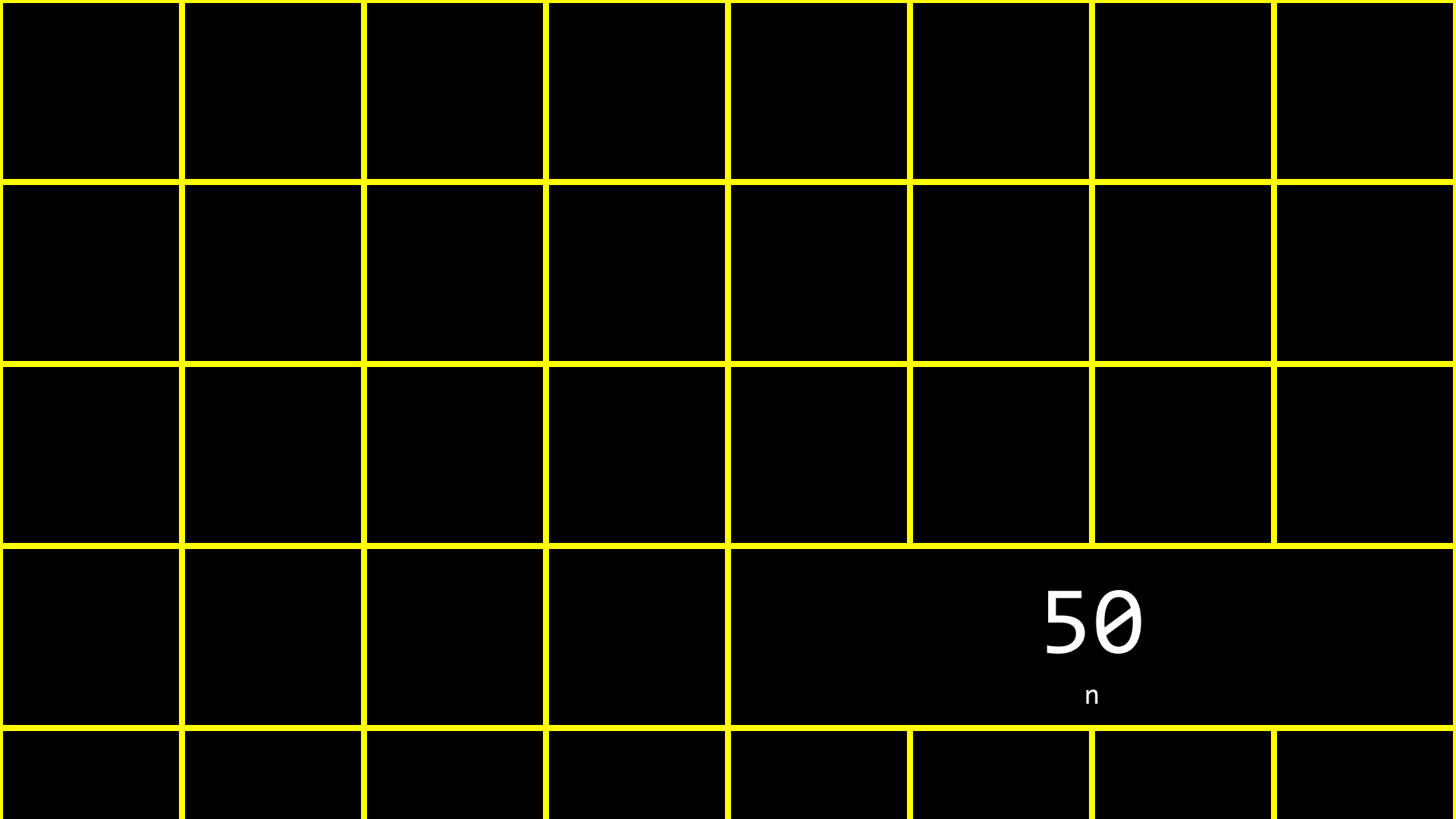
0x1D
0x1E
0x1F

```
int n = 50;
```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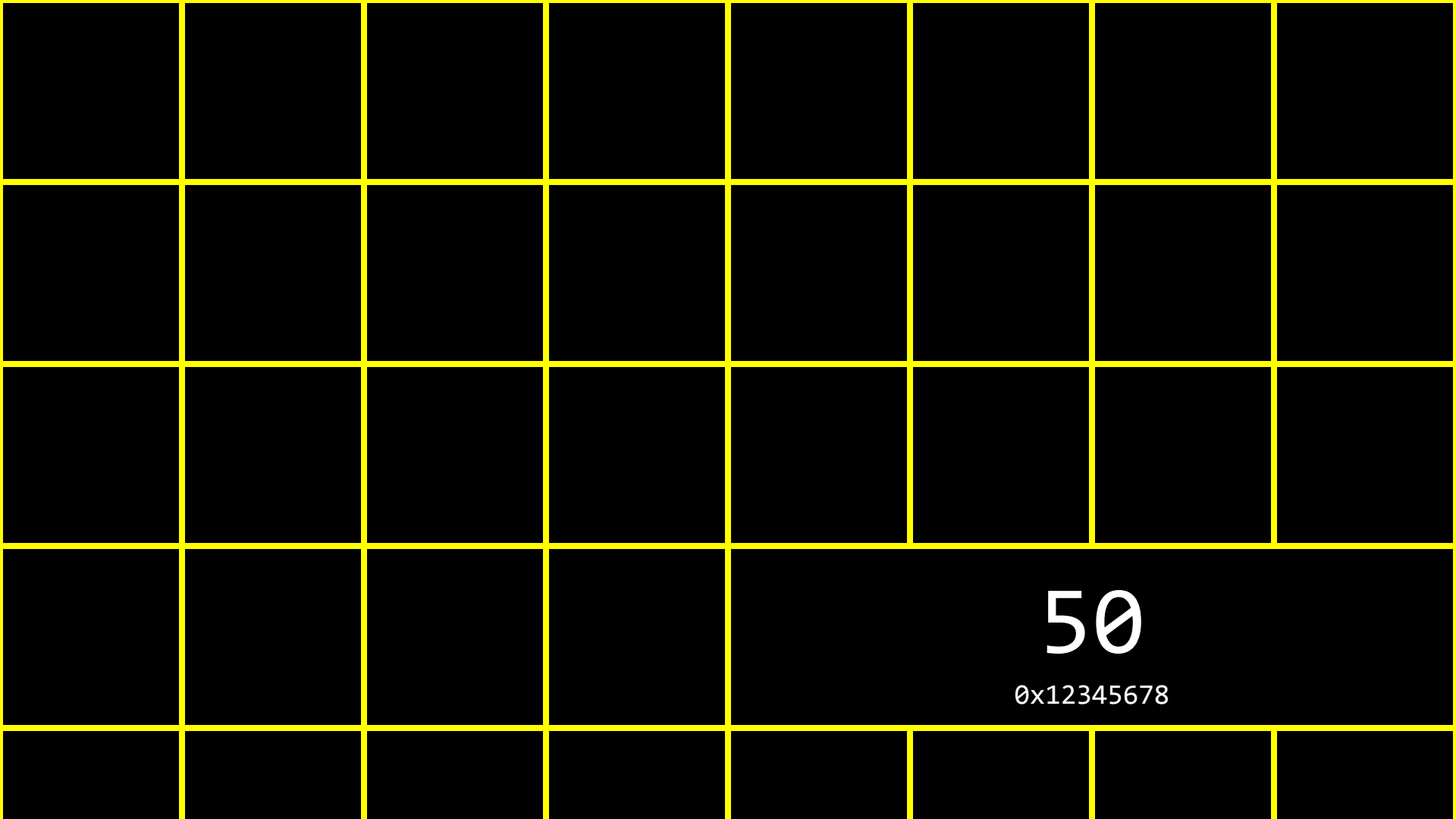
n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0x12345678

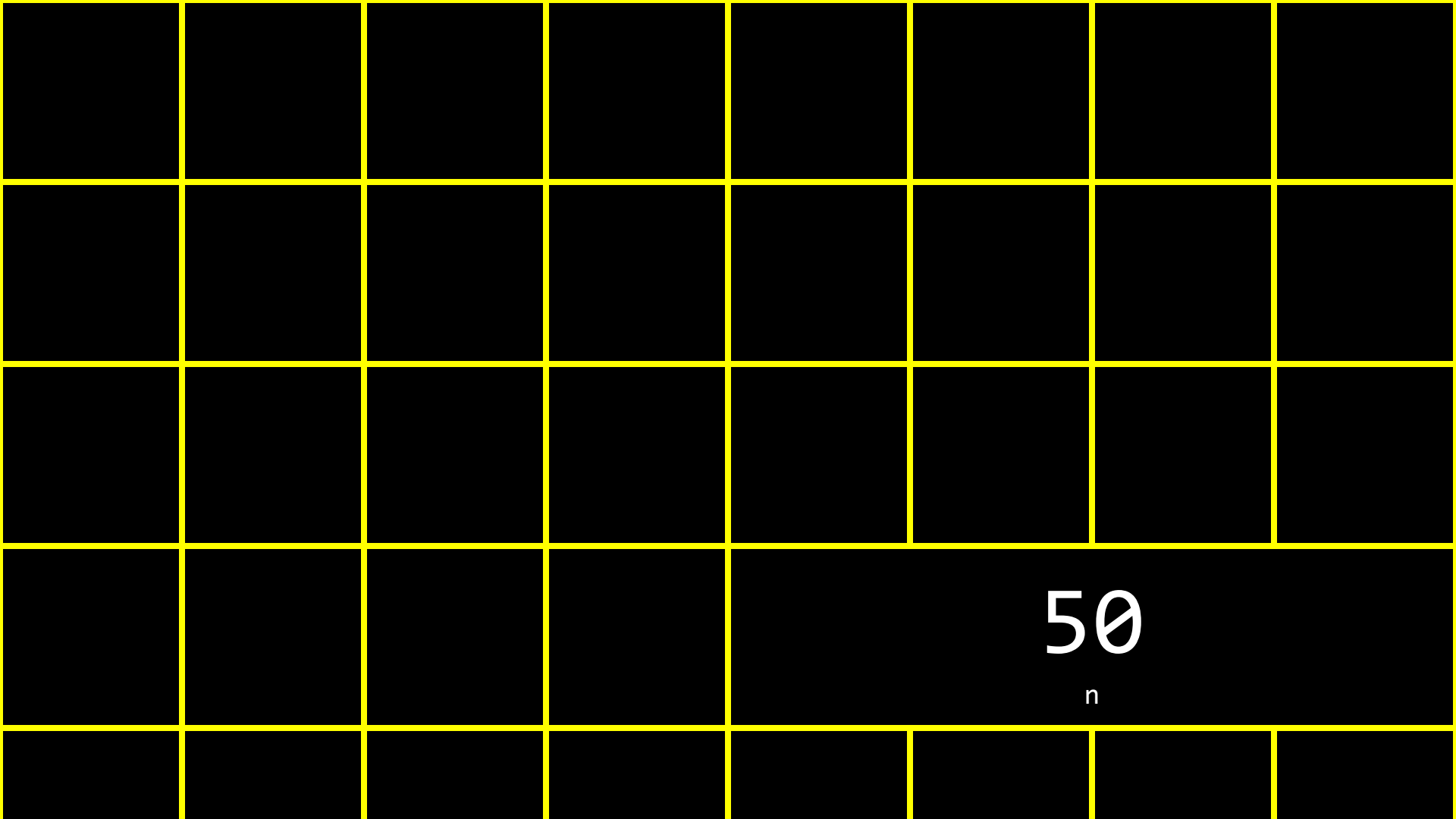
pointers

&

*

```
int n = 50;

int *p = &n;
```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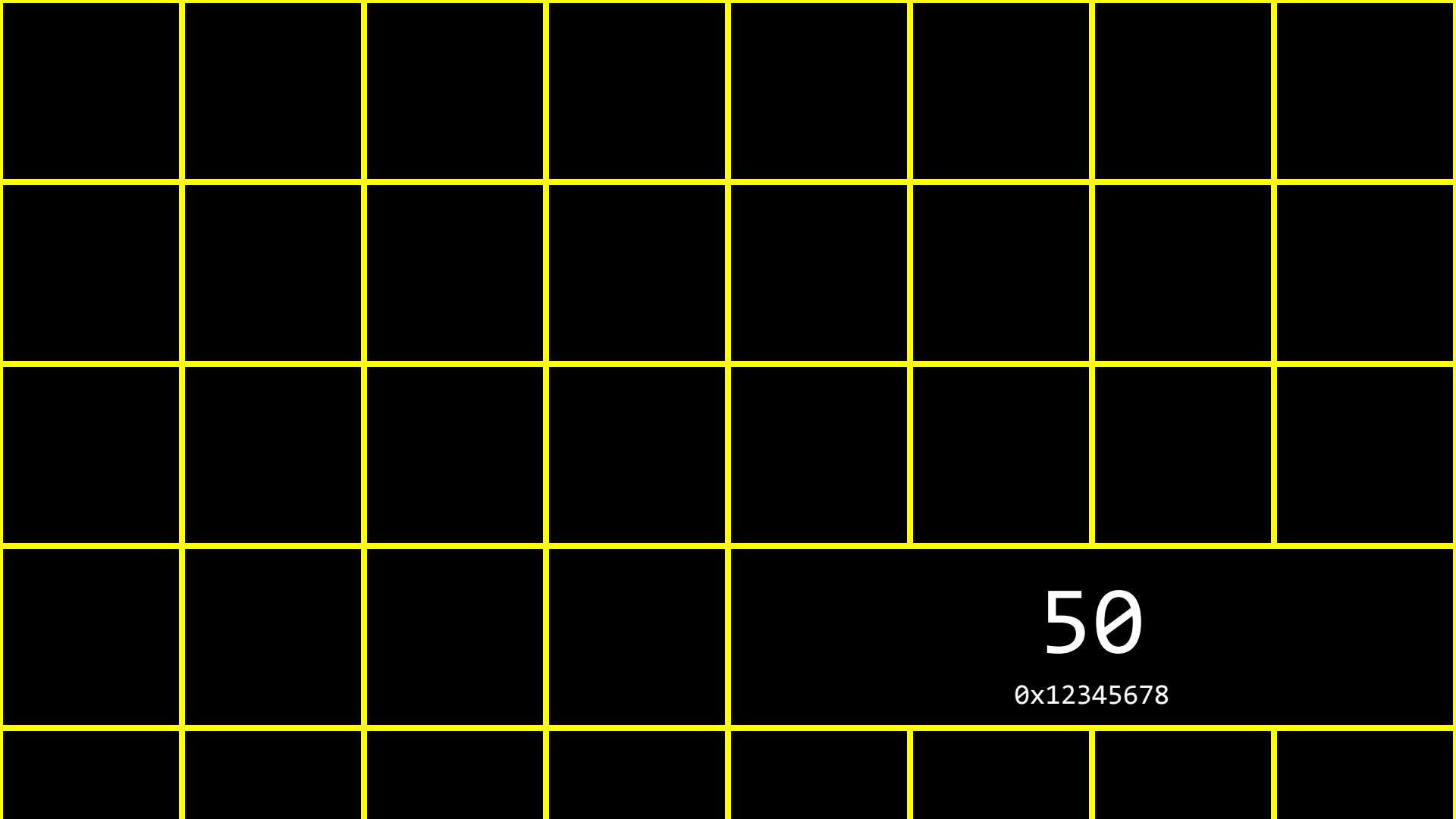
n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0x12345678

0x12345678

p

50

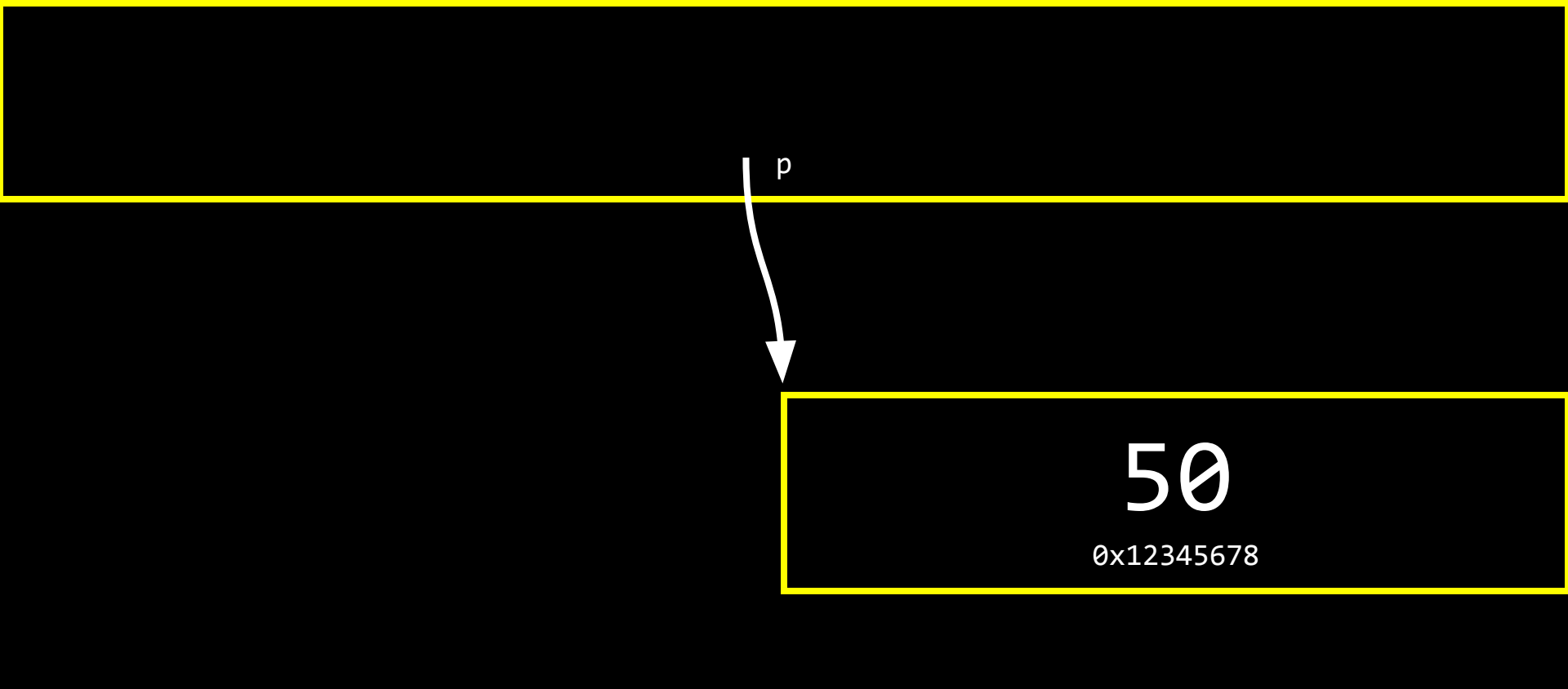
0x12345678

0x12345678

p

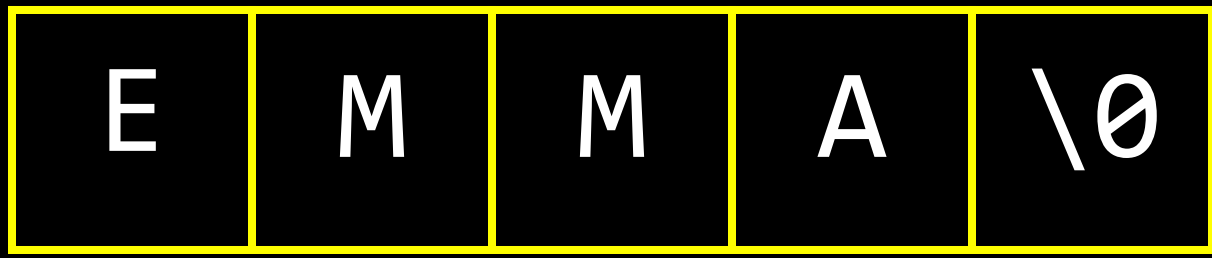
50

0x12345678


p
50
0x12345678

string

```
string s = "EMMA";
```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M
M
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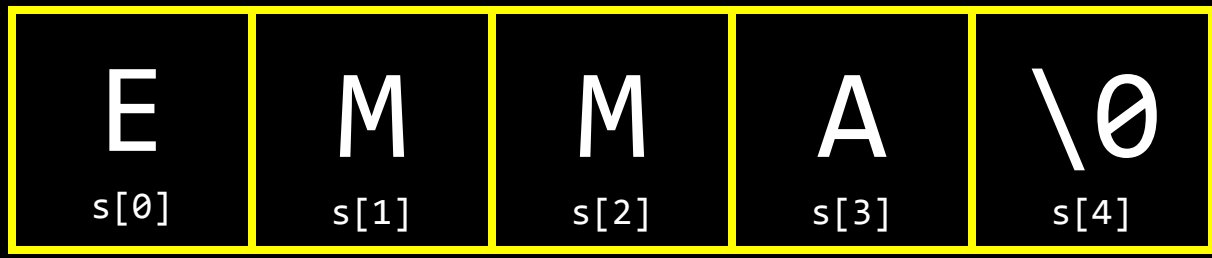
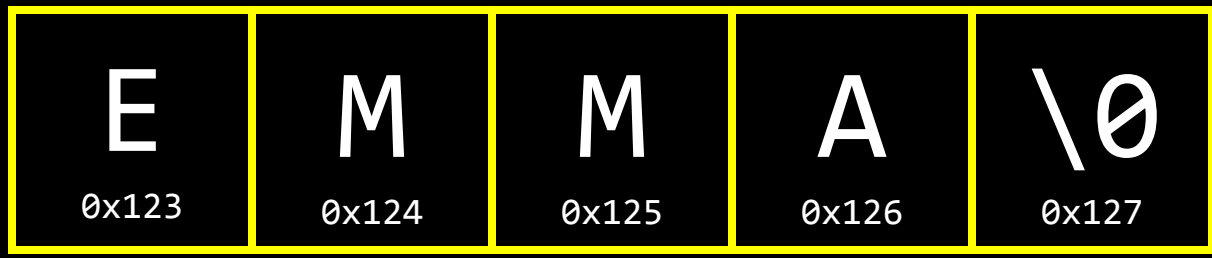

E
s[0]
M
s[1]
M
s[2]
A
s[3]
\0
s[4]


E
0x123
M
0x124
M
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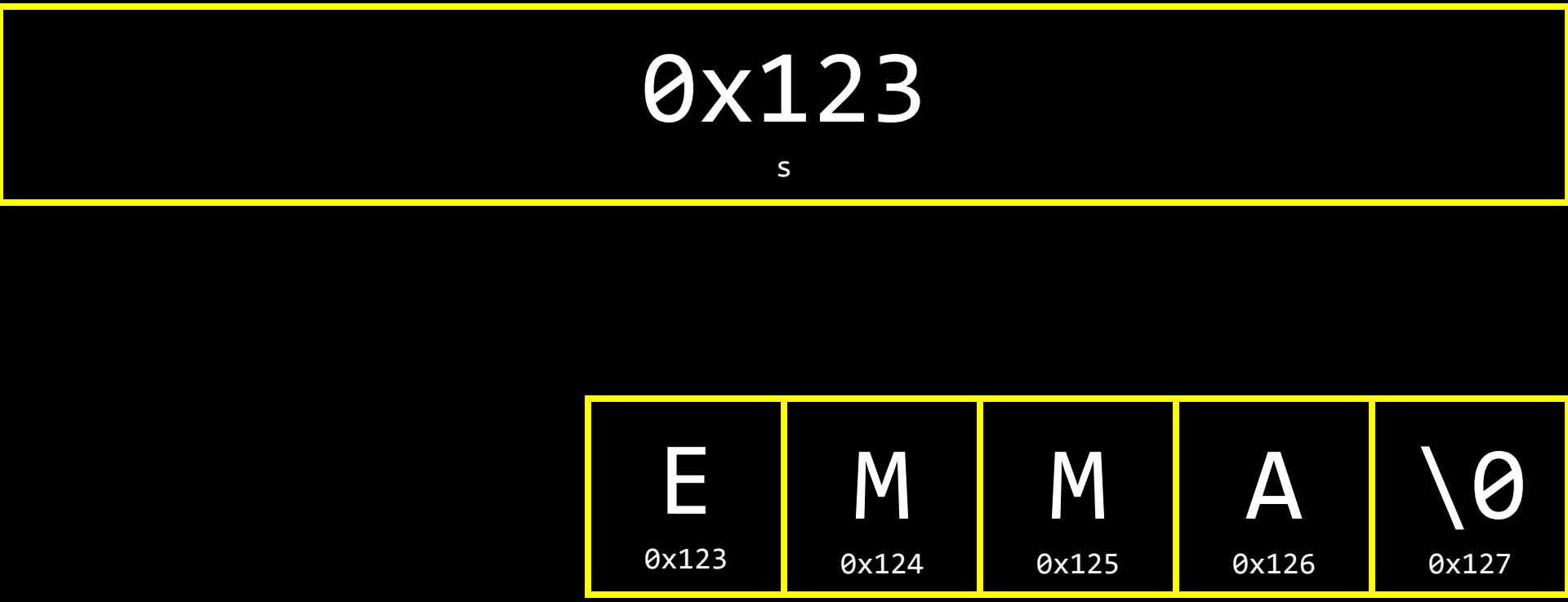
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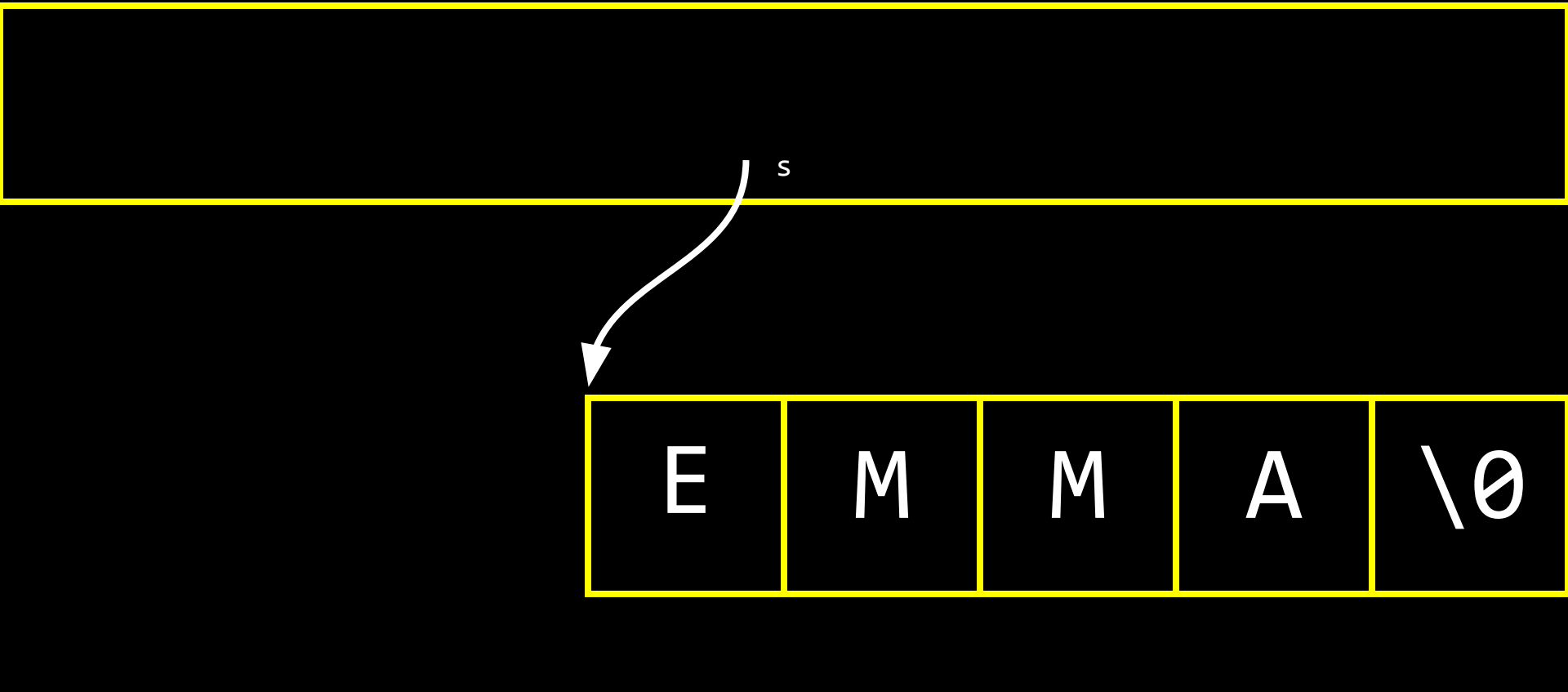
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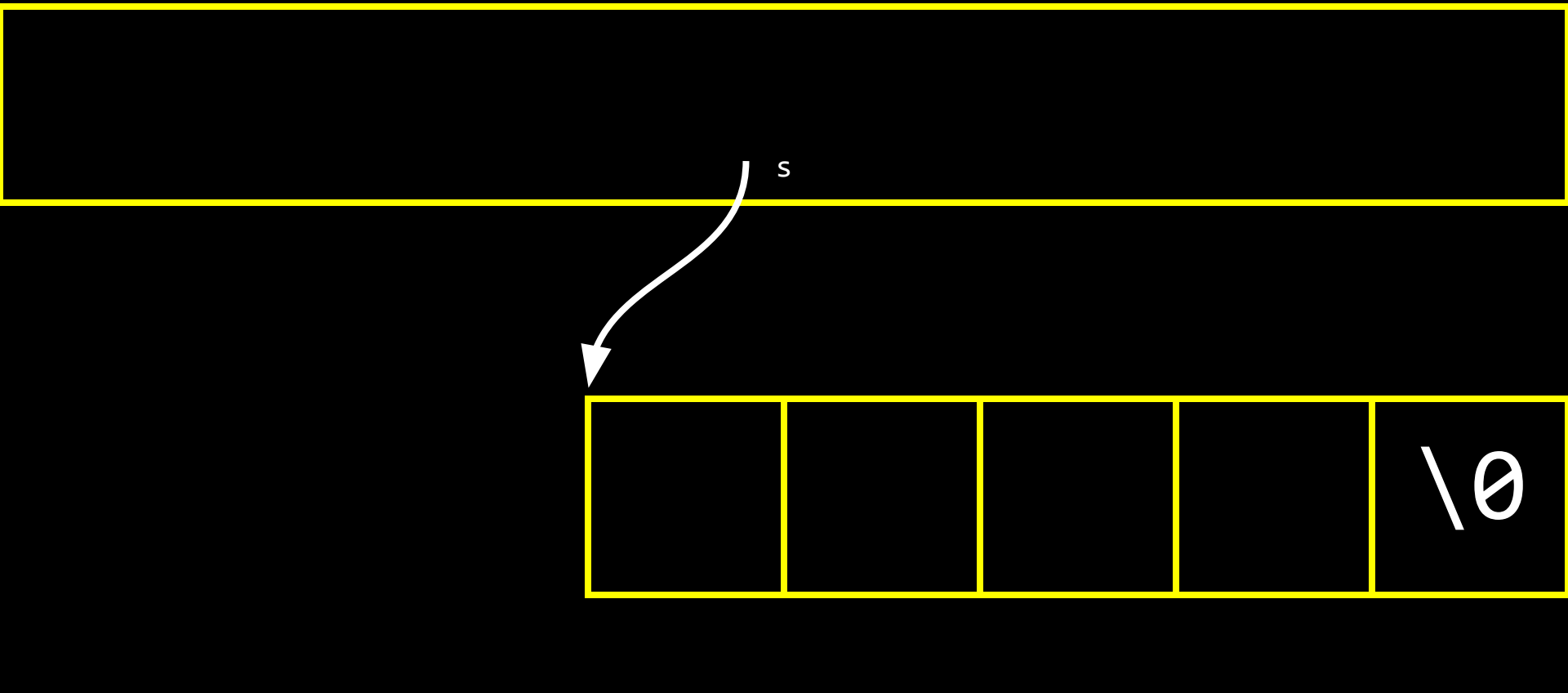
s
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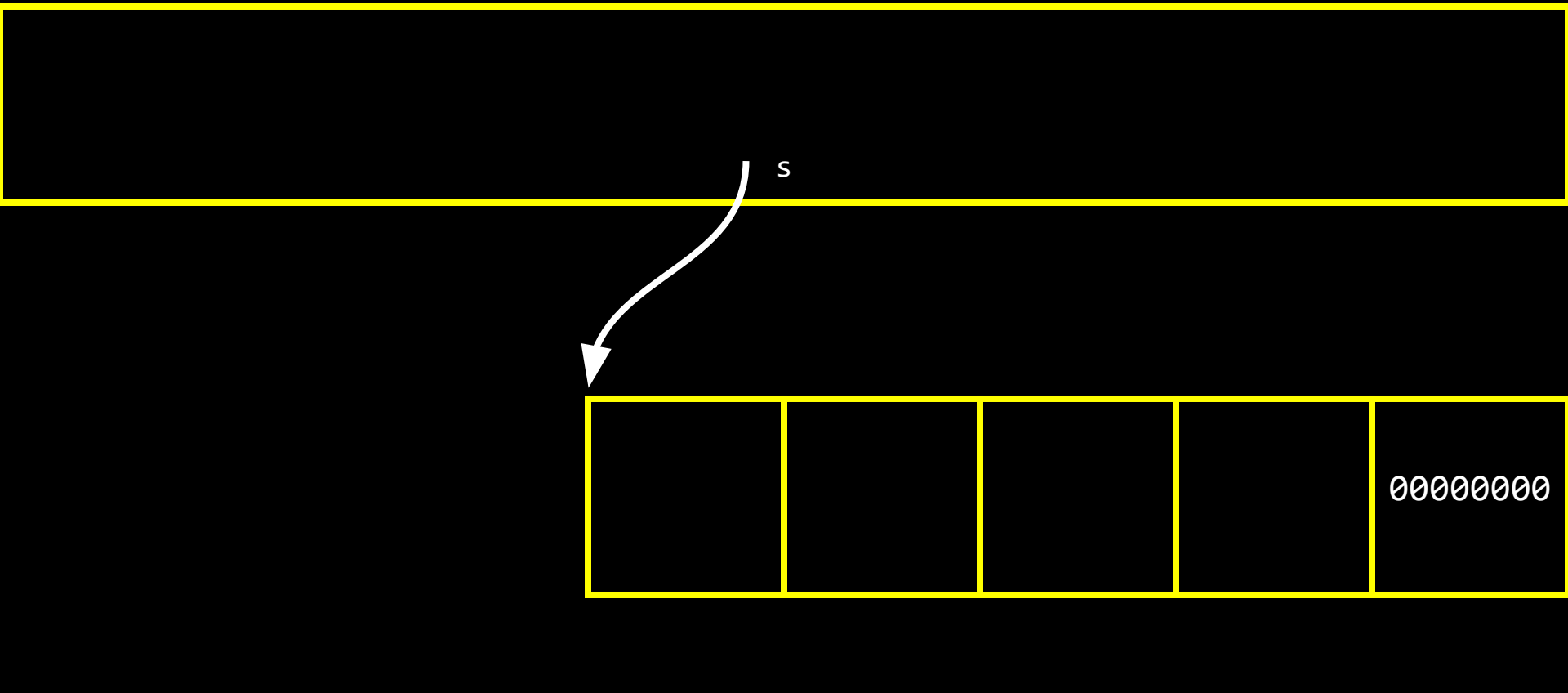

s
00000000

string

THERE IS NO STRING

```
int n = 50;
```

```
int n = 50;

int *p = &n;
```

```c
int n = 50;

int *p = &n;
```

```c
int n = 50;

int *p = &n;
```

```
string s = "EMMA";
```

```
char *s = "EMMA";
```

```
char *s = "EMMA";
```

```
typedef struct
{
    string name;
    string number;
}
person;
```

```
typedef struct
{
    string name;
    string number;
}
person;
```

```
typedef struct
{
    string name;
    string number;
}
person;
```

```
typedef struct
{
    string name;
    string number;
}
person;
```

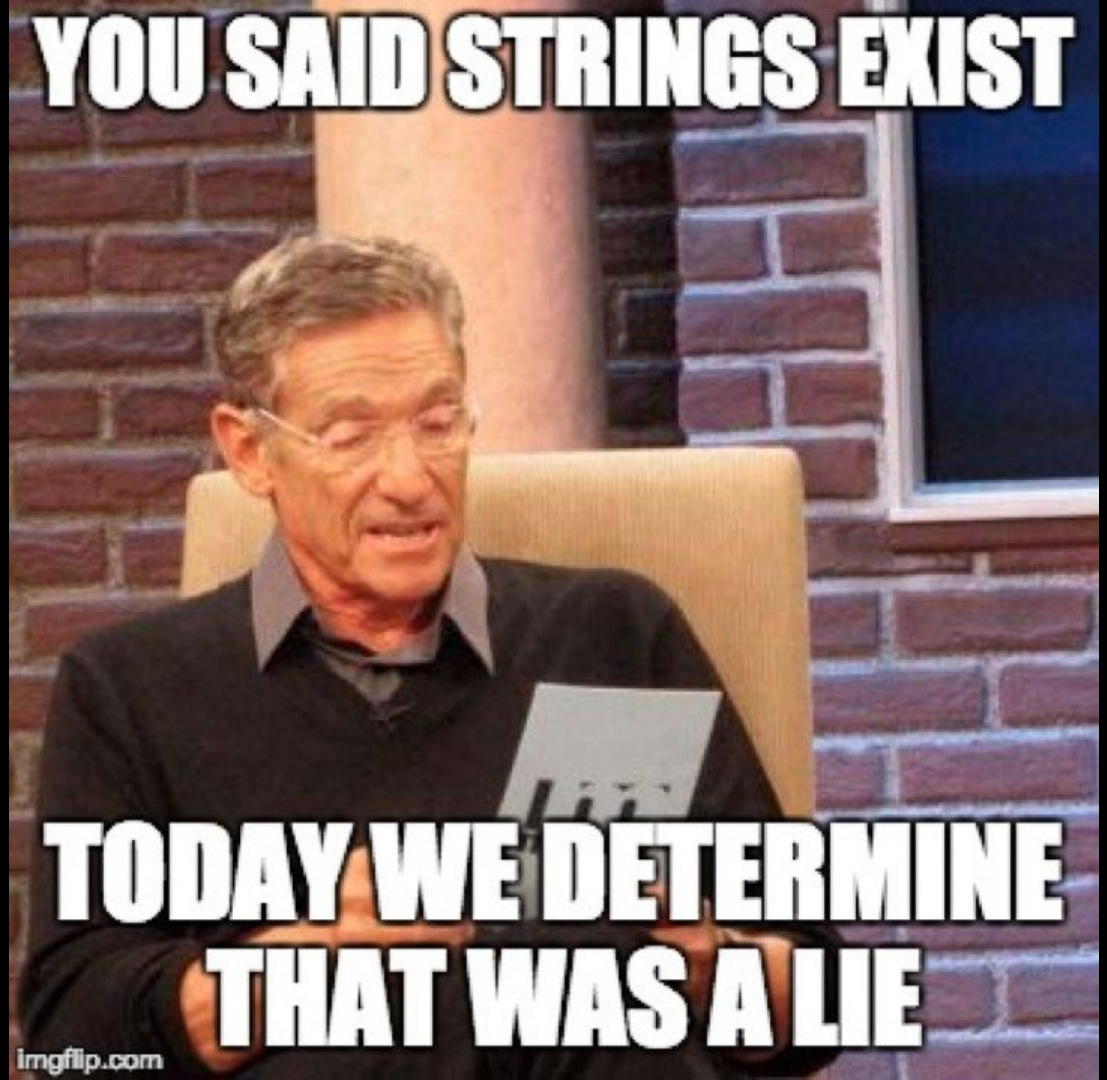
```
typedef char *string;
```

```
typedef char *string;
```

```
typedef char *string;
```

```
typedef char *string;
```

pointer arithmetic


YOU SAID STRINGS EXIST
TODAY WE DETERMINE THAT WAS A LIE
imgflip.com

string

```
char *
```

malloc

free

…

valgrind

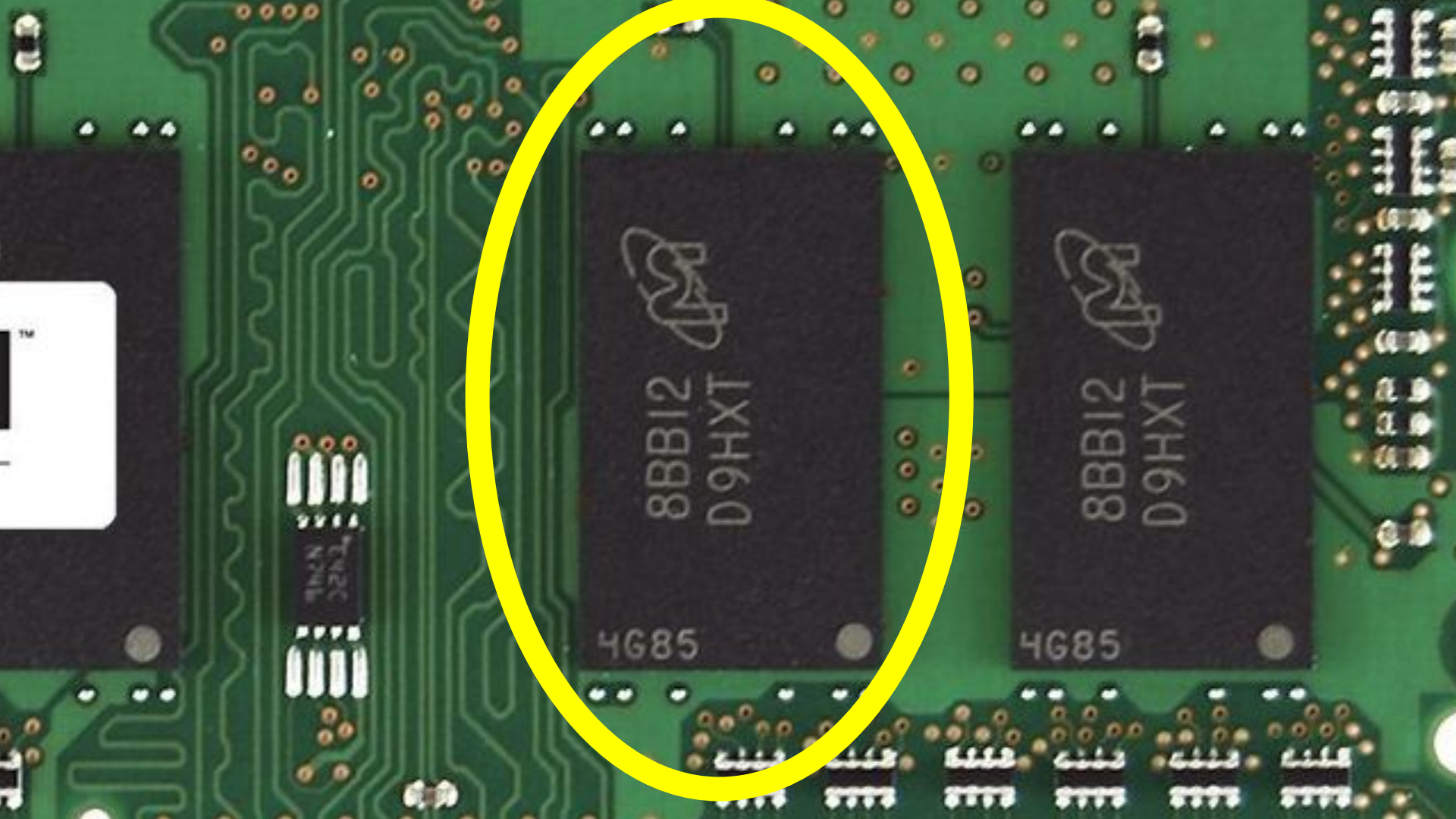
```
void swap(int a, int b)
{



}
```

```
void swap(int a, int b)
{
    int tmp = a;
    a = b;
    b = tmp;
}
```

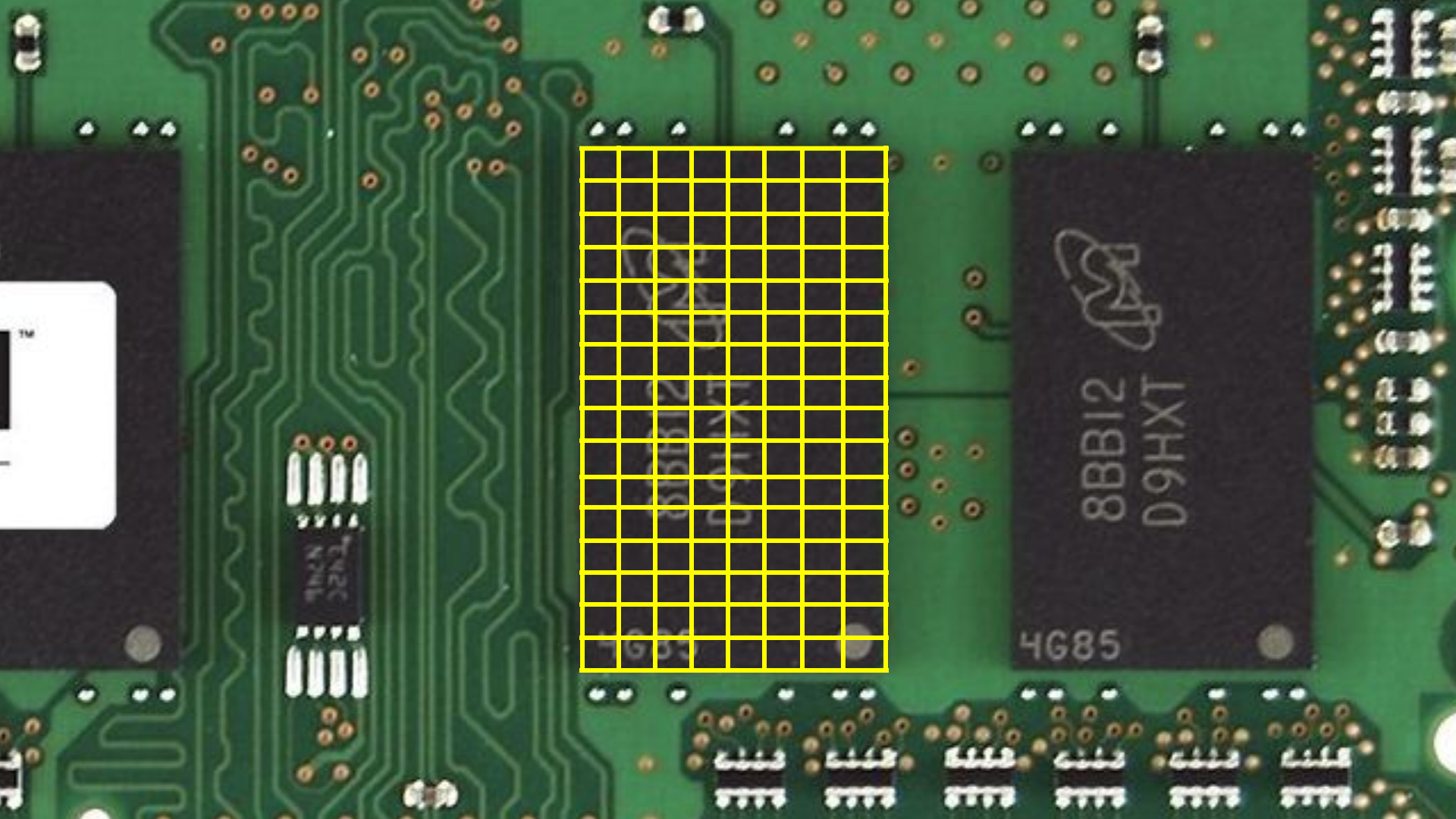
```
void swap(int a, int b)
{
    int tmp = a;
    a = b;
    b = tmp;
}
```

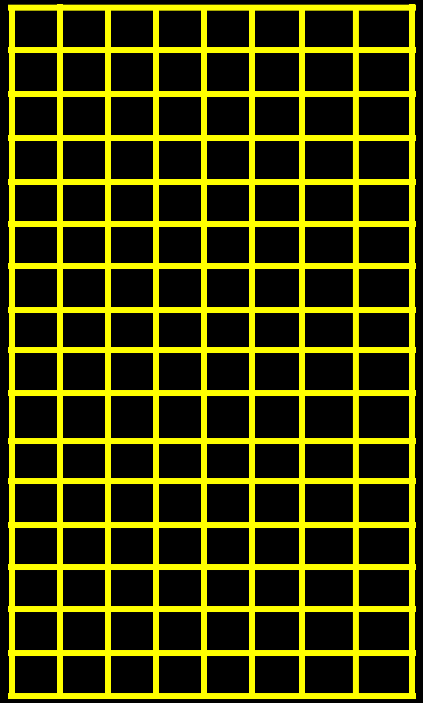

crucial
by Micron
8BBI2
D9HXT
8BBI2
D9HXT
4G85
4G85
4G85
47J6

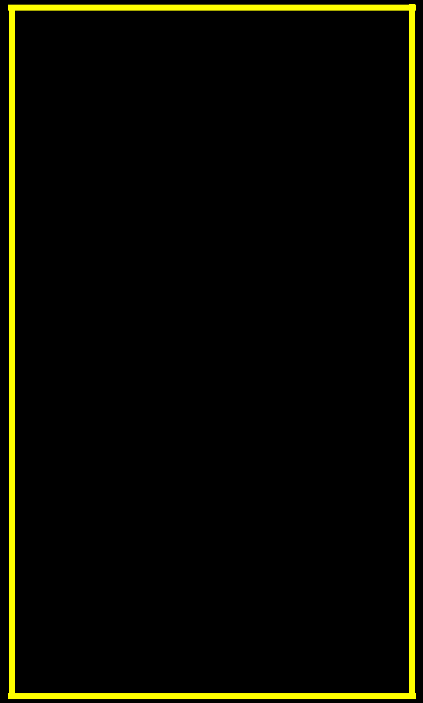

crucial
by Micron
8BBI2
D9HXT
4G85
8BBI2
D9HXT
4G85
4G85
47J6
4G85

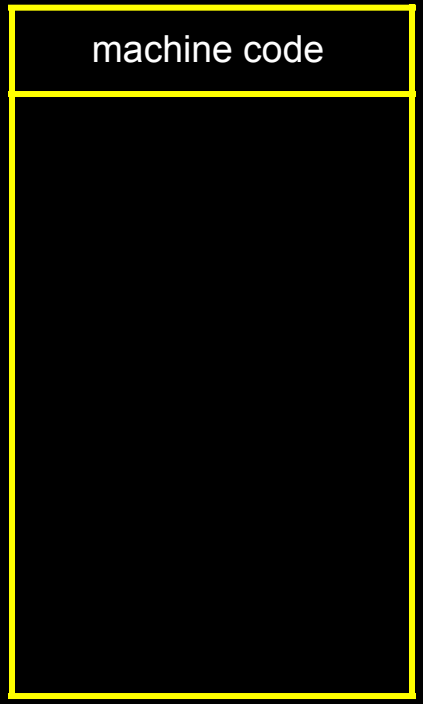

8BBI2
D9HXT
4G85
8BBI2
D9HXT
4G85

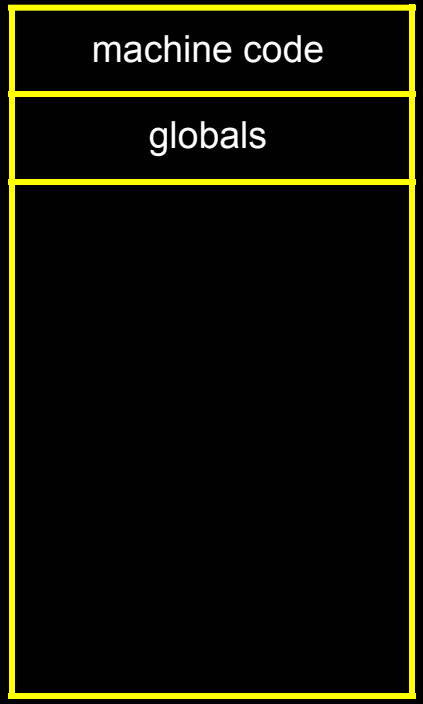

8BBI2
D9HXT
4G85
8BBI2
D9HXT
4G85

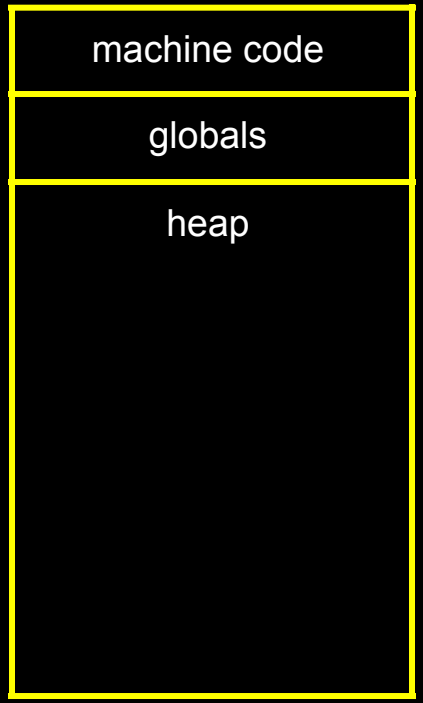

8BBI2
D9HXT
4G85

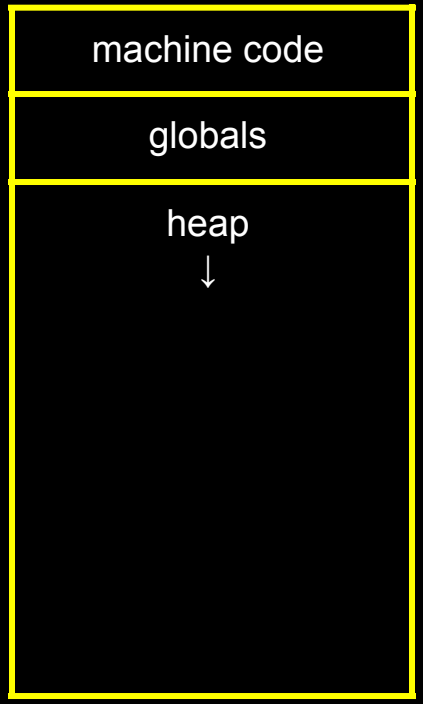


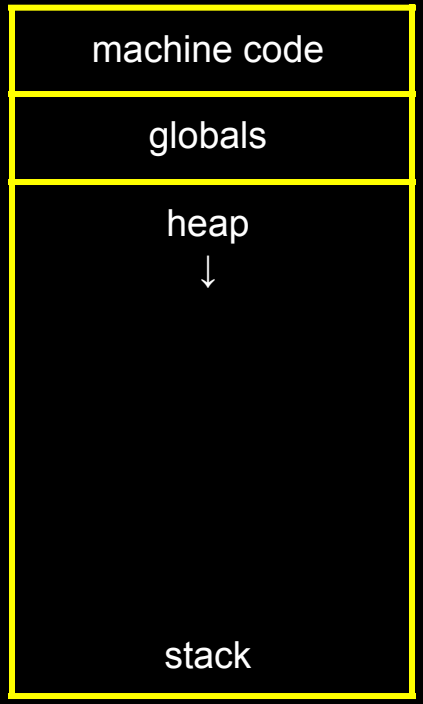


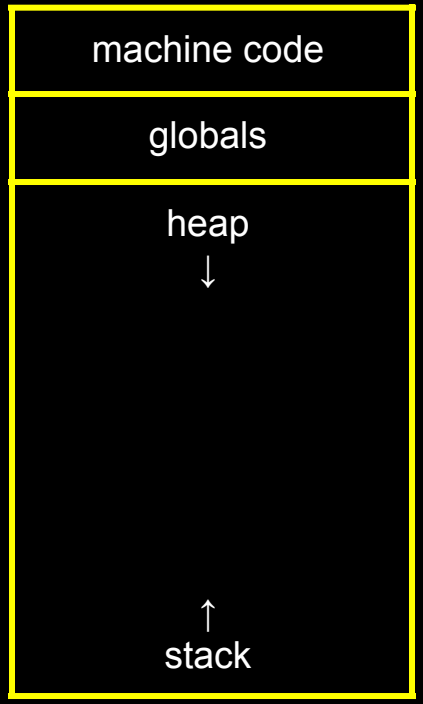

machine code

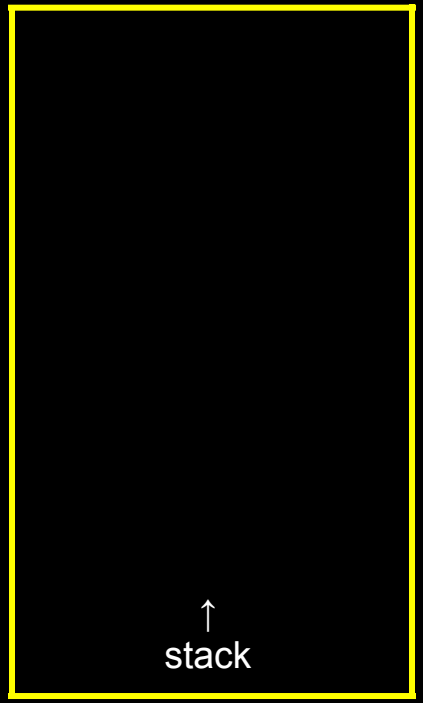

machine code
globals


machine code
globals
heap

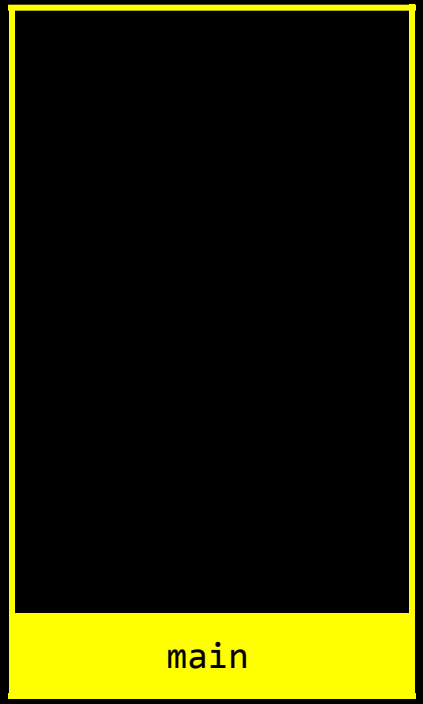

machine code
globals
heap
↓

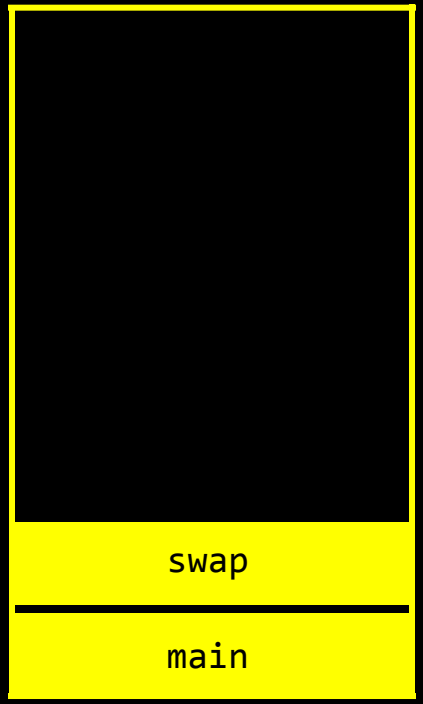

machine code
globals
heap
↓
stack

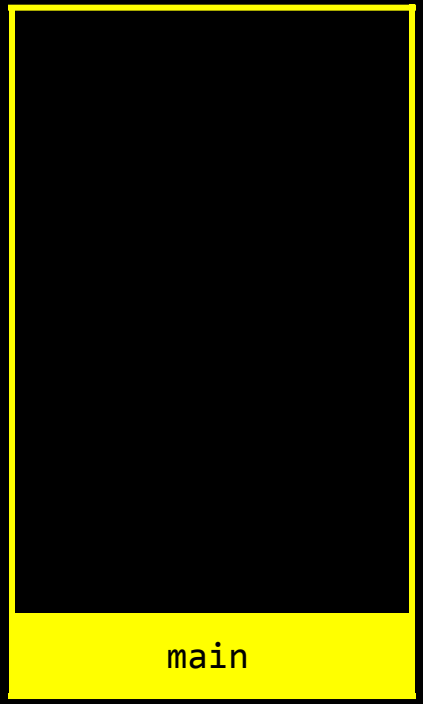

machine code
globals
heap
↓
↑
stack

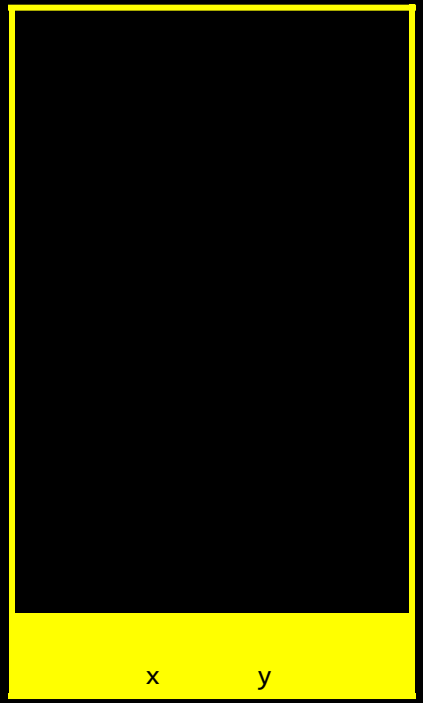

↑
stack

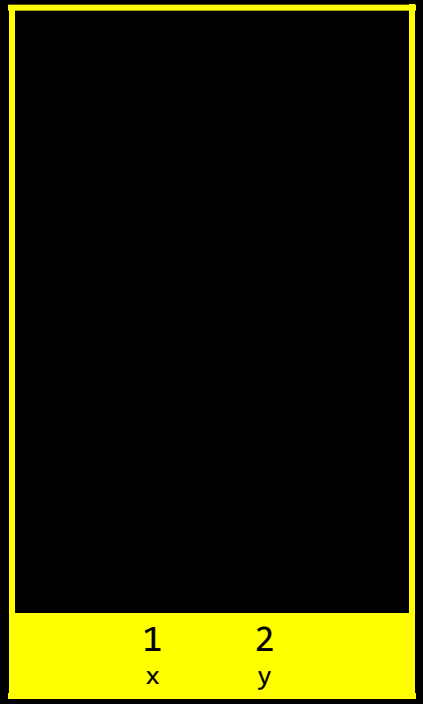
```
void swap(int a, int b)
{
    int tmp = a;
    a = b;
    b = tmp;
}
```

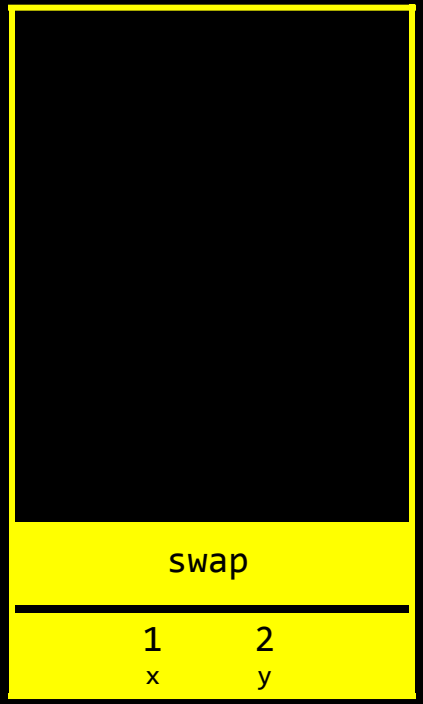

main

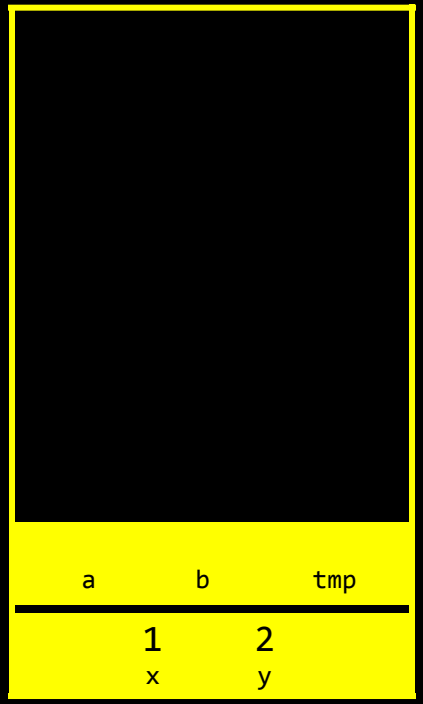

swap
main

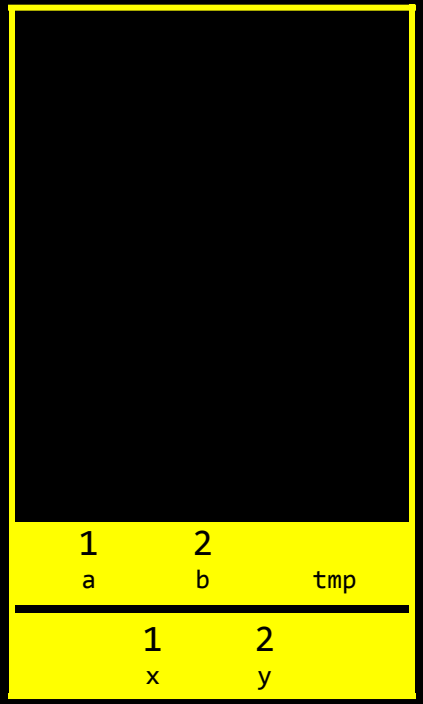

main


x
y

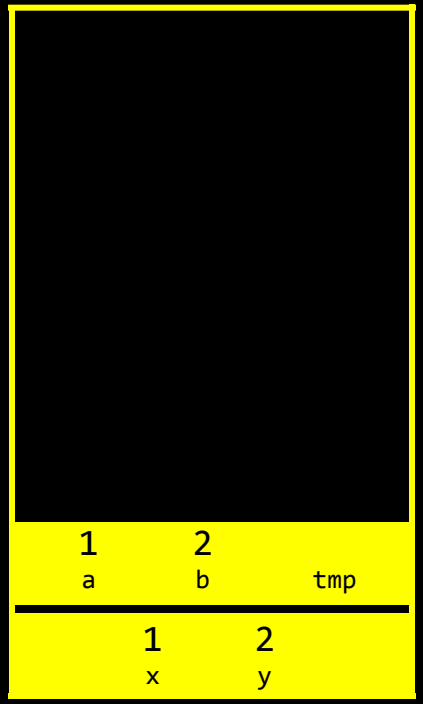

1
x
2
y


swap
1
x
2
y

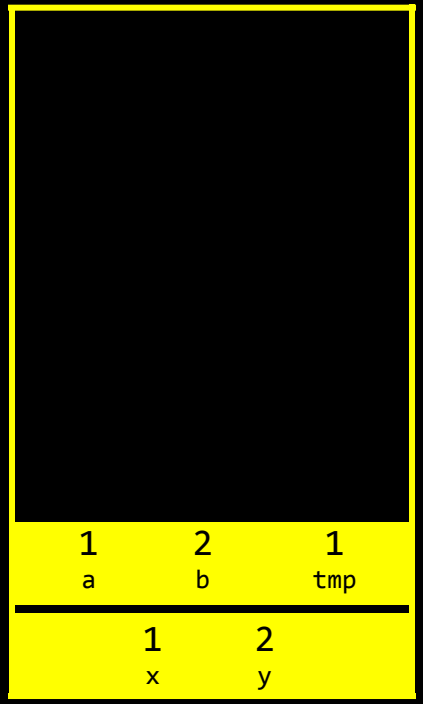

a
b
tmp
1
2
x
y


1
a
2
b
tmp
1
x
2
y

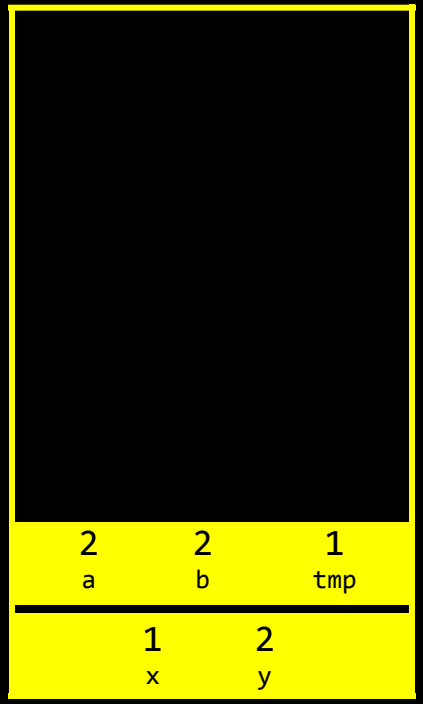
```
int tmp = a;
a = b;
b = tmp;
```



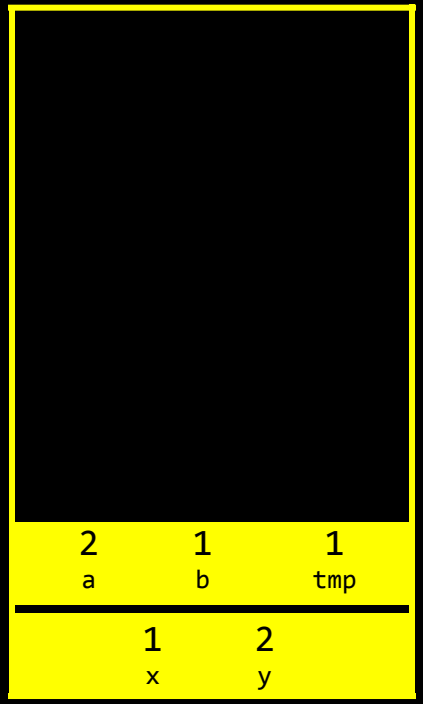
```
int tmp = a;
a = b;
b = tmp;
```

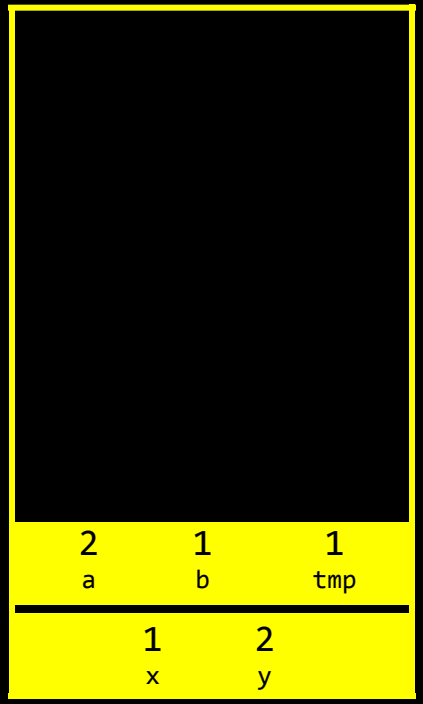


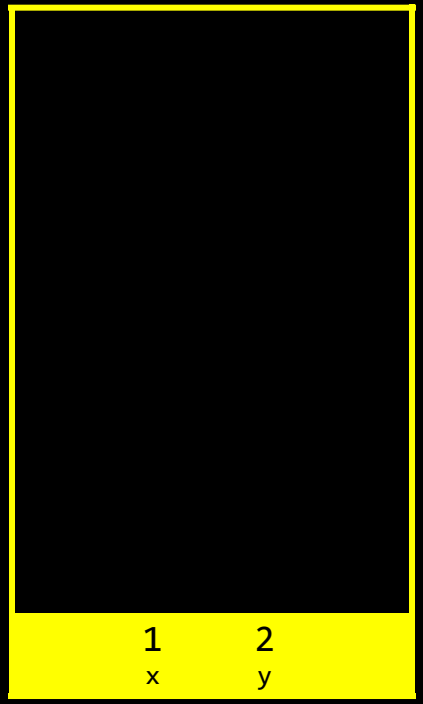
```
int tmp = a;
a = b;
b = tmp;
```



```
int tmp = a;
a = b;
b = tmp;
```

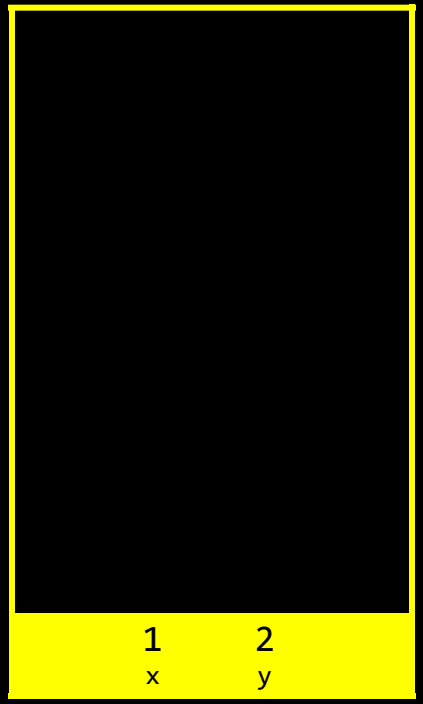


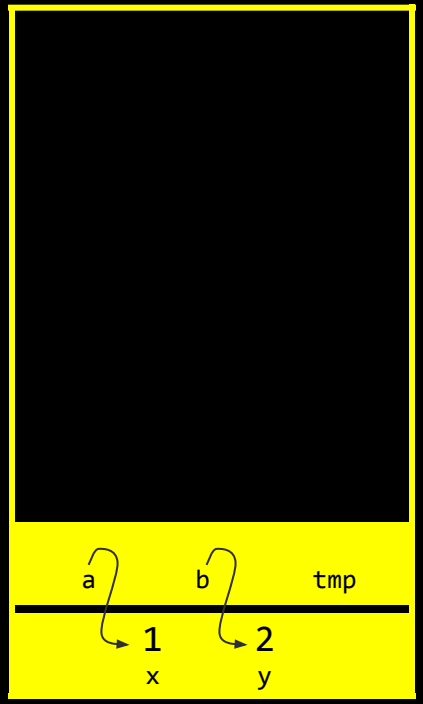

2
a
1
b
1
tmp
1
x
2
y


1
x
2
y

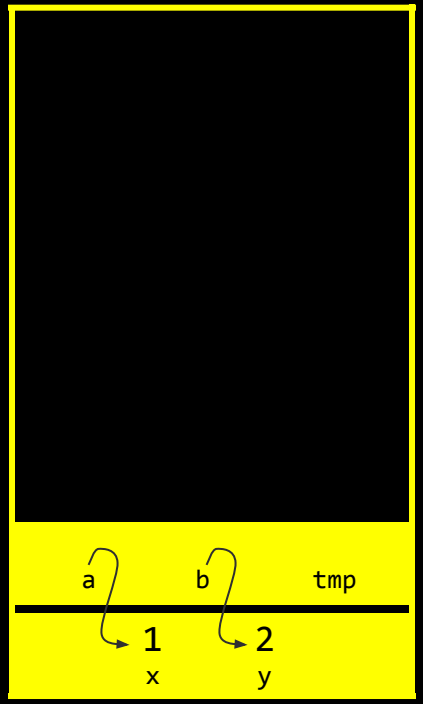
```
void swap(int a, int b)
{
    int tmp = a;
    a = b;
    b = tmp;
}
```

```
void swap(int *a, int *b)
{
    int tmp = *a;
    *a = *b;
    *b = tmp;
}
```

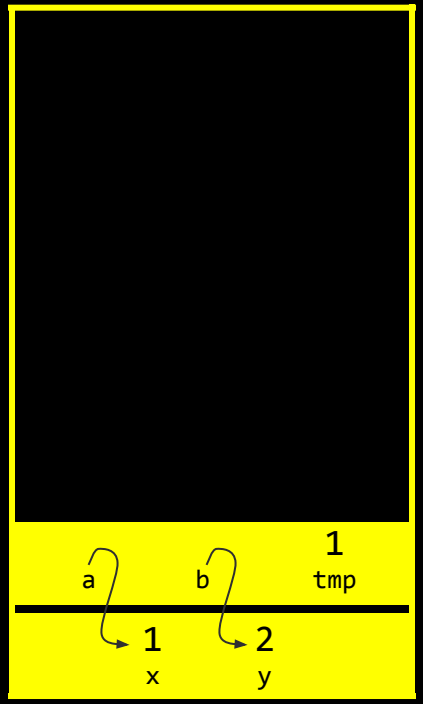

1
x
2
y


a
b
tmp
1
2
x
y

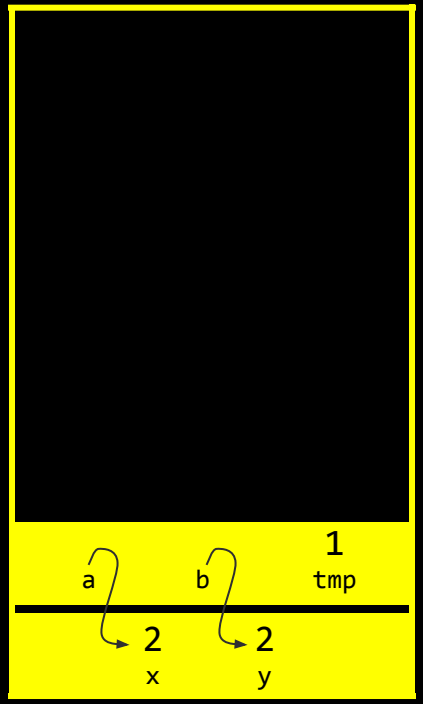
```
int tmp = *a;
*a = *b;
*b = tmp;
```



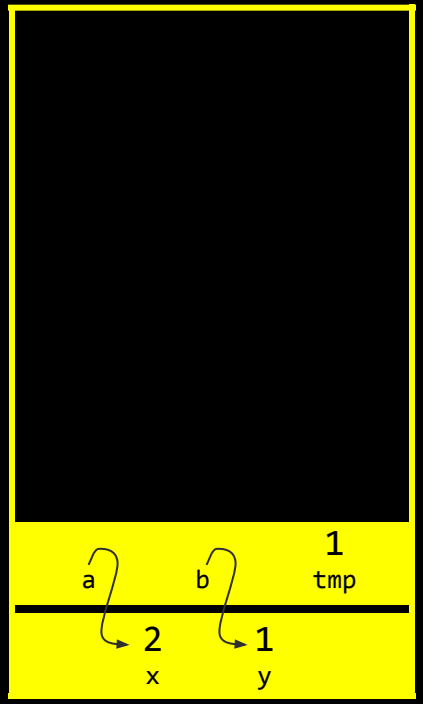
```
int tmp = *a;
*a = *b;
*b = tmp;
```

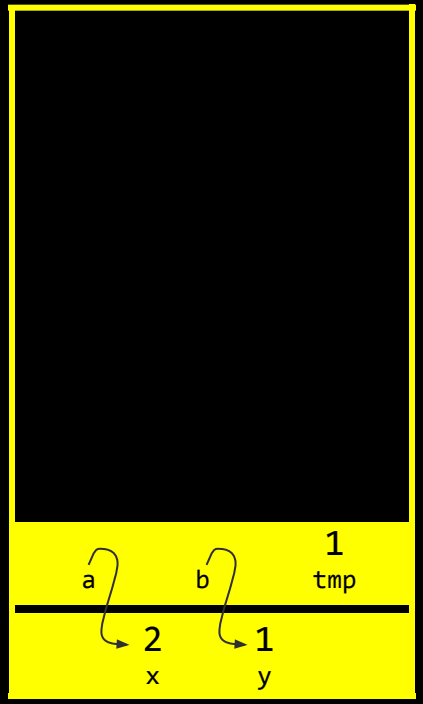


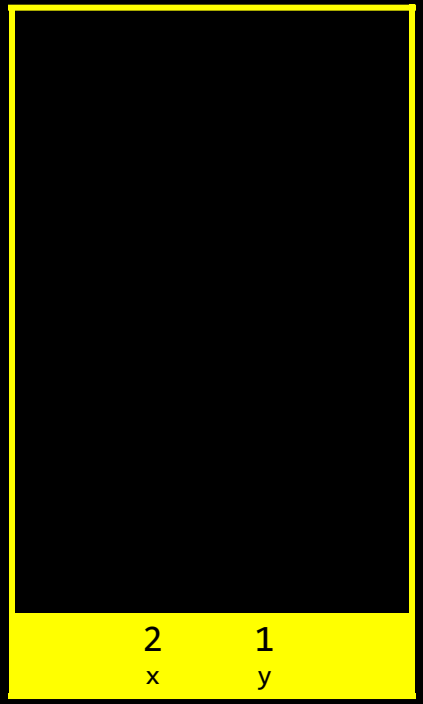
```
int tmp = *a;
*a = *b;
*b = tmp;
```



```
int tmp = *a;
*a = *b;
*b = tmp;
```

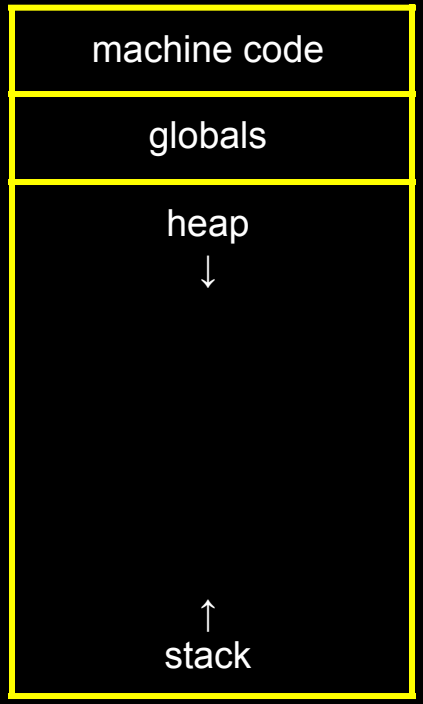


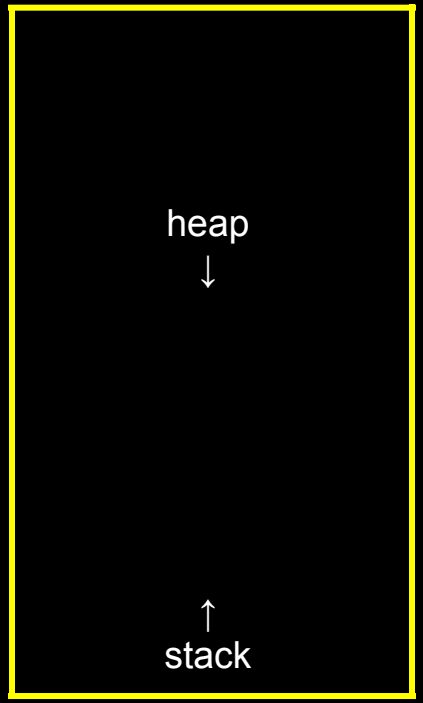

a
b
1
tmp
2
x
1
y


2
x
1
y

```
void swap(int a, int b)
{
    int tmp = a;
    a = b;
    b = tmp;
}
```

```
void swap(int *a, int *b)
{
    int tmp = *a;
    *a = *b;
    *b = tmp;
}
```


machine code
globals
heap
↓
↑
stack


heap
↓
↑
stack

heap overflow

stack overflow

buffer overflow

```
get_char

get_double

get_float

get_int

get_long

get_string

...
```

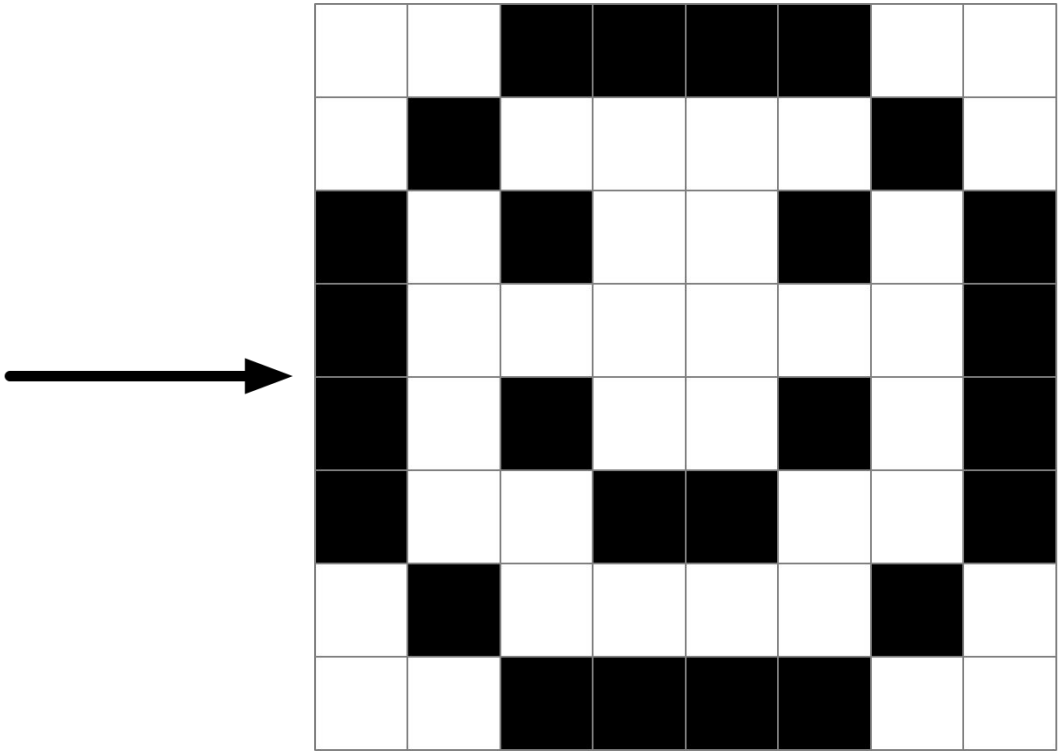
scanf

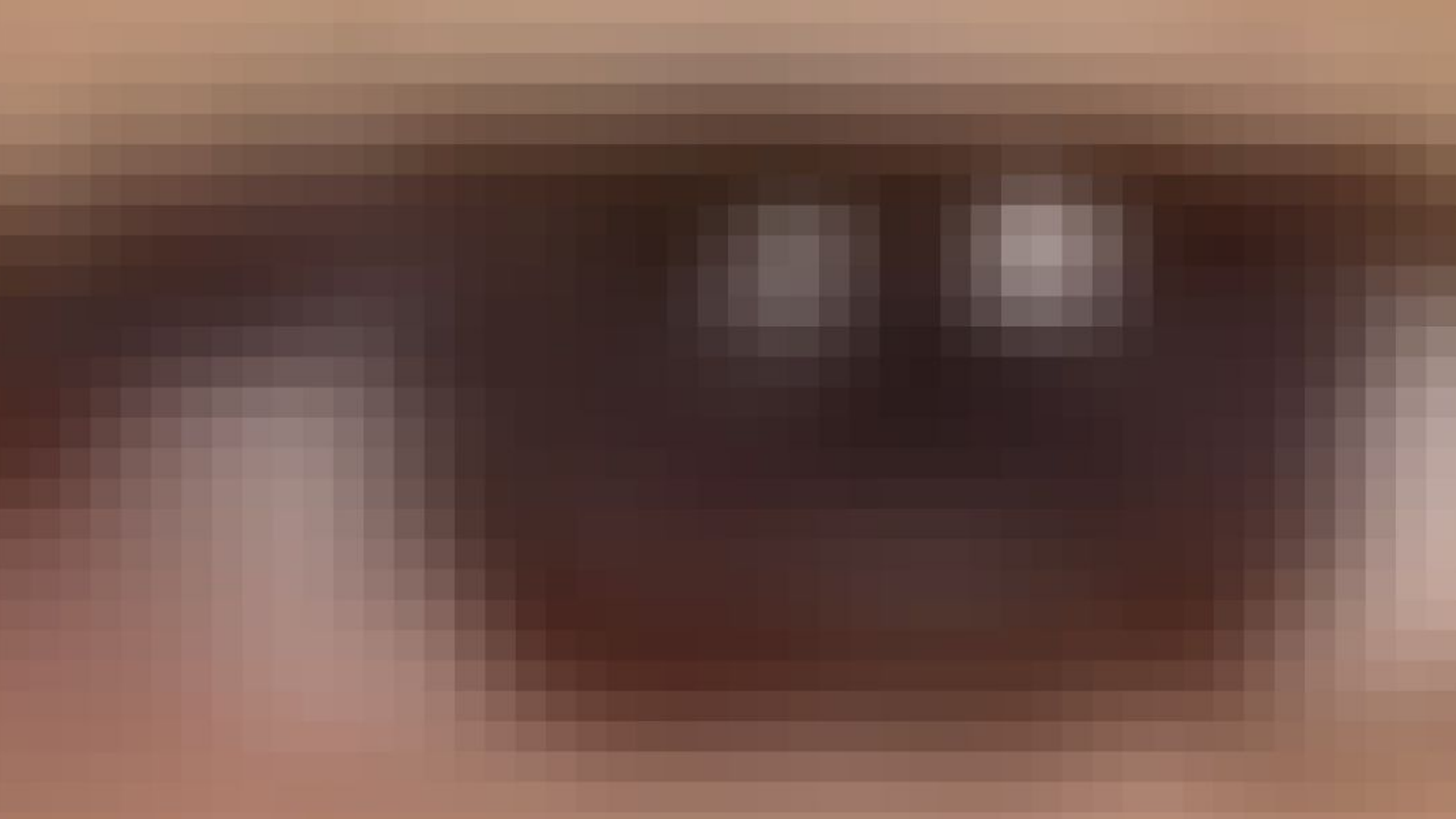
...

file I/O

```
1 1 0 0 0 0 1 1
1 0 1 1 1 1 0 1
0 1 0 1 1 0 1 0
0 1 1 1 1 1 1 0
0 1 0 1 1 0 1 0
0 1 1 0 0 1 1 0
1 0 1 1 1 1 0 1
1 1 0 0 0 0 1 1
```

```
1 1 0 0 0 0 1 1
1 0 1 1 1 1 0 1
0 1 0 1 1 0 1 0
0 1 1 1 1 1 1 0
0 1 0 1 1 0 1 0
0 1 1 0 0 1 1 0
1 0 1 1 1 1 0 1
1 1 0 0 0 0 1 1
```






MAN, I SUCK AT THIS GAME. CAN YOU GIVE ME A FEW POINTERS?
0x3A28213A
0x6339392C,
0x7363682E.
I HATE YOU.

This is CS50